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Enterprise Reference Architectures for Higher Education Institutions: Analysis, Comparison and Practical Uses

Volume I – Thesis Report

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*»Programming without an overall
architecture or design in mind is like
exploring a cave with only a flashlight: You
don't know where you've been, you don't
know where you're going, and you don't
know quite where you are«*

Danny Thorpe

Industrial Doctorate Expedient

DOCTORATS INDUSTRIALS

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Títol del projecte
Disseny d'una arquitectura multinivell per a la provisió, integració i evolució de sistemes d'informació en organitzacions d'educació superior

Empresa
SBS Seidor S.L.

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BREU DESCRIPCIÓ DEL PROJECTE DE RECERCA

L'educació superior és actualment un dels principals motors d'avenç social al mon, a través de les seves funcions característiques de formació de professionals, de recerca de nou coneixement, i d'innovació empresarial i social en col·laboració amb d'altres organitzacions públiques i privades. Normalment s'entén per organitzacions d'educació superior les universitats, les escoles de negoci i els centres de formació professional de nivell superior. Segons els països, les seves funcions, pes específic i relacions pot variar, però és habitual que tots tres tipus d'organitzacions siguin agrupats en el sector denominat en anglès com "higher education industry". Aquest sector conserva fonaments històrics que li donen continuïtat i que avalen les seves funcions, però actualment també està sotmès a forces que qüestionen alguns dels seus trets i formes convencionals i que empenyen el sector a processos d'innovació a molts nivells. En són exemples la creació d'espais d'actuació supra-estatals (European Higher Education Area, European Research Area), les possibilitats i el creixement de la formació virtual i a distancia, de la semi-presencial, la formació dual, i els programes i projectes inter-universitaris o, en general, entre organitzacions de diversos tipus. S'afegeix a això l'aparició, a algunes parts del mon, de noves formes institucionals, com les corporacions universitàries privades o les universitats corporatives, entre d'altres.

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Tot plegat, i com ha passat a molts altres sectors, davant d'aquest escenari de reptes emergents, les organitzacions d'educació superior han de revisar i eventualment replantejar alguns dels seus mecanismes de funcionament, tot procurant fer-los evolucionar cap a un entorn on aquests mecanismes esdevinguin instruments de flexibilitat i innovació, en comptes de barreres per la seva progressió. En organitzacions tant intensives en coneixement i en activitats humanes, entre aquests instruments de funcionament i evolució podem destacar els seus sistemes d'informació de tot ordre, desenvolupats amb les més diverses tecnologies d'informació. Aquests sistemes serveixen per a gestionar tota la informació relacionada la coordinació, seguiment i anàlisi de les seves activitats, amb les seves transaccions i decisions, i més recentment fins i tot amb el proveïment directe d'alguna d'aquestes activitats, com ara la formació a través de sistemes d'aprenentatge virtual (eLearning) o de sistemes de col·laboració virtual en recerca (eScience). Per altra banda, també les organitzacions d'educació superior, per iniciativa pròpia i de les institucions públiques reguladores, han de rendir comptes públiques de les seves actuacions, sovint sotmetent el seu funcionament a processos d'acreditació pública de les seves activitats, o a esquemes internacionals de qualitat (EFQM, ISO 9000 o altres d'específiques). La presència i l'influencia actuals d'aquests referents depèn del tipus d'institució i de les zones geogràfiques, però creix a mida que el sector es diversifica i competeix més internacionalment. A alguns llocs, les organitzacions d'educació superior han de reportar sistemàticament les seves dades d'actuació a les institucions reguladores (Uneix a Catalunya, SIIU a Espanya, RAE al Regne Unit). Tot això implica, per aquestes organitzacions, la necessitat de gestionar de forma correcta i integrada la gran varietat i quantitat de dades que generen, i la necessitat d'analitzar intel·ligentment aquestes dades en benefici de la qualitat dels seus processos, productes i serveis, i en general de la millora de les seves actuacions.

Paradoxalment, però, no existeix encara cap anàlisi públic i formal sobre les necessitats de sistemes d'informació pel sector d'educació superior, més enllà d'algun informe privatiu d'alguna empresa de prospectiva tecnològica. Actualment, al sector, les solucions de sistemes d'informació són directament les configuracions ad hoc de cada organització, basades majoritàriament en desenvolupaments propis, a vegades combinats amb funcionalitat resultant de productes software externs, productes sovint nascuts per altres sectors i després adaptats. Alguns sistemes d'educació superior han provat opcions de provisió molt diverses (sistema únic compartit a California, utilització de sistemes diversos coordinats a Noruega, consorciació del sistema CBUC a Catalunya, etc.). Davant d'aquesta situació, considerem oportú plantejar com a projecte de recerca industrial el disseny d'una arquitectura multinivell per a la provisió, integració i evolució de sistemes d'informació en organitzacions d'educació superior, a partir de l'anàlisi detallat de l'estat de l'art rellevant i dels casos de bones pràctiques que es puguin localitzar i estudiar, tant si són locals com internacionals, integrals or parcials. Es pretén dissenyar una arquitectura que permeti abordar, a diversos nivells (funcions, processos, sistemes, tecnologies, opcions de provisió, etc.), tot allò relatiu al desplegament (provisió, integració i evolució) dels sistemes d'informació de les organitzacions d'educació superior interessades. Utilitzant el símil del Pla Cerdà de Barcelona, aquesta arquitectura ha de servir com a "plànol" que faciliti la construcció i creixement ordenat de la futura "ciutat informàtica" que recolzi l'activitat de qualitat d'aquestes organitzacions. El projecte es planteja en benefici de les decisions estratègiques de la nova unitat de negoci creada per Seidor per aquest sector i amb la voluntat de compartir els resultats, a través de publicacions, amb les organitzacions i institucions d'educació superior.

A més de Seidor i la UOC, també la UPC està interessada en participar en el projecte, mitjançant l'inLab FIB, el Director del qual, Josep Casanovas, ha acceptat de co-dirigir la tesi de doctorat industrial que inicia el projecte. Els dos co-directors pertanyen al 2014 SGR 1534 (consolidat avaluat A).

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Publications

This thesis was partially financed by the Industrial Doctorates Plan promoted by the Generalitat de Catalunya (EXPEDIENT 2014 DI 077). The author of this thesis was the primary researcher.

Despite the dissertation is presented as a monolithic work, some parts of the research were presented at international conferences and prepared in the form of research papers for the publication in several journals.

The complete list of publications derived from the thesis is as follows:

[P1] Sanchez-Puchol, F., & Pastor-Collado, J. A. (2017a). Focus Area Maturity Models: A Comparative Review. In M. Themistocleous & V. Morabito (Ed.), *Information Systems: 14th European, Mediterranean, and Middle Eastern Conference, EMCIS 2017, Coimbra, Portugal, September 7-8, 2017, Proceedings* (p. 531-544). Springer International Publishing. https://doi.org/10.1007/978-3-319-65930-5_42

[P2] Sanchez-Puchol, F., & Pastor-Collado, J. A. (2017b). A First Literature Review on Enterprise Reference Architectures. *Proceedings of the 11th Mediterranean Conference on Information Systems (MCIS 2017)*, 1-12. http://aisel.aisnet.org/mcis2017/15

[P3] Sanchez-Puchol, F., Pastor-Collado, J. A., & Borrell, B. (2017). Towards an Unified Information Systems Reference Model for Higher Education Institutions. *Procedia Computer Science (Special issue CENTERIS 2017 - International Conference on ENTERprise Information Systems)*, *121*, 542-553. https://doi.org/10.1016/j.procs. 2017.11.072

[P4] Sanchez-Puchol, F., & Pastor-Collado, J. A. (2018). Los Modelos de Madurez como Instrumentos de Calidad para la Educación Virtual: Hacia un Catálogo de Referencia [in Spanish]. *XV Foro Internacional Sobre la Evaluación de la Calidad de la Investigación y de la Educación Superior (FECIES 2018)*, 1350-1358. https://www.ugr.es/~aepc/FECIES_16/CapitulosFECIES2018.pdf

[P5] Sanchez-Puchol, F., Pastor-Collado, J. A., & Borrell, B. (2018a). A Critical Review on Reference Architectures and Models for Higher Education Institutions. In A. P. Abraham, J. Roth, & G. C. Peng (Ed.), *Proceedings of the International Conferences Big Data Analytics, Data Mining and Computational Intelligence 2018; Theory and Practice in Modern Computing 2018; and Connected Smart Cities 2018—Part of the Multi Conference on Computer Science and Information Systems (MCCSIS 2018)* (p. 113-120). http://www.iadisportal.org/digital-library/a-critical-review-on-reference-architectures-and-models-for-higher-education-institutions

[P6] Sanchez-Puchol, F., Pastor-Collado, J. A., & Borrell, B. (2018b). First In-depth Analysis of Enterprise Architectures and Models for Higher Education Institutions. *IADIS International Journal on Computer Science and Information Systems*, *13*(2), 30-46. https://doi.org/10.33965/ijcsis_2018130203

[P7] Sanchez-Puchol, F., Pastor-Collado, J. A., & Casanovas, J. (2018a). Theoretical Comparison of Universitary Quality Assurance Maturity Models. In J. Berbegal-Mirabent, F. Marimon, M. Casadesús, & P. Sampaio (Ed.), *Proceedings book of the 3rd International Conference on Quality Engineering and Management, 2018* (p. 401-419). http://icqem.dps.uminho.pt/icqem18_proceedingsbook.pdf

[P8] Sanchez-Puchol, F., Pastor-Collado, J. A., & Casanovas, J. (2018b). What is that Thing Called Internal Quality Assurance System? In *Excellence in Services. 21st International Conference. Conference Proceedings* (p. 593-612). https://sites.les.univr.it/eisic/wp-content/uploads/2018/11/43-Sanchez-Pujol-Pastor-Collado.pdf

[P9] Sanchez-Puchol, F., Pastor-Collado, J. A., & Guàrdia, L. (2018). Maturity Models for Improving the Quality of Digital Teaching. In J. M. Duart & A. Szűcs (Ed.), *10th EDEN Research Workshop. Conference Proceedings (Towards Personalized Guidance and Support for Learning)* (p. 238-253). https://upcommons.upc.edu/bitstream/handle/2117/133380/RW10_2018_Barcelona_Proceedings.pdf?sequence=1&isAllowed=y

[P10] Sanchez-Puchol, F., & Pastor-Collado, J. A. (2019). Internal Quality Assurance Systems for Higher Education Institutions: Perspectives, Opportunities and Guidelines for a New Maturity Model. In J. Maxwell (Ed.), *Higher Education Institutions: Perspectives, Opportunities and Challenges* (p. 1-90). Nova Science Publishers, Incorporated.

[P11] Sanchez-Puchol, F., & Pastor, J. A. (2021). An In-depth Case-Study on the Practical Use of Enterprise Reference Architectures in the Public Tendering of a Universitary Information System [Unpublished manuscript].

[P12] Sanchez-Puchol, F. (2017a). *Towards a Focus Area Maturity Model for Improving Internal Quality Assurance Systems In Higher Education Institutions*. Doctoral Consortium of the 12th International Conference on Design Science Research in Information Systems and Technology (DESRIST 2017), Karlsruhe, Germany, 30 May - 1 June 2017.

[P13] Sanchez-Puchol, F. (2017b). *Towards a Focus Area Maturity Model for Internal Quality Assurance Systems In Higher Education Institutions*. Doctoral Consortium of the 11th Mediterranean Conference on Information Systems (MCIS 2017), Genoa, Italy, 4-5 September 2017.

The full content of all publications is presented in a complementary annex to this Volume.

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Finally, and above all, since the effective execution and writing of this thesis has been done during an agitated period in my personal life, I would like to express my heartfelt gratitude to my family and friends, who gave me their loving care, unconditional support and continuous engagement during my PhD time. They have been all the basis for all my achievements.

Felix Sánchez Puchol
Caseres, Terra Alta, July 2021

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List of Abbreviations

AIS	Association for Information Systems
AR	Action Research
ASIIN	Accreditation Agency Specialized in Accrediting Degree Programs in Engineering, Informatics, the Natural Sciences and Mathematics
CAUDIT	Council of Australasian University Directors of Information Technology
CRUE	Conferencia de Rectores de las Universidades Españolas
CSC	(Finnish IT) Center for Science
CSUC	Consorci de Serveis Universitaris de Catalunya
DESRIST	International Conference on Design Science Research in Information Systems and Technology Conference
Difi	Direktoratet for forvaltning og ikt
DK	Design Knowledge
DyAMM	Dynamic Architecture Maturity Matrix
DSR	Design Science Research
DSRM	Design Science Research Methodology
EA	Enterprise Architecture
EAM	Enterprise Architecture Management
EAMM-edu	Enterprise Architecture Maturity Model for Higher Education
EFQM	European Foundation for Quality Management
EQANIE	European Quality Assurance Network for Informatics Education
ERA	Enterprise Reference Architecture
ESG	Standards and Guidelines for Quality Assurance in the European Higher Education Area
EUNIS	European University Information Systems Organization
EURASHE	European Association of Institutions in Higher Education
FEDS	Framework for Evaluation in Design Science
GUS	Generic Use Situation (for Enterprise Reference Architectures)
HE	Higher Education
HEI	Higher Education Institution
IIEP	International Institute for Educational Planning
IndEA	India Enterprise Architecture framework
INEAF	Iran’s National Enterprise Architecture Framework
inLab FIB	Laboratory of Innovation and Research of the Barcelona School of Informatics
IQAS	Internal Quality Assurance System

IS	Information System
ISO	International Organization for Standardization
IT	Information Technology
ITANA	Enterprise, Business and Technical Architects in Academia
KB	Knowledge Base
MM	Maturity Model
NORA	(Saudi Arabia) National Overall Reference Architecture
	Nederlandse Overheid Referentie Architectuur
OECD	Organization for Economic Co-operation and Development
PUS	Particular Use Situation (for Enterprise Reference Architectures)
QA	Quality Assurance
QMS	Quality Management Systems
RA	Reference Architecture
REF	Research Excellence Framework
RM	Reference Model
SECC	Software Engineering Competence Center
SIIU	Sistema Integrado de Información Universitaria
SURF	Samenwerkende Universitaire Reken Faciliteiten
TOGAF	The Open Group Architecture Framework
TQM	Total Quality Management
UCISA	Universities and Colleges Information Systems Association
UNEIX	Universitat i Recerca en Xifres
UNESCO	United Nations Educational, Scientific and Cultural Organization
UOC	Open University of Catalonia
UPC	Polytechnic University of Catalonia
US	Use scenario
WST	Work Systems Theory

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Abstract (English)

Higher Education Institutions (HEIs) are facing enormous challenges of the environment in which operate. The appearance of new disruptive technologies, consumerization and marketization of studies, new regulations and accreditation requirements or the rapidly changing learner's behaviour represent just few examples of external conditions that are contributing to the advent of a new digital era for HEIs. This emphasis on the digital is having an important impact in educational institutions since is increasingly forcing them to properly manage a great variety and amount of information as well as for enhancing the quality of their processes, products and services in order to improve their efficiency.

In particular, the aforementioned circumstances tend to give rise to notable tensions between the business needs of educational institutions and their information systems (IS) and information technology (IT) infrastructure capabilities. In HEIs, many IS landscapes usually are not more than *adhoc* configurations mainly based in bespoke developments, sometimes mixed with functionalities resulting from external software products commonly arisen for other industrial sectors and later adapted and updated. Considering this background, and assuming the flourishing of a new digital era, it comes to a no surprise than many HEIs are in the urgent need to reconsider their current IS landscape configurations in order to become them real instruments of flexibility, agility.

Enterprise Architecture (EA) is currently accepted as one on the major instruments for enabling organisations in their transformation processes to achieve business-IT alignment. From a practical perspective, EA provides multiple different individual documents or EA artefacts describing various aspects of an organisation from an integrated business-IT perspective. Despite that over the last years EA has been successfully adopted in many industries – especially in manufacturing or information-intensive business environments, such high-tech, retailing or banking – Higher Education (HE) still represents one of the industries/sectors with lower levels of adoption and maturity of EA practices. Further, and in a similar way, the academia also recognizes the need for more scientific research devoted to EA practices in HE-oriented contexts, including the *feasibility of a formalised frameworks and artefacts tailored to suit the structure of HEIs* as well as on how to guide practitioners on the process of using such artefacts in their daily work.

Despite other researchers have already contributed to the research stream of EA artefact usage, the present thesis puts the emphasis particularly on the study Enterprise Reference Architectures (ERAs), as a particular type of EA artefact. In a simple form, ERAs can be understood as generic or abstract templates providing an integrated description of the recommended processes (capabilities), applications (IS) and infrastructures (IT) – including their main interrelationships – that should be found in a typical class or type of organisation Hence, the main aim of the thesis is to extend current existing knowledge on the EA field by developing greater understanding on this specific EA artefacts (since ERAs represent one of the most under-researched artefacts by literature to date), and more in particular, those ERAs specifically targeted to the application domain of the HEIs class of organisation.

Hence, after formally clarifying the concept of ERAs and giving a panoramic view of the current state-of-the-art of existing HEI-oriented ERAs, the thesis proposes an artefact framework build through a Design Science Research (DSR) approach aimed to facilitate practitioners the (re-)use or application of HEI-oriented ERAs in their own specific practical settings. The purpose of the constructed artefact is to support practitioners when preparing and conducting the necessary adjustments to HE-oriented ERAs in order to be successfully applied for their specific needs or purposes grounding on a pre-defined list derived from literature of 23 different potential theoretical scenarios of use of HEI-oriented ERAs. In this vein, the framework provides assistance enabling EA practitioners' autonomy during their professional EA practices by guiding them during the process of reflecting and asking themselves the right questions to capture, understand and systematically document all the knowledge needed for an effective use and application of HE-oriented ERAs.

Keywords: Enterprise Architecture, Reference Architecture, Enterprise Reference Architecture, Higher Education Institutions, Design Science Research.

Abstract (Spanish)

Las Instituciones de Educación Superior (IES) se enfrentan a enormes desafíos derivados del entorno en el que operan. La aparición de nuevas tecnologías disruptivas, la *marketización* de los planes de estudios ofrecidos, nuevas regulaciones y requisitos de acreditación, así como el comportamiento y expectativas cambiantes de los propios estudiantes representan solamente algunos ejemplos de factores externos del entorno que están contribuyendo al advenimiento de una nueva era digital para las IES. Este énfasis en lo digital está teniendo un impacto importantísimo en las instituciones de educación, ya que cada vez más obliga a estas a una gestión más efectiva de toda la información de gestión que recopilan, así como de la calidad de sus procesos y productos a efectos de mejorar la eficiencia del servicio que ofrecen.

En particular, todas estas circunstancias mencionadas previamente tienden a ser el punto de partida a que se produzcan tensiones entre las necesidades de negocio de dichas instituciones, y sus respectivas capacidades de sistemas y tecnologías de la información (SI/TI). En dichas instituciones, los portafolios de SI generalmente no suelen ser más que una serie de configuraciones *adhoc* de sistemas informáticos basados principalmente en desarrollados a media, mezclados a veces con otras funcionalidades ofrecidas por productos *software* externos concebidos para otro tipo de sectores para ser posteriormente adaptados y actualizados. Ante estos antecedentes, y teniendo en cuenta la llegada de una nueva era digital, no sorprende ye muchas IES se encuentren ante una urgente necesidad de reconsiderar sus configuraciones actuales de SI convirtiéndolos en verdaderos instrumentos de flexibilidad y agilidad organizativa.

La Arquitectura Empresarial (AE) es actualmente reconocida como una disciplina que permite configurar procesos de trasformación organizativa a objeto de alinear negocio con TI. Desde un punto de vista más pragmático, la AE proporciona múltiples documentos o artefactos de AE que describen varios aspectos de una organización des de una perspectiva de TI integrada con la de negocio. Y a pesar de que en los últimos años la AE se ha ido adoptando progresivamente de forma exitosa en diversas industrias o sectores – especialmente en los ámbitos de la producción o entornos comerciales intensivos en información, como por ejemplo industrias de alta tecnología, la venta al detalle o la banca – la educación superior (ES) representa hoy en día uno de los sectores con menores niveles de adopción y de madurez en lo que se refiere a las prácticas de AE. Más aún, la propia literatura académica también reconoce explícitamente la necesidad de una mayor investigación científica orientada a la práctica de la AE en contextos específicos de ES, incluyendo aspectos relativos tanto al desarrollo de marcos formales y artefactos adaptados específicamente a las estructuras de una IES, así cómo al desarrollo de recomendaciones prácticas para profesionales de cómo proceder a hacer un uso adecuado de ellos en su día a día.

Aunque otros investigadores ya han contribuido previamente al desarrollo de una corriente centrada en el uso de los artefactos de AE, la presente tesis hace especial hincapié en el estudio de las Arquitecturas de Referencia Empresariales (AREs), entendidas como un artefacto específico o concreto de AE. De forma simple, las AREs pueden considerarse como unas plantillas genéricas o abstractas que proporcionan una descripción integrada de los procesos recomendados (capacidades), aplicaciones (SI) e infraestructuras (TI) – incluidas sus principales interrelaciones –que deberían encontrarse implantadas en una clase o tipología de organización típica. Por tanto, el objetivo fundamental de la presente tesis no es otro que extender el conocimiento existente actualmente en el ámbito disciplinario de la AE por lo que se refiere a la comprensión y el conocimiento de estos artefactos (dado que las AREs representan uno de los artefactos menos investigados hasta la fecha), y en particular de aquellas AREs específicamente concebidas para su aplicación en el dominio específico de las IES, como ejemplo de clase o tipología de organización específica.

Así, después de clarificar formalmente el concepto de ARE y de ofrecer una visión panorámica del estado del arte relativo a las AREs para IES existentes en la actualidad, la tesis propone un marco o *framework* de trabajo construido a través de un enfoque de investigación basado en *Design Science Research* (DSR) destinado a facilitar la (re-)utilización o aplicación práctica de AREs para IES existentes en dominios reales y específicos de trabajo, basándose en una lista teórica de 23 casos de uso potenciales derivados de la literatura. Asimismo, el marco desarrollado proporciona también soporte adicional a la praxis favoreciendo la autonomía de decisión de los usuarios de dichas arquitecturas genéricas actuando como punto de referencia para la captura, reflexión y documentación sistemática de cualquier parámetro de conocimiento vinculante para un uso práctico y eficaz de las mismas.

Palabras clave: Arquitectura empresarial, Arquitectura de referencia, Arquitectura de referencia empresarial, Instituciones de educación superior, Investigación en Ciencia del Diseño.

Abstract (Catalan)

Les Institucions d'Educació Superior (IES) s'enfronten actualment a grans reptes derivats de l'entorn en el qual operen. L'aparició de noves tecnologies disruptives, la *marketització* dels plans d'estudis oferts, noves regulacions i requisits d'acreditació, així com el comportament i expectatives canviants dels mateixos estudiants representen solament alguns exemples dels diversos factors de l'entorn extern que estan contribuint a l'adveniment d'una nova era digital per a les IES. Aquest èmfasi en el fet digital està tenint un impacte importantíssim en les institucions educatives, ja que cada cop més obliga a aquestes a una gestió més efectiva de tota la informació de gestió que recopilen, així com de la qualitat dels seus processos i productes a fi de millorar l'eficiència dels serveis que ofereixen.

En particular, totes aquestes circumstàncies esmentades tendeixen a ser el punt de partida per a que es pugui donar lloc a l'existència de tensions entre les necessitats de negoci d'aquestes institucions, i les seves respectives capacitats de sistemes i tecnologies de la informació (SI/TI). En les dites institucions, els portafolis de SI generalment no acostemen a ser res més enllà d'una sèrie de configuracions *adhoc* de sistemes informàtics basats fonamentalment en desenvolupaments a mida, barrejats tot sovint amb altres funcionalitats oferides per programari extern concebut originàriament per d'altres indústries que posteriorment ha estat adaptat i actualitzat. Davant aquests antecedents, i tenint en compte l'arribada de la nova era digital, no és d'estranyar que moltes IES es trobin davant d'una necessitat urgent de reconsiderar les seves configuracions actuals de SI, tot convertint-los en veritables instruments de flexibilitat i agilitat organitzativa.

L'Arquitectura Empresarial (AE) és actualment reconeguda com una disciplina que permet configurar processos de transformació organitzativa a fi d'assolir l'alineament del negoci amb les TI. Des d'una òptica més pragmàtica, l'AE proporciona múltiples documents o artefactes que descriuen diversos aspectes d'una organització però des d'una perspectiva de TI integrada amb negoci. Tot i que en els darrers anys l'AE s'ha anat consolidant progressivament en diverses indústries o sectors – especialment en els àmbits de la producció o entorns comercials intensius en informació, com per exemple les indústries d'alta tecnologia, la venda al detall o la banca – l'educació superior (ES) resta encara avui en dia com un dels sectors empresarials amb menors nivells d'adopció i de maduresa pel que fa a les pràctiques d'AE. Encara més, la mateixa literatura acadèmica reconeix explícitament també la necessitat d'una major recerca científica orientada a la praxis de l'AE en contextos específics d'ES, tan pel que fa a tot el que és relatiu al desenvolupament de marcs formals i artefactes adaptats específicament a les estructures d'una IES, com al desenvolupament de recomanacions pràctiques per a professionals de com procedir a fer-ne un ús adequat en el seu dia a dia.

Tot i que altres investigadors ja han contribuït prèviament al desenvolupament d'un corrent de recerca centrat en l'ús dels artefactes d'AE, la present tesi posa el focus principalment en l'estudi de les Arquitectures de Referència Empresarials (AREs), enteses com un artefacte específic o concret d'AE. D'una forma simple, les AREs poden considerar-se com unes plantilles genèriques o abstractes que proporcionen una descripció integrada dels processos recomanats (capacitats), aplicacions (SI) i infraestructures (TI) – incloent-ne les principals interrelacions –que haurien de trobar-se implantades en una classe o tipologia d'organització tipus. Per tant, l'objectiu fonamental de la present tesi no és un altre que estendre el coneixement existent actualment en l'àmbit disciplinari de l'AE pel que fa a la comprensió i el coneixement d'aquests artefactes (atès que les ARES representen un dels artefactes menys investigats fins avui dia), i en particular, d'aquelles AREs específicament concebudes per a la seva aplicació en el domini específic de les IES, com a exemple de classe o tipologia d'organització en particular.

Així, després d'aclarir formalment el concepte de ARE i d'oferir una visió panoràmica de l'estat de l'art relatiu a les AREs per a IES existents en l'actualitat, la tesi proposa un marc o framework de treball construït a mitjançant un enfocament de recerca basat en *Design Science Research* (DSR) destinat a facilitar la (re-)utilització o aplicació pràctica d'AREs per a IES en dominis reals específics de treball, tot basant-se en una llista teòrica de 23 casos d'ús potencials derivats de la literatura. Tanmateix, el marc desenvolupat proporciona també suport addicional a la praxi afavorint l'autonomia decisòria dels usuaris d'aquestes arquitectures genèriques tot actuant com a punt de referència per a la captura, reflexió i documentació sistemàtica de qualsevol paràmetre de coneixement vinculant per tal d'assolir un ús pràctic i eficaç d'aquestes.

Paraules clau: Arquitectura Empresarial, Arquitectura de Referència, Arquitectura de Referència empresarial, Institucions d'Educació Superior, Recerca en Ciència del Disseny.

1. Exposition

1.1. Introduction

Higher education (HE) is one of the main engines of progress and social advancement around the world through its well-known functions of mass tertiary education, academic training and research, and business innovation in collaboration with other public and private organisations (Díaz-Méndez et al., 2017, p. 768; Laredo, 2007). Generically, Higher Education Institutions – hereafter referred as HEIs – can be understood as all universities, business schools, colleges of technology, research institutions and vocational education centres that offer post-secondary education, whatever their source of finance or legal status (Campbell & Carayannis, 2013, p. 4). Although this sector still retains historical foundations that give continuity to its functions and traditional role of public service providers of knowledge then accessible for the economy and society (Campbell & Carayannis, 2013, p. 25; Pucciarelli & Kaplan, 2016, p. 312), today modern HEIs are facing enormous challenges raised from an increasingly dynamic and turbulent environment that questions some its conventional features and forms, pushing the HE sector towards new innovation processes and practices at many levels.

In particular, concerns affecting HEIs over the last years include aspects related with globalisation and internationalisation; massification, diversification and increasing marketisation of the HE sector; decreasing unit funding as a consequence of years of cuts in public funding; the continuous emergence of innovative educational technologies – digitalisation, mobile devices, learning analytics, the internet of things, etc. – or, especially in western countries, the general quest for better public services driven by the implementation of sectorial reforms based on the principles of *New Public Management* (Agasisti et al., 2017; Davis, 2017; Shuiyun Liu, 2016; Pucciarelli & Kaplan, 2016). Examples of the impact of the previous forces into the *status quo* of the HE sector worldwide can be the materialisation of education-oriented supra-national spaces as the *European Higher Education Area* or the *European Research Area* (Boezerooy et al., 2007, p. 68; Curaj et al., 2015), the possibilities and unstoppable development of virtual, blended and distance education delivery models (Hill, 2012) or the progressive implementation of dual education and training, or inter-university (or either among different types of institutions) educational programmes and projects (Koudahl, 2010). Moreover, and to all this, one may add in some parts of the world the appearance of new educational institutional forms – as private university corporations or corporate universities, among others (Alonso-Gonzalez et al., 2017) – or the increasing application in HE of new advancements towards ever more interdependent and interrelated *digital transformations*, instead of less and less "ad hoc developments or one-off innovations" (Abad-Segura et al., 2020; Kar & Thakurta, 2018; O'Brien, 2018, p. 4; Wilms et al., 2017).

All in all, and as has happened in many other profit and not-profit sectors, this background is having a tremendous impact on the traditional way that HEIs operate and manage their processes (Oderinde, 2010, p. 5; Tarí & Dick, 2016, p. 273). Hence, HEIs need to review and eventually rethink some of their operation mechanism, trying to make them evolve into an environment where they become truly instruments of flexibility –allowing them to rapidly adapt to the changing demands of society – rather than being barriers to organisational growth and progress. In other words, there is an increasing need for HEIs to shift towards providing an educational service delivery developing "*competitive strategies to assess drivers of change, [and] to devise adequate responses to such change […] that allow for evolution (or even revolution) to happen*" (Pucciarelli & Kaplan, 2016, p. 312). These strategies may include the implementation of the correspondent polices and strategic guidelines setting *"the desired market positioning and respective vision and mission (or vice versa) and corresponding operational change efforts (services, processes, structures) including the respective stakeholders and their values"* (Mettler, Fitterer, et al., 2014, p. 29).

In organisations so intensive in knowledge and in human-related activities like HEIs (Merzuki & Latif, 2009; Díaz-Méndez et al., 2017, p. 775; Volk & Jamous, 2018, pp. 210–211), all previous developments pose high requirements to several organisational structures, and specially to the institution's information systems (IS) landscape developed with the most diverse range of information technologies (IT). On the one hand, HEIs are gradually relaying on these systems to manage all the coordination, monitoring and analysis-related information of their daily activities, including transactions and decisions, and more recently with the direct supply of any of such activities, as for example training through systems of virtual learning (eLearning) or virtual communication and collaborative systems for research (eScience) or social media (Volk & Jamous, 2018, pp. 211–212; Wilms et al., 2017).

On the other hand, HEIs (either on its own initiative or on a mandate from public regulatory institutions) must be held accountable to public stakeholders for its acts. This fact implies the requirement for HEIs of adjusting to quality assurance (QA) changes and reforms, even submitting their activities to public third-body- party audits and accreditation processes subjected to several international quality schemas – for example the International Organisation for Standardization (ISO) 9001 standard, the European Foundation for Quality Management Excellence Model (EFQM), the Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG) and others more specific (Kamat & Kittur, 2017; Manatos et al., 2017b) –. Current presence and influence of such referents depends on the concrete type of educational an geographical area, but it increasingly grows as the sector is more diverse and competes internationally (Dahl Jørgensen et al., 2014; Jarvis, 2014). Further, in some places, HEIs must systematically report their performance data to regulatory institutions – for example Universitat i Recerca en Xifres (WINDDAT/UNEIX) in Catalonia, the Sistema Integrado de Información Universitaria (SIIU) in Spain, or Research Excellence Framework (REF) in the United Kingdom[1] –.

Under such circumstances, again, HEIs need to fully understand the critical role of their implemented IS and deployed IT infrastructure to adequately integrate and manage the great and large variety of information and data that they generate (Abel et al., 2013; Alt & Auth, 2010, pp. 187–188; Natek & Lesjak, 2011). Furthermore, they have to intelligently analyse all these data in the benefit of the quality, cost and efficiency of their process, products and educational service delivery (Musa et al., 2019, pp. 322–323; Pucciarelli & Kaplan, 2016, pp. 314–315; Sprenger et al., 2010).

[1] WINDDAT/UNEIX – http://winddat.aqu.cat/
SIIU – http://www.educacionyfp.gob.es/servicios-al-ciudadano-mecd/estadisticas/educacion/universitaria/siiu.html
REF – https://www.ref.ac.uk/

Paradoxically, there is still no formal and public general analysis conducted – at least that we are aware of – on the true needs for IS for the HE sector, beyond some executive reports undertaken by technology foresight proprietary companies – see for example (Accenture, 2015; Grajek, 2016; Lowendahl & Rust, 2012) –. At present, current IS/IT landscapes in many modern HEIs are no more than straightforwardly the "ad hoc" configurations of each organisation which, "*despite the existence of standards, (...)* are difficult to unify due to *their specialization and historically established traditions*" (Ronzhin & Zelezny, 2018, p. 109).

For instance, these IS/IT landscapes tend to be mainly based in own institution's developments, sometimes mixed with functionalities resulting from external software products commonly arisen for other industrial sectors, and later adapted and updated (Abel et al., 2013; Ajer & Olsen, 2018, p. 4; Alt & Auth, 2010, p. 187; Green, 2007; Svensson & Hvolby, 2012, p. 637). All this gives light to "*portfolios of hundred application systems hosted on a variety of platforms and connected by diverse interfaces"* (Schmidt & Buxmann, 2011, p. 168), where core IS *"remain in hard-shelled silos, protected by both old code and outdated policy"* (Green, 2007, p. 149). Alternatively, and aiming to (partially) solve this situation, some HE systems have proved very diverse IS provisioning options – for example, a unique shared system in California (Andriola, 2014), the use of diverse systems coordinated in Norway (Ajer & Olsen, 2018, p. 4), or the consortium of the *Consorci de Serveis Universitaris de Catalunya* (CSUC) in Catalonia (CSUC, 2015) etc. –.

Whatever the case, the IS/IT complexity growth gives rise to several problems, including bureaucracy, impediments to organisational innovation, increasing maintenance risks and cost, and growing time-to-market in deploying an integrating application and services requested by teachers and students or either emerged from new institutional business requirements (Abel et al., 2013, pp. 90–91; Schmidt & Buxmann, 2011, p. 168). In the concrete context of HE, this so-called "business-IS/IT alignment problem" by the general IS literature (Luftman & Kempaiah, 2007) has been characterised by means of a *turtle-like metaphor* – change in HEIs IS/IT landscapes and infrastructures comes slow and steady (Green, 2007, p. 149) –.

In view of all this background, it is deemed appropriate to consider as an industrial research project the investigation of (multilevel) architectures providing support to the provision, integration and evolution of IS in HEIs, based on the analysis of the relevant state-of-the-art and real cases of good practice that could be identified and studied, whether they were local or international, integral or partial. In particular, it is intended to study here the existing proposed architectures and how they could be helpful to address at different levels (i.e., functions, processes, systems, technologies, provisioning options, etc.) everything related with, among others, the provision, integration and evolution of IS in HEIs. In addition, an instrumental framework for providing support and guidance to practitioners on the use of such multilevel architectures will be also conceived.

Using the *Pla Cerdà* simile in Barcelona (Urbano, 2016), the envisioned framework would have to facilitate the orderly construction and growth of the future "*computer city*" (Namba & Iljima, 2004; Rehring et al., 2019), supporting thus the quality activity of these educational organisations. The main topic and initial approach on which this research project draws on is also the result of the continuous exchange of ideas, dialogue and professional collaboration undertaken over the last years at the *Open University of Catalonia* (*UOC*) among the doctoral candidate and the thesis director proposed for this work: Dr. Joan Antoni Pastor-Collado.

Furthermore, the project will be developed under the auspices of the *Industrial Doctorates Plan* promoted by the *Generalitat de Catalunya*, aimed at helping to improve competitiveness and internationalisation of the Catalan industry. The thesis will be developed within the framework of a cooperative agreement between the *UOC* (acting as academic partner) and *SEIDOR* (acting as the main industrial partner), which has recently launched *SEIDOR Learning Services* as a new strategic business line and has expressed great interest on the research's topic. As a person responsible for the project, the company has nominated Mr. Baptista Borrell, director of the *SEIDOR Learning Services* Business Unit – hereafter referred as *SEIDOR* –.

Besides the *UOC* and *SEIDOR*, the *Polytechnic University of Catalonia* (UPC) – through the *Laboratory of innovation and research of the Barcelona School of Informatics* (inLab FIB*)* has so expressed its interest in participating and contributing on the posed research project. Thus, the director of the inLab FIB Dr. Josep Casanovas it is also proposed as a co-director for this thesis. Both academic co-directors are affiliated to the 2014 SGR 1534 consolidated research group.

Finally, and despite the fact that the present work is mainly posed on the benefit of its main academic and industrial partners, the project is born with the aim of sharing its findings and contributions – in a special manner through a series of publications – with all HEIs around.

1.2. Problem Framing and Identification

After introducing the rationale that justify the thesis, we do now move forward to frame and to positionate the thesis overall intent in terms of the existing knowledge in the IS arena, on which, in the light of the previous section, this work can be adequately set. We did so by conducting a preliminary scoping review aimed to develop a well-articulated and worthy research problem, to be answered next (Ellis & Levy, 2008). The scoping review was executed for the first time during the second semester of 2015 (at the beginning of the thesis) but has been iteratively re-executed posteriorly several times, in order to progressively include new knowledge emerged during the temporal span of the thesis (see support Table 1).

According to (Hovorka & Boll, 2015, p. 1), contributions on IS do not exist in isolation. Therefore, they should be placed into and evaluated in terms of shared commitments or *disciplinary matrix*, representing the background of accepted knowledge by a scientific community. In light of the earlier described motivation, we finally set the *disciplinary matrix* for the thesis to the Enterprise Architecture (EA) field, which represents one of the most important research areas in the IS discipline (Gorkhali & Da Xu, 2017; Saint-Louis & Lapalme, 2018; Schelp & Winter, 2009). Moreover, and given the incommensurability of research conducted on the EA field, the first step of the present research was obviously to narrow the scope of the review to be executed, in order to eventually being able to conceive and shape an affordable research problem to be investigated.

Table 1 – Literature Sources for Framing the Research Problem

#	YEAR	AUTHORS	TITLE	*Research-oriented*	*Practice-oriented*	*Literature on EA*	*Literature on HE*	*Literature on EA artefacts*	*Literature on EA in HEIs*	*Literature on RA/ERAs*	*Support literature*
1	1987	Zachman	A framework for information systems architecture		■	■					■
2	1992	Sowa & Zachman	Extending and formalizing the framework for information systems architecture		■	■					■
3	2006	Ross, Weill & Robertson	Enterprise Architecture as Strategy: Creating a Foundation for Business Execution		■	■					■
4	2006	Bucher, Fischer, Kurpjuweit et al.	Analysis and Application Scenarios of Enterprise Architecture: An Exploratory …	■		■		■			
5	2006	Greefhorst, Koning & van Vliet	The many faces of architectural descriptions	■				■			
6	2006	Boh & Yellin	Using Enterprise Architecture Standards in Managing Information Technology			■		■			
7	2006	Veltman-Van Reekum, et al.	An Instrument for Measuring the Quality of Enterprise Architecture Products		■						■
8	2006	Huschens & Rumpold-Preining	IBM Insurance Application Architecture (IAA) - An overview of the Insurance …		■					■	
9	2007	Luftman & Kempaiah	An Update on Business-IT Alignment:" A Line" Has Been Drawn		■	■					
10	2007	Winter & Fischer	Essential layers, artifacts, and dependencies of enterprise architecture	■				■			
11	2008	Aier, Riege & Winter	Classification of Enterprise Architecture Scenarios	■		■		■			
12	2008	Muller	Right Sizing Reference Architectures; How to provide specific guidance with …	■						■	
13	2008	Smolander, Rossi & Purao	Software architectures: Blueprint, Literature, Language or Decision?	■						■	
14	2008	Chen, Doumeingts, Vernadat	Architectures for enterprise integration and interoperability: Past, present and …	■	■	■					
15	2008	Greefhorst et al.	Referentie-Architectuur: Off-the-Shelf Architectuur		■					■	
16	2009	Greefhorst et al.	Herbruikbare Architectuur		■					■	
17	2009	JISC	Doing Enterprise Architecture : Enabling the agile institution		■				■		
18	2009	Merzuki & Latif	Information Management (IM) for Academic Staff Advancement Programme …	■							■
19	2009	Muller & van de Laar	Researching Reference Architectures and their relationship with frameworks …	■						■	
20	2009	Riihimaa	Combining Enterprise Architecture and Quality Assurance System from Data …	■			■	■		■	
21	2009	Kettunen	Construction of Knowledge-Intensive Organization in Higher Education		■						■
22	2009	Bick & Börgmann	A Reference Model for the Evaluation of Information Systems for an Integrated		■				■	■	
23	2009	Microsoft Corporation	Microsoft Power and Utilities. Smart Energy Reference Architecture		■					■	
24	2010	Roeleven	Why two thirds of enterprise architecture projects fail: An explanation for the …		■		■				
25	2010	Carrillo	Roadmap for the implementation of an enterprise architecture framework …	■				■	■		
26	2010	Oderinde	Using Enterprise Architecture (EA) as a Business-IT Strategy Alignment for …	■					■		
27	2010	Alt & Auth	Campus Management System	■	■						■
28	2010	Cloutier et al.	The Concept of Reference Architectures	■						■	
29	2010	Charles Sturt University	Higher Education Process Reference Model		■				■	■	
30	2011	Purao, Martin & Robertson	Transforming Enterprise Architecture Models: An Artificial Ontology View	■				■			

#	YEAR	AUTHORS	TITLE	*Research-oriented*	*Practice-oriented*		*Literature on EA*	*Literature on HE*	*Literature on EA artefacts*	*Literature on EA in HEIs*	*Literature on RA/ERAs*		*Support literature*
31	2011	Staley & Trinkle	The Changing Landscape of Higher Education		■					■			
32	2011	The Open Group	TOGAF Version 9.1		■								■
33	2011	Greefhorst	Een generieke IT-referentie-architectuur.Versnelling van architectuurontwerp		■						■		
34	2011	Greefhorst & Proper	Architecture Principles. The Cornerstones of Enterprise Architecture		■				■				
35	2011	Tamm, Seddon, Shank & Reynolds	How Does Enterprise Architecture Add Value to Organisations?	■			■						
36	2011	Winter &Aier	How are Enterprise Architecture Design Principles Used?	■					■				
37	2011	de Boer, Schijvenaars & Oord	Referentiearchitecturen in de praktijk. Delen van architectuurkennis in een van ...		■						■		
38	2012	ten Harmsen van der Beek, et al.	The Application of Enterprise Reference Architecture in the Financial Industry	■							■		
39	2012	Sidorova & Kappelman	Realizing the Benefits of Enterprise Architecture: An Actor-Network Theory …	■					■				
40	2012	Svensson & Hvolby	Establishing a Business Process Reference Model for Universities	■					■	■	■		
41	2012	Haki & Legner	New avenues for theoretical contributions in enterprise architecture principles …	■					■				
42	2012	ITANA Working Group	Reference Architecture for Teaching and Learning		■					■	■		
43	2013	Abel, Brown & Suess	A New Architecture for Learning		■					■			
44	2013	Greenhorts	The Dutch State of Practice of Architecture Principles		■				■				
45	2013	Perroud & Inversini	Enterprise Architecture Patterns. Practical Solutions for Recurring …		■		■						■
46	2013	Abraham	Enterprise Architecture Artifacts as Boundary Objects-A Framework of Properties	■					■				
47	2013	Haki & Legner	Enterprise Architecture Principles In Research And Practice: Insights From An …	■	■				■				
48	2013	Barn, Clark & Hearne	Business and ICT Alignment in Higher Education: A Case Study in Measuring …	■					■	■			
49	2013	Weiss, Aier, Winter	Institutionalization and the Effectiveness of Enterprise Architecture Management	■			■						
50	2013	SURF	Hoger Onderwijs Referentie Architectuur (Version 1.0)		■						■		
51	2013	Bonnie & Obitz	Integrating the TOGAF® Standard with the BIAN Service Landscape		■						■		
52	2014	Bischoff, Aier & Winter	Use It or Lose It? The Role of Pressure for Use and Utility of Enterprise …	■					■				
53	2014	Lankhorst	The Value of Reference Architectures		■						■		
54	2014	Löhe & Legner	Overcoming implementation challenges in enterprise architecture management …	■			■		■				
55	2014	Mettler et al.	Does a hospital’s IT architecture fit with its strategy? An approach to measure …		■								■
56	2014	Jarvis	Regulating higher education: Quality assurance and neo-liberal managerialism …	■				■					
57	2015	Timm, Köpp, Sandkuhl et al.	Initial Experiences in Developing a Reference Enterprise Architecture for Small	■							■		
58	2015	Abraham, Air & Winter	Crossing the Line: Overcoming Knowledge Boundaries in Enterprise …	■					■				
59	2015	Coltman,Tallon, Sharma & Queiroz	Strategic IT alignment: twenty-five years on	■			■						
60	2015	Mueller t al.	Because Everybody is Different: Towards Understanding the Acceptance of ...	■					■				
61	2015	Aggarwal	Industry Reference Blueprint for Insurance - Executive Edition		■						■		

#	YEAR	AUTHORS	TITLE	*Research-oriented*	*Practice-oriented*		*Literature on EA*	*Literature on HE*	*Literature on EA artefacts*	*Literature on EA in HEIs*	*Literature on RA/ERAs*		*Support literature*
62	2015	Kotusev, Singh & Storey	Investigating the usage of enterprise architecture artifacts	■					■				
63	2015	Tamm et al.	How an Australian Retailer Enabled Business Transformation Through …		■								■
64	2015	Smith & Watson	The Jewel in the Crown – Enterprise Architecture at Chubb		■								■
65	2015	Kotusev, Singh & Storey	Investigating the usage of enterprise architecture artifacts	■					■				
66	2015	Tamm et al.	How an Australian Retailer Enabled Business Transformation Through …		■								■
67	2015	Smith & Watson	The Jewel in the Crown – Enterprise Architecture at Chubb		■								■
68	2015	Pang	Reference Architecture Models with ArchiMate		■						■		
69	2015	Toppenberg et al.	How Cisco systems used enterprise architecture capability to sustain acquisition…		■								■
70	2016	Syynimaa	Mitigating Enterprise Architecture Adoption Challenges - Improved EA ...	■						■			
71	2016	Pucciarelli & Kaplan	Competition and strategy in higher education: Managing complexity and …	■				■					
72	2016	Bernus, Goranson, Gøtze et al.	Enterprise engineering and management at the crossroads	■			■						
73	2016	Olsen & Trelsgård	Enterprise Architecture Adoption Challenges: An exploratory Case Study of …	■						■			
74	2016	Dang & Pekkola	Root causes of Enterprise Architecture problems in the public sector	■			■						
75	2016	Banaeianjahromi & Smolander,	Understanding obstacles in Enterprise Architecture development	■			■						
76	2016	Foorthuis et al.	A theory building study of enterprise architecture practices and benefits	■			■						
77	2016	Lange, Mendling & Reckert	An empirical analysis of the factors and measures of Enterprise Architecture …	■			■						
78	2016	Derksen & Luftman	Key European IT Management Trends for 2016. Results of an international …		■								■
79	2016	Hinkelmann, Gerber et al.	A new paradigm for the continuous alignment of business and IT: Combining …	■			■						
80	2017	Dang & Pekkola	Problems of Enterprise Architecture Adoption in the Public Sector: Root Causes...	■			■						
81	2017	Bischoff	The Need for a Use Perspective on Architectural Coordination	■					■				
82	2017	Kotusev	Enterprise Architecture: What Did We Study?	■			■						■
83	2017	Kotusev	Eight Essential Enterprise Architecture Artifacts		■				■				
84	2017	Kotusev	The Relationship Between Enterprise Architecture Artifacts		■				■				
85	2017	Alghamdi & Sun	Business and IT Alignment in Higher Education Sector	■						■			
86	2017	Kaisler & Armour	15 Years of Enterprise Architecting at HICSS: Revisiting the Critical Problems	■			■						
87	2017	Niemi & Pekkola	Using enterprise architecture artifacts in an organisation	■					■				
88	2017	Jusuf & Kurnia	Understanding the Benefits and Success Factors of Enterprise Architecture	■			■				■		
89	2017	Nama, Tristiyanto & Kurniawan	An enterprise architecture planning for higher education using the open group …	■						■			
90	2017	Pomerantz	IT Leadership in Higher Education, 2016: The Enterprise Architect. Research …										
91	2017	Lankhost	Enterprise Architecture at Work. Modelling, Communication and Analysis	■	■		■						
92	2017	Amalia & Supriadi	Development of enterprise architecture in university using TOGAF as framework	■					■	■			

#	YEAR	AUTHORS	TITLE	*Research-oriented*	*Practice-oriented*		*Literature on EA*	*Literature on HE*	*Literature on EA artefacts*	*Literature on EA in HEIs*	*Literature on RA/ERAs*		*Support literature*
93	2017	Czarnecki & Dietze	Reference Architecture for the Telecommunications Industry. Transformation ...		■						■		
94	2018	The BIAN Association	BIAN Edition 2019 - A framework for the financial services industry		■						■		
95	2018	Ajer & Olsen	Enterprise Architecture Challenges: A Case Study of Three Norwegian Public …	■						■			
96	2018	Kotusev	TOGAF-based Enterprise Architecture Practice: An Exploratory Case Study	■					■	■			
97	2018	Shanks, Gloet, Asadi Someh et al.	Achieving benefits with enterprise architecture	■			■						
98	2018	Alamri, Abdullah & Albar	Enterprise Architecture Adoption for Higher Education Institutions	■						■			
99	2018	Gampfer et al.	Past, current and future trends in enterprise architecture—A view beyond the …	■	■		■						■
100	2018	Carr & Else	State of Enterprise Architecture Survey: Results and Findings		■		■						
101	2018	Brosius, Aier, Haki & Winter	Enterprise Architecture Assimilation: An Institutional Perspective	■			■						
102	2018	Timm	An Application Design for Reference Enterprise Architecture Models	■							■		
103	2018	Khosroshahi, Hauder & Volkert	Business Capability Maps: Current Practices and Use Cases for Enterprise …	■					■				
104	2018	Zang, Cheng & Luo	A Systematic Review of Business-IT Alignment Research With Enterprise …	■									■
105	2018	Andersen & Ross	Transforming the LEGO Group for the Digital Economy		■								■
106	2019	Kotusev	Enterprise architecture and enterprise architecture artifacts: Questioning the old …	■			■		■				
107	2019	Gong and Jansen	The value of and myths about enterprise architecture	■			■						
108	2019	Ahmad Mohd. Drus & Abu Bakar	Enterprise architecture adoption issues and challenges: a systematic literature …	■			■						
109	2019	Niemi & Pekkola	The Benefits of Enterprise Architecture in Organizational Transformation	■			■						
110	2019	Banaeianjahromi & Smolander	Lack of Communication and Collaboration in Enterprise Architecture …	■			■						
111	2019	Lethbridge & Alghamdi	Framework, Model and Tool Use in Higher Education Enterprise Architecture ...	■	■				■	■			
112	2019	Lean IX	Enterprise Architecture Insights Report 2019	■			■						
113	2019	Iyamu	Understanding the Complexities of Enterprise Architecture through …	■			■						■
114	2019	Guo, Li & Gao	Understanding Challenges of Applying Enterprise Architecture in Public …	■	■								

Source: Own elaboration

We decided to focus on the study on *Enterprise Reference Architectures in Higher Education*, which can be considered as the main topic of the research. This topic can be positioned on the "*user, use & utility research*" stream, which nowadays emerges as relatively new sub-research branch in the EA field (Brenner et al., 2014). Moreover, we argue that the research topic selected suits quite well with the idiosyncrasy of an *Industrial Doctorate* research project, as it facilitate us delivering both conceptually relevant research outputs – i.e., results having the potential to guide and inspire managerial decisions and actions increasing the functionality, efficiency and effectiveness of a firm – as well as instrumentally relevant research outputs – results intended to be immediately useful and applicable in practice – (Drechsler, 2015; Kieser et al., 2015; Wolf & Rosenberg, 2012).

All in all, the referred scoping state-of-art review proved to be a successful tool to identify several existing gaps related with the chosen topic (Müller-Bloch & Kranz, 2015), which in turn, allowed us to frame a detailed research problem. Next, the emanated research problem was further shaped, refined and described in the form of more specific research problems, as detailed in the following section. It must be also noted here that the knowledge acquired during this process also allowed us to (partially) inform the contents of the "*Research Proposal*" associated to this thesis as well as and the conceptual foundations chapter of this report (see following Chapter 2).

1.2.1. Background and Motivation

HEIs are currently confronted with a changing and disruptive environment including a plethora of economic, regulatory and technical challenges, demanding continuous transformation and adaptation in the way HEIs nowadays operate (Alt & Auth, 2010, p. 187; Staley & Trinkle, 2011; Abel et al., 2013; Shuiyun Liu, 2016). Giving answer to such challenges is having a tremendous impact in HEIs, pushing them to operational change efforts – in terms of processes, services and technical infrastructure – in order to adapt themselves to those new external requirements (Pucciarelli & Kaplan, 2016). Considering that modern HEIs are knowledge-based and information-intensive organisations (Kettunen, 2009; Merzuki & Latif, 2009, p. 95), this change encompasses notable implications on their IS/IT landscapes, given the highly interwoven and intricated overall organisational architectures existing in current HEIs (Abel et al., 2013; Alghamdi & Sun, 2017, pp. 3–4; Alt & Auth, 2010; Bick & Börgmann, 2009). The existence of tensions and deviations among business demands and IS/IT needs is not only characteristic in HEIs but also in many other profit and not profit firms, having received considerable attention by both IS researchers and practitioners over the last times (Luftman & Kempaiah, 2007; Coltman et al., 2015; Derksen & Luftman, 2016).

EA is widely recognized as a management instrument for IS's practitioners to cope with such business- IS/IT alignment tensions (Ross et al., 2006; Zhang et al., 2018, p. 18933). In a widely cited definition, (Lankhorst, 2017, p. 3) characterises EA as "*a coherent whole of principles, methods, and models that are used in the design and realisation of an enterprise's organisational structure, business processes, information systems, and infrastructure*". Adopting a similar pragmatic and straightforward approach, (Kotusev et al., 2015, pp. 1–3) refers to EA as "*a collection of special descriptive documents (called EA artefacts) describing various aspects of an organisation from an integrated business/IT perspective intended to bridge the communication gap between business and IT stakeholders, facilitate business transformations and thereby improve business/IT* *alignment*". For instance, conducting an EA practice involves all those managerial activities undertaken by different organisational stakeholders and supported by different artefacts and methodologies, aimed to achieve the ultimate goal of business-IS/IT alignment (Niemi, 2007; Löhe & Legner, 2014; Lankhorst, 2017; Perez-Castillo et al., 2019). Artefacts, methodologies and recommendations prescribed for conducting these EA activities are organized and structured through EA Frameworks, which typically provide very high-level and industry-independent guidance for implementing EA in practice (Greefhorst et al., 2006, pp. 103–104; Hinkelmann et al., 2016, p. 79; Kaisler & Armour, 2017, p. 4814; Lankhorst, 2017, pp. 29–38). Examples of widely accepted EA Frameworks can be The Open Group Architecture Framework (TOGAF) or the Zachman Framework, which are predominantly viewed as well-acknowledged "*de-facto standards*" for the EA industry (Zachman, 1987; Sowa & Zachman, 1992; The Open Group, 2011).

Besides business-IS/IT alignment, the practice of EA may provide many different benefits to organisations, namely improved communication among business-IS/IT stakeholders, increased IT flexibility and efficiency, process standardisation and automatisation, improved responsiveness and flexibility to change or IS/IT cost and risk reduction, to mention just a few (Tamm et al., 2011; Foorthuis et al., 2016; Lange et al., 2016; Jusuf & Kurnia, 2017; Shanks et al., 2018; Gong & Janssen, 2019; Niemi & Pekkola, 2019). Considering such a multiplicity of potential benefits that EA may bring to organisations, over the last decades the EA practice has been increasingly implemented in a wide spectrum of industries and sectors. Studies conducted for example in manufacturing (Andersen & Ross, 2016), retail (Tamm et al., 2015), insurance (Smith & Watson, 2015), IT (Toppenberg et al., 2015) or healthcare (Mettler, Fitterer, et al., 2014) clearly illustrate the widespread dissemination of EA, besides providing strong evidence on how EA can help to add value in different ways to heterogeneous organisations.

Even though interest in EA has lately tremendously grown, the establishment of a successful EA practice is still considered as a challenging task, taking several years to produce the expected benefits (Löhe & Legner, 2014, p. 102; Iyamu, 2019). Existing studies reveal that effective implementation of EA in organisations still remains relatively moderate, leading to divergent levels of success rate and/or EA maturity adoption, depending on the particular industry/sector (Luftman & Kempaiah, 2007; Roeleven, 2010; Carr & Else, 2018; Lean IX, 2019). Additional studies also acknowledge on identifying a series of barriers jeopardizing the effective implementation of EA in organisations, being the insufficient (or the inefficient) use of EA artefacts one of the most prominent of them (Löhe & Legner, 2014, p. 101; Dang & Pekkola, 2016, 2017; Banaeianjahromi & Smolander, 2016, 2019; Ahmad et al., 2019; Guo et al., 2019). According to these studies, EA practitioners tend to perceive many frameworks and methods recommended by prominent EA sources as useless, too abstract, inflexible, complex, with a lack of focus or even difficult to understand. Hence, and instead using them "ad hoc", EA professionals tend to customize and adapt them to their own needs emerged from their particular contexts of practice (Veltman-Van Reekum et al., 2006, p. 1; Kotusev et al., 2015; Broses et al., 2018, p. 3). However, this customisation is not easy, requiring important investments in terms of time, money and resources. This fact causes EA initiatives to be delayed and, in worst-case scenarios, leading organisations to develop their business and IS/IT landscapes without any "architectural pattern" (Perroud & Inversini, 2013). In light of this circumstances, it comes to no surprise that the study on how prescribed EA artefacts, methodologies and frameworks should be effectively adapted, customized and used when implementing EA in different sectors or particular contexts is still considered as one of most important disciplinary research challenges (Weiss et al., 2013, p. 3,16; Löhe & Legner, 2014, p. 102; Kotusev, 2017d, pp. 1730002-19-1730002–1730020; Gampfer et al., 2018, p. 82; Broses et al., 2018, p. 3).

1.2.2. Problem Description

Despite that EA artefact usage is widely acknowledged as a precedent for achieving EA benefits (Foorthuis et al., 2016; Lange et al., 2016; Shanks et al., 2018; Gong & Janssen, 2019, p. 5), effective value realisation of EA does not occur per se. "*EA in itself, as a set of documents, offers no value if it is not used in practice*" (Foorthuis et al., 2016, p. 542). Hence, how EA artefacts and methods are used in practice is what matters (Shanks et al., 2018, p. 141). In other words, If EA artefacts are not adequately used according to the conditions characterising a particular context, they may become useless in terms of EA benefit realisation (Lange et al., 2016; Niemi & Pekkola, 2019). Unfortunately, the problem of *the inadequate understanding and practical usage of EA artefacts* has received poor attention by the EA literature, still requiring further research (Banaeianjahromi & Smolander, 2016, p. 14; Kaisler & Armour, 2017, p. 4814; Kotusev, 2019; Kotusev et al., 2015, p. 2; Niemi & Pekkola, 2017, p. 236).

Historically, most existing research on EA artefact "*use and purpose*" has investigated the topic considering EA artefacts globally, that is, as an aggregate collection of artefacts. These studies are multiple and varied, addressing the topic from different perspectives and points of view (Bucher et al., 2006; Winter & Fischer, 2007; Smolander et al., 2008; Aier et al., 2008; Purao et al., 2011; Sidorova & Kappelman, 2012; Abraham, 2013; Abraham et al., 2015; Bischoff, 2017, p. 94). There also exist other studies adopting a deeper approach, identifying fine-grained use scenarios at the scope of groups or classes of artefacts (Bischoff et al., 2014; Kotusev, 2017c, 2017b; Niemi & Pekkola, 2017). However, studies with a detailed focus on particular EA artefacts have been scarcer. Regarding this kind of studies, architecture principles have been, by far, the most researched artefacts (Greefhorst et al., 2013; Greefhorst & Proper, 2011; Haki & Legner, 2012, 2013; Winter & Aier, 2011). In addition, studies investigating the practical use and application of other EA artefacts like standards (Boh & Yellin, 2006; Mueller et al., 2015), reference models (Timm, 2018, pp. 211–217) or business capability maps (Khosroshahi et al., 2018) have also been conducted. Nonetheless, only the very recent contribution by (Kotusev, 2019) provides an initial systematic analysis on the use in practice of 24 different particular types of EA artefacts.

Notwithstanding that, and assuming that a plethora of EA artefacts have been recommended for being used in practice, there still is clear room for additional research on the practical use of particular EA artefacts, either by providing deeper understanding on those ones already studied, or by exploring those ones not yet researched (Kotusev, 2019; Niemi & Pekkola, 2017). Furthermore, contextual-oriented aspects as the particular organisation type and industry in which EA is implemented or the level of EA organisational adoption may also play an important role influencing, in some or another way, how particular EA artefacts are effectively used or applied in practice. All in all, it can be concluded that there is a *knowledge-action void research gap* on the study of the use and application of particular EA artefacts in practice, since this research stream is not sufficiently mature yet.

In this sense, and over the last years, reference architectures (RA) and reference models (RMs) have been pointed out as particularly useful artefacts for enhancing EA practice. A RA can be defined as generic and reusable architectural description for a class of systems based on best practices (Greefhorst et al., 2008, 2009; de Boer et al., 2011). There are several different types of RAs in terms of granularity, level of abstraction or targeted application domain (Muller, 2008; Cloutier et al., 2010). When the targeted application domain of a RA is set to a specific "class of enterprises", they can be referred as Enterprise Reference Architectures (ERAs). An ERA has been defined as "*a generic EA for a [particular] class of enterprises … [which can be] used as a foundation in the design and realization of a concrete [solution] EA*" (ten Harmen van der Beek et al., 2012, p. 99). Thus, ERAs incorporate "*EA structures*" – descriptions of the most typical business functions/processes, applications and datasets – that characterise an "*archetypical*" instance of an organisation belonging to a determinate industry, sector or field (Greefhorst et al., 2008, 2009; Cloutier et al., 2010; Pang, 2015). However, they still are an abstract type of EA artefact: on the one hand, they provide much more level of detail than more generic RAs typically prescribed in several existing EA Frameworks; on the other hand, they present a lesser level of detail than the particular *solution EA* characterising a determinate organisation (Greefhorst et al., 2009; Muller & van de Laar, 2011, p. 3; Greefhorst, 2011a, p. 1; de Boer et al., 2011; ten Harmsen van der Beek et al., 2012, p. 101).

Grounding on the basic ideas of universality and recommendation, it is argued that ERAs can be "*reused*" as a frame of reference for providing complementary support and guidance in the daily work practice of EA professionals. In other words, ERAs may facilitate (accelerate) the development of the *solution EA* for a particular organisation, leveraging, besides, the general quality of the EA practices conducted (Cloutier et al., 2010, p. 24; ten Harmsen van der Beek et al., 2012; Svensson & Hvolby, 2012, p. 635; Lankhorst, 2014). As a consequence, a plethora of heterogeneous ERAs have been defined for a wide variety of different "class of enterprises" industries and sectors. Such efforts have been mainly concentrated on highly-regulated and service information-intensive industries as banking (Bonnie & Obitz, 2013; The BIAN [2] Association, 2018), telecommunications (Czarnecki & Dietze, 2017), insurance (Huschens & Rumpold-Preining, 2006; Aggarwal, 2015) or utilities/energy (Microsoft Corporation, 2009; Timm, Köpp, et al., 2015).

Nonetheless, and regardless of the existence of such exemplars of ERAs, important avenues for research with this specific type of EA artefact are still currently opened. In particular, further research should be conducted on how they can be formally developed and on how they could be effectively "reused" in practice and in different sectors or industries (Greefhorst et al., 2008, p. 11; Chen, Doumeingts, et al., 2008, p. 657; Cloutier et al., 2010, p. 25; ten Harmsen van der Beek et al., 2012, pp. 102–105).

Considering the relatively low maturity level of EA adoption (Luftman & Kempaiah, 2007, p. 169; Lean IX, 2019, p. 12; Barn et al., 2013; Syynimaa, 2016) and the fact that it can be characterised as an information-intensive and regulated field (Merzuki & Latif, 2009, p. 95; Jarvis, 2014; Volk & Jamous, 2018, p. 211), the HE industry emerges as particular one in which ERAs could potentially play an important role for improving EA practices (Svensson & Hvolby, 2012, p. 635). In line with many other sectors, case studies addressing how different HEIs around the world implement their EA practices reveal that they tend to use TOGAF (The Open

[2] Banking Industry Architecture Network

Group, 2011) as the base EA Framework for their efforts (Joint Information Systems Committee, 2009; Carrillo et al., 2010; Nama et al., 2017; Amalia & Supriadi, 2017; Alamri et al., 2018; Kotusev, 2018; Lethbridge & Alghamdi, 2019). Nonetheless, and when compared with other sectors, the own idiosyncrasy and nature of a HEI seems to have a special significative impact on the effectiveness of the implemented EA practices.

On the one hand, HEIs tend to be structured as rather federated organisations (faculties, centres, and so on). Hence, EA practitioners developing their professional activities in HEIs must confront to a multiplicity of heterogeneous and complex IS/IT landscapes, which tend to be managed in a rather independent and isolated way (Alt & Auth, 2010; Abel et al., 2013; Alghamdi & Sun, 2017, pp. 3–4). Such fact intrinsically complicates the activities and responsibilities associated to their daily work. On the other hand, and given the ultimate mission of HEIs as public service providers of education, key business process characterising educational institutions (e.g., teaching, learning, researching , providing third-mission value) tend to be considerably different than those ones conducted in rather profit-oriented organisations (Pucciarelli & Kaplan, 2016, pp. 311–312). Thus, a HEI represent a very specialized business domain to be architected. Finally, several existing studies also pinpoint to a relative lack of understanding of the EA concept (i.e., EA knowledge) by EA practitioners labouring in HE contexts when compared with EA professionals working in alternative industries (Olsen & Trelsgård, 2016, p. 810; Syynimaa, 2016, p. 504; Ajer & Olsen, 2018, pp. 6–7; Alamri et al., 2018, p. 16.3).

Collectively, all these circumstances seem to hinder the adoption of prescribed EA Frameworks – like TOGAF –in HEIs. EA professionals working in HE tend to refer to them as "*too heavyweight and generic [...without] giving sufficient or specific or practical information about neither how to proceed with EA, nor what an EA might look*" (Joint Information Systems Committee, 2009, pp. 66–67), providing therefore little actionable support and guidance for their daily activities. In sum, there still is a need to foster "*the feasibility of formalized frameworks and [more concrete and constructive] components of EA specifically tailored to suit the structure of HEIs*" (Oderinde, 2010, p. 7).

Some studies have been devoted to build and construct EA artefacts tailored for educational institutions. Most of them have concentrated in the development of maturity models (MMs) (Barn et al., 2013; Syynimaa et al., 2016) and in describing how different institutions adapt the *Architecture Development Method* – i.e., the associated EA methodology prescribed by TOGAF – in their particular setting (Amalia & Supriadi, 2017; Nama et al., 2017; Kotusev, 2018). Unfortunately, literature on the application of ERAs in the HE industry [3] is still in its infancy, being scattered, sparse and meagre. At most, it can be argued that some authors have pinpointed the potential suitability of these artefacts for being reused in different situations and for different purposes (Olsen & Trelsgård, 2016; Riihimaa, 2009, pp. 4–5; Svensson & Hvolby, 2012). Nonetheless, they do represent nothing else than mere suggestions providing simple or just anecdotal evidence on the phenomena. Notwithstanding this, and grounding on non-scholarly and grey literature, it can be argued that several preliminary instances of more or less formalized HEI-oriented ERAs have already been constructed (Bick &

[3] In the remaining of the thesis, and for simplicity purposes, we will use the term "*HEI-oriented ERAs*" to refer to those ERAs with an application targeted domain scoped to describe the EA of the HEIs "class of enterprises".

Börgmann, 2009; Charles Sturt University, 2010; ITANA [4] Working Group, 2012; SURF [5], 2013). This fact should be interpreted as a clear sign on the fact that building architectural knowledge in the form of ERAs is becoming a current trend. Whatever the case, and all in all, it can be concluded that there is a clear *knowledge and evaluation research void gap* on the use of HEI-oriented ERAs since it already is a manifestly under-researched phenomenon.

1.2.3. Specific Problems with Enterprise Reference Architectures in Higher Education Oriented Contexts

The previous general problem can be further decomposed into a set of more specific research problems [RP] with a lower level of abstraction. To do so, we will draw on the concept of "*assimilation*" which has already been used by the EA research community (Brosius et al., 2018). Assimilation refers to the extent to which a new phenomenon – such as an idea, device system, or a method – demonstrates its usefulness as a part of the work life of an organisation (Ramiller, 2004; Brosius et al., 2018, p. 1,3). In words of (Drechsler, 2015, p. 37), "*practitioners first need to be informed about an artefact (for instance, by its designers), become aware of its existence, perceive it, and assess whether they can see how its adoption can benefit them or their organisation, before actual artefact adoption can take place*". Considering that IS-oriented literature has characterised the process of assimilation into three steps – awareness, understanding and use (Brosius et al., 2018, pp. 3–4) – the research problem to be addressed in this thesis can be expressed in terms of the previous concepts as follows:

[RP.1] Lack of awareness on existing HEI-oriented ERAs

According to (Kuechler & Vaishnavi, 2011, pp. 133–124) and (Drechsler, 2015, p. 37), practitioners should previously perceive an artefact as potentially useful for their purposes as a first step to achieve practical utility. Assuming the relatively low levels of maturity of EA practices in many HEIs, practitioners labouring in this field need to be informed and become aware on the existence of such-a-kind of customized EA artefacts. However, the study on the adoption and use of specific EA artefacts in different industries is yet an under-researched area. Thus, EA professionals in HEIs suffer from a lack of transparency regarding on which and how many instances of ERAs tailored to the scope of the HEIs class of enterprises have currently already been constructed.

[RP.2] Insufficient understanding on the concept of ERAs by EA professionals working in HEIs.

Low levels of actionability of the prescribed industry-independent EA artefacts and methods used by EA professionals in the HE arena tend to be considered as one of the major factors hindering EA implementation in educational settlements. An ERA represents a more specific and alternative lightweight type of EA artefact which can be particularized to suit better HEI's requirements and needs of practitioners. For instance, it can be used as a frame of reference instrument to complement

[4] The *Enterprise, Business and Technical Architects in Academia* (ITANA) is an EDUCAUSE community working group focused on developing the skills, tools and suite of resources to assist educational institutions with their business and technical architectural needs.

[5] *Samenwerkende Universitaire Reken Faciliteiten* (SURF, in English *Co-operative University Computing Facilities*) is a cooperative association of Dutch educational and research institutions working together in IT facilities and innovation in order to make full use of the opportunities offered by digitalisation.

and strengthen the quality of daily EA practices. Nonetheless, and besides being aware of existing instances, EA practitioners in HEIs need to clearly understand the concept of ERA, their main features and particularities, and how they can effectively apply it in their daily work activities to achieve their inherent potential value.

[RP.3] Lack of evidence on the use of ERAs in HE-oriented contexts and settings

Finally, and before effective artefact adoption may take place, EA practitioners also need to see some kind of evidence demonstrating (in some or another way) the supposed utility (value) of the artefact since "*the adoption [in practice] of an unproven approach is just too much of a risk*". In this sense, research on the use and application of ERAs stills remains as a largely unexplored topic. In particular, and regarding their application in HE-oriented contents, literature provides little evidence on their potential utility and the benefits that could be achieved from their effective use. For instance, additional empirical research providing stronger evidence on the overall value of HEI-oriented ERAs should be developed.

Besides all the above, and in terms of the local context of practice – i.e., implementing EA in the scope of HEIs in Catalonia –, we had the opportunity to corroborate the previous issues by means of a series of activities:

- A series of informal interviews with different EA practitioners (chief information officers, EA managers and consultants, etc.) conducting their professional activities in different Catalan HEIs. In any case, none of the interviewees was aware on the existence of ERAs nor was able to cite us one example of HEI-oriented ERA.
- The professional *advisor* responsible for the present research project at *SEIDOR* informed us that, despite being a multinational IT service provider for different sectors and industries, the company had not yet been able to establish a permanent, integral and truly effective EA function providing centralized EA support to all its business units.
- Finally, and during the execution of the thesis, we had also the opportunity to participate in a project undertook at *SEIDOR* aimed to develop a bid proposal for creating a new integrated IS of a leading Catalan HEI. When the use of a particular instance of HEI-oriented ERA was proposed to be used as support instrument during the project, none of the project team members – including people with different professional roles, as business managers, EA consultants, IT architects or research and development specialists – had ever heard before about of this type of customized EA artefacts. Further information on this experience will be provided in the remaining of the present thesis report.

1.3. Research Aim and Questions

In order to give answer to the previous practical problems, the main research aim [RA] of this thesis can be described as the study of the concept of ERAs (as a particular type of under-researched EA artefact) and their use and application in HE-oriented contexts (a particular sector/industry in which EA adoption and success ratios have historically been rated as relatively poor, compared with alternative industries). In so doing, we expect to contribute to the current existing EA body of knowledge (1) by providing increased understanding on these EA artefacts, and (2) by exemplifying their potential value (utility) for practitioners, showing evidence on how they could be used and applied in HE-oriented contexts.

In particular, the research questions [RQ] reflecting WHAT to be done in this thesis are as follows:

- [RQ.1] What current knowledge about ERAs is available?
- [RQ.2] Which exemplary instances of HEI-oriented ERAs already exist?
- [RQ.3] How and to what extent can HEI-oriented ERAs be used in practice by different stakeholders?

By answering the first couple of [RQs], we expect to construct a reasonable corpus of knowledge on ERAs, both in general terms, as well as at the more particular scope of existing instances of ERAs with a targeted application domain set to the HEIs' "class of enterprises". Once consolidated, we expect that this organized body of knowledge provides us with the sufficient underlying "know-how" for giving satisfactory answers to the third [RQ] of the thesis, in terms of conceiving some kind of instrument for facilitating (accelerating) the use and application of HEI-oriented ERAs in different scenarios of practice.

1.4. Research Objectives and Intended Audience

After determining what has to be studied, it is time now to discuss HOW it will be realized. To do so, we decided to further break down the established research aim [RA] and research questions [RQ] of the thesis into a set of more detailed and achievable research objectives [RO], configuring in turn, a series of steps shaping and refining the scope, depth, breadth an overall direction of the whole research effort.

Specifically, the following research objectives [RO] are settled for this thesis – detailed in parentheses the particular research question [RQ] to which each research objective [RO] is related to –:

- [RO.1] To *explore* existing knowledge on ERAs ([RQ.1])
- [RO.2] To *identify* existing instances of HEI-oriented ERAs ([RQ.2])
- [RO.3] To *critically evaluate* existing relevant instances of HEI-oriented ERAs ([RQ.2])
- [RO.4] To *build* a framework for facilitating the use of ERAs in HE-oriented contexts ([RQ.3])
- [RO.5] To *identify and collect* possible use scenarios on which HEI-oriented ERAs can be used or applied in practice ([RQ.3])
- [RO.6] To *evaluate* the goodness and practical utility of the framework developed ([RQ.3])
- [RO.7] To *provide* evidence on the practical use of HEI-oriented ERAs ([RQ.3])

According to these research objectives [RO], we argue that main findings and contributions to be achieved from this thesis could be interesting to a relatively wide audience. In general terms, it can be argued that they can be especially relevant to all those parties (individuals) interested, in some or another, way in the practice of EA in HEIs. More particularly, and assuming that an effective use of an ERAs in different HE-oriented contexts could be potentially beneficial for different purposes and for different stakeholders (Benneworth & Jongbloed, 2010; Kettunen, 2014; Niemi, 2007; Ulewicz, 2017; van der Raadt et al., 2008), the contents and results achieved in the following research could be of interests for the following interested parties:

- *IT-oriented professionals in HEIs,* including IS/IT executives, EA architects, IS/IT project managers, technical architects, product specialists, etc.),
- *Non-faculty business-oriented professionals in HEIs*, including university top managers (deans, rectors, directors, senate) faculty/department managers, business architects, project managers, central quality assurance units and managers, or even students.
- *Academics in the IS arena, and specially, those ones researching on the EA sub-stream.* In a more residual way, outputs of the thesis can offer interesting insights for *researchers in the field of HE*.

Finally, the outputs of the thesis may also be interesting to *other external HEI's stakeholders*, such as independent professionals, government institutions, legislators, QA accreditation bodies and agencies, professional associations and many different types of IS/IT suppliers and consulting firms serving HEIs.

1.5. Research Approach

According the nature of the present thesis as an *Industrial Doctorate* research project, we decided to adopt a rather pragmatic stance (Dewey, 2011; James, 2010; Peirce, 1933) as the underlying philosophical grounding for the research. In the IS discipline, the *pragmatism* paradigm is associated with "*action, intervention and constructive knowledge [… appreciated due to its …] its practical usefulness and its ability to bring about informed change action".* (Ågerfalk, 2010, pp. 251–252). Hence, it suits well for addressing problems related to the usefulness of actions and decisions in practice (Alter, 2013a, pp. 22–25; Goldkuhl, 2012b) as is the case with the one stated in our thesis. Literature clearly points out to Action Research (AR) and Design Science Research (DSR) as the most appropriate methodological approaches for conducting pragmatic research (Ågerfalk, 2010; Goldkuhl, 2012b, 2012a). For the purposes of the present thesis, we decided to adopt DSR. Therefore, in the following paragraphs, we will briefly introduce the DSR approach and justify the main reasons for its selection.

DSR's roots can be traced back as far back as the 1960 in engineering disciplines and the sciences of the artificial. Most of the existing IS literature tend to cite Herbert Simon's (1969) "*The Science of the Artificial*" book as the precedent of DSR (Baskerville, 2008, p. 441; Baskerville et al., 2018, p. 364; Winter, 2008, p. 470). Fundamentally, DSR is considered as a problem-solving approach, in which scientific results are applied to "*organisational and societal practical relevant problems*" (Drechsler, 2013; Wieringa, 2010, p. 61; Winter, 2008, p. 473) drawing on situations "*that cannot be definitively described, due to the complexity and pluralistic nature of these problems*" (Hellmuth & Stewart, 2014, p. 3) [6]. Hence, DSR is aimed to give answer to questions *"relevant to human problems via the creation of innovative artefacts, thereby contributing new knowledge to the body of science evidence*" (Hevner & Chatterjee, 2010, p. 5). According to such aim, DSR is generally accepted as highly-potentially research approach for establishing an adequate balance between rigour and relevance of IS scientific contributions (Baskerville et al., 2018, p. 358; Österle et al., 2011; Winter, 2007).

[6] Such kind of problems are usually referred as *wicked problems* (in contraposition to *tame problems*) which can be generically characterized as (i) being difficult to define and formulate, as there are multiple explanations for them, and (ii) having no clear set of possible solutions, which can be better or worse from different angles or points of view (Farrell & Hooker, 2013; Peters, 2017).

Beyond the initial work by Simon, other later influential papers in the DSR sphere – as seminal works by (Hevner et al., 2004; Gregor & Jones, 2007; Hevner, 2007; Peffers et al., 2007; Kuechler & Vaishnavi, 2012; Gregor & Hevner, 2013) – as well as the consolidation of design-centered conferences – as the *International Conference on Design Science Research in Information Systems and Technology Conference* (DESRIST) –, created momentum and established the foundational basis on how DSR is currently understood (Peffers et al., 2018, p. 129). Today, and despite accepting that there is still and ongoing debate on the IS field whether DSR should be formally considered as a research approach or a research paradigm (Baskerville, 2008, p. 442; Kutzner et al., 2018, p. 5; Weber, 2012), literature is conclusive on the fact that DSR is a well-accepted and consolidated alternative for conducting high-quality and theoretically-sound scientific research within both the IS and the management disciplines (Baskerville et al., 2018; Drechsler, 2013; Hoang Thuan et al., 2019; Peffers et al., 2018; van Aken et al., 2016).

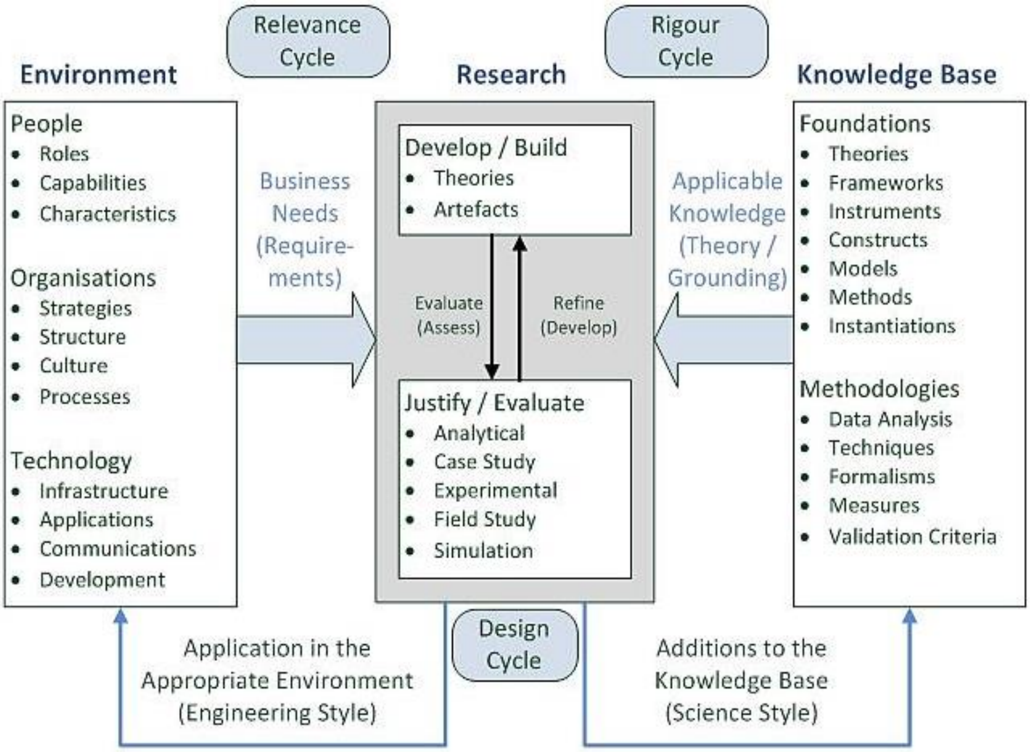

Figure 1 – An Information Systems Oriented Design Science Research Framework
Source: (Glossop, 2016)

Mainstream recognition of DSR in the IS arena is acknowledged to have occurred with the (Hevner et al., 2004) publication in *MIS Quarterly Journal* , becoming one the most cited IS papers ever. In their contribution, Hevner and colleagues provide a "*concise conceptual framework and clear guidelines for understanding, executing and evaluating (design science) research*" in terms of a "*build-evaluate*" cycle (Hevner et al., 2004, p. 75). Also, in a subsequent and also well-known paper, (Hevner, 2007) further extended and refined its original framework by overlying the focus of DSR-oriented activities into three inherent research cycles [7],

[7] Later, (Drechsler et al., 2016) extended this framework further beyond including a fourth research cycle, the *change and impact cycle,* capturing the dynamic nature of IS artefact design.

namely (i) the *Relevance Cycle*, bridging the contextual environment of the research project with the design science activities; (ii) the *Rigor Cycle*, connecting the design science activities with the knowledge base of scientific foundations, experience, and expertise that informs the research project; and finally, (iii) the central *Design Cycle*, iterating between the core activities of building and evaluating the design artefacts and research processes. The resulting overlapped framework is shown in Figure 1. The effectiveness in practice of the framework has also been shown by (Cronholm & Göbel, 2016) in a relatively new paper.

The main goal of a DSR-effort is the creation of *design knowledge* (DK) about innovative solutions giving answers to real-world problems, taking the form of different knowledge contributions, namely *design entities* and *design theories* (Drechsler & Hevner, 2018; Gregor & Hevner, 2013; Hevner et al., 2004; vom Brocke & Maedche, 2019; Winter, 2008).

On the one hand, *design entities* correspond to artefacts resulting of the design process. According to (March & Smith, 1995) this artefacts can take de form of can take the form of *constructs* (vocabularies and languages of a domain), *models* (abstractions, representations and propositions expressing relationships between constructs), *methods* (sets of procedural steps used to perform a task), and *instantiations* (prototypes, applications and complete IS). Later, (Vaishnavi et al., 2017) also pinpointed to *architectures* (high level structures of systems) and *frameworks* (conceptual guides to serve as support or guide) as relevant DSR-oriented "classes of artefacts".

On the other hand, *design theories* refer to abstract and coherent sets of knowledge describing the principles of form and function, methods, and justificatory theories used to describe and guide the development of an artefact designed to accomplish an specific goal or end in the material world (Baskerville & Pries-Heje, 2010; Drechsler & Hevner, 2018; Gregor, 2006; Gregor & Jones, 2007; Kuechler & Vaishnavi, 2012). In this sense, such theories can also encompass or include the previous referred forms of DK (Baskerville & Pries-Heje, 2010; Gregor & Hevner, 2013, p. A3). Considering the complexity of the characteristics and the design process for developing such kind of theories (Baskerville & Pries-Heje, 2010, p. 271; Venable, 2006) developed the notion of *utility theory* as a simplest and more pragmatic alternative type of *design theory*.

In a broad sense, knowledge can be differentiated between λ-knowledge and Ω-knowledge (Drechsler & Hevner, 2018; Gregor & Hevner, 2013; vom Brocke et al., 2020), being the first *prescriptive* and the second *descriptive, explanatory, or predictive,* (Gregor, 2006; vom Brocke & Maedche, 2019, p. 381). *Lambda* (λ-) *or prescriptive knowledge* concerns to the "how" knowledge of human-built artefacts to improve the natural word (Gregor & Hevner, 2013, p. 343,A3), and corresponds to the DK resulting from DSR-oriented efforts in the form of *design entities* and *design theories*. In contrast, *Omega* (Ω -) or *descriptive knowledge* [8] refers to the "what" knowledge about natural phenomena and the laws and regularities among phenomena (Gregor & Hevner, 2013, p. 343). Typical manifestations of such type of knowledge are composed of "*observations, classifications, measurements, and the cataloguing of these descriptions into accessible forms*" (Gregor & Hevner, 2013, p. 343,A3).

[8] (vom Brocke et al., 2020, p. 381) characterize Ω-knowledge as first being descriptive, explanatory, or predictive.

Both forms of knowledge present various relationships and interactions in the performance of a DSR project (Drechsler & Hevner, 2018; Gregor & Hevner, 2013, p. 343) and, together, constitute what is known as the *knowledge base* (KB), as is shown in Figure 2. A KB represents the comprehensible body of knowledge informing and into which is founded a particular DSR domain (Gaß et al., 2012; Gregor & Hevner, 2013). Despite that a DSR-oriented initiative mostly produces *prescriptive knowledge* , it may be pointed out that DSR efforts may also lead to contributions to the Ω-knowledge base in the form of expanded understanding of the of the problem and solution spaces, or the development of new behavioural theories of the artefact in use (Gregor & Hevner, 2013, pp. 346–347; Kuechler & Vaishnavi, 2008).

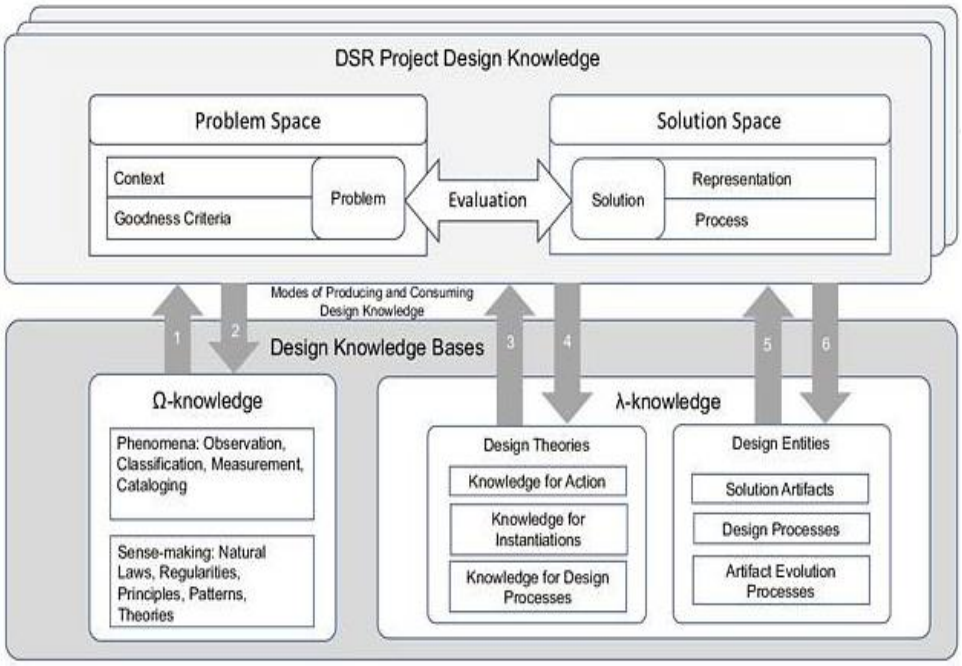

Figure 2 – Anatomy of a Design Science Research Knowledge Base and Roles Associated to Different Types of Knowledge

Source: (vom Brocke et al., 2020)

Finally, and considering all the previous theoretical background, to conclude the present section we proceed now to justify the adequacy of using a DSR-oriented approach for the thesis. To do so in the following Table2 some key DSR postulates are enumerated, together with a brief justification on how they apply for the particular purposes of the present research work.

Table 2 – Justification for the Adoption of a Design Science Research Approach for the Thesis

DSR postulates	Application to this thesis
DSR as a pragmatic approach for constructing knowledge with practical usefulness	• Pragmatism stances considered as a suitable option for being used as underlying philosophical paradigm for Professional Doctorate oriented research projects (Fink, 2006; Kumar & Antonenko, 2014), in line with the characteristics of the present work. • DSR as plausible methodological research approach for conducting pragmatic research (Ågerfalk, 2010; Chynoweth, 2014; Goldkuhl, 2012b). • DSR is research methodological approach aimed to generate constructive knowledge in the form of useful "artefacts" for practice (Hevner et al., 2004; Gregor & Hevner, 2013; Baskerville et al., 2018; Peffers et al., 2018).
DSR allows to establish an adequate balance between rigor and relevance of research contributions	• Professional doctorates tend to be considered as more adequate than traditional academic doctorates for managing tensions between academic relevance and academic rigor (Gill & Hoppe, 2009; Kumar & Antonenko, 2014). • Role of DSR as a theoretically-sound approach for producing and evaluating scientifically ground artefacts has already been justified by existing literature (Fettke et al., 2010; Koppenhagen et al., 2012; Österle et al., 2011; Venable & Baskerville, 2012; Winter, 2007). • Evidence already existing on the effectiveness of DSR for conducting both rigorous and relevant research (Offermann, Blom, Schönherr, et al., 2010; Thakurta et al., 2017, p. 4690). • DSR approaches have been successfully used to conceive EA- artefacts (Löhe & Legner, 2014; Meyer & Helfert, 2013; van Steenbergen, Bos, et al., 2010), and even for being used in HE-oriented contexts (Khashab et al., 2018; Proença & Borbinha, 2018; Syynimaa, 2015, 2016).
DSR is research approach for giving answer to relevant organisational practical problems	• *Alignment of IT and/with the business*" has usually been considered as a top concern for IT managers (Derksen & Luftman, 2016, p. 4), and in particular by IT managers in HE (Grajek & 2017–2018 EDUCAUSE IT Issues Panel, 2018; Grajek & 2018-2019 EDUCAUSE IT Issues Panel, 2019). In this sense, EA is widely acknowledged as a management tool for coping with such business and IS/IT alignment tensions (Ross et al., 2006; Zhang et al., 2018, p. 18933) • EA discipline characterised as an *Applied Design Science* (Glossop, 2016). • Issues related with the inefficient use of EA artefacts affecting in a generalized way to a plethora of heterogeneous organisations in different industries (Banaeianjahromi & Smolander, 2019, p. 878, 2016, p. 5; Dang & Pekkola, 2017, pp. 187–188, 2016; Iyamu, 2019, pp. 287–288).
DSR is a research approach to solve generic "class of problems" by means of "class of artefacts" (i.e., solutions)	• The "*class of problem*" inadequate understanding of EA artefacts and of their practical usage has already been characterised by researchers (Kotusev, 2019; Kotusev et al., 2015; Niemi & Pekkola, 2017). Understanding and reutilisation of ERAs can be viewed as a sub-class of the previous problem. • Research objectives [RO.4- RO.7] operationalized towards the development of an instrument/ framework for facilitating EA practitioners' effective use and application of ERAs in HE scenarios.

Source: Own elaboration

1.6. Research Design

At the heart of any research endeavour stands the research process applied, which encompasses a sequence of steps (roadmap) undertaken in which one or more research methods can be applied (Alturki et al., 2013, p. 1). A variety of possibilities for DSR-compliant research processes are recommended by the academic literature (Achampong & Dzidonu, 2017; Alturki, 2012; Alturki et al., 2011, 2013, 2012; Baskerville et al., 2009; Iivari, 2015; Johannesson & Perjons, 2014; March & Smith, 1995; Nunamaker et al., 1990; Offermann et al., 2009; Österle et al., 2011; Ostrowski et al., 2012; Peffers et al., 2007, 2018; Rossi & Sein, 2003; Takeda et al., 1990; Walls et al., 1992; Wieringa, 2009; Wieringa, 2014). Moreover, some more additional ones particularized for constructing specific "classes of artefacts" have also been posed (Becker et al., 2009; Drechsler, 2014b; Kuechler & Vaishnavi, 2012; van Steenbergen, Bos, et al., 2010).

Considering the main research aim [RA] and the research objectives [RO] operationalised for the thesis, and grounding also on the "*technological rules*" (i.e. action guidelines) proposed by (Venable et al., 2017) to choose and appropriate DSR methodology for a particular research project, we finally decided to use for the thesis the Design Science Research Methodology (DSRM) by (Peffers et al., 2007) as a base methodology. In particular, DSRM defines the following set of steps for a generic DSR-oriented research process: (i) *problem identification and motivation*, (ii) *definition of the objectives (requirements) for a solution*, (iii) *design and development*, (iv) *demonstration*, (v) *evaluation*, and (vi) *communication*.

The reasons for justifying the adoption of such methodological approach are as follows:

- DSRM encompasses and synthetizes all what most of earlier approaches agree in that a rigorous DSR process should be (Gleasure et al., 2012, pp. 10–12).
- DSRM builds upon the basic postulates considered in major DSR foundational masterpieces. On the one hand, it is fully compatible with the general IS DSR framework (Hevner et al., 2004) by defining it by means of a simple "*build-evaluate*" pattern. On the other hand, DSRM also feeds on the 3-Cycle-View (Rigor, Relevance and Design) idea of a DSR-oriented research approach.
- Some criticisms have been raised on the use of DSRM for novice IS scholars/researchers due to its high level of abstraction, hindering thus, its implantation. Nonetheless, DSRM provides much more actionable guidance than the IS DSR framework and the 3-Cycle-View frameworks.
- As a counterpart to its supposed inherent level of abstraction, it can be argued that DSRM is a quite simple and flexible framework, facilitating its usability and applicability. On the one hand, it enables the development of all kind of *design entities* or *design theories* as the main output of a research effort. On the other hand, it offers freedom to the researcher for choosing the most adequate combination of research methods and data collection techniques to each of the configuring stages of the framework (see additional Table 3).
- Finally, literature provides clear evidence on the effective use of DSRM for building different types of EA-oriented artefacts (Aier et al., 2011; Otto et al., 2012; vom Brocke et al., 2014). Furthermore, some of them were later validated within particular HE-contextual situations (Nugroho, 2017; Pulkkinen, 2013; Syynimaa, 2015, 2016).

Table 3 – Research Methods and Techniques Suitable for Design Science Research Projects

Item	Elements
Research methods	Experiments, Surveys, Case studies, Ethnography, Grounded theory, Action research, Phenomenology, Simulation, Mathematical and logical proof, Informed arguments, Criteria-based evaluation, Scenario analysis
Data collection techniques	Questionnaires, (Expert) Interviews, Focus groups, Observations, Document analysis, Data gathering and Testing techniques (Black/white Box)
Data analysis techniques	Quantitative data analysis, Qualitative data analysis

Source: Own elaboration, based on (Johannesson & Perjons, 2014; Venable et al., 2012).

The following Figure 3 portraits the concrete instantiation the DSRM methodology to the particular endeavours undertaken in the present thesis. At the centre of the image, the 6 DSRM's procedural steps representing a nominal process for conducting DSR are reflected. To instantiate such nominal process to a particular research effort, DSRM also offers four different research *entry points*, namely *problem-centered initiation*, (ii) *objective-centered initiation*, (iii) *design and development-centred initiation*, and (iv) *client/context-centered initiation*. Depending on the nature of the phenomena to be researched, the *entry points* represent multiple possibilities for "initiating" a research design process (which may fall into any step of the nominal process defined by the DSRM framework). According to the problem-driven nature of the [RQs] to be addressed in this thesis (see sections 1.2-1.3), we chose a *problem-centred initiation* approach. For instance, the present research goes over the whole set of the stages considered for a canonical DSR project.

At the top part of Figure 3, we also show how the [RQs] defined in the thesis will be addressed in terms of their relationship with the nominal DSR research process to be followed. Hence, and meanwhile [RQ.1-RQ.2] will be addressed during the initial steps of the sequence – *problem identification and motivation* and *definition of the objectives for a solution* stages of the research process –, [RQ.3] will be mostly addressed during the latest ones – *design & development*, *demonstration* and *evaluation* –. The final *communication* stage could be associated to the diffusion of research findings referring to either one of the [RQs] posed.

In addition, and also at the top part of Figure 3, we show the concrete mix of research methods and data collection/ analysis techniques used in each concrete stage of the nominal sequence. In order to increase the rigor of the whole research process, we tried to be as much strict as possible on using a mix of techniques and methods recommended by the literature as suitable for each one of the DSRM stages (Hevner et al., 2004; Johannesson & Perjons, 2014; Sonnenberg & vom Brocke, 2012a; Venable et al., 2012). In this sense, the power of DSR for leveraging diversity in research by fostering the use of multiple- and/or mixed-methods approaches is reflected in the variety of options chosen (Ågerfalk, 2013, pp. 251–253).

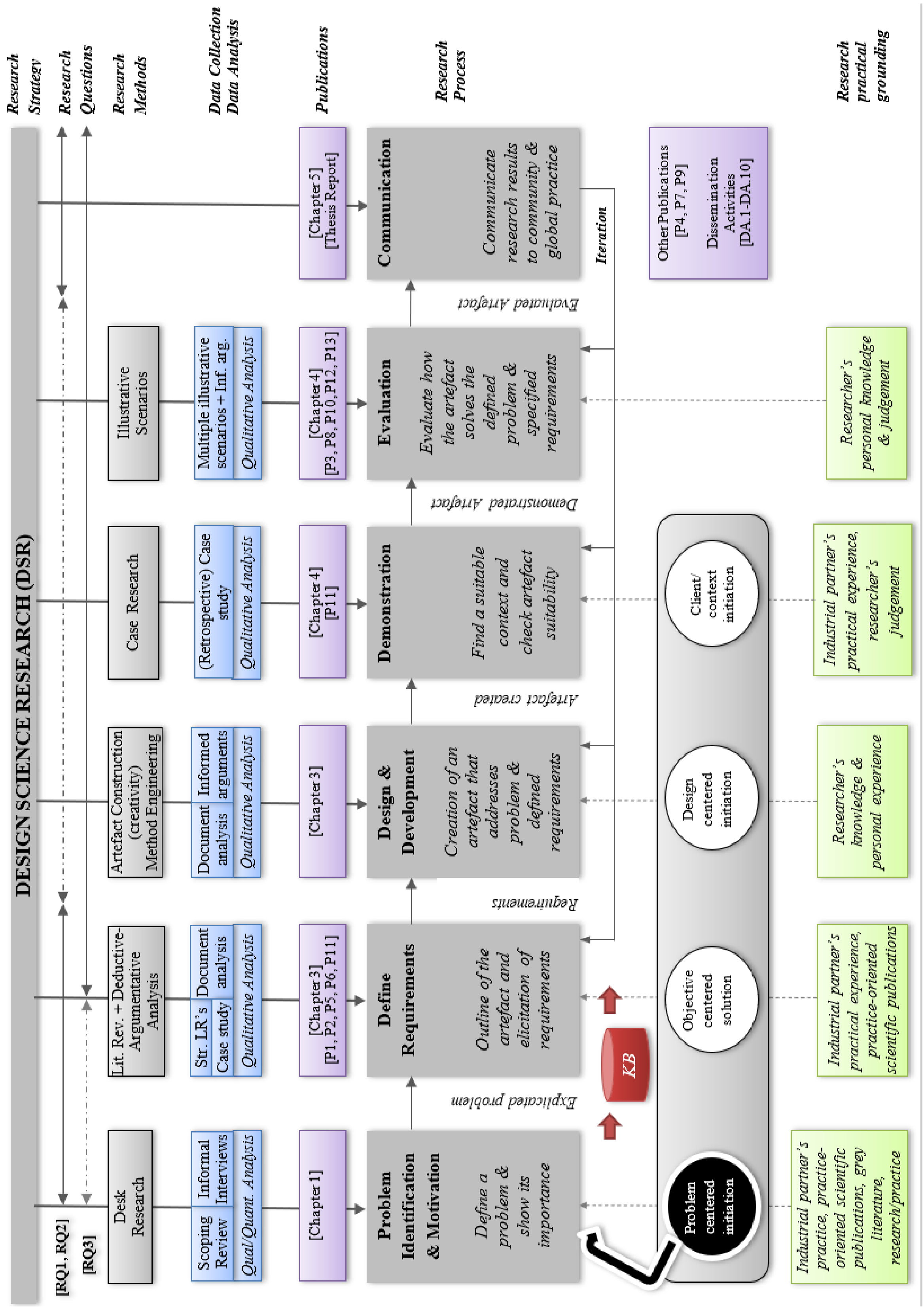

Figure 3 – DSRM Process Detail for the Thesis

Source: Own elaboration

On the other hand, and aiming to be the most consistent as possible with the essence of the 3-Cycle-View (Rigor, Relevance and Design) of a DSR endeavour, expert knowledge emanated from practice (and whenever possible from the particular local context of practice) has also been incorporated across the different stages of the research. Such fact is reflected at the bottom part of previous Figure 3 (green-coloured squares). Additional details on how this knowledge has been used in each stage are provided over the remaining chapters of thesis. According to (Hevner et al., 2004, p. 85)'s foundational work on DSR, evaluation plays an important role during the research process. In this vein, artefacts conceived should be evaluated in terms like "*functionality, completeness, consistency, accuracy, performance, reliability, usability, fit with the organisation and other relevant quality attributes*" (Hevner et al., 2004, p. 85). The particular evaluation criteria applied to each particular case should be based on the requirements/objectives defined for the solution (i.e., the artefact envisioned). In this sense, DSRM epitomizes two differentiated stages for evaluation purposes (*demonstration* and *evaluation* stages), hereof enabling multiple possibilities and forms for achieving evaluation, including "*proof-of-concept*", "*proof-by-demonstration*", "*proof-of-value-added*" or "*proof-of-use*" (Gregor & Hevner, 2013; Nunamaker, Jr. & Briggs, 2011; Venable et al., 2012).

To conclude with aspects related with the research process, in the top-middle part of Figure 3 (violet-coloured squares, labels enclosed within brackets) we also depict how publications [P] [9] produced during the thesis fit into the nominal DSR process followed. The relative position of each one of them reflects reflect its significance in terms of the particular DSRM's stage to which is linked. Furthermore, this relative position should be considered as non-exclusive, in the sense that a particular publication [P] can be significative for different stages of the nominal process.

Readers should note that several publications [P] have been placed as rather outsiders of the nominal stage defined in the DSRM methodology (violet-coloured square at the bottom-right part of Figure 3). This fact should not be interpreted as If those items were totally independent or isolated of the research aim [RA] and objectives [RO] defined. These publications emerge as a derivate of (i) *extending knowledge acquired during the investigation about RMs/RAs to the scope of MMs*, which represent a particular type of artefact which can be constructed on the basis of existing *RMs/RAs* [10] (Mettler, Eurich, et al., 2014, p. 225; Tarhan et al., 2016, p. 129), and (ii*) bringing knowledge acquired during the investigation about HEI-oriented ERAs to the narrower fields of QA in HE and eLearning* [11], since in both cases their encompassing scope could be understood as a subset (part of) of the EA (processes, applications, technologies) characterising a HEI. Potential possibilities of HEI-oriented ERAs for QA-oriented issues will be explored during the last part of the research.

[9] The full list of publications [P] and complementary dissemination activities [DA] resulting from the thesis is provided in section 5.6 (*Research Communication*).

[10] See Chapter 2 (*Conceptual Foundations)* for further details on this particular type of artefacts.

[11] According to recent state-of-practice reports released by well-known supranational institutions (European Commission et al., 2018, pp. 47–91; Gaebel & Zhang, 2018, pp. 53–61), the relevance of eLearning in the wider scope of QA in HEIs is lately progressively growing. Such fact is a consequence of the "normalisation" in the adoption and use by HEIs of (educational) technologies in their usual educational activities. Examples of such educational technologies may range from on line courses to digital teaching platforms and environments or digital certificates. Therefore, external authorities like QA agencies and accreditation bodies have started to develop specific recommendations and guidance on how to apply and interpret the ESG standards in terms of eLearning QA processes (Huertas et al., 2018). Under such circumstances, we deem it a very promising topic deserving more attention for further exploration and research.

1.7. Problems Affecting the Execution of the Thesis

During the temporal span devoted to the present *Industrial Doctorate* project there were a series of factors that negatively affected its execution. These factors have had an important impact on several facets of the thesis, including the research scope and final results achieved. Factors can be grouped into two main categories: (i) *doctoral candidate's personal issues* and (ii) *factors related with the relationship between the doctoral candidate and the main industrial partner of the project (SEIDOR)*.

Considering that personal-oriented issues have already been adequately expressed to the UOC (the academic partner of the thesis) through the corresponding annual Activity Record reports, we consider necessary here to extend the information provided in the referred reports by providing details on how the professional relationship between the doctoral student and the industrial partner of the research project evolved over time. Despite that this narrative could be viewed as a subjective or partial vision regarding on how things and events happened, we strongly believe that visibility on how several facts and events occurred gave rise to a series of problems impacting negatively on the objectives defined for the work to be done for the research project.

In addition, and to conclude this section, we also want to point out here that – in our opinion – the actions and behaviour carried out by the industrial partner of the thesis not only affected the doctoral student but also had a prejudicial impact on the *main academic supervisor* of the thesis.

Further details deepening in all this stuff can be found in an additional annex ("*Volume III – Relationship with the industrial partner of the thesis*") complementary to the present main report of the thesis.

1.8. Structural Outline of the Thesis

The present thesis report at hand is organized into five main chapters. Following a brief introduction, in this initial chapter of the thesis we have exposed the main motivation, aim [RA] and research problem [RP] to be investigated. Next, and grounding on the research problem framed, a set of more particular research questions [RQ] to be answered have been defined, which in turn, have been operationalized later into a correspondent set of research objectives [RO]. In addition, the basics of the of research design approach to be followed in order to found adequate answer to the research questions posed has been also outlined. Finally, the chapter concludes with an epigraph highlighting the main difficulties and problems experimented by the doctoral candidate with the original industrial partner of the research project.

The remaining contents of the present thesis research report have been structured as follows:

- In *Chapter 2*, the *conceptual foundations* describing the main research topic and phenomena to be investigated are presented, in order to provide fundamental understanding about them.

- Following, both *Chapter 3* and *Chapter 4* are devoted to describe how the conducted research has particularly addressed the typical *"build-evaluate*" pattern characteristic of DSR endeavour. On the one hand, *Chapter 3* is focused in illustrating how a KB collecting existing knowledge on ERAs is configured, to be used next as a reference point for constructing an instrument for facilitating practitioners the use of such-a-kind of artefacts in HE-related contexts of practice. On the other hand, *Chapter 4* describes a set of activities and related practical experiences carried out to validate, as much as possible, the instrument constructed as well as to provide basic empirical evidence on the use in practice of ERAs in various HE-oriented scenarios.

- Lastly, *Chapter 5* closes this report by revisiting the research questions posed and summarizing the main research results and outputs achieved. Also, reflections on the whole general research process conducted are revealed by outlining its main limitations [RL] and potential future research lines [FR]. Finally, the chapter closes up by highlighting issues related with the dissemination and communication of the research results and outputs achieved, including a basic impact analysis of the publications [P] produced during the research period. Besides, complementary dissemination activates [DA] also undertook during the temporal span devoted to the thesis are briefly discussed.

Table 4 – Thesis Structure Overview

<table>
<tr><th>THESIS CHAPTER</th><th>MAIN RESEARCH ITEMS ADDRESSED</th></tr>
<tr><td>Chapter 1 – Exposition</td><td rowspan="2">• Research problems [RP.1-RP.3]
• Research aim [RA]
• Definition of research questions [RQ.1-RQ.3]
• Definition of research objectives [RO.1-RO.7]</td></tr>
<tr><td>Chapter 2 – Conceptual Foundations</td></tr>
<tr><td>Chapter 3 – Building an artefact framework</td><td>• Research questions [RQ.1-RQ.2], [RQ.3] (partially)
• Research objectives [RO.1-RO.3]</td></tr>
<tr><td>Chapter 4 – Evaluating an artefact framework</td><td>• Research questions [RQ.3] (partially)
• Research objectives [RO.4-RO.7]</td></tr>
<tr><td>Chapter 5 – Conclusion</td><td>• Research outputs [λ.1], [Ω.1-, Ω.9], [Ω’.1-Ω’.4]
• Publications [P1-P13]
• Dissemination activities [DA1-DA9]
• Research limitations [RL.1-RL.4]
• Future research lines [FR.1-FR.4]</td></tr>
</table>

Source: Own elaboration

2. Conceptual Foundations

2.1. Introduction

This chapter introduces the conceptual background of the most relevant topics for the thesis. First, the concepts of HE and HEI are defined to, subsequently, elaborate on EA and EA artefacts. Next, and as the most relevant particular types of EA artefacts related with the thesis' scope, basic grounding for RAs, ERAs and MMs is also introduced. Finally, and considering the use scenarios for HEI-oriented ERAs explored during the thesis, the notions of QA in HE and IQAS are also presented to close the chapter.

2.2. Higher Education and Higher Education Institutions

In a general sense, the term *Higher Education* (also referred as *Post-Secondary Education*) can be related to "*education or learning at a college or university*" [12]. Several authors have also generically defined HE by extending this simple idea. For example, (Sanchis et al., 2014, p. 174) incorporates to the previous definition the idea of optionality for this concrete type of education, referring to HE as "*non-compulsory education provided after high school, usually at a college or university*". On the other hand, (Deshpande, 2014, p. 186) remarks the administrative idea of formal education implicit in the concept, leading to the achievement of *"academic degrees or professional certifications*". HE can also be viewed from a more systemic approach, considering it as a "*system of accredited institutions providing formal post-secondary education*" (Bennett et al., 2012, p. 232).

There are also several well-accepted definitions of HE proposed by diverse supranational organisations grounding on this systemic perspective. For example, the *World Declaration on Higher Education* assembled in 1998 at the United Nations Educational Scientific and Cultural Organisation (UNESCO), defined HE as "*all types of studies, training or training for research at the post-secondary level, provided by universities or other educational establishments that are approved as institutions of higher education by competent State authorities"* (UNESCO, 1998). Similarly, the Organisation for Economic Co-operation and Development (OECD) refers to the HE sector as "*all universities, colleges of technology and other institutions of post-secondary education, whatever their source of finance or legal status. It also includes all research institutions, experimental stations and clinics operating under the direct control of or administered by or associated with higher education institutions*" (OECD, 2015, p. 34).

It is worthwhile to clarify here the difference among the terms *Higher Education, Tertiary Education* (also referred as *Third-Level Education*) and *Further Education*, which sometimes are used interchangeably. On the one hand, whilst HE includes all establishments whose primary activity is to provide post-secondary education (and regardless of their legal status), *Tertiary Education* is an umbrella term used to cover not only HE but also advanced learning activities at high levels of specialisation and complexity, as for example technical, professional and vocational education and training (Campbell & Carayannis, 2013, pp. 4–7; UNESCO, 2019,

[12] Merriam-Webster online dictionary: https://www.merriam-webster.com/dictionary/higher%20education

p. 108). For instance, it can be considered that *Tertiary Education* both overlaps and encompasses HE. On the other hand, in several Anglo-Saxon countries (e.g., the United Kingdom, Australia, etc.) the term *Further Education* is used to refer to any study after secondary education that is not part of HE (i.e., not taken as part of an undergraduate or graduate degree). Anyway, the previous dichotomies are orthogonal for the purposes of this thesis, and in this sense, both terms can be assumed as synonymous for the present research. Anyway, and as a working definition of HE for the thesis it is assumed the acceptation proposed by Rodriguez Dias (the former UNESCO HE division director) at the inaugural speech of *1st World Conference on Higher Education*: "*all types of education (academic, professional, technical, artistic, pedagogical, long distance learning, etc.) provided by universities, technological institutes, teacher training colleges, etc., which are normally intended for students having completed secondary education, and whose educational objective is the acquisition of a title, a grade, or diploma of higher education* " (Rodrigues Dias, 1998).

Grounding on this definition for HE, a HEI can be defined as any kind of establishment or organisation providing (and accrediting) post-secondary education. Whilst universities represent the main entities of the HE sector, they are not the only educational intuitions. Hence, the term HEIs is a more comprehensive expression used to refer both universities and non-universities of the HE sector as a group (Campbell & Carayannis, 2013, pp. 4–5). Examples of institutions providing education leading to an accreditation or qualification for students may include academies, *seminaries, institutes of technology, schools* or *professional training colleges*. Furthermore, and with the advent of eLearning, new forms of distance education emerged at the beginning of the 1990s in the form of *Virtual or Online Universities*, also typically included within the scope of the term HEI (Meyer, 2009).

The heterogeneity of current existing HEIs is reflexed by several existing classifications providing a number of attributes for differentiating them and illustrating their diversity. In several cases, this attributes may depend on cultural, legal or contextual issues of the country or regional zone where the institution is located (Dittrich & Weck-Hannemann, 2010; European Commission et al., 2018; van Vught et al., 2010). HEIs may vary in their main function and scope of their activities – education, research, training, etc. –, ownership – publicly or privately owned –, financial dimension – held with public or private funds–, type of students – foreign-student oriented vs own country/region/city-student oriented–, the width of educational programmes offered or even the (organisational) size of the institution.

Finally, and independently of the typical characteristics of each particular institution, there seems to be a consensus on the core mission or ultimate goal of a HEI, which tends to be associated to "*contribute to the sustainable development and improvement of society as a whole*" (UNESCO, 1998). In this sense, literature usually reflects 4 main functions for HEIs, which are strongly interlinked and inseparable (Pucciarelli & Kaplan, 2016; Rodrigues Dias, 1998):

i) The development of new knowledge (the research function).
ii) The training of highly qualified personnel (the teaching function).
iii) The provision of services to society (the returning value to society function).
iv) The ethical function, which implies social criticism.

2.3. Enterprise Architecture

Literature reveals the existence of a plethora of ways to approach EA and no universally agreed definition for the concept has already been established (Saint-Louis & Lapalme, 2018; Schöenherr, 2009). As a simple initial approximation, authors like Zachman – who is considered the originator of the concept – describe EA as the "*ontology of an enterprise*" (Dietz, 2006; Kappelman & Zachman, 2013).

Adopting a broader perspective, one of the most cited definitions of EA is that one building upon the definition of "*architecture*" provided by the ISO 42010 standard: "*fundamental concepts or properties of a system in its environment, embodied in its elements, relationships, and in the principles of its design and evolution*" (ISO, 2011, p. 2011). Similarly, (Greefhorst et al., 2006, p. 103) argue that an architecture can be seen as the high level structure of a system, describing its more fundamental aspects as well as providing guidance to those people that builds and designs it. Thus, the concept of "*system*" could be instantiated to a wide number of domains, as for example to an "enterprise" which could be understood as any collection of organisations (e.g., company, an institution, a government agency or even a department) sharing a defined mission and a common set of goals, objectives and resources established to provide value by means of products and services (Lankhorst, 2017, pp. 1–3; The Open Group, 2011). Assuming this vision, the term EA can be used to consider the architecture at the level of an entire organisation.

Other well cited definition of EA is the one proposed by (Lankhorst, 2017, p. 3). He defines EA as "*a coherent whole of principles, methods, and models that are used in the design and realisation of an enterprise's organisational structure, business processes, information systems, and infrastructure*". Similarly, (Ross et al., 2006), refer to EA as "*the organizing logic for business processes and IT infrastructure, reflecting the integration and standardization requirements of the company*". For instance, EA *is not supposed to solely create a holistic and detailed model of the entire enterprise but relies on various architecture subdomains, which deliver aggregates [and] therefore, a major concern of EA is to integrate the various architectural domains on which it depends"* (Gampfer et al., 2018, p. 72; Jonkers et al., 2006, p. 64). Figure 4 summarizes the previous idea reflecting the different typical architectural levels of an EA.

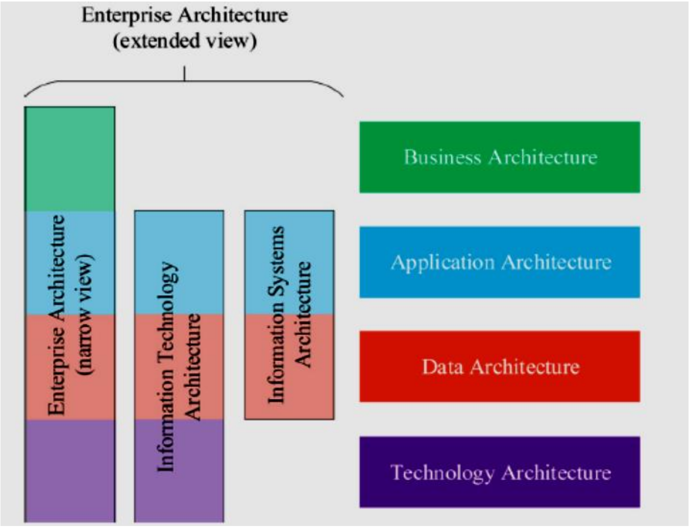

Figure 4 – An Enterprise Architecture View with its Sub-Architectural Domain Levels Detailed
Source: (Gampfer et al., 2018, p. 72)

Over the last times, Kotusev has criticized previous approaches considering that they are *purely philosophical* and unrealistic, *offering little advice in a practical sense* [13] . He argues that the EA term has been used as rather just an umbrella term for denoting a single comprehensive description of an organisation that is developed and then used by stakeholders (Kotusev, 2019, p. 11). Thus, he alternatively proposes to define EA in a rather straightforward and practical manner as *"a collection of special documents (artefacts) describing various aspects of an organisation from an integrated business and IT perspective intended to bridge the communication gap between business and IT stakeholders, facilitate information systems planning and thereby improve business and IT alignment".* This definition leads us to the traditional dual characterisation of EA as both as *a product* – complex set of very diverse architectural descriptions (artefacts) –, and as *a process* – the use of previous architectural descriptions as part of the EA practice –. Literature usually refers to this EA practices as Enterprise Architecture Management (EAM), embracing all planning, delivery and governance processes used in EA aimed to ultimately improve business-IT alignment (Bischoff et al., 2014, pp. 133–134; Lange et al., 2016). Again, (Kotusev, 2017a, pp. 1730001-16-1730001–1730018) provides a consolidated vision of all the previous stuff defining EAM as a "*decentralized network of independent but interacting processes (development, decision-making, coordination and implementation), artefacts (enterprise level and business unit EA artefacts) and actors (managers, architects and IT staff)*".

Conducting an effective EA practice by producing, updating and using EA artefacts by different actors and for multiple purposes, may lead to the creation of EA value (benefits) for organisations in many different forms (Gong & Janssen, 2019; Shanks et al., 2018). Benefits can be both at *organisational level* – business-IT alignment, improved communication among stakeholders, organisational agility and flexibility, etc. – or at rather more *EA project level* – improved governance and management, cost and risk reductions, quality enhancements, etc. – (Tamm et al., 2011; Foorthuis et al., 2016; Lange et al., 2016; Jusuf & Kurnia, 2017; Shanks et al., 2018; Gong & Janssen, 2019; Niemi & Pekkola, 2019). Unfortunately, the establishment of a successful EA practice is a challenging and daunting task, taking several years to (effectively) realize the expected value (Löhe & Legner, 2014, p. 102; Iyamu, 2019; Niemi & Pekkola, 2019). In this vein, literature reveals the existence of a series of EA inhibitor factors – ranging from organisational contextual factors to more rather political or even legislative external issues – that may compromise the successful implementation of EA practices in organisations (Löhe & Legner, 2014, p. 101; Dang & Pekkola, 2016, 2017; Banaeianjahromi & Smolander, 2016, 2019; Ahmad et al., 2019; Foorthuis et al., 2016, p. 4).

2.4. Enterprise Architecture Artefacts

The concept of EA artefact has been addressed by different authors over the years. For example (Greefhorst et al., 2006, p. 103), grounding on the ISO 42010 vision of "*architecture*" as a high-level structure of a system, argues that such systems need to be described in a document (i.e., architectural description) and structured into manageable "chunks". On the other hand, (Abraham, 2013; Abraham et al., 2015) describes EA models as central artefact types in EAM, and characterises them as *Boundary Objects* (Lee, 2007; Rosenkranz et al., 2014; Star, 2010). In particular, he highlights "*their ability to offer a common frame of reference for diverse*

[13] The most important facet of enterprise architecture management is communication – interview with Svyatoslav Kotusev (https://www.mosaiic.com/blog/2018/10/16/interview_svyatoslav_kotusev/)

stakeholder groups by providing a high-level representation of the basic enterprise structures" (Abraham et al., 2015, p. 3). Finally, and in line with earlier rationales, (Kotusev et al., 2015, pp. 2–3) refers to EA artefacts as the most basic underlying components of EA, and defines them as single "*descriptive documents providing a specific view of an organisation from the perspective of its business and IT*". For instance, EA documentation "*represents the collection of individual artefacts describing various aspects of EA*".

Different EA sources recommend a plethora of EA artefacts as suitable for being used in EA practices (Bischoff et al., 2014; Kotusev, 2017b; Spewak & Hill, 1992; The Open Group, 2011; Winter & Fischer, 2007) . EA artefacts can be very diverse in terms of nature, range or level of abstraction. For example, in his well-cited EA definition, (Lankhorst, 2017) explicitly cites principles, methods, and models. Concerns may be raised here on the applicability of previous definitions to methods (EA methodologies) [14] since, in our view, the notion of architectural description suits particularly well to EA models. In this sense, it is quite common to found in the literature the term *EA product* for referring globally to all kinds of EA artefacts regardless its form, structure or type (Foorthuis et al., 2016; Lange et al., 2016; Shanks et al., 2018).

Being the basic underlying elements of an EA practice, the key role of *EA artefact use* for the success of EA practice has been signalled by many studies. Despite not being strictly mandatory (Bischoff et al., 2014), *EA artefact use* is widely acknowledged as a precedent for EA value realisation (Foorthuis et al., 2016; Lange et al., 2016; Shanks et al., 2018; Gong & Janssen, 2019, p. 5). Nonetheless, EA artefacts "*in itself, as a set of documents, offers no value if it is not used [correctly] in practice*" (Foorthuis et al., 2016, p. 542). For instance, how effectively EA artefacts are actually used in practice (both in terms of concordance with predefined explicit EA norms as well as the particular contextual conditions in which their used/applied) is what really matters (Foorthuis et al., 2016, pp. 541–543; Shanks et al., 2018, p. 141). Otherwise, they may become useless in terms of EA benefit realisation (Lange et al., 2016; Niemi & Pekkola, 2019).

To conclude with this section, an important concept related to both EA artefacts and EA practices is the concept of *Enterprise Architecture Framework*. EA artefacts, methodologies and knowledge derived from EA practices is usually organized, structured and systematized using that kind of architectural frameworks (Greefhorst et al., 2006, pp. 103–104; Hinkelmann et al., 2016, p. 79; Lankhorst, 2017, pp. 29–38). According to (Zachman, 1997) an EA Framework is "*a logical structure for classifying and organizing the descriptive representations of an Enterprise [i.e. EA artefacts] that are significant to the management of the Enterprise as well as to the development of the Enterprise's systems*". In general, EA Frameworks "*encompass a model for architectural descriptions, as well as a method to produce them … [although] some architecture frameworks focus on the architectural descriptions [i.e., EA artefacts], while others focus on the method [i.e., process-step methodology for implementing EA]* (Greefhorst et al., 2006, p. 103). In addition, some EA Frameworks also include or suggest additional supporting instruments for EA practices as for example, modelling and architecture description languages and notations or even software tools, which, collectively, configure what has been commonly referred as the "*EA toolbox*" (Lange et al., 2016; Perez-Castillo et al., 2019; Pérez-Castillo et al., 2020; Weiss et al., 2013, p. 1).

[14] A methodology specifies a set of procedural steps defining how enterprise architecting is to be performed to yield an EA. In this sense, they can be viewed as something different to EA models, representing the architectural description or representation of an EA.

Thus, the utility of EA Frameworks for practitioners relies on the fact that they "*enable focused concentration on selected aspects of an object without losing a sense of the contextual, or holistic, perspective*" (Zachman, 2007). In other words, they provide Standardised, high-level and industry-independent guidance for implementing EA practices. Hence, EA practitioners should adequately adapt and tailor the rather generic artefacts and tools provided by these frameworks to their particular own needs (Kotusev et al., 2015).

Over the years, a great number of different EA Frameworks and architectural approaches have been created and developed more or less independently of each other. However, none of them has been deemed superior to any of others, being one of the most current EA challenges deciding which one best fits (i.e., is less onerous and labour-intensive to adopt) the particular modus operandi of an organisation (Kaisler & Armour, 2017, p. 4814). However, typical examples of well-acknowledged EA Frameworks could be TOGAF (The Open Group, 2011) or the Zachman Framework (Zachman, 1987; Sowa & Zachman, 1992). Both them are predominantly viewed as "*de-facto standards*" for the EA industry and have been adopted by many industrial, commercial, governmental, and academic organisations all over the world (Kaisler & Armour, 2017, p. 4814; Lapalme et al., 2016, p. 111).

In the successive sub-sections, we proceed to briefly describe generic RAs, ERAs and MMs as the most relevant particular types of EA artefacts associated to the scope of the thesis.

2.4.1. Reference Architectures

The proliferation and diversification of different architectural approaches and frameworks for conducting EA over the years has boosted the emergence of a wide and divergent set of interpretations of the concept of RA. This variability is further increased by several terminological inconsistences affecting terms as "*Enterprise Architecture*", "*Enterprise Architecture Framework*", "*Reference Architecture*" or even "*Reference Model*". All this terms tend to be used somewhat interchangeably in the literature, but several nuances and particular features can be associated to each one of them (Bernus & Noran, 2010; Muller & van de Laar, 2009, 2011; Oliver Thomas, 2006). This flaws have been summarized in a very illustrative way by (Cloutier et al., 2010, pp. 14–15), who claim on the lack of maturity of the term *Reference Architecture* since "*although not being novel (…) in the business world, many architects do not have a consistent notion of what this actually is*". Likewise, the form that the term takes "*is still not solidified (…) and has become a term to mean many things to different people (…) either within the same industry or not*" (Cloutier et al., 2010, pp. 14–15).

Notwithstanding the above, the application of heterogeneous architectural approaches in different domains and contexts has progressively led to the generation of a huge amount of knowledge – both technical and contextual – about such domains. Such fact has triggered the need of more formal ways to capture, document and communicate knowledge generated to different organisations. RAs can be viewed as a response to these needs, as, in some way, they encapsulate (i) the built up experience captured over the years about the problems identified in a particular domain and (ii) the many possible solutions to this problems in different circumstances (Muller & van de Laar, 2009). It must be noted here that RAs have emerged not only in the EA arena (Noran, 2007), but also in many other IT-related fields or disciplines, as for example in Software Engineering (Angelov et al., 2012; Smolander et al., 2008).

(Greefhorst, 2011a; Greefhorst et al., 2009) simply define RAs as "*generic architectures for a class of systems based on best practices"*. In a more elaborated working definition, (Cloutier et al., 2010) affirm that RAs "*capture the essence of existing architectures, and the vision of future needs and evolution to provide guidance to assist in developing new system architectures*". Hence, RAs are Standardised architectures providing a frame of reference for a vertical sector, domain or field of interest (Lankhorst, 2014; Paradkar, 2018). In contrast to very specific *solution architectures*, RAs are considered as "abstract architectures" since they are not implemented directly (Cloutier et al., 2010), nor do they prescribe any concrete commercial product or platform (Greefhorst et al., 2009, p. 9, 2008). On the contrary, RAs play an important role as a foundation for the design of specific *solution architectures* in a determined domain since they are considered as authoritative sources of information providing a "template" (or "blueprint") for guiding and constraining the instantiation of more concrete *solution architectures* in particular field/domain (de Boer et al., 2011; U.S. Department of Defense, 2010). Such a "template" is often based on the generalisation of a set of solutions "*capturing the accumulated architectural knowledge of thousands man-years of work*" (Cloutier et al., 2010, p. 14), which may have been "*generalized and structured for the depiction of one or more architecture structures based on the harvesting of a set of patterns (…) observed in a number of successful implementations* (Paradkar, 2018). Furthermore, they show how to compose these parts together into a solution.

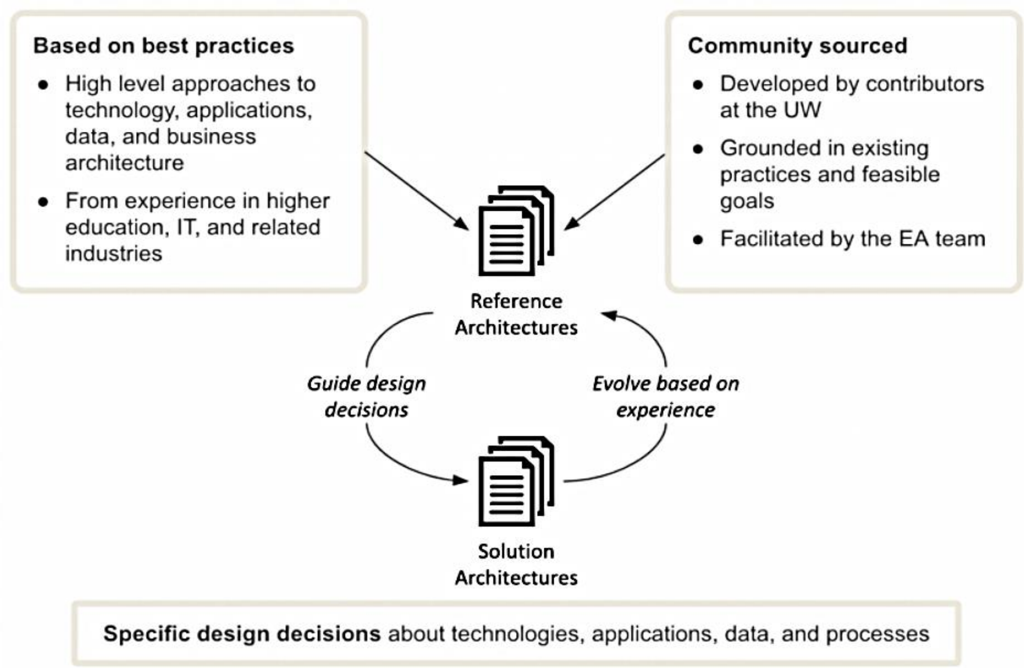

Figure 5 – Reference Architectures and Solution Enterprise Architectures

Source: Adapted from "*IT Connect. Information technology tools and resources at the UW*" (Univ. of Washington, 2020)

As a consequence, the re-utilisation in multiple contexts of the architectural structures provided by RAs prevents reinventing the wheel and fosters the re-validation of solutions for already solved problems(Cloutier et al., 2010; Greefhorst et al., 2009, 2008; Lankhorst, 2014). Re-using RAs does not imply, however, to lose design freedom. Instead, this means that architectural structures provided by RAs should be conveniently *instantiated, selected, parameterized, formatted and/or supplemented* when designing/architecting a very specific and context-dependent *solution architecture* (Greefhorst et al., 2009, p. 12; Greefhorst, 2011a, p. 1;

Lankhorst, 2014). Hence, they can be viewed as something like a "*backbone*" providing true and actionable useful guidance for practice (Lankhorst, 2014; Paradkar, 2018).

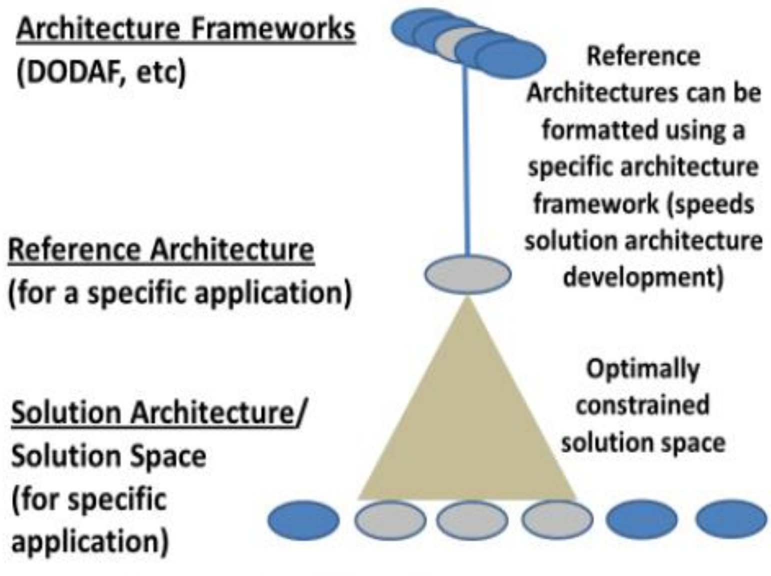

Figure 6 – Simplified Enterprise Architecture Hierarchy

Source: (Gump et al., 2018)

An important facet of RAs is that they should not be considered as static artefacts. In order to maximize their value, RAs have to be contemplated as dynamic and mutable artefacts (Greefhorst et al., 2009). RAs continuously evolve embodying (i) the (historical) flow of proven concepts and known problems from existing *solution architectures*, (ii) new envisioned requirements for (future) architecture reuse, and (iii) new needs emerged from the domain or field of application of the RA (Cloutier et al., 2010). Hence, and in some way, an up to date RA in line with recent developments and terminology provides a simplified reflection of the state-of-the-practice in a determined domain (Greefhorst, 2011a, p. 1). Temporal evolution of RAs should be adequately managed, for example, establishing a version control policy for differentiating between different releases and versions of the artefact. Notwithstanding that, a RA would be much more stable than more specific *solution architectures*, which can be influenced by personal preferences, budget, time or other context-specific factors (Cloutier et al., 2010).

Questions may arise regarding who/whom are those involved/responsible of the construction/ building process of a RA. In order to boost its universality, acceptance and becoming a "frame of reference", a RA should be drawn up by (representatives of) all those interested stakeholders in a particular field or application domain. Typically, this is done by means of some form of collaborative effort leaded by a "neutral" organisation/entity/actor (Greefhorst et al., 2009, p. 4). Following this approach would probably increase the utility and potential value of the RA since it will be much more significative and re-used by many more actors active in the domain of application. In this sense, and besides speeding up architectural efforts directed to define a specific *solution architecture,* typical potential value (benefits) associated to the use of RAs use include improving the quality of architecture practices in an organisation, and the facilitation of interoperability and regulatory compliance among entities involved in a particular domain (Cloutier et al., 2010; Lankhorst, 2014; Paradkar, 2018).

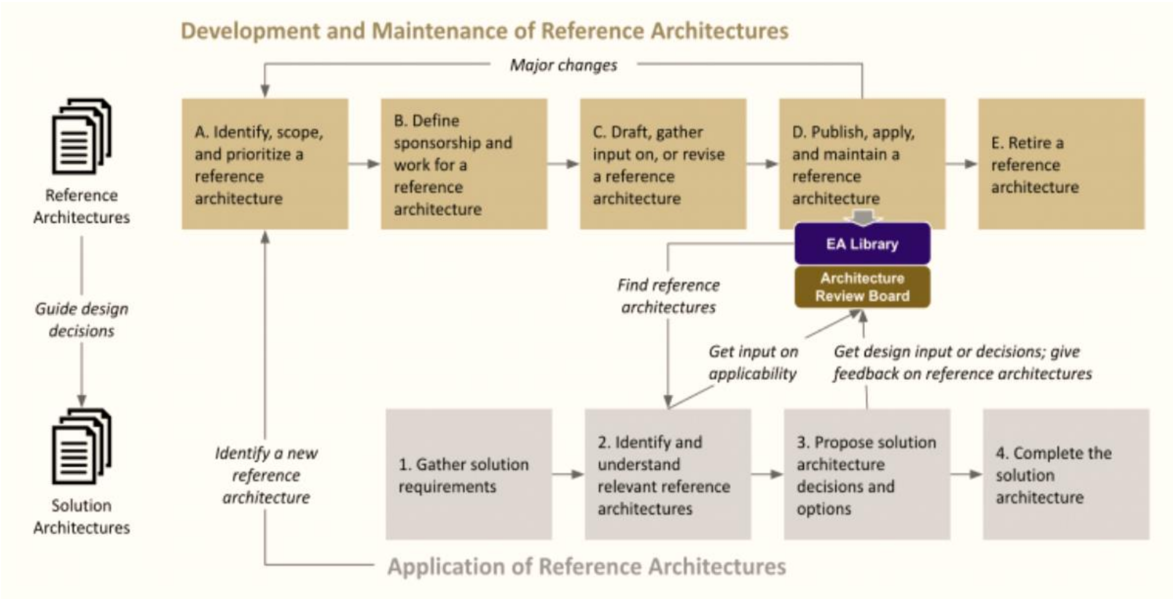

Figure 7 – Development, Maintenance and Application of Reference Architectures

Source: Adapted from "*IT Connect. Information technology tools and resources at the UW*" (University of Washington, 2020)

Regardless of some similarities, RAs should not be confused with prescribed EA Frameworks like TOGAF. Although both provide best practices and different means to describe a particular architecture, their focus is totally different[15]. On the one hand, EA Frameworks "*describe an example taxonomy of the kinds of architectural views that an architect might consider developing, and why, and provides guidelines for making the choice for developing particular views* (Schmelzer, 2009). EA Frameworks give enterprise architects the tools they need to adequately describe and collect requirements, but without mandating any specific architecture type. This clearly differs for RAs which, on the other hand, go one step further by accelerating the EA process for a particular architecture type (Paradkar, 2018). Furthermore, and while it might be argued that RAs provide more of a methodology than a framework does, RAs are most characterised by their "*template*" component – i.e., high-level domain specific diagrams – than by providing a methodology (de Boer et al., 2011, p. 1; Paradkar, 2018; Schmelzer, 2009).

Unfortunately, there is no clear consensus on the criteria characterising such a "*template*" component. This fact gives light on to the existence of a plethora of RAs that can greatly differ from each other in terms of nature, shape and level of detail (Greefhorst et al., 2006, 2009; Muller, 2008). From this perspective, a RA may be seen as a *bundle or package assembling a set of interrelated elements.* Many elements (EA artefacts) have been referred as suitable to be or form an integral part of a RA, including among others, *a common (architectural) vision, principles, guidelines, recommendations, vocabularies, lexicons, taxonomies, ontologies, catalogues,*

[15] This is not to say that RAs and EA Frameworks are incompatible. On the contrary, they can (should) be perfectly used together. Think for example in TOGAF, as a *de-facto standard* for EA practice. In this case, the TOGAF framework explicitly provides a methodology for developing the EA practice, the so-called TOGAF Architecture Development Method (ADM). In this sense, and without prejudice on the existence of other alternative methods, (i) an EA Framework (i.e., the TOGAF ADM methodology) – could be used to build a RA. Similarly, (ii) a RA could be used complementary_with and EA Framework (i.e., TOGAF) to develop a very specific "solution architecture". This is the case represented in Figure 6 (Simplified Enterprise Architecture Hierarchy).

architectural patterns, reusable designs, best practices, conceptual models, building blocks, implementation guides (or insights for use and application), existing solution architectures, (technical) standards or even *maturity models* (Cloutier et al., 2010; de Boer et al., 2011; Greefhorst et al., 2006, 2009; Greefhorst, 2011a; Lankhorst, 2014; Paradkar, 2018). Hence, and considering the overwhelming amount of knowledge that can be potentially captured in so many different and heterogeneous forms by a RA, the number of elements conforming a RA have to be limited for being useful and manageable for practitioners (de Boer et al., 2011, p. 1; Muller, 2008; Muller & van de Laar, 2009, p. 5).

In this sense, and in line with the definition of architecture provided by the ISO 42010 norm, it tends to be accepted that to be considered *strictly* a RA it must contain at least (i) a *"(reference) model*" (RM) [16] and (ii) *architectural principles/guidelines*. On the one hand, the RM provides and "ideal representation" of the most relevant components, objects and interrelationships that articulate the RA's application domain or field. On the other hand, architecture principles tend to be more prescriptive, providing guidance and direction on how the design and evolution of the "structure" (i.e., components and objects described in the RM) should be translated into a more specific *solution architecture*, ensuring thus, a faster and better architectural design process – i.e., the main *raison d'etre* of a RA (de Boer et al., 2011; Greefhorst, 2011a, 2011b; Greefhorst et al., 2009, 2008).

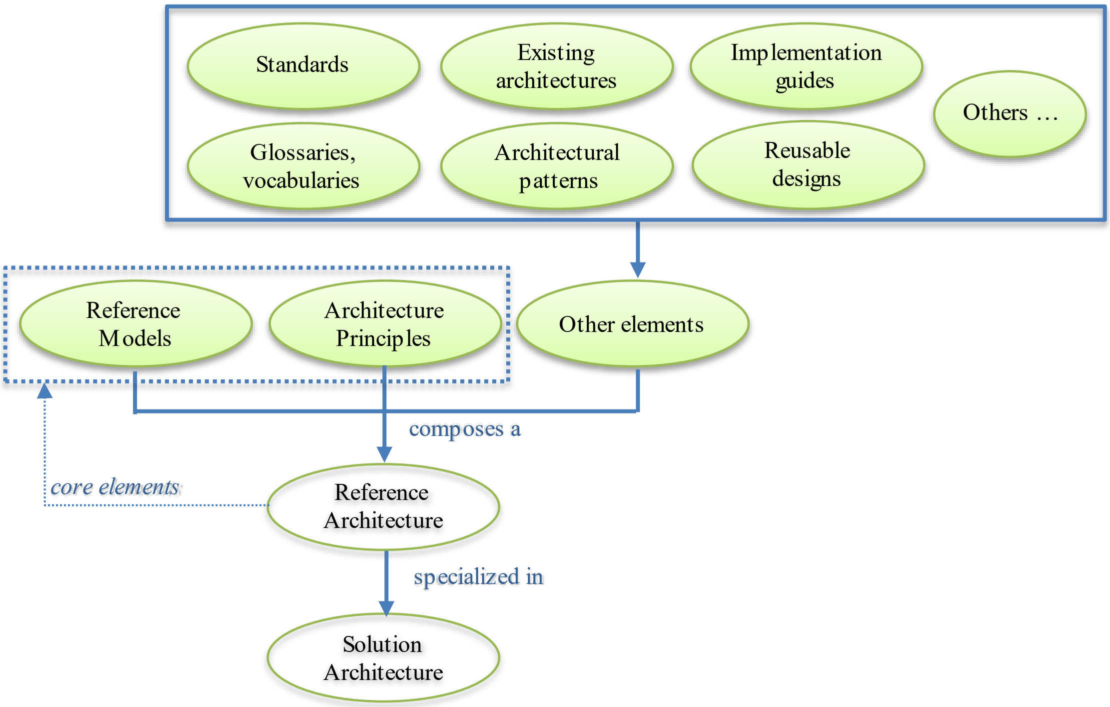

Figure 8 – Elements Configuring Reference Architectures

Source: Own elaboration

Anyway, and whatever the elements configuring a particular instance of a RA, it is important to note that *"the information to be captured in a RA is interdependent ... [and therefore] the relevant relations between all pieces also have to be captured to provide practical guidance in using the different kinds of information"*

[16] Assume here the term "*reference model*" as a synonym of "structure", which can be captured in a RA in so many different forms including *architectural patterns, building blocks, conceptual model, reusable design*, etc. For instance, the term "*Reference Model*" should be understood as somewhat like an *umbrella term*, encompassing the earlier referred items.

(Muller, 2008, p. 2048). Unfortunately, and in practice, such level of detail on the traceability (in terms of mutual coherence and connection) among the elements that compose a RA is often not achieved, remaining either implicit or, at worst, simply not detailed (Greefhorst et al., 2008, p. 10; de Boer et al., 2011, p. 1).

For example, and on the one hand, a number of artefacts usually referred as a "*reference architecture*" do not offer much more than a simple collection of generic architectural principles. For instance, and *in stricto senso*, these artefacts should not be considered as such (i.e., a RA). A plausible explanation for this fact could be that the architecture was still in the construction phase: meanwhile architectural principles could have been defined first; the RM would still be pending of development. Analogously, and on the other hand, there are artefacts encompassing just a "*reference model*" (RM) and no (explicit) architectural principle referred as "*reference architecture*". In this case, it could be argued, as earlier suggested, that (some) architectural principles can be implicitly "derived" [17] from the own RM. Whatever the case, all this rationale contributes enormously to the earlier referred terminological confusion between the terms "*reference model" and "reference architecture".* In some cases, the term *Part-Reference Architecture* (Greefhorst et al., 2008, p. 10) is considered by the literature to point out those incomplete RA missing one of the key structural elements earlier referred.

To conclude with this section, and considering the key role of both architectural principles and RMs as main elements characterising a RA, in the successive sub-sections we briefly further elaborate on them.

2.4.1.1. Architecture Principles

Architecture principles have been widely addressed by (Greefhorst & Proper, 2011), who developed a conceptual framework providing a solid foundation for characterising them. To highlight the critical role of them in the scope of EA, Greefhorst and Proper refer to them as the *cornerstone of EA*.

Architecture principles can be defined as declarative statements that normatively prescribe a property (i.e., an essential aspect) of architecture. They are considered as normative in the sense that they intend to provide a norm that people should adhere to (Greefhorst & Proper, 2011, p. 44; Greefhorst et al., 2013, p. 20). Architecture principles may refer either to the design or to the representation of an architecture (Seltzer, 2010). In addition, and just like *solution architectures* are different in nature than RAs, architecture principles may also have different level of universality (Haki & Legner, 2012). In the successive paragraphs, the focus is put in those ones considered in RAs.

Architecture principles forming part of a RAs tend to be generic in nature, often reflecting common or generally-accepted best practices that have proven to work in practice (Greefhorst et al., 2009, p. 11; Greefhorst & Proper, 2011, p. 137). In addition, they can also relate, link or point out to relevant standards, legislation, domain constraints, or mandatory frameworks (Cloutier et al., 2010, p. 16; Greefhorst et al., 2009, p. 13). In this case, their intrinsic normative nature may become into mandatory. Their main focus is to provide guidance at tactical level (e.g., actionable guidance and/or direction for practitioners in their daily work) on how the "structure" (i.e., components and objects of the ideal domain described by the RM) should be transformed into a more specific *solution architecture* (de Boer et al., 2011; Greefhorst, 2011a, 2011b; Greefhorst et al., 2009, 2008).

[17] Think about in "simple" architectural principles as *modularisation* or *component loose-coupling*, for example.

RAs may contain hundreds of architecture principles providing support to a potentially broad target audience of practitioners – e.g., architecture designers, implementers, users, etc. – (Greefhorst & Proper, 2011, p. 135). As a consequence, architecture principles in RAs tend to be organized into repositories classifying them in several criteria. In the scope of EA, these criteria refer to (i) the architecture domain to which they relate – business, data, application, technology –, and (ii) to the most important (architecture) quality properties on which they have a positive influence – functionality, reliability, portability, efficiency, usability, etc. – (Greefhorst & Proper, 2011, p. 155). As a matter of fact, in the following Table 5 we reproduce and example of architectural principle extracted from (Greefhorst & Proper, 2011, p. 155).

Table 5 – Example of Architecture Principle

Name/statement	**A.5 Processes Are Standardised**
Type of information:	Business
Quality attributes:	Reliability, efficiency, maintainability, portability
Rationale:	• Standard processes are repeatable, predictable, scalable and more efficient. • Process standardisation is often required in order to comply with certain legislation or quality standards.
Implications:	• A standard process exists and is based upon current and best practices of departments. • All departments adhere to the standard process.

Source: (Greefhorst & Proper, 2011, p. 155)

2.4.1.2. Reference Models

According to (Oliver Thomas, 2006, p. 491) the concept of RM – or specifically *reference information model* – can be explained as *"the concretion of the term 'information model' on the basis of the constituent attribute of user-sided acceptance".* In this sense, RMs – also referred as *universal models, generic models* or *model patterns* – can be defined as information models used for supporting the construction of other models (Fettke et al., 2006, p. 469; Fettke & Loos, 2003a, pp. 35–38; Pajk et al., 2012, pp. 455–456).

(Fettke & Loos, 2003a, pp. 37–38) define an information model as a representation of a certain domain of the real world made for purposes of a subject. Such representation consists in three main components, namely (i) the *object system*, the subjective interpretation of the domain of the real world, (ii) the *model system*, the subjective representation of the object system, and (iii) the *representational relation*, which is the description of the relation between the object and model system. The primary aim of an information model is the "*reduction of complexity of the real world in order to simplify the construction process of IS"* (Fettke & Loos, 2003a, p. 38). Such vision goes along with two pivotal claims on RMs (Frank, 2007, p. 119): "*On the one hand, reference models are intended to provide appropriate descriptions of an application domain. On the other hand, reference models are aimed at delivering blueprints for a distinctively good design of information systems and related organisational settings*".

For instance, a RMs consist of "a minimal *set of unifying concepts, axioms and relationships within a particular problem (...) independent of specific standards, technologies, implementations, or other concrete details*" (MacKenzie et al., 2006, p. 29). The notion of "reference" emphasises here the reusability of the model (from a use-oriented perspective) as a starting point for the developing of more specific (conceptual) models, since it represents a category or class of domains (Becker et al., 2010; Fettke & Loos, 2003a, p. 35; Timm, Sandkuhl, et al., 2017, p. 333). According to (Oliver Thomas, 2006) concerns regarding the reusability of the RM have to be taken into account when developing and building the RM, and are related with model attributes like universality and recommendation.

All in all, what a RM "*brings to table is a is a very clear view (usually on-a-page) of the domain of interest something that is reusable, and (...) can be tweaked*" (Pang, 2015). As an example of a well-known RM, in Figure 9 we reproduce the "*OSI Reference Model*", which is aimed for understanding and designing a flexible, robust and interoperable network architecture facilitating communication between different systems without requiring changes to the logic of the underlying hardware and software.

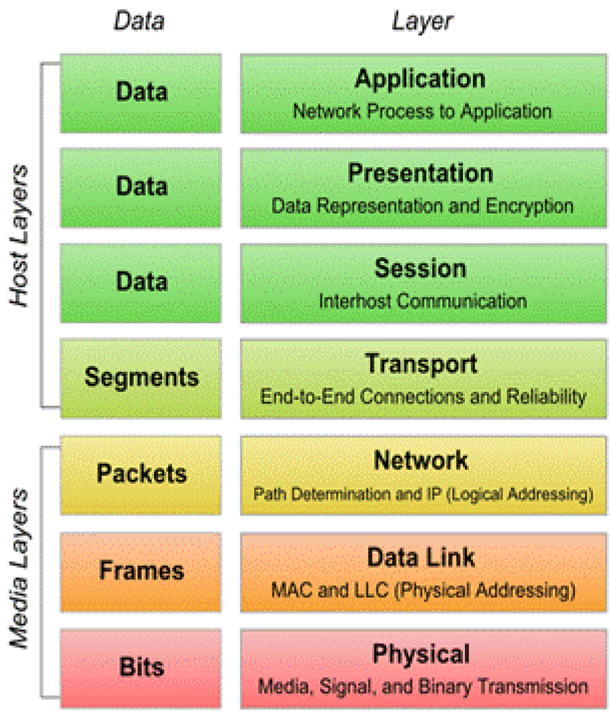

Figure 9 – The OSI Reference Model

Source: (Bench Partner, 2019)

2.4.2. Enterprise Reference Architectures

An ERA can be viewed as a particular subtype of RA in which the targeted domain is set to the EA model representative of a specific "class of enterprises" or industry. As any other RA, it can be used as a foundation in the design and realisation of concrete or organisation-specific *solution architecture* "*belonging to a certain class of enterprise, in multiple context, affecting different stakeholders*" (ten Harmsen van der Beek et al., 2012, p. 99). Grounding on the concepts of EA and RA, ten Harmsen van der Beek and colleagues provide the following working definition for an ERA: *"a generic EA for a [particular] class of enterprises, that in a coherent whole of EA design principles, methods and models which are used as foundation in the design and realization of the concrete EA that consists of three coherent partial architectures: the business architecture,* *the application [i.e. IS] architecture and the technology architecture"* (ten Harmsen van der Beek et al., 2012, p. 99).

Table 6 – Elements Configuring a Definition for Enterprise Reference Architecture

	Enterprise Architecture (EA) Elements
EA1	Partial Architectures for Business, Application and Technology
EA2	Coherent whole of principles, methods and models
EA3	Design and realization purpose
	Reference Architecture (RA) Elements
RA1	Generic template or abstract blueprint
RA2	For an architecture for a particular class (i.e., enterprise class)
RA3	Provides a common vocabulary and structure
RA4	To support design and implementations

Source: (ten Harmsen van der Beek et al., 2012)

An ERA still represents an abstract type of EA artefact, but to a lesser extent than a (generic) RA. On the one hand, they provide much more level of detail than generic RA, as for example, the "foundation" RA prescribed by the own TOGAF framework. On the other hand, they present a lesser level of detail than the *solution EA architecture* found in a certain enterprise or organisation. For instance, ERAs "*sit between these frameworks and solution architectures and provide for domain-specific guidance that both aides implementers and supports improved interoperability for an enterprise"*(Gump et al., 2018, p. 36). To put it in other words: an ERA built with an application scope targeted to the *HEIs class of enterprises* will foster and accelerate the design and implementation of the *organisation-specific EA of a single HEI* (e.g., a university).

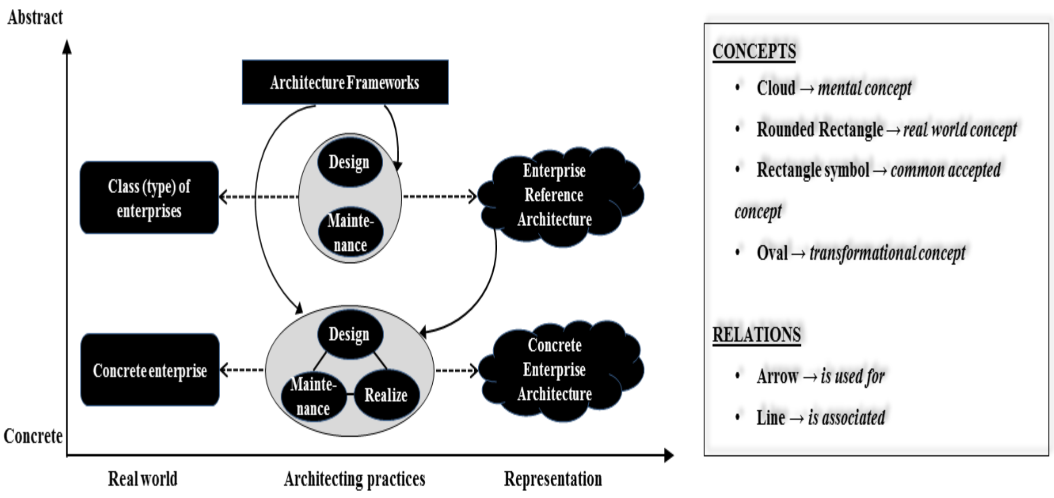

Figure 10 – Conceptual Model of Enterprise Reference Architectures

Source : Partially adapted from (ten Harmsen van der Beek et al., 2012)

According to the domain of application of an ERA, its associated RM should provide a detailed and integrated representation of the EA of an "ideal" class of organisation. Nonetheless, such domain could be relatively complex to represent, including many different and heterogeneous domain objects (i.e., processes, capabilities, functions, actors, applications, data, services, servers, databases, etc.) and interrelationships to capture. This can be difficult to be represented in a clear and simple "one-page" RM [18]. Thus, and in practice, RMs in ERAs tend to be decomposed into several partial RMs (usually on the basis of the typical sub-layers of an EA) representing several disjoint views of the whole domain of interest [19]. This fact is represented in the following Figure 11.

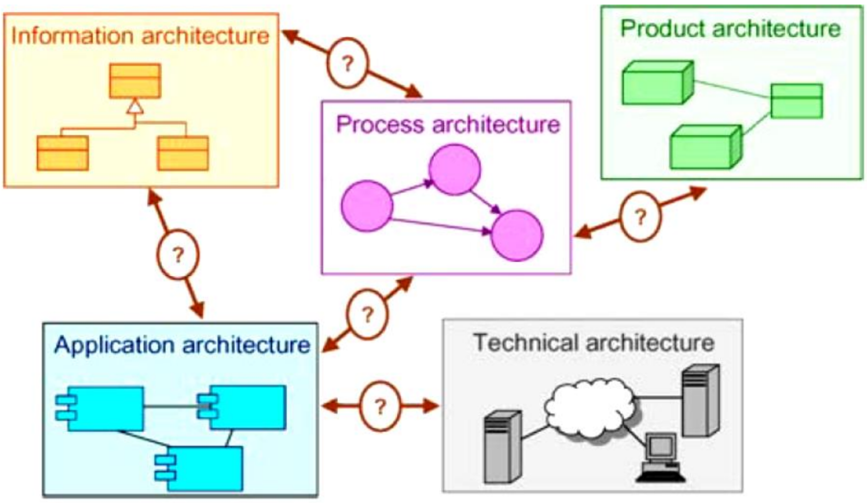

Figure 11 – Integration of Reference Models Representing the Different Architectural Layers of Enterprise Architecture

Source : (Jonkers et al., 2006)

Each one of the partial RM can be viewed as "anchor" RM, with holistic viewpoints at different levels of granularity and addressing different stakeholders' subjects of interest. For instance, compositionality and coherence between partial RMs representing the whole complexity of the EA architecture of an "ideal" class of organisation becomes a critical issue for building and developing an ERA (Arbab et al., 2007; Jonkers et al., 2006, p. 64; Lankhorst, 2017, pp. 43–47). Unfortunately, not all existing instances of ERAs provide such a consistent and integrated vision representing the whole set of interactions, dependencies and relationships (i.e., vertical correspondence) among the domain objects belonging to each partial RM. An example of this situation can be found, for example, in the CAUDIT [20] ERA for HEIs, which provides two different partitioned RMs representing the business and data EA sub-domains. Tus it only provides a partial representation of the EA of an "ideal" HEI.

Considering that an ERA is a particular sub-type of RA, all the rationale stated in the earlier section for them also applies for ERAs. For instance, no additional theoretical background on ERAs will be detailed in this section. Nonetheless, and to close it, in the following table we provide a set of representative ERAs scoped for

[18] Obviously, the specific level of detail and granularity established for the ERA has also an important impact on the complexity of the RMs associated.

[19] This partial RMs are sometimes referred as "*blueprints*", "*landscapes*" or "*maps*", even further contributing on the terminological inconsistences affecting the terms "*reference model*" and "*reference architecture*".

[20] The *Council of Australasian University Directors of Information Technology k (CAUDIT)* is a not for profit association owned by the Australasian universities and a number of major Australian research organisations, supporting executives and their teams through the provision of a broad range of services, fostering collaboration, leadership and good practice among its members.

a variety of different "classes of enterprises" or industries in order to show the variety and heterogeneity of existing approaches.

Table 7 – Examples of Enterprise Reference Architectures

ACRONYM	ARCHITECTURE NAME	INDUSTRY	REFERENCES
BIAN	*Banking Industry Architecture* Network Reference Architecture	Banking	(Bonnie & Obitz, 2013; The BIAN Association, 2018)
MIRA-B	*Microsoft Industry Reference Architecture* for Banking	Banking	(Microsoft Corporation, 2012)
ACORD	*Association for Cooperative Operations Research and Development* Reference Architecture	Insurance	(Neugebauer, 2009)
IAA	IBM *Insurance Application Architecture*	Insurance	(Huschens & Rumpold-Preining, 2006)
eTOM	*Enhanced Telecom Operations Map* Framework	Telecommunications	(Czarnecki et al., 2013; Czarnecki & Dietze, 2017)
DoDAF	*Department of Defense Architecture Framework*	Defense (U.S.)	(U.S. Department of Defense, 2010)
MoDAF	*Ministry of Defence Architecture Framework*	Defense (U.K.)	(U.K. Ministry of Defense, 2012)
SCOR	*Supply-chain operations reference* Model (and extended frameworks associated)	Supply chain	(Medini & Bourey, 2012; Supply Chain Council, 2014)
-	Oracle Retail Reference Architecture	Retail	(Oracle Corporation, 2017)
HERA	The Open Group *Healthcare Enterprise Reference Architecture*	Healthcare	(The Open Group, 2018)
SERA	Microsoft's *Smart Energy Reference Architecture* for Utilities	Energy & utilities	(Microsoft Corporation, 2009)
MURA	*Microsoft's Upstream Reference Architecture*	Oil & gas	(Microsoft Corporation, n.d.)
INDEA	*India Enterprise Architecture Framework*	eGovernance/ public sector (India)	(IndEA Working Group, 2018)
NORA	*National Overall Reference Architecture*	eGovernance/public sector (Saudi Arabia)	(Government of Saudi Arabia, n.d.)
CAUDIT	*Council of Australasian University Directors of Information Technology Enterprise* Architecture Commons for Higher Education	Higher education (Australia & New Zealand)	(CAUDIT, 2016)
HORA	*Hoger Onderwijs Referentie-Architectuur*	Higher education (Netherlands)	(Samenwerkende Universitaire Reken Faciliteiten [SURF], 2019)
RATL	*Reference Architecture for Teaching and Learning*	Higher education	(Abel et al., 2013; ITANA Working Group, 2012)

Source: Own elaboration

2.4.3. Maturity Models

MMs or alternatively *maturity assessment models* are "*normative reference models that embrace the assumption of predictable evolution and change patterns*" (Salah et al., 2014, p. 318). A simple definition for a MM has been proposed by (Becker et al., 2009, p. 213) who state that a MM "*consists of a sequence of maturity levels for a class of objects*". Hence, their main goal is to "*outline the conditions when certain examined objects reach the best (perfect) state for their intended purpose*" (Wendler, 2012, p. 1318). In so doing, a MM provides a simplified representation of reality minimizing the "*complexity perception over a truly complex phenomenon*" (Domingues et al., 2016). Consequently, MMs have been developed and used in a plethora of research and application fields, especially in IS, Software Engineering and Business Process Management (Mettler, 2010, 2011; Tarhan et al., 2016; Wendler, 2012). In the particular scope of EA, these artefacts have been widely used as a measurement instrument of the level of adoption or assimilation of EA practices in different types of organisations (Bachoo, 2019; Luftman & Kempaiah, 2007; Vallerand et al., 2017).

Specialized literature on MMs tends to describe maturity as "*the state of being complete, perfect or ready*" (Wendler, 2012, p. 1318). To reach such a desired state, an evolutionary transformation path from an initial to a target stage needs to be progressed by an entity under examination. MMs are used to outline this transformation processes by defining successive and hardly-reversible stages or levels of maturity. Each one of this maturity levels signify step by step "patterns of change" designating the desirable capabilities against the scrutinized entity (Lahrmann & Marx, 2010, p. 522; Patas et al., 2013, p. 354; Reis et al., 2017, p. 644; Salah et al., 2014, p. 318). This entity under scrutiny could be any object of interest – e.g. a person, a process, a software product, an organisational function or even a social system – describing certain aspects of maturity of a determined application domain (Domingues et al., 2016; Mettler, 2011). Hence, MMs represent an especial class of dynamic conceptual models (Winter, 2017) capturing and supporting organisational change "*insofar as they represent an instrument for decision-makers to assess an organisation's actual state, derive actions for improvement, and evaluate these actions afterwards in terms of their effectiveness and efficiency*" (Ofner et al., 2015, pp. 4–5).

From a structural point of view, MMs typically consist of two main components (Lasrado et al., 2015; Mettler, 2011; Patas et al., 2013; Salah et al., 2014; Tarhan et al., 2016): (i) a "*reference domain model*, providing a set of dimensions representing the fundamental elements/criteria that should be examined of the addressed domain (i.e., *what needs to be measured*), and (ii) an *assessment method/procedure*, providing guidance (performance rating and scales) on how elements and criteria included in the RM have to be measured. There are several typologies to classify MMs based on the structural attributes characterising them (Saavedra et al., 2016). Probably, one of the most significative is that one that allows discriminating a MM on the basis of its underlying construction maturity principle (Lahrmann & Marx, 2010, p. 523; Lasrado et al., 2015; Ofner et al., 2015, p. 6). On the one hand, *staged MMs* specify an ideal path of maturity development of the entity under scrutiny through a set of concrete stages. In order to achieve one concrete level (stage) of maturity, compliance or compliment with all the requirements/elements defined in such individual maturity level is required. On the other hand, *continuous MMs* allow a scoring of elements at different maturity levels. Therefore, the (global) maturity achieved by the scrutinized entity could be either the (weighted) sum of the individual scores or the individual maturity levels achieved in the different dimensions defined.

More recently, *focus area MMs* have been introduced by (van Steenbergen, Bos, et al., 2010; van Steenbergen et al., 2008, 2013, 2007) as a new variant of MMs that can be distinguished from traditional approaches of *continuous* and *staged* based MMs. On the one hand, *focus area MMs* depart from the common practice of previous MMs of considering only five generic maturity levels. On the other hand, the targeted maturity domain of a *focus area MMs* is defined by a set of focus areas having their own specific number of maturity levels, being the overall maturity of the assessed domain the combination of the maturity levels of the focus areas defined. Such a fine-grained and flexible structural configuration postulates *focus area MMs* as an excellent tool for providing tangible step-by-step process improvement advice in a wide range of functional domains since they can be specifically particularized and/or configured to such determined application domains (Spruit & Röling, 2014; van Steenbergen, Bos, et al., 2010; van Zwienen et al., 2019).

	1	2	3	4	5
FA 1	X				
FA 2	X				
FA 3		X			
FA 4		X			
…					

Staged MM

	1	2	3	4	5
FA 1	X	X	X	X	X
FA 2	X	X	X	X	X
FA 3	X	X	X	X	X
FA 4	X	X	X	X	X
…					

Continuous MM

	1	2	3	4	5	6	7	…
FA 1	X				X			
FA 2		X		X				
FA 3	X		X			X		
FA 4				X			X	
…								

Focus Area MM

Figure 12 – Three Types of Maturity Models

Source: (van Steenbergen et al., 2008)

MMs may have a practical application or be just conceptual abstractions being sustained on maturity and capability concepts (Domingues et al., 2016, p. 381; Wendler, 2012). From the first perspective, and depending on their potential practical utility (usefulness), MMs can be also classified as: (i) *descriptive*, allowing the current (as-is) state of maturity of a targeted domain or object to be assessed; (ii) *prescriptive*, enabling the definition of concrete roadmaps for improvement towards a desired (to-be) state, as well as checking their effectiveness; and (iii) *comparative*, providing support for conducting internal or external comparative benchmarking (De Bruin et al., 2005; Pöppelbuß & Röglinger, 2011).

Finally, MMs can be considered as artefacts quite related with RM/Ras. As stated at the beginning of the present section, MMs are considered as "*normative reference models*" (Mettler, Eurich, et al., 2014, p. 225; Salah et al., 2014, p. 318; Tarhan et al., 2016, p. 129). The relationship among RAs and MMs can be articulated in several ways (Lahrmann & Marx, 2010). For example, RMs and architecture principles encompassed in RA can be used as a "blueprint" to define the underlying elements/dimensions configuring the "*reference domain model*" of the MM (Kang et al., 2010; Westermann et al., 2016). Further, the "*reference domain model*" can also be derived from the combination of multiple existing RAs in the application domain addressed by the MM (Weber et al., 2017). Finally, a RA may just simply suggest or recommend the use of a specific MM as a complementary tool for measurement purposes.

We exemplify all the previous rationale by means of several illustrative examples showing how several different ERAs have been related with different EA-oriented MMs:

- (van Zwienen et al., 2019) tailored the *Dynamic Architecture Maturity Matrix* (DyAMM) – a generic *focus area MM* for measuring EA maturity in a sector-independent organisation (van Steenbergen, Bos, et al., 2010; van Steenbergen et al., 2013) – to the particular domain of healthcare. They do so by extending and incorporating to the original DyAMM's "*reference domain model*" elements defined in the ZIRA healthcare-oriented ERA.

- Similarly, the HORA HEI-oriented ERA suggests the use of DyAMM for measuring maturity of EA practices in HEIs [21]. Assuming that HORA can play a role as a key EA artefact in fostering the quality of EA practices in Dutch HEIs, the DyAMM could be used as a self-assessment instrument providing HEIs an (indirect) measure on the (perceived) effectiveness on HORA's usage. In this case, and instead of modifying the original structure of the *focus area MM,* what HORA provides to such end is a tailored version of the original DyAMM adapted to the idiosyncrasy and language of HEIs (Architecten Beraad Hoger Onderwijs [22] et al., 2018; Architecten Beraad Hoger Onderwijs & SOGETI, 2018).
- Finally, and in a similar vein, the RATL HEI-oriented ERA developed under the auspices of EDUCAUSE suggests the use of the *Enterprise Architecture Maturity Model for Higher Education* (EAMM-edu). This MM has been derived on the basis of other existing well-known sector-independent MMs for measuring EA practice maturity [23].

2.5. Quality Assurance in Higher Education

QA has currently become one of the major concerns for modern HEIs worldwide (Asif & Raouf, 2013, p. 2010; A. Davis, 2017; Tarí & Dick, 2016, p. 273). As a matter of fact, a recent survey conducted by the *International Institute for Educational Planning* of the UNESCO reveals that near the 90% of QA managers surveyed from more than 371 HEIs worldwide consider QA as a critical institutional policy for their institutions (Martin & Parikh, 2017, pp. 28–29). The increasing relevance of QA in HEIs has also been reflexed in the academia. For example, (Steinhardt et al., 2017, p. 223) reported the analysis of 1.610 articles from 399 different journals from 1996 to 2013 in a scientometric study on QA for teaching and learning. Similarly, (Alzafari, 2017, pp. 265–267) reported the analysis of 2.289 publications from 1965 to 2015 in a co-citation analysis of literature on quality in HEIs. All in all, it can be concluded that QA in HEIs has become nowadays into a complex, heterogeneous and multidisciplinary mature research field (Alzafari, 2017; Steinhardt et al., 2017).

Unfortunately, and when looking to the specialized literature, despite that notable efforts have been devoted to the provision of more or less comprehensive definitions for the concepts of quality, and QA in HEIs, it seems like that no consensus on a widely accepted definition has yet been achieved (Elassy, 2015; Harvey & Green, 1993; Kamat & Kittur, 2017; Ryan, 2015; Schindler et al., 2015). Since providing a detailed analysis on this ongoing discussion is out of the scope of the present thesis, for the purposes of this research it is assumed that QA in HEIs generically *refers to guarantee the quality of HEI's processes, activities and services for all institutional stakeholders, including both internal and external ones.*

[21] See *Hoger Onderwijs Referentie Architectuur (version 2.1). Zelftoets Volwassenhei*.
Available at https://hora2.surf.nl/index.php?title=Zelftoets_Volwassenheid

[22] The Higher Education Architects' Council

[23] See *Enterprise Architecture Maturity Model (EAMM-edu) Working Group*.
Available at https://spaces.at.internet2.edu/display/itana/Enterprise+Architecture+Maturity+Model+%28EAMM-edu%29+Working+Group

2.5.1. Internal Quality Assurance Systems of Higher Education Institutions

Over the last years, European HEIs have been seriously affected by regulatory reforms and changes fostered by the Bologna Process, which in turn, has pushed them to the institutionalisation of new QA practices, processes and mechanisms (Curaj et al., 2015; Shuiyun Liu, 2016; Pucciarelli & Kaplan, 2016; Seyfried & Pohlenz, 2018). Among other developments, HEIs have been forced to plan, design and implement their own IQAS from a set of standards, principles and recommendations established in the ESG standards (Kettunen, 2012; Manatos et al., 2017b; Seyfried & Pohlenz, 2018).

The ESG can be viewed as an European "*reference model providing guidance to universities for the implementation of their internal quality management systems and to the external accreditation and evaluation agencies*" (Manatos et al., 2017b, p. 345). Nonetheless, HEIs can also find guidance on how to develop their own IQAS in more traditional QA frameworks and models, as for example TQM, the EFQM framework or the ISO 9001 standard (Dahl Jørgensen et al., 2014; Kamat & Kittur, 2017; Rosa et al., 2012). It is also worthwhile to point out here the recent release of the ISO 21001 norm (Camilleri, 2017; ISO, 2018), which represents a particularisation of the ISO 9001 tailored for IQAS in educational organisations.

Despite that compliance with the ESG is mandatory for European HEIs, guidelines and recommendations included in the standards are not prescriptive as regards "the structure and contents" of the IQAS to be implemented (Kettunen, 2012, p. 525; Rosa et al., 2012, p. 129). In other words, HEIs still conserve their autonomy to develop QA systems and procedures according to their specific missions, objectives, goals and institutional culture (Cardoso et al., 2017; Kettunen, 2012, p. 525; Tavares et al., 2016, p. 1050). Notwithstanding the foregoing, the implementation of an IQAS has been recognized as a complex tasks for many HEIs, which have had (and still have) to invest a lot of time, money and human resources on the implementation of those systems (Papadimitriou & Westerheijden, 2010, pp. 229–230).

In a simple way, an IQAS can be viewed as the result of the progressive institutionalisation of the QA practices, rules and tools undertaken within a HEI, resulting into a "formal" system aiming at ensuring the quality of all the institutional activities (Mårtensson et al., 2014, p. 534; Vukasovic, 2014). According to (Tavares et al., 2017, p. 1294), an IQAS "*would entail the existence of a quality policy, the creation of formal mechanisms and structures, participation of stakeholders, articulation with information systems, information transparency and continuous quality improvement*". Furthermore, a formalized IQAS implies "*a coherent and structured approach which is meant to ensure quality in every aspect of the institution's activities"* or, in other words *"the existence of a quality policy articulated with the pursuit of the institution's objectives, as well as clearly defined internal procedures, responsibilities and means necessary to attain these objectives*" (Tavares et al., 2017, p. 1298). Supplementing this view, (Kettunen, 2008, p. 325) defends that an IQAS may also facilitate HEIs to give answer to external regulations and norms: "*an IQAS may refer to the environments and quality assurance systems of the international and national levels and the environment and quality assurance system of an individual HEI*".

In contrast to these rather static-oriented visions of what is an IQAS, other authors adopt a more dynamic-oriented perspective to define and characterise them. For example, (Daromes, 2016, p. 89) refers to an IQAS "*as a plan, implementation, control, and development of the university's quality standards in order to obtain* *stakeholder satisfaction and ensure that the quality of graduates in accordance with the standard competencies defined*". Whatever the case, and independently of the perspective adopted, according to the ESG 2.0, the main purpose or goal of an IQAS must be "*to provide information to assure the higher education institution and the public of the quality of the higher education institution's activities (accountability) as well as provide advice and recommendations on how it might improve what it is doing (enhancement)"* (ESG 2015).

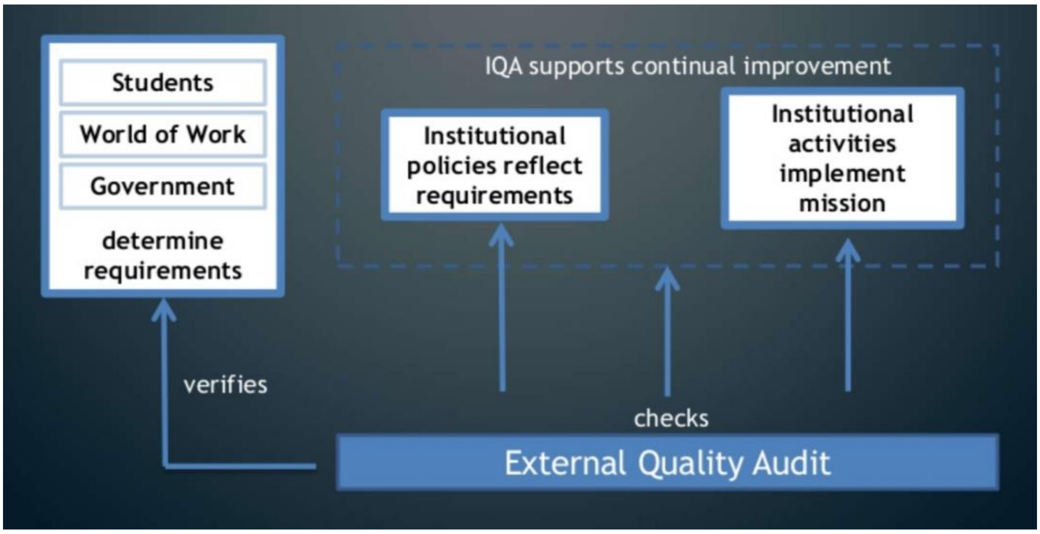

Figure 13 – A Simple Internal Quality Assurance System of Higher Education Institutions

Source: (Camillieri, 2016)

2.5.2. Integrating Enterprise Architecture and Quality Assurance in Higher Education

The likelihood of synergy and complementary nature of Quality Management Systems (QMS) [24] and IS has historically been suggested by the specialized literature from both disciplinary fields (Alič, 2018; Barata & Rupino da Cunha, 2017; Forza, 1995; Lin et al., 2012). In this regard, calls towards more integrated and *shared views* of IS and QMS in the manner that they depend on, support, and reinforce each other, have proliferated on the basis of "*tightly intertwining the two to achieve more than the sum of the parts*" (Rupino da Cunha & Dias de Figueiredo, 2005, p. 2245).

From the narrower scope of QA in HEIs, there is a current trend towards greater levels of integration of the implemented IQAS with other organisational management systems, including IS (Manatos et al., 2017a, 2017b, pp. 348–350; Mourad, 2017). For example, current literature recognized the critical role of IS in terms of collecting, storing and consolidating information records and products (e.g., Data Warehouses, Document Management Systems, etc.), in facilitating data-driven decision-making at all institutional levels (e.g., educational data mining, academic analytics, etc.) or even to foster information and data dissemination as a response of institutions to increasing external accountability demands (Cardoso et al., 2017, p. 336; Duarte et al., 2014, pp. 947–948; Kahveci et al., 2012; Manatos et al., 2017b, pp. 348–350). Nonetheless, despite "*a*

[24] The term IQAS tends to be used in the specialized HE literature to refer to the QMS implemented in HEIs

shared organisational view of IS and QMS is appealing and considered desirable in the literature, but there is a lack of practical guidance on how to do it" (Barata & Cunha, 2017, p. 289).

EA has also been pinpointed as a promising approach for supporting the mutual understanding and benefits of IS/QMS (Alter, 2013b, p. 99, 2017; Geskus & Dietz, 2009; Mezzanotte & Dehlinger, 2014), and, in particular, for IQAS of HEIs (Olsen & Trelsgård, 2016, p. 808; Riihimaa, 2009; Svensson & Hvolby, 2012, p. 641; Syynimaa, 2010). Considering that core processes of HEIs should be defined in the IQAS, EA may play an important role in describing the information, applications and technical infrastructure supporting the core process defined in the IQAS (Riihimaa, 2009). In other words, solution EA for a particular a HEI's could be seen as an extension of the IQAS, or alternatively, the IQAS as a subset of the own HEI's solution EA.

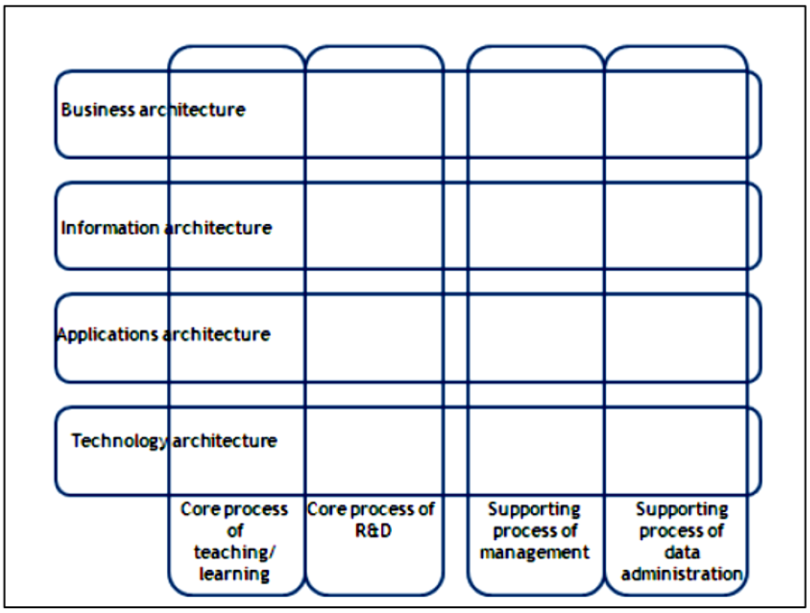

Figure 14 – Enterprise Architecture as an Extension of Core Processes of an Internal Quality Assurance System

Source: (Riihimaa, 2009)

Considering such background, the possibilities for using HEI-oriented ERAs (or even more generic types of RAs) to further improve the design, implementation and monitoring of IQAS will be explored in this thesis. In this sense:

- One of the use scenarios analysed in *Chapter 4* will be related with the potential of ERAs as a documental support for implemented IQAS – see publication [P8] –. In addition, it can also be hypothesised that RA/ERAs could be used to develop a more specific RM/RAs targeted to an IQAS in line with existing suggestions found in the literature calling to expand the current scope of enterprise modelling practices (Köhler et al., 2018; Sandkuhl et al., 2018).
- Also, and analogously to earlier referred existing *focus area MMs* posed as measurement instruments of the maturity of EA practice in organisations, RAs/ERAs could be used to foster to development of highly-contextual *focus area MMs* devoted to measure the implementation IQAS maturity level achieved in different HEIs – see publication [P10] –.

- Finally, and as a complementary work, considering that QA for eLearning is currently considered of the most import trends and concerns for QA accreditation bodies and agencies (Huertas et al., 2018), the possibilities of RAs and MMs as assessment tools in such a particular scope of application will be also explored – see publications [P4], [P7] or [P9] –.

3. Building an Artefact Framework for Facilitating the Use of HEI-oriented ERAs

3.1. Introduction

This chapter describes the process followed for building an instrumental framework aimed to facilitate the practical use and application of HEI-oriented ERAs by different stakeholders. As a first step to such endeavour, and taking as a starting point the introductory scoping review conducted for framing the research problem, a KB is constructed to enlighten existing relevant knowledge for the remaining research steps. Once consolidated, this KB is used for putting forward the need of developing such an envisioned artefact. Next, the basic design requirements of the artefact that will guide its construction are derived from both theoretical and practical collected knowledge. Finally, a framework for facilitating HEI-oriented ERAs use and application is constructed by building upon existing similar artefacts and by articulating the convenient adaptations for adequately shaping and fitting the form of the resulting artefact to HE-oriented practical contexts of application.

The contents included in this chapter correspond to the (ii) *definition of the objectives (requirements) for a solution* and (iii) *design and development* stages of the DSRM research approach followed during this thesis. Besides, and on the one hand, the results achieved during the construction of the KB in the first part of the chapter provided the information required for *giving answer to the first couple of research questions [RQ.1-RQ.2]* of thesis. On the other hand, the contents included in the second part of the chapter represent the *first steps towards* providing an adequate answer to *the third research question of the thesis [RQ.3]*.

3.2. Creating a Structured Knowledge Base for the Research Domain

The starting point for constructing the KB was the preliminary scoping review developed for framing the research problem (see section 1.2). The results achieved allowed us to get initially engaged with the main topics of the research as well as to define the 3 research problems [RP1-RP3] of the thesis.

To acquire further existing relevant knowledge to be consolidated next into a more structured KB for the thesis, we conducted a couple of literature reviews focused on capturing (i) general knowledge existing on ERAs, and (ii) capturing more specific knowledge on already existing examples of HEI-oriented ERAs. In both cases, the reviews conducted can be categorized as rather descriptive-oriented IS literature reviews (Paré et al., 2015, p. 186; Rowe, 2014) aiming to contribute to the existing body of knowledge through the synthesis and analysis of the findings emerged from the reviewed sources (Gregor, 2006; Schryen et al., 2015).

In the successive sub-sections, we provide concrete details on the referred literature reviews.

3.2.1. Current Knowledge on Enterprise Reference Architectures

To identify existing knowledge on ERAs, we conducted an structured literature review following well-known recommendations for conducting such reviews in the IS discipline (Levy & Ellis, 2006; Schryen, 2015; vom Brocke et al., 2009; Webster & Watson, 2002). The concrete details (scope, focus and procedural steps undertaken) to execute the literature review are detailed in publication [P2] and therefore, will not be detailed here again. Nonetheless, and since that at the moment of writing the present lines several new relevant contributions had been identified, in the following Table 8 we present an updated version of the main results achieved from the review (new contributions appear highlighted in grey in the table).

Despite that the analysis and conclusions reflected in the paper can still be considered as valid, the following additional nuances and/or considerations can be derived from the new identified sources:

- Firstly, a set of contributions from the Dutch EA School of practice focused on the topic of ERAs have been reflected in Table 8 (references #1, #5, #8–#10). All these contributions were written in Dutch and were explicitly excluded from the original analysis due to language restrictions. In terms of the framework used for literature analysis and interpretation, this collection of sources puts emphasis on aspects related with the "what" of ERAs, and in particular, in providing (working) definitions for the concept and describing the main components or elements characterising them. However, and in general terms, these papers don't bring much more additional knowledge on ERAs, in the sense that most knowledge provided by these contributions had already previously been captured in the original paper [25]. Perhaps, the most relevant additional knowledge emanated from the new sources could be the following:

  i) The works by (de Boer et al., 2011) and (Greefhorst, 2011b) include interesting insights on how to make ERAs available by means of documenting them through accessible semantic wikis to facilitate their free dissemination and consultation.

  ii) (Greefhorst et al., 2008) discusses on several typologies of ERAs, differentiating between ERAs and *standard (reference) architectures*. Whilst the former represents a RA for a class of enterprises, the latter are also a sub-type of RAs – and for instance, an abstract architecture – but limited to the context of a specific organisation. In this sense, a *standard (reference) architecture* represents an organisation-specific selection and implementation of a RA, but not being directly linked to the realisation of a specific solution. *Standard (reference) architectures* would typically be associated to rather large-scale organisations consisting of several smaller organisations or business units. All in all, and in some way, such differentiation is consistent with the conceptualisation of ERAs provided by several authors like (Fattah, 2009) or (Niemi & Pekkola, 2017) – references #4 and #25 –.

  Besides all the above, (Greefhorst et al., 2009) also suggest the possibility of classifying ERAs on the basis of several attributes, namely (i) the particular *"class of enterprises"* scoped by the architecture – for example HEI-oriented ERAs vs. insurance-oriented ERAs –, (ii) *open* vs. *closed* ERAs, (iii) *commercial* vs. *publicly available* ERAs or even (iv) *non-binding* vs. *mandatory* ERAs.

  iii) To conclude with new references from the Dutch school, it must be also recognized the significance of reference of #19 (Greefhorst, 2015), since it provides interesting insights on critical success factors for ERAs. These factors relate both to the development as well as the implementation process (i.e., use and application) of an ERA.

[25] In other words, the new considered sources were already referenced by sources considered in the original analysis conducted when writing publication [P2].

On the one hand, development-oriented critical success factors for ERAs include:

- *contributing to the objectives of an organisation addressing a common problem,*
- *jointly draw up or in close collaboration with all the stakeholders in the sector itself,*
- *good structure and correct level of detail,*
- *accessibility (ideally open and available free of charge)*
- *linking up and mutual consistence with other ERAs of adjacent sectors.*

On the other hand, implementation-oriented critical factors for ERAs include:

- *governance set up,*
- *to be part of (inspire) the change process*, and finally, and for the sake of continuity,
- creation of an *architect community where experiences and best practices with the application of the ERA are shared for the collective.*

- Secondly, a second set of new publications (references #27–#31) represent additional extensions to the earlier works leaded by Timm and already described in the original paper (Timm, Köpp, et al., 2015; Timm, Sandkuhl, et al., 2017; Timm, Wißotzki, et al., 2015). Among the new contributions presented in the referred publications, the following aspects should be highlighted:

    i) References #27–#28 include additional prescriptive knowledge complementing previous works on how to build and construct ERAs (Timm et al., 2018; Timm & Sauer, 2017).

    ii) In reference #29, Timm provides an application design framework providing relevant knowledge on different scenarios of use and application for RMs developed (i.e., configured) as a structural component of an ERA.

    iii) References #30–#31 provide a complete and detailed description of the whole process for developing a new ERA, taking as an example the construction of a financial-oriented ERA (Timm & Sandkuhl, 2018a, 2018b).

- Finally, there can also be identified a set of more “residual” contributions (references #32–#35) providing interesting insights about different facets of ERAs:

    i) The contribution by (Paradkar, 2018) is quite similar to the one by (Lankhorst, 2014) already contemplated in the original paper. It additionally includes a quite interesting discussion in terms of how to differentiate ERAs from EA Frameworks.

    ii) The work by (Gump et al., 2018) is also similar to the contributions by Timm and colleagues, since it discusses the whole process for developing an ERA. In this particular case, the ERA developed is within the scope of to the secure mobile communications industry.

Table 8 – Structured Knowledge on What Is Known About Enterprise Reference Architectures

	META-DATA AND DESCRIPTIVE INFORMATION				NATURE					ADOPTION				PRACTICES			IMPACT	
	Contribution (Authors / date)	**Research method**	**Level of study**	**Universality of study**	**Definitions**	**Components**	**Conceptual models**	**Taxonomies**	**Documentation**	**Adoption factors**	**Success factors**	**Stakeholders**	**Uses**	**Design methods**	**Mapping methods**	**Selection models**	**Value / Benefits/ Purpose**	**Impact measures**
1	(Greefhorst et al., 2008)	CO	C	B	✓	✓		✓										
2	(Muller, 2008)	CO	C	G	✓	✓		✓	✓								✓	
3	(Muller & van de Laar, 2009)	CO	C	G	✓				✓									
4	(Fattah, 2009)	CO	C	G	✓			✓					✓					
5	(Greefhorst et al., 2009)	QT	C	G	✓	✓		✓										
6	(Cloutier et al., 2010)	CO	C	G	✓	✓	✓	✓			✓	✓	✓				✓	
7	(Schmidt & Buxmann, 2011)	MX	O	S														✓
8	(de Boer et al., 2011)	CO	C	S	✓	✓			✓			✓	✓					
9	(Greefhorst, 2011a)	CO	C	S	✓	✓												
10	(Greefhorst, 2011b)	CO	C	S	✓	✓			✓									
11	(Lange et al., 2012)	MX	O	G														✓
12	(ten Harmsen van der Beek et al., 2012)	DS	C	B	✓	✓	✓					✓	✓				✓	
13	(Zimmermann et al., 2013)	CO	C	G	✓	✓									✓			
14	(Lankhorst, 2014)	CO	C	G	✓	✓					✓						✓	
15	(Tambouris et al., 2014)	QL	O	S		✓												
16	(Kotzampasaki, 2015)	DS	C	G												✓		
17	(Timm, Köpp, et al., 2015)	DS	C	S										✓				
18	(Timm, Wißotzki, et al., 2015)	QT	O	S						✓								
19	(Greefhorst, 2015)	QT	C	G							✓							
20	(Aulkemeier et al., 2016)	DS	C	S										✓				

	META-DATA AND DESCRIPTIVE INFORMATION				NATURE					ADOPTION				PRACTICES			IMPACT	
	Contribution (Authors / date)	**Research method**	**Level of study**	**Universality of study**	**Definitions**	**Components**	**Conceptual models**	**Taxonomies**	**Documentation**	**Adoption factors**	**Success factors**	**Stakeholders**	**Uses**	**Design methods**	**Mapping methods**	**Selection models**	**Value / Benefits**	**Impact measures**
21	(Lange et al., 2016)	MX	O	G														✓
22	(Olsen & Trelsgård, 2016)	QL	O	S						✓							✓	
23	(Czarnecki & Dietze, 2017)	NA	C	S	✓	✓			✓									
24	(Jusuf & Kurnia, 2017)	MX	O	G														✓
25	(Niemi & Pekkola, 2017)	QL	O	S								✓	✓					
26	(Timm, Sandkuhl, et al., 2017)	DS	C	B										✓				
27	(Timm & Sauer, 2017)	MX	C	B										✓				
28	(Timm et al., 2018)	DS	O	B										✓				
29	(Timm, 2018)	DS	C	B								✓	✓				✓	✓
30	(Timm & Sandkuhl, 2018a)	DS	C	B		✓				✓				✓				
31	(Timm & Sandkuhl, 2018b)	DS	C	B		✓				✓				✓			✓	
32	(Paradkar, 2018)	CO	C	G	✓												✓	
33	(Gump et al., 2018)	MX	C	S	✓							✓		✓			✓	
34	(Kotusev, 2019)	QT	O	G								✓	✓				✓	
35	(Kurnia et al., 2020)	MX	C	G								✓	✓				✓	

LEGEND

<u>Level of study</u>*: C → Core topic | O → Other topics covered* ╬ ***<u>Universality of study</u>*** *: G → General | S→ Specific | B→ Both*
<u>Research Method</u>*: CO → Conceptual/theoretical | DS → DSR | QL → Qualitative Research | QT → Quantitative Research | MX→ Mixed Methods | NA → Not Assigned*

Source: Own elaboration

iii) Finally, the works by (Kotusev, 2019) and (Kurnia et al., 2020) offer interesting insights on the use of RAs/ERAs, despite they are not entirely focused on this particular type of artefacts.

On the one hand, (Kotusev, 2019) provides a systematic and unified analysis on the use and purpose in practice of 24 common different types of EA artefacts. Among the EA artefacts included, Kotusev described in detail the possibilities of *Technology Reference Architectures*, *Capability Reference Models*, *Value Reference Models* or *Business Reference Architectures*.

On the other hand, (Kurnia et al., 2020) also provides a unified analysis on the potential activities or scenarios of use of different typologies of EA artefacts. In particular, they describe 8 activity areas reflecting different aspects of the EA practice in organisations, including relevant artefacts, activities, benefits and blockers. In some cases, activities cannot be directly associated or related with a particular type of EA artefact.

3.2.2. Existing Examples of HEI-oriented ERAs

The second literature review conducted was principally devoted to identify and analyse already existing instances of HEI-oriented ERAs (or RMs). Analogously to the previous review, the concrete methodological details can be found in publications [P5] and [P6] [26].

Furthermore, and as already introduced earlier in the theoretical chapter of the thesis (see Section 2.4.3), since RMs and architecture principles embedded in a RA might be used as a structural part (i.e., *reference domain model*) of a MM we also decided to widen the scope of the review to existing EA-oriented MMs. We did so to detect the potential existence of ERAs non-covered by the search criteria defined in publications [P5] and [P6].

To uncover existing EA-oriented MMs, we drew on already undertaken literature reviews focused on this type of EA artefacts (Meyer et al., 2011; Sobczak, 2013; Vallerand et al., 2017). Also, and considering that, for example, the Dutch's HORA national ERA for HE also is associated with a *focus area MM*, we also conducted an additional review centred on this specific typology of MMs. We conducted this additional review since no one of the reviews evaluated (Meyer et al., 2011; Sobczak, 2013; Vallerand et al., 2017) referred explicitly to this type of MMs.

The complete details and procedural approach followed on this latter review on *focus area MMs* can be found in publication [P1]. A total set of 8 EA-oriented MMs were finally uncovered and analysed – see the following Table 9 –. However, none of the *reference domain models* configuring the 8 EA-oriented MMs investigated was grounded or constructed on the basis of any *existing* ERA or RM.

[26] Publication [P6] corresponds to an extended version of publication [P5]. This latter publication was selected as one of the best papers in the *2018 Multi-Conference on Computer Science and Information Systems* held in Madrid. As a consequence, an extended version of the paper was requested by the conference organizers to be published in the *IADIS International Journal on Computer Science and Information Systems* ([P6]).

Table 9 – Enterprise Architecture Maturity Model Instruments

	Maturity Model	Acronym	Base Reference	Type	Source Literature Review				Origin
					(Meyer et al., 2011)	(Sobczak, 2013)	(Vallerand et al., 2017)	(Sanchez-Puchol & Pastor-Collado, 2017) [P1]	
#1	Gartner's IT Score Maturity Assessment for EA	–	(Blosch & Burke, 2017)	CO			✓		Consultancy
#2	Forrester's EA maturity assessment tool	–	(Cullen & DeGennaro, 2011)	FA			✓		Consultancy
#3	National Association of State Chief Information Officers' Enterprise Architecture Maturity Model	NASCIO-EAMM	(National As-sociation of State Chief Information Officers, 2003)	CT	✓	✓	✓		Public Administration
#4	Department of Commerce Enterprise Architecture Capability Maturity Model	A-CMM	(U.S. Department of Commerce, 2007)	CT	✓	✓	✓		Public Administration
#5	Center for Information Systems Research at MIT Enterprise Architecture Maturity Model	CISR-EAMM	(Ross, 2004)	ST			✓		Academia
#6	US Government Accountability Office Enterprise Architecture Management Maturity Framework	EAMMF	(U.S. Government Accountability Office, 2010)	ST	✓		✓		Public Administration
#7	Strategic Alignment Maturity Model	SAMM	(Luftman, 2000; Luftman & Kempaiah, 2007)	CT	✓				Academia
#8	TOGAF EA Maturity Model	TOGAF	(The Open Group, 2011) (*)	UD		✓			Standardisation organisation
#9	DyA Architecture Maturity Matrix	DyAMM	(van Steenbergen, Schipper, et al., 2010)	FA				✓	Academia

(*) *At the moment, TOGAF refers to A-CMM for EA maturity evaluations. However, it is expected that future versions of the standard may include a MM to measure adoption of the TOGAF itself.*

Legend → CO: Continuous | ST : Staged | FA: Focus area | UD: Under development

Source: Own elaboration

The following (multi)-Table 10 reflects a current updated version of the outputs achieved in the original reviews presented in publications [P5] and [P6] (updates are highlighted in grey). The table itself can be viewed as a catalogue as well as a comparative framework of the current developments on HEI-oriented ERAs. It is structured on the basis of four main groups of attributes defined to characterise each one of specific examples found: *identifying attributes, general scope attributes structural attributes* and *usage attributes*.

Again, the conclusions and derivatives reported in the original papers are totally valid. Nonetheless, and given that several new instances have emerged (and have been detected) a *posteriori*, in the following we provide some additional comments complementing the conclusions achieved in the aforementioned publications:

- Several “early detected” relevant HEI-oriented ERAs have achieved a higher level of maturity as time has gone by. This is the case, for example, of the Dutch’s HORA and the CAUDIT’s HEI-oriented ERAs, which have recently launched new releases of the architecture including notable improvements. In particular, HORA released its 2.1 version on September 15th 2019 (SURF, 2019). Similarly, CAUDIT released its 2.0 version by the end of 2019 (CAUDIT, 2019).

  On the other hand, the UCISA initiative has been recently closed, and now, the UCISA ‘s original architecture model is going to be further developed and improved under the auspices of EUNIS, adopting a more international perspective (EUNIS, 2019b, 2019a). Up to date, EUNIS has extended the UCISA UK HE final version by adding a third level of capabilities, increasing hence, the depth of the original proposal.

- In line with previous “preliminary” national-oriented developments, additional new instances have also appeared over the last times. Examples of such contributions could be the Indian UEAF , the Finnish OPI or even the Norwegian developments – which can be decomposed focused in (i) the particularisation for the HE sector of the *Difi* national architecture principles for the public sector, (ii) and the (partial) REDA HEI-oriented ERA (Anastasiou, 2019; Bergh-Hoff et al., 2015; Difi, 2010; Melve & Smilden, 2015; NIC EA, 2019) –. All these referred instances of HEI-oriented ERAs are also linked or related, in some or another way, with a more generic national (e-government) RAs.

  Besides, we have been able to identify an IT-oriented RM for Universities in Iran, which seems to be [27] an extension of the more generic *Iran’s National Enterprise Architecture Framework* (INEAF) for public sector organisations and agencies (National Enterprise Architecture Committee, 2018). The approach followed in Iran seems to be quite consistent to the one followed in India, in which UEAF represents the extension for the HE industry of the developments encompassed in the national *India Enterprise Architecture* (IndEA) framework for eGoverment (IndEA Working Group, 2018). The INEAF national Indian framework explicitly declares that the responsibility for developing sector-oriented extensions in the form or ERAs/RM is left to concrete stakeholders of each particular industry (banking, energy, municipalities, healthcare, education, etc.).

[27] No definitive evidence found in this sense.

- In line with the previous developments, it must also be highlighted the recent appearance of SURA in Egypt, which has a particular focus on the concept of "*smart university*" (Uskov et al., 2016). In fact, it is considered as "*part of the Egyptian endeavours to build a knowledge society through developing the outputs of universities and raising the education process efficiency for a better future of higher education*" [28] (Arab Republic of Egypt Ministry of Communications and Information Technology, 2019; SECC , 2019). Nonetheless, and although it is sponsored by the Egyptian government, no evidence has been found on their relationship or linkage with a more generic national RA. Unfortunately, very few information about SURA is currently accessible, and therefore a detailed analysis of this ERA could not be carried out. In similar line to this case, we have been unable to found evidence on some type or relationship between CHE²A (which can be viewed as a HEI-oriented RM) and the more generic *Marco de Referencia de EA para el Estado Colombiano* (Llamosa-Villalba et al., 2015; Ministerio de Tecnologías de la Información y las Comunicaciones, n.d.).

- Several works reporting on the use of EA artefacts in the HE sector also suggest that in different countries, and under the absence of a specialized HEI-oriented ERA, practitioners may use instead recommendations, models, and principles encompassed in more generic national public sector/eGovernance RAs.

  For example, (Lethbridge & Alghamdi, 2019, p. 143) report on the fact that in Saudi Arabia many EA practitioners in HE use the Saudi Arabian *National Overall Reference Architecture* (NORA) prescribed for public sector organisations (Government of Saudi Arabia, n.d.) [29]. Since NORA is not a specialized HEI-oriented ERA, it has not been included in the comparative analysis.

- Besides all the above, over the last time several rather research-oriented approaches have also appeared. Examples of such instances could be the *Unified Architecture Model for University 3*.0 or the *SOA System Reference for Interconnected Modern Higher Education* (Fajar et al., 2018; Pańkowska, 2016).

- Finally, several initiatives identified in the original analysis have definitely no further evolved and have been definitively closed – e.g., the earlier referred UCISA UK HE Model or the Trust and Identity Reference Architecture (TIER) –.

All in all, data collected in the following Table 10 reveals that there is an increasing global/international trend towards the study and development of HEI-oriented ERAs, which can be interpreted as an indicator (re)-confirming the relevance on the topic of study chosen for the thesis. In this sense, and during the last five-year period (2015-2020) the number of existing initiatives and proposals has notably increased worldwide. Furthermore, some of the most important initial proposals of HEI-oriented ERA – as the Dutch's HORA or the Australian's CAUDIT – have also evolved during this five-year period by releasing more elaborated versions of the architectures, including notable improvements respect their first initial release.

[28] Besides SURA, no further developments on HEI-oriented ERAs or related artefact originated in the African continent have been identified. At most, efforts developed from the South African government to develop a Central Application Service for HEIs should be noted at this point (Department of Higher Education and Training, 2016).

[29] Caution should be taken on the fact that both the Kingdom of Saudi Arabia *National Overall Reference Architecture* and the *Nederlandse Overheid Referentie Architectuur* national RAs share the same acronym (HORA).

Table 10 – Existing Enterprise Reference Architectures and Models for Higher Education

(a) Identifying attributes

Artefact Name	Abbreviator	Type	Bibliographic References	Status
Hoger Onderwijs Referentie Architectuur	HORA	ERA	(SURF, 2013, 2019)	Active
ITANA Reference Architecture for Teaching and Learning	RATL	ERA	(Abel et al., 2013; ITANA Working Group, 2012)	Active
CAUDIT Enterprise Architecture Commons for Higher Education	CAUDIT	ERA	(CAUDIT, 2016, 2017, 2019; Lemon, 2019)	Active
The Trust and Identity Reference Architecture	TIER	ERA	(Internet2 [30], 2019; TIER-Data Structures and APIs Working Group, 2016)	Closed
Cloud Computing Architecture for Higher Education	CLOUD	ERA	(Mircea & Andreescu, 2011; Pardeshi, 2014)	Unknown
ICT Enterprise Architecture Principles for the Norwegian Higher Education Sector [31] & Reference Architecture for Digital Exams [32]	Difi-HE & RADE	ERA	(Bergh-Hoff et al., 2015; Difi, 2010, 2012; Olsen & Trelsgård, 2016, pp. 806–809) (Melve & Smilden, 2015)	Active
OPI Reference Architecture for Higher Education Study and Teaching Support Services and Administration	OPI	ERA	(Anastasiou, 2019; CSC – IT [33], 2018)	Active
Unified Architecture Model for University 3.0 (student learning environment)	UNI-3.0	ERA	(Pańkowska, 2016, p. 3)	Closed (estimated)
SOA System Reference for Interconnected Modern Higher Education in Indonesia	SOA-RI	ERA	(Fajar et al., 2018)	Unknown
University Enterprise Architecture Framework	UEAF	ERA	(NIC EA, 2019; Sengupta, 2019)	Active

[30] Internet2 is a member-driven advanced technology community founded by the US' leading HEIs in 1996. It provides a collaborative environment where US research and education organisations can solve common technology challenges and develop innovative solutions in support of their educational, research and community service missions.

[31] This common set of IT architecture principles represents a concretisation (and a joint interpretation) for the HE sector of the overarching IT general architecture principles for the Norwegian public sector, established by the *Direktoratet for forvaltning og ikt (Difi,* in English *Agency for Public Management and eGovernment).* These principles form part of the Norwegian common national EA for the public sector, which is mandatory to all governmental agencies. Difi is responsible for managing and developing the overall architecture principles but the respective sectors and public bodies are responsible for incorporating the architecture principles into their own (sectorial) architecture.

[32] It represents a partial national Norwegian HEI-oriented ERA in the sense that its application domain is limited to the scope of digital examination. It could be hypothesised whether it represents a first step or effort towards a more complete (full) national HEI-oriented ERA developed by means of an incremental approach.

[33] The *IT Center for Science* (CSC-IT) is a Finnish center of expertise in information technology owned by the Finnish state and higher education institutions. CSC provides internationally high-quality ICT expert services for higher education institutions, research institutes, culture, public administration and enterprises to help them thrive and benefit society at large.

Artefact Name	Abbreviator	Type	Bibliographic References	Status
Smart University Reference Architecture	SURA	ERA	(Arab Republic of Egypt Ministry of Communications and Information Technology, 2019; SECC [34], 2019)	Active
EUNIS [35] Higher Education Institutions Capability Canvas	EUNIS-HEI	RM	(EUNIS, 2019b, 2019a)	Active
UCISA[36] United Kingdom Higher Education Capability Model	UCISA	RM	(Anderson, 2018; UCISA, n.d.; UCISA EA Community of Practice, 2017)	Closed
Colombian Higher Education Enterprise Architecture	CHE^2A	RM	(Llamosa-Villalba et al., 2015, 2014)	Active (estimated)
Charles Sturt University Higher Education Business Process Reference Model	CSU-BPM	RM	(Charles Sturt University, 2010)	Closed (estimated)
Higher Education-IUP Business Process Model	HE-IUP	RM	(Reiner, 2014)	Closed
Business Process Reference Model for Higher Education	BPRM-HE	RM	(Svensson & Hvolby, 2012)	Unknown
Higher Education Information Systems in Croatia	HE-ISC	RM	(Frackmann, 2007)	Closed
The ICOPER (eContent+ Best Practices Network) Reference Model for Outcome-based HE	ICOPER	RM	(Pawlowski & Kozlov, 2013; Simon et al., 2011)	Closed
Unified Information Systems Reference Model for Higher Education Institutions	UISRM-HE	RM	(Sanchez-Puchol et al., 2017)	Active
e-education Application Framework	eEdSF	RM	(Fagan, 2003)	Closed
Univ. of Tras-o-Montes e Alto Douro Multidimensional IS Architecture	UTAD-ISA	RM	(Bessa et al., 2016)	Active (estimated)
Reference Model of IS for an Integrated Campus Management	RMIS-ICM	RM	(Bick & Börgmann, 2009)	Closed
Reusable Process Model Structure for Higher Education	RPMS-HE	RM	(Van der Merwe, 2005)	Closed
Value Chain for Higher Education	VC-HE	RM	(Hutaibat, 2011)	Closed
Reference Model of University IT Architecture	UNITA	RM	(Chen et al., 2016)	Unknown
ICT Technical Reference Model for Iran Universities	TRM-IRA	RM	(Ahmadi et al., 2007; National Enterprise Architecture Committee, 2018)	Unknown

[34] The *Software Engineering Competence Center* (SECC) is an Egyptian leading ICT organisation aiming at bridging the gap between the technologies needed to overcome the economical-social-environmental challenges and the current existing technologies.

[35] The *European University Information Systems Organisation* (EUNIS) is a supranational non-profit organisation that brings together those who are responsible for the management, development and the policy for Information Technology in Higher Education in Europe. The objective of EUNIS is to contribute to the development of high quality information systems.

[36] The *Universities and Colleges Information Systems Association* (UCISA) is the United Kingdom member-led professional body for digital practitioners in education. . The objective of UCISA is to actively promote networking, collaboration and shared inspirational thinking to help transform teaching, learning and research by supporting operational efficiency and an excellent student experience.

(b) General scope attributes

	Abbreviator	Goal	Origin	Level of detail (1)	Universality
Declared/considered as ERAs	HORA	Standardization	Both	Detailed	Regional/National (Netherlands)
	RATL	Facilitation	Practice	Detailed	General
	CAUDIT	Standardization	Both	Detailed	Regional/National (Australia & New Zealand)
	TIER	Facilitation	Practice	Semi-detailed	General
	CLOUD	Facilitation	Academia	Aggregated	General
	Difi-HE	Standardization	Both	N/A (2)	Regional/National (Norway)
	RADE	Standardization	Both	Detailed	Regional/National (Norway)
	OPI	Standardization	Both	Detailed	Regional/National (Finland)
	UNI-3.0	Facilitation (1)	Academia	Semi-detailed	General
	SOA-RI	Standardization (1)	Academia	Aggregated	Regional/National (Indonesia)
	UEAF	Standardization	Both	Detailed	Regional/National (India)
	SURA	Standardization	Practice	Unknown (3)	Regional/National (Egypt)
Declared/considered as RMs	EUNIS-HEI	Standardization	Practice	Detailed	General
	UCISA	Standardization	Practice	Detailed	Regional/National (United Kingdom)
	CHE^{2}A	Standardization	Both	Semi-detailed	Regional/National (Colombia)
	CSU-BPM	Facilitation	Practice	Detailed	Particular (United States)
	HE-IUP	Facilitation (1)	Both	Semi-detailed	General
	BPRM-HE	Standardization (1)	Academia	Aggregated	General
	HE-ISC	Standardization (1)	Practice	Aggregated	Regional/National (Croatia)
	ICOPER	Facilitation	Both	Detailed	General
	UISRM-HE	Facilitation	Academia	Semi-detailed	General
	eEdSF	Standardization (1)	Academia	Aggregated	General
	UTAD-ISA	Facilitation (1)	Academia	Semi-detailed	Particular (Portugal)
	RMIS-ICM	Standardization (1)	Academia	Aggregated	General
	RPMS-HE	Standardization (1)	Academia	Aggregated	General
	VC-HE	Standardization (1)	Academia	Aggregated	General
	UNITA	Facilitation (1)	Academia	Aggregated	General
	TRM-IRA	Standardization	Both	Aggregated	Regional/National (Iran)

(1) Mostly based on the authors appreciation after analysing information sources found

(2) Does not apply for a partial-ERA encompassing just a set or architecture principles.

(3) No information available/accessible for determining it.

(c) Structure and content attributes

	Abbreviator	Generic EA dimensions				HE domain dimensions				Notation			Princi-ples		Documen-tation		
		Business	Data	Applications	Technology	Teaching & learning	Research & develop.	Support services	Third mission	Formal	Semi-formal	Unformal	Explicitly included	Not transparent	Specification	Wiki/website	Doc/.textual sup.
Declared/considered as ERAs	HORA	■	■	■	□	■	■	■			■		■		■	■	
	RATL	■	■			■		■			■			■		■	
	CAUDIT	■	■			■	■	■	□		■			■			■
	TIER			■	■			■		■				■		■	
	CLOUD			□	■	□	□	□				■		■			■
	Difi-HE	–	–	–	–	–	–	–	–	–	–	–	■				■
	RADE	■	■	■	■	□					■		■		■		
	OPI	■	□	□		■		■					■			■	
	UNI-3.0	■		■	□	■		□			■		■				■
	SOA-RI	□	□	□		■					■		■				■
	UEAF	■	■	■	■	■	■	■	□		■		■				■
	SURA	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Declared/considered as RMs	EUNIS-HEI	■				■	■	■	□		■			■			■
	UCISA	■				■	■	■	□		■			■			■
	CHE²A	■				■	□	■				■	□				■
	CSU-BPM	■				■	■	■			■			■		■	■
	HE-IUP	■				■	■	□				■		■		■	■
	BPRM-HE	■				■					■			■			■
	HE-ISC	□		□		□		□				■		■			■
	ICOPER	■		□		■					■		■		■		
	UISRM-HE			■		■	■	■			■		■				■
	eEdSF			■		□		□				■		■			■
	UTAD-ISA			■		■		■			■			■			■
	RMIS-ICM	□		■		■		■				■		■			■
	RPMS-HE	■				■		□			■			■			■
	VC-HE	■				□	□	□	□			■		■			■
	UNITA				■	□		□				■		■			■
	TRM-IRA			□	□	?	?	?	?			■	?	?			■

■ *full support* | □ *partial support* | – *not applicable*

X *unknown or not enough information available*

(d) Practical use attributes

	Abbreviator	Validation		Accessibility			Practicability		
		Tested	Unclear	Free	Restricted	Charged	Concrete guidelines	Basic recommend.	Unclear
Declared/considered as ERAs	HORA		■	■			■		
	RATL		■	■				■	
	CAUDIT		■		■				■
	TIER		■	■				■	
	CLOUD		■	■				■	
	Difi-HE		■	■			–	–	–
	RADE		■	■				■	
	OPI	■		■			■		
	UNI-3.0		■	■					■
	SOA-RI		■	■					■
	UEAF		■	■			■		
	SURA	?	?		■		?	?	?
Declared/considered as RMs	EUNIS-HEI		■	■				■	
	UCISA		■	■				■	
	CHE^{2}A	□			■			■	
	CSU-BPM		■	■			■		
	HE-IUP		■	■					■
	BPRM-HE		■	■					■
	HE-ISC		■	■					■
	ICOPER	■		■			■		
	UISRM-HE		■	■					■
	eEdSF		■	■					■
	UTAD-ISA		■	■					■
	RMIS-ICM		■	■					■
	RPMS-HE	□		■			■		
	VC-HE		■	■					■
	UNITA		■	■					■
	TRM-IRA	■		■					■

■ *full support* | □ *partial support* | – *not applicable*

? *unknown or not enough information available*

3.2.3. Consolidating the Knowledge Base: Main Findings and Essential Conclusions

Several interlinked findings can be drawn from the contributions collected and consolidated on the previous KB. They can all be synthetized as follows:

- *First*, and in general, the results achieved show that the concept of ERAs has received an increasingly growing interest both from academia and practice. This fact is shown by the diversity and heterogeneity of the information sources identified. However, and collectively, the number of existing contributions with a clear focus on the topic should be still qualified as limited.

- *Second*, there is a notable and relatively well-established corpus of knowledge devoted to the definition, description and understanding of the nature of ERAs (i.e., *"what*"). For example, the working definition provided by (ten Harmsen van der Beek et al., 2012) is relatively well accepted in terms of universality. In addition, there is also a good background of contributions addressing topics such as the elements and components that characterise an ERA, classifications stating how these different components are structurally interrelated or even on how to adequately document ERAs to make them as much accessible as possible.

  Concerns arise, however, when the focus is set on nomenclature issues. Hence, terminological inconsistence is quite usual in the literature when referring to artefact names (titles). Inconsistences can be found both at the more general or global level of ERAs (i.e., *enterprise reference architecture vs reference enterprise architecture* vs *reference model*, etc.) as well as at the more fine-grained level of the compositional elements characterising an ERA (i.e., *conceptual model* vs. pattern vs. *reference model* vs. *landscape*, etc.). As a consequence of this lack of homogeneity, problems arise when trying to compare knowledge from different sources, since a single term can have different meanings (or refer to a different type of artefact) in each particular one of the sources consulted.

- *Third*, a clear trend can be found during the last triennium (2017-2019) towards the development of prescriptive-oriented knowledge on ERAs (i.e., the *"how to*"). Contributions in this stream of research have been mainly leaded by the works by Timm and colleagues. However, these contributions tend to put the focus more at the more fine-grained level of the RMs that are embedded as a component of an ERA, than in the own ERA as a whole. This group of contributions addresses different possible strategies for building and constructing an ERA, namely through inductive (abstracting from individual ERAs to agree on a final one providing common understanding), deductive (deriving an ERA from generally accepted knowledge) or hybrid (combining previous ones) approaches. Finally, the work by (Kotzampasaki, 2015) is also significative since it proposes a process method for selecting an adequate ERA to be used or applied, given a determinate set of contextual requirements or factors .

- *Fourth*, and in contrast to previous aspects, much more attention should be put on researching issues related with the adoption, use and application of ERAs (i.e., the "*why*" and the "*how*"). This claim is valid both at general level as well as at the more particular level of different industries or sectors. For example, we were not able to find any case study providing empirical account on the use of ERA in HE settlements. At most, few works merely mention possible potential benefits derived of the usage of these abstract artefacts. (Frackmann, 2007; Greefhorst, 2015; Olsen & Trelsgård, 2016; Svensson & Hvolby, 2012). Nonetheless, they seem to provide from weak to none empirical evidence for corroborating the value assertions claimed. Beyond this, it could also be highlighted the work by (Niemi & Pekkola, 2017) – which provides descriptions of scenarios of use for different EA artefacts in the public sector – or the works leaded by Timm which tend to include demonstrations on the applicability of their findings in rather financial-oriented contexts.

Summing up, there still is an urgent need to develop "in-depth" case studies providing empirical account to gain more insights on how to use or apply ERAs. This finding is consistent with earlier claims that can be found in practice-oriented literature on EA in HEIs (Joint Information Systems Committee, 2009, pp. 61-65,76). In fact, this call for further empirical research could be easily extended to other under-researched topics about ERAs, including *adoption/assimilation* issues or *critical success factors*.

- Fifth, a plausible explanation for the scarcity of empirical studies on ERAs could be the tremendous difficulties to establish accurate quantitative metrics and indicators to evaluate the ERA's use and subsequently derived impacts. In truth, this still represents a recurrent issue in the current literature, representing thus, a clear open issue for further research (Cloutier et al., 2010, p. 25). Possibly, the own structural complexity inherent to ERAs, or even the disparity of potential benefits that may provide an ERA when adequately used by several users or stakeholders can be factors hindering the definition of such accurate indicators. Moreover, the fact that EA benefits tend to be of indirect nature – i.e., taking some time from the initiation of the EA work to effective realisation of the expected benefit from this work (Foorthuis et al., 2016; Iyamu, 2019; Niemi & Pekkola, 2019) – may further difficult the establishment of adequate quality metrics.

  To alleviate this, we believe that MMs can play an interesting role here as measurement instruments. Given their structural characteristics, MMs may represent an opportunity for defining measurement mechanisms incorporating a temporal-evolutive perspective integrating different metrics/indicators associated to different areas/aspects characterising a determined application domain. In particular, *focus area MMs* can suit well for these purposes since they allow a much more fine-grained measurement approach than more traditional MMs.

- *Sixth,* and as introduced above, a relatively important number of contributions argue on the different potential value that can be achieved from an appropiate use of ERAs by different users/stakeholders – see for example (Cloutier et al., 2010; Gump et al., 2018; Lankhorst, 2014; Paradkar, 2018) –. Besides being a fragmented corpus of knowledge (i.e., multiple heterogeneous information sources referring to different value/benefits), claims and assertions in this sense are usually made grounding on mere suggestions or the personal appreciation of the information source's authors. Contributions that form part of this corpus of knowledge tend to include an enumeration of diverse use situations in which ERAs could be potentially valuable for different users, but unfortunately, provide little practical advice/guidance/information on how they have to proceed to effectively realize such ERA's potential value.

  Over the last years, more elaborated contributions trying to harmonize the (in some way) rather isolated referred corpus of knowledge into more or less systematic frameworks have appeared (Kotusev, 2019;

Kurnia et al., 2020; Niemi & Pekkola, 2017; Timm, 2018). These frameworks tend to provide more detailed levels of conciseness, additional information about the use situations analysed, and clearer traceability about the (i) the EA artefact related (i.e., to be used) in the use scenario described, (ii) the potential value/benefit that could be achieved from its use, and (iii) the involved stakeholders in the use situations described. Unfortunately, and despite these frameworks have different *scale* – number of use situations considered –, *scope* –concrete artefact or group of artefacts taken as a reference for the analysis – and *conciseness* – detail and quality of the information provided – none of them provides a complete list of typical use scenarios suitable for ERAs, nor specifically particularized for HE-oriented contexts.

All in all, this finding is consistent with existing claims found in the literature about the relative immaturity of EA application scenarios in practice, which in turn, may present differences depending on the industry or sector analysed or being investigated (Aier et al., 2008, p. 15; Bucher et al., 2006; Kudryavtsev et al., 2018, p. 83). Despite that, it must be acknowledged that latter referred contributions directed towards developing more systematic frameworks have contributed to partially alleviate this drawback, and may constitute a good starting point for developing more elaborated contributions. For example, the works and contributions by (Timm, 2018) or (Greefhorst et al., 2013) – which are exclusively framed to the scope of use situations related with RMs and architecture principles – could play an interesting role for new developments related with the study of ERAs usage, since both them describe insights on use situations related with the two essential core components of an ERA.

- *Seventh*, it can be affirmed that, nowadays, there is a considerable number of different, comprehensive, and well-grounded instances of HEI-oriented ERAs. In this sense, the current situations differ significantly from that of five years ago: over the last quinquennial (2014-2019), there have been lots of efforts towards the development of new proposals of these architectures or, alternatively, to release new extended versions of already existing ones.

  On the one hand, there is a group of instances promoted by different governments as part of their respective national eGovernance initiatives. These programs are usually launched by national/regional governments (or similar institutions) aiming at fostering digital transformation process or at improving the IS/IT inter-operation levels between different administrations and/or agencies in their respective public sectors. In these cases, it is possible to argue the existence of a coercive isomorphic tendency in HEIs regarding the adoption, assimilation and usage of these top-down promoted HEI-oriented ERAs

  On the other hand, there is also another group of HEI-oriented ERAs that have been leveraged through rather bottom-up approaches. Such ERAs typically emerged as a result of collaborative standardisation process participated by different groups of parties and/or stakeholders with interests in the HE arena (e.g., the CAUDIT, the RATL or the UCISA proposals). In these cases, it could be discussed the existence of mimetic (or even normative) behaviours in HEIs regarding the adoption/use of these instances of HEI-oriented ERAs (i.e., institutions and organisations tend to imitate what seems to be successful, since they do not want to stay behind the *pioneers)*.

Whatever the case, it can be concluded that the study on the adoption, assimilation and use of HEI-oriented ERAs grounding on isomorphism theories (DiMaggio & Powell, 1983; Powell & Colyvas, 2008; Powell & DiMaggio, 1991; Scott, 2013) seems to be a promising line for future research.

3.3. Towards a New Artefact Framework for Facilitating the Use and Application of HEI-oriented ERAs

Drawing on the previous diagnosis, it can be concluded that there is plenty of room for additional research devoted to address the problem of the inefficient practical use and application of ERAs by different stakeholders (i.e., users of the architecture), and more specifically, on their use in rather HE-related contexts. To that end, in this thesis we particularly put the focus on the development of an instrument (i.e., a framework artefact) for facilitating EA practitioners all the process related with the use and application of such abstract architectures. We expect that this new framework would be primarily useful to practitioners working in the HE arena by providing them utility for the following purposes:

O1. To foster the awareness, understanding and acceptance of HEI-oriented ERAs.
O2. To provide a common and simple template with the knowledge required during the process of ERAs usage.
O3. To serve as actionable instrument to empower the autonomy of EA practitioners in HE-oriented contexts.
O4. To be a complementary EA support tool to the current toolbox of methods, frameworks and artefacts actually used by practitioners in HE-oriented contexts.

3.3.1. Motivating the Need for a New Artefact Framework

The need for the previously envisioned framework emerges from the overall general lack of practical-oriented knowledge on the use and application of ERAs. On the one hand, and despite several existing documental sources seem to converge in pointing out the potential benefits that can be derived from the identification, documentation and use of ERAs, collectively, they constitute a rather scattered and poor corpus of knowledge. On the other hand, these sources neither provide conclusive evidence to corroborate the proclaimed value claims regarding ERAs usage, nor practical insights or guidelines on how to act to effectively realise these (potential) value. In general terms, both facts can be considered as a consequence of the lack of empirical studies devoted to such architectures.

Under this background, and in line with similar studies in the EA field during the last years, it seems adequate to pose the construction of some kind of generalized and systematic instrument framework consolidating, integrating and homogenizing the rather scattered knowledge existing to date. For instance, the envisioned framework should clearly document all key characteristics and aspects relevant for an appropriate use and application of ERAs. In particular, it should include (i) a clear enumeration of the different (and most common) use situations or application scenarios [37] suitable for being addressed with an ERA, (ii) the main typologies of users/practitioners/stakeholders involved in the USs covered, and (iii) the potential benefits that could be derived from the particular use of the architecture in each situation. Besides, and assuming that ERAs can characterised as domain-specific artefacts (Cloutier et al., 2010, pp. 23–25; ten Harmsen van der Beek et al.,

[37] Literature refers indistinctly to "*use situations*", "*application scenarios*", "*uses in practice*" and several other analogous expressions to denote how an EA artefact is used in practice. For simplicity purposes, the term use scenario (US) will be used in the remaining of the thesis.

2012, p. 98), and the fact that their practical usage or application may vary from industry to industry (Aier et al., 2008, p. 15; Kudryavtsev et al., 2018, p. 83); the instrument framework to be developed in this research will be focused on the use of ERAs in the concrete target application domain of HE.

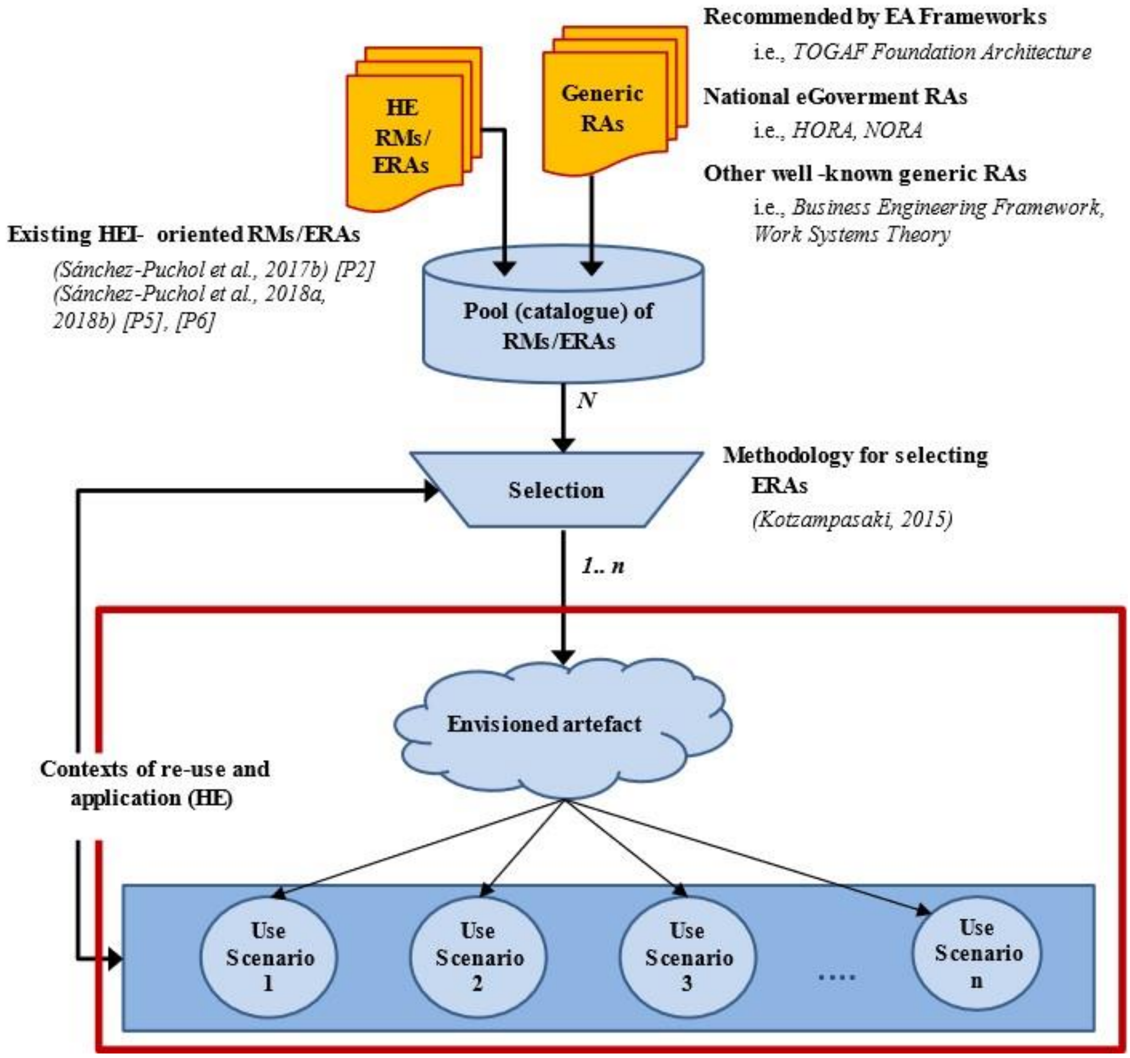

Figure 15 – Schema of the Envisioned Instrument Framework

Source: Own elaboration

It should be remarked here, however, that the purpose of the envisioned artefact is not to prescribe mechanical methods (for example, a sequential procedure of normative steps devoted to guide the transformation of an ERA into a concrete solution EA) to be strictly followed by practitioners. In contrast, the artefact is aimed to shed light on the multiple different USs in which it could make sense to put in practice these generic architectures by describing them and by providing basic and generic practical guidelines or recommendations on how they should be used in each US identified.

To conclude, the envisaged instrument framework should not be seen as an independent or isolated artefact. On the contrary, it should be viewed as a complementary practical tool for working together with the current set of EA tools, products and/or practices currently being used by EA practitioners in their respective particular settlements. In a similar way, it should be view as an “interlinked” artefact with prior existing prescriptive knowledge, and, in particular, (i) with existing knowledge on how to build and construct ERAs (earlier referred works leaded by Timm), and (ii) with the selection methodology for ERAs proposed by (Kotzampasaki, 2015), which enables the identification of a suitable ERA (or group of ERAs) relevant for being used in different USs given a determined context or area of interest – for example HE, as depicted in previous Figure 15 –.

Summing up, the artefact framework to be constructed arises as a plausible response to the general problem of insufficient understanding and ineffective practical usage of EA artefacts, as posed at the initial chapter of this thesis (Banaeianjahromi & Smolander, 2019, pp. 886–893; Dang & Pekkola, 2017, pp. 185–190; Kotusev, 2019; Niemi & Pekkola, 2017). In fact, the problem could be viewed even messier in the specific case of HEI-oriented ERAs, since these EA artefacts still remain largely unused by practitioners due to their lack of awareness on their existence as well as their low level of acceptance in the HE spheres. Notwithstanding that, the envisioned framework should not be viewed as something like a *silver bullet* or a "*universal answer*" to the problem at hand, but rather as soothing like a "*satisfactory solution*" for the problem, in terms of Simon's (1969, 1996) terminology. Hence, the artefact must be considered as provisional knowledge representing a first step on the road to further developments devoted to create new, more tailored and powerful tools/artefacts to accelerate the use of EA artefacts in HEIs, which in turn, would probably lead to improved success ratios of EA initiatives undertaken in these organisations.

3.3.2. Relevance and Novelty of the New Envisioned Artefact Framework

It is acknowledged that DSR-oriented research aims to create new knowledge in the form of artefacts to solve relevant practical problems (Hevner et al., 2004; Hevner & Chatterjee, 2010). Nonetheless, DSR does not aim to address a particular or determined problem, but rather more general "*class of problems*" to which the identified particular/specific research problem belongs to (Gregor & Hevner, 2013, p. 349). Dresch et al. (as cited in Veit et al., 2017, p. 299) refer to the concept of "*class of problem*" as "*the organisation of a set of problems, of practical or theoretical nature, containing artefacts, evaluated or not, useful for action in organisations*". In this sense, and despite both the problem and the respective associated artefacts constructed to face the problem "*are always unique in their context, both [them](…) may share common characteristics that allow an organisation within the class of problems, which enables generalization and the advancement of knowledge in the area*" (Veit et al., 2017, p. 299).

If we circumscribe the above rationale to the specific targeted application scope of the present research, the practical problem to be addressed – i.e., *the lack of understanding and use/application of HEI-oriented ERAs* – can be seen as a "sub-class" of problem belonging to the more generic "*class of problem*" related with the *inadequate understanding of EA artefacts and their practical usage*, whose relevance has already been reported and documented in the existing EA literature (Aier et al., 2008, p. 15; Kotusev, 2019, p. 3; Kotusev et al., 2015; Kudryavtsev et al., 2018, p. 83; Niemi & Pekkola, 2017). Since the practical relevance of the problem to be addressed in this research has already been discussed in Section 1.2, we will no further elaborate on it here.

The second aspect related with DSR-initiatives considered in the introductory paragraph of this section refers to the *novelty* of the artefacts constructed with the aim of providing "*answers*" to the desired problem to be addressed. In a DSR context, the condition of *novelty* of artefacts should not only be strictly understood in terms of a radical change or innovation, since "*in many cases, the new design research contribution is an* *important extension of an existing artefact or the application of an existing artefact in a new application domain*" (Gregor & Hevner, 2013, p. 343).

As shown in earlier sections of this chapter, during the efforts undertaken to generate a KB for this research we were not able to detect the existence of any artefact providing "*satisfactory answers*" to the problem being investigated here. Nonetheless, we were able to identify a series of existing artefacts and frameworks that might be viewed as relevant for giving answer to *relatively similar* problems than the one faced in this research. For instance, and to conveniently justify the *novelty* of our envisioned instrument framework, existing similar artefacts should be investigated and scrutinized first in more detail to detect their main deficiencies, weaknesses or drawbacks hindering their ability to provide "*satisfactory answers*" to the researched problem in the present thesis.

3.3.3. Uncovering Similar Existing Artefacts

A total of 8 artefacts with similar attributed purposes to the one to be conceived in this research were identified. In the successive sections, we proceed to briefly describe the most relevant features and details of each one of them [38].

3.3.3.1. Catalogue of Application Scenarios for Enterprise Architecture Models

(Bucher et al., 2006) state that, when populated with artefact dependency data, EA models can constitute the foundation of a variety of application scenarios. To gain a basic idea of their possibilities of use and application, Bucher and colleagues conducted a theoretical review to identify and collect the application scenarios considered in the literature. As a result, they provide a catalogue enumerating 15 different scenarios of use for EA models, including a brief (and rather poorly-detailed) description of them. In their catalogue, the authors did not give concrete details on which particular(s)s EA model(s) can be specifically associated to each one of the scenarios identified, although they alert that "*some application scenarios refer only to a single EA layer, while others refer to all EA layers, from strategy to technical infrastructure*" (Bucher et al., 2006, p. 31).

Table 11 – Application Scenarios of Enterprise Architecture Models

APPLICATION SCENARIOS	DESCRIPTION
IT Business Alignment	Given its hierarchical, multilayer structure, EA models are an ideal foundation to the application of IT in an appropriate and timely way, in harmony with business strategies, goals, and needs.
Business Continuity Planning	EA models may help to identify multistage cross-layer dependencies (i.e., dependencies between products, business processes, applications, and IT infrastructure elements).
Security Management	EA models can support the definition of access rights by documenting which roles need read and/or write access to sensitive data objects while participating in the execution of certain business processes.
Technology Risk Management	EA model can play a role for knowing which technology platform supports certain business processes.
Project Portfolio Planning	In terms of a project portfolio, EA models can be used to depict the benefits and risks of certain projects related to other projects, to products, to processes, to applications, etc. Thus, an EA model helps to analyse a project's contribution to strategy implementation and possible project conflicts.

[38] For clarity purposes, the original terminology and nomenclature used by different authors to refer either their respective conceived artefacts or to the different USs described by their contribution will be respected during this section contents.

APPLICATION SCENARIOS	DESCRIPTION
Project Initialization	EA models can help to specify project's scope and to avoid redundant development activities.
Business Process Optimization	Business process optimization initiatives can also benefit from EA as well. Since EA models usually depict high-level business processes and their relations to applications, information objects, etc., duplicate processes and/or processes without proper information system support can be detected
Quality Management	EA models provide proper documentation of processes, roles, organisational entities, and their interrelationships (e.g., process ownership).
Compliance Management	The same applies to compliance management, where EA models can help to verify compliance with legal requirements as well as voluntary codes.
Post-Merger Integration (dependency con GAP analysis)	EA can also provide guidance for post-merger integration when processes, organisational structures, applications, IT systems, etc. need to be unified and/or consolidated. Here, the comparison of two EA models provides valuable help for the identification of similarities, differences, overlaps and gaps.
Adoption of commercial off-the-shelf software	EA helps to define the project scope and to identify possible gaps of a certain COTS product as, well as its relevant technical and organisational interfaces.
Sourcing Decisions	Sourcing decisions are of growing importance for a company' s competitiveness. EA models support the decision-making process by depicting critical dependencies of the elements considered to be in-or outsourced (business processes, applications).
IT Service Management	EA provides fundamental information for IT service management, (i.e., relations between products, business processes, applications, and software components). Dedicated IT service management tools can link this information to real-time performance data. Thus, in case of a system component failure, impacts on strategically important business processes and products can be identified.
Management of IT Operations Costs	EA can help to eliminate redundancies, to allocate IT resources appropriately and to establish sophisticated and transparent billing schemes.
IT Consolidation	Last but not least, IT consolidation initiatives use EA models to reveal costly multi-platform strategies and wasted IT resources originating from personal preferences of certain stakeholders and / or a lack of enterprise-wide coordination.

Source: Adapted from (Bucher et al., 2006, pp. 31–32)

3.3.3.2. Model of Enterprise Architecture Standards Use for Information Technology Resource Shared Management

(Boh & Yellin, 2006) investigated the effectiveness of using EA standards to improve IT shared management. To this end, they constructed a theoretical model relating the potential benefits (outcomes) of using EA standards to manage 4 different types of IT resources, namely Physical IT Infrastructure, IT and human infrastructure, business applications and data. Their model hypothesizes that, among others, the use of EA standards for managing IT resources would lead to different organisational benefits, including improved levels of data and application integration, reduced heterogeneity of the physical IT Infrastructure, and reduced replication of human IT infrastructure services.

To test their hypothesis, Boh and Yellin conducted a cross-sectional firm-level survey considering both companies working and not working with EA standards. Grounding on responses from 112 companies, the authors found a significant positive effect between the use of EA standards and effective IT resource shared management.

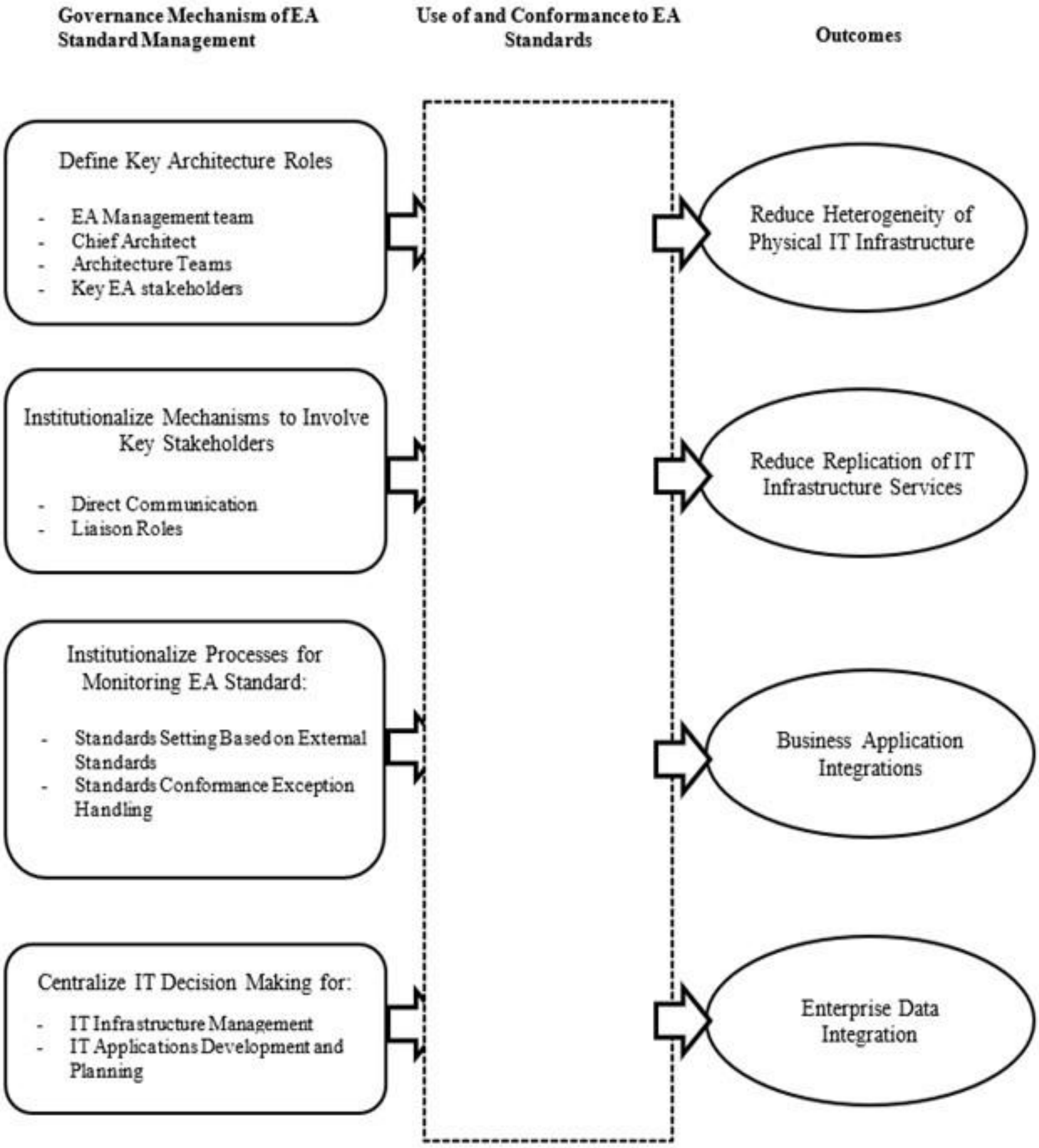

Figure 16 – Model of Enterprise Architecture Standards Use for Information Technology Resource Shared Management

Source: Adapted from **(Boh & Yellin, 2006)**

3.3.3.3. Classification of Enterprise Architecture Use Scenarios in Practice

(Aier et al., 2008) developed a classification of EA scenarios in practice. The authors characterised the concept of EA scenario as the representation of different combinations of EA contexts and different possible EA project types in such contexts. Grounding on data collected from organisations practicing EA in different industries, they based their classification on a combination of determining factors (related with the EA practice) into statistically relevant clusters. Clusters emerged from 3 main determining group-factors of EA, namely *adoption of advanced architectural design paradigms and modelling capabilities*, (ii) *deployment, monitoring of EA data and services* and (iii) *organisational penetration of EA*.

Their resulting classification revealed the existence of 3 main essential and generic EA scenarios in practice (i.e., clusters), – *EA initiators*, *EA Engineers* and *IT Architects* – offering very basic insights on how to approach EA in practice. In addition, their resulting framework neither provides clear traceability at the particular scope of EA artefact level, since the combination of group-factors used for defining the uncovered clusters addresses the construct of EA artefact as an aggregate concept (i.e., a global collection of artefacts).

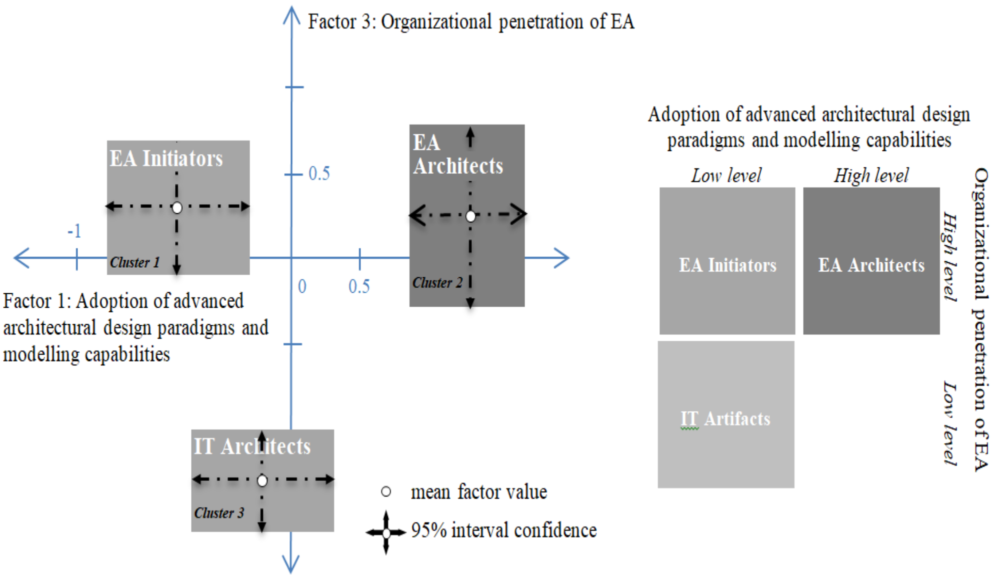

Figure 17 – Classification of Enterprise Architecture Scenarios in Practice

Source: Adapted from (Aier et al., 2008)

3.3.3.4. Catalogue of Uses in Practice of Enterprise Architecture Principles

To gain better understanding on the state-of-practice of EA principles in the Nederland's, the Architecture Principles Working Group of the *Netherlands Architecture Forum* surveyed the Dutch's EA community on the practical application and perceived value of this particular type of EA artefacts (Greefhorst et al., 2013). The survey allowed the authors to portray the state of affairs on EA principles in Netherlands on the basis of 4 main groups of parameters, (i) the *aspects documented when specifying the principles*, (ii) the *main stakeholders involved in their definition*, (iii) the *most common usages given to them in practice*, and (iv) the *perceived value associated to their practical use*.

As a result, a large catalogue collecting a wide spectrum of uses in practice of EA principles pointed out by the survey's respondents emerged. Unfortunately, the results achieved were not detailed enough to provide details on the direct correspondence among each one of use situations described and their (correspondent) value perceived by stakeholders when using EA principles in such a determined use situation.

Table 12 – Catalogue of Uses in Practice of Enterprise Architecture Principles

ASPECT TO BE DOCUMENTED	DRIVER	INVOLVED STAKEHOLDERS	USAGE	ADVANTATGES
• Statement • Rationale • Implications • Alternatives • Name • Actions • Definitions of concepts • Compliance assessment • Visualization • Current practice • Desired practice • Examples of current practices • Obstacles • Implementation guidance • Open issues • Assumptions • Solutions that are available • Person that is accountable • Person that maintains • External sources used • Importance/priority • Related principles	• Goals and objectives • Values • Issues • EA design Issues • Risks • Potential rewards • Constraints • Observed impacts	• Board of directors • Senior management (direct reports to board of directors) • Second-level management (direct reports to senior management) • Business managers • Business transformation employees (i.e., business analysts) • Business operations employees • IT Managers • IT design and transformation employees (i.e., functional designers & developers) • IT operation employees • Other	**INSIDE THE EA FUNCTION** • Support strategic decision-making • Support tactical decision-making (including architectural design decisions) • Support operational decision making (including design decisions) • Specify architectural contracts and/or project start architectures • Determine system requirements • Compliance testing • Transfer knowledge • Support portfolio management • Stimulate discussion • Capability-based planning • Other areas outside EA (strategic planning, policy making, design, business operations **OUTSIDE THE EA FUNCTION** • Application portfolio management • Purchase management • Security • Data exchange • Tax and legal decisions • Organisational context of application development • Corporate values	• Generate discussion during their definition • Support decision-making • Raising awareness • Clarity on issues where people had different opinions • Alignment of strategic goals with design of business and IT • Understanding of EA • One common way of validating EAs and business cases • Cost reduction and knowing why • Make explicit what is most important for the business • Make and end discussions • Simplification and insight • Discussing them is easy since they are high-level • Buy-in from all the various business domains on a consistent approach to strategic decision-making • The insight that all different parts of the organisation have a common mission and strategy • Providing clear boundaries for projects

Source: Adapted from (Greefhorst et al., 2013)

3.3.3.5. Framework of Enterprise Architecture Artefact Use Situations

(Niemi & Pekkola, 2017) developed a quite concise conceptual framework for describing use situations of EA artefacts. Their framework is inspired on the well-known IS success/use theory (Burton-Jones & Straub, 2006; DeLone & McLean, 1992), complemented with additional knowledge more specific to the EA discipline – namely, the EA grid framework for organizing EA by (Pulkkinen, 2006), the classification of EA stakeholder's roles by (Niemi, 2007), and the 4 roles of (software) RAs by (Smolander et al., 2008) –.

Table 13 – Framework of Enterprise Architecture Artefact's Use Situations

USE SITUATION	MOTI-VES	STAKEHOLDERS		EA ARTEFACTS			EA DEVELOP. PHASE
		PRIMARY	SECON-DARY	PRODUCT DOMAIN	PRODUCT LEVEL	SERVICE	
Create EA product	TS [a] /IM [b]	EA team, Project	N.A.	All	***All***	No	N.A./ Initiation
Provide support for architects	TS [a] /IM [b]	EA team (central)	EA team	All	***All***	Yes	N.A
Provide support for projects	IM [b]	EA team/ Consultant partner	Project	All	***All***	Yes	Initiation
Provide modelling support	TS [a] /IM [b]	Consultant partner	Project	All	Project	Yes	N.A./Initiation
Review project architecture	IM [b]	EA team (central)	Project	All	Project	Yes	All
Define and plan solution	IM [b]	Project	N.A.	All	***All***	No	Initiation/ Analysis
Design and implement solution	IM [b] /CM [c]	Project	N.A.	All	Project	No	Design/ Impl.
Execute solution acquisition	IM [b] /CM [c]	Project, Supplier	N.A.	All	Project	No	Analysis
Maintain solution	CM [c]	IT maintenance	N.A.	System, Technology	Project, Impl.	No	N.A.
Plan solutions update	IM [b] /CM [c]	Project	N.A.	All	EA, LoB, Project, Impl	No	Initiation
Support management	OP [d]	Mgmt./ EA team	Mgmt.	Business, System	EA	Yes	N.A.
Support strategic planning	OP [d]	Top mgmt./EA team	Top mgmt.	Business	EA	Yes	N.A.
Train and instruct	CM [c]	All	All	All	EA	Yes	N.A.
Present content	CM [c]	All	All	All	EA	No	N.A.
Take part in EA team meetings	CM [c]	EA team (central)	EA team (central)	N.A.	EA, **RA**, LoB	Yes	N.A.

LEGEND		
Motives		
[a] TS = Support target state decision making	[c] CM = Support communication	
[b] IM = Guide implementations;	[d] OP = Support other planning activities	
Stakeholders		
Primary stakeholder(s)	Those ones interacting with EA products and/or producing EA services *(e.g., architect, projects, IT organisation and management, IT maintenance, Consultant partner)*	
Secondary stakeholder(s)	Those ones acting as service recipients (i.e., vehicles for the creation and use of EA products), if applicable *(i.e., EA governance, management, maintenance, Consultant partners, Suppliers).*	
Product domain		
Business	System	All
Information	Technology	
Dev. phase (phase of the development project in which the EA artefacts are (mainly)		
Project initiation	Design	Testing
Analysis	Implementation	All
Example of description (Use Situation 8 – "Execute solutions acquisition")		
"*This use situation involves the use of EA products in the solution acquisition process. They were suggested to be used as background material, for providing potential suppliers an overview of the solution and its purpose. Project-level architecture was seen to be the most useful for this purpose*".		

Source: Adapted from (Niemi & Pekkola, 2017)

The framework is essentially composed by 9 core elements characterising EA artefact usage. Most of these elements are typified as multiple-value categorical fields, which facilitates the understanding of the whole framework. It also includes an additional textual field for describing in detail the use situation – see the bottom part of previous Table 13 –. In terms of EA artefact's scope level, the framework adopts a rather intermediate-level aggregation approach taking as a reference point for analysis typologies or groups of EA artefacts. Generic RAs – highlighted in bold in the previous table – is one of the EA artefact groups contemplated by the framework. Drawing on data collected from a large Finnish public sector organisation, the authors identified, categorized and described a total set of 15 different use situations for the different categories of EA artefacts fixed by the framework.

3.3.3.6. Application Design Framework for Reference Models

Adopting a similar approach than in the earlier contribution, but limiting the framework's scope to RMs, (Timm, 2018) conceived what he termed as an *Application Design Framework*. In his paper, Timm argues that the application (process) of a RM to a concrete determined domain "*is a context-dependent task [than] … requires an intensive knowledge transfer between the [model] constructor and its user"*(2018, p. 209). To overcome this problem, Timm constructed a framework to systematically document in what context a RM can be applied and what benefits it may offer to its users when adequately applied. Hence, the author argues that putting in practice his *Application Design Framework* when preparing and conducting a RM application process in a specific context would be a useful tool for a RM's successful application.

Table 14 – Application Design Framework for Reference Models

ASPECT	ITEM	LOGIC OF THE ASPECT	SUGGESTED VALUES
i) RM Specifics	RM Scope	What type of model is the RM?	Suggests the use of (Fettke & Loos, 2002) categorisation of RM's scope (e.g., elementary model, area model, company model)
	RM Perspective	Does the RM address behaviour or structure?	Suggests the use of (Fettke & Loos, 2002) categorisation of RM's views (e.g., behaviour | structure)
	RM Language	What modelling language is used?	Suggests the use of (Fettke & Loos, 2002) categorisation of RM's languages (e.g., natural language, semi-formal language, formal language)
ii) RM Reuse	Marketing	How can the RM be retrieved?	Typifies whether the RM is publicly accessible or not (cost issues not considered)
iii) RM Communication	Documentation	Addressed Problem, Intention, Context	Textually describes the addressed problem, Intention and Context
	Addressed Stakeholders	Who are addressed RM users?	Lists identified potential stakeholders (users) of the RM (e.g., financial institutes, IS Vendors, consultancy, auditing)
iv) RM Value	General Benefits	What benefits does the RM application offer (costs, quality, risk, time, competitive advantage)?	Details potential general benefits of a RM (e.g., ▼cost, ▲quality, ▼risk, ▼time, ▲competitive advantage)
	Model Specific Value	Are there RM specific values (e.g., EA specific benefits)?	Identifies other possible derived EA benefits
v) RM Application Scenarios	Description of Scenarios	Different scenarios should be discussed related to the model scope.	i) Construction of Specific Models ii) IS Development iii) Consultancy iv) Analysis v) Knowledge Transfer vi) Software Procurement vii) Migration Paths Support
	Dimensions of Application	Discuss breadth, detail, depth, volume or use of language of RM application	Textual description of how can be applied the RM in terms of the suggested dimensions, based on the particular context of application
vi) RM Adjustment Strategy	Compositional Adjustment Mechanisms	The RM should indicate in which cases composition may occur or give identified guidelines.	Descriptions of those areas or elements from the original RM have been deleted, changed or supplemented.
	Generic Adjustment Mechanisms	Depending on the RM Scope, the RM designer should define appropriate design principles (according to problem domain) which could be applied by the RM user	Suggests the use of (vom Brocke, 2007) categorisation of design principles for RM (i.e., aggregation, specialisation, instantiation, analogy)

Example of Application Scenarios for a financial-oriented RM (Regulatory Compliance Management)

#	APPLICATION SCENARIO	DESCRIPTION	STAKEHOLDERS	RELATED RM VALUE
(I)	GAP Analysis with Individual Models	RM user develops a specific model	Financial institutes	• Risk Mitigation • Regulatory Compliance Management quality improvement
(II)	Development of Compliance Software	RM as a development framework	IS Vendors	• Decrease of development time • Product quality improvement
(III)	Analysis of new regulations	RM as a consulting artefact	Financial institutes, IS Vendors, consultancy, auditing	• Decrease time of implementation • Improve integration quality
(IV)	Building a coherent Compliance RM	RM used to evaluate models	Financial institutes	• Cost and time reduction of Reference Compliance Organisation • Risk mitigation • Regulatory Compliance Management quality improvement
(V)	Personnel Training	RM as a means for training	Financial institutes, IS Vendors, consultancy, auditing	• Knowledge transfer • Risk mitigation

Source: Adapted from (Timm, 2018)

Timm conceived his framework drawing on existing theoretical literature on RMs, which allowed him to identify a total of 7 generic scenarios of use for RMs – aspect (v) in Table 14 –. To demonstrate the practical utility of the framework created, he exemplified its use for the case of a RM conceived for being re-used in the application domain context of regulatory compliance management within financial institutions – second part of earlier Table 14 –. A total set of 5 particular scenarios of use for the financial-oriented RM were identified, including a very detailed narrative describing how the application framework developed can be used in practice for the first particular scenario considered– i.e., *(I) Gap Analysis with Individual Models –.*

3.3.3.7. Systematic Description of Enterprise Architecture Artefact's Use

The contribution by (Kotusev, 2019) constitutes another systematic framework for analysing and describing how EA artefacts are used in practice. The framework was elaborated through an inductive approach grounding on evidence data captured form 22 international companies (from different industry sectors) practicing EA.

In terms of scope, the framework works at the level of specific EA artefacts. IT describes how 24 different EA artefacts are used in practice by means of 4 basic dimensions, namely the *artefact name, its informational contents, its main practical usage,* and *its main key purpose*. All these elements are typified as descriptive text fields within the framework. In this sense, and from a structural point of view, the resulting artefact is a quite simple. The following Table 15 presents an excerpt of the original framework proposed by (Kotusev, 2019) including data of several of the 24 EA artefacts considered.

Table 15 – Systematic Description of Enterprise Architecture Artefact's Uses

ARTEFACT	INFORMATIONAL CONTENTS	PRACTICAL USAGE	KEY PURPOSE
Roadmaps (also called investment roadmaps, capability roadmaps, application roadmaps and technology roadmaps)	Structured graphical views of all planned IT initiatives in specific business areas having direct business value).	Developed collectively by architects and senior business leaders, used to prioritize and schedule planned IT investments and updated periodically according to changes in strategic business priorities.	Achieve clear traceability between the business strategy and future IT investments.
Technology Reference Models (also called *technical reference models* and *technology reference architectures)*	Structured graphical representations of all technologies used in an organisation.	Created primarily by architects and subject-matter experts, used mostly to select appropriate technologies for new IT initiatives and periodically updated according to the changes in the technological environment.	Achieve better techno-logical consistency and reduce complexity of the IT landscape.
Principles *(*also called *maxims* and *drivers*)	Global high-level guidelines influencing all decision making and planning in an organisation.	Formulated collaboratively by architects and senior business leaders, used to assess the appropriateness of all other architectural decisions and periodically revised, often once a year.	Facilitate overall conceptual consistency between business and IT.
Business Capability Models *(*also called *business capability maps* and *capability reference models*)	Provide structured graphical representations of all organisational business capabilities, their relationship and hierarchy graphical representations of all organisational business capabilities, their relationship and hierarchy.	Developed collectively by architects and senior business leaders, used to focus future IT investments on the most important business capabilities and periodically "re-heatmapped" according to the changes in the business strategy.	Align strategic business goals with the priorities for IT investments and thereby improve strategic business and IT alignment
Guidelines *(*also called *simply standards*)	IT-specific implementation level prescriptions applicable in narrow technology-specific areas or domains.	Established by architects and relevant subject-matter experts, used to select appropriate implementation approaches for new IT initiatives and updated according to learned best practices and acquired experience with respective technologies and products.	Facilitate reuse of proven best practices and reduce general technical complexity of the IT landscape.
Landscape Diagrams *(*also called *simply* and *architectural repository, relational diagrams*, etc.)	Technical "boxes and arrows" schemes of different scopes and granularities describing the organisational IT landscape.	Created and owned predominantly by architects, used mostly to plan the implementation of new IT solutions and their integration into the current IT environment and periodically updated to reflect the evolution of the organisational IT landscape.	Help architects understand, analyse and modify the structure of the IT landscape.

ARTEFACT	INFORMATIONAL CONTENTS	PRACTICAL USAGE	KEY PURPOSE
Inventories *(*also called *asset registers* and *architectural repositories*)	Structured catalogues of currently available IT assets describing their essential properties and features.	Created and owned primarily by architects, utilized for reusing existing IT assets in new IT initiatives, decommissioning legacy IT assets and maintained current to accurately reflect the actual state of the IT landscape.	Achieve better control of the available IT assets, increase their reuse and ease the management of their lifecycles.
Patterns *(*also called *reference architectures*)	Generic reusable solutions to commonly occurring problems in the design of IT systems.	Established by architects and subject matter experts, used to select Standardised solution components for new IT solutions and periodically updated according to the changes in preferred implementation approaches.	Increase the reuse of proven "building blocks," reduce technical risks and heterogeneity of the IT landscape
IT Principles *(*also called *simply principles*)	Global high-level IT-specific guidelines influencing all IT related decisions and plans in an organisation.	Formulated by architects, used to assess the technical feasibility of all IT-related planning decisions and reviewed on a periodical basis, often yearly.	Promote the use of consistent approaches to IT and facilitate better conceptual homogeneity of IT-related decision making.
Target States (also called *target architectures, future state architectures* and *business reference architectures)*	High-level graphical descriptions of the desired long-term future state of an organisation.	Developed collectively by architects and senior business leaders, used to define long-term strategic goals for IT investments and periodically updated according to the changes in the business strategy, often on a yearly basis.	Enable strategic dialog business and IT and facilitate business and IT alignment in the long run
Enterprise System Portfolios *(*also called *application portfolios, application models,* etc.)	Structured high-level mappings of all essential IT systems to relevant business capabilities.	Created and owned by architects, used to rationalize the organisational IT landscape, manage the life cycle of major IT assets and updated periodically according to the changes in the landscape.	Control the duplication and reuse of IT assets; facilitate the analysis of the IT landscape and its overall.
Conceptual Data Models *(*also called *enterprise data models* and *information models)*	Abstract definitions of the main data entities critical for the business of an organisation and their relationship.	Developed collaboratively by architects and business leaders, used to align all new IT solutions to organisation-wide information requirements and periodically updated according to the changes in the business and its operations.	Achieve better global data consistency and uniform handling of information in all IT systems.
Logical Data Models *(*also called *logical information models, canonical data models* and *data schemas)*	Logical or even physical platform-specific definitions of the key data entities and their relationship.	Created and owned mostly by architects, used to select appropriate data structures for new IT initiatives and periodically revised according to the changes in business operations and their information requirements.	Achieve better logical data consistency and interoperability between different IT systems.

Source: Extracted from (Kotusev, 2019)

Nonetheless, the structural simplicity inherent to the framework also causes several trade-offs when analyzing other alternative structural characteristics. For example, if we consider the integrity of the contents included for the structural elements forming framework, the contents element "*practical usage*" explicitly include information related with the users (stakeholders) of each EA artefact. In other words, the framework does not present a "single" structural element for capturing, in a more isolated and accurate way, the particular information related with RM's users. On the other hand, and although the framework works at the scope of particular EA artefact level, it puts the focus on a wide number of different EA artefacts. Further, it also results somewhat limited in terms of depth, since it just provides few details on how an EA artefact could be used in practice. In this vein, the framework just explores one single potential use situation for each one of the 24 EA artefacts investigated.

Whatever the case, and despite the great number of EA artefacts addressed, the framework does not formally provide explicit support for ERAs. On the one hand, the framework contemplates specific typologies of RAs (i.e., *Technology Reference Architectures/Models*). On the other hand, it seems like that the framework associates or links RAs with *patterns,* considering both them as synonyms. Similarly, the framework seems to associate *Target States* to *Business Reference Architectures*. All in all, and collectively, it can be argued that the framework addresses in a rather independent way several use situations plausible for different EA artefacts that, together, could be viewed as typical component elements that (may) configure an ERA (e.g., *principles, inventories*, different types of *models*, etc.). This EA artefacts considered in the Kotusev's framework suitable to form part of an ERA have been highlighted in bold in previous Table 15.

3.3.3.8. Framework of Activity Areas Constituting the Enterprise Architecture Practice

Finally, and in a quite recent contribution, (Kurnia et al., 2020) proposed a framework for connecting and providing clarity on the relationship between (i) artefacts and activities constituting the EA practice, with the correspondent (ii) potential EA benefits derived from the artefact's usage, and (iii) the (possible) blockers hindering the effective realisation of such benefits.

To elaborate the framework, the authors used a rather inductive approach grounding on data gathered from interviews with EA practitioners representing different companies and industry sectors. As shown in the following Figure, the resulting framework is a quite simple proposal consisting of just 5 core structural elements, namely *(EA activity) areas, artefacts*, *(EA) activities*, *benefits and blockers*. In this case, the framework takes as a reference the concept of (EA) activity areas, which in turn, can be decomposed into several (inter-related) specific activities reflecting different aspects of the EA practice. Hence, "*each of these activity areas implies certain activities supported by some EA artefact ... leading to specific organisational benefits that are often impeded by some blockers*" (Kurnia et al., 2020, p. 5585).

As a consequence, the framework does not work at the particular scope level of EA artefacts since it has not enough explicative power to establish univocal relationships among EA activities (i.e., use situations) and particular EA artefacts. Furthermore, several of the activity areas described by the framework may be associated to different particular types of EA artefacts. Besides, and in line with the latest artefact discussed in the earlier section, some of the particular EA artefacts considered in an isolated way by the framework could be also considered as typical artefacts suitable of being part of an ERA. In the following Figure 18, which portrays the original framework proposed by (Kurnia et al., 2020), they have all been highlighted in bold.

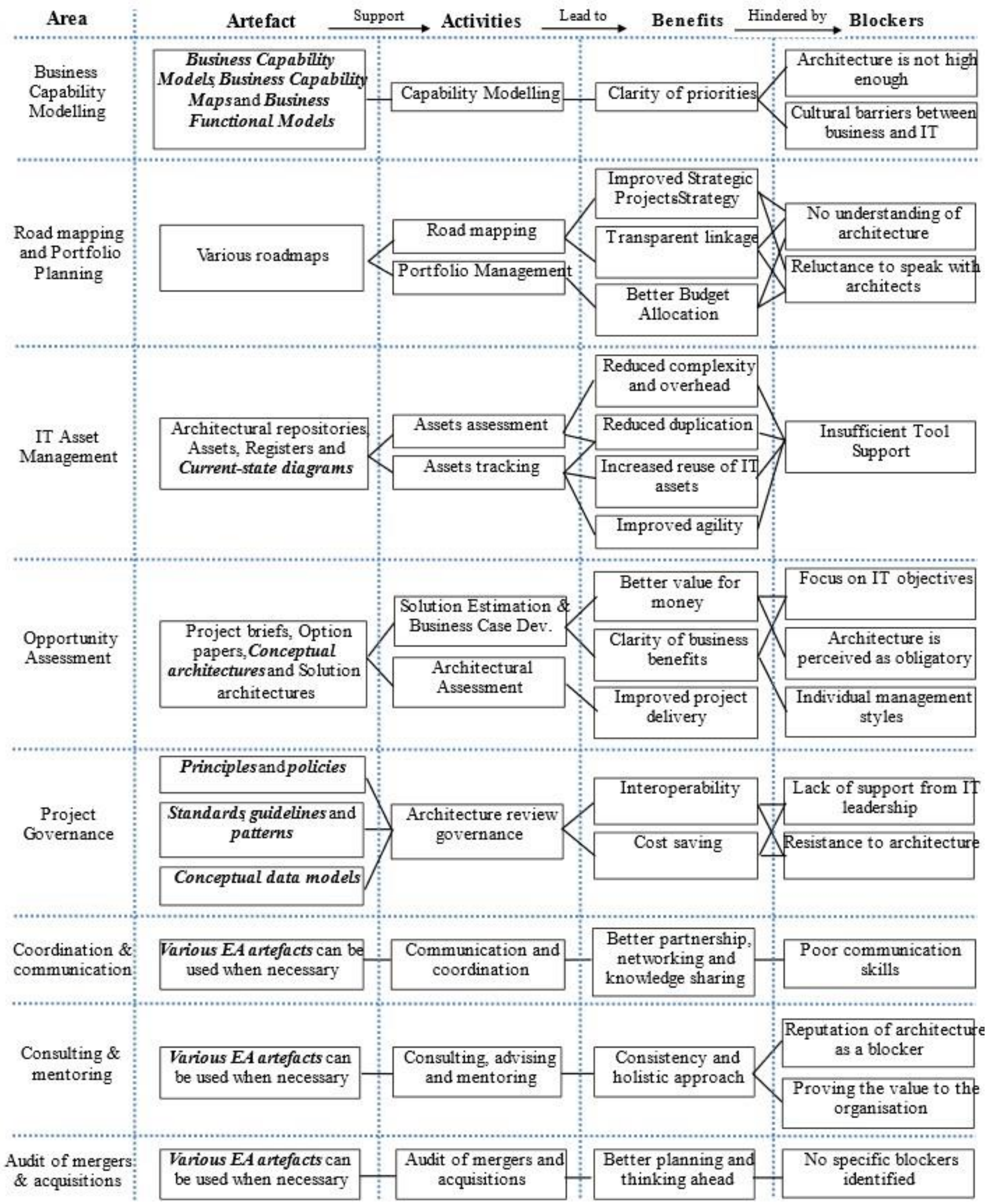

Figure 18 – Framework of Activity Areas Constituting Enterprise Architecture Practice

Source: Adapted from (Kurnia et al., 2020)

3.3.4. Confirming the Novelty of the Envisioned New Artefact Framework

The earlier set of described artefacts represents a variety of heterogeneous instruments that, collectively, and in some or another way, provide different alternatives for giving solutions to problems related with the usage of EA artefacts in practice. However, we conclude that none of them provides a "*satisficing answer*" (Simon, 1969, 1996) to the (sub)-class of problem to be addressed in this thesis – i.e., the *lack of understanding and use/application of HEI-oriented ERAs* – since none of them provides an adequate support (i.e., "*works well*") to sort out issues related with the use or application of such a particular type of EA artefact.

Table 16 provides a brief summary highlighting and comparing different aspects characterising each one of the investigated artefacts in terms of their appropriateness (adequateness) to provide responses to the practical problem faced in this thesis. As reflected in the contents included in the table, it can be argued that, in some or another way, all of them present several shortcomings/drawbacks that hinder their suitability to provide "*satisficing answers*" to our investigated research problem.

They main shortcomings identified during the previous analysis can be summarized as follows:

- None of the reviewed artefacts addresses the use of EA artefacts at the specific level scope of ERAs.
- Frameworks investigated take as a reference point different scope levels of EA artefact aggregation, ranging from artefacts adopting an individual EA artefact scope to others considering EA artefacts as "whole" (i.e., an aggregate collection of artefacts).
- Several of investigated frameworks do not provide clear traceability in terms of the relationship between the EA artefacts analysed, the USs considered, the potential benefits that could be derived from the application of the EA artefact in each one of the US described, and the users (stakeholders) involved in the USs considered.
- Finally, few of the investigated artefacts offer (detailed) descriptive information illustrating – from a practical point of view or perspective – how EA artefacts should be used by practitioners in each particular US described.

Summing up, the previous rationale brings to light the convenience of developing new instruments alleviating the shortcomings identified in already existing ones, hindering their appropriateness to provide "*satisficing answers*" to our research problem posed. For instance, contents of Table 16 provide the justificatory rationale for confirming the novelty of our envisioned instrument framework.

Notwithstanding that, it should be argued here that the analysis summarized in Table 16 also allows to detect interesting features included in the frameworks investigated which might represent an interesting or valuable "starting point" when thinking about the creation of new and more elaborated artefacts. We will take into account such "*uncovered knowledge*" later during the subsequent remaining research steps still to be conducted.

Table 16 – Synopsys of the Investigated Artefacts Addressing Enterprise Architecture Artefact's Use

REFERENCE	EA ARTEFACT SCOPE			CONTEXT OF THE RESEARCH	MAIN OBSERVATIONS AND CONSIDERATIONS
	EA artefact as a whole	Groups/classes of EA artefacts	Particular type of EA artefact		
(Bucher et al., 2006)			EA Models	Theoretical model	• Focus only in a single EA artefact, which may constitute or form part of an ERA. • Good level of USs considered, although few descriptive details are provided about them. • No specific details about the benefits to be achieved during the use/application scenarios considered.
(Boh & Yellin, 2006)			EA Standards	Theoretical model validated with data from a firm-level survey (112 responses of different companies)	• Focus only in a single EA artefact which may constitute or form part of an ERA. • Very limited number (4) of USs explicitly considered. • The relationship between the concrete benefits derived from using EA standards in each use/application scenario is clearly defined.
(Aier et al., 2008)	✓			Cluster analysis based on data from a questionnaire filled by EA experts from Germany & Switzerland	• Too high level of abstraction. Does not provide traceability at the level of particular EA artefacts. • Very limited number (3) of USs explicitly considered.
(Greefhorst et al., 2013)			EA Principles	Data from a survey to Dutch EA practitioners	• Focus only in a single EA artefact, which may constitute or form part of an ERA. • High number of USs considered, as well as potential benefits derived from the use of EA principles enumerated. • The relationship between the benefits derived of using EA principles in each US is not clearly detailed. • No descriptive details provided for the enumerated USs
(Niemi & Pekkola, 2017)		✓		Theoretical model based on an in-depth case study of a Finish public sector large organisation	• Taxonomy for segregating RAs somewhat lax and too-dependent of organisational issues (possible organisational bias derived from the case study to infer the resulting framework). • The concept of RA adopted by the framework seems to assimilate them to "*architectural guidelines*". • Very good level of USs considered, including detailed descriptions.
(Timm, 2018)			EA RMs	Theoretical framework derived from existing literature. Model validated with a real case study	• Focus only in a single EA artefact which may constitute or form part of an ERA. • Relatively limited number (7) of USs considered. • Provides only descriptive details for one of the USs defined.
(Kotusev, 2019)			24 different EA artefact	Framework based on data from 22 "mini-case studies of Australian, New Zealand and international organisations from different industry sectors practicing EA	• Too wide. Puts the focus on many different types of EA artefacts. • Treats in a disaggregated way those EA artefacts that might be encompassed (or form part of) an ERA. • High number of USs defined (but concerns may arise on their suitability for ERAs, given the broad number of different EA artefacts considered by the framework). • Only associates a unique "key" practical usage/purpose to each particular EA artefact.
(Kurnia et al., 2020)		✓		Framework based on data from interviews to 5-year experienced EA practitioners representing different companies and industries	• Segregation or classification of EA artefacts not mutually exclusive (i.e., includes categories as "*other types of artefact*"). • Contemplates several single EA artefacts which may constitute or form part of an ERA. • Does not provide full/complete traceability at the level of particular EA artefact. • Moderated number of USs considered.

Source: Own elaboration

3.4. Defining Requirements for the New Artefact Framework

Once consolidated the KB of the research domain, justified the relevance of the problem to be addressed and the novelty of the envisioned artefact directed towards providing "*satisficing answers*" to the defined problem, it is time now to advance to the next stage of the DSRM methodology: *define requirements*. Naturally, the main goal of this stage of the DSRM methodology is to make explicit the requirements that will shape the form and function of the envisioned solution artefact.

Although several definitions have been proposed for the concept of requirement (Ryan et al., 2015), at its simplest a requirement can be understood as "*something that governs what, how well, and under what conditions a product [i.e., an artefact] will achieve a given purpose*" (Electronic Industries Association, 1999, p. 67). Requirements elicited in this stage of the research process should be taken into account later, during the artefact's construction process, and should be grounded on existing knowledge in a given research field (Hevner, 2007; Lawrence et al., 2010, p. 115; Peffers et al., 2007). Hence, the final set of requirements determined at this point of the research should allow an "*understanding of the goals that can be achieved with its help as well as accepted assumptions and existing limitations*" (Kudryavtsev et al., 2018, p. 80).

Following existing recommendations on requirement determination considered by foundational literature on DSR (Hevner, 2007; Hevner et al., 2004), we relied on both theoretical as well as rather practice–oriented documental information sources to define them. In particular, the following sources were used:

a) References uncovered during the initial scoping review of the research (section 1.2) and during the literature review processes performed to build a consolidated KB (sections 3.2.1 and 3.2.2). References collected when conducting the previous activities include theoretical pieces but also more practitioner's-oriented literature capturing information and details about how the EA practice is conducted in real settings. In this sense, practitioner's-oriented pieces with a specific focus in HE (or in the public sector) have been prioritized during the requirement's elicitation process (see following paragraphs).

b) An explorative case study conducted on the use of a HEI-oriented ERAs at the particular context of a Catalan IS/IT service provider firm. The details and findings from this practical experience can be found in publication [P11]. This case study complements the above referred practitioner's-oriented knowledge about EA practices in a twofold way:

    i) First, the study allowed us to incorporate knowledge capturing the idiosyncrasy of current local (Catalan) practice of EA in HE-oriented contexts.

    ii) Second, the study allowed us to capture knowledge about the use of HEI-oriented ERAs from the perspective of a third-party HEI's external stakeholder. HEI's external stakeholders may have no deep EA-expertise, but can also be interested in using ERAs to take advantage of the potential value that they can offer. Such rather perspective on the use of EA artefacts by HEI's external providers is rarely documented in the existing literature.

c) Knowledge acquired during the analysis and evaluation of similar existing artefacts (section 3.3).

d) Theoretical literature on quality attributes and properties of EA artefacts and frameworks.

e) Theoretical literature on requirements (attributes) for artefacts developed through DSR-oriented approaches.

Literature addressing requirement's definition and elicitation reveals the existence of different approaches for typifying them (Braun et al., 2015; Drechsler, 2014a; Gehlert et al., 2009; Gill & Hevner, 2011; Helfert et al., 2012; Johannesson & Perjons, 2014, pp. 103–116; Pohl, 2010; Verschuren & Hartog, 2005). Typically, these approaches tend to differentiate between *functional requirements* (i.e., requirements specifying the behaviour (function) or features of determined system or artefact, and *non-functional requirements* (i.e., those ones describing the quality of the system or artefact's features).

For the purposes at hand, we used a combination of the proposals by (Johannesson & Perjons, 2014) and (Prat et al., 2015), which provide slightly extended taxonomies of requirement's typologies but tailored specifically for DSR-enabled artefacts. By adopting such approaches as a reference point, we were able to define a more complete set of requirements for shaping the form and function of our envisioned artefact framework.

The particular categories considered for typifying the requirements to be defined were as follows:

(i) *Functional* or *activity requirements.* Requirements concerning the behaviour or function of the artefact.
(ii) *Structural requirements*. Requirements concerning the structure of the artefact.
(iii) *Environmental requirements*. Requirements concerning the environmental qualities of the artefact.
(iv) *Goal requirements.* Requirements concerning the major goal or purpose for which the artefact is conceived.
(v) *Evolution requirements.* Requirements concerning the potential evolvement capacity of the artefact.

Grounding in all this background, we finally defined a set of 8 requirements – *Requirement [RE]* – for the artefact to be constructed. The information concretizing the characteristics of this set of requirements defined as well as providing transparency on how they have been defined is presented in the following tables.

On the one hand, Table 17 shows the identifying information for the requirements defined. The table details the requirement identifier, name, description and typology according to the earlier approach referred. It should be highlighted here that all the categories considered for typifying the requirements of our envisioned artefact have been covered by, at least, one of the requirements proposed for the envisioned artefact. Furthermore, since the typifying categories defined for the requirements are not mutually-exclusive, one particular requirement defined can be typified by several of the described categories.

On the other hand, Table 18 provides transparency in terms of the different documental sources from which each requirement has emerged or has been derived of. The contents of table have been segmented by grouping sources used to elicit requirements according to the breakdown presented at the beginning of this section. Note that, in most cases, each requirement proposed draws on both theoretical as well as practitioner's-oriented sources. To foster readers understanding, the documental source's title is also explicitly displayed in the table.

Table 17 – Requirements Defined for the New Envisioned Artefact Framework

#Id	Name	Requirement Description	Requirement Type				
			Goal	*Environmental*	*Structural*	*Activity*	*Evolution*
[RE.1]	**Particularity**	The degree or quality of an artefact to be tailored to a specific typology of object or item. The framework to be developed must be focused at the scope of ERAs.	■		■	■	
[RE.2]	**Understandability**	The degree to which an artefact can be understood by a user, both at a global level as well as at the more detailed level of the elements and relationships between elements characterising the artefact. The framework to be developed should be as most understandable as possible for the potential users of an ERA.		■	■		
[RE.3]	**Completeness**	The degree to which an artefact contains all necessary elements and relationships between elements required for addressing the problem for which it has been conceived The framework to be developed should be as most complete as possible.			■		
[RE.4]	**Consistence**	The degree of uniformity and freedom from conflicts or contradictions among the elements of an artefact. The artefact to be developed must be as consistent as possible, providing clear traceability between EA artefact USs, users (i.e., stakeholders) involved in the US, and the benefits derived from using an ERA in the US.			■	■	
[RE.5]	**Level of detail**	The degree to which an artefact provides both a holistic view and a sufficient level of detail in the relevant areas characterising the artefact. In particular, the artefact must consider the multiple possibilities of re-use of ERAs, and from the perspective of different potential HEI's stakeholders that may take advantage of using the ERA.			■	■	
[RE.6]	**Accessibility**	The degree to which an artefact is available without barriers to use (i.e., ideally open, free of charge and published in such a way that is easy to find and read). The framework to be developed should be totally accessible.		■			
[RE.7]	**Adaptability**	The degree of ease with which an artefact can be changed in order to correct defects, to meet new requirements or to make future maintenance easier. The framework to be developed should be as flexible as possible.		■			■
[RE.8]	**Usefulness**	The degree to which an artefact provides utility (value) for its users in order to achieve a certain goal. The framework to be developed should be as useful and applicable in practice as possible, aiming to facilitate the use and application in practice of HEI-oriented ERAs.	■				

Source: Own elaboration

Table 18 – Sources for Deriving the Desired Requirements for the New Artefact Framework

REFERENCE	INFORMATION SOURCE TITLE	[RE.1] *Particularity*	[RE.2] *Understandability*	[RE.3] *Completeness*	[RE.4] *Consistence*	[RE.5] *Level of detail*	[RE.6] *Accessibility*	[RE.7] *Adaptability*	[RE.8] *Usefulness*
Analysis of similar EA artefacts									
Section 3.3	Present report	■		■	■	■			■
Analysis of similar EA artefacts									
(Sanchez-Puchol et. al 2020)	Using Enterprise Reference Architectures: An Exploratory Case Study ….		■		■		■		■
EA practice in HE and the Public Sector									
(Joint Information Systems Committee, 2009)	Doing Enterprise Architecture: Enabling the agile institution	■	■			■			
(Greefhorst, 2015)	Succesfactoren voor referentie-architectuur	■			■	■	■	■	
(Olsen & Trelsgård, 2016)	Enterprise Architecture adoption challenges: An exploratory case study of …		■						■
(Dang & Pekkola, 2017)	Problems of Enterprise Architecture Adoption in the Public Sector: Root …		■						
(Kotusev, 2018)	TOGAF-based Enterprise Architecture Practice: An Exploratory Case Study		■			■		■	■
(Lethbridge & Alghamdi, 2019)	Framework, Model and Tool Use in Higher Education Enterprise Architecture …		■						
(Guo et al., 2019)	Understanding Challenges of Applying Enterprise Architecture in Public Sectors		■	■					■
Theory on quality of EA artefacts									
(Veltman-Van Reekum et al., 2006)	An Instrument for Measuring the Quality of Enterprise Architecture Products		■					■	
(Oderinde, 2010)	Using Enterprise Architecture (EA) as a Business-IT Strategy Alignment for …	■							
(Kotusev et al., 2015)	Investigating the Usage of Enterprise Architecture Artefacts		■			■			■
(Timm, Hacks, et al., 2017)	Towards a Quality Framework for Enterprise Architecture Models		■	■		■		■	
(Sanchez-Puchol et al., 2018)	First In-depth Analysis of Enterprise Architectures and Models for Higher …	■	■	■		■	■		■
Theory on DSR artefacts									
(March & Smith, 1995)	Design and natural science research on information technology		■	■	■	■			
(Gill & Hevner, 2011)	A Fitness-Utility Model for Design Science Research						■	■	■
(Drechsler, 2014a)	Extending the Fitness-Utility Model for Management Artefacts in IS Design …						■	■	■
(Johannesson & Perjons, 2014)	An Introduction to Design Science – Define Requirements		■	■	■		■	■	■
(Prat et al., 2015)	A Taxonomy of Evaluation Methods for Information Systems Artefacts		■	■	■			■	

Source: Own elaboration

Finally, and to conclude this section, we performed a comparison analysis between the earlier uncovered investigated existing artefacts in terms of the proposed requirements for the envisioned artefact framework. Given the heterogeneity of the artefacts to be compared, in order to be able to compare them in an effective way we had to proceed first with a "*normalisation*" process of the structural elements (as well as their inter-relationships) configuring each one of the artefacts.

Trying to be as more as rigorous as possible in this "*normalisation*" process, and inspired by already conducted comparison analysis of relatively similar artefacts found in the literature (Lahrmann & Marx, 2010; Patas et al., 2013), we fundamentally relied on two main support techniques: ontological meta-modelling and reciprocal translation analysis. On the one hand, ontological meta-modelling (Henderson-Sellers, 2012; Laarman & Kurtev, 2010), "*deals with the abstraction and classification of model components according to their content*" (Patas et al., 2013, p. 356). On the other hand, reciprocal translation analysis is a qualitative meta-ethnography oriented technique that supports the translation (merging) of similar themes or concepts into each other (Dixon-Woods et al., 2005, p. 48; Noblit & Hare, 1988). The "*normalisation*" process applied to the artefacts to be compared was as follows:

- On the one hand, we first tried to define a correspondence mapping between the elements of each artefact. This mapping was done in terms of homomorphism – i.e., establishing a direct correspondence between each construct of each artefacts compared, grounding on the similarity of the meaning of each structural element – (Prat et al., 2015, p. 256).
  For example, the construct "*Practical Usage*" of the (Kotusev, 2019)'s framework, was correlated with the constructs (elements) (i) "*Use Situation*" of the (Niemi & Pekkola, 2017) 's framework, (ii) "*Application Scenario*" of the (Bucher et al., 2006)'s catalogue, (iii) "*Activities*" of the (Kurnia et al., 2020)'s framework and (iv) "*Usage*" of the (Greefhorst et al., 2013) 's catalogue.
- On the other hand, we analysed individually each structural element of each artefact investigated to detect possible "*construct overload*" – i.e., the fact that content considered as part of one element in a determined artefact could be correlated with the content of 2 or more constructs of other artefacts –.
  For example, the construct "*Practical Usage*" of the (Kotusev, 2019)'s framework can be correlated with the constructs "*Primary Stakeholders*" and "*Secondary Stakeholders*" of the (Niemi & Pekkola, 2017) 's framework, since the content of the construct "*Practical Usage*" of the (Kotusev, 2019)'s framework includes explicit information relative to the stakeholders who create or use the EA artefact in practice.
- Finally, we used the well-known "*5 Whys*" technique to group all the previous "*normalized*" elements into a *baseline* or *reference point* for comparing all artefact frameworks (in terms of coverage) regarding the 5 aspects recommended by the technique used, namely *"what", "why", "how", "by whom" and "when"*.

The results of this "*normalisation*" process are shown in Table 19, which will surely help to better understand the described process. Each "*normalized*" element (horizontal rows) having a correspondence (i.e., addressed by) a particular framework (vertical rows) is marked on the table with a check symbol (✓). When at least one of the "*normalized*" elements forming part of the aspect being analysed is addressed by a determined framework, then it is considered that the framework effectively *covers* this facet. Hence it is marked with a black circle symbol (●) in the table.

Table 19 – Normalisation of the Structural Elements of the Existing Investigated Artefacts for Comparative Purposes

ASPECT	"*NORMALIZED*" ELEMENTS	*Catalogue of Application Scenarios for EA Models* (Bucher et al., 2006)	*Model of EA Standards Use for IT* (Boh & Yellin, 2006)	*Classification of EA Use Scenarios in practice* (Aier et al., 2008)	*Catalogue of Uses in Practice of EA Principles* (Greefhorst et al., 2013)	*Framework for EA Artefact Use Situations* (Niemi & Pekkola, 2017)	*Application Design Framework for RMs* (Timm, 2018)	*Systematic description of EA artefact' s use* (Kotusev, 2019)	*Classification of EA Activity Areas in Practice* (Kurnia et al., 2020)
What		●	●	●	●	●	●	●	●
	Artefact Details/Information contents	✓	✓	✓	✓ [(a)]	✓	✓	✓	✓
	Documentation information		✓		✓		✓	✓ [(d)]	
	Accessibility information						✓		
Why / For What		●	●	●	●	●	●	●	●
	Use Situation / Application Scenario / Practical Usage	✓	✓	✓	✓	✓	✓	✓	✓
	Motive/Benefit/Key Purpose/Value	✓	✓		✓	✓	✓	✓	✓
	Blockers								✓
How						●	●		●
	Descriptive details / exemplary case studies providing insights on the practical usage					✓	✓ [(c)]		✓
	Specific mechanisms or strategies for EA artefact usage in practice						✓		
By Whom					●	●	●	●	●
	Stakeholders involved in the artefact creation/development					✓		✓ [(e)]	
	Stakeholders involved in the artefact usage/application				✓	✓	✓	✓ [(e)]	✓ [(f)]
When						●			
	Development phase (in terms of an EA Project)					✓			
	Coverage level (total of ●)	2	2	2	3	5	4	3	4
	"Normalized" elements (total of ✓)	3	4	2	5	7	8	6	6
	Declared number of USs addressed	15	4	3	23[(b)]	16	7	24	11[(g)]

Legend

[(a)] The catalogue includes drivers that motivate EA principles.
[(b)] Computed both EA-oriented and non-EA oriented uses.
[(c)] Includes only one US described in detail.
[(d)] The framework element "*Informational contents"* includes rough details on how addressed EA artefacts are documented.
[(e)] The framework item "*Practical usage* "provides details on the stakeholders involved in both the creation/development and use/application of the EA artefact.
[(f)] Case descriptions of the EA "*Activity Areas*" (i.e., USs) documented by the artefact's framework provide basic information about stakeholders.
[(g)] 8 EA "Activity Areas" encompassing 11 EA basic "activities".

Source: Own elaboration

Finally, bottom-part of Table 19 displays aggregated information about all the artefact frameworks compared, including:

(i) The *coverage level of the artefact framework* in terms of the 5 aspects assessed – aggregate of (●) marks for each one of the table's columns –,
(ii) The total number of *"normalized" elements* addressed by each framework – aggregate of (✓) marks for each one of the table's columns –,
(iii) The total count of *USs* addressed by each framework (with independence of the particular EA artefact's level scope adopted by each artefact framework).

Once established the *baseline* for comparison, we finally evaluated the compliance level of all the investigated artefacts with the set of requirements [RE1-RE.8] proposed for our envisioned artefact. We excluded from this analysis requirement [RE.8] *Usefulness*, since not enough evidence was found in the documental sources of the investigated artefacts to perform such evaluation.

Also, for the assessment purposes of other requirements we explicitly drew on the following data presented in Table 19:

- The total number of *"normalized"* elements was used as one of the parameters taken into account for evaluating requirement [RE.2] *Understandability*.
- *Coverage level* was used as a parameter for evaluating requirement [RE.3] *Completeness*.
- The total number of *USs addressed* was used as a parameter for evaluating requirement [RE.5] *Level of detail.*

Finally, and for the remaining requirements defined, the evaluative analysis performed was grounded on the descriptive information relative to each one of the artefacts provided in precedent section 3.3.3.

The results achieved of the comparative analysis are shown in the following Table 20. Harvey Balls are used to represent the scores achieved by each artefact to facilitate reader's comprehension. Data provided in the table clearly shows "at a glance" the main weaknesses and strengths of each one of the investigated artefacts in terms of the elicited requirements requested for the desired artefact. In this sense, the analysis reveals that none of the compared artefacts provides a strong level of support [39] for each one of all the requirements desired for the new envisioned artefact.

For instance, the earlier finding provides additional and explicit evidence for further confirming our preliminary claim (section 3.3.4) arguing on the lack of availability of already existing artefacts providing "*satisfactory answers*" to the research problem faced in the thesis. Finally, and overall, the analysis conducted can be also viewed as an additional justification of the *novelty* of the envisioned artefact to be constructed.

In sum, and once concluded the activities directed towards accomplishing with the goals of the DSRM methodology stage centred on defining requirements for the desired envisioned artefact, it is possible now to advance to next phase of the methodology: *design and development*.

[39] Strong level of support refers to achieve high level scoring mark (either ◕ or ●) when evaluating one requirement.

Table 20 – Compliance of Existing Investigated Artefacts with the Requirements Proposed for the New Artefact Framework to be Constructed

#ID	Requirement [*]	*Catalogue of Application Scenarios for EA Models* (Bucher et al., 2006)	*Model of EA Standards Use for IT* (Boh & Yellin, 2006)	*Classification of EA Use Scenarios in practice* (Aier et al., 2008)	*Catalogue of Uses in Practice of EA Principles* (Greefhorst et al., 2013)	*Framework for EA Artefact Use Situations* (Niemi & Pekkola, 2017)	*Application Design Framework for RMs* (Timm, 2018)	*Systematic description of EA artefact' s use* (Kotusev, 2019)	*Classification of EA Activity Areas in Practice* (Kurnia et al., 2020)
		EXISTING SIMILAR ARTEFACTS							
[RE.1]	*Particularity*	◑	◕	◔	◕	◑	◕	◕	◑
[RE.2]	*Understandability*	◑	◑	◑	◑	◕	◕	◑	◕
[RE.3]	*Completeness*	◔	◔	◔	◑	●	◕	◑	◕
[RE.4]	*Consistence* [**]	◑	◕	◔	◑	●	●	●	●
[RE.5]	*Level of detail*	◕	◔	◔	●	◕	◑	●	◑
[RE.6]	*Accessibility*	●	●	●	●	●	●	●	●
[RE.7]	*Adaptability*	●	●	◑	●	◕	◕	●	●

[*] [RO.8] *Usefulness* not compared due to lack/insufficient information/evidence for evaluative purposes.

[**] Since frameworks by (Niemi & Pekkola, 2017) and (Kurnia et al., 2020) work at the scope level of classes or groups of EA artefacts, an "optimist" approach has been adopted considering the class or group of EA artefacts as the reference point for assessing the *consistence* of this framework. Besides, the framework by (Aier et al., 2008) – which works at the aggregate level scope of EA artefacts – *consistence* has been considered as unclear.

HARVEY BALLS VALUE DESCRIPTIONS

Particularity	◔ Focus on EA artefacts in general.	◑ Focus on groups of EA artefacts	◕ Focus on particular EA artefacts (including typical ones that may form part of an ERA).	● Focus on ERAs (as an independent/ aggregate artefact).
Understandability	◔ Low (1 Item)	◑ Medium (2 Items)	◕ High (3 Items)	● Very High (4 Items)
	ITEMS (1 POINT FOR EACH ITEM) • *Clear and uncomplicated language used (plain language / no abuse of technical EA-oriented jargon).* • *Includes typified categories (list of suitable values) for most of the elements configuring the artefact.* • *Provides descriptive details or exemplary case studies on the USs considered.* • *Simplicity of the artefact (less than 7 "normalized" elements).*			
Completeness	◔ <= 2 aspects covered	◑ 3 aspects covered	◕ 4 aspects covered	● 5 aspects covered
Consistence	◔ Unclear relationship or not specified/detailed ◑ Details relationship EA artefact ⟷ Use Scenario (US) ◕ Details relationship EA artefact ⟷ Use Scenario (US) ⟷ Benefits ● Details relationship EA artefact ⟷ Use Scenario (US) ⟷ Benefits ⟷ Stakeholders (users involved)			
Level of detail	◔ 1 to 6 scenarios considered	◑ 7 to 12 scenarios considered	◕ 13 to 18 scenarios considered	● >= 19 scenarios considered
Accessibility	◔ Barriers in terms of access and cost for use	◑ Barriers in terms of access for use	◕ Barriers in terms of cost for use	● No barriers for use
Flexibility	◔ Very hard to change or extend	◑ Hard to change or extend	◕ Easy to change or extend	● Very easy to change or extend

Source: Own elaboration

3.5. Design and Development the New Artefact Framework

The third stage of the DSRM methodology corresponds to the *design and development* activity, which is devoted to construct an artefact fulfilling the requirements defined in the previous step. According to the (Peffers et al., 2007, p. 55) "*a design research artefact can be any designed object in which a research contribution is embedded in the design. This activity includes determining the artefact's desired functionality and its architecture and then creating the actual artefact*". In this sense, meanwhile "*in some of the research […] the design and development activities are further subdivided into more discrete activities whereas other researchers focus more on the nature of the iterative search process*".

Unfortunately, little additional information is given by the Peffers and colleagues in their paper about how to conduct this activity. In fact, the existing DSR literature focussed on providing guidance on how to undertake the *design and development* activity is nearly inexistent. Several causes may justify this scarcity of generic guidance as for example the immensity of different artefacts suitable to be generated through a DSR-endeavour or even the own idiosyncrasy of this particular DSR activity, since (in some or another way) artefact creation inherently relies on "*the creativity, experience, intuition, and problem solving capabilities of the researchers*" (Baskerville et al., 2019; Hevner et al., 2004, p. 96).

Assuming this earlier background, and for the purposes of designing and developing the envisioned artefact framework of this research, we adapted the generic approach proposed by (Johannesson & Perjons, 2014, pp. 117–131) for conducting this particular DSR activity. Johannesson and Perjons consider that the *design and development* activity can be structured in 4 sub-activities – namely (i) *imagine and brainstorm*, (ii) *assess and select*, (iii) *sketch and build* and (iv) *justify and reflect* – which can be carried out in parallel or iteratively.

In the successive sections, we provide further details on how we performed these activities for the present research. Nonetheless, and for simplicity purposes, we finally integrated the first couple of sub-activities into a single one, which we labelled as "*generate, select and asses design alternatives*". As main inputs for conducting these sub-activities we used (i) the requirements defined for the artefact, (ii) the information derived from the comparative analysis of similar existing artefacts already conducted, and finally (and as a supplementary resource whenever needed) the (iii) existing uncovered knowledge on ERAs already consolidated into the generated KB for the research domain.

3.5.1. Generate, Select and Assess Design Alternatives

The main goal of this sub-activity is to generate and asses different plausible design alternatives for constructing the envisioned artefact framework to, subsequently, choose one (or more of them) as the most appropriate(s) for being the basis of the development strategy of the artefact framework to be constructed.

To generate a set of plausible design alternatives for constructing our artefact framework, we mainly relied on the descriptive information and the comparative analysis of existing similar artefacts already done. In this sense, and *a priori*, 3 generic and simple alternative design strategies could be considered for constructing the envisioned artefact framework:

(#1) Developing a completely new artefact from scratch.

(#2) Taking as a reference point one of the existing artefacts and update, enhance, evolve or convert it into a new one.

(#3) Combining the structure/content of several existing artefacts to construct a new artefact framework.

To choose the most adequate development strategy for our new envisioned artefact, we basically relied on information derived from the conducted comparative analysis of existing similar artefacts. In this sense, we rapidly discarded a design approach based on constructing a new artefact from scratch – i.e., design alternative (#1) – since (i) none of the artefacts investigated has been created through a systematic procedural or methodological approach, and (ii) some of the investigated artefacts achieved good scoring marks in some (but not all) of the requirements assessed. For instance, choosing a development design strategy based on building upon the combination of knowledge embedded in already existing artefacts – a *hybrid approach* mixing design alternatives (#2) and (#3) – seems to be quite more adequate.

In particular, a good approach seems to be the selection of one of the existing investigated artefacts as a baseline or starting point for the construction process, to subsequently enrich and complement it with structural components/elements and contexts included in other investigated artefacts. Obviously, the question arises to what artefact choose as a reference point for the construction.

Finally, we decided to take as a baseline for our artefact's construction process the *Application Design Framework for RMs* created by (Timm, 2018) since:

- On the one hand, this framework ranks quite well in terms of requirements [RE.3] *completeness* and [RE.4] *consistence*, as shown by the scoring grades in earlier Table 20.
- On the other hand**,** the framework also works relatively well in terms of requirement [RE.1] *particularity*, since it is devoted to RMs (one of the fundamental or core elements suitable of being part of an ERA).

Another alternative candidate for being considered as a baseline for our new envisioned artefact would have been the *Framework for EA Artefact Use Situations* by (Niemi & Pekkola, 2017). Despite it ranks slightly better in terms of the referred [RE.3] and [RE.4] than the *Application Design Framework for RMs* in previous Table 20, unfortunately it works at the scope level of groups or classes of EA artefacts. Such fact may complicate the accomplishment of requirement [RE.1] *particularity*. Further, the achievement of [RE.5] *level of detail* (i.e., providing transparency on the traceability of the relationship *EA artefact ⟷ Use Scenario ⟷ Benefits ⟷ Users* involved) might also be strongly compromised. Similar rationales could be considered when considering alternative artefacts – i.e., the *Systematic Description of EA Artefact's Use* by (Kotusev, 2019) or the *Classification of EA Activity Areas in Practice* by (Kurnia et al., 2020) – for being used as a starting base point in the construction process for our new envisioned artefact.

Summing up, taking as a baseline artefact for our construction process the *Application Design Framework for RMs* created by (Timm, 2018) seems consistent with the posed design alternative (2) – *taking as a reference one of the existing artefacts.* However, and when looking the information displayed in Table 20 relative to this artefact, a clear drawback seems to arose in terms of accomplishment with requirement [RE.5] *Level of detail*, since it represents the framework's worst rating mark for all the requirements assessed.

Hence, and to alleviate such deficiency, during the new artefact's construction process it could be worthwhile to consider additional knowledge. In other words, incorporating additional knowledge embedded in other alternative investigated artefacts into the "*shape and form*" of the artefact taken as a reference starting point for the construction process (the *Application Design Framework for RMs*) would probably allow us to build a new artefact achieving higher levels of compliance in terms of the requirement [RE.5] *Level of detail*. All this last rationale is rather consistent with the design alternative (3) – *combining the structure/content of several existing artefacts to construct a new artefact*.

Summarizing, by following a hybrid approximation combining design alternatives (2) and (3) during the new artefact's construction process, it would be possible to conceive a much more adequate and balanced [40] new artefact for facilitating the use and application of HEI-oriented ERAs in practice.

3.5.2. Sketch and Build

The overarching goal of this second sub-activity of the *design and development* DSRM stage is to explicitly build the envisaged artefact framework, in accordance with the earlier established set of requirements. In words of (Johannesson & Perjons, 2014, p. 123) this activity implies "*reusing and adapting parts from existing solutions, inventing new elements, and combining them in an innovative way*".

According to the hybrid development strategy adopted, the artefact chosen as a starting reference point for the construction process has been the *Application Design Framework for RM*. However, and before formally starting the construction process itself, there is a previous need to define a set of mechanisms to formalize and operationalize which changes and alterations can be made to the originally conceived artefact taken as a reference for the construction of the new envisioned artefact. To do so, we relied on existing literature on Method Engineering which can be defined as the "*the engineering discipline to design, construct and adapt methods, techniques and tools for the development of information systems*" (Brinkkemper, 1996, p. 276; Bucher et al., 2017, 2017; Offermann, Blom, Levina, et al., 2010; Sunyaev et al., 2009). The suitability and applicability of Method Engineering to the field of EA has been extensively discussed in existing literature (Buckl et al., 2011; Mayer et al., 2019; Riege & Aier, 2009; Ylimäkia & Halttunen, 2005).

Inspired by this background, and for the needs at hand, we developed a set of *transformation mechanisms* for being used during our construction process (see following Table 21). This *transformation mechanisms* were based (adapted) on *general adaptation mechanisms* [41] typically used in Method Engineering research endeavours (Becker et al., 2007; vom Brocke, 2007; Zivkovic et al., 2007). In addition, and assuming that our artefact to be developed could be viewed as an EA-oriented instrument (i.e., a tool for supporting EA practitioners), we also took as a reference (for constructing our *transformation mechanisms*) the set of *transformation operations for EA models* proposed by (Purao et al., 2011), as they "*build on the ontology of the artificial as a foundation, and allow explicit acknowledgement of the progression of EA models [i.e., how they are designed and used] in practice*" (2011, p. 389).

[40] In the sense of achieving a high score mark for all requirements [RE] desired for the new artefact framework

[41] Sometimes referred also as *design principles.*

Table 21 – Transformation Mechanisms Used for Developing the New Artefact Framework

<table>
<tr><th rowspan="2">NAME</th><th rowspan="2">DESCRIPTION</th><th rowspan="2">TYPE</th><th colspan="2">IMPACT ON THE STRUCTURE CONSTRUCTED ARTEFACT</th></tr>
<tr><th>SEMANTICS</th><th>BLOCK</th></tr>
<tr><td>Projection (P)</td><td>Transformation of an object into a form that consists only of those elements that are required in a determined situation.</td><td>Restrictive: Reducing the number of objects that shape the form of an artefact</td><td>Aspect: Discarding some information (i.e., element) of the constructed artefact as a unary operation. As a result, the structure (i.e., aspects) of the artefact is reduced.</td><td>I</td></tr>
<tr><td>Aggregation (A)</td><td>Transformation of an object by means of the takeover of elements delivered by one of more objects, to build (assemble) a resulting object according to a specific requirement or needs.

Caution should be paid on the compatibility of assembled elements as well as on how to combine them.</td><td>Extensive: Increasing the number of objects that constitute or shape the form of an artefact</td><td>Aspect: Adding some information (i.e., element to the constructed artefact. As a result, the structure (i.e., one or several aspects) of the artefact is extended</td><td>I</td></tr>
<tr><td>Refinement (R)</td><td>Transformation of a particular element configuring a determined object by modifying its meta-data or properties (name or data type)</td><td>Alterative: Adjusting the attributes of an object configuring an artefact</td><td>Element: Variation of the information that characterizes an element (i.e., element type/name)</td><td>I</td></tr>
<tr><td>Derivation (D)</td><td>Transformation of a particular element configuring a determined object by adjusting its scope of plausible valid values.

Caution should be paid on the compatibility of the new potential set of plausible values defined and the data type of the element.</td><td>Restrictive/Extensive: Depending on the variations introduced (object's scope reduction or widening)</td><td>Element: Variation of the plausible values that can be adopted by a determined element (i.e., possible element values)</td><td>I</td></tr>
<tr><td>Connection (C)</td><td>Transformation of an object by means of the creation of arbitrary associations between existing particular elements configuring the object.

Caution should be paid on the compatibility between the elements of the object connected.</td><td>Restrictive: Establishing an association between a (set of) objects determining an artefact</td><td>Aspect/element: Establishing a relationship of dependence between elements belonging to different aspects of the artefact</td><td>I</td></tr>
<tr><td>Instantiation (I)</td><td>Instantiation refers to creating a particular instance of an object by enumerating a particular set of specific values for all the elements characterising an object according to a context of application.

Caution should be paid on the compatibility of the specific values defined and the meta-data/properties of each respective element.</td><td>Restrictive: Adjusting the attributes of an object configuring an artefact</td><td>(Particular) instance: Assigning the necessary detail (i.e., concrete element values) in order to create a tangible instance of the artefact</td><td>I</td></tr>
<tr><td>Selection (S)</td><td>Selection refers to limiting or restricting the set of existing particular instances of an object only to a particular subset according to a set of pre-defined conditions that must be satisfied by all remaining instances.</td><td>Restrictive: Reducing the number of existing particular instances of a determined artefact.</td><td>Multiple instances: Discarding some existing particular instances of the constructed artefact on the basis of a set of defined conditions that artifact's element values must accomplish</td><td>II</td></tr>
</table>

Source: Own elaboration, based on the mechanisms defined by (Becker et al, 2007; vom Brocke 2007) and (Purao et al., 2011).

Once defined the *transformation mechanisms* to be used to operate against the chosen artefact to be used as a reference, we proceed with the construction process itself. In this sense, and when looking to the *Application Design Framework for RM* from a structural point of view, the original artefact proposed by Timm consists of 2 main different components or blocks of information:

- A first component block (*Block I*) devoted to summarize all the relevant information of a RM that should be considered for its successful RM application or use. This component assembles a series of elements (*items*) grouping them into 6 *application aspects* (see again section 3.3.3.6 for concrete details). An exemplary instantiation of this component block I is also provided for the particular case of a financial-oriented RM (in particular, Regulatory Compliance Management) in the original paper by Timm.
- On the other hand, a second component block of the artefact (*Block II*) collects and aggregates information related with the "generic" USs – hereafter referred as GUS – in which a generic RM model could (make sense) to be applied in practice. In particular, the original artefact provides an enumeration of 7 GUS for RMs derived from existing literature. Although not clearly detailed in the original documental source, it could be inferred that the main elements characterising a GUSs would include (i) its descriptive name (*application scenario*), (ii) involved users (*stakeholders*) and (iii) potential benefits derived from RM's use (*related benefits*). Finally, Timm also defines and enumerates 5 exemplary generic USs (GUS') for applying in practice such Regulatory Compliance Management RM, which can be viewed as particularisations of the GUS defined earlier). Finally, a particular US – hereafter referred as GUS – showing and describing the particularities and details on how 1 of the 5 GUS's defined was executed and conducted in the specific settlement of a German financial institution is also provided. The information of the PUS offers details on how the GUS. The following Figure 19 represents visually the earlier rationale characteristic of the Timm's original artefact in order to make it more understandable for readers.

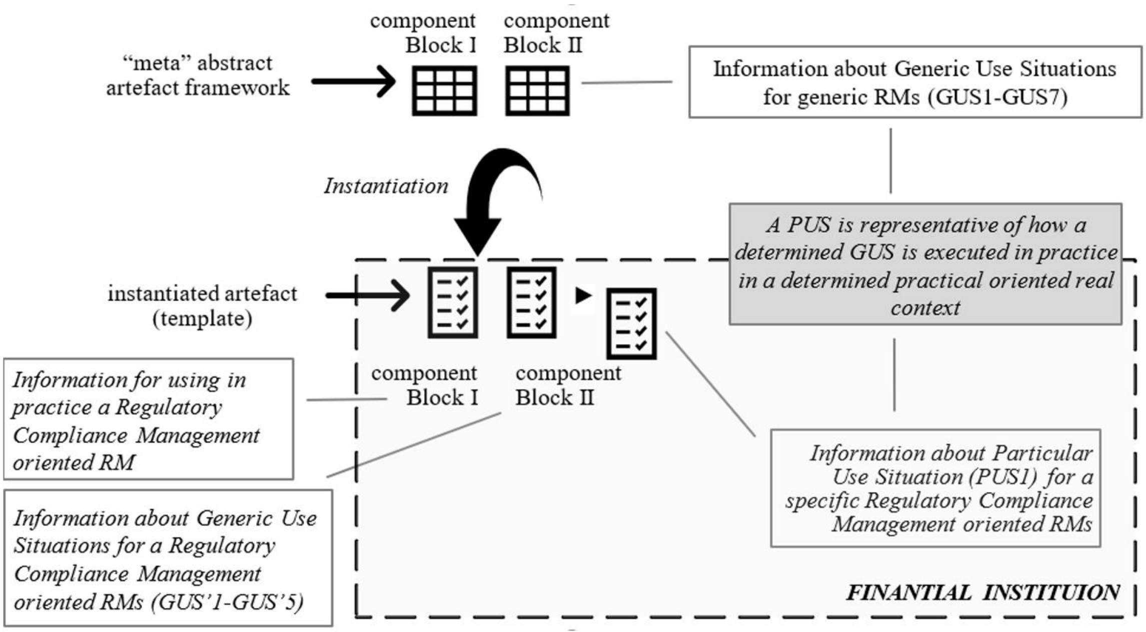

Figure 19 – Logic of Form and Function of the Artefact Framework Taken as a Reference Point

Source: Own elaboration

Since Timm's framework is going to be used as a reference point for constructing our envisioned artefact, its logic is also relatively similar the one that will govern our framework. However, and assuming that the operative of Timm's original artefact is limited only to RMs, the main action lines adopted during the construction process of the artefact will be directed towards extending its applicability to the wider scope of HEI-oriented ERAs by:

- Providing a more specific and clear definition of all the structural elements – both for component Blocks I and II – configuring each one of the components configuring the artefact (i.e., extending its "meta-structure").
- Extending the structural elements configuring the that artefact to incorporate additional ones capturing information relevant for the process of preparing and using an ERA, not just a RM (component *Block I*). This first component Block of the artefact framework should be later instantiated by practitioners when putting in practice our artefact framework considering the specific information of the concrete exemplar instance of HEI-oriented ERA going to be used for their own particular purposes.
- Determining, structuring and describing an appropriate set of representative GUSs in practice for HEI-oriented ERAs (component *Block II*).
  This second part of the artefact framework should be later instantiated by practitioners when putting in practice our artefact framework considering the specific information of the concrete context of practice in which the earlier ERA is going to be used. Such an instantiation will correspond to the concept of PUS defined earlier.

In this sense, and although the design of any kind of artefact always involves an inherent part of creativity, the following basic procedure was iteratively applied for designing the "meta-structure" of the new artefact: [42]

- First, the Projection (P) *transformation operation* was applied to identify which structural elements belonging to the original Timm's artefact should remain in the new one being constructed, either in the state and form in which they were already defined or by performing some kind of alteration in them.

- Second, for all the structural elements that will configure the "meta-structure" of the new artefact, the following *transformation operations* were applied (whether considered necessary, and in the specific order described below) to shape the definitive form and function of the new instrument framework: *Aggregation (A) | Refinement (R) | Derivation (D)*.

- Finally, the *Connection (C) transformation operation* was applied to link several interrelated structural elements of the "meta-structure" of new framework to guarantee the internal coherence of the new artefact.

All the previous *design decisions* taken during the previous design process at the particular level of the structural elements configuring the new artefact were mainly guided by the main aim of being aligned with the structural- and activity-oriented requirements defined for the artefact in the earlier section 3.4. Also, they were conveniently grounded on existing theoretical and practical knowledge from the EA discipline. All these details as well as the particular *transformation operations* applied to each artefact's structural element are described in the following tables. First, Table 22 presents all the structural elements corresponding to the Block I component of the artefact – i.e., information relative to the ERA being applied/used in practice –. Second, and on the other hand, Table 23 presents the structural elements constitutive of the component Block II of the artefact – information describing HE-oriented practical context in which would make sense to put in practice (re-use) an ERA –.

[42] The procedure was applied to both constituent components (blocks I and II) of the original reference artefact.

Table 22 – Designed Artefact Framework (Component Block I – Information Relative to the Enterprise Reference Architectures to be Used in Practice)

ASPECT	ASPECT DESCRIPTION	ELEMENT GROUP		ELEMENT NAME	ELEMENT DESCRIPTION	ELEMENT TYPE		POSSIBLE ELEMENT VALUES	JUSTIFICATORY DETAILS (*)
Architecture Specifics	Main characteristics of the architecture	#1	Architecture Details	Name	*Architecture's name*	Textual Field	Mandatory	Textual field	*Aggregation (A)* - New element aggregated for identifying the name of the architecture to be used.
				Type	*Architecture's type*	Single-Value	Mandatory	[Generic RA | HEI-oriented ERA | Other]	*Projection (P) + Refinement (R)* - Element refined from the original artefact (aspect *specifics*, item *scope*) − i.e., what type of model is the RM. Applied at architecture's level in the new artefact, instead than at RM level like in the original one. *Derivation (D)* - Element values derived from existing literature on ERAs (see section 2.4.2)
				Objectives	*Architecture's declared objective(s)*	Single-Value	Optional	Textual field (descriptive)	*Projection (P) + Refinement (R)* - Element refined from the original artefact (aspect *communication*, item *documentation*) – i.e., addressed problem, intention and context. Applied at architecture's level in the new artefact, instead than at RM level like in the original one. - According to literature on CSF's for ERAs (Greefhorst, 2015) "*An ERA is not an objective in itself but must contribute to the objectives of the organisation. However, reference architectures do not provide a (full) answer to the question of whether and where they should be applied … [but] addresses a common problem".*
				Language	*Language in which the architecture is written*	Single-Value	Mandatory	[Language (ISO 639) code]	*Aggregation (A)* - New element aggregated to describe in which language is written the architecture. - According to literature on CSF's for ERAs (Greefhorst, 2015) – "*the ERA should be easy to read and unders-tand*". - The original language in which is written the architecture may be an obstacle for adopting an using the architecture (Banaeianjah-romi & Smolander, 2019; Dang & Pekkola, 2017) – "*willingness to use EA products, personnel lack of EA knowledge" –.* *Derivation (D)* - For element values, there can be used the ISO 639-1 code list (SIL International, 2020) for classifying languages.
				Origin	*Geographical zone where the architecture was conceived*	Single-Value	Optional	[Country (ISO 3166) code) | Europe | Africa | Asia | Americas | Oceania | International]	*Aggregation (A)* - New element based on foundational literature on ERAs (de Boer et al., 2011; Greefhorst et al., 2008; ten Harmsen van der Beek et al., 2012) referring to country-dependent issues that may affect the construction and use of an ERA. *Derivation (D)* - For element values there can be used the ISO 3166 (Wikipedia, 2020) code list for classifying countries.

<table>
<tr><th>ASPECT</th><th>ASPECT DESCRIPTION</th><th colspan="2">ELEMENT GROUP</th><th>ELEMENT NAME</th><th>ELEMENT DESCRIPTION</th><th colspan="2">ELEMENT TYPE</th><th>POSSIBLE ELEMENT VALUES</th><th>JUSTIFICATORY DETAILS (*)</th></tr>
<tr><td rowspan="6">Architecture Specifics</td><td rowspan="6">Principal characteristics defining the basics of the architecture</td><td rowspan="3">#1</td><td rowspan="3">Architecture Details</td><td>Construction</td><td>Parties involved in the creation, elaboration or drawn up of the architecture</td><td>Single-Value</td><td>Mandatory</td><td>[Industry | Academia | Both | Others Unknown]</td><td>Aggregation (A)
- New element based on literature on CSF's for ERAs (Greefhorst, 2015) – "an ERA must be drawn up by or in close collaboration with the stakeholders in the sector itself" –.
Derivation (D)
- Possible element values derived from traditional classification frameworks of similar artefacts (Fettke et al., 2006; Mettler, 2011).</td></tr>
<tr><td>Usage</td><td>Generic context of use to which the architecture is directed or devoted to</td><td>Single-Value</td><td>Mandatory</td><td>[In Industry | In Research | Both | Unknown]</td><td>Aggregation (A)
- New element based on already existing classification frameworks for similar artefacts (González Vázquez et al., 2012).
Derivation (D)
- Possible element values derived from the same previous sources.</td></tr>
<tr><td>Detail level</td><td>Amount of information detail offered by the architecture (i.e., different levels or hierarchies of information aggregation)</td><td>Single-Value</td><td>Mandatory</td><td>[High, Medium, Low]</td><td>Aggregation (A)
- New element based on CSFs literature for ERAs (Greefhorst, 2015) – "the correct level of detail is also important: not too much (because then there is insufficient commonality) but also not too little)" – .already existing classification frameworks for similar artefacts (González Vázquez et al., 2012).
Derivation (D)
- Possible element values derived from homonymous elements of already existing taxonomies for determining the level of detail of EA architectural descriptions (Greefhorst et al., 2006).</td></tr>
<tr><td rowspan="3">#2</td><td rowspan="3">Architecture Scope (coverage)</td><td>EA domains addressed (depth)</td><td>Main EA domain levels addressed by the architecture</td><td>Multiple-Value</td><td>Mandatory</td><td>[Business | Information Systems | Information Technology]</td><td>Aggregation (A)
- New element based on universally accepted EA architectural domains (see section 2.3).
Derivation (D)
- Possible element values derived from the same previous sources.</td></tr>
<tr><td>HE domains addressed (width)</td><td>Extent of HEI-oriented domains addressed by the architecture</td><td>Multiple-Value</td><td>Optional (1)</td><td>[Teaching & Learning | Research | Support Activities | Third Mission]</td><td>Aggregation (A)
- New element based on literature specialized in HE (Campbell & Carayannis, 2013, p. 5; Pucciarelli & Kaplan, 2016).
Derivation (D)
- Possible element values derived from the same previous sources.</td></tr>
<tr><td>Audience</td><td>Audience to which the architecture is mainly addressed</td><td>Multiple-Value</td><td>Optional</td><td>[Managerial-oriented | Technology-oriented | Educational-oriented | Others]</td><td>Projection (P) + Refinement (R)
- Element refined from the original artefact (aspect communication, item addressed stakeholders). Applied at architecture's level in the new artefact, instead than at RM level like in the original one.
Derivation (D)
- Possible element values derived from traditional classification frameworks of similar artefacts (Fettke et al., 2006; Mettler, 2011).</td></tr>
</table>

ASPECT	ASPECT DESCRIPTION	ELEMENT GROUP		ELEMENT NAME	ELEMENT DESCRIPTION	ELEMENT TYPE		POSSIBLE ELEMENT VALUES	JUSTIFICATORY DETAILS [(*)]
		#3	Architecture Status	Stage	*Current lifecycle stage of development of the architecture*	Single-Value	Mandatory	[On Going | Finished/Closed | Last Update | Unknown.]	*Aggregation (A)* - New element based on specialized literature on ERAs (Greefhorst et al., 2009) – *"it must be clear how the management of the reference archive is invested. This makes it clear how the architecture evolves and how changes to it the architecture can be applied"*. *Derivation (D)* - Possible element values derived from the same previous sources.
				First Release Year	*Year in which the architecture was first released*	Single-Value	Optional	Year	*Aggregation (A)* - New elements based on specialized literature on ERAs: (Greefhorst, 2011b) – *"the dividing line between applications and infrastructure is a difficult one and is emphatically laid down differently in this version of the architecture than in earlier versions"*. (de Boer et al., 2011) – *"in any case, every new version of the reference architecture will must be provided with clear explanations of the amended components. Better is over not to publish new versions of the entire architecture at once, but coherent implement grouped changes"*
				Current Release	*Current release version of the architecture*	Single-Value	Optional	Textual field	
Architectural Components	Main characteristics of the architectural components conforming the architecture	#4	RMs	Number	*Number of RMs included in the architecture*	Single-Value	Mandatory	Integer	*Aggregation (A)* - New element for quantifying the number RMs included in the architecture.
				Representation	*Modelling Language used for representing the RMs*	Single-Value	Mandatory	[Formal | Semi-Formal | Unformal] [(2)]	*Projection (P) + Refinement (R)* - Element existing in the original artefact (*RM Language*) and renamed for the new developed framework. *Derivation (D)* - Possible element values derived from homonymous elements of existing taxonomies for determining the way architectural information is represented in EA architectural descriptions (Greefhorst et al., 2006).
				Perspectives Addressed	*Main perspectives addressed by the architecture. A perspective is a dedicated set of inter-related elements reflexing a particular aspect of an EA*	Multiple-Value	Optional	[Active Structure, Behaviour, Passive Structure, Motivation, Composite, Others] [(3)]	*Projection (P) + Refinement (R)* - Element existing in the original artefact (*RM Perspective*) and renamed for the new developed framework. *Derivation (D)* - Possible element values proposed in the original model extended from the ArchiMate 3.1 standard specification (The Open Group, 2019).
				Coherence	*Coherence (i.e., consistence and integration) between the domain objects (concepts) defined in the different perspectives and domains addressed by the architecture*	Multiple-Value	Mandatory	[Within Domains, Between Domains, None, Unclear]	*Aggregation (A)* - New element for defining the global coherence of the RMs forming part of the architecture. Element based on EA specialized literature (Cloutier et al., 2010; Lankhorst, 2017; Muller, 2008). *Derivation (D)* - Possible element values derived from the same previous sources.

ASPECT	ASPECT DESCRIPTION	ELEMENT GROUP		ELEMENT NAME	ELEMENT DESCRIPTION	ELEMENT TYPE		POSSIBLE ELEMENT VALUES	JUSTIFICATORY DETAILS [*]
		#5	Principles	Number	*Number of principles included in the architecture*	Single-Value	Mandatory	Integer	*Aggregation (A)* - New element for quantifying the principles considered by the architecture.
				Nature	*Whether the principles are made explicit by the architecture or not*	Single-Value	Optional [4]	[Implicit | Explicit | Unclear]	*Aggregation (A)* - New element for describing whether principles included in the architecture are implicitly expressed or not. (i.e., implicit). Element grounded on specialized literature for ERAs (see section 2.4.1.1). - Possible element values derived from the same previous sources.
				Motivation/Rationale	*Whether the principles describe their main intent or benefit of adhering to the principle*	Single-Value	Optional [5]	[Yes | No]	*Aggregation (A)* - New elements for describing whether the ERA contains additional informational details on (architectural) principles included. The element is based on specific literature on EA architectural principles (Greefhorst & Proper, 2011; Haki & Legner, 2012; Stelzer, 2010; Van Bommel et al., 2007). *Connection (C)* - Element values must be consistent with the set of values defined for the element *EA domains addressed (depth).*
				Implications	*Whether the principles include indications on how they can be met (i.e., tailored for a specific context)*	Single-Value	Optional [5]	[Yes | No]	
				Impacted EA domains	*EA domain's addressed when adhering to the architecture principle*	Multiple-Value	Optional [5]	[Business | Information Systems | Information Technology] [6]	
		#6	Other non-Essential Elements	Non-essential components included	*Additional elements (artefacts) included in the architecture beyond RMs and principles*	Multiple-Value	Mandatory	[Architectural Vision | Vocabulary/ Glossary/Catalogue | Taxonomies | Patterns | Best Practices |Technical Standards | Norms | Guidelines/ Recommendations for Use | Conceptual Models | Case Examples | Existing Solution Architectures | Maturity Models | Others | None]	*Aggregation (A)* - New element for enumerating all the components configuring the ERA to be used. *Derivation (D)* - Possible element values based on specialized literature on ERAs (see section 2.4.1).
Architecture Content Transformation	Details on how the main architectural contents can be tailored to a particular domain context of application or specific determined need	#7	Adjustment Strategy	Suitable generic transformation mechanisms	*Generic transformation mechanisms suitable to be used for tailoring/ applying the architectural contents - especially the RMs - to a particular domain context/specific need*	Multiple-Value	Optional	[Projection | Instantiation | Refinement | Specialisation | Derivation | Linking | Others | Unclear] [7]	*Projection (P) + Refinement (R)* - Element contained in the original framework (aspect *adjustment strategy*, item *generic adjustment mechanisms*). Applied at architecture's level in the new artefact, instead than at RM level like in the original one. *Derivation (D)* - Elements values based on operations for understanding the design and use of EA models defined by (Purao et al., 2011)
				Other architecture's specific transformation mechanisms	*Other specific transformation mechanisms (or instruments) defined by the architecture to assists the efforts required for tailoring or applying the architectural contents to a particular domain context/ specific need*	Textual Field	Optional	Descriptive textual field *(for example, indications for compulsory elements)*	*Projection (P) + Refinement (R)* - Element refined form the original artefact (aspect *adjustment strategy*, item *compositional adjustment mechanisms*). Applied at architecture's level in the new artefact, instead than at RM level like in the original one. *Derivation (D)* - Possible values for this element can be obtained from specialized literature on design principles for RMs (vom Brocke, 2007) or EA principles (Haki & Legner, 2013; Stelzer, 2010).

<table>
<tr><th>ASPECT</th><th>ASPECT DESCRIPTION</th><th>ELEMENT GROUP</th><th>ELEMENT NAME</th><th>ELEMENT DESCRIPTION</th><th colspan="2">ELEMENT TYPE</th><th>POSSIBLE ELEMENT VALUES</th><th>JUSTIFICATORY DETAILS (*)</th></tr>
<tr><td rowspan="4">Architecture communication</td><td rowspan="4">Dissemination of the concepts of the architecture</td><td>#8 Documentation</td><td>Nature</td><td>Nature of the documental support in which the architectural content is provide</td><td>Multiple-Value</td><td>Mandatory</td><td>[Semantic Wiki | Specification Document | Standard Document | Academic Paper | Professional Article | Report/Working Paper | Informal Communication/Document | Other Textual Support]</td><td rowspan="3">Aggregation (A)
- New element for quantifying the number RMs included in the architecture. Element is grounded on specialized literature on ERAs (Greefhorst et al., 2009) – “is ideally open, available free of charge and supplier independent (no dependence on a specific commercial approach, tool implementation, etc.) and published in such a way that it is easy to find [… and] not to create barriers to use”.
Derivation (D)
- Element values for documentation’s nature adapted from specialized literature on ERAs(de Boer et al., 2011; Greefhorst, 2011b; Greefhorst et al., 2008).
- Element values for availability (cost, accessibility) derived from traditional classification frameworks of similar artefacts (Fettke et al., 2006; Mettler, 2010, 2011).</td></tr>
<tr><td rowspan="3">#9 Availability</td><td>Cost</td><td>Whether the architecture’s contents are freely available</td><td>Single-Value</td><td>Mandatory</td><td>[Free | Charged]</td></tr>
<tr><td>Accessibility</td><td>Barriers of access to the architecture’s contents</td><td>Single-Value</td><td>Mandatory</td><td>[Public/Open | Partial/Limited | Private/Exclusive]</td></tr>
<tr><td>Community of practice</td><td>Existence of an active community of practitioners sharing concerns and experiences on the architecture</td><td>Single-Value</td><td>Unknown</td><td>[Yes | No]</td><td>Aggregation (A)
- New element for quantifying the number RMs included in the architecture. Element based on specialized lite-rature on ERAs (Greefhorst et al., 2009) – “for the sake of continuity , it is advisable that an architect community be created for the collective where experiences and best practices are shared with the application of the reference architecture”.</td></tr>
</table>

(*) ***Note:*** *Information about the design decisions taken during the development stage of the artefact included in previous table for reader’s comprehensibility/understanding purposes, but do not strictly from part of the resulting structure of the artefact framework “itself” (grey column in previous table)*

DESCRIPTITIVE INFORMATION FOR ELEMENT VALUES DEFINED IN THE ARTEFACT

(1) Only applies for HEI-oriented ERAs (#element 1: Architecture Details [Type] = “HEI-oriented ERA”)

(2) *Formal*: Languages for automatic model generation (Rapide, C2, etc.)
Semi-Formal: Modelling notation language (Unified Modelling Language, Business Process Modelling Notation, etc.)
Unformal: Natural language, graphs, diagrams etc.

(3) *Active Structure*: Elements representing “subjects” of activity (business actor, application components, nodes or devices that display actual behaviour)
Behaviour: Elements representing behaviour performed by actors (processes, functions, events, and services).
Passive Structure: Elements representing objects on which behaviour is performed (information objects, physical objects).
Motivation: Elements representing the context or the reason behind the architecture of an enterprise (stakeholders, roles, value/utility, driver, assessment, goal, outcome, requirements, etc.).
Composite: Elements consisting of other elements, possibly from multiple aspects or domain layers of the architecture.

(4) Only applies when (#element 5: Principles [Number] = >0)
(5) Only applies for explicit principles (#element 5: Principles [Nature] = “Explicit”)
(6) Only available those values defined in (#element 2: Architecture Scope [EA domains addressed])

(7) *Projection*: Transforming a (set of) *objects* by selecting a subset of *attributes*.
Instantiation: Creating a (set of) *objects/events* based on a construct in the meta-architecture model.
Refinement: Elaboration of a (set of) *conceptual objects/events* by addition of invented *attributes*. Decomposition of a (set of) *conceptual objects/events* by identifying *component* objects.
Specialisation: Adding variations to a (set of) *objects* by adding *invented attributes*.
Derivation: Manipulation of attributes of a (set of) *objects* to derive values for related *objects*; Transformation of *objects* into other *objects*.
Linking: Establishing a connection between a (set of) objects/events.

Source: Own elaboration

Table 23 – Designed Artefact Framework (Component Block II – Information Relative to the Practical Context in which the Enterprise Reference Architecture is/will be Used

ELEMENT NAME	**ELEMENT DESCRIPTION**	**ELEMENT TYPE**		**POSSIBLE ELEMENT VALUES**	**JUSTIFICATORY DETAILS (*)**
Particular Use Scenario (PUS) Name	*Descriptive name of the specific PUS to be described*	Textual Field	Mandatory	Textual field	*Aggregation (A)* - New element aggregated for identifying the PUS.
Particular Use Scenario Description	*Textual description providing details of the specific PUS described. Description should provide details on how the earlier ERAs have been used in the real context of practice*	Textual Field	Mandatory	Textual field	*Projection (P)* - Element included in the original reference artefact (other investigated artefacts also advocate for providing details on existing examples of artefacts' usage). - Possible element values can be inferred from existing case studies /illustrative examples within the specialized ERA's literature or even by own personal professional experience.
Id. Generic Use Scenario (GUS)	*Identification associated to the GUS of which the PUS being described is representative of*	Static (constant) Single-Value	Mandatory	Id. Generic Use Scenario (GUS)	*Aggregation (A)* - New element aggregated for identifying the GUS. *Connection (C)* - Element values must be consistent with the set of values defined for the element *Id. Generic Use Scenario* (GUS_1) of the pre-defined "*static list*" of GUS (see following Table 25).
Generic Use Scenario Name	*Descriptive name associated to the GUS of which the PUS being described is representative of*	Static (constant) Single-Value	Mandatory	Textual field	*Projection (P)* - Element existing in the original reference artefact. *Connection (C)* - Element values must be consistent with the set of values defined for the element *Generic Use Scenario Name* (GUS_2) of the pre-defined "*static list*" of GUS (see following Table 25).
Generic Use Scenario Description	*Basic textual description associated to the GUS of which the PUS being described is representative of*	Static (constant) Single-Value	Mandatory	Textual field	*Projection (P)* - Element existing in the original reference artefact. *Connection (C)* - Element values must be consistent with the set of values defined for the element *Generic Use Scenario Description* (GUS_3) of the pre-defined "*static list*" of GUS (see following Table 25).
Possible Dependences with other Generic Use Scenarios	*Possible (temporal) dependences of the PUS being described with other GUS* *Detailing dependences in this field <u>may</u> suppose a pre-requisite for successful execution of the PUS being described*	Multiple-Value	Mandatory	List of [Id. Generic Use Scenario (GUS)] | None	*Aggregation (A)* - New element based on the "*development phase*" element existing in the (Niemi & Pekkola, 2017) 's investigated artefact. - Dependences should be grounded whenever possible on existing literature on EA. Alternatively; they can also be based on personal experience/judgement and/or common sense. *Connection (C)* - Element values must be consistent /chosen from the set of values defined for the element *Possible dependences* (GUS_5) of the pre-defined "*static list*" of GUS (see following Table 25).

ELEMENT NAME	ELEMENT DESCRIPTION	ELEMENT TYPE		POSSIBLE ELEMENT VALUES	JUSTIFICATORY DETAILS [(*)]
Involved Users/Stakeholders	*Stakeholders or users of the ERA(s) that may be involved in the PUS being described*	Multiple-Value	Mandatory	[HEIs | HEIs/Administrators & Executive managers | HEIs/ Quality Assurance & Standards Groups | HEIs/ EA Specialists | HEIs/ IS&IT Managers | HEIs/ IS&IT Specialists | HEIs/ Business & Domain Managers | HEIs/ Business & Domain Specialists | HEIs/ Other Employees | Clienteles | External Consultants | Other HEIs & competitors | Government entities & regulators | Quality assurance regulators | IS/IT vendors and providers | Suppliers | Other External Stakeholders] [(1)]	*Projection (P)* - Element existing in the original reference artefact. *Derivation (D)* - Element values based on existing EA stakeholder taxonomies of EA (Niemi, 2007; The Open Group, 2011; van der Raadt et al., 2008) and HEI's stakeholder taxonomies (Benneworth & Jongbloed, 2010; Kettunen, 2014; Klenk & Seyfried, 2016, p. 236; Labanauskis & Ginevičius, 2017; Marić, 2013) *Connection (C)* - Element values must be consistent /chosen from the set of values defined for the element *Involved Users/Stakeholders* (GUS_4) of the pre-defined "static list" of GUS (see following Table 25).
Potential Benefits Achieved	*Potential benefits achieved from the use of the ERA in the PUS being described*	Multiple-Value	Mandatory	[▲ quality | ▼ cost | ▲ time | ▲ flexibility | ▼ risk | ▲ competitive advantage | ➤ Others (specific benefit can be detailed)]	*Projection (P)* - Element existing in the original reference artefact. *Derivation (D)* - Element option values defined in the original model (quality, cost, time, risk and competitive advantage) extended with additional options (flexibility, others) for better capturing additional (and rather) intangible potential benefits. - More specific benefit details – value "*others*" – for each particular PUS can also be inferred from existing taxonomies on EA benefits (Gong & Janssen, 2019; Jusuf & Kurnia, 2017; Niemi & Pekkola, 2019; Shanks et al., 2018) *Connection (C)* - Element values must be consistent /chosen from the set of values defined for the element *Potential Benefits* (GUS_6) of the pre-defined "*static list*" of GUS (see following Table 25).
Practical Application Guidelines Followed in Practice	*Description of the main operative/practical guidelines followed by ERA's users during the effective execution of the PUS described*	Textual field	Mandatory	Textual field	*Aggregation (A)* - New element based on existing practical literature on obstacles/problems for using EA artefacts in HE contexts – "*too heavyweight, insufficient practical guidance"* (Joint Information Systems Committee, 2009, pp. 66–67; Oderinde, 2010, p. 7). - Possible field value may be consistent with the set of values defined for the element *Recommended Practical Application Guidelines* (GUS_7) of the pre-defined "*static list*" of GUS (see following Table 25). Alternatively, the field value may override the earlier values by providing additional details on how they have been specifically extended, tailored, adapted or particularized during the concrete PUS.
Potential Blockers	*Description of potential blockers or factors hindering the successful use or application of the ERA during the PUS described*	Textual Field	Optional	Textual field	*Aggregation (A)* - New element based on the "*blockers*" element existing in the (Kurnia et al., 2020) 's investigated artefact. - Possible field values could be obtained from existing taxonomies of EA artefact problems/blockers taxonomies (Banaeianjahromi & Smolander, 2019; Dang & Pekkola, 2017; Kaisler & Armour, 2017; Kurnia et al., 2020)

*[(*)] **Note:** Information about the design decisions taken during the development stage of the artefact included in previous table for reader's comprehensibility/understanding purposes, but do not strictly from part of the resulting structure of the artefact framework "itself" (grey column in previous table)*

DESCRIPTITIVE INFORMATION FOR ELEMENT VALUES DEFINED IN THE ARTEFACT

#	STACKEHOLDER CATEGORY	CONSTITUTIVE GROUPS, COMMUNITIES AND MEMBERS
1	*HEIs*	University/School/Faculty (institutional level).
2	*HEIs/ Administrators & Executive Managers*	Rector, President/Dean, Vice-president, Vice-chancellor, Senior administrators, Heads of Department, Governors, etc.
3	*HEIs/ Quality Assurance & Standards Groups*	Quality managers, QA units/functions, Quality technics, Data and process owners, Technical standard bodies, etc.
4	*HEIs/ EA Specialists*	EA Managers, EA architects, EA teams, EA boards and committees, etc.
5	*HEIs/ IS&IT Managers*	IS/IT corporate functions, Chief Information Officers, Unit heads of IS/IT Architecture, Chief Data Officers, Chief Technology Officers, Boards of IS/IT Directors, IS/IT Managers, etc.
6	*HEIs/ IS&IT Specialists*	IS/IT Project managers and architects, IS/IT technical staff, IS analysts, Software architects, Technical designers, Developers, Programmers, IS/IT operations and maintenance technics, etc.
7	*HEIs/ Business & Domain Managers*	Program/portfolio managers, Project management office professionals, Functional managers, Faculty/ School Managers, Product and line managers (procurement/acquisitions, human resources, financials, etc.)
8	*HEIs/ Business & Domain Specialists*	Project managers, Business analyst and designers, Functional architects, Business/process analysts, Business process experts, Process designers, etc.
9	*HEIs/ Other Employees*	Faculty, administrative staff, support staff.
10	*Clienteles*	Students, Graduates.
11	*External Consultants*	External consultants and EA specialists.
12	*Other HEIs & Competitors*	Other Universities/Schools/Faculties, Other private and public institutions of post-secondary education, Distance education providers.
13	*Government Entities &Regulators*	State/federal/regional governments; State Federal/Regional Education Ministries; State/federal/regional financial aid agencies, State/Federal/ Regional research councils and authorities; Tax authorities; Patent offices, etc.
14	*Quality Assurance Regulators*	Institutional and programmatic accrediting bodies/agencies, Quality assurance accreditation/audit bodies/agencies, Media/ranking agencies, Professional associations.
15	*IS/IT Vendors and Providers*	IS/IT service providers, Software vendors, computer and hardware vendors, etc.
16	*Suppliers*	Insurance companies, Utilities, Contracted services, Other resource suppliers, etc.
17	*Other External Stakeholders*	Business companies, Chambers of commerce, Special interest groups, Industry research councils, Alliances and consortia, Foundations, Donors, Secondary education providers, Alumni, Banks and financial intermediaries, Sponsors, Non-profit organisations, Other partners, etc.

Source: Own elaboration

Finally, to complement the "meta-structure" of the component Block II of our envisioned artefact we needed to elaborate a representative enumeration set of GUSs tailored (suitable) for HEI-oriented ERAs. Such enumeration was conceived as a *"static list" of 3-tuples* <GUS_1, GUS_2, GUS_3> including the following information characterising a GUS tailored for HEI-oriented ERAs – see *Basic Tuple* elements of the "*static list"* of GUSs shown in Table 25 –.

- *Id. Generic Use Scenario (GUS)*
- *Generic Use Scenario Name*
- *Generic Use Scenario Description*

To elaborate the referred *"static list"* of GUS tailored for HEI-oriented ERAs we proceed in rather iterative way as described as follows:

- Grounding on the documental information of the 8 investigated artefacts in section 3.3.3, we first identified a set of GUS for EA artefacts. We did so by compiling all the "*use situations*", "*application scenarios*", and "*uses in practice*" for different types of EA artefacts suggested by the investigated frameworks. In those cases in which similar "*situations*", "*applications*" or "*uses*" were suggested by several frameworks, they were finally unified into a single one. A total set of 29 *candidate* GUS to be considered in the definitive list was obtained – see following Table 24 –. The rationale followed in this first step is consistent with the Projection (P) and Instantiation (I) *transformation operations* defined in Table 21.

- Next, to guarantee the applicability and transferability of these 29 *candidate* GUS for EA artefacts to the particular scope of application of HEI-oriented ERAs, for each one of the candidate GUS we looked for confirmative evidence on existing literature on ERAs. Thus, to evaluate the quality of the evidences found in the literature we used *stylized facts* [43] as an assessment technique. In particular, and inspired on the classification-taxonomy for assessing the quality of design knowledge proposed by (Fettke et al., 2010, pp. 353–354) we applied the following criteria:

    - Level 1: *Plausible statement without further justification* (i.e., the statement is not obviously false and neither conceptually nor empirically supported).
    - Level 2: *Plausible statement that is proven by mere conceptual consideration, without empirical evidence* (i.e., a key critical success factor is taken into consideration to justify the statement).
    - Level 3: *Plausible statement that is proven by simple expert opinion/judgement* (i.e., questionnaire, interview, focus group, etc.).
    - Level 4: *Statement that is backed up by exemplary practical experience* (i.e., illustrative in-depth case study, action research, etc.).

[43] Stylized facts can be conceptualized as "*interesting, sometimes counterintuitive, patterns in empirical data (empirical generalisations, accumulations of evidence) documented in different sources*" (Houy et al., 2015, p. 228). They constitute knowledge in the form of generalized and simplified statements describing interesting characteristics and relationships concerning empirically observable phenomena (Heine et al., 2005; Helfat, 2007). Stylized facts "*put their focus on the most relevant aspects of observable phenomena by abstracting from details –stylization–* " (Houy et al., 2015, p. 228), and therefore, they are broadly supported and simplified representations of complex relationships that are not necessarily valid in every situation and context. Stylized facts do not aim to represent causal relationships but rather interesting correlations that are observable in reality (Heine et al., 2005; Houy et al., 2013, 2015). Stylized facts have their origin in the field of economics (Heine et al., 2005; Helfat, 2007) and have been successfully used in various other fields of research, including the IS (Houy et al., 2015).

- Level 5: *Statement that has held well in a variety of heterogeneous applications/contexts* (i.e., through an experiment or multiple case studies).
- Level 6: *Statement that applies without exception or which can be deductively derived from acknowledged statements*.

In addition, the evidences found were also typified into 4 basic "categories" depending on their particular practice application scope:

- Category 1 - Evidence found with *no specific or related application scope*.
- Category 2 - Evidence found for an application scope related with a *profit-oriented organisation*.
- Category 3 - Evidence found for an application scope related with a *public sector organisation*.
- Category 4 - Evidence for an application scope related with a *HEIs*.

The results achieved in this second step are also shown in the following Table 24.

- Third, to determine the final *"static list"* of GUS tailored for HEI-oriented ERAs, the following inclusion criteria was applied to the 29 *candidate* GUS identified in the previous step in order to guarantee their applicability and transferability to HE-oriented contexts of practice:

Category 4 [Evidence for HE-oriented targeted application scope]	*OR*	*(Category 1 OR Category 2 OR Category 3)* [No evidence found for a HE-oriented targeted application scope, but evidence found for all the remaining typified categories]

No inclusion criteria based exclusively on the quality level of evidences found was finally applied. This decision was taken due to both the scarcity and the relatively low level of quality of the evidences found, which would had led to the exclusion of most *candidate* GUSs assessed. All in all, a final set of 22 GUSs –18 consistent with the first part of the condition and 4 additional more with the second one – were finally considered to be included in the definitive *"static list"*. The rationale followed in this step is consistent with the Selection (S) *transformation operation* defined in Table 21.

- Finally, we extended the information associated to the final "*static list"* of 22 GUS tailored for HEI-oriented ERAs by providing additional information for each GUS inferred. In particular, we extended each item of the "*static list"* by creating an additional 4-*tuple* <GUS_4, GUS_5, GUS_6, GUS_7> encompassing information that might be relevant for users considering the use in practice of an ERA for a specific and determined PUS representative of the GUS being described – see following Figure 20 for a visual representation of this logic –.

The information included in this *Extended Tuple* for each GUS of the 22 defined in the "*static list" of* GUS tailored for HEI-oriented ERAs was as follows – see the *Extended Tuple* element fields in Table 25 –.

- *Possible dependences with other GUS* considered in the "*static list*".
- *Involved Users/Stakeholders* susceptible of taking part (participate) in the GUS being described.
- *Potential benefits which* could be effectively achieved from the effective usage of ERAs in the GUS being described.

- *Practical Application Guidelines* that might be followed by involved users/stakeholders when participating or taking part in the GUS being described.

The complete information of the "*static list*" of GUS is reproduced in the following Table 25. In most cases, the informative details compiled for each GUS were extracted from (i) the existing literature on ERAs used for defining the GUS, (ii) the descriptive information of the investigated artefacts in section 3.3.3, and (iii) generic literature on EA artefact's benefits and stakeholders. In those cases for which previous background resulted insufficient – as for example, for the information relative to the *Possible dependences with other GUS* element – information was complemented with personal knowledge and judgement bases on our personal experience and common sense.

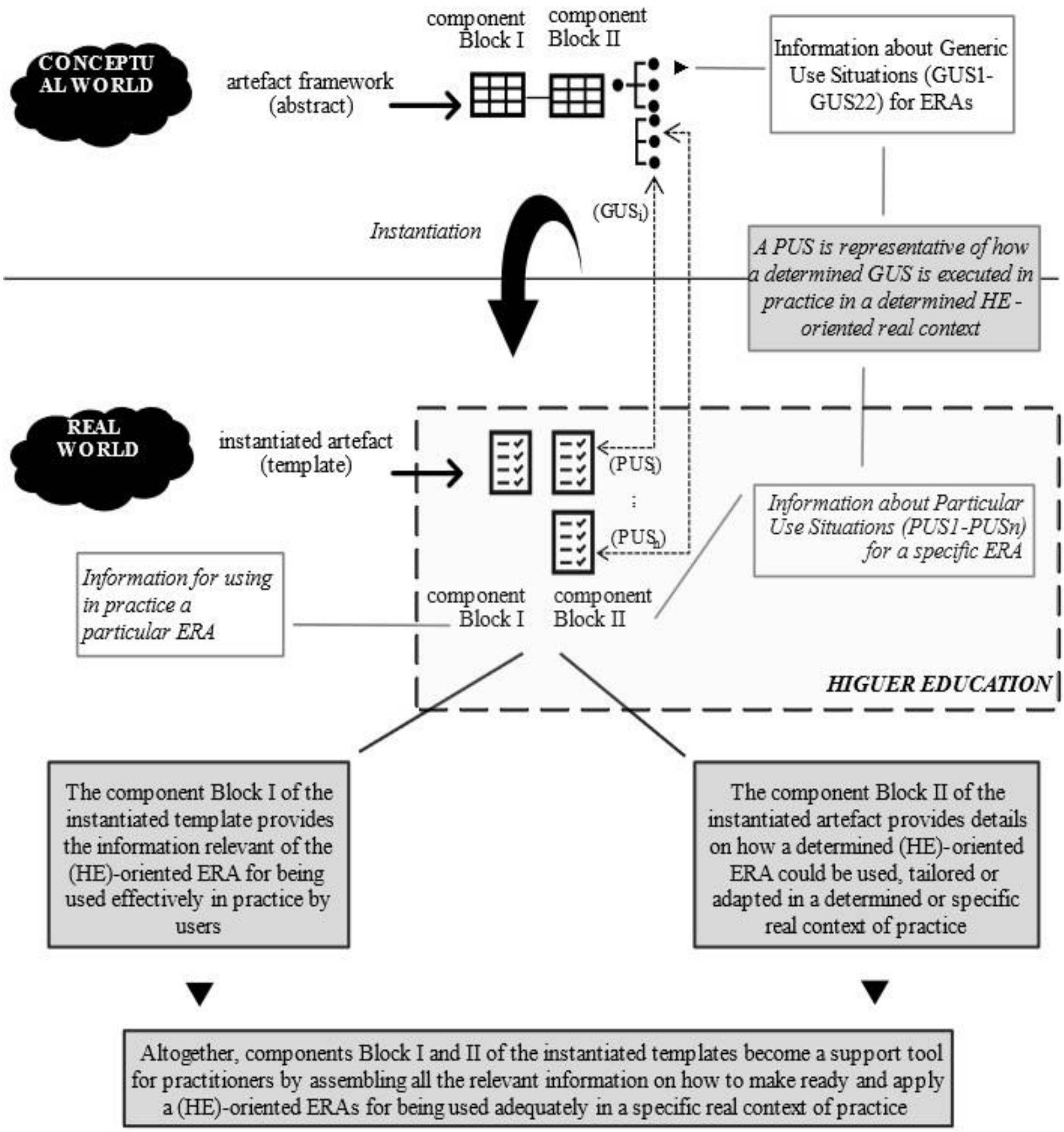

Figure 20 – Logic of Form and Function of the Artefact Framework Constructed

Source: Own elaboration

Readers must note that the information provided by the "*static list"* of GUS tailored for HEI-oriented ERAs is consistent with (several) component elements of the "meta-structure" defined in Table 23 for the component Block II of our constructed artefact. For instance, and as represented in earlier Figure 20, it is expected that when EA practitioners put in practice our instrument framework in their own settlements, they were able to create, compliment and reflect through a framework's instantiation template representative of their ERA's usage in their particular context of practice (i.e., their specific PUS) by means of:

- Linking or establishing a correspondence between their particular PUS with a representative generic GUS defined in the artefact framework.
- Considering which one(s) and what information provided by the existing HEI-oriented ERA(s) suits better for their specific purposes in the PUS in which they are involved.
- Adapting and tailoring (or even overriding, if necessary) the information and/or several of actionable recommendations provided by the "*static list"* of GUSs of the instrument framework to the specificities and contextual requirements of the PUS in which they are involved.
- Extending and complementing all the earlier knowledge with additional information relevant to the comprehension or the effective execution in practice of the PUS in which they are involved.

All in all, this earlier rational can be also viewed as consistent with the *Instantiation (I) transformation operation* defined in Table 21. Since the instantiation of our constructed artefact framework will be the main focus of study of following chapter of the thesis, additional details and examples will be provided later in this report.

Finally, and to conclude with this epigraph, in the following Figure 21 a dependency graph for the 22 GUSs defined for the constructed artefact framework is presented. The graph suggests and hypothesizes on the idea that behind the practical use of ERAs there could exist some kind of evolution or progression – i.e., maturity capturing the "quality" of such practice –. Hence, the use of ERAs by EA practitioners could range from rather relatively simple uses – referred as *basic scenarios* in Figure 21 – to other much more "complex" stadiums of use – referred as *advanced scenarios* in Figure 21 – which in turn, may also bring better, improved or more intense benefits to all those involved, in some or another way, within the US. However, achieving such advanced levels of expertise in the effective usage of ERAs may require, probably, higher levels of knowledge and EA practical expertise by those involved (i.e., using the ERA), which may be progressively acquired in previous "*easier*" uses, as depicted by the dependences of the Figure 21 graph.

Despite that this previous idea is line with earlier research suggesting temporal dependences on the use of different types of EA artefacts (Kotusev, 2017c; Niemi & Pekkola, 2017) our suggestions and observations captured during this research are insufficient to establish conclusive results. Thus, further research and more empirical studies should be conducted to formally confirm our hypothesis.

Table 24 - Justificatory Evidence Matrix for the Artefact's Generic Use Scenarios Inferred

a) Scenarios with supporting evidence found for the Higher Education sector (HE)

CANDIDATE GENERIC USE SCENARIOS (GUS)		INVESTIGATED EXISTING ARTEFACTS CONSIDERING THE GENERIC USE SCENARIOS							
ID	**NAME**	*Catalogue of Application Scenarios for EA Models* (Bucher et al., 2006)	*Model of EA Standards Use for IT* (Boh & Yellin, 2006)	*Classification of EA Use Scenarios in practice* (Aier et al., 2008)	*Catalogue of Uses in Practice of EA Principles* (Greefhorst et al., 2013)	*Framework for EA Artefact Use Situations* (Niemi & Pekkola, 2017)	*Application Design Framework for RMs* (Timm, 2018)	*Systematic description of EA artefact' s use* (Kotusev, 2019)	*Classification of EA Activity Areas in Practice* (Kurnia et al., 2020)
GUS1	CONTENT PRESENTATION (1)			✓(3)		✓			
GUS2	TRAIN AND INSTRUCT				✓	✓	✓		✓
GUS3	TAKE PART IN (EA) MEETINGS/ STIMULATE DISCUSSIONS				✓	✓			
GUS4	REFERENCE POINT FOR COMMON BASIS OF UNDERSTANDING AND INTERACTION			✓(3)					✓
GUS5	SUPPORT FOR CREATING AN EA PRODUCT, RM or ERA					✓			
GUS6	MODELLING SUPPORT FOR DEVELOPING A SPECIFIC SOLUTION ARCHITECTURE					✓	✓		
GUS7	PROJECT INITIALISATION SUPPORT	✓		✓(3)	✓	✓			

ID	LITERATURE SOURCES ON RA/ERAs RESPALDING THE IDENTIFIED GENERIC USE SCENARIOS					
	Generic/Non-context specific	Private sector	Public sector/eGovernance	HE		Evidence quality level
GUS1				✓	(Sanchez-Puchol & Pastor, 2021) [P11]	4
GUS2				✓	(Sanchez-Puchol & Pastor, 2021) [P11]	4
		✓			(ten Harmsen van der Beek et al., 2012)	3
	✓				(Cloutier et al., 2010; Muller, 2008)	2
GUS3				✓	(Sanchez-Puchol & Pastor, 2021) [P11]	4
				✓	(Svensson & Hvolby, 2012)	1
GUS4	✓				(Cloutier et al., 2010; Muller, 2008)	2
		✓			(ten Harmsen van der Beek et al., 2012)	3
				✓	(Olsen & Trelsgård, 2016)	3
GUS5			✓		(Timm, Köpp, et al., 2015)	4
			✓		(Timm, Sandkuhl, et al., 2017)	4
			✓		(Gump et al., 2018)	4
		✓			(Aulkemeier et al., 2016)	4
		✓			(Timm & Sandkuhl, 2018a, 2018b)	4
	✓				(Cloutier et al., 2010; Muller, 2008)	2
				✓	(Fajar et al., 2018)	4
				✓	(Pańkowska, 2016)	4
GUS6	✓				(Lankhorst, 2014; Paradkar, 2018)	1
	✓				(Cloutier et al., 2010; Muller, 2008)	2
		✓			(ten Harmsen van der Beek et al., 2012)	3
				✓	(Svensson & Hvolby, 2012)	2
				✓	(Sanchez-Puchol & Pastor, 2021) [P11]	4
GUS7				✓	(Sanchez-Puchol & Pastor, 2021) [P11]	4
		✓			(ten Harmsen van der Beek et al., 2012)	3

CANDIDATE GENERIC USE SCENARIOS (GUS)		INVESTIGATED EXISTING ARTEFACTS CONSIDERING THE GENERIC USE SCENARIOS								LITERATURE SOURCES ON RA/ERAs RESPALDING THE IDENTIFIED GENERIC USE SCENARIOS					
ID	NAME	*Catalogue of Application Scenarios for EA Models* (Bucher et al., 2006)	*Model of EA Standards Use for IT* (Boh & Yellin, 2006)	*Classification of EA Use Scenarios in practice* (Aier et al., 2008)	*Catalogue of Uses in Practice of EA Principles* (Greefhorst et al., 2013)	*Framework for EA Artefact Use Situations* (Niemi & Pekkola, 2017)	*Application Design Framework for RMs* (Timm, 2018)	*Systematic description of EA artefact' s use* (Kotusev, 2019)	*Classification of EA Activity Areas in Practice* (Kurnia et al., 2020)	Generic/Non-context specific	Private sector	Public sector/eGovernance	HE		Evidence quality level
GUS8	SUPPORT FOR IS/IT INTEROPERABILITY DECISION-MAKING		✓		✓			✓	✓	✓				(Lankhorst, 2014; Paradkar, 2018)	1
												✓		(Gump et al., 2018)	2
										✓				(Cloutier et al., 2010; Muller, 2008)	2
											✓			(ten Harmsen van der Beek et al., 2012)	3
												✓		(Lemmetti & Pekkola, 2014)	2
													✓	(Fajar et al., 2018)	2
												✓		(Ajer & Olsen, 2018)	2
GUS9	SUPPORT FOR IS/IT INTEGRATION DECISION-MAKING		✓	✓(3)	✓			✓		✓				(Cloutier et al., 2010; Muller, 2008)	2
													✓	(Svensson & Hvolby, 2012)	2
											✓			(ten Harmsen van der Beek et al., 2012)	3
													✓	(Fajar et al., 2018)	2
													✓	(Pańkowska, 2016)	2
												✓		(Ajer & Olsen, 2018)	2
GUS 10	BUSINESS PROCESS STANDARISATION AND OPTIMISATION	✓								✓				(Lankhorst, 2014; Paradkar, 2018)	1
													✓	(Svensson & Hvolby, 2012)	2
GUS 11	SUPPORT FOR IT INFRAESTRUCTURE HARMONISATION DECISION-MAKING	✓	✓	✓(3)				✓					✓	(Svensson & Hvolby, 2012)	2
													✓	(Pańkowska, 2016)	2
GUS 12	DOCUMENTAL SUPORT FOR QUALITY ASSURANCE AUDITS	✓											✓	(Riihimaa, 2009)	1
													✓	(Olsen & Trelsgård, 2016)	1
GUS 13	SUPPORT FOR IS/IT (OUT)SOURCING, PROVISION AND ACQUISTIONS DECISIONS	✓			✓	✓	✓				✓			(ten Harmsen van der Beek et al., 2012)	3
										✓				(Cloutier et al., 2010)	2
										✓				(Lankhorst, 2014; Paradkar, 2018)	1
												✓		(Lemmetti & Pekkola, 2014)	4
													✓	(Olsen & Trelsgård, 2016)	3
GUS 14	SUPPORT FOR MERGER AND INTEGRATION INITIATIVES	✓							✓	✓				(Lankhorst, 2014; Paradkar, 2018)	1
													✓	(Syynimaa, 2010)	1
GUS 15	REFERENCE FOR INDUSTRY/SECTORIAL BENCHMARKS, COMPARISONS AND MAPPINGS								✓	✓				(Lankhorst, 2014; Paradkar, 2018)	1
												✓		(Gump et al., 2018)	2
													✓	(Svensson & Hvolby, 2012)	2

CANDIDATE GENERIC USE SCENARIOS (GUS)		INVESTIGATED EXISTING ARTEFACTS CONSIDERING THE GENERIC USE SCENARIOS								LITERATURE SOURCES ON RA/ERAs RESPALDING THE IDENTIFIED GENERIC USE SCENARIOS					
ID	NAME	*Catalogue of Application Scenarios for EA Models* (Bucher et al., 2006)	*Model of EA Standards Use for IT* (Boh & Yellin, 2006)	*Classification of EA Use Scenarios in practice* (Aier et al., 2008)	*Catalogue of Uses in Practice of EA Principles* (Greefhorst et al., 2013)	*Framework for EA Artefact Use Situations* (Niemi & Pekkola, 2017)	*Application Design Framework for RMs* (Timm, 2018)	*Systematic description of EA artefact's use* (Kotusev, 2019)	*Classification of EA Activity Areas in Practice* (Kurnia et al., 2020)	Generic/Non-context specific	Private sector	Public sector/eGovernance	HE		Quality of the evidence
GUS 16	CONSULTANCY ARTEFACT						✓		✓	✓				(Cloutier et al., 2010; Muller, 2008)	2
													✓	(Sanchez-Puchol & Pastor, 2021) [P11]	4
GUS 17	SUPPORT FOR IS/APPLICATION DEVELOPMENT				✓	✓	✓					✓		(Gump et al., 2018)	2
													✓	(Svensson & Hvolby, 2012)	2
											✓			(ten Harmsen van der Beek et al., 2012)	3
GUS 18	IDENTIFICATION OF OPPORTUNITIES OF COOPERATION AND COORDINATION (SYNERGIES) AMONG DIFFERENT SECTORIAL UNITS/ENTITITES	✓(2)										✓		(Lemmetti & Pekkola, 2014)	2
													✓	(Fajar et al., 2018)	2
													✓	(Pańkowska, 2016)	2
													✓	(Olsen & Trelsgård, 2016)	2
												✓		(Ajer & Olsen, 2018)	2
										✓				(Cloutier et al., 2010; Muller, 2008)	2

b) Scenarios with supporting evidence found for the Public Sector (PS)

CANDIDATE GENERIC USE SCENARIOS (GUS)		INVESTIGATED EXISTING ARTEFACTS CONSIDERING THE GENERIC USE SCENARIOS								LITERATURE SOURCES ON RA/ERAs RESPALDING THE IDENTIFIED GENERIC USE SCENARIOS					
ID	**NAME**	*Catalogue of Application Scenarios for EA Models* (Bucher et al., 2006)	*Model of EA Standards Use for IT* (Boh & Yellin, 2006)	*Classification of EA Use Scenarios in practice* (Aier et al., 2008)	*Catalogue of Uses in Practice of EA Principles* (Greefhorst et al., 2013)	*Framework for EA Artefact Use Situations* (Niemi & Pekkola, 2017)	*Application Design Framework for RMs* (Timm, 2018)	*Systematic description of EA artefact's use* (Kotusev, 2019)	*Classification of EA Activity Areas in Practice* (Kurnia et al., 2020)	Generic/Non-context specific	Private sector	Public sector/eGovernance	HE		Evidence quality level
GUS 19	GAP ANALISYS WITH AN INDIVIDUAL MODEL			✓(3)			✓	✓	✓	✓	✓	✓		(Cloutier et al., 2010; Muller, 2008) (ten Harmsen van der Beek et al., 2012) (Lemmetti & Pekkola, 2014)	2 3 2
GUS 20	DELIVER A ROADMAP, MIGRATION, TRANSITION OR TRANSFORMATION PATH			✓(3)			✓	✓	✓	✓	✓	✓		(Cloutier et al., 2010; Muller, 2008) (ten Harmsen van der Beek et al., 2012) (Lemmetti & Pekkola, 2014)	2 3 2
GUS 21	SUPPORT FOR (OPERATIONAL) BUSINESS-IS/IT ALIGNMENT	✓		✓(3)				✓		✓	✓	✓ ✓ ✓		(ten Harmsen van der Beek et al., 2012) (Timm, Köpp, et al., 2015) (Timm, Sandkuhl, et al., 2017) (Timm & Sandkuhl, 2018a, 2018b) (Lemmetti & Pekkola, 2014)	2 2 2 2 2
GUS 22	FRAMEWORK FOR LEGAL/TECHNICAL REGULATORY COMPLIANCE	✓			✓		✓	✓		✓ ✓ ✓	✓ ✓	✓ ✓		(Cloutier et al., 2010) (Lankhorst, 2014; Paradkar, 2018) (Timm, Wißotzki, et al., 2015) (ten Harmsen van der Beek et al., 2012) (Timm & Sandkuhl, 2018a, 2018b) (Timm, Köpp, et al., 2015) (Ajer & Olsen, 2018)	2 1 1 3 4 2 3

LEGEND

(1) Referred as "Present Content" in the original framework by (Niemi & Pekkola, 2017).

(2) "*IT service Management*" and "*Management of IT Operation Costs*" scenarios defined in the original framework have been embedded and unified in this scenario.

(3) The 3 "macro" use scenarios (i.e., *clusters*) contemplated in the original framework have been decomposed into different and more fine-grained scenarios considered in the matrix.

c) Scenarios discarded due to lack of evidence

CANDIDATE GENERIC USE SCENARIOS (GUS)		INVESTIGATED EXISTING ARTEFACTS CONSIDERING THE GENERIC USE SCENARIOS								LITERATURE SOURCES ON RA/ERAs RESPALDING THE IDENTIFIED GENERIC USE SCENARIOS					
ID	**NAME**	*Catalogue of Application Scenarios for EA Models* (Bucher et al., 2006)	*Model of EA Standards Use for IT* (Boh & Yellin, 2006)	*Classification of EA Use Scenarios in practice* (Aier et al., 2008)	*Catalogue of Uses in Practice of EA Principles* (Greefhorst et al., 2013)	*Framework for EA Artefact Use Situations* (Niemi & Pekkola, 2017)	*Application Design Framework for RMs* (Timm, 2018)	*Systematic description of EA artefact's use* (Kotusev, 2019)	*Classification of EA Activity Areas in Practice* (Kurnia et al., 2020)	Generic/Non-context specific	Private sector	Public sector/eGovernance	HE		Evidence quality level
GUS 23	IT ASSET TRACKING AND MANAGEMENT							✓	✓	✓				(Cloutier et al., 2010)	2
GUS 24	PROGRAM/PROJECT PORFOLIO PLANNING	✓			✓	✓		✓	✓						
GUS 25	SECURITY MANAGEMENT	✓			✓			✓							
GUS 26	TECHNOLOGY RISK MANAGEMENT	✓								✓				(Cloutier et al., 2010)	2
GUS 27	SUPPORT FOR ARCHITECTURAL PROJECT GOVERNANCE				✓	✓		✓	✓						
GUS 28	OPTIONS/ OPPORTUNITY ASSESMENT							✓	✓						
GUS 29	SUPORT FOR STRATEGIC PLANNING AND MANAGEMENT DECISION-TAKING				✓	✓		✓							

Source: Own elaboration.

Table 25 – Designed Artefact Framework (Component Block II – Generic Use Scenarios considered)

a) Scenarios with supporting evidence found for the Higher Education sector (HE)

BASIC TUPLE (static constant fields)			EXTENDED TUPLE (suggested values to be chosen/adapted/tailored)			
<GUS$_1$>	**<GUS$_2$>**	**<GUS$_3$>**	**<GUS$_4$>**	**<GUS$_5$>**	**<GUS$_6$>**	**<GUS$_7$>**
ID GENERIC USE SCENARIO	**GENERIC USE SCENARIO NAME**	**GENERIC USE SCENARIO DESCRIPTION**	**POSSIBLE DEPENDENCES**	**POTENTIALLY INVOLVED USERS/STAKEHOLDERS**	**POTENTIAL BENEFITS**	**RECOMMENDED PRACTICAL APPLICATION GUIDELINES**
GUS1	CONTENT PRESENTATION	This GUS involves using the ERA's components (especially visual components like RMs or conceptual maps) just as presentation material.	None	➤ HEIs/ Administrators & Executive Managers ➤ HEIs/ Quality Assurance & Standards Groups ➤ HEIs/ EA Specialists ➤ HEIs/ IS&IT Managers ➤ HEIs/ IS&IT Specialists ➤ HEIs/ Business & Domain Managers ➤ HEIs/ Business & Domain Specialists ➤ HEIs/ Other Employees ➤ Clienteles ➤ External Consultants ➤ IS/IT Vendors and Providers ➤ Suppliers	▲ **Quality**: Improved/better information quality, sharing, and documentation ➤ **Other**: Improved communication/understanding among different stakeholders ➤ **Other**: Improved staff skills/capabilities/knowledge	1. Business-oriented components of the ERA – for example, RMs describing functions, processes, capabilities, etc. – may be preferred and more comprehensible to business-oriented and most of the external stakeholders of the HEI. 2. More detailed and technically-oriented components of the ERA – for example, RMs describing applications, infrastructure, etc. – may be preferred by IS/IT and EA-oriented stakeholders of the HEI. 3. EA visualisation techniques (Lê, 2015; Naranjo et al., 2013; Roth et al., 2014) may be used to improve the original appearance (colour coding, distinctive shapes, etc.) of the ERA's components used training materials to provide more clear, appealing and easy-to-understand presentations.
GUS2	TRAIN AND INSTRUCT	This GUS involves using the ERA's components as instructional materials for training different stakeholders anywhere something regarding the specifics of a HEI's "enterprise class" needs to be instructed. Training can also be self-motivated to refreshing one's memory on a particular aspect of EA.	Content presentation (#GUS1)	➤ HEIs/ EA Specialists ➤ HEIs/ IS&IT Managers ➤ HEIs/ IS&IT Specialists ➤ HEIs/ Business & Domain Managers ➤ HEIs/ Business & Domain Specialists ➤ HEIs/ Other Employees ➤ External Consultants ➤ IS/IT Vendors and Providers	▲ **Quality**: Improved/better information quality, sharing, and documentation ➤ **Other**: Improved staff skills/capabilities/knowledge	1. Use of analogies and metaphors – i.e., like the EA-city planning (Guetat & Dakhli, 2009; Namba & Iljima, 2004; Rehring et al., 2019) or other ones typically used in the IS discipline (Gazendam, 1999; Kendall & Kendall, 1994; Smolander et al., 2008) – to favour the knowledge transfer process.
GUS3	TAKE PART IN (EA) MEETINGS/ STIMULATE DISCUSSIONS	This GUS involves using the ERA as a vehicle for providing a common context for stimulating discussions or dialogue between diverse stakeholders during (team) meetings.	Content presentation (#GUS1)	➤ HEIs/ EA Specialists ➤ HEIs/ IS&IT Managers ➤ HEIs/ IS&IT Specialists ➤ HEIs/ Business & Domain Managers ➤ HEIs/ Business & Domain Specialists ➤ HEIs/ Other Employees ➤ External Consultants ➤ IS/IT Vendors and Providers ➤ Suppliers	➤ **Other**: Improved communication/understanding among different stakeholders ➤ **Other:** Creation and maintenance of common visions	No practical application guidelines recommended since this GUS may conducted in a real practice by means of multiple PUS with different casuistry.

BASIC TUPLE (static constant fields)			EXTENDED TUPLE (suggested values to be chosen/adapted/tailored)			
<GUS$_1$>	<GUS$_2$>	<GUS$_3$>	<GUS$_4$>	<GUS$_5$>	<GUS$_6$>	<GUS$_7$>
ID GENERIC USE SCENARIO	**GENERIC USE SCENARIO NAME**	**GENERIC USE SCENARIO DESCRIPTION**	**POSSIBLE DEPENDENCES**	**POTENTIALLY INVOLVED USERS/STAKEHOLDERS**	**POTENTIAL BENEFITS**	**RECOMMENDED PRACTICAL APPLICATION GUIDELINES**
GUS4	REFERENCE POINT FOR COMMON BASIS OF UNDERSTANDING AND INTERACTION	This GUS involves using the ERA as a reference point – i.e., providing a common and unified vocabulary/terminology/lexicon – for shared understanding among different stakeholders.	Train and instruct (#GUS2) Take part in (EA) meetings/Stimulate discussions (#GUS3)	➤ HEIs ➤ Clienteles ➤ External Consultants ➤ Other HEIs & Competitors ➤ Government Entities &Regulators ➤ Quality Assurance Regulators ➤ IS/IT Vendors and Providers ➤ Suppliers ➤ Other External Stakeholders	▲ **Quality**: Improved/better information quality, sharing, and documentation ➤ **Other**: Improved communication/understanding among different stakeholders ➤ **Other**: Creation and maintenance of common visions	1. Provide a single, unique and accessible point of access to the ERA being used to all involved stakeholders/participants in a determined situation or for a particular purpose (Greefhorst, 2015; Greefhorst et al., 2009). 2. ERAs providing a clear and structured documentation could be preferable (Buckl et al., 2009; de Boer et al., 2011; Greefhorst, 2011b)
GUS5	SUPPORT FOR CREATING AN EA PRODUCT, RM or ERA	This GUS involves the use of different parts or components of one or more existing ERAS during the integral process – including the collection of adequate data and information sources as well as the design, construction and validation – for creating a new ERA, RM or complementary EA product.	Reference point for common basis of understanding and interaction (#GUS4) Project initialisation support (#GUS7)	➤ HEIs/ EA Specialists ➤ HEIs/ IS&IT Managers ➤ HEIs/ IS&IT Specialists ➤ HEIs/ Business & Domain Managers ➤ HEIs/ Business & Domain Specialists ➤ Other HEIs & Competitors ➤ External Consultants ➤ Government Entities &Regulators ➤ Quality Assurance Regulators ➤ IS/IT Vendors and Providers ➤ Suppliers ➤ Other External Stakeholders	▼ **Time**: Shorter project/activity/ product development cycle times ▼ **Cost**: Reduced cost of EA architecting/modelling activities (reusability of already existing and validated ERA/RMs). ▼ **Risk**: Lessening of architecting/ modelling activities risk (reusability of already existing and validated ERA/RMs). ➤ **Other**: Creation and maintenance of common visions	1. Application of existing inductive/deductive/ hybrid methodological approaches for guiding the construction process of the new EA product, RMs/ERAs (Peyman et al., 2013; Timm et al., 2018; Timm, Sandkuhl, et al., 2017; Timm & Sauer, 2017). 2. Use of generic RA/RMs – as for example the Work Systems Framework (Alter, 2013), the Business Engineering Framework (Aier et al., 2009) or the Application Architecture Reference Model Blueprint (Hrabe & Buchalcevova, 2011) – as a starting baseline template during the construction process or for shaping the form/defining the skeleton of the new EA product/RM/ERA to be created.
GUS6	MODELLING SUPPORT FOR DEVELOPING A SPECIFIC SOLUTION ARCHITECTURE	This GUS involves using the ERA as a guide for transforming (i.e., designing, realising, tailoring and reusing) a generic and abstract ERA into a particular solution EA of an organisation, according to its context-specific needs and requirements.	Gap analysis with an individual model (#GUS19)	➤ HEIs/ EA Specialists ➤ HEIs/ IS&IT Managers ➤ HEIs/ IS&IT Specialists ➤ HEIs/ Business & Domain Managers ➤ HEIs/ Business & Domain Specialists ➤ External Consultants	▼ **Time**: Speed-up the enterprise architecting process and/or delivery of the solution EA (knowledge contained in the ERA reduces learning and development times) ▼ **Cost**: Reduced cost of EA architecting/modelling activities (reusability, not having to start from scratch) ▲ **Quality**: Improved quality of the resulting solution EA (grounded on best architectural practices within an enterprise class incorporated in the ERA) ▼ **Risk**: Lessening of architecting/ modelling activities risk (focus put on already validated critical areas of an enterprise class to be worked on) ▲ **Competitive advantage**: Access to sectorial validated knowledge and best practices included in the ERA	1. Tailoring an ERA into a particular solution EA is an activity that always involves an inherent part of creativity during its development. 2. Basic guidelines for practical ERA realisation and transformation proposed by (de Boer et al., 2011) can provide certain guidance for daily work practice: ▪ Identification of the architectural objects defined by the ERA that are relevant to be applied into the specific EA solution architecture, according to the particular contextual organisational in which the ERA is going to be applied. ▪ Establishment of the correspondence (i.e., traceability) between the domain objects defined in the ERA and the domain object characterising the specific solution EA, providing the correspondent justification for such inter-connection. ▪ Management and maintenance of the established relationships/ mappings that may emerge due to potential changes derived from either new version of the ERA or new organisational requirements/constraints arisen in the organisation where the ERA is being applied.

BASIC TUPLE (static constant fields)			EXTENDED TUPLE (suggested values to be chosen/adapted/tailored)			
<GUS$_1$>	<GUS$_2$>	<GUS$_3$>	<GUS$_4$>	<GUS$_5$>	<GUS$_6$>	<GUS$_7$>
ID GENERIC USE SCENARIO	**GENERIC USE SCENARIO NAME**	**GENERIC USE SCENARIO DESCRIPTION**	**POSSIBLE DEPENDENCES**	**POTENTIALLY INVOLVED USERS/STAKEHOLDERS**	**POTENTIAL BENEFITS**	**RECOMMENDED PRACTICAL APPLICATION GUIDELINES**
GUS7	PROJECT INITIALISATION SUPPORT	This GUS involves using the ERA at the initiating phases or steps of a project as a support tool to determine its initial scoping and design.	Train and instruct (#GUS2)	➤ HEIs/ EA Specialists ➤ HEIs/ IS&IT Managers ➤ HEIs/ IS&IT Specialists ➤ HEIs/ Business & Domain Managers ➤ HEIs/ Business & Domain Specialists ➤ External Consultants ➤ IS/IT Vendors and Providers ➤ Suppliers	▼ **Risk**: Avoiding later redundant activities during the project development cycle ▼ **Time**: Shorter project/activity/ product development cycle times	No practical application guidelines recommended since this GUS may conducted in a real practice by means of multiple PUS with different casuistry.
GUS8	SUPPORT FOR IS/IT INTEROPERABILITY DECISION-MAKING	This GUS involves using the ERA as a support guide to ensure IS/IT interoperability (i.e., defining interfaces/standards to enable collaboration, interaction and information exchange both at intra-organisational level as well and among different organisations). Interoperability can be analysed at different levels of scope – business, processes, information, services, etc. – and perspectives – potentiality, compatibility, efficiency, etc. –.	Train and instruct (#GUS2)	➤ HEIs/ EA Specialists ➤ HEIs/ IS&IT Specialists ➤ HEIs/ Business & Domain Specialists ➤ Other HEIs & Competitors ➤ External Consultants ➤ Government Entities &Regulators ➤ Quality Assurance Regulators ➤ IS/IT Vendors and Providers ➤ Suppliers ➤ Other External Stakeholders	▼ **Cost**: Reduced IS/IT costs ▼ **Risk**: Reduced IS/IT risks (physical threats, technical/infrastructure failures, human errors, etc.) ▲ **Flexibility**: Increased organisational agility/ responsiveness ➤ **Other**: Increased interoperability and integration	1. Use of EA interoperability measurement instruments to evaluate the degree of interoperability of different architectural objects: ▪ EA interoperability assessment methods/ frameworks (Chen, Vallespir, et al., 2008; Elmir & Bounabat, 2010) ▪ EA interoperability metrics, indicators and MMs (Daclin et al., 2008; Guédria et al., 2008).
GUS9	SUPPORT FOR IS/IT INTEGRATION DECISION-MAKING	This GUS involves using the ERA as a communal repository of plausible integration points and their potential degree of integration (i.e., combining multiple objects and elements to function together as a unified whole). Integration can be attached at different levels of scope (i.e., process, application and data) and perspectives (horizontal vs vertical).	Train and instruct (#GUS2)	➤ HEIs/ EA Specialists ➤ HEIs/ IS&IT Specialists ➤ HEIs/ Business & Domain Specialists ➤ External Consultants	▼ **Cost**: Reduced IS/IT costs ▲ **Quality**: Improved/better information quality, sharing, and documentation ▲ **Flexibility:** Improved IS/IT architecture flexibility (reduced waste and redundancy) ▲ **Flexibility**: Increased organisational agility/ responsiveness ➤ **Other**: Increased interoperability and integration	1. Use of EA complexity measurement instruments and methods to support decision-making: ▪ Development of object/structure dependency matrices (Barroero et al., 2010; The Open Group, 2011). ▪ Application of federated (Fischer et al., 2015; Lankhorst, 2004) , ontology-based (Antunes et al., 2014) or holistic-oriented (Shaofeng Liu et al., 2010; M. Themistocleous & Irani, 2003; Wangler & Paheerathan, 2000; Winter, 2003) EA integration methodologies. ▪ EA multilevel complexity metrics and indicators (González-Rojas et al., 2017; Lakhrouit & Baina, 2015b, 2015a; Singh & van Sinderen, 2015)

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ID GENERIC USE SCENARIO	**GENERIC USE SCENARIO NAME**	**GENERIC USE SCENARIO DESCRIPTION**	**POSSIBLE DEPENDENCES**	**POTENTIALLY INVOLVED USERS/STAKEHOLDERS**	**POTENTIAL BENEFITS**	**RECOMMENDED PRACTICAL APPLICATION GUIDELINES**
GUS10	BUSINESS PROCESS STANDARDISATION AND OPTIMISATION	This GUS involves using an ERA as a reference to develop an efficient business process structure based on a set of common and generally well-proven functionalities in institutions within the sector.	Train and instruct (#GUS2)	➤ HEIs/ Quality Assurance & Standards Groups ➤ HEIs/ EA Specialists ➤ HEIs/ Business & Domain Managers ➤ HEIs/ Business & Domain Specialists ➤ HEIs/ Other Employees ➤ Clienteles ➤ External Consultants	▲ **Quality**: Improved/better information quality, sharing, and documentation ▲ **Flexibility**: Increased organisational agility/ responsiveness ➤ **Other**: Increased standardisation/reusability	1. Business process key performance indicators and metrics (Van Looy & Shafagatova, 2016) should be associated to the processes defined in the ERA in order to be able of measure improvements and to control process change. 2. Specific/tailored metrics and indicators for typical processes characteristic of a HEI can be obtained from current existing QA-oriented measurement instruments (Chen et al., 2017; Rezgui et al., 2017).
GUS11	SUPPORT FOR IT INFRAESTRUCTURE HARMONISATION DECISION-MAKING	This GUS involves using an ERA as a support tool to achieve better control of the overall adequacy of the available IT infrastructure by helping to identify costly multi-platform strategies or wasted IT resources originated from personal preferences due to the lack of an enterprise-wide perspective.	Train and instruct (#GUS2)	➤ HEIs/ EA Specialists ➤ HEIs/ IS&IT Specialists ➤ HEIs/ Other Employees ➤ External Consultants ➤ IS/IT Vendors and Providers ➤ Suppliers	▼ **Cost**: Reduced IS/IT costs ▼ **Risk**: Reduced IS/IT risks (physical threats, technical/infrastructure failures, human errors, etc.) ▲ **Flexibility**: Improved IS/IT architecture flexibility (reduced waste and redundancy)	1. Use of the ERA in conjunction with existing conceptual methods for designing IT infrastructure, such as standardisation, consolidation and virtualisation (Krüger et al., 2012).
GUS12	DOCUMENTAL SUPORT FOR QUALITY ASSURANCE AUDITS	This GUS involves using the own ERA's materials as documental support tool for either internal or external QA/QM audit or accreditation purposes.	Business process standardisation and optimisation (#GUS10)	➤ HEIs/ Administrators & Executive Managers ➤ HEIs/ Quality Assurance & Standards Groups ➤ HEIs/ IS&IT Managers ➤ HEIs/ Business & Domain Managers ➤ HEIs/ Business & Domain Specialists ➤ Other HEIs & Competitors ➤ External Consultants ➤ Clienteles ➤ Government Entities &Regulators ➤ Quality Assurance Regulators ➤ Other External Stakeholders	▼ **Time**: Shorter project/activity/ product (QA documentation) development cycle times ▲ **Quality**: Improved quality of the resulting product/output (reusability of knowledge embedded in the ERA) ➤ **Other**: Improved compliance with regulations/ standards and auditability ➤ **Other**: Better structural relationships within a company, industry or domain	1. Subsets or portions of the business-/IS-oriented RMs and landscapes provided by the ERA can work perfectly as a starting point for developing a graphical representation summarizing the HEI's IQAS/QMS currently implemented. 2. Glossaries and vocabularies included within the ERA can be used to provide formal definitions of the constitutive objects of the IQAS/QMS included in graphical representations. 3. Documentation existing for the ERA may require some adaptations to the format/ requirements requested by the QA accredi-tation/audit body/entity.
GUS13	SUPPORT FOR IS/IT (OUT)SOURCING, PROVISION AND ACQUISTIONS DECISIONS	This GUS involves using the ERA as a support tool for defining an organisational acquisition program by helping to identify possible functional and technical gaps of certain existing commercial-of-the-shell and/or vendor-integrated products.	Support for IS/IT intero-perability decision-making (#GUS8) Support for IS/IT integration decision-making (#GUS9) Business process standar-disation and optimisation (#GUS10) Support for IT infrastructure harmonisation decision-making (#GUS11)	➤ HEIs/ IS&IT Managers ➤ HEIs/ IS&IT Specialists ➤ IS/IT Vendors and Providers ➤ Suppliers	▼ **Cost**: Reduced IS/IT costs (internal IS/IT procurement/ tendering processes) ▲ **Flexibility**: Increased agility in the choice of suppliers ▼ **Risk**: Lower risks for acquisition management through multi-sourcing ▲ **Quality**: Improved/better (IS/IT procurement-oriented) information quality, sharing, and documentation	1. Use of multi-criteria provision/acquisition selection methods (Boyd & Geiger, 2010; Setti et al., 2015). Results of the analysis performed with the ERA should by explicitly considered in the selection criteria established.

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<GUS$_1$>	<GUS$_2$>	<GUS$_3$>	<GUS$_4$>	<GUS$_5$>	<GUS$_6$>	<GUS$_7$>
ID GENERIC USE SCENARIO	**GENERIC USE SCENARIO NAME**	**GENERIC USE SCENARIO DESCRIPTION**	**POSSIBLE DEPENDENCES**	**POTENTIALLY INVOLVED USERS/STAKEHOLDERS**	**POTENTIAL BENEFITS**	**RECOMMENDED PRACTICAL APPLICATION GUIDELINES**
GUS14	SUPPORT FOR MERGER AND INTEGRATION INITIATIVES	This GUS involves using the ERA to determine the new solution EA of the organisational entity emerged of the initiative, by identifying common architectural domain objects existing in the current solution EA of each one of the entities to be unified.	Documental support for quality assurance audits (#GUS12) Deliver a roadmap, migration, transition or transformation plan (#GUS20)	➤ HEIs/ Administrators & Executive Managers ➤ HEIs/ IS&IT Managers ➤ HEIs/ Business & Domain Managers ➤ External Consultants ➤ Other HEIs & Competitors ➤ Other External Stakeholders	➤ **Other:** Improved communication/understanding among different stakeholders ➤ **Other:** Creation and maintenance of common visions ▼ **Time**: Shorter project/activity/ product development cycle times ▼ **Risk**: Lower risks of failure for the initiative (miss-evaluations or calculations of assets) ▲**Quality**: Improved/better information quality, sharing, and documentation (homogenisation in the definition of requirements, elimination of discrepancies between documents, etc.)	1. Use of the ERA in conjunction with merger/integration methodologies tailored for HEIs to characterise the desired to-be solution EA scenario to be achieved after finishing the initiative (Sułkowski et al., 2019; Syynimaa, 2010).
GUS15	REFERENCE FOR INDUSTRY/ SECTORIAL BENCHMARKS, COMPARISONS AND MAPPINGS	This GUS involves using the ERA as a reference mark against which other sector-related frameworks can be assessed, measured, related or compared.	Gap analysis with an individual model (#GUS19)	➤ HEIs ➤ Other HEIs & Competitors ➤ Government Entities &Regulators ➤ Quality Assurance Regulators ➤ IS/IT Vendors and Providers ➤ Suppliers ➤ Other External Stakeholders	➤ **Other:** Improved compliance with regulations/ standards and auditability ➤ **Other:** Better structural relationships within a company, industry or domain ➤ **Other:** Increased standardisation/reusability	1. Use of techniques as ontological meta-modelling (Fettke & Loos, 2003b; Henderson-Sellers, 2012; Wand & Weber, 1993), matrix-like structures (Bernus et al., 1996) or translation analysis (Dixon-Woods et al., 2005, p. 48; Noblit & Hare, 1988) that allow the establishment of correspondences between elements members of different structures – i.e., *homomorphism* (Patas et al., 2013, p. 356) –.
GUS16	CONSULTANCY ARTEFACT	This GUS involves using the ERA as consulting artefact for multiple consultancy purposes, since it can be can be viewed as a provider of consolidated and up-to-date knowledge captured from real HEIs.	Project initialisation support (#GUS7)	➤ HEIs ➤ External Consultants ➤ Other HEIs & Competitors ➤ Government Entities &Regulators ➤ Quality Assurance Regulators ➤ IS/IT Vendors and Providers ➤ Suppliers ➤ Other External Stakeholders	▼ **Time**: Shorter project/activity/ product development cycle times (consultancy product/service) ▲ **Quality**: Improved quality of the resulting product/output (reusability of knowledge embedded in the ERA) ➤ **Other**: Better structural relationships within a company, industry or domain ➤ **Other**: Improved consolidation, synergies, collaboration and reduced conflict of interest	No practical application guidelines recommended since this GUS may conducted in a real practice by means of multiple PUS with different casuistry.
GUS17	SUPPORT FOR IS/ APPLICATION DEVELOPMENT	This scenario GUS using the ERA as a standard to determine requirements, functionalities or features that have to be implemented by an IS or application to become a *conformant product* (i.e., regulation-specific software)., in terms of a specific regulation, standard or normative	Support for IS/IT (out)sourcing, provision and acquisitions decisions (#GUS13) Gap analysis with an individual model (#GUS19)	➤ HEIs/ IS&IT Specialists ➤ HEIs/ Business & Domain Specialists ➤ IS/IT Vendors and Providers	▼ **Cost**: Reduced IS/IT costs (regulation-specific software product) ▼ **Time:** Shorter project/activity /product development cycle times ▲ **Quality**: Improved quality of the resulting product/output (regulation-specific software product)	1. Document and discourse/content analysis techniques could be of certain utility to infer requirements from the documentation existing for the ERA (Krippendorff, 2012; Oates, 2005, pp. 233–244; Potter & Wetherell, 1987). 2. Iterative and agile-oriented software development methodologies may enable and foster the execution of multiple validation episodes to the compliance checks defined for the software (Larman, 2003; Martin, 2014).

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ID GENERIC USE SCENARIO	**GENERIC USE SCENARIO NAME**	**GENERIC USE SCENARIO DESCRIPTION**	**POSSIBLE DEPENDENCES**	**POTENTIALLY INVOLVED USERS/STAKEHOLDERS**	**POTENTIAL BENEFITS**	**RECOMMENDED PRACTICAL APPLICATION GUIDELINES**
GUS18	IDENTIFICATION OF OPPORTUNITIES OF COOPERATION AND COORDINATION (SYNERGIES) AMONG DIFFERENT SECTORIAL UNITS/ENTITITES	This GUS involves using the ERA to identify potential opportunities of coordination of cooperation to leverage synergies among different actors related in some or another way within the HE industry. Typical examples of opportunities involving several entities may include the cooperative development of shared applications and services, the establishment of common strategies for optimizing or rationalizing IT resource allocation among different sectorial entities, or even the establishment of cross-sectorial platforms.	Support for creating an EA product, RM or ERA (#GUS5) Documental support for quality assurance audits (#GUS12) Reference for industry/sectorial benchmarks, comparisons and mappings (#GUS15) Consultancy artefact (#GUS16) Framework for Legal/Technical Regulatory Compliance (#GUS22)	➤ HEIs ➤ Clienteles ➤ External Consultants ➤ Other HEIs & Competitors ➤ Government Entities &Regulators ➤ Quality Assurance Regulators ➤ IS/IT Vendors and Providers ➤ Suppliers ➤ Other External Stakeholders	▼ **Cost**: Reduced IS/IT costs (due to economies of scale, efficiency) ➤ **Other**: Increased standardisation/reusability ➤ **Other**: Better structural relationships within a company, industry or domain ➤ **Other**: Improved consolidation, synergies, collaboration and reduced conflict of interest ➤ **Other**: Provided a holistic view of the organisation/sector	No practical application guidelines recommended since this GUS may conducted in a real practice by means of multiple PUS with different casuistry.

b) Scenarios with supporting evidence found for the Public Sector (PS)

BASIC TUPLE (static constant fields)			EXTENDED TUPLE (suggested values to be chosen/adapted/tailored)			
<GUS$_1$>	<GUS$_2$>	<GUS$_3$>	<GUS$_4$>	<GUS$_5$>	<GUS$_6$>	<GUS$_7$>
ID GENERIC USE SCENARIO	**GENERIC USE SCENARIO NAME**	**GENERIC USE SCENARIO DESCRIPTION**	**POSSIBLE DEPENDENCES**	**INVOLVED USERS/ STAKEHOLDERS**	**POTENTIAL BENEFITS**	**PRACTICAL APPLICATION GUIDELINES**
GUS19	GAP ANALISYS WITH AN INDIVIDUAL MODEL	This GUS involves comparing a desired or intended target EA with a current or baseline architecture. The ERA may play a role both as a target or baseline architecture, and the basic premise is to highlight a shortfall between the baseline and the target architecture in order to reveal possible areas of improvement	Train and instruct (#GUS2)	➤ HEIs/ EA Specialists ➤ HEIs/ IS&IT Specialists ➤ External Consultants ➤ IS/IT Vendors and Providers	▼ **Time**: Speed-up the enterprise architecting process and/or delivery of the solution EA ▼ **Cost**: Reduced cost of EA architecting/modelling activities (reusability of already existing and validated ERA/RMs). ▲ **Quality**: Improved/better information quality, sharing, and documentation ▼ **Risk**: Lessening of architecting/ modelling activities risk (reusability of already existing and validated ERA/RMs).	1. Typically potential sources of gap (The Open Group, 2011) may range from process and data gaps (cross-training requirements, inefficiencies and duplicates) to applications and infrastructure gaps (elements impacted, eliminated, created or modified). 2. Use of the ERA in conjunction with several existing systematic approaches for developing gap analyses in the context of EA – matrix-based gap analysis (The Open Group, 2011), semantic web based gap analysis (Diefenthaler & Bauer, 2013) or axiomatic design based gap analysis (Behrouz & Fathollah, 2016) –.

BASIC TUPLE (static constant fields)			EXTENDED TUPLE (suggested values to be chosen/adapted/tailored)			
<GUS$_1$>	**<GUS$_2$>**	**<GUS$_3$>**	**<GUS$_4$>**	**<GUS$_5$>**	**<GUS$_6$>**	**<GUS$_7$>**
ID GENERIC USE SCENARIO	**GENERIC USE SCENARIO NAME**	**GENERIC USE SCENARIO DESCRIPTION**	**POSSIBLE DEPENDENCES**	**INVOLVED USERS/ STAKEHOLDERS**	**POTENTIAL BENEFITS**	**PRACTICAL APPLICATION GUIDELINES**
GUS20	DELIVER A ROADMAP, MIGRATION, TRANSITION OR TRANSFORMATION PATH	This GUS involves using the ERA as an (intermediate) transition architecture to figure out an ordered sequence of EA initiatives required in order to make an architectural transformation journey from a current (as-is) solution EA towards a future desired or targeted (to-be) solution EA. An ERA may help to achieve an overall understanding on how new systems or processes will work within a new overall (planed) IT infrastructure or how emerging technologies may fit with (current) existing ones.	Gap Analysis with an Individual Model (#GUS19) Modelling support for developing a specific solution architecture (#GUS6)	➤ HEIs/ EA Specialists ➤ HEIs/ IS&IT Managers ➤ HEIs/ IS&IT Specialists ➤ HEIs/ Business & Domain Managers ➤ HEIs/ Business & Domain Specialists	▼ **Time**: Speed-up the enterprise architecting process and/or delivery of the solution EA ▼ **Cost**: Reduced cost of EA architecting/modelling activities (reusability of already existing and validated ERA/RMs). ▲ **Quality**: Improved/better information quality, sharing, and documentation ➤ **Other**: Provided a holistic view of the organisation/sector	1. Application of systematic methodologies or procedures for creating EA roadmaps (Hirvonen & Pulkkinen, 2004; Parnitzke, 2013).
GUS21	SUPPORT FOR (OPERATIONAL) BUSINESS-IS/IT ALIGNMENT	This GUS involves using an ERA as baseline for creating (virtual) architectural alignment layers as a mechanism for business-IS/IT alignment. Architectural alignment layers encompass dedicated mapping artefacts (i.e., services) decoupling point-to-point relationships between business objects (process functions, etc.) and IS/IT objects (data, applications, etc.), and grouping therefore IS/IT functionalities from a business perspective.	Deliver a roadmap, migration, transition or transformation plan (#GUS20)	➤ HEIs/ Administrator and Executive managers ➤ HEIs/ EA Specialists ➤ HEIs/ IS&IT Managers ➤ HEIs/ Business & Domain Managers	➤ **Other**: Improved alignment to organisational strategy ▲ **Flexibility**: Increased organisational agility/ responsiveness ➤ **Other**: Provided a holistic view of the organisation ➤ **Other:** Creation and maintenance of common visions	1. Application of virtual decoupling oriented methodologies for business-IS/IT alignment (Aier & Winter, 2009; Mettler, Fitterer, et al., 2014).
GUS22	FRAMEWORK FOR LEGAL/TECHNICAL REGULATORY COMPLIANCE	This scenario GUS prescribing (or strongly recommending) the use of an ERA to verify compliance with legal requirements as well as voluntary codes. In this sense, the ERA should be seen as a “contract” that needs to be complied.	Reference for industry/sectorial benchmarks, comparisons and mappings (#GUS15) Deliver a roadmap, migration, transition or transformation plan (#GUS20)	➤ HEIs ➤ Clienteles ➤ External Consultants ➤ Other HEIs & Competitors ➤ Government Entities &Regulators ➤ Quality Assurance Regulators ➤ IS/IT Vendors and Providers ➤ Suppliers ➤ Other External Stakeholders	➤ **Other**: Improved compliance with regulations/ standards and auditability ➤ **Other**: Better structural relationships within a company, industry or domain ➤ **Other**: Improved consolidation, synergies, collaboration and reduced conflict of interest ➤ **Other**: Provided a holistic view of the organisation/sector	1. EA-oriented compliance assessment methodologies (Čyras & Riedl, 2012; Foorthuis et al., 2012) can be used to check and test the level of conformance against the ERA, which should be used as a reference point for assessment. 2. Regulatory codes must be contemplated in a wide sense, including legal or technical aspects that may affect the business processes, data/information or IS/IT of a class of enterprises.

Source: Own elaboration

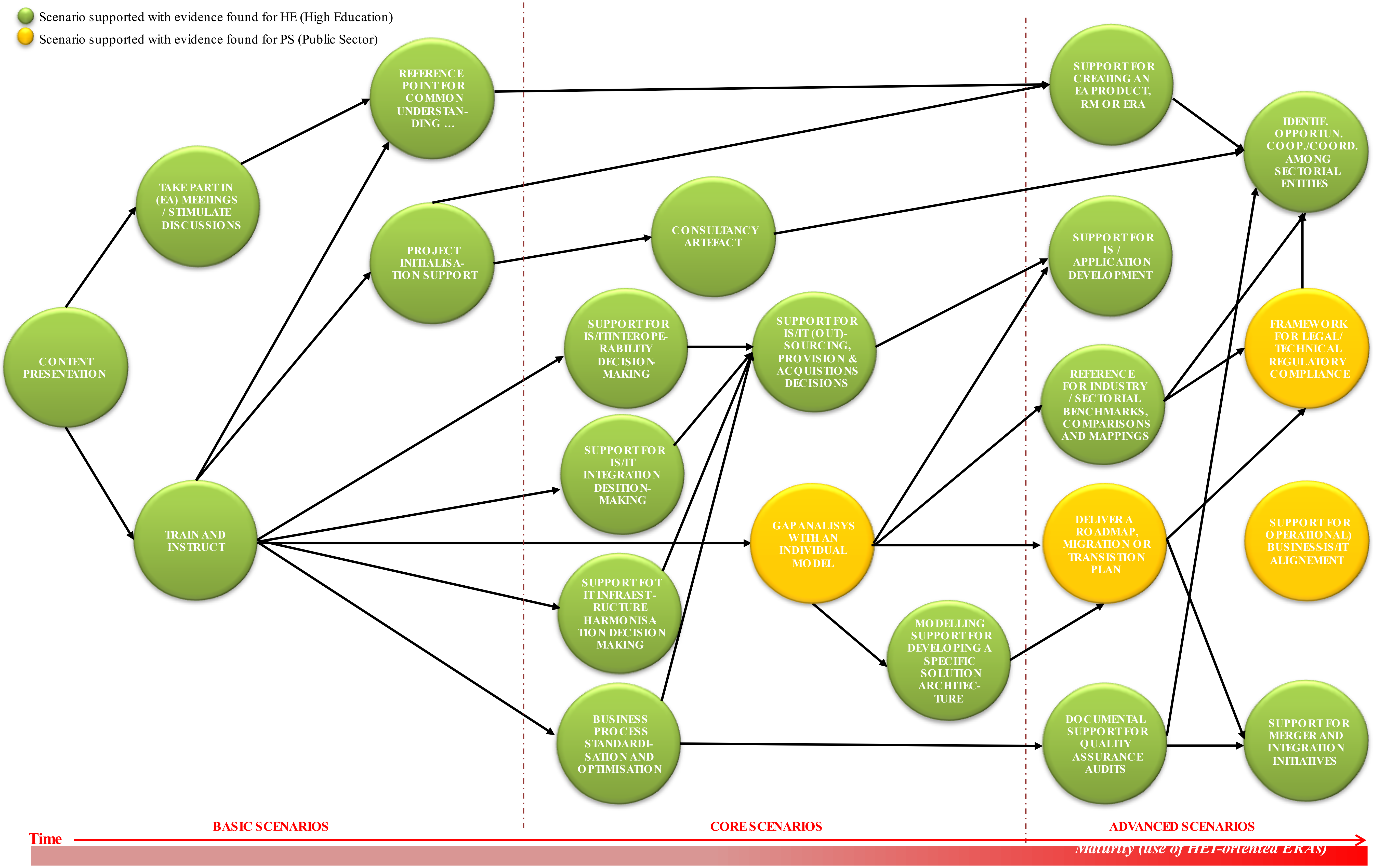

Figure 21 – Dependency Graph of Use Scenarios for Higher Education-Oriented Enterprise Reference Architectures

Source: own elaboration

3.5.3. Justify and Reflect

Justify and reflect represents the last sub-activity to be conducted during the *design and development* stage of the DSRM methodology. Two main goals can be associated to this ending sub-activity: first, to clearly specify the justification of the structure and functionality of the conceived artefact; second, to reflect over the entire *design and development* process followed in order to construct the envisioned artefact. In the following paragraphs, we briefly elaborate on how such goals have been achieved in terms of the present research.

First, and regarding the justification of the design decisions adopted, (Johannesson & Perjons, 2014) refer to the convenience of documenting the *design rationale* followed during the whole design process, including alternative decisions considered as well as the list of design decisions finally made including those reasons and arguments leading to such taken design decisions. According to the same authors (2014, p. 126) this *design rationale* adopted can be one of the most valuable outcomes of a DSR project since "*it records design decisions including potential pitfalls. This knowledge can be of great value to subsequent projects, and in particular, it may help designers to avoid dead ends and other kind of problems*".

The *design rationale* followed in this research has already been detailed during the previous sections. On the one hand, the major design alternatives considered as well as the final decision determination of following a rather *hybrid* development strategy have been clearly documented in section 3.5.1 (*Generate, Select and Assess Design Alternatives*). Similarly, and on the other hand, design decisions related to the "meta-structure" of the constructed artefact as well as the final set of GUSs for HEI-oriented ERAs finally considered in the constructed instrument framework have also been justified in the earlier section 3.5.2 (*Sketch and Build*, Tables 22 to 25). Hence, no further considerations on the *design rationale* will be made again. For instance, in the remaining of this section the focus will be exclusively put on the second goal of this sub-activity: reflecting on the entire design process followed.

To do that in a relatively simple way, we proceed to compare the new instrument framework conceived with the 8 artefacts previously investigated in section 3.3.4 following the same comparative approach. The following couple of tables show the results achieved for the analysis performed. On the one hand, Table 26 provides an extended version including our new conceived artefact of the results obtained after applying the homogenizing "*normalisation*" process to all the structural elements configuring each artefact compared. On the other hand, Table 27 provides an extended version considering our developed artefact of the assessment analysis performed to each one of the artefacts in terms of level of accomplishment will all the requirements [RE] to be assessed.

Data presented in Table 26 reveals that our new constructed instrument framework achieves very good results in terms of (i) levels of coverage (total of ●) and (ii) number of USs considered. As a consequence, these issues are in turn reflected in the subsequent Table 27 when assessing artefact's compliance in terms of the requirements [RE] to be assessed since our artefact framework reaches the maximum score possible when being individually evaluated for compliance with requirement [RE.3] (*completeness*) and with requirement [RE.5] (*level of detail*).

Table 26 – Normalisation for Comparative Purposes of the Structural Elements of the Existing Investigated Artefacts and the New Artefact Framework Developed

FACET	"NORMALIZED" ELEMENTS	*Catalogue of Application Scenarios for EA Models* (Bucher et al., 2006)	*Model of EA Standards Use for IT* (Boh & Yellin, 2006)	*Classification of EA Use Scenarios in practice* (Aier et al., 2008)	*Catalogue of Uses in Practice of EA Principles* (Greefhorst et al., 2013)	*Framework for EA Artefact Use Situations* (Niemi & Pekkola, 2017)	*Application Design Framework for RMs* (Timm, 2018)	*Systematic description of EA artefact' s use* (Kotusev, 2019)	*Classification of EA Activity Areas in Practice* (Kurnia et al., 2020)	*Our Constructed Artefact Framework*
What		●	●	●	●	●	●	●	●	●
	Artefact Details/Information contents	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Documentation information		✓		✓		✓	✓		✓
	Accessibility information						✓			✓
Why / For What		●	●	●	●	●	●	●	●	●
	Use Situation / Application Scenario / Practical Usage	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Motive/Benefit/Key Purpose/Value	✓	✓		✓	✓	✓	✓	✓	✓
	Blockers								✓	✓
How						●	●		●	●
	Descriptive details / exemplary case studies providing insights on the practical usage					✓	✓		✓	✓ [(a)]
	Specific mechanisms or strategies for EA artefact usage in practice						✓			✓
By Whom					●	●	●	●	●	●
	Stakeholders involved in the artefact creation/development					✓		✓		
	Stakeholders involved in the artefact usage/application				✓	✓	✓	✓	✓	✓
When						●				●
	Development phase (in terms of an EA Project)					✓				
	Temporal dependencies (in terms of artefact's usage)									✓
	Coverage level (total of ●)	2	2	2	3	5	4	3	4	**5**
	"Normalized" elements (total of ✓)	3	4	2	5	7	8	6	6	**9**
	Declared number of USs addressed	15	4	3	23	16	7	24	11	**22**

Legend [(a)] To be developed in the following chapter

Source: Own elaboration

Table 27 – Compliance Level of Evaluated Artefact's in Terms of the Requirements Defined

		Existing Artefacts								
#Id	**Requirement**	*Catalogue of Application Scenarios for EA Models* (Bucher et al., 2006)	*Model of EA Standards Use for IT* (Boh & Yellin, 2006)	*Classification of EA Use Scenarios in practice* (Aier et al., 2008)	*Catalogue of Uses in Practice of EA Principles* (Greefhorst et al., 2013)	*Framework for EA Artefact Use Situations* (Niemi & Pekkola, 2017)	*Application Design Framework for RMs* (Timm, 2018)	*Systematic description of EA artefact' s use* (Kotusev, 2019)	*Classification of EA Activity Areas in Practice* (Kurnia et al., 2020)	*New developed framework*
[RE.1]	*Particularity*	◑	◕	◔	◕	◑	◕	◕	◑	●
[RE.2]	*Understandability*	◑	◑	◑	◑	◕	◕	◑	◕	◕
[RE.3]	*Completeness*	◔	◔	◔	◑	●	◕	◑	◕	●
[RE.4]	*Consistence*	◑	◕	◔	◑	●	●	●	●	●
[RE.5]	*Level of detail*	◕	◔	◔	●	◕	◑	●	◑	●
[RE.6]	*Accessibility*	●	●	●	●	●	●	●	●	●
[RE.7]	*Adaptability*	●	●	◑	●	◕	◕	●	●	◕
Σ[RO]	***TOTAL COMPLIANCE SCORE***	***18***	***18***	***12***	***21***	***23***	***22***	***23***	***22***	***26***
Σ[RO] /4*n	***AVERAGE COMPLIANCE SCORE***	***64,29%***	***64,29%***	***42,86%***	***75,00%***	***82,14%***	***78,57%***	***82,14%***	***78,57%***	***92,86%***

◔ 1 point ◑ 2 points ◕ 3 points ● 4 points

Source: Own elaboration

In addition, data from Table 26 shows that our new artefact constructed presents the highest number of "*normalized*" elements – total count of ✓ in Table 26 – of all the artefacts evaluated. Whilst this latter aspect seems to have little affection in terms of requirement [RE.4] (*consistency*), on the contrary it tends to compromise the full achievement of requirement [RE.2] (*understandability*) due to the relatively high overall structural complexity of the constructed artefact when compared with other already existing ones.

Whatever the case, results presented in Table 27 allow us to conclude that the design process undertaken for constructing our new instrument artefact seems to have been successful (effective) in order to develop a new and better artefact for the purposes defined – see again section 3.1– since, when compared with other existing ones reaches a higher average compliance score – last row of earlier Table 27 –.

Finally, to conclude with this chapter, and as a colophon for the present justify and reflect sub-activity, in the following Figure 22 we present an extended and actualized version of Figure 15 representing a detailed schema of the instrument artefact constructed describing its fundamental logic of form and functioning.

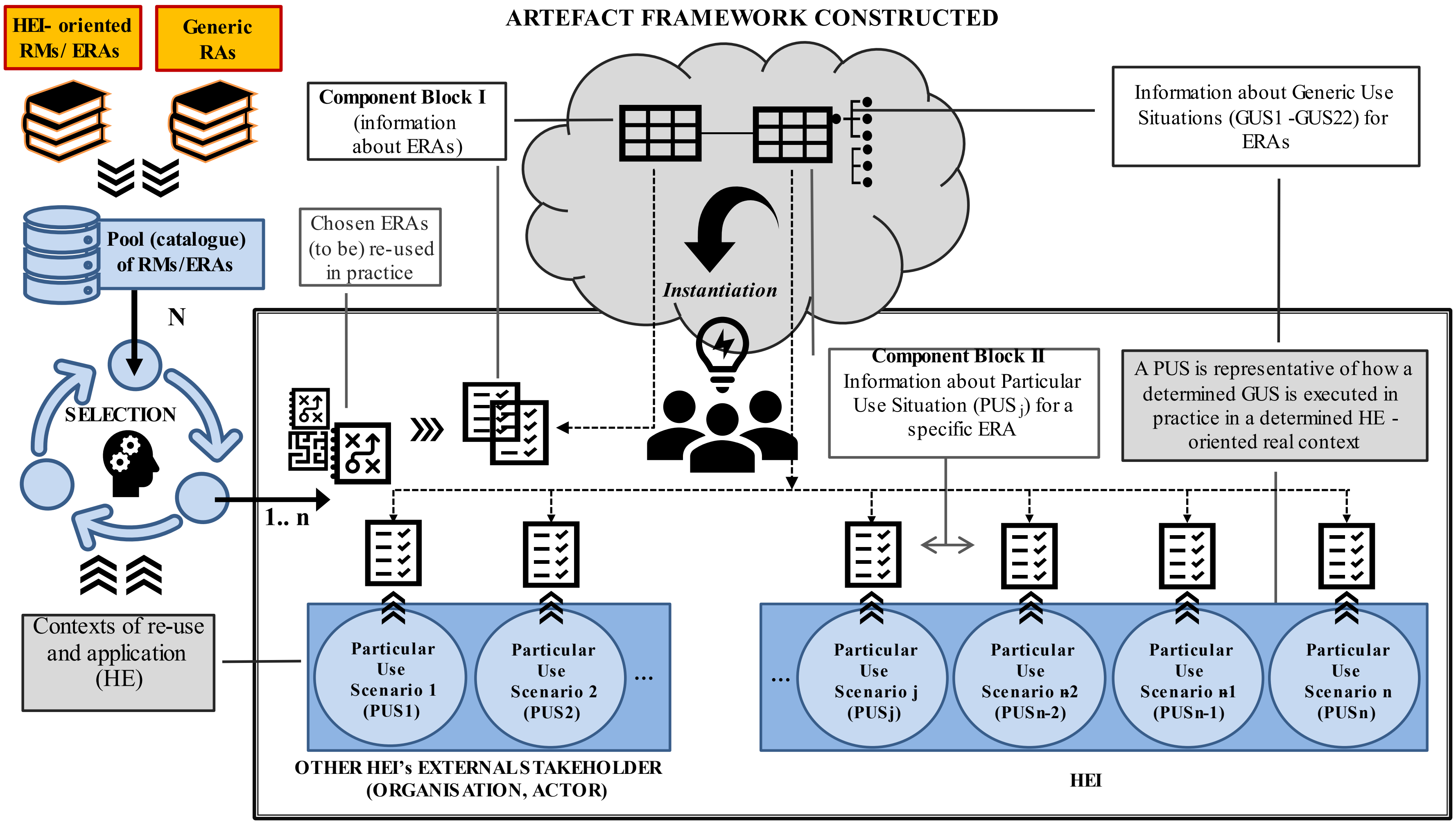

Figure 22 – Extended Detailed Schema of the Artefact Framework Constructed and its Implications

Source: own elaboration

4. Evaluating the New Artefact Framework for Facilitating the Use of HEI-oriented ERAs

4.1. Introduction

This chapter describes the activities conducted during the research devoted to evaluate the artefact framework constructed. Hence, and first of all, foundational knowledge about DSR evaluation is presented, including the concept of *evaluation strategy* and how it can be used to complement the evaluation stages explicitly considered by the DSRM methodological approach adopted for this research. Following, we detail how all this background has been implemented in our research project by describing the concrete evaluation strategy defined as well as the specific evaluation episodes defined to operationalize and execute it. Evaluation episodes have been conceived having in mind a double perspective: on the one hand, the evaluation of artefact framework constructed (i.e., the *design product*) through its application in several practical experiences that took place in different HE-oriented contexts in which ERAs were actually used. On the other hand, we also performed an evaluation from the perspective of the specific DSR research process followed during this research (i.e., the *design research)* by discussing it from the perspective of the 7 quality guidelines for DSR-oriented research proposed by (Hevner et al., 2004).

The contents included in this chapter correspond to the (iv) *demonstration* and (v) *evaluation* stages of the DSRM methodological approach adopted for this research, *supplementing and extending* therefore the *earlier conducted steps* described in the second part of Chapter 3 towards providing answers to *the third research question of the thesis [RQ.3].*

4.2. Evaluating Artefacts in Design Science Research

Nowadays, DSR has gained wide acceptance in the IS community as a valid research approach for solving practical problems by means of the construction and subsequent introduction in practice of artefacts conceived through a simple *build/evaluate* pattern (Baskerville et al., 2018; Gregor & Hevner, 2013; Hevner et al., 2004; Peffers et al., 2018). Most existing DSR methodologies tend to defer evaluation activities to the end of the research process, once the artefact has already been constructed (Alturki, 2012; Johannesson & Perjons, 2014; Österle et al., 2011; Vaishnavi et al., 2017). This is also the case for the DSRM methodological approach chosen for the present thesis, which particularly considers 2 different evaluation activities: *demonstration* – i.e., showing whether the artefact works as intended in a determined problem instance –, and *evaluation* – showing the utility of the artefact constructed in a wide range of contexts of practice – (Peffers et al., 2007).

However, and despite this approach represents a "*richer mode for evaluation than is generally accepted to support applied social science research, [… it] does not embed a specific iterative evaluation process into DSR, as some methodologies do*" (Peffers et al., 2018, p. 133). Thereby, evaluating artefacts at the end of the research process may have serious drawbacks, including (among others) resource and time inefficiencies due to wasting by *messing design flaws* until the artefacts is constructed (Abraham et al., 2014, p. 2; Sonnenberg & vom Brocke, 2012b, p. 381; Venable et al., 2016, pp. 79–80).

To avoid that, over the last years several alternative methodological approaches have proliferated reconsidering the "*traditional sequence of build first, evaluate later*", moving therefore towards more iterative and cyclic-oriented proposals, and leveraging the role of evaluations within DSR in a twofold way (Abraham et al., 2014; Sonnenberg & vom Brocke, 2012a). On the one hand, new methodological approaches recommend the execution of more evaluation episodes through the whole DSR process. On the other hand, they also advocate for validating not only the artefact – the *design product* – but also the entire process followed to it – i.e., the *design research* –. Moreover, such new DSR methodological approaches have been complemented by additional studies providing (i) new evaluation patterns and recommendations at the more fine-grained level of specific evaluation episodes, and (ii) by suggesting convenient evaluation criteria and techniques to be used also at the particular scope of individual evaluation episodes (Abraham et al., 2014; Cleven et al., 2009; Dinter & Krawatzeck, 2015, pp. 5–7; Kotze et al., 2015, pp. 6–7; Mettler, Eurich, et al., 2014; Peffers et al., 2012; Prat et al., 2015, 2014; Sonnenberg & vom Brocke, 2012b, 2012a).

In this sense, and for the purposes of this thesis, we decided to use the *Framework for Evaluation in Design Science* (FEDS) (Venable et al., 2012, 2016) as a reference point to (i) design an overall *evaluation strategy* for the artefact constructed during the research, and (ii) to incorporate additional evaluation activities and checks to the nominal sequence of DSR stages defined by the original DSRM methodology. We chose the FEDS framework since it is probably the most cited and well-acknowledged DSR instrument for such purposes.

4.2.1. Artefact Evaluation Strategy

In a general sense, the FEDS framework can be viewed as a support tool for defining at a rather "*macro-level*" perspective an *evaluation strategy* (i.e., a "*planned trajectory*" set of evaluation episodes) for a DSR constructed artefact. From a more "*micro*" or operative perspective, the FEDS framework can be understood as a bi-dimensional characterisation of DSR evaluation episodes. The first dimension considers the functional purpose of the evaluation (i.e., the *why to evaluate*) which can be either *formative* or *summative*. The second dimension refers to the paradigm chosen for evaluation (i.e., the *how to evaluate*) which can be either *artificial* or *naturalistic*. Such a bi-dimensional approach tends to be further extended with a third dimension of analysis, which can be viewed as rather orthogonal to the earlier ones: the temporal perspective of evaluation (i.e., the *when to evaluate*).

On the one hand, *formative* evaluations are used *"to produce basis for successful action in improving the characteristics or performance of the evaluand"* and tend to focus on consequences supporting *"the kinds of decisions that intend to improve the evaluand*" (Venable et al., 2016, p. 78). On the other hand, *summative evaluations* are used to "*provide a basis for creating shared meanings about the evaluand in the face of different contexts*" which focus is rather put on "*meanings and support the kinds of decisions that intend to influence the selection of the evaluand for an application*" (Venable et al., 2016, pp. 79–80).

Formative evaluations usually take place *ex-ante* – while the artefact is being developed – meanwhile *summative* ones are usually executed *ex-post* – once the artefact has been constructed – (Wiliam & Black, 1996). It should be made clear here that the temporal dichotomy *ex-ante/ex-post* exclusively refers to the *timing* of the evaluation, and therefore, it is certainly plausible either that *summative evaluations* may be required on an *ex-ante* basis or that *ex-post* evaluations may have a *formative* purpose (Abraham et al., 2014, p. 2; Venable et al., 2016, pp. 79–80).

Finally, a*rtificial* evaluation is used to test design hypotheses to understand why an artefact works, and usually takes place prior to artefact construction (*ex-ante*). Supporting research techniques for conducting this type of evaluation activities may include laboratory experiments, simulations, criteria-based analysis, theoretical arguments or mathematical proofs (Venable et al., 2012, 2016). On the contrary, *Naturalistic* evaluation is rather devoted to show that an artefact is able to solve a real problem when used by real users. Thus, it generally takes place once the artefact has been constructed (*ex-post*) [44] typically involving research methods like case studies, field studies, field experiments, surveys, ethnographies or action research (Venable et al., 2012, 2016).

Grounding on the *why* and *how* evaluative dimensions, the FEDS framework defines 4 basic "*theoretical*" strategies for evaluating a DSR artefact, ranging from an elemental or simple evaluation strategy, to other alternative and more robust or comprehensive strategies (see following Table 28). Each "*theoretical*" strategy provides a different template recommending the most adequate "*trajectory set*" of individual evaluation episodes according to a couple of criteria: the *artefact type* to be evaluated [45] and the *circumstances surrounding* (i.e., restrictions, boundaries, etc.) the research endeavours conducted.

Table 28 – Strategies for Artefact (Design Product) Evaluation in Design Science Research

NAME	BASIC DESCRIPTION	CIRCUSNTANCE SELECTION CRITERIA
Quick & Simple	The Quick & Simple strategy conducts relatively little formative evaluation and progresses quickly to summative and more naturalistic evaluations. The evaluation trajectory of this strategy includes relatively few evaluation episodes (perhaps even only one summative evaluation at the end). Such a strategy is low cost and encourages quick project conclusion, but may not be reasonable in the face of various design risks.	If small and simple construction of design, with low social and technical risk and uncertainty.
Human Risk & Effectiveness	The Human Risk & Effectiveness evaluation strategy emphasises formative evaluations early in the process, possibly with artificial, formative evaluations, but progressing quickly to more naturalistic formative evaluations. Near the end of this strategy more summative evaluations are engaged, which focus on rigorous evaluation of the effectiveness of the artefact, that is, that the utility/benefits of the artefact will continue to accrue even when the artefact is placed in operation in real organisational situations and over the long run, despite the complications of human and social difficulties of adoption and use.	If the major design risk is social or user oriented *and/or* If it is relatively cheap to evaluate with real users in their real context *and/or* If a critical goal of the evaluation is to rigorously establish that the utility/benefit will continue in real situations and over the long run

[44] According to (Abraham et al., 2014; Prat et al., 2015) *ex-post/naturalistic* evaluations of an artefact – i.e., showing that an artefact is actually useful in the "*three realities*" paradigm of real tasks, real systems, and real users as evaluation realities (Sun & Kantor, 2006) – are certainly desirable in DSR endeavours.

[45] According to (Drechsler, 2015, p. 35; Drechsler & Dörr, 2014, pp. 7–8), within the IS arena 4 different types of socio-technical artefacts can be differentiated for analytical purposes: *technical artefacts* (hardware and software systems with no end-user interaction); *technical artefacts that consider social aspects* (those artefacts including the end-users' perspective); *[pure] socio-technical artefacts* that comprise IT, people, and business processes comprehensively and in integrative way); and *social artefacts* (artefacts that comprise social/ organisational structures, processes, and people).

NAME	BASIC DESCRIPTION	CIRCUSNTANCE SELECTION CRITERIA
Technical Risk & Efficacy	The Technical Risk & Efficacy evaluation strategy emphasises artificial formative evaluations iteratively early in the process, but progressively moving towards summative artificial evaluations. Artificial summative evaluations are used to rigorously determine efficacy of the artefact, that is, that the utility/benefits derived from the use of the artefact are due to the artefact, not due to other factors. Near the end of this strategy more naturalistic evaluations are engaged.	If the major design risk is technically oriented *and/or* If it is prohibitively expensive to evaluate with real users and real systems in the real setting *and/or* If a critical goal of the evaluation is to rigorously establish that the utility is due to the artefact, not something else.
Purely Technical Artefact	The Purely Technical strategy is used when an artefact is purely technical, without human users, or planned deployment with users is so far removed from what is developed to make naturalistic evaluation irrelevant. This strategy is similar to the Quick & Simple strategy, but favours artificial over naturalistic evaluations throughout the process, as naturalistic strategies are irrelevant to purely technical artefacts or when planned deployment with users is far in the future.	If artefact is purely technical (no social aspects) *or* artefact use will be well in future and not today.

Source: (Venable et al., 2016, pp. 81–82)

Considering these 4 “theoretical” strategies defined by the FEDS framework, the *evaluation strategy* finally followed during the present research could be seen as something rather in-between the “*quick and simple*” and the “*human risk & effectiveness*” theoretical approaches. This claim is grounded on the following rationale:

- on the one hand, the “*purely social”* nature of our constructed artefact framework as well as the mail goal associated to this research on showing its *practical utility/usefulness*. Both these facts seem to suit well for a “*human risk & effectiveness*” strategy, meanwhile other more technically-intensive strategies (i.e., “*technical risk & efficacy*” and “*purely technical artefact*”) should be discarded.
- on the other hand, the own idiosyncrasy of the present research project – a *Professional Doctorate* one – as well as the problems surrounding our relationship with the industrial partner of the research (see section 1.7) led us to think about adopting a rather conservative “*quick & simple*” evaluation approach.

In sum, despite accepting that the “*human risk & effectiveness*” strategy could be viewed as the most optimal one for our purposes, research boundaries occurred during the execution of the thesis led us to finally adopt a rather *hybrid* evaluation strategy. The specific *trajectory set* of evaluation episodes finally executed is presented in the following Figure 23 (red-coloured trajectory). Readers must mote that, when compared with the nominal sequence of DSR stages considered by the DSRM methodology, the *trajectory set* proposed adds 3 additional evaluation activities – corresponding to evaluation episodes E1 to E3 –. The remaining E4-E5 episodes correspond, respectively, to the *demonstration* and *evaluation* stages considered by the original DSRM approach. The particular details characterising each one of the evaluation episodes defined for the thesis are detailed in the following section.

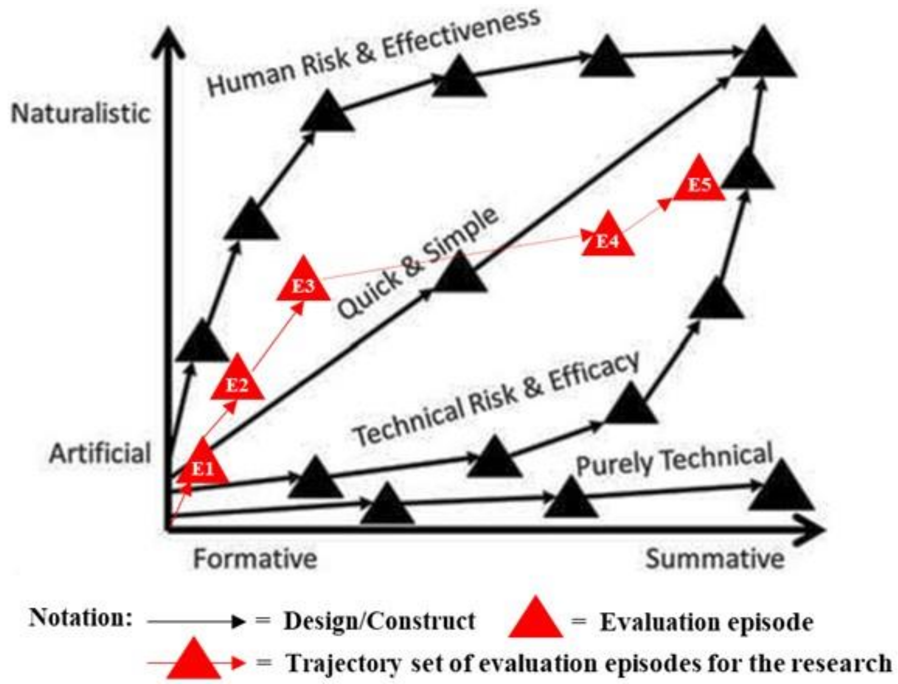

Figure 23 – Evaluation Strategy for the Research

Source: Adapted from (Venable et al., 2016, p. 80)

4.2.2. Sequence of Particular Evaluation Episodes

To operationalize the earlier *trajectory set* of evaluation episodes to be executed, we drew on specialized literature on evaluation for DSR initiatives in the IS arena (Abraham et al., 2014; Cleven et al., 2009; Peffers et al., 2012; Prat et al., 2015; Sonnenberg & vom Brocke, 2012a, 2012b). Collectively, all these contributions offer a reasonable corpus of knowledge providing guidance and practical recommendations on how to concretize and characterise a determined DSR evaluation episode. In particular, these contributions tend to provide about the *what* to evaluate – i.e., which properties or characteristics of the artefact constructed should be evaluated – as well as on the *how* to evaluate – i.e., techniques, methods, criteria and patterns applicable to particular evaluation activity or episode (i.e., *demonstration*, *evaluation*) –. Thereby, they suit perfectly well to complement the more generic recommendations provided by the FEDS framework.

Details of the evaluation episodes conducted during the present research are detailed in the following Table 29. To enhance transparency and readers comprehension, we extended the (Shrestha et al., 2014)'s *reporting logic structure model to communicate DSR evaluation in IS* to delineate each evaluation episode to be conducted. Since evaluation episodes E1, E2 and E3 have already been documented earlier in this report – see again sections 1.2, 3.4 and 3.5 – in the remaining of this chapter we will focus exclusively on detailing the 3 last episodes of the strategy adopted. Readers must note here that evaluation episode E6 – which is related with the evaluation of the *research design or research process followed* – is not represented in the trajectory set of episodes portrayed in Figure 23. This is due to the fact that the FEDS framework is exclusively focussed in evaluation episodes related with the *design product*. Thus, details about the evaluation episode E6 will be described in detail in the following section 4.4.

Table 29 – Details of the Evaluation Episodes Conducted During the Research

	WHY	***WHEN***		***WHAT***		***HOW***		
Episode	**Purpose of Evaluation**	**Evaluation Setting**	**DSRM Activity Correspondence**	**Evaluand**	**Evaluation Focus**	**Paradigm of the Evaluation**	**Evaluation Method**	**Evaluation Instruments**
EVAL 1 (E1)	Formative (diagnosis)	Ex-Ante	Problem Identification & Motivation	Design Product (Artefact)	Problem Relevance	Artificial	Desk Research Informal Expert Interviews	Framework for identifying research gaps in IS literature reviews (Müller-Bloch & Kranz, 2015) EA assimilation theory (Brosius et al., 2018; Drechsler, 2015)
EVAL 2 (E2)	Formative (diagnosis)	Ex-Ante	Problem Identification & Motivation	Design Product (Artefact)	Artefact novelty	Artificial	Literature Review Document Analysis	"Class" of problem to be solved with the artefact
EVAL 3 (E3)	Formative / (partially) Summative	Ex-Post	Define Requirements Design & development	Design Product (Artefact)	Artefact's shape and form	Artificial	Comparison with similar existing artefacts	Artefact Requirements [RE.1-RE.7]
EVAL 4 (E4)	Summative	Ex-Post	Demonstration	Design Product (Artefact)	Artefact's suitability/ applicability (single context/ particular problem instance)	(Pseudo)-Naturalistic	Retrospective Case Study (1) (application in real-project)	Descriptive evaluation showing suitability of the artefact constructed

Episode	WHY	WHEN		WHAT		HOW		
	Purpose of Evaluation	**Evaluation Setting**	**DSRM Activity Correspondence**	**Evaluand**	**Evaluation Focus**	**Paradigm of the Evaluation**	**Evaluation Method**	**Evaluation Instruments**
EVAL 5 (E5)	Summative	Ex-Post	Validation	Design Product (Artefact)	Artefact's utility/usefulness (use in multiple different contexts)	(Pseudo)-Naturalistic (2)	Multiple Illustrative Scenarios (application in real-project) & Informed arguments + *Interviews, Questionnaires, Focus Groups (Intended)* (3)	Descriptive evaluation illustrating utility/usefulness of the artefact [RE.8] *Use of metrics* (3) *operationalizing (perceived) usefulness by users as defined in several IS theories* *EA Success Models (Lange et al., 2016; Niemi & Pekkola, 2019)* *Technology Adoption Models (Davis, 1989; Davis et al., 1989; Venkatesh et al., 2003; Venkatesh & Bala, 2008)*
EVAL 6 (E6)	Summative	Ex-Post	No direct correspondence	Design Research (Research Method)	DSR methodology	Artificial	Informed arguments	Alignment/compliance with (Hevner et al., 2004) quality guidelines for conducting DSR in IS

(1) Retrospective application of the artefact framework to a real executed project reported in the exploratory case described in publication [P11].

(2) An evaluation based on a multiple case study approach was in fact intended, but do to research boundaries was finally impossible to execute. Hence, an approach based on illustrative scenarios based on real experiences was finally implemented (further details in successive sections).

(3) In italics, characterisation of evaluation activities intended but finally not conducted.

Source: Own elaboration

4.3. Evaluating the Design Product

In a general sense, the evaluation of an artefact from a DSR-oriented perspective involves putting it in practice to reveal its flaws or to identify possible enhancements to increase its utility from the perspective of expert users of the defined problem domain. To do so at the particular scope of our research, we drew on a series of practical experiences [PE] encompassing several uses in practice of HEI-oriented ERAs, by different types (roles) of users/stakeholders, and in different particular contextual settings.

For choosing and selecting these practical experiences [PE], we took as a reference point (Yin, 2014)'s recommendations for (multiple) case study selection in combination with (Patton, 2014)'s purposeful sampling strategies. In a general sense, we argue that a rather mixed *convenience/opportunistic* [46] selection strategy was followed to choose these practical experiences [PE] for our evaluation purposes. Unfortunately, and especially during the last temporal span of the research, we experimented tremendous limitations in terms of accessibility to real practical contexts providing us the minimum conditions that a rigorous scientific (evaluation) activity deserves.

Notwithstanding the above, and aiming to foster as much as possible the credibility and transferability of the future results and conclusions achieved, the following criteria (Lincoln & Guba, 1985; Oates, 2005, pp. 294–295) were taken into account when choosing the practical experiences [PE] for the evaluation episodes:

- Variability of the practical experiences [PE] selected to avoid "*singular cases*".
- Considering practical experiences [PE] involving the use of more than one single ERA.
- Considering similar or representative practical experiences [PE] to those ones uncovered or covered to a limited extent (i.e., weak empirical account) by existing literature.
- Choosing practical experiences [PE] covering as many as possible different uses in practice of ERAs, and involving the participation of different HEI-oriented stakeholders (both internal and external to the HEI).
- Including practical experiences [PE] in which the benefits or the utility of either HEI-oriented ERAs or more generic RAs could be assessed or discussed. Assuming that a HEI-oriented ERA is a much more specialized and less abstract type of artefact than a generic RA, our artefact constructed would also be useful for the latter type of artefacts.

In sum, an attempt has been made to cover the largest and most diverse possible number USs, contexts of practice and diversity of ERA's exemplars, but taking into account simultaneously the accessibility limitations to the adequate empirical field we had to face.

The list of practical experiences [PE] chosen for the evaluation episodes conducted during the research is shown in the following Table 30. The table correlates each one of the practical experiences [PE] conducted with its correspondent DSRM evaluation episode and the main research method or technique used for evaluation. Further, and since "*with respect to demonstration and evaluation, DSRM is outcome-based*" (Peffers et al., 2018, p. 133) the table also presents the main goal associated to each activity episode. Finally, readers should

[46] While in a *convenience strategy* cases are selected on the basis of minimum effort, time and money; an *opportunistic strategy* entails choosing cases that emerge from following leads during field work.

also note that indicated with the label "o*ther practical experiences not considered for an evaluation episode* ", the table informs on the fact that, despite being originally planned (or emerged) as potential practical experiences [PE.4-PE.5] to shed light on to evidence on the utility of our artefact constructed, they were finally not considered as valid (rigorous enough) for being considered an evaluation episode. Reasons leading us to discard them and brief details of how they were carried out and occurred will be provided in the following sub-section 4.4.3.

Table 30 – Practical Experiences Conducted to Demonstrate/Evaluate the Design Product

DSRM ACTIVITY	**PRACTICAL EXPERIENCE [PE]**	**RESEARCH METHOD**	**FOCUS OF EVALUATION**
Demonstration	*[PE.1] – Developing a bid proposal for a new IS of a Catalan Higher Education Institution*	Retrospective Case Study	Suitability/ Applicability
Evaluation	*[PE.2] – Conceiving a new Information Systems Reference Model for Higher Education Institutions* *[PE.3] – Formalizing and Describing the Internal Quality Assurance System of a Higher Education Institution*	Multiple Illustrative Scenarios	Utility/ Usefulness
Other practical experiences not considered for an evaluation episode	*[PE.4] – Supporting the IS/IT Strategic Plan of a Catalan Higher Education Institutions* *[PE.5] – Towards a Catalan Higher Education Oriented Enterprise Reference Architecture*	*Descriptive narrative*	*Simple evidence on the use in practice of ERAs*

Source: Own elaboration

To close this section, we briefly elaborate now about *case studies* and *illustrative scenarios*, since they represent the main research methods used for the evaluation episodes conducted during the research. Both them are well-established research methods not only in the general IS arena (Galliers, 1985; Hughes et al., 2017; Reeder & Turner, 2011) but also at the more particular level of DSR artefact evaluation (Gregor & Hevner, 2013; Hevner et al., 2004; Peffers et al., 2012). Nonetheless, they often tend to be used somewhat interchangeably in the literature.

On the one hand, *case studies* are an appropriate research method when there is a need to gain concrete, contextual, and in-depth knowledge about a specific real-world subject [47]. *Case studies* tend to be considered good research methods for the purposes of describing, comparing, evaluating and understanding different aspects of a research problem (McCombes, 2019). Their focus is on studying in-depth "*one 'instance' of the thing to be investigated (the case), in order to obtain a rich and detailed insight into the 'life' of that case, as well as its complex relationships and processes"* (Oates, 2005, p. 141). Therefore, they involve the examination of a contemporary phenomenon in its natural setting, over a period of time, and by employing multiple methods of data collection to gather information from the real world subject (Keutel et al., 2014; Recker, 2013, p. 95; Yin, 2014). This information may include broad and diverse "*factors, issues, politics, processes and relationships that constitute the messiness of the real world"* (Oates, 2005, p. 142). Hence, by "*exploring all these factors and painting a detailed picture of how they link together, a researcher will try to explain how and why certain outcomes may occur in a particular situation*" (Benbasat et al., 1987, p. 370). Despite one unique (and complex) *case study* may be enough for conducting an in-depth study of a single matter or subject,

[47] This subject of study can be a person, group, place, event, organisation, or a particular phenomenon.

multiple *case studies* should be conducted to adequately compare and bring to light different aspects of a determined research problem (Gustafsson, 2017).

On the one hand, *(Illustrative) scenarios* can be defined as stories about people and their activities (Potts, 1995; Shin et al., 2006, p. 978). They can be viewed as narrative descriptions in plain language of "*common work activities performed by individuals who occupy specific roles in specific contexts* (Reeder & Turner, 2011, p. 978). According to (Carroll, 1999, p. 2), the use of *scenarios* as research method may allow to "*highlight goals suggested by the appearance and behaviour of the system, what people try to do with the system, what procedures are adopted, not adopted, carried out successfully or erroneously, and what interpretations people make of what happens to them*".

In sum, whilst *case studies* allow for the application of artefacts in real world situations to evaluate their suitability or utility, *scenarios* do also apply for the same goal, but to more rather synthetic or artificial situations specifically designed for evaluation purposes (Peffers et al., 2012, p. 402). Furthermore, *scenarios* "*do not apply an artefact […] over a time period*" (Szopinski et al., 2019, p. 11). For instance, and despite interesting and rich insights can be generated using *scenarios*, it should be always taken into consideration that they may contain explicit assumptions and/or simplifications about reality.

4.3.1. Demonstration

The *demonstration* stage of the DSRM methodology entails the evaluation of a constructed artefact to solve one or more instances of the problem leading to its conception. It corresponds to a "*light-weight*" type of evaluation activity mainly devoted to illustrate the feasibility or the applicability of the artefact constructed in at least one determined real context of application (Peffers et al., 2007, 2012; Venable et al., 2012, pp. 424–426). Hence, it tends to be rather viewed as an *early* evaluation activity that should be followed by more extensive ones (Peffers et al., 2007; Prat et al., 2015, p. 232).

To demonstrate our artefact constructed, we adopted a similar approach than (Peffers et al., 2007) in their seminal paper introducing the DSRM methodology. In particular, we retrospectively apply the constructed artefact to the real case described in publication [P11]. The paper describes the works and activities undertaken within an IS/IT service provider company for developing a bid proposal of a new integrated IS for a Catalan HEI. This project involved several different real uses of HEI-oriented ERAs which can be associated and referred to different GUS encompassed by our artefact framework constructed. The adoption of a retrospective *case study* as a research method for this evaluation episode allowed us to show the consistence and suitability of several particular instantiation templates of our artefact – see again details regarding the logic of form and function of the artefact in Figure 22 – in terms of the "*three realities"* paradigm as stated by (Sun & Kantor, 2006) – i.e., "*real systems*" → first definitive "release" of the artefact , "*real tasks/problems*" → real *SEIDOR*'s initiative, "*real users*" → ourselves and other team members as direct participants in the project) –.

4.3.1.1. Developing a Bid Proposal for a New IS of a Catalan Higher Education Institution

This first practical experience [PE.1] was internally developed at *SEIDOR* as a response to a tendering process calling for bid proposals to develop a new integrated IS for a well-known Catalan HEI. It run for 3 months (starting from February 2016) and entailed an intensive usage in practice of several HEI-oriented ERAs.

Since the details about the project as well as the contextual particularities and how HEI-oriented ERAs were actually used during the project are already described in publication [P11], to avoid redundancy we do not reproduce them here again. Thereby, the contents of the present sub-section will be strictly focussed to discuss the overall goal of the *demonstration* stage within the DSRM methodology: showing the suitability and feasibility of an artefact *to solve a particular instance of the problem posed*. Since to achieve such goal we retrospectively applied our artefact to the facts and events occurred during the initiative held at *SEIDOR*, it must be clear that at the time the experience took place our artefact had not been hitherto available. For instance, no explicit reference to it will be found in publication [P11].

Hence, in this sub-section we present an instantiation template of our artefact framework constructed "*consistent*" with the different usages made of different HEI-oriented ERAs in *SEIDOR* as a *proof-of-concept* to show the feasibility and suitability of the artefact constructed for a real case. Hence, and assuming that templates presented in this sub-section emerge as a retrospective application of the artefact, we do not explicitly discuss here about its utility as a "facilitator" tool for guiding or assisting practitioners in using/applying HEI-oriented ERAs in practice. This will be, precisely, the main focus and core of the contents and discussions of the successive section corresponding to the *evaluation* activity of the DSRM methodology.

During the project undertook at *SEIDOR*, there can be identified 5 PUS, in which 3 different HEI-oriented ERAs were used in practice. These 5 PUS that actually occurred can be related to 6 of the 22 GUS described by our artefact framework, as shown in the following Table 31.

Table 31– Particular Use Situations for Enterprise Reference Architectures Occurred in Practice During Practical Experience 1

PUS for ERAs made during the project undertook at *SEIDOR*	**HEI-oriented ERAs used during the PUS**	**GUS to which the PUS undertook at *SEIDOR* can be related**
Create awareness of the concept of ERAs (PUS-I)	HORA, RATL, CAUDIT	Content Presentation (GUS1) Train and Instruct (GUS2)
Discussion for choosing a suitable/ adequate ERA for the project (PUS-II)	HORA, RATL, CAUDIT	Take part in (EA) meetings/ Stimulate discussions (GUS3)
Facilitating shared understanding of the project's scope among team members (PUS-III)	HORA	Project initialisation support (GUS7)
Describing the proposed TO-BE solution for the new IS (PUS-IV)	HORA	Modelling support for developing a specific solution architecture (GUS6)
Providing "added value" for the bid proposal presented (PUS-V)	HORA	Consultancy artefact (GUS16)

Source: Own elaboration

Since 3 different HEI-oriented ERAs were used during the activities done at *SEIDOR*, 3 different instantiation templates – 1 template for each architecture – have to be generated collecting and synthetizing those critical aspect and knowledge related with the architectures that should be taken into account for their appropriate use or application in practice. These 3 templates generated correspond to the instantiation of the Component Block I of the artefact framework constructed (i.e., information related with the ERAs used) which are reproduced in the following Table 32.

Table 32 – Instantiation Template of the Artefact Framework for Practical Experience 1 – Information Relative to Enterprise Reference Architectures (Component Block I)

Architecture Specifics	***Architecture Details***	Name	Hoger Onderwijs Referentie Architectuur (HORA) Version 1.1
		Type	HEI-oriented ERA
		Objectives	Collection of instruments for organizing the organisation and information management of Dutch higher education institutions. It describes a higher education institution at a level at which it is independent of institution-specific choices. It can be used by higher education institutions as a mirror for their own organisational structure and information management.
		Language	Dutch (nl)
		Origin	NDL (528)
		Construction	Both *(Industry & Academia)*
		Usage	Both *(In industry & In Research)*
		Detail Level	High
	Architecture Scope	EA domains addressed (scope)	Business, Information Systems, Information Technology
		HE domains addressed (width)	Teaching & Learning, Research, Support Activities
		Audience	Managerial-oriented, Technology-oriented
	Architecture Status	Stage	On Going
		First Release Year	2013
		Current Release	Release 2.1 (15 September 2019)
Architecture Components	***RMs***	Number	6 (*Business model, Business function model, Information model, Business process model, Application model, Application platform model*)
		Representation	Semi-formal
		Perspectives Addressed	Active Structure *(applications),* Behaviour *(business functions, business processes, services),* Passive Structure *(business objects),* Composite *(application infrastructure)*
		Coherence	Within Domains, Between Domains
	Principles	Number	10 (*see HORA's semantic wiki for their detailed description*)
		Nature	Explicit
		Motivation/Rationale	Yes
		Implications	Yes
		Impacted EA domains	Business, Information Systems, Information Technology
	Other non-Essential Elements	Non-essential components included	Architectural Vision, Vocabulary/Glossary/Catalogue, Best Practices, Technical Standards, Guidelines/ Recommendations for Use, Case Examples, Maturity Models, Other (*ArchiMate file*)
Architecture Content Transformation	***Adjustment Strategy***	Suitable generic transformation mechanisms	Instantiation, Refinement, Derivation, Linking
		Other architecture's specific transformation mechanisms	N/A
Architecture Communication	***Documentation***	Nature	Semantic Wiki
	Availability	Cost	Free
		Accessibility	Public/Open
		Community of practice	Yes

Architecture Specifics	***Architecture Details***	Name	Reference Architecture for Teaching and Learning (RATL) First Release
		Type	HEI-oriented ERA
		Objectives	RATL is a resource for architecture in teaching and learning enterprises, primarily institutions of higher education. Using the RATL, architects and other leaders can map their enterprise, assess its maturity, model the effect of new goals, and plan for proposed changes. RATL was developed in response to ongoing disruptive changes in the practice of teaching and learning, and the perceived need for a reference architecture that bridges existing standards efforts and discussions in the higher education community.
		Language	English (en)
		Origin	USA (840)
		Construction	Industry (*ITANA Learning Working Group*)
		Usage	In Industry
		Detail Level	High
	Architecture Scope	EA domains addressed (scope)	Business
		HE domains addressed (width)	Teaching & Learning, Support Activities
		Audience	Managerial-oriented, Educational-oriented
	Architecture Status	Stage	On Going
		First Release Year	2014
		Current Release	First Release (2014)
Architecture Components	***RMs***	Number	2 (*Capabilities model*, *Information/data model*)
		Representation	Semi-formal
		Perspectives Addressed	Active Structure (*roles, tools*) Behaviour (*capabilities, processes, perspectives*) Passive Structure (*information objects*)
		Coherence	Within Domains
	Principles	Number	0
		Nature	N/A
		Motivation/Rationale	N/A
		Implications	N/A
		Impacted EA domains	N/A
	Other non-Essential Elements	Non-essential components included	Vocabulary/Glossary/Catalogue, Technical Standards, Guidelines/Recommendations for Use (*scenarios*), Conceptual Models, Maturity Models
Architecture Content Transformation	***Adjustment Strategy***	Suitable generic transformation mechanisms	N/A
		Other architecture's specific transformation mechanisms	A ***scenario*** describes a common set of circumstances in a teaching and learning enterprise, a typical goal for change, and considerations for responding to the change. Scenarios are linked to interrelated assets that may be affected or needed, and may include real-life case studies from other enterprises.
Architecture Communication	***Documentation***	Nature	Semantic Wiki
	Availability	Cost	Free
		Accessibility	Public/Open
		Community of practice	Yes

Architecture Specifics	***Architecture Details***	Name	CAUDIT Enterprise Architecture Commons for Higher Education Version 1.0
		Type	HEI-oriented ERA
		Objectives	CAUDIT is a repository of standardised reference architectures that describe the structure of higher education institutions (…) and provides a generalised view of how universities are organised and the information they use. These resources can be used in a variety of ways, such as a starter kit to accelerate an institution's business and data architecture, a reference point to explore commonalities and differentiators for the institution, and a communication tool to engage stakeholders. In particular, CAUDIT can help to: • increase the value and efficiency of architecture teams • facilitate the exchange of architectural knowledge and good practice in the sector, • support interoperability and collaboration between organisations • improve engagement with industry in major projects.
		Language	English (en)
		Origin	AUS (036)
		Construction	Both (*Council of Australasian University Directors of Information Technology, EA service providers, Australian and New Zealand University representatives*)
		Usage	Both (Industry & Research)
		Detail Level	High
	Architecture Scope	EA domains addressed (scope)	Business
		HE domains addressed (width)	Teaching & Learning, Support Activities
		Audience	Managerial-oriented, Educational-oriented
	Architecture Status	Stage	On Going
		First Release Year	April 2016
		Current Release	Version 2.0.1 (23rd May 2019)
Architecture Components	***RMs***	Number	2 (*Capabilities model, Data model*)
		Representation	Semi-Formal
		Perspectives Addressed	Active Structure (*organisation model – i.e., internal business roles*) Passive Structure (*topics, data entries*) Behaviour (*value chains/streams, capabilities*) Passive Structure (*data/topics*) Composite (*locations, products & services*) Motivation (*stakeholder, suppliers & partners, consumers & markets*)
		Coherence	Within Domains
	Principles	Number	0
		Nature	N/A
		Motivation/Rationale	N/A
		Implications	N/A
		Impacted EA domains	N/A
	Other non-Essential Elements	Non-essential components included	Vocabulary/Glossary/Catalogue, Recommendations for Use

Architecture Content Transformation	***Adjustment strategy***	Suitable generic transformation mechanisms	Unclear
		Other architecture's specific transformation mechanisms	Business-oriented RM can serve as an anchor for assessing perspectives such as strategic importance, maturity and relationships to business operational pain points, capital investment and organisation structure.
Architecture Communication	***Documentation***	Nature	Web Page
	Availability	Cost	Free (*Creative Commons Attribution 4.0 International Public License*)
		Accessibility	Partial/Limited (*CAUDIT Membership/authorisation required*)
		Community of practice	Yes

Source: Own elaboration

On the other hand, information relative to the specific 5 PUS identified in the experience should be reflected within the correspondent instantiation template [48] relative to the second Component Block of the artefact constructed. In our case at hand, these 5 different PUS that actually occurred at *SEIDOR* can be associated to 6 different GUS of the "*static list"* embraced by our artefact. Therefore, 6 different instantiation templates relative to Component Block II are created. It should be noted here that the PUS1 "*Create awareness of the concept of ERAs*" occurred at SEIDOR can be better mapped to a couple of the GUSs encompassed by the artefact framework constructed, namely "*GUS1-Content Presentation*" and "*GUS2-Train and Instruct*".

In sum, it can be concluded that the templates presented in Tables 32-33 represent a consistent instantiation of the artefact constructed to the actual usage given to HEI-oriented ERAs at *SEIDOR,* providing therefore simple evidence *(proof-of concept)* on the *feasibility* and *suitability* of the artefact constructed to a single real instance representative of the problem to be solved (i.e., tackled, addressed) for which it was envisioned.

[48] The following conventions should be taken into account when interpreting the information shown in Table 33:

- Normal text → this font type is used for elements of the artefact framework defined as (s*tatic) Single-Value* element type. The chosen value for these elements in an instantiated template corresponds to one of the specific values pre-defined in the *static-list* of GUSs developed when constructing the artefact (see Table 25). Pre-defined values for the *basic-tuple* of GUS elements remain as constant values for all possible instantiation templates of the artefact framework.
- ~~Crossed text~~ → this font type is used for elements of the artefact framework defined as *Multiple-Value* element type. ~~Crossed text~~ indicates that a plausible option-value of those ones pre-defined within the *extended-tuple* set of elements of the *static-list* of GUSs defined when constructing the artefact (see Table 25) has not been selected (i.e., does not apply) for a determined PUS. Similarly, ~~crossed text~~ is also used within the structural element item "*Practical Application Guidelines Followed*" to indicate that pre-defined *Recommended Practical Application Guidelines* – element < GUS$_7$> of the *extended-tuple* set of elements of the *static-list* of GUSs – neither applies for the particular instantiation template representative of a determined PUS.
- **Text in bold** → this font type is used for elements of the artefact framework defined as *Multiple-Value* element type. **Text in bold** indicates that a plausible option-value of those ones pre-defined within the *extended-tuple* set of elements of the *static-list* of GUSs defined when constructing the artefact (see Table 25) has been selected (i.e., effectively applies) when constructing the instantiation template representative of a determined PUS. Similarly, **Text in bold** is also used within the structural element item "*Practical Application Guidelines Followed*" to indicate that pre-defined *Recommended Practical Application Guidelines* – element < GUS$_7$> of the *extended-tuple* set of elements of the *static-list* of GUSs – effectively applies for this particular instantiation template representative of a determined PUS.
- *Text in italics* → this font will be typically used for elements of the artefact framework defined as s *Textual field*. Hence, *Text in italics* is used to indicate that an information element value of the instantiated template provides specific information that is not included (i.e., not pre-defined) within the "*static list"* of GUS defined during the construction stage of the artefact framework.

Conventions used for the instantiation template in Table 33 will also apply and be used in the remaining instantiation templates relatives to all other practical experiences [PE] discussed during the report (these conventions only apply for those templates related to Component Block II of the artefact framework).

Table 33 – Instantiation Template of the Artefact Framework for Practical Experience 1 – Information Relative to the Specific Uses of the Architectures (Component Block II)

Particular Use Scenario (PUS) Name	*Create awareness of the concept of ERAs (PUS-I)*
Particular Use Scenario Description	*Details can be found in sections 4.4,5.1 & 6 of publication [P11]*
Id. Generic Use Scenario (GUS)	GUS1
Generic Use Scenario Name	CONTENT PRESENTATION
Generic Use Scenario Description	This GUS involves using the ERA's components (especially visual components like RMs or conceptual maps) just as presentation material.
Possible Dependences with other Generic Use Scenarios	None
Involved Users /Stakeholders	➤ ~~HEIs/ Administrators & Executive Managers~~ ➤ ~~HEIs/ Quality Assurance & Standards Groups~~ ➤ ~~HEIs/ EA Specialists~~ ➤ ~~HEIs/ IS&IT Managers~~ ➤ ~~HEIs/ IS&IT Specialists~~ ➤ ~~HEIs/ Business & Domain Managers~~ ➤ ~~HEIs/ Business & Domain Specialists~~ ➤ ~~HEIs/ Other Employees~~ ➤ ~~Clienteles~~ ➤ **External Consultants** ➤ **IS/IT Vendors and Providers** ➤ ~~Suppliers~~
Potential Benefits Achieved	▲ ~~Quality: Improved/better information quality, sharing, and documentation~~ ➤ **Other: Improved communication/understanding among different stakeholders** ➤ **Other: Improved staff skills/capabilities/knowledge**
Particular Application Guidelines Followed in Practice	1) **Business-oriented components of the ERA – for example, RMs describing functions, processes, capabilities, etc. – may be preferred and more comprehensible to business-oriented and most of the external stakeholders of the HEI.** 2) **More detailed and technically-oriented components of the ERA (for example, RMs describing applications, infrastructure, etc. – may be preferred by IS/IT and EA-oriented stakeholders of the HEI.** ~~3) EA visualisation techniques may be used to improve the original appearance (colour coding, distinctive shapes, etc.) of the ERA's components used in the presentation materials to provide more clear, appealing and easy-to-understand presentations.~~ ❖ *Used architectural content material from different existing ERAs (in this case, HORA, RATL and CAUDIT).* ❖ *Focus on the business and IS RMs included within the chosen ERAs (in this case, the business function, data object and application RMs included in HORA).* ❖ *Architectural content provided by the ERAs (i.e., models and descriptions) used as presentation material "as-is", without changing its original appearance.* ❖ *Presentation materials used were written in an understandable language for the audience (English version of the RMs used).*

Potential Blockers	• *Lack of basic or foundational knowledge on EA by the involved users/stakeholders/audience.* • *Presentation materials written in a non-understandable language for the involved users/stakeholders/audience.* • *Use of too much material from many different ERAs may result a bit overwhelming for the involved users/stakeholders/audience.*

Particular Use Scenario (PUS) Name	*Create awareness of the concept of ERAs (PUS-I)*
Particular Use Scenario Description	*Details can be found in sections 4.4,5.1 & 6 of publication [P11]*
Id. Generic Use Scenario (GUS)	GUS2
Generic Use Scenario Name	TRAIN AND INSTRUCT
Generic Use Scenario Description	This GUS involves using the ERA's components as instructional materials for training different stakeholders anywhere something regarding the specifics of a HEI's "enterprise class" needs to be instructed. Training can also be self-motivated to refreshing one's memory on a particular aspect of EA.
Possible Dependences with other Generic Use Scenarios	➤ **Content presentation (#GUS1)**
Involved Users /Stakeholders	➤ ~~HEIs/ EA Specialists~~ ➤ ~~HEIs/ IS&IT Managers~~ ➤ ~~HEIs/ IS&IT Specialists~~ ➤ ~~HEIs/ Business & Domain Managers~~ ➤ ~~HEIs/ Business & Domain Specialists~~ ➤ ~~HEIs/ Other Employees~~ ➤ **External Consultants** ➤ **IS/IT Vendors and Providers**
Potential Benefits Achieved	▲ ~~**Quality**: Improved/better information quality, sharing, and documentation~~ ➤ **Other: Improved staff skills/capabilities/knowledge**
Particular Application Guidelines Followed in Practice	~~1) Use of analogies and metaphors - like the EA-city planning or other ones typically used in the IS discipline - to favour the knowledge transfer process.~~ ❖ *Used architectural content material from few different existing ERAs (in this case, HORA, RATL and CAUDIT).* ❖ *Use of rather high-level RMs (those ones with the higher levels of abstraction within ERAs chosen) to simplify the information provided to audience/ apprentices as well as to improve its understanding and comprehension.* ❖ *Use of the vocabularies and catalogues – whether included or provided by the ERA(s) chosen – providing specific descriptions of particular objects/entities describing the domain addressed* ❖ *Knowledge transfer process complemented by supplementary theoretical explanations about the targeted domain addressed provided by the instructor/speaker.*
Potential Blockers	• *Non availability of ERA's documentation written in an understandable language by the audience/apprentices.* • *Lack of basic (foundational) knowledge on EA and/or ERAs by the audience/apprentices.* • *Use of too much material/contents from different exemplars of ERAs may compromise audience/apprentices' comprehensiveness or understanding.*

Particular Use Scenario (PUS) Name	*Discussion for choosing a suitable/adequate ERA for [a determined] project (PUS-II)*
Particular Use Scenario Description	*Details can be found in sections 5.2 and 6 of publication [P11]*
Id. Generic Use Scenario (GUS)	GUS3
Generic Use Scenario Name	TAKE PART IN (EA) MEETINGS/ STIMULATE DISCUSSION
Generic Use Scenario Description	This GUS involves using the ERA as a vehicle for providing a common context for stimulating discussions or dialogue between diverse stakeholders during (team) meetings.
Possible Dependences with other Generic Use Scenarios	➤ **Content presentation (#GUS1)**
Involved Users /Stakeholders	➤ ~~HEIs/ EA Specialists~~ ➤ ~~HEIs/ IS&IT Managers~~ ➤ ~~HEIs/ IS&IT Specialists~~ ➤ ~~HEIs/ Business & Domain Managers~~ ➤ ~~HEIs/ Business & Domain Specialists~~ ➤ ~~HEIs/ Other Employees~~ ➤ **External Consultants** ➤ **IS/IT Vendors and Providers** ➤ ~~Suppliers~~
Potential Benefits Achieved	➤ **Other: Improved communication/understanding among different stakeholders** ➤ ~~Other: Creation and maintenance of common visions~~
Particular Application Guidelines Followed in Practice	**No practical application guidelines recommended since this GUS may conducted in a real practice by means of multiple PUS with different casuistry.** ❖ *Used architectural content material from few different existing exemplars of ERAs (in this case, HORA, RATL and CAUDIT).* ❖ *Use of the ERA(s) as a "physical object" or platform providing a common basis for conversations to foster cooperative/collaborative action, while allowing diversity in personal interpretations.* ❖ *Consensus decision achieved by project's team through the identification of lowest common denominators or critical agreement points on the basis of the architectural contents of the ERA(s) taken as a reference.*
Potential Blockers	• *Lack of interest/motivation/involvement in taking active part in the discussions by those involved in the meeting/s.* • *Use of several ERAs as a platform or common basis for conversations may difficult the achievement of agreements or consensus among stakeholders involved in discussions.*

Particular Use Scenario (PUS) Name	*Describing [a] proposed TO-BE solution for a new IS (PUS-IV)*
Particular Use Scenario Description	*Details can be found in sections 5.4 and 6 of publication [P11]*
Id. Generic Use Scenario (GUS)	GUS6
Generic Use Scenario Name	MODELLING SUPPORT FOR DEVELOPING A SPECIFIC SOLUTION ARCHITECTURE
Generic Use Scenario Description	This GUS involves using the ERA as a guide for transforming (i.e., designing, realising, tailoring and reusing) a generic and abstract ERA into a particular solution EA of an organisation, according to its context-specific needs and requirements.
Possible Dependences with other Generic Use Scenarios	➤ ~~Gap analysis with an individual model (#GUS20)~~
Involved Users /Stakeholders	➤ ~~HEIs/ EA Specialists~~ ➤ ~~HEIs/ IS&IT Managers~~ ➤ ~~HEIs/ IS&IT Specialists~~ ➤ ~~HEIs/ Business & Domain Managers~~ ➤ ~~HEIs/ Business & Domain Specialists~~ ➤ **External Consultants *(external EA Specialists)***
Potential Benefits Achieved	▼ **Time: Speed-up the enterprise architecting process and/or delivery of the solution EA (knowledge contained in the ERA reduces learning and development times)** ▼ ~~**Cost**: Reduced cost of EA architecting/modelling activities (reusability, not having to start from scratch)~~ ▲ **Quality: Improved quality of the resulting solution EA (grounded on best architectural practices within an enterprise class incorporated in the ERA)** ▼ ~~**Risk**: Lessening of architecting/ modelling activities risk (focus put on already validated critical areas of an enterprise class to be worked on)~~ ▲ ~~Competitive advantage: Access to sectorial validated knowledge and best practices included in the ERA~~
Particular Application Guidelines Followed in Practice	1) **Tailoring an ERA into a particular solution EA is an activity that always involves an inherent part of creativity during its development.** 2) ~~Basic guidelines for practical ERA realisation and transformation provided by de Boer et alt. can provide certain guidance for daily work practice.~~ ❖ *HORA used as base reference ERA.* ❖ *Informal use of the RMs and catalogues provided by the ERA architecture chosen as a "blueprint" or primary source of inspiration for developing a first release of the desired solution architecture.*
Potential Blockers	• *High complexity of the solution (TO-BE) architecture to be modelled (great number of process, applications, data objects, etc.).* • *High complexity of the selected ERA to be used as a reference (great number of RMs, architectural principles, transformation mechanisms, non-availability of manageable documentation, use of a very formal modelling language, too excessive level of detail, etc.).* • *A formal gap analysis does not represent an essential pre-requisite when a rather creative approach (i.e., no formal methodological guidelines/recommendations) is followed.* • *Lack of specific knowledge and/or practical experience about ERAs by involved users/ stakeholders in the modelling activities.*

Particular Use Scenario (PUS) Name	*Facilitating shared understanding of [a] project's scope among team members (PUS-III)*
Particular Use Scenario Description	*Details can be found in sections 5.3 and 6 of publication [P11]*
Id. Generic Use Scenario (GUS)	GUS7
Generic Use Scenario Name	PROJECT INITIALISATION SUPPORT
Generic Use Scenario Description	This GUS involves using the ERA at the initiating phases or steps of a project as a support tool to determine its initial scoping and design.
Possible Dependences with other Generic Use Scenarios	➤ **Train and instruct (#GUS2)**
Involved Users /Stakeholders	~~➤ HEIs/ EA Specialists~~ ~~➤ HEIs/ IS&IT Managers~~ ~~➤ HEIs/ IS&IT Specialists~~ ~~➤ HEIs/ Business & Domain Managers~~ ~~➤ HEIs/ Business & Domain Specialists~~ ➤ **External Consultants** ➤ **IS/IT Vendors and Providers** ➤ **Suppliers**
Potential Benefits Achieved	~~▼ **Risk**: Avoiding later redundant activities during the project development cycle~~ ▼ **Time: Shorter project/activity/product development cycle times**
Particular Application Guidelines Followed in Practice	**No practical application guidelines recommended since this GUS may conducted in a real practice by means of multiple PUS with different casuistry.** ❖ *HORA used as reference/base ERA.* ❖ *Use of the business RM of the architecture chosen to provide a general vision "at a glance" of the general scope and the main subset of functional areas of a HEI that will be impacted during the implementation of a new IS.* ❖ *Use of the ERA chosen in combination with additional and/or complementary tools (i.e., in this case, the "student-academic" lifecycle) to envision a first draft or version of the project scope/design.*
Potential Blockers	*No specifically identified.*

Particular Use Scenario (PUS) Name	*Providing "added value" for the bid proposal presented (PUS-V)*
Particular Use Scenario Description	*Details can be found in sections 5.5 and 6 of publication [P11]*
Id. Generic Use Scenario (GUS)	GUS16
Generic Use Scenario Name	CONSULTANCY ARTEFACT
Generic Use Scenario Description	This GUS involves using the ERA as consulting artefact for multiple consultancy purposes, since it can be can be viewed as a provider of consolidated and up-to-date knowledge captured from real HEIs.
Possible Dependences with other Generic Use Scenarios	➤ **Project initialisation support (#GUS7)**
Involved Users /Stakeholders	➤ ~~HEIs~~ ➤ **External Consultants** ➤ ~~Other HEIs & Competitors~~ ➤ ~~Government Entities &Regulators~~ ➤ ~~Quality Assurance Regulators~~ ➤ **IS/IT Vendors and Providers** ➤ **Suppliers** ➤ **Other External Stakeholders**
Potential Benefits Achieved	▼ **Time: Shorter project/activity/ product development cycle times (consultancy product/service)** ▲ **Quality: Improved quality of the resulting product/output (reusability of knowledge embedded in the ERA)** ➤ ~~**Other**: Better structural relationships within a company, industry or domain~~ ➤ ~~**Other**: Improved consolidation, synergies, collaboration and reduced conflict of interest~~
Particular Application Guidelines Followed in Practice	**No practical application guidelines recommended since this GUS may conducted in a real practice by means of multiple PUS with different casuistry.** ❖ *HORA used as reference/base ERA.* ❖ *Use of the architectural contents of the ERA chosen as a justificatory source of knowledge for the actions/decisions taken/adopted during the consultancy process.* ❖ *Use the architectural contents of the ERA chosen to justify the "goodness" and/or differentiated value offered/delivered by the actions/decisions taken/adopted during the consultancy process, in terms with other existing/plausible alternatives.* ❖ *Use of the architecture contents as support material for the generation of documentation of the consultancy process (i.e., in this particular case, documenting the executive summary of the bid proposal document).* ❖ *Focus on best practices, patterns and architecture principles provided by the chosen ERA.*
Potential Blockers	*No specifically identified.*

Source: Own elaboration

4.3.2. Evaluation

The following stage of the DSRM methodology corresponds to the *evaluation* activity, which represents a more extensive evaluation episode than the earlier *demonstration* one (Venable et al., 2012, pp. 431–432). In this stage, the focus of evaluation is put on testing "*how well the artefact supports a solution to the problem*" (Peffers et al., 2007, p. 56), and particularly "*on whether the artefact works over a range of contexts*" (Peffers et al., 2018, p. 133). Hence, the ultimate goal of the activity is "*to show that an artefact is both applicable and useful in practice (...) by comparing the objectives of a solution to actual observed results from use of the artefact*" (Peffers et al., 2007, p. 56; Sonnenberg & vom Brocke, 2012b, p. 395). To achieve such goal, the artefact constructed has to be deployed "*in the real world (...) and be used by real users to conduct real tasks*" (Abraham et al., 2014, p. 6) by means of an adequate interplay of the "*three realities*" paradigm (Sonnenberg & vom Brocke, 2012b). For instance, the *evaluation* stage of the DSRM methodology can be intrinsically viewed as a naturalistic evaluation episode, which should be designed "*by choosing from among multiple realities and multiple levels of granularity for measurements or metrics*" (Venable et al., 2012, p. 450).

Considering the rationale above, initial idea for performing the *evaluation* of our constructed framework was through the use of a *multiple case study* approach. According to (Myers, 1997; Walsham, 1995), *case studies* allow for the observation of complex effects meanwhile maintaining great levels of flexibility for the researchers. Hence, by fixing the artefact framework to be evaluated as basic the *unit of analysis* for the *case* to be investigated, adopting a multiple *case study* approach seemed us a perfect methodological approach for testing the utility of our constructed instrument (i) over a more or less extended period of time, and (ii) in several different settlements or context of practice. In this vein, by later surveying or interviewing direct participants (i.e., real users of the artefact) involved in the *cases* investigated, we would probably have been able to collect and gather direct data about the effects (utility) of our artefact's usage in practice [49]. Unfortunately, it was nearly impossible for us to implement such approach due to the already referred accessibility restrictions to real field practices. For instance, we had to relax our initial pretensions and, instead of drawing on a *multiple case study* approach, we finally were forced to implement the *evaluation* stage of the DSRM methodology by using a *multiple illustrative scenario* approach.

Obviously, the adoption of such a more relaxed approach involved as a counterpart a series of restrictions or drawbacks in terms of (i) the final scope (width and depth) of the DSRM *evaluation* episode performed, (ii) and the different aspects of the artefact's utility that finally could be evaluated. In other worlds, a "formal" *evaluation* episode compliant with the desired "*three realities*" paradigm could not be finally completed since:

- Although the *evaluation* episode conducted was done through *scenarios* grounded in true and real practical experiences [PE], the utility of our constructed instrument could be just evaluated on the basis of its *simulated* usage and/or application.

[49] Considering the main goal and objective defined for our artefact framework (see section 3.3), as already suggested in previous Table 29 existing theoretical frameworks like the *EA Success Models* (Lange et al., 2016; Niemi & Pekkola, 2019), *Technology Acceptance Models* (Davis, 1989; Davis et al., 1989; Venkatesh et al., 2003; Venkatesh & Bala, 2008) or even *Theory of Boundary Objects* (Abraham, 2013; Abraham et al., 2015; Lee, 2007; Rosenkranz et al., 2014; Star, 2010) could be taken as a reference to provide an adequate background (i.e., constructs and metrics) for articulating such data gathering and collection instruments.

- The role of "*real users*" of the artefact to be evaluated was finally played by ourselves the researchers. In other words, we assumed a double role both as *constructors* as well as *"proxy" users of the own artefact* to be evaluated itself. Despite this fact guarantees that the artefact is tested when used by users with a (supposed) solid background and skills in terms of EA knowledge and practice, the results and conclusions achieved under such evaluative approach may be limited by some kind of bias [50].

Summing up, we acknowledge that the *evaluation* approach adopted for the *evaluation* stage only allowed us to perform a limited evaluation of the instrument constructed. In fact, and in *stricto senso*, we argue that the conclusions inferred will be just grounded in several *utility sings or hints* resulting from a rather "*pseudo-naturalistic"* evaluation. In this sense, we believe worthwhile to point out here that the own DSR literature concedes that, under certain circumstances [51], "*untested meta-artefacts, if designed appropriately*" may also have a place in the IS arena (Gleasure, 2014, pp. 100–101). Notwithstanding that, we also state here that the following narratives of the practical experiences [PE] upon which the instrument framework developed was finally evaluated not only offer rich insights and descriptions but also (simple, basic) empirical account on the usage in practice of HEI-oriented ERAs in different context of practice, which nowadays represent one of the most important lines of (further) research as a phenomena still not adequately covered by already existing research (Ågerfalk, 2014; Ågerfalk & Karlsson, 2020; Avison & Malaurent, 2014).

The remaining of this section is organized as follows. First, the following sub-sections describe in detail the practical experiences [PE.2-PE.3] representing the real *scenarios* in which the usage of the artefact constructed will be illustrated. To enhance readers understanding the contents of this sub-sections have been structured in a common way: first, the details about the specific real context of practice in which the experience occurred are presented; next, the narrative concentrates on *simulating/representing* how our constructed artefact could have been used/applied under the circumstances described by correspondent context of practice. Finally, the last sub-section of the epigraph is devoted to collectively reflect and discuss on the *utility sings* and *hints* that can be derived from the described *illustrative applications* of our constructed artefact. Regarding this last section, readers must be aware that the focus of the *evaluation* episode is just (and only) on the utility (in practice) of the artefact constructed, but not on the utility (or whatever other quality attribute) whatever other complementary tool/framework mentioned during the narratives.

4.3.2.1. Conceiving a New Information Systems Reference Model for Higher Education Institutions

This second practical experience [PE.2] also took place within *SEIDOR's Learning Services* business unit in the temporal period between February and April 2017 [52]. During the pre-liminary contacts that were initially held with the industrial partner of the project at the beginning of the research, one of the main wishes expressed by the company was the possibility that the project could produce as an output some kind of artefact or conceptual tool useful at the business unit level to strengthen, in some or another way, the initial portfolio of products and services offered to its clients.

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[50] Deeper discussions about research limitations and restrictions will be provided in following sections 4.4 and 5.4.

[51] Fundamentally, (i) when the scale and scope of the initial design theorizing is so challenging and unusually complex as to warrant a contribution in its own right, or (ii) when the financial, technological, or personnel resources required to build and evaluate an instantiated artefact are not yet available arena (Gleasure, 2014).

[52] Additional details on this practical experience [PE.2] can be found in publication [P3].

Figure 24 – Higher Education Technology Landscape

Source: Encoura Eduventures Research – "*Introducing the Higher Education Technology Landscape 2017*"
https://encoura.org/introducing-the-higher-education-technology-landscape-2017/

Among the several alternatives discussed for achieving such goal, one that seemed particularly promising to the professional *advisor* of this research was the design of some kind of model establishing a link or correlation among (i) applications that could typically be found deployed in any HEI, (ii) the main institutional processes supported by this applications, and (iii) the different functionalities supported by the set of exiting products existing in the market offered by different IS/IT vendors and providers. In a nutshell, it was desired by *SEIDOR* some kind of artefact connecting the *demand* (generic needs and requirements in terms of application and IS) and the *supply* (existing products in the market offered by software manufacturers) of a HEI.

Context of the practical experience

As a starting point for the experience, the first activity done was to try to delimitate (in some or another way) *shape the form* of the envisioned model by typifying what should be understood in terms of the envisioned product by *supply* and by *demand*.

Regarding the *supply* side, things seemed to be relatively clear. At that time there already exist a number of technology /IS landscapes provided by different firms or institutions summarizing into a rather *one-page-graphic* a more or less complete list of products offered by different providers and software manufacturers (see the earlier example shown in Figure 24). Further, several al them also provide some indications about the main business process of a HEI supported by the different products – i.e., see bottom part of Figure 24: student enrolment, learning and instruction, etc. –. Hence, these landscapes already were offering a quite complete enumeration of existing market products, which, and according to *SEIDOR*'s particular needs/requirements, could be eventually extended with complementary information from additional documental sources [53].

Whatever the case, all this knowledge provided a reasonable background to identify a manageable list of software tools, packages and applications available in the market interesting for *SEIDOR's Learning Services* unit, in the sense of being potentially relevant pre-packaged *off-the-shelf-software* intended for being implemented (*customized*) in future projects or initiatives emerged for the business unit. Hence, and from the perspective of the *supply* side there was a quick consensus on the fact that the problem from the *supply-side* perspective could be reduced just to:

i) Fix a definitive set of "core" available products in the market devoted for HEIs considered to be relevant for *SEIDOR* from a commercial perspective.
ii) Investigate and analyse the basic features implemented by each of the "core" products considered, and determining which specific HEI's business processes were supported by the included product's features.
iii) Finally, (and eventually), to investigate which, if any, Catalan HEIs was already using (implemented, deployed) any of the "core" market products identified.

On the other hand, and from the perspective of the *demand-side*, a little bit more discussion arose. Having in mind the preliminary results of our investigations, the use of a HEI-oriented ERA as an abstract tool representing the requirements (needs) of an "ideal" HEI seemed a good idea a priori. The problem was,

[53] Examples of this sources can be several different existing surveys and sectorial reports produced by consulting firms and organisations at international level – i.e., Gartner magic quadrants, Forrester Waves, EDUCAUSE Horizon reports and surveys – and at more national or local level– i.e., *UNIVERSITIC* or *TIC 360* reports by the *Conferencia de Rectores de las Universidades Españolas* (CRUE) –.

however, to determine which one of the existing HEI-oriented ERAs should be used as a reference point. In fact, and at the time of conducting the practical experience, we already were aware on the existence of HORA – the Dutch's national HEI-oriented ERA – which, at a first glance, could represent a reasonable pick since:

i) It was a relatively well-mature and consolidated artefact – i.e., first released in 2013 and therefore, with 4 or 5 years of active life time –.
ii) It has a clear focus on the business (processes) and IS (applications) domain layers of the EA of a HEI.
iii) It provided a very high level of granularity when compared with other existing exemplars – great details on the specific domain objects modelled belonging to the different EA layers of a particular HEI –.

For instance, HORA seemed us to be a suitable artefact for being taken as a reference for the purposes of *archetyping* "theoretical" IS and applications that typically could be found implemented or deployed in whatever HEI. Furthermore, HORA also provided very detailed information about interrelationships between the business process of a HEI and the different types of application or IS providing support to them.

Nonetheless, our thesis professional *advisor* made us became aware that HORA came also with several drawbacks – at least for being used "as-is" – for our desired purposes. On the one hand, its high level of detail also represented a problem as *SEIDOR* was interested in a much more "*lightweight*" product. On the other hand, the first public version release of HORA explicitly acknowledged some limitations and points of improvement, as for example, in aspects related with on-line education or processes and functions related with the management of institutional research activities. Considering that one of most important clients of *SEIDOR*'s was a very important Catalan on-line HEI, HORA's limitations obviously became a significant issue. Besides, and lastly, it also had been taken into account the probable bias introduced by HORA towards representing an "idealized archetype" of (just) a Dutch HEI, since it was conceived as a national-oriented mandatory framework.

In sum, what *SEIDOR* really needed was a much more comprehensive and integrative tool based on knowledge embedded not only in just one single architectural exemplar (like HORA), but also within other already existing architectural models. In addition, this tool should also ideally be much more "*in-tune*" with the idiosyncrasy and particularities of Catalan HEIs, since they were viewed as key targeted customers of the *Learning Services* business unit. In this vein, it came to light the idea of engaging diverse local experts and professionals working in the Catalan HE arena into a collaborative effort to "co-create" the envisioned product. Summarizing, and assuming all the earlier background, together with our professional *advisor* we concluded that it would be worthwhile to conceive a new, own, and more specific tool tailored to the specific needs of *SEIDOR*.

Unfortunately, the project did not finally run as planned. On the one hand, it was impossible for us to join and create a more or less permanent team – i.e., including IS/IT managers, EA architects and similar professional roles working in Catalan universities – for running the initiative. On the other hand, *SEIDOR* executives increasingly started to put the pressure under the shoulders of the doctoral student to amortize the investment made for the research project, being forced therefore to contribute and collaborate with other internal projects of the company. Things this way, the initially proposed approach was never implemented.

Instead, and assuming these internal pressures to provide some kind of "*tangible result*" of the research project being conducted, we finally decided to build ourselves the envisioned product. Unfortunately, adopting this alternative approach entailed giving up the idea of conceiving an artefact for connecting the *demand* and *supply*. Thus, the final scope considered for the tool to be finally created was restricted to address just the *demand-side* of the problem by unilaterally constructing a new RM which we called *Unified Information Systems Reference Model for Higher Education Institutions* (UISRM-HE). In the following paragraphs we illustrate how our artefact framework constructed could have been used during the process carried on in *SEIDOR* to build it.

Illustrating the use of the artefact framework constructed

Considering that the new re-defined scope of the RM to be constructed turned to be much more specific and well-defined, a good way to start using the constructed instrument framework would have been to check the information relative to the "*static list"* of GUSs for using HEI-oriented ERAs in practice, corresponding to the second component Block of our instrument. Quickly, one can became aware that the creation of a new RM suits perfectly well with the specifications of the "*GUS5- Support for Creating an EA product, RM or ERA*".

According to the item element *Recommended Practical Application Guidelines* suggested for GUS5 – i.e., element <GUS_7> of the *Extended Tuple* in Table 25 – a couple of practical action lines could be followed: (1) *application of inductive/deductive/hybrid methodological approaches for creating the new EA product, RM or ERA*, and (2) the *use of generic RA/RMs as a starting baseline template during the construction process or for shaping the form/defining the skeleton of the new EA product, RM or ERA to be created*. Thus, a reasonable way to proceed would have been to assume both these recommendations but by conveniently adapting and tailoring to our purposes. Or in other worlds, to the PUS (representative of the GUS5) devoted to use several HEI-oriented ERAs to develop the new envisioned UISRM-HE.

According to first *Recommended Practical Application Guideline* suggested, 3 different approaches could be followed to build our new RM, namely deductive, inductive or hybrid. Since an hybrid approach would entail active the involvement during the process of professionals and experts in the targeted application domain (Timm, Sandkuhl, et al., 2017), such option could be easily discarded due to the referred affordability problems for engaging in the initiative external personnel to *SEIDOR*. Regarding the choice between a deductive or an inductive approach (Martens et al., 2015; Peyman et al., 2013; Scholta, 2016; Timm & Sauer, 2017), the latter approach should probably adopted since it is consistent with our specific requirement of generating a new RM by consolidating several existing exemplars of HEI-oriented ERAs. More in particular, one could be inspired by the *procedure for deriving architectural models in public administrations* proposed by (Scholta, 2016) [54], which can be synthetized in 3 main steps: (i) *provide/choose source models*, (ii) *create a merged model by identifying/ grouping common elements*, and (iii) *assemble final RM*. The following lines detail how these 3 procedural steps could be specifically applied in the application context represented by the present described PUS held at SEIDOR.

To carry on the first procedural step, a literature review should have been conducted to found candidate source models for being merged and integrated. Table 34 summarizes a state-of-art-and-practice review (conducted on February-March 2017) enumerating existing HEI-oriented ERAs, RMs and similar EA artefacts.

[54] The initial proposal by (Scholta, 2016) was further refined by (Scholta et al., 2019; Timm et al., 2018) to generate a final 6-step based procedural method: (i) *provide/choose source models*, (ii) *create merged model*, (iii) *identify common elements*, (iv) *group elements*, (v) *evaluate groups*, and (vi) *assemble final RM.*

Table 34 – Enterprise Architecture Artefacts Tailored for Being Used in Higher Education

	Contribution	Focus	Breadth	Scope
IS & applications /IT Generic RMs	Generic Reference Application Architecture[69]	IS	General	General
	Application Architecture Reference Blueprint Model[70]	IS	General	General
	CORA Reference Model[40]	IS / IT	General	General
Enterprise Reference Architectures for HEI	HORA Reference Architecture[41,71,72]	BU/IS/IT	Netherlands	HE
	RATL Reference Architecture[43]	BU / IS	USA	HE
	CAUDIT Reference Architecture[42,73]	BU / IS	Australia	HE
	TIER Reference Architecture[74]	BU / IS	USA	HE
	Cloud Computing Architecture for HE[75,76]	BU/IS/IT	General	HE
Business (Process) RMs for HEI	Value Chains for Higher Education[44,60]	BU	General	HE
	Charles Sturt Business Process Model[45]	BU	General	University
	HE-IUP Business Process Model[61]	BU	General	HE
	Business Process Reference Model for HE[16]	BU	General	HE
	Process bundle (Academic cycle) of campus management[77]	BU	General	HE
IS & applications / IT RMs for HEI	Information Systems (Conceptual) Model[62]	BU/IS	Croatia	HE
	Campus Information Systems Conceptual Model[78]	IS	General	HE
	e-education Application Framework[79]	IS	General	HE
	Univ. of Tras-o-Montes e Alto Douro of Multidimensional ISA[63]	IS	Portugal	University
	Ohio State Univ. Conceptual Reference Architecture Model[64]	IS/IT	US	University
	SAP Value Map for Education & Research[65,66]	IS	General	HE
	Eduventures 2017 Higher Education Technology Landscape[80]	IS	General	HE
	WSO2 Connected Education Reference Architecture[67]	IT	General	HE
	BROCADE Campus Network Infrastructure Reference Architecture[68]	IT	General	HE
Other EA generic artefacts tailored for HEI	EDUCAUSE Administrative & IT Systems Snapshot[13]	IS/IT	Generic	HE
	EDUCASE EDS ECAR Core Higher Education IS Catalog[81]	IS	Generic	HE
	ICT (Enterprise) Architecture Principles[28,82]	BU/IS/IT	Norway	HE
	Model for Evaluation of IS for an Integrated Campus Management[83]	IS	Generic	HE
	KARTTURI EA HE Adoption Maturity Model[84]	BU/IS/IT	Finland	HE
	Cost-Benefit Model for Campus Management Systems[77]	BU/IS		

Legend. BU : Business Layer | IS: Information System Layer | IT: Information Technology Layer

Source: Own elaboration (extract from publication [P3], page 545)

When conducting in practice this review, from the whole spectrum of suitable candidate sources identified, 8 different models/artefacts were finally chosen to be integrated when creating the new UISRM-HE [55]:

(i) 3 of the 5 identified HEI-oriented ERAs: the *Hoger Onderwijs Referentie Architectuur* (HORA), the *Trust and Identity Reference Architecture* (TIER) and the *Cloud Computing Architecture for HE* (CLOUD). CAUDIT and RATL architectures were excluded since they did not explicitly provide any RM covering the application or the IS domain level of a typical EA of a HEI.

(ii) 2 HEI-oriented IS-RMs: the *e-education Application Framework* (eEdSF) and the *Reference Model of IS for an Integrated Campus Management* (RMIS-ICM), since they explicitly contemplate applications and IS that could be found in the EA of a HEI.

(iii) 3 additional complementary artefacts that, despite not formally being and ERA or a RM, provide and include sensitive information about applications and IS that could be found within a HEI.

[55] It should be noted here that the decision taken was conditioned by our level of knowledge and awareness on existing EA artefacts tailored for HEIs at the time of conducting the practical experience. In other worlds, alterative artefacts that could have also been taken into account – as for example, the UEAF or the OPI architectures – were not explicitly considered at that moment, since either they had not ben yet created/released or due to accessibility issues to their existing public documentation.

- On the one hand, a couple of resources developed by EDUCAUSE – the Administrative & IT Systems Snapshot (*EDUCAUSE IS Snapshot*) and the *IS/IT Generic Core Higher Education IS Catalog* (EDUCAUSE Core IS Catalog). Both them are quite focused on providing details about IS and applications in HEIs from a functional perspective, suiting well, therefore, for the purposes at hand.
- On the other hand, the *Campus Information Systems Conceptual Model* (Cobarsí et al., 2008). This model was created grounding on empirical data gathered Spanish universities. This, it was finally chosen to, in some way or another, trying to incorporate some kind of "*local context knowledge*" in the resulting product.

Once chosen the source models to be integrated, the second step of the (Scholta, 2016)'s methodological approach puts properly the focus on the creation of a *merged model* grouping common elements found in the different sources. To effectively conduct in practice this step, there is a need to analyse in-depth, first, the contents and the domain objects modelled (represented) by all the source models. This process of deeper analysis of the contents provided by each one of the models to be merged would clearly have been fostered in the real practice if we had used our artefact framework constructed. In this sense, attention should have had to be paid to component Block I of the framework, since it puts the focus on providing guidance (assistance) to identify critical knowledge that should be taken into account by practitioners when using or applying in practice a specific exemplar of ERA. Hence, the use of our artefact framework would have probably accelerated all the process of reading, collecting, analysing and synthetizing all that stuff.

The following Table 35 presents the instantiation templates corresponding to the component Block I of our constructed artefact framework representative of the ERAs and RMs used during the merging process. 5 different templates [56] have been generated showing the information relative to such sources used– i.e., no templates generated for the 3 remaining simpler artefacts –. The templates generated collect, summarize and document in a simple way all the knowledge resulting from an intensive process of reading, analysis and reflection about the *base documentation* existing for the models to be merged, which provides core information about their main characteristics and features – i.e., semantic wikis in the case of HORA and TIER architectures (SURF, 2013; TIER-Data Structures and APIs Working Group, 2016) and several academic papers for the remaining ones (Bick & Börgmann, 2009; Fagan, 2003; Mircea & Andreescu, 2011; Pardeshi, 2014) –.

When considering the information reflected by these templates, it could be argued that several decisions that we took in practice when constructing the envisioned model could have been different. For example, the information provided by templates relative to CLOUD and eEdSF architectures seems to reflect that they both are quite poor-detailed models, grounding in just a couple of papers, and having no supporting community of practice providing advice (*tips and tricks*) on how to practically use them. Also, these architectures are the result of already closed initiatives (no more versions expected to be generated in the future). Hence, a plausible alternative would have been to explicitly exclude them from the merger process (these decision would have clearly reduced its complexity, but having little impact (in terms of quality) on the final product conceived).

[56] Since the version of HORA used in this practical experience was the same (1.1 version) used in earlier [PE.1], the instantiation template corresponding to this particular ERA has not been reproduced again here to avoid redundancy. Hence, the instantiation template presented in Table 32 for HORA also applies for this second practical experience.

Table 35 – Instantiation Template of the Artefact Framework for Practical Experience 2 – Information Relative to the Enterprise Reference Architectures (Component Block I)

Architecture Specifics	***Architecture Details***	Name	Trust and Identity in Education and Research (TIER) Reference Architecture
		Type	HEI-oriented ERA
		Objectives	The TIER Architecture assists executive stakeholders, campus IT architects and TIER community members in understanding the functional components for identity and access management in a higher education institution, and how those components relate to one another. The TIER Architecture simplifies campus processes and advances inter-institutional collaboration and research through an open-source toolset and a set of campus architectural practices that answer the challenges posed by identity and access control at higher education institutions. The TIER Architecture provides tools, software and architectural patterns that enable institutions to effectively and securely manage access to institutional resources and to foster inter-institutional collaboration.
		Language	English (en)
		Origin	USA (840)
		Construction	Industry (*)
		Usage	In industry
		Detail Level	Low
	Architecture Scope	EA domains addressed (scope)	Business, Information systems, Information technology
		HE domains addressed (width)	Support Activities
		Audience	Technology-oriented
	Architecture Status	Stage	Finished/Closed (**)
		First Release Year	2016 (presented at November 2015)
		Current Release	2018 version (**)
Architecture Components	***RMs***	Number	2 (*the Business Context for TIER, the Reference Architecture Base Layer)*
		Representation	Unformal
		Perspectives Addressed	Active structure *(persona/role, institutional system of records – i.e., student information systems, human resources, CRM, etc. –)* Behaviour *(services – i.e., person registration and update, groups service, provisioning service, etc. –)* Passive Structure *(master person store)* Composite (*infrastructure integration services – APIS, messaging, Workflow, Orchestration)* Motivation (*campus and external service providers)*
		Coherence	Unclear
	Principles	Number	0
		Nature	N/A
		Motivation/Rationale	N/A
		Implications	N/A
		Impacted EA domains	N/A
	Other non-Essential Elements	Non-essential components included	Vocabulary/glossary/catalogue, Guidelines/ recommen-dations for use (*narrative walkthroughs*), Maturity models, Others *(software platform implementation of the InCommon Trusted Access Platform)*
Architecture Content Transformation	***Adjustment Strategy***	Suitable generic transformation mechanisms	Instantiation, Others
		Other architecture's specific transformation mechanisms	N/A

Architecture Communication	***Documentation***	Nature	Semantic Wiki
	Availability	Cost	Free
		Accessibility	Public/Open
		Community of practice	Yes

(*) Collaborative effort leaded by Internet2 – a community providing cloud solutions, research support, and services tailored for research and education. 49 US campuses collectively provided $1.25 million per year for three years to support this effort.

(**) With TIER's successful conclusion in 2018, the InCommon Trusted Access Platform was created with a sustainable funding model to ensure its benefits for the entire community into the future. It is a community-built software platform offering a complete suite of suite offering a complete suite of identity and access management services, enabling single sign-on access to collaborations and the cloud. The Trusted Access Platform software may be used without fees, as-is, without warranty or support of any kind, and for non-commercial purposes only (Apache 2.0 license).

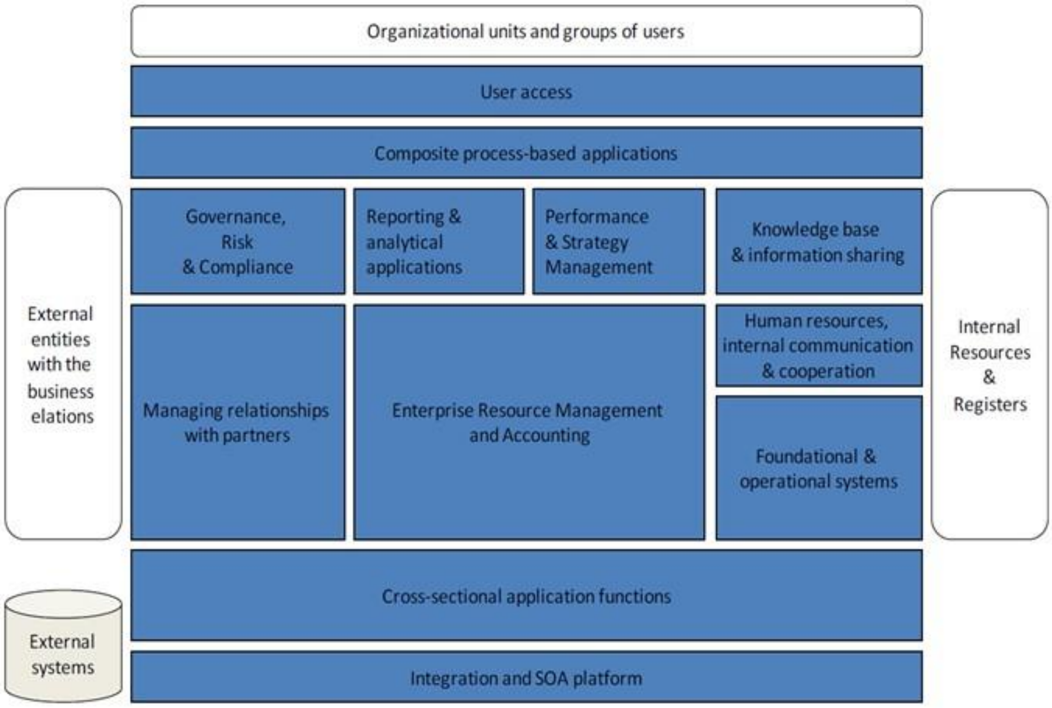
Architecture Specifics	***Architecture Details***	Name	e-education Application Framework
		Type	HEI-oriented ERA (*application's RM*)
		Objectives	To be a framework of analysis of existing application in HEIs (in terms of their primary focus/purpose and stage of development) and mapping future application possibilities.
		Language	English (en)
		Origin	USA (840)
		Construction	Academia
		Usage	Unknown
		Detail Level	Low
	Architecture Scope	EA domains addressed (scope)	Information Systems
		HE domains addressed (width)	Teaching & Learning, Support Activities
		Audience	Managerial-oriented, Educational-oriented
	Architecture Status	Stage	Finished/Closed
		First Release Year	2003
		Current Release	2003
Architecture Components	***RMs***	Number	1
		Representation	Unformal
		Perspectives Addressed	Active structure *(applications)*
		Coherence	Within Domains
	Principles	Number	0
		Nature	N/A
		Motivation/Rationale	N/A
		Implications	N/A
		Impacted EA domains	N/A
	Other non-Essential Elements	Non-essential components included	None
Architecture Content Transformation	***Adjustment Strategy***	Suitable Generic Transformation Mechanisms	Instantiation, Others
		Other architecture's specific transformation mechanisms	N/A
Architecture Communication	***Documentation***	Nature	Academic paper
	Availability	Cost	Free
		Accessibility	Public/Open
		Community of practice	No

Architecture Specifics	***Architecture Details***	Name	Reference Model (*for the Evaluation*) of Information Systems for an Integrated Campus Management
		Type	HEI-oriented ERA
		Objectives	Holistic reference model for the evaluation and selection of an integrated campus management system. This reference model supports the structured and systematic selection of such integrated information systems in order to facilitate the strategic choice of software for supporting the business processes of a higher education institution.
		Language	English (en)
		Origin	Germany (246)
		Construction	Academia
		Usage	Unknown
		Detail Level	Low
	Architecture Scope	EA domains addressed (scope)	Business *(very limited support)*, Information Systems
		HE domains addressed (width)	Teaching & Learning, Support Activities
		Audience	Managerial-oriented, Educational-oriented
	Architecture Status	Stage	Finished/Closed
		First Release Year	2009
		Current Release	2009
Architecture Components	***RMs***	Number	1
		Representation	Unformal (*textual representation)*
		Perspectives Addressed	Active structure *(applications)*
		Coherence	Unclear
	Principles	Number	0
		Nature	N/A
		Motivation/Rationale	N/A
		Implications	N/A
		Impacted EA domains	N/A
	Other non-Essential Elements	Non-essential components included	Others *(requirements for integrated software/applications: cost, efficiency, user friendliness, ease of use, reliability, flexibility, vendor support, central data basis, soft facts)*
Architecture Content Transformation	***Adjustment Strategy***	Suitable generic transformation mechanisms	Others
		Other architecture's specific transformation mechanisms	N/A
Architecture Communication	***Documentation***	Nature	Academic paper
	Availability	Cost	Free
		Accessibility	Public/Open
		Community of practice	No

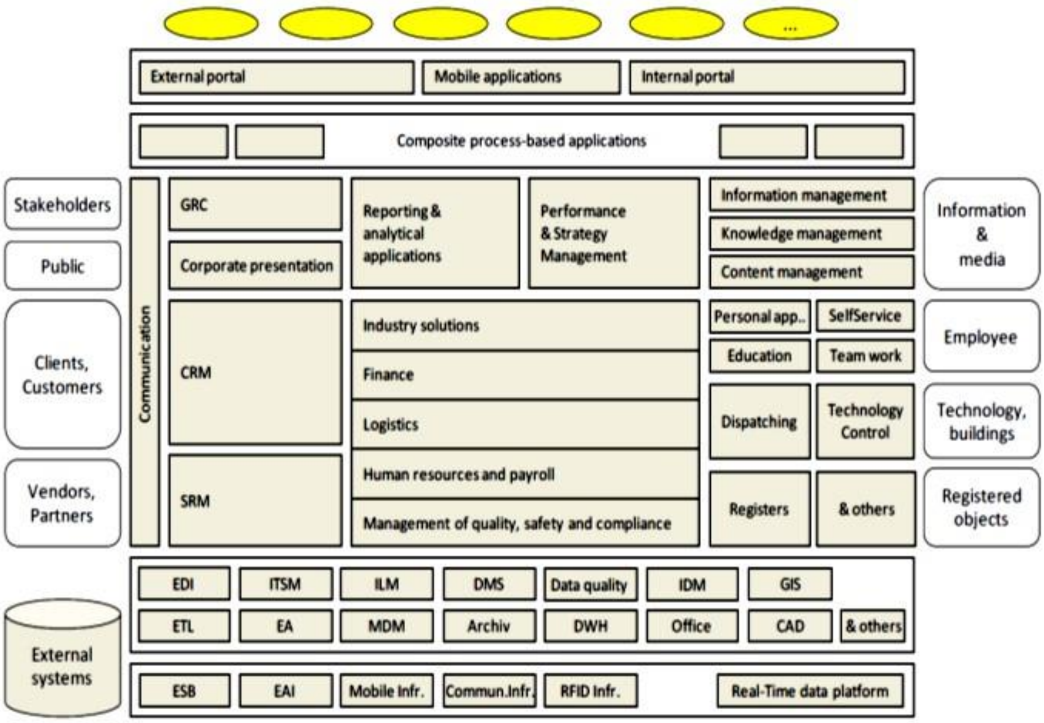
Architecture Specifics	***Architecture Details***	Name	Cloud Computing Architecture for Higher Education Version 1.0
		Type	HEI-oriented ERA
		Objectives	Evaluation of the existence of a service-oriented architecture at the level of the institution that offers the necessary infrastructure for cloud implementation
		Language	English (en)
		Origin	International
		Construction	Academia
		Usage	Unknown
		Detail Level	*(Very)* Low
	Architecture Scope	EA domains addressed (scope)	Information Systems | Information Technology
		HE domains addressed (width)	Teaching & Learning, Support Activities
		Audience	Technology-oriented, Others
	Architecture Status	Stage	Unknown
		First Release Year	2011
		Current Release	Release 1.0
Architecture Components	***RMs***	Number	1
		Representation	Unformal
		Perspectives Addressed	Active structure *(applications)*, Composite (*infrastructure, integration services)*
		Coherence	Between Domains
	Principles	Number	1 *(service-oriented architecture)*
		Nature	Implicit
		Motivation/Rationale	Yes
		Implications	N/A
		Impacted EA domains	Yes
	Other non-Essential Elements	Non-essential components included	Recommendations for Use *(very generic)*
Architecture Content Transformation	***Adjustment Strategy***	Suitable generic transformation mechanisms	Instantiation, Others
		Other architecture's specific transformation mechanisms	N/A
Architecture Communication	***Documentation***	Nature	Academic paper
	Availability	Cost	Free
		Accessibility	Public/Open
		Community of practice	No

Source: Own elaboration

Once finished the analysis of the contents and domain objects encompassed by each one of the source sources to be merged, the next decision should have been focussed towards defining a *criterion for unification* for grouping common elements (domain objects) found in different source models. Again, the actual use in practice when conducting the experience would have probably helped to accelerate the decisions and actions finally carried on. For example, if we had turned back our attention again to component Block II of the constructed artefact, the second *Recommended Practical Application Guideline* suggest the use of *generic RA/RMs as a starting baseline template during the construction process or for shaping the form/defining the skeleton of the* *new EA product, RM or ERA to be created* – see Extended *Tuple* element <GUS$_7$> of the *GUS5* item element defined in the "*static list*" of GUS provided in Table 25 –.



a) Generic Application Architecture Blueprint



b) Detailed Application Architecture Blueprint

Figure 25 – Application Architecture Reference Blueprint Model

Source: (Hrabe & Buchalcevova, 2011)

In fact, what we really did in real practice when creating the UISRM-HE model could be viewed as a particularisation of this recommendation. Specifically, and for the purposes of the PUS we faced at that moment, we assumed as a reference point (Hrabe & Buchalcevova, 2011)'s *Application Architecture Reference Blueprint Model*. This model had already been identified during the previous state-of-art-and-practice review, as shown at the top part of Table 34. In particular, and for the specific purposes of our PUS directed towards the construction of the new UISRM-HE, we adopted the latter perspective since the envisioned RM represents a specific artefact tailored for being used in rather HE-oriented contexts. Hence, we used the idea of "*key blocks of applications*" introduced by Hrabe and Buchalcevova's as the main *criteria for unification* of the different architectural domain objects defined (modelled) by each one of the source models/artefacts to be merged.

The following Table 36 helps to clarify this idea. For example, the key block *Enterprise Resource Management and Accounting* defined in the generic Hrabe and Buchalcevova's model – Figure 25(a) – can be easily associated to the concept of *Enterprise Administrative Information System*, representing a typical IS usually found in the more specific targeted domain of a HEI's application landscape. When looking to the source models to be integrated, this type of IS can be identified in a couple of them, namely the *EDUCAUSE Core IS Catalog* and the *eEdSF* architecture – see middle-central part of Table 36 –. In contrast, the TIER architecture does not include any reference to *Enterprise Administrative Information Systems,* but alternatively, refers to *Student Administration Systems* and *Human Resource Management Systems*.

Table 36 – Establishing Correspondences Between Information Systems and Applications Considered by Different Models

	Suggested Information Systems and Application Modules	**Educause Core IS Catalog [81]**	**Educause IS Snapshot [13]**	**e-education Framework [79]**	**Campus Wide IS [78]**	**IS Evaluation Model [83]**	**HORA Ref. Archit. [41,71]**	**TIER Ref. Archit. [74]**	**Cloud HE Ref. Archit. [75,76]**
Portals & User Access						√	√		
	University Web Portal			√		√	√		
	Administrative / Internal Portals								√
	Academic Portals								√
	Research Portal						√		
	Open Educational Portal						√		
	Search Engines						√		
	Form & Template Generator Systems						√		
	Survey Systems						√		
Administrative Enterprise Information System / Enterprise Resource Planning (ERP)		√		√					
	Student Administration *(can also be part of SIS)*	√	√			√	√	√	
	Admission /Enrollment/ Registration System	√			√	√			√
	Student Scholarship & Financial Aid Management System	√			√				
	Research Administration System (contracts & grants)	√	√				√		
	Financial Management System	√	√			√	√		√
	Payment Systems						√		
	Human Resource Management System	√	√	√		√		√	√
	Payroll System	√					√		
	Personnel (Staff) Management System	√					√		
	Staff Time–Tracking Registration System		√				√		
	Corporate Training System			√			√		
	Promotion Tracking System						√		

Source: Own elaboration (extract from publication [P3], page 549)

However, and when viewed together, it can be considered that this couple of applications or IS can encompass the same "*logical function*" than an integrated *Enterprise Administrative Information System* within a HEI's application landscape. For instance, when constructing the resulting final UISRM-HE, we merged both them into a unique "*key functional block*" labelled as *Administrative Enterprise Information System/ Enterprise Resource Planning (ERP)* – see again the middle-central part of the referred Table 36 –.

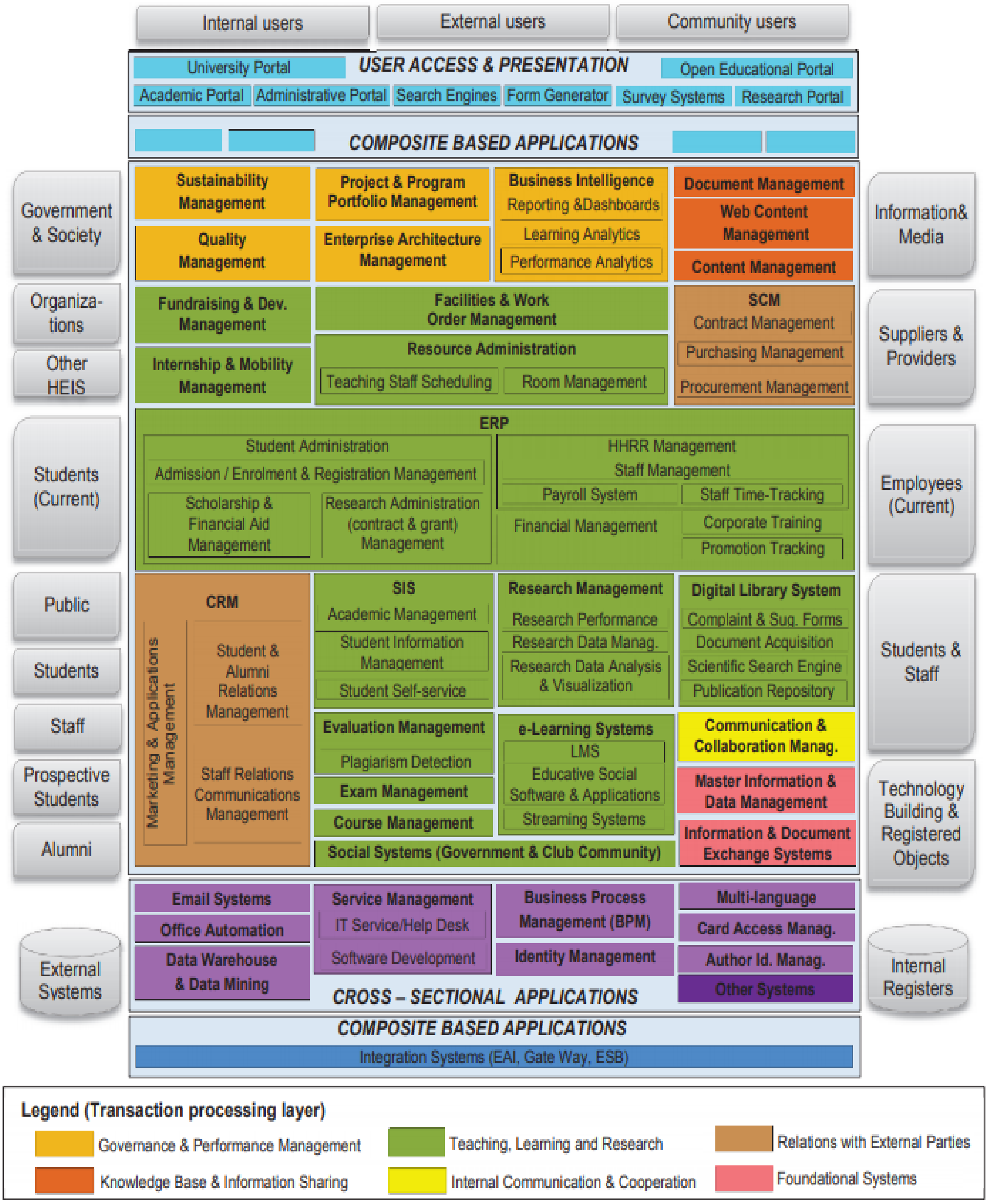


Figure 26 – Resulting Artefact Produced During the Second Practical Experience

Source: Own elaboration (extract from publication [P3], page 548)

The earlier rationale was iteratively applied to all the identified domain objects modelled in each one of sources model to be merged, until a *unified* and *universal* product was reached by saturation. The complete details on the merging process followed – i.e., defining the relationships and links between domain objects (applications and IS) encompassed within the different source models – can be found in publication [P3], pages 549-551. Minor adjustments were applied in the IS/ applications' final nomenclature used for the resulting UISRM-HE in order to harmonize the terminology of the final product conceived. In addition, and for the case of the Dutch's HORA national HEI-oriented ERA, the most (national) context-dependent applications considered in original specification of the architecture were not taken into account during the merge and unification process conducted.

The resulting UISRM-HE created during this second practical experience [PE.2] is shown in previous Figure 26. It provides a visual representation of the final RM achieved after conducting the last step of the procedural approach followed – i.e., *assemble final RM* –. Again, the original blueprint provided by Hrabe and Buchalcevova's was used as a reference point during this last step of the (Scholta, 2016)'s procedure followed to distribute, organize and positionate the resulting unified "*build blocks*" of ISs/applications inferred during the previous merger process.

Regarding the model finally conceived, it must be highlighted here that it was latterly used as a support tool by an important Catalan HEI when creating it IS/IT Strategic Plan (additional details on these developments corresponding to practical experience [PE.4] will be provided in the following section 4.3.3.1). Moreover, and as already mentioned during the narrative of the present experience, the efforts we carried out to develop the new UISRM-HE within *SEIDOR* were described in publication [P3], which was latter accepted for being presented at a well-known IS Conference. All in all, both these facts can be understood as implicit validations of the UISRM-HE produced, despite that a formal evaluation of this artefact is out of the formal scope of the DSRM *evaluation* episode being conducted. In contrast, and up to our knowledge, no specific usage of the UISRM-HE produced was finally made or done within *SEIDOR*.

Finally, and to conclude with the present narrative about the illustrative use of our instrument framework constructed for the present practical experience [PE.2], in the following Table 37 we reproduce the instantiation templates corresponding to the PUS representative of the usage made of the chosen HEI-oriented ERAs for constructing the new UISRM-HE (component Block II of the artefact framework constructed).

Table 37 – Instantiation Template of the Artefact Framework for Practical Experience 2 – Information Relative to the Specific Use of the Architectures (Component Block II)

Particular Use Scenario (PUS) Name	*Creating a new HEI-oriented IS/Application RM tailored for SEIDOR SBS (UISRM-HE)*
Particular Use Scenario Description	*Details can be found in publication [P3] (pages 595-602)*
Id. Generic Use Scenario (GUS)	GUS5
Generic Use Scenario Name	SUPPORT FOR CREATING AN EA PRODUCT, RM or ERA
Generic Use Scenario Description	This GUS involves the use of different parts or components of one or more existing ERAS during the integral process – including the collection of adequate data and information sources as well as the design, construction and validation – for creating a new ERA, RM or complementary EA product.

Possible Dependences with other Generic Use Scenarios	➤ ~~Reference point for common basis of understanding and interaction (#GUS4)~~ ➤ ~~Project initialisation support (#GUS7)~~
Involved Users /Stakeholders	➤ ~~HEIs/ EA Specialists~~ ➤ ~~HEIs/ IS&IT Managers~~ ➤ ~~HEIs/ IS&IT Specialists~~ ➤ ~~HEIs/ Business & Domain Managers~~ ➤ ~~HEIs/ Business & Domain Specialists~~ ➤ ~~Other HEIs & Competitors~~ ➤ ***External Consultants (role adopted)*** ➤ ~~Government Entities &Regulators~~ ➤ ~~Quality Assurance Regulators~~ ➤ ~~IS/IT Vendors and Providers~~ ➤ ~~Suppliers~~ ➤ ~~Other External Stakeholders~~
Potential Benefits Achieved	▼ **Time: Shorter project/activity/product development cycle times** ▼ ~~Cost: Reduced cost of EA architecting/modelling activities (reusability of already existing and validated ERA/RMs).~~ ▼ **Risk: Lessening of architecting/modelling activities risk (reusability of already existing and validated ERA/RMs).** ➤ **Other: Creation and maintenance of common visions**
Particular Application Guidelines Followed in Practice	**1) Application of existing inductive/deductive/ hybrid methodological approaches for guiding the construction process of the new EA product, RMs/ERAs.** **2) Use of generic RA/RMs as a starting baseline template during the construction process or for shaping the form/defining the skeleton of the new EA product/RM/ERA to be created.** ❖ *Inductive approach conducted grounding on the methodological procedure proposed by* (Scholta, 2016) *: (i) choosing source models, (ii) creating a merged model by identifying/ grouping common elements, and (iii) assembling final RM.* ❖ *Use of Hrabe and Buchalcevova's Application Architecture Reference Blueprint Model as a reference base for assembling the final resulting model as well as defining criteria for finding commonalities between source models (blocks of similar IS and applications) for unifying them.* ❖ *Lack or scarcity of candidate source models could be handled by considering as source model other similar existing HEI-oriented EA artefacts (independent catalogues, glossaries, etc.)*
Potential Blockers	• *Terminological heterogeneity and semantic differences in the nomenclature of the elements forming part of different source models difficult the merging and unification process.* • *Lack or under-representativity of source models may lead to biased resulting unified models.* • *The more source models to be considered for being unified, the more complex the merging process will be.* • *Bias of the resulting model can compromise its acceptability for certain groups of stakeholders.*

Source: Own elaboration

The first elements of the instantiation template address the identificative data of the PUS occurred during the practical experience [PE.2], including its descriptive narrative. Next, the template addresses information relative to GUS representative of the PUS being described by the template. In other words, the PUS "*Creating a new HEI-oriented IS/Application RM tailored for SEIDOR SBS (UISRM-HE)*" being detailed by the instantiation template in Table 37 represents an exemplary particular case or US of the more general "*GUS5–Support for Creating an EA product, RM or ERA*" contemplated by the artefact framework constructed. It should be noted here that, values chosen in the instantiation template related with the GUS5 – namely, *Id. Generic Use Scenario (GUS), Generic Use Scenario Name*, and *Generic Use Scenario Description* – have been directly instantiated from (correspond to) the pre-defined values within the "*static list*" of GUSs defined by the abstract artefact framework constructed.

The following elements of the template need to be complimented by *choosing, adapting or tailoring* the different alternative options provided by the correspondent elements <GUS_4, GUS_5, GUS_7> of the *Extended Tuple* relative to the GUS5 item of the "*static list*" of GUSs encompassed by component Block II of the artefact constructed. To be consistent, this *selections* and *particularisations* have to reflect the specificities and concrete circumstances surrounding the particular usage given to the several HEI-oriented ERAs chosen for creating the new UISRM-HE during the experience conducted at *SEIDOR*.

For example, since no dependence with other generic GUS defined within our framework were identified during the experience, no value has been signalled for the item "*Possible Dependences with other Generic Use Scenarios*" in the instantiated template. Caution should be taken at this point, however, considering our *double role* played as both users and developers of the artefact framework being evaluated. On the other hand, the element item "*Involved Users/Stakeholders*" is set to the value "*External Consultants*" since this value represents best our role played during the experience. Considering that we build the UISRM-HE with no additional support, none of the other alternative roles suggested by the element <GUS_5> – *Potentially Involved Users/Stakeholders* [57] of the "*static list*" of GUSs has been additionally chosen in the instantiated template. Finally, and regarding the subsequent "*Potential Benefits Achieved*" element item of the template, there could be argued that 3 of the 4 potential benefits suggested by element <GUS_6> – *Potential Benefits* [58] of the "*static list*" of GUSs defined by the constructed artefact were effectively realised in practice when creating the new UISRM-HE:

i) a reduction of the time invested for conceiving the new RM – i.e., we did not have to start *from scratch* –
ii) a reduction of the bias flaws (i.e., risk) for the final RM created, since we relied on already existing HEI-oriented ERAs – i.e., reusability of already pre-validated expert knowledge –.
iii) the achievement of a shared vision, since the UISRM-HE provides a unified perspective encompassing a plethora or already existing models (at least, at the moment the experience really occurred).

[57] *Potentially Involved Users/Stakeholders → Extended Tuple* element <GUS_5>, corresponding to item list GUS5 of the "*static list*" of GUSs defined in component Block II of our constructed instrument framework.

[58] *Potential Benefits → Extended Tuple* element <GUS_6>, corresponding to item list GUS5 of the "*static list*" of GUSs defined in component Block II of our constructed instrument framework.

The final remaining elements of the template refer to the more specific contextual conditions and peculiarities of the PUS occurred at *SEIDOR*. Thus, and on the one hand, the element item "*Particular Application Guidelines Followed in Practice*" informs that both the two *Recommended Practical Application Guidelines* [59] suggested by our constructed artefact constructed were effectively followed (considered) in practice when using the chosen HEI-oriented ERAs to build the new UISRM-HE [60]. Furthermore, the element item of the template also synthetizes how such generic guidelines were specifically reshaped, adapted and particularized when applied during the experience [61] . In some way, this rationale could be view as something like *extending* and *overriding* the pre-defined values fixed in the "*static list*" of GUSs during the construction stage of the artefact framework. Lastly, and on the other hand, the item element "*Potential Blockers*" of the instantiated template details several aspects that, in some or another way, played an important role as inhibitors for the usage made of the HEI-oriented ERAs during the PUS conducted at *SEIDOR*, as for example, terminological issues related with the different nomenclatures used by the different source models.

4.3.2.2. Formalizing and Describing the Internal Quality Assurance System of a Higher Education Institution

This third practical experience [PE.3] is linked with the activities carried out on a regular basis at the Barcelona School of Informatics of the UPC – hereafter referred just as FIB – to monitor, maintain and enhance the quality of the educational products and services delivered to its students. After 3 years of the last successful accreditation of its grades and masters in informatics, the FIB's council of Deans was increasingly becoming concerned with the preparations to successfully confront a new external accreditation process directed towards renewing the accreditations of the centre's grades and masters, and expected for the year 2020

UNIVERSITAT POLITÈCNICA DE CATALUNYA

Codi RUCT	Denominació	Visita	Semestre	G	M	D	% G ACR	% M ACR
024	Universitat Politècnica de Catalunya - Transversal	2020	Primer	63	68	41	71%	51%
	Centre 1 - Per confirmar							
	Centre 2 - Per confirmar							

(a) Institutions/faculties (expected) to undergo an IQAS certification in 2020 (text in Catalan)

Facultat d'Informàtica de Barcelona (Barcelona)								
4313321	Màster	Enginyeria informàtica	15/12/2016	15/12/2020	2020	Segon	Novembre	Primera
4313730	Màster	Intel·ligència artificial	15/12/2016	15/12/2020	2020	Segon	Novembre	Primera
4313729	Màster	Innovació i investigació en informàtica /Innovation and Research in Infor	15/12/2016	15/12/2020	2020	Segon	Novembre	Primera

(a) FIB's programmes that must renew their accreditation in year 2020 (text in Catalan)

Figure 27 – Planning of Quality Assurance External Visits to Catalan Centres Offering Official Programs for Year 2020

Source: AQU Catalunya. Available for download at https://www.aqu.cat/doc/doc_54607647_1.pdf

[59] *Recommended Practical Application Guidelines* → *Extended Tuple* element <GUS$_7$>, corresponding to the item list GUS5 of the "*static list*" of GUSs defined in component Block II of our constructed framework.

[60] This rationale is indicated in the template's element value by highlighting in bold the recommendations suggested by the artefact framework.

[61] The specific adaptations to the suggested *Recommended Practical Application Guidelines* made during the during the PUS are described in italics in the template's element value.

In this sense, and over the last years, the *Catalan University Quality Assurance Agency* had been promoting a paradigm shift towards a more lightweight-oriented approach in its quality audit strategy of Catalan HEIs. In particular, the agency had been launching a new audit approach focused on the *certification* of the quality of the IQAS implemented in the institutions/faculties rather than on the individual assessment of each individual one of the educational programmes offered by the institutions. In this sense, the *FIB's* perceived as a very good opportunity being one of the UPC's pioneering centres in participating in these new certification processes, in order to positionate itself as a reference faculty within the UPC in terms quality-oriented issues.

Context of the practical experience

Considering earlier FIB's experiences in already faced QA accreditation processes over the last's years, at the time of conducting this experience there were several QA practices currently running at FIB that especially worried faculty's personnel involved in managing QA issues. On the one hand, the own idiosyncrasy and complexity of the IQAS implemented at the institution, since it was a rather "hybrid" system. In other worlds, there a was notable balance between existing QA procedures and tools implemented both at university-wide level (i.e., UPC) as well as at faculty level (i.e., FIB). In some way, this "federated" vision of an IQAS was being perceived in some way as a blocker by QA professionals for carrying out an integrated management and monitoring of the implemented system "*as a whole*". On the other hand, and giving the new audit approach being fostered by the local *Quality Agency* focussed on the certification of the implemented IQAS, previous QA audit reports [62] relative to earlier accreditation processes reflexed an important number of recommendations and suggestions for IQAS improvement made by auditors, revealing thus several structural weaknesses and misalignments of the currently running system at FIB.

Under this background, and considering our knowledge on both EA and QA for HEIs, we raised to QA-oriented staff at FIB's the idea of exploring the application of the concept of ERA to the narrower specific scope of IQAS of HEIs aiming to generate alternatives, ideas and potential solutions to alleviate some of the referred drawbacks, which in turn, may lead the institution to face the future certification audit process with greatest chances of success. In this sense, our initial thought was grounded on the premise that the scope of a typical IQAS (i.e., its organisational structures, processes and procedures implemented, supportive IS or applications devoted for collecting data and quality evidences, etc.) could be viewed as nothing else than a subset of the EA (i.e., processes, applications, data records and technologies) of a HEI [63]. Hence, we hypothesised that making use of ERAs as a lens for assessing the IQAS currently running at FIB could be valuable for:

i) providing a clear and uniform vision of the whole system implemented, describing in a simple and homogeneous way all its basic structural elements and characteristic features;
ii) making easier the identification of deficiencies and potential suitable lines of action directed towards their improvement, correction or mitigation.

Illustrating the use of the artefact framework constructed

One possible way to generate ideas to assess the applicability of HEI-oriented ERAs at the scope of IQAS of HEIs would have been through the use of our artefact framework constructed. Analogously to the earlier sub-

[62] Accreditation reports related to UPC's faculties/centres can be accessed at https://estudis.aqu.cat/informes/Web/Inici

[63] See again earlier Figure 14 included in Chapter 2.

section, we illustrate in the following how our constructed instrument could have been used for the specific requirements derived from the practical context described above.

Under the statement that an IQAS's scope could be viewed as rather a subset of the whole EA of a HEI, a first suitable idea could have been to explore the use of an existing exemplar of HEI-oriented ERA as a facilitator model for creating a more detailed one describing the structural composition of the IQAS implemented at FIB. In fact, this way to proceed represents one of the most common uses of an ERA – i.e., transforming, tailoring or adapting an abstract ERA into a detailed particular *solution EA* according to context-specific requirements –. However, in the present case, such a *transformation* should be only circumscribed to those parts (i.e., the subset) of the HEI-oriented ERA corresponding to the scope of an IQAS.

When looking to the "*static list*" of GUSs defined by the artefact framework constructed, the rationale above clearly corresponds to the "*GUS6-Modelling support for developing a specific EA solution architecture"*. Besides, and when looking the list, one could also certainly argue that "*GUS12- Documental support for quality assurance audits"* would also be a GUS that could apply for the purposes at hand. Therefore, and *a priori*, both GUS-6 and GUS-12 would represent the most suitable (generic) uses of a HEI-oriented ERA that would make sense according to the specific necessities identified for the FIB.

Unfortunately, and in real practice, we did have neither the time nor the resources to afford such efforts, and in particular, for defining a *solution architecture* representative of the IQAS implemented at FIB. Getting to know in detail all the particularities of the IQAS to define a relatively good or accurate model would have led us to review a lot of heterogeneous and scattered documentation describing system as well as to interview some representatives of the QA-staff involved in the daily operative of the IQAS. Assuming all this work and activities was utterly impossible for us at that time.

Therefore, we finally considered constructing a simpler but more understandable artefact representing only the most important components and interrelationships of a comprehensible but generic IQAS in an integrated and homogeneous way. Assuming the new paradigm shift promoted by the *Catalan University Quality Assurance* towards quality audits based on the certification of IQAS implementations, we believed that such envisioned artefact could be interesting not only for QA-oriented staff at FIB bust also for QA staff of other faculties and centres in Catalonia. In this sense, this new artefact could be viewed as something like a RA targeted for IQAS of HEIs. However, and from the perspective of the "*static list*" of GUSs defined by our artefact framework, its construction process could be better associated with the logic described by the "*GUS5-Support for Creating an EA product, RM or ERA*" than with the earlier considered "*GUS6-Modelling support for developing a specific EA solution architecture"*. All in all, both GUS5 and GUS12 probably represent best those GUS encompassed by our artefact constructed that represent best the PUSs we faced when effectively working in this practical experience [PE].

Now, we proceed to describe how our constructed framework could have been used during the process followed to construct the new envisioned RA targeted for IQAS of HEIs, which represents in fact the first PUS of the described practical experience [PE]. In this sense, and turning our attention to the generic *Recommended*

Practical Application Guidelines suggested by the artefact framework constructed [64], 2 main basic guidelines are suggested: (i) *the application of inductive/deductive/hybrid methodological approaches for creating the new EA product, RM or ERA*, and (ii) the *use of generic RA/RMs as a starting baseline template during the construction process or for shaping the form/defining the skeleton of the new EA product, RM or ERA to be created*. We argue that the decisions and actions we effectively took when constructing the new RA could be effectively viewed as a particularisation of the earlier generic guidelines.

We start first with the first guideline suggesting different suitable approaches for the construction process of the new envisioned product. Considering that the envisioned RA was going to be developed by ourselves, the *hybrid approach* could be clearly rule out from the beginning. In contrast, reasonable doubts could be raised on the convenience about using either an inductive or deductive constructing approach for the new RA. On the one hand, adopting an inductive constructing approach would have implied to proceed with an in-depth analysis of exiting HEI-oriented ERAs to determine how well each one of the existing exemplars covered the scope of a comprehensive IQAS of HEIs [65]. On the other hand, adopting a deductive approach for construction would have required having a deep knowledge about the concept of IQAS of HEIs.

To gain the appropriate level of information to take an informed decision we decided to conduct a scoping review on foundational literature on QA for HEIs. The main goal of the review was to uncover "*generally accepted*" knowledge on the concept of IQAS of HEIs. For instance, we paid special attention on already existing literature reviews having a focus in aspects like working definitions, theoretical models, frameworks, standards or similar existing tools characterising, in some or another way, those systems [66]. Particularities and details about on how this review was executed can be found in publication [P10].

Grounding on the analysis of the sources collected, we finally concluded that:

- Despite no universally accepted definition of IQAS exists yet, there is on the contrary a notable amount of (rather scattered) documental sources addressing foundations and typical components characterising this type of particular systems.
- Although there were plenty of frameworks, models, standards and tools aimed to provide more or less formal conceptualisations of what an IQAS of HEIs is, collectively these contributions tend to be very diverse and heterogeneous in terms of scope, nature and size. Moreover, none of them could be formally considered as being a RA proposal for this kind of systems.

Under such background, and at the time we were working in the experience, we finally decided to adopt a deductive-oriented approach. Since we had no subjective or clear criteria for deciding about the adequacy or "goodness" of existing HEI-oriented ERA in terms of their level of coverage regarding the scope of an IQAS

[64] See again element <GUS7> of the *Extended Tuple* of elements corresponding to item "*GUS5-Support for Creating an EA product, RM or ERA"* in earlier Figure 25.

[65] That is, to analyse and how well the object domains modelled in the RMs being part of the different instances of existing HEI-ERAs include those typical elements characteristic of a comprehensive IQAS of HEIs.

[66] See for example (Alzafari, 2017; Brookes & Becket, 2007; Dahl Jørgensen et al., 2014; Farahsa & Tabrizi, 2015; Haris, Washizaki, & Fukazawa, 2017; Haris, Washizaki, Fukazawa, et al., 2017; Harvey & Williams, 2010; Kamat & Kittur, 2017; Manatos et al., 2017a; Mora et al., 2017; Pal Pandi et al., 2016; Pratasavitskaya & Stensaker, 2010; Rosa et al., 2012; T. Ryan, 2015; Sahney, 2016; Schindler et al., 2015; Steinhardt et al., 2017; Tarí & Dick, 2016).

of HEIs, we believed that adopting a rather deductive approach consolidating well-accepted knowledge from the specialized literature in QA for HE would finally lead us to a much more accurate final product.

Once decided upon the general approach for constructing the new RA, we put the focus next on the second guideline suggested for the "*GUS5- Support for Creating an EA product, RM or ERA*" by our constructed artefact, which refers to the use of complementary and generic RA/RMs as a baseline or reference point when constructing a new EA product, RM or ERA. In this sense, it can be argued here that in practice, when we actually proceed for constructing the envisioned RA tailored for IQAS of HEIs, we implicitly adopted this guideline. Hence, instead of starting from scratch, we used (part of) *Work Systems Theory (WST)* (Alter, 2013b) as the basic skeleton for shaping its initial form. Basically, we decided to use WST for 2 main reasons:

- First, WST can be view as a rather "*sector-independent*" ERA since it provides an intermediate level of abstraction – in the sense of being more detailed than a generic RA as for example TOGAF foundational EA – but at the same time (much) more abstract than a typical ERA – as for example HORA or any other HEI-oriented EA –. In a nutshell, the main components and principles defined by WST could be used as a foundation in the design and realisation of a concrete solution architecture of any type (i.e., "*sector-independent*") organisation.
- Second, WST is based on the concept of work system. By definition, a work system can be understood as a system "*in which human participants and/or machines perform work (processes and activities) using information, technology, and other resources to produce specific products/services for specific internal and/or external customers*" (Alter, 2013b, p. 75). Drawing on this definition as well as on the fact that WST provide "a *perspective for understanding systems in organisations […] focusing on the appropriate scope for the work system in relation to the problems and opportunities at hand"* (Alter, 2013b, p. 75,85), we became aware that an IQAS of HEIs could be characterised as a special (particular) case of work system typically found in HEIs (see additional details for this rationale in publication [P8], pages 593,600). For instance, an IQAS represents a suitable and viable example of work system inheriting "*most of the properties that are applicable to the general case*" (Alter, 2013b, p. 77).

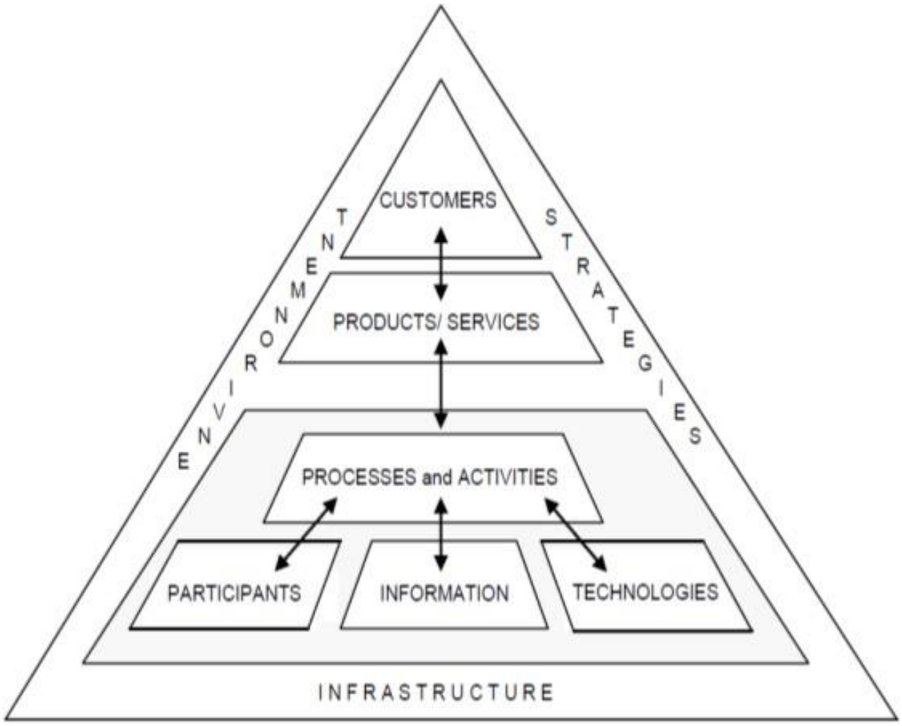
Summarizing, and as a recap of all the rationale described up to this point, the activities that we actually did when working in practice directed towards the construction of a new RA targeted for IQAS of HEIs (i) by means of a *deductive approach* grounding on knowledge from literature in QA for HE, and (ii) the use of WST as a base artefact for avoiding to start from scratch the construction process represent a PUS of ERAs in the specific context of practice (we faced) at FIB, being in turn representative of the "*GUS5-Support for Creating an EA product, RM or ERA*" as defined by our artefact constructed.

According to the premises above, when we started to construct the new RA the need to understand in more detail the foundations of WST quickly emerged. In this sense, our main aim was to try to better understand as soon as possible its potential possibilities for being used pragmatically. When looking for existing information and documentation about WST we became aware that it nowadays is a totally consolidated and well-accepted framework within the IS arena, having a solid background in both scientific and professional literature. In the following paragraphs, we illustrate how our artefact framework constructed would have served us as a guide during the process of acquiring an optimum level of expertise on WST for our purposes. In particular, the emphasis is put on showing how the structural elements of the component Block I of the artefact would have helped us to focus – i.e., reduce our time and efforts spent in acquiring an adequate level of proficiency – on those facets of WST more related with its applicability for real practical purposes.

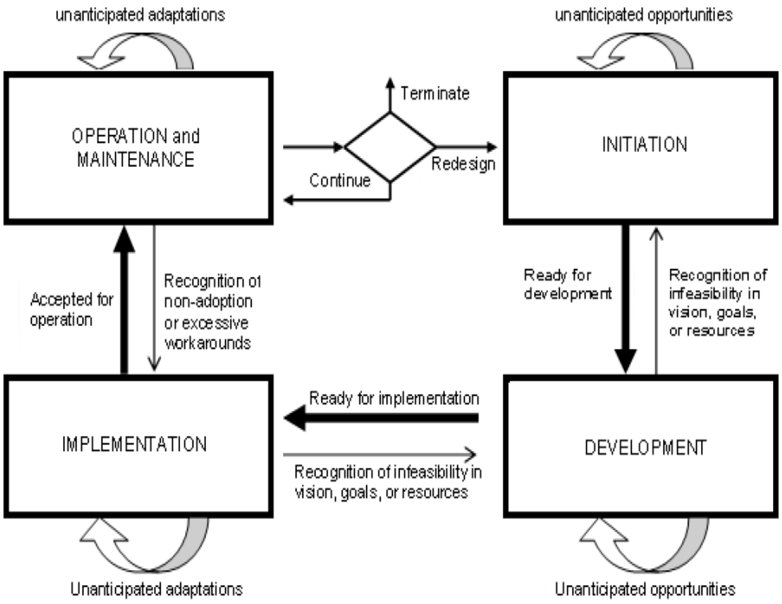
WST is formally defined as an integrated body of theories suitable for analysing, designing and understanding systems in organisations, whether or not those systems use IT intensively (Alter, 2013b). First released at the beginning of the 1990's (Alter, 1995), WST has periodically gone over several "*extensions*" and "*applications*" overcoming initial limitations of the original product and addressing deficiencies later observed during its practical use. According to the documentation reviewed, the 2013 (fifth) release should be considered as the current version of the framework (Alter, 2013b).

From a structural point of view, WST consists of three basic components, namely (i) a definition of work system, (ii) the *Work Systems Framework* – summarizing a relatively static view of a work system as it operates during a particular time, and (iii) the *Work System Life Cycle Model* (or *Framework*) – summarizing how work systems change over time through a combination of planned and unplanned changes (Alter, 2015, p. 5).

Hence, both *Work Systems Framework* and *Work System Life Cycle Model* can be viewed as the main RMs provided by WST to describe respectively the static and dynamic point of view of a generic work system. The scope of the work system taken as a reference could range from a simple project to a whole organisational enterprise (Alter, 2017).



(a) Work Systems Framework



(b) Work Systems Lifecycle Model

Figure 28 – Components of Work Systems Theory

Source: (Alter, 2013b)

The *Work System Method* represents one of the most important *applications* of the previous models. According to (Alter, 2013b, p. 83), it *"was originally developed as a straightforward application of general problem solving that started from whatever work system problems, opportunities, or issues launched the analysis*". More formally, *Work System Method* is defined as a flexible systems analysis/design method for business professionals based on seeing the system under analysis as the smallest work system that has a problem or an opportunity in an organisation, which in turn, motivates its analysis (Alter, 2006, 2015, p. 7). In this vein, the *Work System Method* can be viewed as a systematic aid that guides the transformation of a *work system* (WS) from an initial state (S_A) to a target state (S_Z), given a common context type (K).

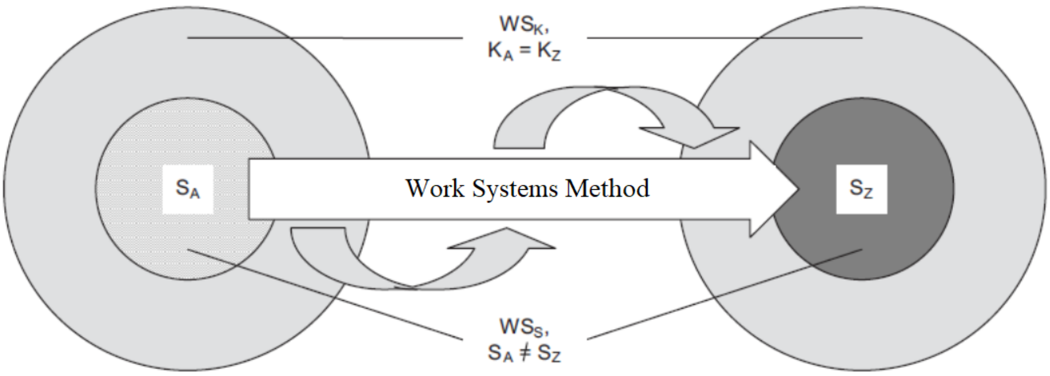


Figure 29 – A Simple Vision of the Work Systems Method

Source: Adapted from (Alter, 2013b)

A core complementary tool for putting in practice effectively the *Work System Method* is the work systems snapshot. A *work system snapshot* of a particular work system *·is a model of that work system that is useful discussions of what the work system is and what work*" (Alter, 2015, p. 7), representing all the elements encompassing a work system within a stylized “*formatted one-page summary*” (Alter, 2010b, p. 6, 2013b, p. 85). A *work system snapshot* can be either used to summarize either the "as is" work system to be created/improved or the "to be" work system that will exist after any proposed changes are finally implemented (Alter, 2006, 2010b, p. 12). Whatever the case, the use in practice of a *work systems snapshot* can be conveniently complemented with other analytical models and techniques such as “*flow charts, swim lane diagrams, and fishbone diagrams*” (Alter, 2015, p. 7).

Customers	Products & Services
• Loan applicant • Loan officer • Bank’s Risk Management Department and top management • Federal Deposit Insurance Corporation (FDIC) (a secondary customer)	• Loan application • Loan write-up • Approval or denial of the loan application • Explanation of the decision • Loan documents

Work Practices (Major Activities or Processes)
• Loan officer identifies businesses that might need a commercial loan. • Loan officer and client discuss the client’s financing needs and discuss possible terms of the proposed loan. • Loan officer helps client compile a loan application including financial history and projections. • Loan officer and senior credit officer meet to verify that the loan application has no glaring flaws. • Credit analyst prepares a “loan write-up” summarizing the applicant’s financial history, providing projections explaining sources of funds for loan payments, and discussing market conditions and applicant’s reputation. Each loan is ranked for riskiness based on history and projections. Real estate loans all require an appraisal by a licensed appraiser. (This task is outsourced to an appraisal company.) • Loan officer presents the loan write-up to a senior credit officer or loan committee. • Senior credit officers approve or deny loans of less than $400,000; a loan committee or executive loan committee approves larger loans. • Loan officers may appeal a loan denial or an approval with extremely stringent loan covenants. Depending on the size of the loan, the appeal may go to a committee of senior credit officers, or to a loan committee other than the one that made the original decision. • Loan officer informs loan applicant of the decision. • Loan administration clerk produces loan documents for an approved loan that the client accepts.

Participants	Information	Technologies
• Loan officer • Loan applicant • Credit analyst • Senior credit officer • Loan committee and executive loan committee • Loan administration clerk • Real estate appraiser	• Applicant’s financial statements for last three years • Applicant’s financial and market projections • Loan application • Loan write-up • Explanation of decision • Loan documents	• Spreadsheet for consolidating information • Loan evaluation model • MS Word template • Internet • Telephones

(a) Snapshot for a loan approval work system

Customers	Product/ Services
• Executives and managers who need to determine the organization's plans for the future. • Systems analysts and enterprise architects who need to align current and future systems with any agreed vision and mission of the organization	• Models that are used for organizational design/engineering • Results of analyzing those models or simulation runs of those models • Understandings and commitments produced by using those models.

Major Activities and Processes

• Executives charter the OD/EE effort.
• Designers/engineers gather information about the organization and its performance.
• Designers/engineers discuss relevant information with executives, managers, and other stakeholders to verify its accuracy and to identify or clarify issues.
• Designers/engineers and modeling experts produce and validate models that describe the organization and its current and/or future operation.
• The models may be used in a variety of ways:
  • Modeling experts may analyze the models, may perform and analyze simulation runs of models, and may explain the results to executives and managers.
  • Executives and other stakeholders may discuss the models or may use them interactively with the help of modeling experts.
  • The interactions between executives, managers, and other stakeholders during joint deliberations to create the model may generate new understandings and better communication.
• Designers/engineers update the model based on learnings from its use, thereby making it easier to pursue OD/EE efforts in the future

Participants	Information	Technologies
• Executives and managers • Designers/engineers • Other stakeholders • Modeling experts	• Goals of the design/engineering effort • Organizational issues and challenges • Measures of organizational performance • Description of the organization's main processes and structure	• Models produced, used, or improved by the design/engineering effort • Word processors and other typical office and communication technologies

Environment	• Ideally, the OD/EE work system should be designed to operate effectively within the surrounding environment, including the organizational culture, history, politics, demographics, worldview, competitive challenges, and so on.
Infrastructure	• Ideally, the human, informational, and technical infrastructure that the OD/EE work system shares with other work systems should be sufficient.
Strategies	• Ideally, the OD/EE work system should support the organization's strategy and should be designed consistent with that strategy.

(b) Snapshot for an organisational design work system

Figure 30 – Snapshot Examples for Different Work Systems

Source: (Alter, 2010a) and (Alter, 2017)

As early mentioned, over the years several extensions improving and overcoming limitations of the original WST release have progressively appeared, including (i) *work system design spaces* – an organized set of common directions for change that may help business and IT professionals to identify possibilities for improving work system elements, subsystems of a work system, or even a work system as a whole – (Alter, 2010c, 2013b, pp. 87–88, 2010e), (ii) the *work systems metamodel* – a more detailed specification of the *Work Systems Framework* in which each of its elements is re-interpreted in a more detailed way – (Alter, 2013a, 2010d), (iii) *work systems principles* – a series of principles that should apply to any work system that can be used to evaluate it independently of the problems and/or opportunities that launched the analysis (Alter, 2004; Alter & Wright, 2010)–, (iv) *theory of workarounds* – a process theory (augmented by a set of factors that interact to influence each step) to determine whether possible work systems workarounds are considered and how they are executed (Alter, 2014) – or (v) *systems interaction theory* – a theory for analysis covering almost all intentional/ unintentional interactions between work systems (Alter, 2018) –. Taking into account the item elements by our artefact framework constructed, from all these previous extensions our focus should have been put in acquiring additional knowledge on *work systems principles* since component Block I of the artefact framework points out principles (see aspect #5 "Architectural Components" → element #5 "*Principles*" in Table 22) as one of the core components of any ERA.

<table>
<tr><th colspan="2">Customers</th><th colspan="2">Products & Services</th></tr>
<tr><td colspan="4">#1: Please the customers.
#2: Balance priorities of different customers.</td></tr>
<tr><th colspan="4">Work Practices (Major activities or Processes)</th></tr>
<tr><td colspan="4">#3: Match process flexibility with product variability.
#4: Perform the work efficiently.
#5: Encourage appropriate use of products.
#6: Control problems at their source.
#7: Monitor the quality and timing of both inputs and outputs.
#8: Boundaries between steps should facilitate control.
#9: Match the work practices with the participants.</td></tr>
<tr><th>Participants</th><th colspan="2">Information</th><th>Technology</th></tr>
<tr><td>#10: Serve the participants.
#11: Align participant incentives with system goals.
#12: Operate with clear roles and responsibilities.</td><td colspan="2">#13: Provide information where it will affect actions.
#14: Protect information from inappropriate use.</td><td>#15: Use cost/effective technology.
#16: Minimize effort consumed by technology.</td></tr>
<tr><td>Infrastructure</td><td colspan="3">#17: Take full advantage of infrastructure.</td></tr>
<tr><td>Environment</td><td colspan="3">#18: Minimize unnecessary conflict with the external environment.</td></tr>
<tr><td>Strategies</td><td colspan="3">#19: Support the firm's strategy.</td></tr>
<tr><td>Work System as a whole</td><td colspan="3">#20: Maintain compatibility and coordination with other work systems.
#21: Incorporate goals measurement, evaluation, and feedback.
#22: Minimize unnecessary risk.
#23: Maintain balance between work system elements.
#24: Maintain the ability to adapt, change and grow.</td></tr>
</table>

Figure 31 – Current 24 Work Systems Principles

Source: (Alter & Wright, 2010, p. 8)

In a formal sense, *work systems principles* can be defined as a set of "*of normative principles that can be used to evaluate current or proposed work system in organisations*" (Alter & Wright, 2010, p. 3). *Work systems principles* emerged as a response to practical difficulties experimented by many teams in "*searching for improvements other than relatively obvious changes such as recording data that wasn't being recorded or sharing data that wasn't being shared"* (Alter, 2013b, p. 87). For instance, "*introducing a set of general guidelines [i.e., principles] for thinking about the various types of improvements [for a work system] seemed a plausible way to make sure that the teams would think about each element and would have a basis for comparing the current status and possible modifications to a set of ideals*" (Alter, 2004, p. 1606; Alter & Wright, 2010, p. 5). Figure 31 presents the current version of *work systems principles* including a total set of

24 "proposition-like" *principles* developed iteratively from 2002 to 2004. Particular details as well as the main rationale/motivation behind each of them can be found elsewhere (Alter, 2004; Alter & Wright, 2010).

Finally, we were also interested in learning how the different tools that integrate WST have been earlier effectively used in practice for different purposes. We discovered a great number of documental sources describing in detail how WST has been used or applied for describing and analysing different particular types of work systems in many different contexts of practice [67]. After reviewing these sources, we concluded that several basic strategies of action for tailoring or adapting the generic elements of a work system to the particularities of a specific case of work system could be inferred – see examples in earlier Figure 30 –. These inferred strategies are summarized in Table 38, which includes an example of each strategy extracted from the exemplary work systems shown in Figure 30. In addition, the table also shows the correspondence between the strategies inferred with typical EA *transformation mechanisms* of EA architectures – see aspect "architecture content transformation" → element #7 "*Adjustment Strategy*" in previous Table 22 –.

Table 38 – Typical Strategies for Tailoring Generic Elements of a Work System

STRATEGIES OF ACTION FOR WST APLICATION	**EXAMPLE**	**TRANSFORMATION MECHANIMS**
Interpreting or reframing the 9 components configuring a work system as defined in the *Work Systems Framework* in terms of the particular and specific context to which the work system described belongs.	In the snapshot presented in Figure 30 (a), the term "*work practices*" is used instead of the term "*process & activities*" defined in the original framework	*Refinement (decomposition)* transformation operation
The work systems snapshot can be used to provide a detailed description of the particular items that describe in detail the 9 core elements that configure a work system.	In the snapshot presented in Figure 30 (b), the "*participants*" that are involved in the work systems are "executives & managers", "designers & engineers, "other stakeholders" and "modelling experts".	*Instantiation* transformation operation
The arrows inside the Work Systems Framework indicate that specific components of a work system should be in alignment. The works systems snapshot can be used to provide further details on such interrelationships.	In the snapshot presented in Figure 30 (a), the sentence "*loan officer presents the loan write-up to a senior credit officer or loan committee*" provides clear details on the alignment between *process & activities* (e.g., presents), *participants* (loan officer, senior credit officer, loan committee) and *information* (e.g., loan write-up).	*Linking* transformation operation
The work systems snapshot can be used to define particular *attributes* or *variables* (e.g., goals, characteristics, restrictions, metrics, performance expectations, risk probabilities, etc.) that can take multiple values or need to be calibrated.	In the snapshot presented in Figure 30 (a), the sentence "*senior credit officers approve or deny credits of less than $400.000*" involves an activity restriction, depending on the credit amount requested.	*Refinement* transformation operation

Source: Own elaboration

In the following Table 39, we present an instantiation template corresponding to the component Block I of our artefact framework summarizing the information related with WST as the only RA involved in the tasks and activities conducted during this PUS.

[67] See for example the application of WST for the analysis of generic ISs (Alter, 2008), hiring work systems (Alter, 2013b), customer services of a financial organisations (Marjanovic & Murthy, 2016), healthcare information exchange services between providers (Johnsen et al., 2016), electronic document and records management systems (Goldschmidt et al., 2012) or academic mobility e-services between universities (Basitt et al., 2013), to cite only a few.

Table 39 – Instantiation Template of the Artefact Framework developed for Practical Experience 3 – Information Relative to Enterprise Reference Architectures (Component Block I)

Architecture Specifics	***Architecture Details***	Name	Work Systems Theory
		Type	Generic RA (*can be viewed as generic ERA*)
		Objectives	To provide a perspective for analysis, design understanding systems in organisations, whether or not those systems use IT intensively
		Language	English (en)
		Origin	USA (840)
		Construction	Academia
		Usage	Both *(In industry & In Research)*
		Detail Level	Low
	Architecture Scope	EA domains addressed (scope)	Business, Information Systems, Information Technology
		HE domains addressed (width)	N/A
		Audience	Managerial-oriented, Technology-oriented
	Architecture Status	Stage	On Going
		First Release Year	1992
		Current Release	2013 version *(5th release)*
Architecture Components	***RMs***	Number	2 (*work systems framework)* (*)
		Representation	Unformal
		Perspectives Addressed	Active Structure (*participants, customers, technologies*), Behaviour (*processes and activities*) Passive Structure (*information*), Composite (*product /services, environment, infrastructure*), Other (*strategy*)
		Coherence	Within Domains, Between Domains
	Principles	Number	24
		Nature	Explicit
		Motivation/Rationale	Yes
		Implications	No
		Impacted EA domains	Business, Information Systems, Information Technology
	Other non-Essential Elements	Non-essential components included	*Work System Design Spaces. Service Value Chain Framework, Theory of Workarounds, Systems Interaction Theory, etc. –*
Architecture Content Transformation	***Adjustment Strategy***	Suitable generic transformation mechanisms	Instantiation, Refinement, Linking
		Other architecture's specific transformation mechanisms	Work System Snapshot (*one-page organized summary template of the work system's scope and operation)*
Architecture Communication	***Documentation***	Nature	Academic Paper, Professional Article
	Availability	Cost	Free
		Accessibility	Public/Open
		Community of practice	Yes

(*) *Work Systems Life Cycle not explicitly used during the practical experience*

Source: Own elaboration

For example, since WST can be viewed as a generic RA, the element "*HE domains addressed (width)"* of the instantiation template is set to a value of "*N/A*" indicating that WST does not formally address specifically the EA of a HEI. Also, and despite that the only RM encompassed by WST effectively used during the PUS was the *Work Systems Framework* – see following paragraphs –, the element item "*Number"* forming part of the element's group "*RMs"* of the template is set to 2, informing that not only *Work Systems Framework* but also *Work Systems Lifecycle Model* are both at the core of WST. In this sense, the element item "*Perspectives*

Addressed" of the same element's group indicates that the basic components characterising a work system as defined by the *Work Systems Framework* cover facets mostly related with Active and Passive structures as well as Behaviour and Composite perspectives. Finally, and although with a relative low level of detail – see element item "*Detail Level*" of the element's group "*Architecture Details*"– the template also reflects that the arrows showing alignment between core components of a work system (as represented by *Work Systems Framework)* suggest the existence of domain object coherence within and between typical EA architectural domain layers.

It is also interesting to observe how the instantiated template makes evident in a simply way the existing WST's extensions and improvements uncovered during the process of analysis and reflection of the documentation reviewed. Some of these extensions and improvements appear explicitly represented in the element's group "*Adjustment Strategy*" of the template. For example, whilst the inferred generic strategies of action for WST – shown in Table 38 – appear reflected in the element item "*Suitable Generic Transformation Mechanisms"*, the *work systems snapshot* has been characterised as "*Other architecture's specific transformation mechanisms*", since we understood it as a complementary tool for articulating or concretizing the referred strategies of action for the case of a particular work system. Finally, the remaining uncovered WST's extensions and improvements discovered (i.e., *Work System Design Spaces*, *Theory of Workarounds*, *Systems Interaction Theory*, etc.) can be viewed as rather complementary "*Non-essential components*" of the framework. Readers should note, however, that information relative to *Work Systems Principles* appears reflected in the "*Principles*" element group of the instantiated template, since they represent a key core component of any RA/ERA.

Once clarified the application possibilities of the features offered by WST, the focus of attention should have been put on how to use them for the purposes of the current PUS: creating a RA tailored for IQAS of HEIs. Hence, in the following lines we describe the activities and lines of action taken in practice, which represent the concretisation of the *Recommended Practical Application Guidelines* suggested by our constructed artefact for such purposes.

In contrast to inductive approaches, no systematic methodological procedure for deductively constructing a RM or ERA seems to exist (Timm et al., 2018; Timm, Sandkuhl, et al., 2017; Timm & Sauer, 2017). Hence, we deemed necessary to apply an "*adhoc*" approach for conceiving the envisioned RA. Details of the procedure followed in practice can be found in publication [P8] pages 597-602, but can be synthetized as follows:

- First, a complementary literature review was conducted searching within the specialized literature in QA for HE for definitions of the concept of IQAS of HEIs. Multiple heterogeneous sources were considered for review to gain as much representability as possible on the different perspectives on the concept.
- Next, by using "*key word in context*" facilities provided by several software tools (e.g., Acrobat Reader, Ms. Word, Google Chrome, etc.), the full text of the definitions found were scrutinized and skimmed to identify keywords corresponding (representative of) to generic elements (components) of a work system as defined by the *Work Systems Framework*.
- Keywords uncovered in the earlier step were accumulatively mapped into their correspondent definitional work system's element (component) as defined within the *Work System Framework* to progressively and incrementally build the envisioned RA. For example, the keyword "*students*" found in several uncovered definitions was mapped to the core element "*participants*" defined by the *Work System Framework*.

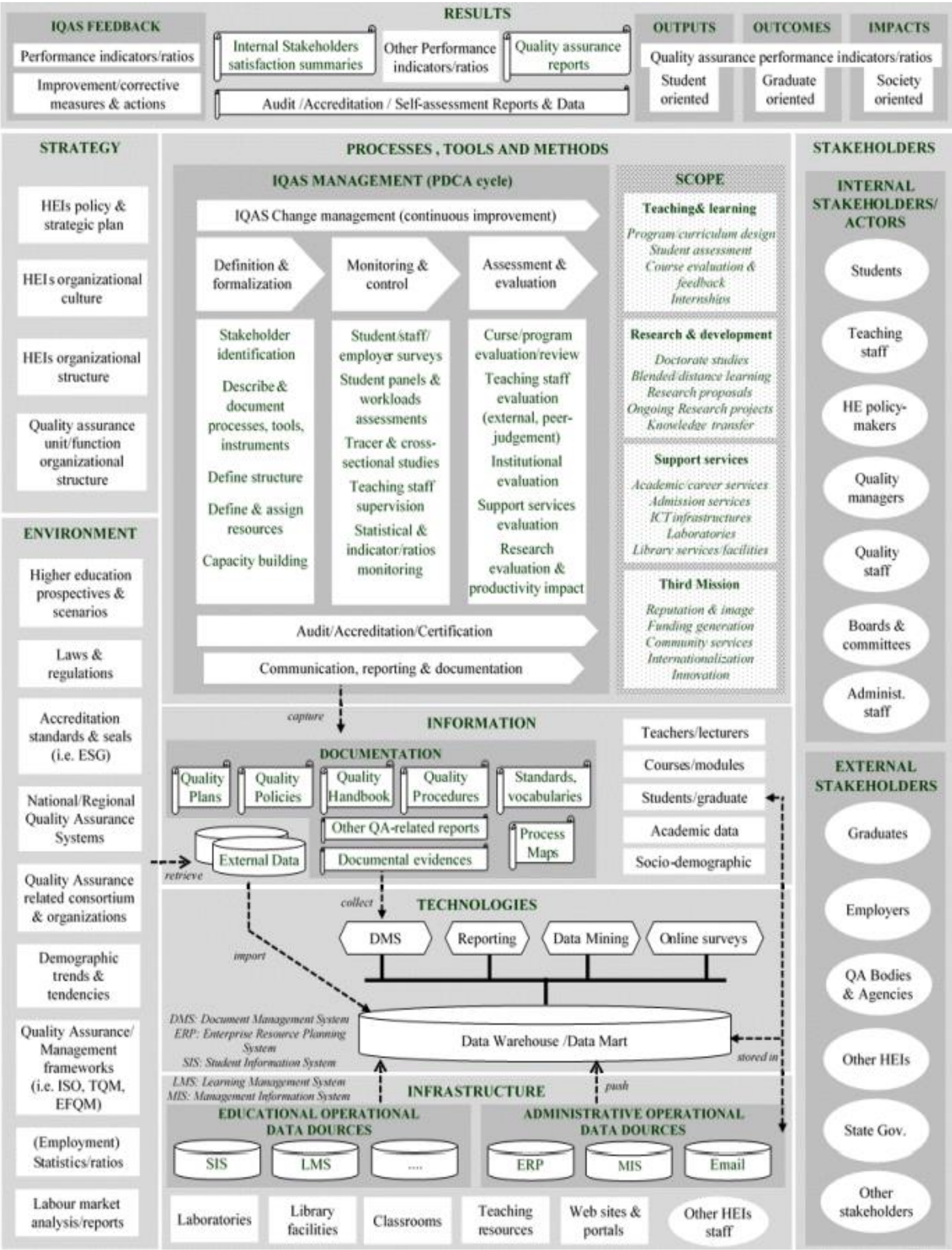


Figure 32 – Generated Reference Architecture Targeted for the Domain of Internal Quality Assurance Systems of Higher Education Institutions

Source: Own elaboration (publication [P8], page 602)

- Finally, several adjustments/refinements were made to the earlier obtained intermediate model to better describe and shape the particularities, idiosyncrasy and specificities more characteristics of an IQAS of

HEIs[68]. To do so, we complemented the earlier definitions uncovered by reviewing the following additional complementary knowledge sources:

i) quality principles considered in well-known standards as the ESG 2.0 (Manatos et al., 2017b; ESG, 2015) or the ISO 21.001 (Camilleri, 2017; ISO, 2018)

ii) reports edited by well-known supranational organisations as for example the UNESCO (Martin, 2018; Martin & Parikh, 2017) or the *European Association of Institutions in Higher Education* (EURASHE) (Dahl Jørgensen et al., 2014)

iii) academic literature focused on IQAS of HEIs (Asif & Raouf, 2013; Cardoso et al., 2017; Davis, 2017; Kettunen, 2012; Klenk & Seyfried, 2016; Papadimitriou & Westerheijden, 2010; Seyfried & Pohlenz, 2018; Tavares et al., 2016, 2017; Vukasovic, 2014).

iv) and lastly, our personal background and knowledge gained from past professional experiences.

The following Table 40 represents the particular instantiation template corresponding to the second component Block of our artefact constructed for the PUS being described. Since the logic and rationale for generating the template would be the same than the one described in the previous subsection for describing practical experience [PE.2], in the following lines we only focus on providing the rationale and justification for the values chosen for all the element items of the template.

The initial element items of the template correspond to the identifying data of the PUS, that is, the usage given to WST for constructing our RA targeted for IQAS of HEIs. This PUS corresponds to a particular application case of the more generic "*GUS5–Support for Creating an EA product, RM or ERA*" considered by our artefact framework.

Table 40 – Instantiation Template of the Artefact Framework Developed for Practical Experience 3: Information Relative to the First Practical Usage Given to Architectures (Component Block II)

Particular Use Scenario (PUS) Name	*Creating a RA targeted for IQAS of HEIs*
Particular Use Scenario Description	*Details can be found in sections 3 and 4 of publication [P8], pages 597-602*
Id. Generic Use Scenario (GUS)	GUS5
Generic Use Scenario Name	SUPPORT FOR CREATING AN EA PRODUCT, RM or ERA
Generic Use Scenario Description	This GUS involves the use of different parts or components of one or more existing ERAS during the integral process – including the collection of adequate data and information sources as well as the design, construction and validation – for creating a new ERA, RM or complementary EA product.

[68] For example, the component "*customers*" of the original model obtained after step 3 was later renamed to "*stakeholders*" to better reflect the great variety of individuals and/or entity bodies that can be concerned with an IQAS. Similarly, the term "*actors*" was preferred for denoting the "*participants"* of an IQAS of HEIs, since it represents a much more commonly used term in QA contexts. The term "*results*" was preferred than "*product &services*" to designate the outputs provided by an IQAS. Also, we enriched the model by further decomposing the component "*results*" into 3 sub-components: "*outputs*", for designating short-term results of the IQAS, "*outcomes*" for middle-term results, and "*impacts*", for rather long-term results.

Possible Dependences with other Generic Use Scenarios	➤ **Reference point for common basis of understanding and interaction (#GUS4)** ➤ ~~Project initialisation support (#GUS7)~~
Involved Users /Stakeholders	➤ ~~HEIs/ EA Specialists~~ ➤ ~~HEIs/ IS&IT Managers~~ ➤ ~~HEIs/ IS&IT Specialists~~ ➤ ~~HEIs/ Business & Domain Managers~~ ➤ ~~HEIs/ Business & Domain Specialists~~ ➤ ~~Other HEIs & Competitors~~ ➤ **External Consultants** *(adopted the role of an external QA specialist)* ➤ ~~Government Entities &Regulators~~ ➤ ~~Quality Assurance Regulators~~ ➤ ~~IS/IT Vendors and Providers~~ ➤ ~~Suppliers~~ ➤ ~~Other External Stakeholders~~
Potential Benefits Achieved	▼ **Time: Shorter project/activity/product development cycle times** ▼ ~~Cost: Reduced cost of EA architecting/modelling activities (reusability of already existing and validated ERA/RMs).~~ ▼ ~~Risk: Lessening of architecting/ modelling activities risk (reusability of already existing and validated ERA/RMs).~~ ➤ ~~Other: Creation and maintenance of common visions~~
Particular Application Guidelines Followed in Practice	**1) Application of existing inductive/deductive/ hybrid methodological approaches for guiding the construction process of the new EA product, RMs/ERAs.** **2) Use of generic RA/RMs as a starting baseline template during the construction process or for shaping the form/defining the skeleton of the new EA product/RM/ERA to be created.** ❖ *Deductive approach followed grounding on knowledge derived from a scoping review of specialized literature on QA in HEIs.* ❖ *Use of several artefacts provided by WST – Work Systems Framework, work system snapshot, etc. – acting as reference point and basic template for defining the skeleton of a RA tailored for the scope of IQAS in HEIs.* ❖ *"Adhoc" deductive procedural approach executed based on 3 main steps:* *i) search of formal definitions of IQAS within specialized literature,* *ii) keyword (content) analysis of the definitions found to identify items representative of the structural elements characterising a wok system as defined by the Work Systems Framework,* *iii) mapping of the items found to their correspondent generic elements of the Work Systems Framework to derivate an initial version of the resulting RA,* *iv) further specialisation and enrichment of the earlier preliminary version of the RA on the basis of knowledge acquired from commentary specialized literature in IQAS of HEIs.*
Potential Blockers	• *Vast amount of literature needed to review and interpret for the conducted approach.* • *Terminological heterogeneity on the concepts and theories analysed from different heterogeneous literature sources.* • *WST learning curve for being used as a supporting RA may compromise temporal benefits derived from not having to start from scratch.*

Source: Own elaboration

Regarding the element item "*Possible Dependences with other Generic Use Scenarios"* the value *"Reference point for common basis of understanding and interaction (#GUS4)"* appears as marked in the template. Despite the new RA was constructed by ourselves in a standalone way an in-depth study of existing documentation about WST was needed to understand its possibilities for practical usage. This knowledge acquisition process was critical for viewing IQAS of HEIs as a particular case of a work system, and therefore for using a *Wok Systems Snapshot* as a baseline for constructing the envisioned RA. Since this rationale of use of WST is consistent with the description for the GUS4 [69] by the "*static list*" of GUSs defined by our artefact framework, it appears as checked in the earlier template.

The value "*External Consultants*" chosen for element item "*Involved Users/Stakeholders*" reflects our role as external QA experts basically adopted during the PUS. Regarding the "*Potential Benefits Achieved*" from the usage made of WST there could be argued here that it certainly contributed to reduce the time spent in the process of creating the new RA – if we would have to create the RA from scratch, the process undertook would have been probably longer–. Thus, the value "*Shorter project/activity/product development cycle times*" appears selected for the instantiated template. Next, the value informed for the element item "*Particular Application Guidelines Followed in Practice*" provides a summarized of the "*adhoc*" approach followed to construct the new RA. Finally, the value informed by the template for the item element "*Potential Blockers*" reflects on diverse issues that proved to be inhibitors during the "*adhoc*" procedure for constructing the new envisioned product, as for example, difficulties found to interpret the vast, heterogeneous and sometimes contradictory literature in the field of QA for HEIs, or the temporal cost (i.e., learning curve) spent in achieving a good command of WST for being adequately used in practice as a blueprint for creating the envisioned RA.

In addition to the described PUS given to WST for constructing a new RA targeted for IQAS of HEIs, we also argue that our artefact framework could also have been used for giving support other activities we did in this practical experience [PE.3]. In particular, their use might have been potentially interesting when looking for alternatives in order to provide some kind of evidence for validating the "*goodness"* of the new RA recently created. In general, a simple way to evidence the validity of a new artefact can be by means of its direct application into a particular case. If we circumscribe this rationale to our new created RA, it would imply the transformation, parametrisation and adaptation of the generic RA constructed to represent, capture and describe the specificities of the implemented IQAS in a specific HEI. As suggested at the beginning of this sub-section, this PUS related with the new created RA could be linked with the "G*US12-Documental Support for Quality Assurance Audits*" defined by our artefact framework (despite that in our case, we were not under the immediate pressure of having to confront a formal audit procedure).

Obviously, the ideal candidate IQAS for this purpose would have been the IQAS implemented at FIB. Nonetheless, and as already stated, such alternative was quickly rejected due to affordability issues. Therefore, other plausible alternatives had to be considered. The main criteria used to identify these potential alternatives were as follows:

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[69] According to element <GUS$_3$> of the *Basic Tuple* corresponding to item GUS4 of the "*static list*" of GUSs shown in Table 25: "*This GUS involves using the ERA as a reference point – i.e., providing a common and unified vocabulary/terminology/lexicon– for shared understanding among different stakeholders. –.*"

(i) based on a true real experience (i.e., the IQAS to be described had to be effectively implemented in a real HEI).

(ii) free and quick availability and accessibility to documental support available describing the form and function of the IQAS to be chosen as an exemplary case.

(iii) clarity, richness and completeness of the descriptive information provided by the documental sources found regarding the IQAS to be used as a reference case.

According to criteria above, we finally decided to take the IQAS implemented at University of Duisburg-Essen (Germany) as the study case for the application of our new RA constructed. In fact, the "*solution architecture*" representing such IQAS was exclusively developed by transforming and tailoring the new created RA according to the complementary information provided by the study case report about the particularities of that IQAS provided by (Ganseuer & Pistor, 2017). This report forms part of a wider library of 8 study cases produced by the UNESCO Institute for Educational Planning (IIEP) [70] describing different casuistic on how 8 different HEIs around the world conceived, designed and implemented their own IQAS. We considered thus, that having the documentation of the exemplary IQAS taken as a reference for applying the new constructed RA in a compact and homogeneous format would help us to speed-up time and efforts invested in provided the evidence desired.

Similarly to the first PUS described, we argue here that the task and activities we did in practice when describing the "*solution architecture*" of the IQAS implemented at University of Duisburg-Essen would have been assisted by the use of the artefact framework created. In the following lines we illustrate how this assistance could have been in practice meanwhile describing the tasks we actually execute at that moment.

Regarding this second PUS, the focus of attention should have been totally put into the second component Block of the artefact constructed framework, since no additional information or knowledge about ERAs was apparently needed. Since the PUS seems clearly representative of the generic GUS12, a first logical approach would have been to consider the *Recommended Practical Application Guidelines* suggested by our artefact. According to the element item <GUS_7> corresponding to the *Extend Tuple* of elements defined for GUS12 of the of the "*static list*" of GUSs shown in Table 25, the following generic actions are proposed:

(i) subsets or portions of the business-/IS-oriented RMs and landscapes provided by the ERA can work perfectly as a starting point for developing a graphical representation summarizing the HEI's IQAS/QMS currently implemented,

(ii) glossaries and vocabularies included within the ERA can be used to provide formal definitions of the constitutive objects of the IQAS/QMS included in graphical representations,

(iii) documentation existing for the ERA may require some adaptations to the format/ requirements requested by the QA accreditation/audit body/entity.

[70] The full library of study cases is accessible at the IIEP-UNESCO website: "*Governance & Quality assurance – Innovative and Cost-effective Solutions for IQA Systems*". http://www.iiep.unesco.org/en/our-expertise/governance-quality-assurance

From these 3 generic guidelines recommended by the artefact constructed, only the first one of them could be taken as a reference in our PUS since at that time (i) the FIB was not being formally facing an external QA audit process, and (ii) no specific vocabulary/glossary or alternative supporting documentation was yet provided for the new constructed RA. In particular, what we did in practice was to made use of the *work systems snapshot* – a specific transformation mechanism provided by WST to describe particular cases of work system – as a support tool for creating the *solution architecture* describing the specificities and intrinsic characteristics implemented by the IQAS working at University of Duisburg-Essen.

In some way, this way to proceed could be viewed as compatible with the recommendations of the first generic guideline. Nonetheless, we did not use the original template provided by WST as shown in the examples provided in Figure 30. In contrast, we used a *reshaped version* of the tool considering as *core elements* of the work system to be described those ones defined by our newly constructed RA, as depicted in the earlier Figure 32. In this sense, our way to proceed could be viewed perhaps as rather more an adaptation or customisation than a strict application of the first suggested guideline by our constructed artefact. Whatever the case, in the real practice we proceed in a relatively analogous way than we did in the *adhoc* construction process of the earlier PUS of this practical experience [PE.3] for constructing the new RA tailored for IQAS of HEIs:

- First, we looked for "*text chunks*" or sentences written in the study case report taken as a reference to identify how and what structural core elements (and sub-elements) defined in our adapted *work systems snapshot* had been implemented by the IQAS as implemented at University of Duisburg-Essen. We adopted a relatively "*broad perspective*" in this search by using keywords like "*environment*", "*strategy*", "*actors*", "*document*", "*result*" "*people*", "*process"*, "*technology*" and similar ones for search purposes, in line with the component-elements defined in Figure 32.

- Next, we associated the identified "*text chunks*", statements or sentences found in the study case report with their correspondent core elements and sub-elements as defined in our adapted *work systems snapshot* version template. For example, the expression "*Deputy vice-chancellor for institutional planning and resources and deaneries of faculties*" found in the report was mapped to the component "*actors*" of our adapted *work systems snapshot* template, since both "*deputy vice-chancellor*" and "*deaneries of faculties*" describe specifically how *QA-staff* involved in the operative of a generic IQAS – see right-middle part of the RA model shown in Figure 32 – was specifically organized at University of Duisburg-Essen.
- We accumulatively and iteratively mapped all the "*text chunks*", statements and sentences identified in the case study report to progressively refine and complete a final version representative of the IQAS implemented at University of Duisburg-Essen of the adapted snapshot template.
  Saturation point was reached when mapping additional chunks or statements found in the case study report did not provide further understanding – i.e., additional detail in the adapted *work systems snapshot* template – about the form and functioning implemented IQAS at University of Duisburg-Essen.

The final resulting version of our adapted *work systems snapshot* template representing the achieved description of the IQAS implemented at University of Duisburg-Essen can be found in publication [P8], pages 604-606. To facilitate reader's comprehensibility and understanding, the following Figure 33 shows an excerpt of the result achieved.

STRATEGY	***HEIs Strategy.*** The university's wide development plan sets out its main guidelines, strategies as well as its future aims and objectives. The following guidelines frame the development of the university (pp. 21-22): to offer an academic education based on science and research; development of teacher training in the research and education and balance between a central profile and a decentralized system of self-governance and self-responsibility. *"Faculties and organizational sub-units are responsible for their own strategic development and receive a budget for this purpose"* (pp. 23). *"Deaneries are responsible for writing the development plan of the faculty, in accordance with the university-wide development plan, and for the autonomous management of financial and human resources"* (pp. 23). ***WS Strategy*** Alignment between organizational strategy and Work system (IQA) strategy: quality policy is based on recognition of the importance of a balanced relationship between central and decentralized responsibilities for assurance and development of quality. "*The framework for quality development was established in the university's strategy for developing teaching and learning*" (pp. 25) *"A deputy vice-chancellor (DVC) for institutional planning and resources is responsible for quality assurance at the central university level, while at faculty level it is the responsibility of the deanery. [...]. Both central and faculty levels are supported by a central service unit, the Centre for Higher Education Development and Quality Enhancement (CHEDQE)"* (pp. 22). *"CHEDQE is responsible for the quality assurance system at the UDE [...] ensuring quality in in research and teaching, service, and management areas is devolved to the particular organizational sub-units (faculties, etc.)"* (pp. 24-25).
ENVIRONMENT	Mainly driven by the conditionings derived from the European Higher Education Area) and local federate state regulations. ***Regulatory environment.*** *"The federal states are responsible for the basic* funding and organization of HEIs *and each state has its own laws governing higher education [...] Regulations applying to the accreditation of degree programmes may differ from state to state"* (pp. 11-12) ***Demographic environment.*** "*Political objective to **increase the academic participation rate** to 50 per cent, with its consequent demands on levels of academic inclusion*" (pp. 14) ***Organizational culture.*** Characterized by a high degree of autonomy at faculty level: "*commitment to extending decentralized responsibility, including creative freedom within the core processes of teaching and learning, and supported by a culture of mutual trust in the drive to enhance quality"* (pp. 25). Heterogeneity of students viewed as an opportunity to promote diversity (pp. 23). ***Labour market.*** *"procedures for curriculum design at UDE ensure that the expected learning outcomes of its study programmes are oriented towards **the demands and current developments** of the jobs market, either by including **jobs market analysis** or involving employers in the curriculum design process"* (pp. 37)
ACTORS	**Deputy vice-chancellor** for institutional planning and resources and **deaneries** of faculties (pp. 24). **Central service unit (CHEDQE)**. Flexible composition, depending on which staff members are working on the different tasks. **40 employees** working on continuous standard tasks. Two teams have specific responsibility for quality assurance: (i) the data **management team** (5 members) + (ii) the **evaluation team** (2 members) (pp. 24). Teams also comprise **temporary staff members** (pp. 24). *"During preparations for system accreditation, the communication process has been supervised by: a **steering committee** consisting of representatives of the rectorate, the administration, and the faculties, coordinated by CHEDQE; and a **project advisory body** comprising deans, administrative directors of faculties, unions, and students together" (pp.36).* *"Some faculties have introduced **employers' councils to factor employers'** (...) into study programme design & revision (pp. 36)*
RESULTS	***Outputs and outcomes*** (pp. 29-30, 34-35) **Key performance indicators & ratios** **Annual quality assurance faculty reports** **Target and performance agreement reports** **Institutional evaluation self-reports** **Institutional evaluation peer review and external reports** **Student course satisfaction reports** **Summaries** (graduate tracer studies, faculty QA annual reports) ***Improvement actions and measures*** *"system accreditation involved communication about the **adjustments** and the **newly developed tools**, and **implementation** of the necessary **changes**" (pp. 28)* *"The information gathered is used in the **ongoing development of the university's study programmes**. (pp. 32)* *"the task of preparing UDE for system accreditation involved communication about the **adjustments and the newly developed tools, and implementation of the necessary changes** (pp. 28)*

Figure 33 – Description of the Internal Quality Assurance System Implemented at University of Duisburg-Essen

Source: Own elaboration (extract of publication [P8], page 604)

The particular instantiation template of the component Block II corresponding to this second PUS relative to practical experience [PE.3] could be as the one shown in the following Table 41. Since its rationale for generation is based in the same assumptions than other templates already introduced in this report, in the following we only describe those element items of the template requiring major adjustments or adaptations in terms of the pre-defined values recommended by element item GUS12 of the "static list" of GUS defined by our constructed artefact

Table 41 – Instantiation Template of the Artefact Framework Developed for Practical Experience 3: Information Relative to the Second Practical Usage Given to Architectures (Component Block II)

Particular Use Scenario (PUS) Name	*Documenting the IQAS implemented at University of Duisburg-Essen*
Particular Use Scenario Description	*Details can be found in in section 5 of publication [P8], pages 603-606*
Id. Generic Use Scenario (GUS)	GUS12
Generic Use Scenario Name	DOCUMENTAL SUPORT FOR QUALITY ASSURANCE AUDITS
Generic Use Scenario Description	This GUS involves using the own ERA's materials as documental support tool for either internal or external QA/QM audit or accreditation purposes.
Possible Dependences with other Generic Use Scenarios	➤ ~~Business process standardisation and optimisation (#GUS10)~~
Involved Users /Stakeholders	➤ ~~HEIs/ Administrators & Executive Managers~~ ➤ ~~HEIs/ Quality Assurance & Standards Groups~~ ➤ ~~HEIs/ IS&IT Managers~~ ➤ ~~HEIs/ Business & Domain Managers~~ ➤ ~~HEIs/ Business & Domain Specialists~~ ➤ ~~Other HEIs & Competitors~~ ➤ **External Consultants** *(adopted the role of an external QA specialist)* ➤ ~~Clienteles~~ ➤ ~~Government Entities &Regulators~~ ➤ ~~Quality Assurance Regulators~~ ➤ ~~Other External Stakeholders~~
Potential Benefits Achieved	▼ **Time**: Shorter project/activity/product (QA documentation) development cycle times ▲ **Quality**: Improved quality of the resulting product/output (reusability of knowledge embedded in the ERA) ➤ ~~**Other**: Improved compliance with regulations/standards and auditability~~ ➤ ~~**Other**: Better structural relationships within a company, industry or domain~~
Particular Application Guidelines Followed in Practice	❖ **Subsets or portions of the business-/IS-oriented RMs and landscapes provided by the ERA can work perfectly as a starting point for developing a graphical representation summarizing the HEI's IQAS/QMS currently implemented.** ❖ ~~Glossaries and vocabularies included within the ERA can be used to provide formal definitions of the constitutive objects of the IQAS/QMS included in graphical representations.~~ ❖ ~~Documentation existing for the ERA may require some adaptations to the format/ requirements requested by the QA accreditation/audit body/entity.~~ ❖ *Use of a specific transformation mechanism (work systems snapshot) to achieve the adequate focus for the documentation of the IQAS to be generated.* ❖ *Use of complementary information sources describing the particularities and specificities of the IQAS to be documented (in terms of the RA used).* ❖ *Search and identification of representative items (i.e., particularisations, instantiations) of the core elements and sub-elements defined by the architecture used as a reference in the complementary sources related with the IQAS to be documented.* ❖ *Progressive homogenisation/ integration of the different representative items found in the previous step into a unified final artefact/model/product (until saturation is reached).*

Potential Blockers	• *Use of relatively immature or partial ERAs/RAs (architectures presenting a lack of some structural elements like principles, glossaries, vocabularies, specific transformation mechanisms or ill-defined RMs) may be ineffective or insufficient for being used in practice.* • *Unclear, heterogeneous or scattered descriptive documents of the IQAS to be documented may contain inconsistencies or may result too complex for being used as complementary information sources when tailoring or transforming knowledge embedded by the ERA/RA used as a reference.* • *Architecture's users potential lack of knowledge on basic concepts related with QA in HEIs.*

Source: Own elaboration

For example, and regarding the element item "*Potential Benefits Achieved*" during the PUS described, it can be argued that the main benefits realized might be associated with time savings achieved from the use of a RA and the *work systems snapshot* as tools for accelerating the process followed to produce the description of the IQAS implemented at University of Duisburg-Essen. In addition, quality improvements in terms of the resulting documentation conceived may also be alleged as a consequence of using a *work systems snapshot* to produce a comprehensive, well-structured and *single- one-page* concentrated documentation format.

Also, and as already commented, the element item "*Particular Application Guidelines Followed in Practice*" of the instantiated template reflects the fact that only the first pre-defined generic recommendation guideline suggested by our artefact framework constructed makes sense for the activities taken in practice during the second PUS. In addition, the template's value summarizes also the key points on how it could be nuanced and adapted for the specific purposes of producing the desired descriptive documentation of the IQAS implemented at University of Duisburg-Essen. Lastly, the element item "*Potential Blockers"* highlights several aspects that hampered the execution of the earlier narrated activities and tasks, as for example, the lack of sufficient expertise in QA issues by architecture's users, or the existence of heterogeneous and/or incoherent documentation of the IQAS to be described jeopardizing its homogenisation into a simpler, integrative and understandable format (as the one represented by a *work systems snapshot*) –.

Finally, to conclude with this sub-section, and in a similar vein than in the earlier practical experience [PE.2] described, all the efforts we did for conceiving the new RA tailored for IQAS of HEIs as well as its correspondent application to the case of the IQAS implemented at University of Duisburg-Essen were detailed in the form and format of an academic publication [P8], which was later accepted in a well-known international QM international conference. Again, such fact could be understood as an implicit *validation* of our work done, despite being formally out of the scope of a DSRM evaluation episode. Lastly, it should also be recognized that despite that the outputs and knowledge derived from all our work was made available to QA managers at FIB, we did not have any feedback on their posterior usage to date.

4.3.2.3. Discussion on the Utility Signs Perceived for the Artefact Framework

As stated at the beginning of this section, the ultimate goal of the *evaluation* stage of the DSRM methodology puts the focus on testing how well the artefact works in practice. Thus, the practical utility of the artefact constructed needs to be assessed over a range of contexts (Abraham et al., 2014, p. 3,8; Baskerville et al., 2018; Peffers et al., 2018, p. 133; Sonnenberg & vom Brocke, 2012b; Venable et al., 2016). According to Peffers and colleagues seminal paper presenting the DSRM methodology, the assessment of the artefact can done by comparing the defined objectives of a solution to the observed or measured results from an actual artefact's usage in practice (Peffers et al., 2007, p. 56).

In terms of the present research, the notion of utility of our constructed artefact has been indirectly shaped (i.e., captured) by means of the (goal-oriented) defined requirement [RE.8] *Usefulness* – see again Table 17 and section 3.4 –. This requirement refers to the degree to which the artefact constructed provides value for its users to achieve a certain goal or aim. Specifically, the main goal for our framework was set to *facilitate (i.e., assist. guide) the use and application of HEI-oriented ERAs by different stakeholders.* This main goal has in turn, and for operability purposes, further decomposed into 4 principal sub-goals, namely i) *fostering the awareness, understanding and acceptance of HEI-oriented ERAs*, (ii) *providing a common/simple template summarizing knowledge required for effective ERA's usage*, (iii) *serving as actionable instrument to practitioners in the HE arena*, and (iv) *becoming a complementary support tool to the current EA tool-box already used by practitioners.* Following, we discuss the perceived behaviour of our constructed artefact during previous evaluation episodes, taking into account as well the impact and nuances derived from the aforesaid limitations and restrictions we faced for the effective execution of the evaluations effectively conducted.

The following Table 42 summarizes the main *utility signs* and *hints* that can be perceived of the illustrative application of our artefact framework in earlier practical experiences described [PE.1-PE.3]. In order to achieve deeper, fine-grained details for the analysis, the information displayed in the table relates the utility *signs/hints* identified in each one of practical experiences [PE] conducted/assessed in terms of the 4 operative sub-goals attached to the artefact- Correlations found are marked with a check-box (✓) in the correspondent cell of the table and details about the rationale for justifying the correlation identified are also provided in the adjacent right-columns of the table. Whilst accepting that limitations inherent to the *evaluation* episodes conducted does not allow us to achieve unconclusive results from the analysis performed, data shown in Table 42 offers a minimal point of reference for reflexion and discussion.

In general terms, it could be argued that the artefact constructed might work especially well as a collector instrument of the essential "*critical knowledge*" that practitioners should have in mind when trying to put in play an ERA in their daily work practices according to their context-specific needs. In an antagonist way, evaluation performed does not allow to establish any rationale hypothesis on the artefact's potential as a complementary EA tool, since none of the practical experiences [PE] assessed offered an adequate context of practice for perceiving any utility *hint/sign* in this sense. From the perspective of the remaining artefact's sub-goals attributed to the artefact, our evaluations performed only allow to perceive very elemental signs/symptoms of practical usefulness in one of the whole set practical experiences [PE] conducted (see particular details in Table 42) and therefore, under such circumstances is quite complicate, for example, to establish definitive conclusions about the *transferability* to other HE-oriented situations and contexts of the utility *hints/signs* diagnosed, since they would practically be based on mere speculations or conjecturing.

All in all, and collectively, results derived from the earlier analysis only seem to suggest (point out) that the artefact framework constructed might work as an enabler/facilitator for the effective use/application of HEI-oriented ERAs in practice, but defiantly, no conclusive result on this sense can be strongly asserted.

Table 42 – Artefact Framework signs of Utility Derived from the Evaluation Activities Conducted

GOALS FOR THE ARTEFACT FRAMEWORK CONSTRUCTED	PRACTICAL EXPERIENCES [PE.1]	[PE.2]	[PE.3]	UTILITY HINTS/SIGNS PERCEIVED FOR THE ARTEFACT FRAMEWORK CONSTRUCTED
O1 – To foster the awareness, understanding and acceptance of HEI-oriented ERAs.		✓		• The representative instantiation templates generated for practical experience [PE.2] providing synthetized and structured knowledge relative to all different HEI-oriented ERAs/RMs used in practice could have been helpful for practitioners to (i) better understand the main structural differences existing among architectural exemplars in use; and (ii) to increase their consciousness on the adequacy of each concrete architectural exemplar for the purposes of inductively creating the new ISRM-HE model. • Being aware of these aspects could have led, perhaps, to a slightly more efficient/simplified construction process of the *ISRM-HE model* during practical experience [PE.2], for example, by skipping some of the ERAs/RMs exemplars used as a source for creating it.
O2 – To provide a common and simple template with the knowledge required during the process of ERAs usage.	✓	✓	✓	• The information provided by the instantiation templates generated for the practical experiences assessed seemed to effectively capture and synthetize all the knowledge required by those involved in the different PUSs undertaken to proceed with an adequate use/application of the architectural exemplars in use.
O3 – To serve as actionable instrument to empower the autonomy of EA practitioners in HE-oriented contexts.			✓	• The instantiation templates derived for practical experience [PE.3] could have played a significative role as a guide for practitioners during their time invested in acquiring an adequate level of expertise of WST, the "sector-independent" ERA used during the experience. Anyway, such knowledge acquisition process led them to discover *work systems snapshot* as a particular mechanism provided by WST for transforming (i.e., describing, tailoring or adapting) the *generic* components configuring a "*standard*" or "*reference*" work system into the *specific* elements configuring a particular case or instance of existing work system. • Getting to know in detail the potential of specific transformation mechanisms (or other commentary elements/ components) encompassed by ERAs in use, might work for practitioners as a platform for giving rise to ideas, insights or practical lines of action providing direction about further activities/tasks that could be done or decisions that could be taken in their particular contexts of practice. For example, in practical experience [PE.3], drawing on the concept of *work systems snapshot* practical lines of action could be uncovered to develop a RA tailored for IQAS of HEIs as a particular case of work system grounding on the "*standard" or "reference*" configuration of work system as defined by WST.
O4 – To be a complementary EA support tool to the current toolbox of methods, frameworks and artefacts actually used by practitioners in HE-oriented contexts.				• No utility signs/hints in this sense can inferred from the evaluation episodes conducted.

Legend

[PE.1] – Developing a bid proposal for a new IS of a Catalan Higher Education Institution

[PE.2] – Conceiving a new Information Systems Reference Model for Higher Education Institutions

[PE.3] – Formalizing and Describing the Internal Quality Assurance System of a Higher Education Institution

Source: Own elaboration

Obviously, additional deeper evaluation episodes should be performed to determine clearer conclusions on the legitimate practical usefulness of our constructed artefact. Such new episodes should ideally be directed towards overcoming the inherent constraints of the episodes already done during this research, including for example in-depth case studies providing stronger empirical account (i.e., accurate testing/assessment) on the artefact's usefulness perceived on the basis of a true and real usage made of our artefact by those practitioners involved in the case under investigation. Furthermore, this additional study should encompass as many as possible real projects and diverse HE-oriented settings giving light to as many as possible different USs in practice of HEI-oriented ERAs. Probably these new studies may shed light on additional insights, rich descriptions and rigorous evidences providing a better background for further backing and extending the earlier suggested/hypothesised utility signs into rather more definitive, conclusive and transferrable claim and assertions regarding the usefulness of our constructed artefact. Whatever the case, issues and aspects related with opportunities for further research will be deeper discussed in the final chapter of the present report.

4.3.3. Other Practical Experiences Conducted

Besides the earlier described experiences, and as referred at the beginning of the present section, during the temporal span of our research we also had the opportunity to conduct (or indirectly participate in) several other professional activities and projects that might have represented an opportunity to gather additional feedback about the practical utility of the artefact constructed. Unfortunately, and due to several circumstances [71] we were not able to articulate them into "formal" DSR evaluation episodes having the minimal levels of rigour required for such purposes.

Nonetheless, and assuming that if it would have been possible to conduct them under more strict conditions of control – in terms of investigative accuracy – they would probably have been a source of interesting additional value for the thesis [72]. In the following paragraphs we briefly provide a summary of a couple of them.

4.3.3.1. Supporting the IS/IT Strategic Plan of a Catalan Higher Education Institution [73]

This fourth practical experience [PE.4] is related with the efforts undertaken at internal level at the UPC to develop its 2019-2021 IS/IT Strategic Plan. The main goal of this plan was to define the new IS/IT service model that must support the university's strategy, including the roadmap of initiatives to be executed in the period 2019-2021 for these purposes. In particular, it was conceived with the aim of designing an agile, flexible and focused IS/IT service model allowing the whole UPC's community to make informed decisions and effective/efficient administration.

The elaboration of the plan was promoted since October 2018 within the auspices of the UPC Action Plan 2018-2021, which envisaged the transformation of the UPC into a full-digital university. The IS/IT Strategic

[71] For example, time or costs restrictions, access barriers to field work, non-availability of an operative version of the artefact framework constructed at the time of the activity/project, lack of commitment of the professional partner, or bad focus (in terms of the thesis defined scope) of the main objectives of the activity/project participated.

[72] As for example, conducting rigorous "*ex-post*" evaluations of the artefact constructed, obtaining additional data and first-hand empirical evidence on the usage of ERAs in practice, complementing "*ex-ante*" evaluation episodes conducted during the artefact's construction process, etc.

[73] Descriptive details for this section have been extracted from "*Ponències de difusió del Pla Estratègic TIC de la UPC 2021*" (https://www.upcnet.es/ca/noticies/ ponencies-de-difusio-del-pla-estrategic-tic-de-la-upc-2021) and "*Pla Estratègic de les TIC UPC 2019-2021*" (https://tv.upc.edu/continguts/pla-estrategic-de-les-tic-upc-2019-2021)

Plan was articulated through a participatory process lasting 10 months, in which more than 125 people from different university groups and services – both at the corporate sphere (vice-chancellors, directors, etc.) as well as the level of *Transversal Management Units* (heads, managers and technicians) – evaluated, among others, the applications, infrastructures, working methods, and security of the UPC. Project's leadership was carried out by IThinkUPC/UPCNet – the IS services consultancy company of the UPC – which also contributed to the project with several IS consultant experts and EA specialists in HE. A total of 20 final deliverables were generated during the project execution, with more than 2,000 slides and more than 200 projects proposed, which were grouped in turn, into 11 global areas of action.

From a methodological management perspective, a three-staged approach was carried on to conceive the new plan:

1) First, to diagnose and scrutinize the current situation of the institution, in the first *AS-IS* stage both the corporative as well as the *Transversal Management* organisational units of the UPC were analysed from an IS/IT perspective, including their applications, technological infrastructure, IS and IT operative and management processes, security issues, people involved (including his/her talent) and finally, their governance model, organisation and cost of IS/IT – see following Figure 34 for a diagnose example –.

2) In the second *TO-BE* stage, and departing from the previous diagnosis made, several different potential scenarios of future evolution to be achieved by the institution were generated to, finally, decide on the most suitable one. A total of 18 strategic initiatives on which "*the action*" of the strategic plan had to be focused in order to achieve the desired future scenario were defined.

3) Finally, in the last *TO-DO* stage, the previous strategic initiatives were further decomposed into more than 200 smaller projects, which once organized and prioritized, make up the roadmap of IS/IT projects to be executed at the university until year 2021.

Figure 34 – Extract of the 2019-2021 IS/IT Strategic Plan of the Polytechnic University of Catalonia (text in Catalan)

Source: PETIC UPC 2019. Available at https://espaitic.upc.edu/ca/pla-estrategic/petic-upc21-presentacio-final-v1-0.pdf

The relationship of our research with the activities conducted at UPC to develop its 2019-2021 IS/IT Strategic Plan relies on the fact that, during the first steps of the project, the team of IThinkUPC/UPCNet explicitly used our UISRM-HE conceived model– see again section 4.3.2.1 about our activities conducted and results achieved from practical experience [PE.2] –. In particular, our model was used to scrutinize and identify the main shortcomings and deficiencies of the existing IS/application landscape running at the institution.

However, and as researchers, we were aware about that fact *a posteriori*, when an informative follow-up meeting about the *state-of-affairs* of the plan was held at the university. In fact, we were only able to later confirm unequivocally the use in practice of our UISRM-HE model in the UPC's project during a subsequent informal interview with IThinkUPC/UPCNet's professionals which were involved in the initiative. Unfortunately, we corroborated that our model's practical usage was done in a rather informal way. Moreover, it was used without the explicit support and/or guidance of our constructed artefact framework. Under such circumstances, the practical experience did not provide us a valid context of practice [74] for evaluating and establishing conclusive arguments on the utility/usefulness of our constructed artefact[75]. Nonetheless, it would have certainly be a nice opportunity to conduct a study case for gathering rich insights and empirical evidence on the practical use of HEI-oriented ERAs, which to date, is still a phenomenon insufficiently covered by existing specialized literature.

Whatever the case, and from the perspective of the utility/usefulness of our artefact, a couple of reflections could be derivate from the project conducted at UPC:

- First, arguments could be raised on the needless of our constructed artefact since IThinkUPC/UPCNet professionals were able to use in practice a HEI-oriented ERA/RM (in a more or less effective way) without our artefact's support. Important aspects here can be the simplicity, comprehensiveness and understandability of the architectural artefact used. For instance, the relative *simplicity* of our UISRM-HE model (at least compared with other existing instances) probably made easier practitioners its autonomous applicability without the additional support of our artefact.

  Nonetheless, the question arises whether IThinkUPC/UPCNet staff would have been able to made a similar autonomous use of a HEI-ERA under the assumption of having used a different and more complex exemplar – HORA or CAUDIT, for example – than the one – UISRM-HE model – they actually use. Under such circumstances, it could be certainly hypothesised that our constructed artefact would have help practitioners to achieve a better (more effective) architecture' usage.

[74] The usage given in practice to our UISRM-HE model at UPC could be compatible with the specifications of several of the GUSs considered by our constructed artefact, as for example the "*GUS19–Gap Analysis with an Individual Model*" or the "*GUS20 –Deliver a Roadmap, Migration, Transition or Transformation*".

[75] It must be highlighted here that, at that moment of time, we considered the possibility of arranging more additional meetings with IThinkUPC/ UPC Net personnel directly involved in the UPC's IS/IT strategic plan initiative to i) introduce them our constructed artefact as well as (ii) to interview them on their perception about whether the newly presented artefact would have been useful– in some or another way – for improving the quality of their EA practice. The idea behind the scenes was, in fact, to try to obtain some kind of "indirect" measure or evidence on the utility of our artefact constructed. Nonetheless, we finally discarded such possibility since we considered that the feedback that we would have obtained would most likely incorporate high levels of bias (i.e., feedback obtained for a long time after the real use of the model, responses grounded on personal perceptions instead that on a real usage made of our artefact constructed, etc.).

- Second, it might also be argued here that the usage made of the UISRM-HE model during the developments of the IS/IT Strategic Plan at UPC could have been much more profitable. In this sense, a similar or analogous rationale than in the previous point could be posed regarding the *complexity* or *difficulty* of the intended architectural use to be made in practice: the more complex the desired or intended architectural use, the greater need for additional or complementary support for architecture's users – i.e., see again reflexions on the maturity of ERA's usage in practice stated in section 3.5.2 and Figure 21–.

  For instance, and considering the adopted methodological approach adopted at UPC to develop the IS/IT Strategic Plan, it could be argued here that an explicit use of our constructed artefact by practitioners involved in the development of the UPC's IS/IT Strategic Plan would probably have led to a much more extensive, profitable or effective usage of the UISRM-HE model during the project [76]. In other worlds, we hypothesize that the use in practice at UPC of our conceived artefact framework might have helped to create awareness in those involved in the project about the potential possibilities (value/benefits) derived of making a more intensive use of the UISRM-HE model's through the whole project executed.

Summarizing, if as researchers we would have had the adequate level of accessibility to the context of practice (e.g., sites, individuals, etc.) involved in the project for conceiving the IS/IT Strategic Plan at UPC, we would have probably obtained not only rich insights about the practical usage of HEI-oriented ERA/RMs in a real situation but also important data and valuable feedback on the practical utility of our conceived artefact. Notwithstanding that, we also reaffirm here than the real usage made in practice at UPC of our UISRM-HE model becomes a manifest contribution of this thesis, since it represents a direct result of the work done. Further its use in practice during a real project can be viewed as a (partial) evaluation of the produced model itself.

4.3.3.2. Towards a Catalan Higher Education Enterprise Reference Architecture

This final fifth practical experience [PE.5] had its origin in December 2018 at the annual *Meeting of the Computer Services of the Catalan Universities* [77] held at the UPC in Barcelona. During the intermediate break of the event, we had the opportunity to have an informal talk with the general director of the CSUC, in which we introduce him on the main topic as well as on the main general lines of our research. Quickly, he manifested his interest in going deeper on several aspects of our work, including having a longer discussion on the plausibility of thinking about the creation of a Catalan HEI-oriented ERA. Considering such interest, we all agreed on the need to schedule a new meeting for discussing in more detail about existing exemplars of HEI-oriented ERAs as well as on the different approaches adopted in several countries for constructing their models.

The agreed meeting was finally held on January 17th 2019 at the Dean's Office of the FIB. The participants in the meeting were the general director of the CSUC, the thesis professional *advisor*, the thesis main academic

[76] In fact, it would be reasonable to think about the possibility of having used the UISRM-HE model in several activities within any of the methodological *AS-IS/TO-BE/TO-DO* stages defined in the UPC initiative. Hence, and among the different GUSs for HEI-oriented ERAs contemplated by our artefact constructed, some of the most plausible to occur during the elaboration of an IS/IT Strategic Plan would be "*GUS9-Support for IS/IT Integration Decision-Making*", *"GUS18– Identification of Opportunities of Cooperation and Coordination (Synergies) Among Different Sectorial Units/Entities"*, or *"GUS21–Support for (operational) Business-IS/IT Alignment*", to mention only a few.

[77] *Trobada dels Serveis Informàtics de les Universitats de Catalunya*.

supervisor and the doctoral candidate. The meeting lasted near a couple of hours and was structured into two main parts:

- During the first part, the doctoral candidate introduced the rest of attendees on the basics about ERAs and their potential utility in practice for different stakeholders. This background was exemplified later by presenting in more detail de Dutch approach, including the most important components and features of HORA version 2.0 HEI-oriented architecture. Finally, the doctoral candidate complemented the previous explanations by giving some details on other different approaches, presenting also other exemplars of HEI-oriented ERAs developed in other countries. Emphasis was particularly put in Australian advancements – i.e., the CAUDIT architecture – as well as in the Finnish and Norwegian proposals – e.g., OPI and RADE architecture + Difi HEI-oriented principles, respectively –.
- During the second part of the meeting, a free discussion involving all attendees was opened to exchange ideas and opinions on how a similar approach could be adopted for within local Catalan context. In this sense, the general director of the CSUC remarked the fact that there can be analysed potential opportunities of collaboration between us and the CSUC's *IT-Business Strategic Alignment* working group, since this group was being also analysing this type of EA artefacts. However, the CSUC 's group still was in an earlier stage of study of ERAs than us.

Unfortunately, and beyond the aforesaid meeting, no further progress was made – partly due to the fact that the professional relationship among the doctoral candidate and *SEIDOR* concluded around that time –. Anyway, and for the future, we believe it would be worthwhile to continue exploring opportunities that might be derived from these initial contacts, since they might lead to interesting insights on how to foster the usage/applicability of HEI-oriented ERAs within the scope of the *Catalan Universitary System*. In this vein, several of the GUSs considered by our artefact as for example "G*US5 – Support for Creating an EA product, RM or ERA"* or the *"GUS18– Identification of Opportunities of Cooperation and Coordination (Synergies) Among Different Sectorial Units/Entities"*, might provide some direction to put *the first stone in the way* for such purposes.

4.4. Evaluating the Design Research

Finally, the last episode defined within the trajectory set of evaluation episodes defined for the present research is devoted to evaluate the research method (i.e., *design research*) followed/conducted. For this purpose, we decided to use as a principal evaluation instrument the well-known 7 DSR quality guidelines proposed by (Hevner et al., 2004)'s in their seminal paper. These guidelines are typically used as a somewhat like a general "*quality check*" by many IS-oriented DSR initiatives. From the perspective of the FEDS framework, this final evaluation activity could be characterised as a rather *artificial/ex-post* evaluation episode (it must be remembered here that the FEDS framework does not formally address evaluation episodes from the perspective of the design research).

The application of the (Hevner et al., 2004)'s DSR quality guidelines to this research is presented in the following Table 43. The first couple of columns of the table enumerate the guideline number and the original formulation of the guideline. In the remaining right-sided columns, basic justificatory considerations on how each guideline has been applied (accomplished) during the research are also provided, together with a basic numeric indicator estimating the guideline's achievement degree level.

Table 43 – Application of Design Science Research Quality Guidelines to the Research Design Process

Guideline Name	**Guideline Description**	**Application in this Research**	**Reference Sections**
#1. Design as an Artefact	*DSR must produce a viable artefact in the form of a construct, a model, a method, or an instantiation.*	In the IS arena, DSR puts the focus on building different forms of sociotechnical artefacts (Carlsson et al., 2011, p. 111; Drechsler, 2013, pp. 14–15; Gregor & Hevner, 2013, p. 340). Initially, DSR outputs were usually distinguished according to the March and Smith (1995) classification, considering *constructs, models, methods* and *instantiations.* Later, this classification has been extended by other researchers including additional forms of DSR outputs, including (among others) *architectures*, *design principles*, *frameworks* or even *technological rules*. (Drechsler, 2013; Dwivedi et al., 2014; Offermann, Blom, Schönherr, et al., 2010; Purao, 2013; Rossi & Sein, 2003; Vaishnavi et al., 2017). In the case of this thesis, a framework is constructed at the design and development stage of the research.	Sections 1.3 to 1.4 Sections 3.3 to 3.5
#2. Problem Relevance	*The objective of design science research is to develop technology-based solutions to important and relevant business problems*	The framework constructed is devoted to improve the awareness, understanding and effective use and application of HEI-oriented ERAs in practice by different stakeholders (i.e., practitioners interested or aiming to use the envisioned artefact). The relevance of the research topic has been shown through the corresponding review of the existing literature on EA artefact usage, which clearly pinpoints the problem of insufficient understanding and ineffective practical use of EA artefacts, and in particular, of HEI-oriented ERAs. This problem still represents one of the major challenges within the EA research field.	Section 1.2 Section 3.3.2
#3. Design Evaluation	*The utility, quality, and efficacy of a design artefact must be rigorously demonstrated via well-executed evaluation methods*	Evaluation has been carried out throughout the entire research process by means of a global evaluation strategy grounded in 6 particular episodes, which represents the evaluation concept for the artefact constructed. The design of each one of the evaluation episodes has been focused towards the assessment of the artefact framework's requirements defined, which were derived from both theoretical and practitioners-oriented knowledge collected from (i) literature reviews in EA for HE, (ii) business local (Catalan environment) context of practice specific data, and (iii) theoretical literature focused on DSR requirement's definition/elicitation. Due to several research project boundaries (see sections 1.7 , 4.4.3 and 5.4), the utility of the artefact constructed could only be demonstrated and evaluated by means of a retrospective case study and multiple illustrative scenarios based on different real practical situations of ERA's usage. In each case, a representative instantiation template of the constructed artefact framework was generated. Under such circumstances, only a rather partial *naturalistic/ex-post* evaluation could be executed. The utility sings inferred from the illustrative application of our artefact framework seems to suggest that it might be useful for practitioners (see sections 4.3.2 and 5.3).	Section 1.6 Sections 3.5.3 Sections 4.2 to 4.4 Sections 1.7, 4.3.2 and 5.4 (limitations)

Guideline Name	Guideline Description	Application in this Research	Reference Sections
#4. Research Contributions	*Effective design science research must provide clear and verifiable contributions in areas of the design artefact, design foundations, and/or design methodologies*	Despite that the ultimate goal of DSR is to produce prescriptive knowledge as basic outcome, it can also produce descriptive knowledge (Gregor & Hevner, 2013; vom Brocke et al., 2020). In the case of this thesis, the research has produced both prescriptive and descriptive outputs [78]. On the one hand, the artefact framework constructed for facilitating the use and application in practice of HEI-oriented ERAs represents the major prescriptive output of the thesis. On the other hand, and among the most relevant descriptive contributions generated during the research there can be highlighted (i) a structured state-of-the-art--and-practice of current knowledge in ERAs, (ii) a catalogue of current existing exemplar of HEI-oriented ERAs, or (iii) basic empirical accounts on the usage in practice of HEI-oriented ERAs in real settings.	Sections 1.3 to 1.4 Sections 5.3 and 5.6
#5. Research Rigor	*Design science research relies upon the application of rigorous methods in both the construction and evaluation of the design artefact.*	To ensure research rigor, the whole research efforts have been grounded on foundational knowledge on DSR in IS (Gregor & Hevner, 2013; Hevner, 2007; Hevner et al., 2004). Furthermore, the DSRM methodology (Peffers et al., 2007) – perhaps one of the most accepted and tested DSR methodology (Cronholm & Göbel, 2016) – has been used as a reference point to guide whole research process. Further, both artefact's construction and evaluation activities defined within the DSRM methodology have been grounded on well-known DSR-oriented reference frameworks, patterns and guidelines devoted to provide guidance on how to characterise and configure activities. On the one hand, the artefact' construction has put the focus on overcoming the weaknesses and limitations identified in already existing artefacts devoted to solve relatively similar problems than the one for which our artefact framework has been conceived. Taking as a baseline general recommendations for designing DSR artefacts proposed by (Johannesson & Perjons, 2014), we drew upon knowledge on design principles for *reference modelling* (Becker et al., 2007; vom Brocke, 2007; Zivkovic et al., 2007) and *ontological operations for EA artefacts* (Purao et al., 2011) to conceive our new artefact. On the other hand, the evaluation strategy defined for our research relies on the FEDS framework (Venable et al., 2016). Furthermore, the trajectory set of evaluation episodes operationalizing the evaluation strategy chosen has been designed taking into account existing templates, patterns and recommendations born from the specialized IS-oriented literature on DSR evaluation providing assistance on how to characterise/ configure individual evaluation episodes (Dinter & Krawatzeck, 2015; Kotze et al., 2015; Peffers et al., 2012; Prat et al., 2015; Shrestha et al., 2014; Sonnenberg & vom Brocke, 2012a, 2012b).	Sections 1.5 to 1.6 Sections 3.4 to 3.5 Sections 4.2 to 4.4

[78] A complete list and additional details about of the main research outputs, results and contributions produced during the thesis will be provided in the following chapter (see sections 5.3-5.6).

Guideline Name	Guideline Description	Application in this Research	Reference Sections
#5. Research Rigor *(continued)*	*Design science research relies upon the application of rigorous methods in both the construction and evaluation of the design artefact.*	Regardless of the efforts to conceive a research process based on rigorous DSR background, limitations inherent to the artefact's evaluation activities finally executed – see *#3. Design Evaluation* guideline comments – leads us to recognize that further assessment/ testing regarding the constructed artefact 's utility still remains pending. In particular, further evaluation activities should be performed putting into play the constructed artefact in several more particular situations representative of different HE-oriented practical contexts. The information gathered and collected from these evaluation activities would provide the complementary evidence needed to establish more conclusive results regarding our artefact's usefulness for EA practitioners working in the HE arena.	Sections 1.5 to 1.6 Sections 3.4 to 3.5 Sections 4.2 to 4.4
#6. Design as a Search Process	*The search for an effective artefact requires utilizing available means to reach desired ends while satisfying laws in the problem environment*	The search for an effective artefact was mainly informed by the descriptive information collected about existing similar artefacts devoted to provide solutions to similar problems than the one to be solved/tackled by our envisioned artefact. Also, and through a comparative analysis, we were able to detect both the strengths and weaknesses of the investigated artefacts in terms of the requirements defined for our new envisioned one. Drawing on the main deficiencies detected on these similar artefacts, 3 main generic design strategies were posed: (i) developing a new artefact from scratch, (ii) taking one artefact as a reference to further evolve it, or (iii) combining several already existing artefacts to conceive a new one. Finally, and *hybrid approach* combining the second and third alternatives was finally implemented as the most suitable one. Whatever the case, it should be recognized here that a much more iterative and collaborative design process for conceiving the new artefact considering would have been certainly desirable, including for example, opinion/knowledge provided/emerged by/from some representatives of the (intended) artefact's audience (EA experts and professionals working in the environment of the HE arena).	Sections 3.3 and 3.5.1
#7. Communication of Research	*Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.*	The most important results and outputs achieved during the research process conducted have been conveniently communicated to both technology-oriented as well as management-oriented audience by means of (i) papers presented at international conferences on IS/QM/HE, (ii) articles published in IS-oriented journals, (iii) book chapters aimed at professionals in the HE arena, and (iv) several others dissemination events in which we had the opportunity to, in some or another way, provide details about the research activities carried out.	Sections 5.3 and 5.6

Source: Own elaboration

5. Conclusion

5.1. Introduction

This final fifth chapter of the thesis reflects on the whole research process conducted and summarizes the main research results, outputs and contributions achieved. In first instance, the main research aim [RA] and research questions [RQ] posed at the beginning of the thesis are revisited to think about what has been learned and to asses to what extend they can be answered grounding on new knowledge emerged from the research activities carried out. Following, the most significant outputs produced during the research are enumerated and discussed according to what is expected from a DSR-oriented research endeavour. The second part of the chapter is devoted to critically reflect on *what worked* and *what did not work* as expected during the research executed. In this vein, the main research drawbacks and limitations [RL] inherent to any piece of research are highlighted, together with potential opportunities and recommendations for further research [FR].

Finally, the chapter addresses the last vi) *communication* stage of the DSRM methodology adopted by discussing on the different types, intended audience, and impact attained by the set of publications [P] and dissemination activities [DA] produced during the thesis aimed at disseminating and wide spreading the main results achieved. Lastly, the report is closed up with a *concluding remarks* section as a final recapitulation of all the efforts undertook.

5.2. Revisiting the Main Research Aims and Questions

As stated during the first chapter of this report, the main research aim [RA] of this thesis has been the study and investigation of the concept of ERAs, as well as their re-use and application by practitioners in HE-oriented contexts. To achieve such aim, the tasks to be done were structured into a set of 3 main research questions [RQ], which in turn, were further decomposed into a detailed set of 7 research objectives [RO] further refining the scope, depth, breadth an overall direction of all the research efforts.

Now, it is time to review, discuss, and assess *up to what extent* each one of the research questions [RQ] and corresponding research objectives [RO] posed have been conveniently answered and reached, respectively.

[RQ.1] – What Current Knowledge About Enterprise Reference Architectures is Available?

> It must first be clear at all what ERAs really are, before they can be used in an effective way in practice. Hence, this first research question [RQ] of the thesis was designed to uncover the essential foundations of these under-researched EA artefacts to date. In order to answer this question, we articulated a structured literature review to *explore* existing knowledge on ERAs [RO.1]. To provide a panoramic and organized view of the discovered knowledge about ERAs, existing contributions found were organized into 4 main categories – namely *nature*, *adoption*, *practices* and *impact* – depending on their main topic addressed.
>
> Besides confirming our initial suspicions about the scarce amount of research conducted on ERAs, the analysis of the reviewed literature sources found led us to conclude that most of the research done has mostly focussed on addressing the *nature* (i.e., the *what is*) of ERAs, and in particular, in providing more

or less rigorous working definitions for the concept, including discussions and different rationales about the structural elements (*reference/conceptual models*, *principles*, etc.) that characterise ERAs or recommendations on how they should be ideally documented to foster their availability and effective usage in real practice. In addition, the analysis conducted also seems to point out for the existence of a secondary but relatively well-established stream of research focussed on *practices* about ERAs (i.e., the *how*), and particularly, in providing prescriptive recommendations on how-to rigorously build such kind of particular EA artefacts.

On the other hand, existing contributions directed towards addressing issues regarding the *adoption* and the *impact factors* of ERAs (i.e., the *to what extent* and the *why*) could considered as much more heterogeneous, scattered and backed in relatively low-quality evidences. For example, we identified several contributions providing insights about *adoption factors* or the *critical success factors* about ERAs. However, claims asserted by many of these contributions tend to be backed in anecdotal evidence or just the mere opinion or suggestions of their authors. At most, only few works devoted to address *critical success factors* of ERAs have been backed in basic expert opinion captured by simple questionnaires or interviews. In a similar vein, but constituting another quite scattered stream of research, we also found a great number of contributions shedding light on (i) different possible practical uses/applications of ERAs, (ii) potential benefits (short/middle term effects) and impacts (long term effects) that could be achieved from their effective use/application, and (iii) typical stakeholders/users involved in the architecture's practical use situations. Unfortunately, nearly none of them is provides strong empirical evidence on the assertions stated.

All in all, the literature review conducted clearly shows that there still is plenty of room for conducting supplementary research on different facets relative to this specific EA artefacts. In particular, much more studies should be directed to provide stronger evidence and detailed account showing how organisations belonging to different industries and sectors can take advantage of understanding and using ERAs in the wide variety of practical contexts and domains of application.

[RQ.2] – Which Exemplary Instances of Higher Education Institution-Oriented Enterprise Reference Architectures Already Exist?

This second research question was designed to narrow the scope of the previous one by putting the attention into a determined target domain of application for ERAs: HE. This sectorial choice is justified due to the historical lack of maturity of EA practices in this specific sector. Particularly, the focus of this second research question is fixed on *identifying* [RO.2] and *critically evaluating* existing instances of ERAs tailored for the HE domain [RO.3] on the basis of the (foundational) knowledge about ERAs acquired while giving answers to the previous research question.

Considering that ERAs can be originated both from academia and industry, we articulated a structured (comparative) literature review including both academic and grey literature with the aim of widening as much as possible the *width* (number of HEI-oriented ERAs exemplars identified) and *depth* (level of detail and granularity of the analysis performed) of the study. Further, we tried to be as comprehensive as possible by considering for analysis not only HEI-oriented ERAs but also HEI-oriented RMs.

A total of 27 different exemplars of HEI-oriented RMs/ERAs were considered for analysis. Most of them were created or first-time released during the 2015-2019 period, clearly reflexing a progressive increasing interest on the topic over the last years. Such fact can be viewed, in turn, as a clear sign confirming the relevance and currentness of the topic chosen for the thesis. For analysis purposes, we constructed an *adhoc* framework providing a quadruple perspective for artefact's comparison drawing on the structural properties or attributes characterising them – namely, *identifying* attributes, *general scope* attributes, *structure and content* attributes, and *practical use* attributes. The analysis performed not only provides transparency about the existing HEI-oriented RMs/ERAs exemplars but also enables comparing exemplars "*at a first glance*", facilitating therefore the identification of similarities and differences existing between exemplars. In general, it can be concluded that exemplars examined present notable differences in terms of nature, scope and form. Such heterogeneity in their configurative form and function may also lead, in turn, to significative differences in the potential benefits that could be realised from their use or application in real settings. Moreover, the analysis also seemed to point out on the existence of some kind of *archetypes* or "pseudo-categories" of ERAs/RMs tailored for HE.

First, there can be identified a notable set of architectural exemplars constructed by means of some kind of collaborative effort (typically in the form of *consortiums*) involving participation or engagement of as many as different stakeholders/interested actors in the HE domain itself. In terms of their configurative structure based on the attributes considered by our framework of analysis they tend to be quite complete, accurate and rigorous exemplars, which in turn, can be enabled from either a *top-down* or a *bottom-up approach*.

On the one hand, the *top-down* approach could be linked to architectural artefacts driven or motivated by national/regional initiatives launched by some type of authority – governments, HE public agencies, etc. – directed towards modernizing, digitalizing or improving the efficiency of their public IS/IT service/resource provision in their correspondent HE sectors. In these cases, the architecture tends to be articulated within these initiatives as a mean (instrument) for achieving the objectives established. In other words, HEIs should (or must, in many cases) tailor and adapt their current business processes and IS/IT landscapes to be "*compliant*" or "*aligned*" with the guidelines, models, principles stated by the ERA in order to be financed or suitable to be participants of the public resources/services provisioned by administrations. Examples of HEI-oriented ERAs within this *archetype* can be the national architectures fostered by several countries as Nederland's (HORA), India (UEAF/IndEA), Finland (OPI) or Norway (Difi & RADE).

On the other hand, *bottom-down* approaches could be associated to architectures enabled from collaborative partnerships in which, instead of public administrations, the own practitioners are those who mainly take the lead for promoting and fostering their construction and development. Usually, these efforts are directed towards conceiving an ERA or RM providing a *standardised* vision on how (part of) the EA of a typical HEI "*should ideally be*". Hence, the architectural artefact conceived is pretended to capture, abstract, integrate and organize all kinds and types of *best practices* generally accepted by all parties/actors interested or playing a role in the HE sector. In general, the architectural artefacts that could be associated within this category tend to be (a little bit) less accurate, detailed and (in several cases) somewhat more incomplete than the earlier described one, since in no few cases they only cover (address) part or a subset of the characteristic domain layers of an EA [79]. Existing ERAs/RMs that could be typified within this *category* could be CAUDIT, RATL, TIER or UCISA architectures.

Finally, another third *archetype* of HEI-oriented ERAs/RMs could be considered for typifying those architectural artefacts emerged as a result of rather *stand-alone* or individual initiative. They typically emerge as a result of a relatively wide or ambitious EA effort conducted in a particular HEI directed towards developing a tailored *solution* EA model for this specific settlement. However, this product achieved is considered – for example given their completeness, the high level of detail achieved – as suitable to be also helpful or representative enough for being re-used/applied as a "*reference*" – i.e., with the correspondent adaptations and particularisations – in other different HEIs. However, and from a structural compositional point of view architecture within this *archetype* should be characterised as being quite heterogeneous and context-dependent, since they typically incorporate very specific aspects and facets inherent to the determined HE settlement for which they were initially conceived. While these artefacts tend to emerge as a result of professional projects and initiatives undertook in a determined HEI –for example, the *Charles Sturt* University Business Process Reference Model (CSU-BPM) or the *Tras-o-Montes e Alto Douro* University IS Architecture (UTAD-ISA) – they can also come to birth from the academia – e.g., the *Unified Architecture Model for Universities* (UNI-3.0) –. However, in this later case, in not a few occasions these models tend to be nothing else than just *conceptual artefacts* conceived for teaching and learning purposes, entailing relatively low levels of adaptability/applicability for being used in real EA practices.

In sum, and whatever the case, additional research should be conducted to confirm all the previous rationale. Also, more research should be directed to conceive a more accurate catalogue of HEI-oriented ERAs/RMs, including new emerged exemplars or additional attributes/properties for comparison. Finally, and interesting additional line of research could be the study if this artefacts from the perspective of *institutional theory* (DiMaggio & Powell, 1983; Powell & DiMaggio, 1991) in order to investigate the effects of different pressures/ coercive forces pushing EA practitioners to use in practice these particular type of EA artefacts.

[RQ.3] – How and To What Extent Can Higher Education Institution Oriented Enterprise Reference Architectures Be Used in Practice and by Different Stakeholders?

This last research question was designed with the aim of providing new answers to the yet unresolved problem – according to the specialized literature on EA artefacts – of the inadequate (lack of) understanding and practical use in practice of EA artefacts, and in particular, of HEI-oriented ERAs as a very specific type of EA artefact. For instance, great part of the efforts undertook during the second part of the research have been directed towards the execution of a set of activities for *building* a framework for facilitating the use of ERAs in HE-oriented contexts [RO.4]. Conceiving an artificial artefact (Simon, 1969, 1996) to be introduced in practice is a way to generate *action*, *change* and *improvement* (Ågerfalk, 2010, p. 252), and therefore one of the plausible ways to search for searching potential alternatives or paths of developed for generating "*satisfactory solutions*" to a determined stated (generic) practical problem.

[79] In many cases, the domains usually covered by these artefacts are the business and data layers or, alternatively, the applications and IT/infrastructure layers. When only one EA domain layer is covered, these artefacts tend to be rather referred as RMs instead of ERAs – for example *business process RMs* or *application RMs/landscapes* –.

Drawing on knowledge uncovered acquired while responding previous research questions, a new *abstract* artefact framework has been conceived by tailoring, adapting and overcoming shortcomings found in already existing EA artefacts/instruments born to address (i.e., sort out, tackle) relatively similar problems to the one under scrutiny in the present thesis. And careful and depth analysis of these artefacts, together with both academic- and practitioner-oriented knowledge on EA artefacts and theoretical literature on desirable properties for artificial artefacts allowed us to defined a set of requirements for shaping the form and function (i.e., the conditions) that the envisioned artefact should accomplish for its given purpose.

In addition, the performed comparative analysis of similar existing EA artefacts performed also lead us to *identify* and *collect* a basic set of practice-oriented GUSs, in which the re-utilisation and/or application of HEI-oriented ERAs [RO.5] by different stakeholders and users may lead to a plethora of benefits, both at the more individual EA-project level as well as at a rather more organisational level. This GUSs were later incorporated/embedded as a structural part of the new artefact framework constructed during the design and development activities undertaken to build it fulfilling the earlier stated requirements. The design and development activities conducted were mainly guided and inspired by general adaptation mechanisms (i.e., design principles) derived from the Method Engineering discipline and by existing ontology-based transformation operations for EA (artefact) models.

To *evaluate* the practical utility (i.e., usefulness) of the artefact constructed [RO.6], it has been tested by simulating its practical application through a retrospective case study and a couple of illustrative scenarios. All them were based on true real practical experiences. Specific instantiation templates of the artefact framework constructed representative of the different PUSs of HEI-oriented ERAs that really occurred during the practical experiences investigated were generated to in order to assess their utility for practitioners involved in the use situations. The PUS investigated encompassed the use and application of different exemplars of ERAs in a variety of specific HE-oriented settlements and contexts of practice. However, the rather limited evaluation approach finally conducted did not allow us to achieve totally conclusive results about the constructed artefact's utility. At most, the assessment performed during the evaluations conducted were only enough to perceive/infer several signs of utility suggested that the artefact constructed might be effective for facilitating and assessing practitioners willing to use HEI-oriented ERAs in their particular contexts of professional practice. Notwithstanding that, the evaluation performed were significative enough to offer basic insights and evidence on the practical usage of HEI-oriented ERAs in real practices [RO.7].

All in all, further rigorous (case) studies representative of the most diverse uses/applications in practice of HEI-oriented ERAs should yet be effectively conducted to infer definitive conclusions on the alleged utility claims for the artefact constructed. These studies might in turn shed light on new ideas and suggestions for subsequently upgrading the final product resulting of this research.

5.3. Research Outputs and Contributions

The main outputs and contributions achieved during this research can be classified according to the *Lambda* (λ-) and *Omega* (Ω -) knowledge classification scheme by (Gregor & Hevner, 2013), as earlier introduced in section 1.5. (λ-) or *prescriptive knowledge* correspond to DK in the form of artefacts, design principles or design theories built by humans to improve the natural word. Contributions to (Ω-) or *descriptive/ exploratory/ predictive knowledge* enhance our understanding of the world and phenomena that technologies harness, typically manifested in the form of observations, classifications, measurements or the cataloguing of these descriptions (Chandra et al., 2015; Drechsler & Hevner, 2018; Gregor & Hevner, 2013; Gregor & Jones, 2007; Hevner et al., 2004; vom Brocke et al., 2020; vom Brocke & Maedche, 2019).

Despite that DK generated when designing and constructing of our artefact framework clearly represents the λ-knowledge generated during this DSR-oriented research, we also argue that the thesis has produced interesting and relevant Ω- knowledge contributions. The detailed list of outputs derived from the research works and activities conducted are enumerated as follows:

Prescriptive-oriented outputs/contributions

[λ.1] An artefact framework for facilitating the process of using/applying HEI-oriented ERAs in different practical contexts.

Descriptive/explorative-oriented outputs/contributions

[Ω.1] A structured synthesis harmonizing the current state-of-art-and-practice of the domain body of knowledge of ERAs, grounding on the (Gregor, 2006)'s taxonomy of IS-theory types to organize it.

[Ω.2] A complete catalogue of current existing instances and exemplars of HEI-oriented ERAs.

[Ω.3] A comparative analysis providing transparency on the major attribute's characteristics, similarities and differences of current existing exemplars of HEI-oriented ERAs.

[Ω.4] A descriptive set of (generic) practical situations of use/application for HEI-oriented ERAs, including a dependency graph suggesting plausible inter-relationships or dependences among them.

[Ω.5] The design, development and (limited) implementation [80] of an evaluation concept for the artefact framework constructed [λ.1] including (i) an evaluation strategy grounded on the FEDS framework (Venable et al., 2012, 2016), and (ii) its correspondent operationalized trajectory set of evaluation episodes based on well-known and accepted patterns and recommendations for characterising DSR evaluation episodes (Abraham et al., 2014; Cleven et al., 2009; Peffers et al., 2012; Prat et al., 2015, 2014; Shrestha et al., 2014; Sonnenberg & vom Brocke, 2012b, 2012a).

[Ω.6] A new IS *Reference Model* for HEIs constructed through an inductive approach integrating and unifying already existing exemplars of HEI-oriented ERAs/RMs.

[Ω.7] A new *Reference Architecture* targeted to the specific application domain of IQAS of HEIs grounding on the theoretical concept of *work system* (Alter, 2013b), including an exemplary instantiation for the specific IQAS implemented in a German HEI.

[Ω.8] Novel empirical account providing rich insights and descriptions evidencing how HEI-oriented ERAs are actually used in reality – a phenomena not previously adequately covered by already existing research –, and in particular, from the perspective of an external HEI's stakeholder like a (local) IS/IT service provider consultancy firm.

[Ω.9] Greater understanding and clarifications about the similarities and differences on the twin concepts of RMs, RAs and ERA.

[80] See section 5.4 on research limitations.

In addition, we also believe that our research has also shed light on to complementary outputs/contributions [81]. They can be viewed as indirect results emerged during related work conducted in this research aimed to extend or apply acquired knowledge on RMs/RAs to the narrower spectrum of QA and eLearning practices within HEIs. Among the most relevant of them, the following ones can be highlighted:

Complementary outputs/contributions

[Ω'.1] A structured literature review comparing existing *focus area MMs*, since these artefacts not only can be constructed grounding upon existing RM/RAs but have also been signalled by literature as suitable instruments for assessing the maturity of EA practices. Moreover, some documental sources hypothesize about their appropriateness as instruments that might serve for (indirectly) measuring (perceived) ERA's effective usage.

[Ω'.2] An inclusive new definition for the concept of *IQAS implementation maturity*, grounding on a comprehensive review of specialized literature in QA for HEIs.

[Ω'.3] A structured comparative literature review resulting in a comprehensive catalogue of existing MMs for assessing the quality of QA practices implemented in HEIs.

[Ω'.4] A structured comparative literature review resulting in a comprehensive catalogue of existing MMs for assessing the quality of eLearning practices in HEIs.

To further clarify the role played by the earlier outputs within the whole spectrum of the research conducted, in the following Table 44 we show the correspondence among the research outputs [λ, Ω, Ω'], publications conceived [P] and research objectives [RO] and questions [RQ] defined. Readers should note that void cells in column *Research Publication* implies that none of the generated publications [P] addresses in particular a determined research objective [RO], but not objective's achievement. In addition, a determined publication [P] may be related with several different outputs/contributions [λ, Ω, Ω'] and/or research objectives [RO].

Table 44 – Relationship Among Research Outputs, Questions, Objectives and Publications of the Research

RESEARCH OUTPUT	RESEARCH PUBLICATION	RESEARCH OBJECTIVE	RESEARCH QUESTION
[Ω.1]	[P2]	[RO.1] To *explore* existing knowledge on ERAs	[RQ.1]
[Ω.2], [Ω.3]	[P5], [P6]	[RO.2] To *identify* existing instances of HEI-oriented ERAs	[RQ.2]
[Ω'.1]	[P5], [P6]	[RO.3] To *critically evaluate* existing relevant instances of HEI-oriented ERAs	[RQ.2]
[λ.1]	-	[RO.4] To *build* a framework for facilitating the use of ERAs in HE-oriented contexts	[RQ.3]
[λ.1], [Ω.4]	-	[RO.5] To *identify and collect* possible use scenarios on which HEI-oriented ERAs can be used or applied in practice	[RQ.3]

[81] We refer here to these complementary descriptive outputs as [Ω'] just for informative purposes, in the sense of explicitly differentiating them of those descriptive outputs [Ω'] more directly related with the main research aim [RA] posed for the thesis.

RESEARCH OUTPUT	RESEARCH PUBLICATION	RESEARCH OBJECTIVE	RESEARCH QUESTION
[Ω.5]	-	[RO.6] To *evaluate* the goodness and practical utility of the framework developed	[RQ.3]
[Ω.8]	[P3], [P8], [P11]	[RO.7] To *provide* evidence on the practical use of HEI-oriented ERAs	[RQ.3]
[Ω.6], [Ω.7], [Ω.9] [Ω'.1-Ω'.4]	[P1], [P3], [P4], [P7], [P9], [P10], [P12], [P13]	*Related complementary work*	

Source: Own elaboration

To conclude this section, and given the fact that prescriptive-oriented contributions tend to be viewed as the most representative ones of what "*should be expected*" from a DSR-oriented initiative, we briefly reflect now on the novelty of the artefact framework constructed [λ.1].

Issues relative to the innovativeness of DSR contributions have been widely discussed by DSR literature (Baskerville, 2008; Chatterjee, 2015, p. 10; Gregor & Hevner, 2013; Hevner & Chatterjee, 2010, pp. 3–8; Johannesson & Perjons, 2014, pp. 10–11). In particular, one of the most prominent aspects discussed is "*the question of what distinguishes routine, professional, commercial, or industrial design from design science*" (Wagner et al., 2020, p. 560). In this sense, a clear consensus exits on the fact that, in contrast to *routine design* or the application of best practices, DSR should make or create novel contributions to knowledge (Dresch, Pacheco Lacerda, et al., 2015, p. vii; Hevner & Chatterjee, 2010, p. 3; Wagner et al., 2020, p. 560). In other words, the *contribution type* of a DSR initiative is determined by the form of which the artefact conceived extends the current exiting (base of) knowledge. In this vein, (Gregor & Hevner, 2013) provide a 2x2 matrix framework to classify *DSR contributions' novelty* depending on the "*knowledge start-points (e.g., maturities) of the research project to support a clearer understanding of the project goals and the new contributions to be achieved*" (2013, p. 345).

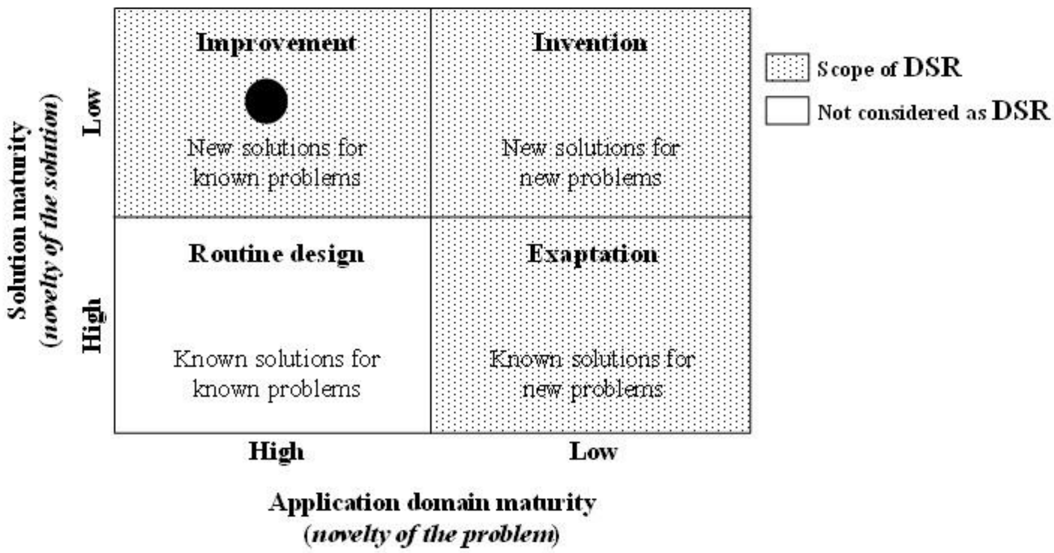

Figure 35 – Positioning the Artefact Framework Constructed in the Gregor & Hevner Matrix

Source: Own elaboration.

More in particular, a DSR *contribution type* can be classified according to a couple of dimensions, namely (i) the *application domain maturity* (x-axis) – which denotes the maturity (i.e., in terms of knowledge start-points) of the practice for which the contribution is intended for –; and the (ii) solution *maturity* (y-axis) – which refers to the maturity level of existing artefacts that could be used as starting point for finding solutions –. This leads to matrix characterising 4 different typologies of contributions (Gregor & Hevner, 2013; Johannesson & Perjons, 2014, pp. 10–11):

- *Invention – New Solutions for New Problems*. These contributions are radical innovations addressing an unexplored problem context, offering a novel and unexpected solution. Innovations are rare in DSR.
- *Improvement – New Solutions for Known Problems*. These contributions address a known problem offering either a new solution or a substantial enhancement – in terms of properties or qualities – of an existing one. Improvements are the most common type of DSR contribution.
- *Exaptation – Known Solutions Extended to New Problems*. These contributions adapt an existing solution to a problem for which it was not originally intended (i.e., an existing artefact is repurposed, or exapted, to a new problem context). Exaptations tend to occur frequently in DSR.
- *Routine Design – Known Solutions for Known Problems*. This contribution can be viewed as incremental innovations addressing a well-known problem by making minor modifications to an existing solution. Despite that routine designs do not count as DSR contributions – they do not produce knew general knowledge of interests – they can still be valuable design contributions.

Considering this rationale, we conclude that our artefact framework constructed [λ.1]. should be specified as an *improvement* – as shown in Figure 35 – *because* it represents *a new solution to an existing problem*.

5.4. Research Limitations

As any other piece of research, this one also comes with its own limitations. In this section we briefly discuss on those ones that, under our view, may represent a more significative impact on both rigor and relevance (i.e., quality of the findings and ability to answer the research questions [RQ] stated) of our study. In general, these limitations arise as a consequence of methodological issues or due to aspects related with ourselves as researchers. Thereby, the main potential research limitations [RL] that could be related to the present thesis are synthetized as follows:

[RL.1] Problems and pressures derived from the industrial/professional nature of the (doctoral) research project finally impacting in the candidate's performance

During the thesis execution, there have been certain *cultural issues* – to refer to them in a rather simple way – which could be related to the intrinsic nature of our research as being part of an industrial/professional doctorate project that played an undisputable role as hinderers for the research project's normal advancement due to their direct impact on the daily life of the doctoral candidate.

In this sense, and despite the fact that the own regulations introduced by the *Generalitat de Catalunya* to monitor the collaborative relationship among different partners involved in an *Industrial Doctorate Project* reinforced the typical pressures affecting doctoral candidates in terms of cost, time and resources available for conducting their research, the truth is that in this case the most significative concern that had to be managed by the doctoral candidate during time spent in the research were the regular tensions between the academic partner – i.e., main academic *supervisor* – and the industrial/professional partner – i.e., professional *advisor* –. These tensions were mainly due to their different and (nearly always) opposite expectations regarding the thesis outputs and results. In some way, and taking some obvious distances, there could be traced an analogy among the referred different expectations and the endless discussions and debates found in the academic literature about the *rigour* vs. *relevance dichotomy* of research. Evidently, whilst *rigour* would represent the perspective of the academic partner of thesis (i.e., quality products and publications at a rather long term) *relevance* would represent the position of the industrial/professional part (immediately actionable products at a rather short term).

Whatever the case, the doctoral candidate had to continuously struggle his mind during the temporal thesis span on how to handle the referred tensions between the *supervisor* and the *advisor*, in order to avoid to take side. Despite that, at the more individual level, the bi-lateral relationships between the candidate and both thesis *supervisor* and *advisor* were quite good – especially in the first case –, continuous disputes and clashes among them not only complicated to carry out a fluent mentoring process of the candidate but also made feel him uncomfortable in not so many times. All in all, these circumstances had a very negative impact in the candidate's confidence, motivation and performance, clearly representing therefore the most significant restriction of the thesis. The definitive straw to all this situation definitely came when the industrial partner of the project decided to abruptly and unliterally bring to an end the relationship. It must be recognised here that, at that time, and possibly as a consequence of all the circumstances described above, the research project was already out of time and scope in terms of the initially scheduled research plan according to the regulations and normative prescribed by the *Industrial Doctorate Plan*.

Notwithstanding that, and to conclude, it should be denounced here that this decision entailed a tremendous professional and personal cost (both in terms of physical and mental stress) for the doctoral candidate, leading him to take and ample time to take care about himself. Such fact partly explains, in turn, the total time spent to finalize the thesis. In this sense, it must be highlighted here that the constant support and guidance from the academic thesis *supervisor* during the last part of the research has been a key factor for its effective conclusion, avoiding and preventing the doctoral candidate from having to do it in the most absolute solitude and isolation.

[RL.2] Threats to validity of literature reviews conducted to build the KB of the research

There are several intrinsic aspects to literature reviews conducted for building the KB of the research that should be considered. Regardless of taking as a reference well-known frameworks and recommendations for conducting rigorous IS literature reviews (Levy & Ellis, 2006; Rowe, 2014; Schryen, 2015; Vom Brocke et al., 2015; Webster & Watson, 2002) concerns about their internal validity could be raised.

For example, a first limitation could be alleged regarding the relatively restricted set of keywords used as starting point in both reviews conducted. Probably, a broader search – i.e., including names of specific EA artefacts or even broader inclusion criteria – would have probably yielded more results on which to build our KB. This means that we might have missed in our subsequent analysis relevant literature on ERAs or already existing exemplars of HEI-oriented ERAs. On the other hand, concerns could also be raised regarding the relatively lax *quality checks* applied the documental sources chosen for subsequent analysis. In this sense, it must be taken into account the rather scarce academic literature on ERAs – at least compared with other streams of research within the IS arena, or even the own EA field – which led us to consider for both literature reviews practitioner's oriented documental sources (grey literature) to adequately proceed with our analysis. For example, many important exemplars of existing HEI-oriented ERAs tend to be documented in rather non-academic texts and formats – e.g., semantic wikis – in order to foster and boost their accessibility and dissemination.

In this sense, and in general, when looking for sources to conduct our literature analysis we always have in mind to achieve, as much as possible, and adequate balance between completeness and comprehensiveness of the reviews. For instance, and when considering the inclusion/exclusion criteria of the HEI-oriented ERAs chosen for being compared, we adopted a rather *optimistic approach* in the sense of not being totally strict on the exemplars finally considered for analysis. Thus, incomplete architectures – in the sense of not formally including both RMs and design principles, the core components of an ERA – or also partial architectures – exemplars principally considering either just 1 of the typical EA domain layers or only a subset of the whole scope of a HEI's domain (i.e., teaching, learning, research, support services, etc) – were taken into account.

Finally, additional concerns may be raised in terms of the reliability of the reviews conducted. For example, when conducting the first review capturing existing knowledge about ERAs, some researcher's bias could be argued when coding, classifying and organizing the studies to be analysed in terms of the conceptual framework based on (Gregor, 2006)'s taxonomy of IS-theory types subsequent taken as a reference for analysis. Similarly, some bias can be argued during the second review devoted to compare HEI-oriented ERAs due to the inherent researcher's subjectivity when interpreting/evaluating the information collected relative to the different properties and attributes of each one of the architectural exemplars assessed.

All in all, and despite all the above, we are quite confident on the accuracy and validity of the findings and conclusions achieved in terms of trustfulness for both reviews conducted. In this sense, and given the yet relative immaturity of the research topic under study in the thesis, the absence of prior similar studies – perhaps with the exception of (Fettke et al., 2006; Fettke & Loos, 2003a) surveys on business-process oriented RMs which inspired us to build the comparative framework of HEI-oriented ERAs – did not allow us to execute additional validity and quality checks. Thereby, multiple iterative executions of the searches defined for the reviews conducted where done to yield final up-to-date analysis as much as possible.

[RL.3] Limited access to people and organisations suitable to provide data for the research

A third limitation corresponds to the insufficient level of engagement or involvement achieved of industry/sector participants during the research conducted, especially during the artefact's design and evaluation activities performed. In other words, we experimented notorious problems to gain access to the right "*empirical field*" – i.e., appropriate practitioners and/or organisations related with the Catalan HE arena suitable to provide us a practical context for gathering *raw data* for our research purposes –.

During the temporal span of this research project, we had the opportunity of having several informal conversations with different professionals working, in some or another way, within the Catalan HE arena which gave us the opportunity to introduce our interlocutors on the main topic of our research. In most cases, professionals consulted declared themselves as being inexperts or at most beginners in EA practices. Further, none of those practitioners contacted told us to be aware about the existence of HEI-oriented ERAs. Assuming that organisational entities are dependent on its organisational members, it should come as to no surprise that it was extremely complicate for us to find opportunities for testing our constructed artefact in real settlements – i.e., EA projects or initiatives involving the usage of ERAs giving us the opportunity of gathering data about artefact's behaviour [82] –. In other words, and as postulated by the *relevance cycle* inherent to any DSR-oriented endeavour, it was hard for us to *bridge the contextual environme*nt with our DSR particular activities conducted during the research (Drechsler et al., 2016; Hevner, 2007).

Thereby, and considering the typical "*build/evaluate*" pattern of any DSR initiative, such argued limited engagement of (local) EA experts or practitioners during the research efforts conducted has had a rather twofold impact on the results achieved. On the one hand, and further beyond the descriptive data and knowledge derived from the explorative case study carried out within the scope of our industrial partner (see details in publication [P11]), it would certainly have been desirable to had the opportunity to capture and collect additional (expert) knowledge emerged from EA local practitioners to be conveniently *incorporated* or *embedded* in the constructed artefact, especially in the *design and development* stages of the DSRM process executed. Aiming to mitigate this drawback, during the artefact's construction process we considered (i.e., incorporated) expert knowledge derived from existing literature on EA artefacts tailored for HE scopes of application or, alternatively, on ERA's usage in other alternative (highly-regulated) sectors and industries. On the other hand, our inability to gain convenient access to real contexts of practice has also strongly conditioned the effective implementation of the evaluation concept defined to assess the utility of the artefact constructed, as further concretized in the following research limitation [RL].

[RL.4] Constrained implementation of the evaluation concept defined for the artefact framework constructed

Finally, important concerns could be also raised about the evaluation performed to assess the utility of the artefact framework constructed. Partly, this limitation is a consequence of the earlier argued accessibility issues to real appropriate contexts of practice. Under such circumstances, we were finally forced (i.e., limited) to implement the latest evaluation episodes defined for our artefact through a multiple illustrative scenario approach, based on a retrospective application of the artefact. This final evaluation approach implemented clearly represents another limitation of the research since it did not allow us to execute a *pure* "*ex-post/naturalistic*" evaluation – i.e., real systems/artefacts, real projects/tasks, (by) real users – as recommended by literature on DSR artefact evaluation (Abraham et al., 2014; Prat et al., 2015; Sonnenberg & vom Brocke, 2012a; Venable et al., 2016).

Consequently, no definitive conclusion regarding the constructed artefact's utility could be unequivocally achieved. At most, the evaluation performed enable us to derive basic utility signs suggesting (pointing out) the potential usefulness of the artefact constructed for its stated purpose. Moreover, and given the fact that

[82] It is assumed here that organisational members of institutions or entities operating in the HE arena would be the same recipient audience (users) of our constructed artefact.

in the several simulated (retrospective) artefact applications conducted we also acted as a proxy of real users – i.e., we, played the role of being those practitioners putting in play (using) the artefact to be evaluated –, concerns on the reliability of the utility signs perceived might well be risen due to bias generated as a consequence of the inherent subjectivity derived for playing a dual role as both *artefact-developers* as well as *artefact-users*. For instance, the results and conclusions achieved from the assessment activities conducted should be taken with caution by readers.

Beyond the above, there are other several aspects related with the evaluation performed that may also deserve some attention. For example, concerns might be argued regarding the size and selection strategy for the practical experiences [PE] upon which the evaluation activities performed were based. Despite being real practical experiences encompassing several different USs for HEI-oriented ERAs, concerns about their representativeness could be raised due to the relatively small number of practical experiences (cases) considered and the opportunistic and purposeful-oriented sample selection strategy chosen. For instance, the *sufficiency* and *validity* to establish trustful inferences on the *transferability* of the utility signs perceived to the overall HE arena [83] could be called into question. Similarly, this rational could also be extended to made arguments whether the evaluations conducted provide the required evidence to confirm (i.e., prove) either the pre-defined list of GUSs for HEI-oriented ERAs use/application embedded in the proposed artefact (see contents of Table 25) or the hypothesised maturity dependences existing between different GUSs (see Figure 21), despite they were mainly inferred from existing literature.

Obviously, all the above goes without saying that new cases or practical experiences [PE] devoted towards providing further evidence on the *expected* utility of the artefact built should definitely be conducted. Moreover, these studies must include evaluation episodes executed under the scope of *real*, *naturalistic* settings and contexts of practice. In this sense, and despite our evaluation concept defined recommends several well-known *middle-range* IS-theories/frameworks as candidate sources for identifying theoretical constructs suitable for establishing appropriate metrics for measuring artefact ‘s utility– see again details of the EVAL5 episode in Table 29 –, the truth is that the operationalisation of clear and concise metrics or variables for capturing artefact’s utility is pending yet.

5.5. Recommendations for Further Research

Throughout the contents of this report, we have already signalled some feasible ideas for improvement and complementary research that would be desirable to carry out in order to further extend results achieved in the thesis. Now we proceed to discuss them in more depth and detail, including some new implications derived from the earlier section discussing research limitations [RL].

To offer a more integrated and homogeneous view about all them, we have grouped them for discussion into 4 general lines of further research [FR]. They are as follows:

[83] By *overall HE arena* we understand here plausible situations/contexts/settlements of real practice including different types of HEIs – universities, polytechnics, colleges, private institutions of education, etc. – as well as several other different entities/actors in which a HEI-oriented ERA usage would be plausible for whatever purpose – i.e. HEI’s external providers, accreditation agencies, government entities, etc. – (Dittrich & Weck-Hannemann, 2010; McCormick & Borden, 2017; van Vught et al., 2010).

[FR.1] Extending the current knowledge and understanding about ERAs

Despite that this thesis contributes to develop greater understanding on the concept of ERAs, there still are several opportunities for additional research on the topic. For example, more fine-grained characterisations and taxonomies of ERAs could be developed aiming to further clarify (from a structural point of view) what formally constitutes a *partial* or an *uncomplete* ERA. Also, assuming that ERAs tend to be developed for rather highly-regulated sectors or industries (Lankhorst, 2014; Paradkar, 2018), the study of this EA artefacts from the theoretical lens of *isomorphism* (DiMaggio & Powell, 1983; Powell & DiMaggio, 1991) could probably be helpful to better understand different pressures (e.g., legislative coercions) mediating (impacting) practitioner's willingness to use ERAs in their own contexts of practice.

Another especially fruitful avenue of research to the future would be the definition of concise and clear indicators and metrics to measure potential benefits (i.e., value) of re-using ERAs by different types of users/stakeholders. A particularly interesting line of investigation could be the analysis of the possibilities offered by *focus area MMs* to provide a holistic measurement instrument for effective ERA's usage. This particular type of MMs could suit perfectly well for this purpose since, due to their inherent structural characteristics, they allow for much more fine-grained measurement approaches than more traditional ones. *Focus area MMs* usually distinguish much more levels of maturity, define smaller (incremental) steps between these maturity levels, and represent in a much more explicit way the existing dependencies between the (focus) areas characterising the MMs targeted domain (van Steenbergen et al., 2013, p. 43). Assuming the diverse set of benefits and beneficiaries who can take advantage from an effective ERA's usage, *focus area MMs* can play an interesting role as integrators (i.e., aggregators) unifying different indicators and metrics. A starting point for such this efforts could be the work by (van Zwienen et al., 2019), who adapted and tailored the DyAMM – a generic EA-oriented *focus area MM* (van Steenbergen, Bos, et al., 2010) – by incorporating/integrating focus areas related with the Dutch's healthcare-oriented ERA.

Disposing of such metrics and indicators would surely be helpful for developing more studies providing richer evidence to conveniently prove the overall value of this particular type of EA artefacts (Cloutier et al., 2010, p. 25). For instance, there is a clear need for conducting additional (case) studies providing rich insights and better empirical accounts on the use of ERAs in different application contexts, since they have only been covered to a very limited extend by existing research. Furthermore, they might also lead to new opportunities for increased awareness and better understanding by EA practitioners of this particular type of EA artefacts.

Finally, we also envision opportunities for creating new exemplars of ERAs in different current emergent and highly-regulated (sub)-sectors/industries, as for example renewable energies, sustainable urban mobility or life sciences, to mention just a few. The challenge here would be not only the own process for constructing the architectural exemplars but also to create easily-readable, accessible and non-ambiguous documentation for them, in order to foster their adequate dissemination and consistent understanding among multiple potential stakeholder communities interested in these new abstract architectures created.

[FR.2] Extensions and automatisation of the catalogue of existing HEI-oriented ERAs

There are also several opportunities for improving the built catalogue of HEI-oriented ERAs. On the one hand, an obvious line of work could be to extend it by including additional attributes or properties for comparing exemplars of HEI-oriented ERAs. On the other hand, it is also important to be aware that, in order to be a valuable, the catalogue has to be up-to-date, that is, it has to be viewed as a dynamic artefact. Thus, there is a constant need to maintain the currentness of the catalogue by progressively adding new emerging architecture exemplars. This can be achieved by incorporating to the catalogue constructed convenient *control version management* features. Finally, but perhaps from a little more micro perspective, there also are possibilities for creating *mappings* establishing and defining the correspondence (links) among the different architectural domain objects – i.e., processes, applications, capabilities, actors, data records, infrastructures, etc. – defined by each one of the architectural exemplars. We think that several initial works in this sense are being conducted by the EUNIS *EA Special Interest Group* [84].

In addition, and aiming to increase transparency and fostering dissemination of existing exemplars of these abstract architectural artefacts, an interesting idea could be to automatize the catalogue constructed by creating and on-line accessible inventory. The works in this line could be inspired, for example, on the *Reference Model Catalog* [85] – an only inventory of RMs (Peyman et al., 2013, p. 3) – administered by the *Institute for Information Systems* (*Deutsches Forschungszentrum für Künstliche Intelligenz*).

[FR.3] Improved implementation of the evaluation concept defined for the artefact framework constructed

Despite that during the process conducted during this research for building the artefact framework proposed we explicitly defined a clear evaluation concept for evaluating it, further studies should be conducted to unequivocally prove its usefulness for practitioners developing their activities in the HE arena. These extensive efforts should be principally directed to overcome the limitations inherent to the evaluation activities performed during the present thesis, which can be summarized into 3 main fronts of investigation.

First, more (in-depth case) studies should be conducted to provide empirical account on the achievement to instantiate the artefact constructed for new real-based cases and practical experiences [PE]. By capturing observations, measurements and rich descriptions regarding the actual use and application rationale followed by practitioners of the instantiation templates derived from the framework, these new studies would probably allow to derive much more conclusive claims about the artefact's utility. Second, these new studies should be conducted in as many as possible heterogeneous and different contexts of practice in order to be able to derive plausible conclusions on the *transferability* to the whole HE domain of the artefact's utility claims. And thirdly, since in the illustrative scenarios carried on during this thesis the application in practice of the constructed artefact was done by assuming ourselves a role of active users involved in the artefact's use, new studies to be done should still confirm and corroborate also whether the artefact constructed can be effectively put in play by "true" practitioners in a standalone, autonomous and reliably way.

[84] See https://www.eunis.org/task-forces/enterprise-architecture/

[85] The *Reference Model Catalog* can be accessed at the following URL: http://rmk.iwi.uni-sb.de

Finally, and beyond all of the above, there also are other additional issues that may deserve future attention. For example, despite that the pre-defined list of GUSs for HEI-oriented ERAs use and application embedded within the artefact proposed has been (mostly) grounded on existing literature (see again Tables 24-25), new studies should be directed to evaluate (confirm) the suitability of all the 22 GUS conforming the list. In particular, the emphasis should be put on these GUS not explicitly considered during the evaluation activities of the thesis, being therefore still open for discussion. Similarly, and as earlier advanced, more research should be done to prove or disprove our hypothesis about the existence of *maturity dependences* between the GUS defined (see again Table 25 and Figure 21).

[FR.4] Improving and extending the artefact framework constructed

Finally, additional research could also be conducted for improving or extending the artefact framework constructed to evolve it into a much more mature artefact. Such improvements could be achieved, for example, by executing additional iterative DSR "*build-evaluate*" cycles to the resulting artefact of this thesis, in such a way that knowledge acquired during each iteration can be progressively incorporated into new (improved) iterated versions of the artefact.

For example, we envision opportunities to improve from a structural point of view the resulting artefact of this thesis by providing more accurate definitions of several of its configurative elements (e.g., element *potential blockers* of the Component Block II of the artefact). Similarly, and regarding the list of GUSs embedded within the artefact, no concrete *Recommended Practical Application Guideline* is provided for some USs – e.g., GUS3 (*Take part in EA Meetings/Stimulate Discussions*), GUS7 (*Project Initialisation Support*) or GUS16 (*Consultancy Artefact*) –. Finally, and perhaps from the perspective of the actionability of the artefact created, complementary guidance and more concrete *easy-to-follow* instructions should be provided to practitioners willing to use it in practice. Whatever the case, the impact of all these improvements should be adequately tested and re-assessed against the artefact requirements [RE] defined.

Besides, and still referring to the actionability of the artefact proposed, an interesting idea could be the construction of some kind of *prototype tool* – a simple *Excel* worksheet or *Access* database would be enough in the first instance – *including* or *incorporating* all the intrinsic knowledge captured by the artefact constructed. We strongly believe that such-a-kind of *prototype tool* would not only simplify the execution of additional tests and evaluative episodes for validating the utility of the artefact constructed but also could have a positive impact on fostering practitioner's willingness to use the artefact. Moreover, this *prototype tool* would probably also have a positive impact in terms in increasing practitioners' efficiency (time spent or invested when using the artefact) during the whole process of reflecting, thinking about or capturing all the implicit knowledge required by them for conveniently re-using/applying determined exemplar of HEI-oriented ERA for their PUS (i.e., needs and interests derived from their specific US).

In fact, and from an ideal point of view, it would be nice that this *prototype tool* would embed all the implicit knowledge required for giving assistance to the whole rational represented by the schema shown in Figure 22. However, and as a prerequisite for that, more research should be conducted to determine the correspondent link between (i.e., most relevant set of decision criteria for binding) our artefact framework constructed and (Kotzampasaki, 2015)'s methodology for ERA's selection. In other worlds, we are envisioning an ideal *prototype-tool* capable of supporting practitioners in order to make informed decisions about:

- choosing out one (or several) of the many existing HEI-oriented ERAs fitting well for their *context of practice* (i.e., type of institution, involved practitioner's experience/skills on EA, etc.) as well as *desired goals* (intended GUS or potential benefit expected to obtain from the architecture's re-use or application)
- capturing and acquiring all the knowledge needed for conveniently tailoring, transforming or adapting the chosen (abstract) HEI-oriented ERA(s) according to their PUS (i.e., needs and interests derived from their specific US).

All in all, we envision a *prototype-tool* as being something like a practical and semi-automatized decision-making tool implementing what, in some or another way, way could be viewed as a rather preliminary or rudimentary *design-theory-nexus* for HEI-oriented ERAs selection and usage, in line with (Pries-Heje & Baskerville, 2008) .

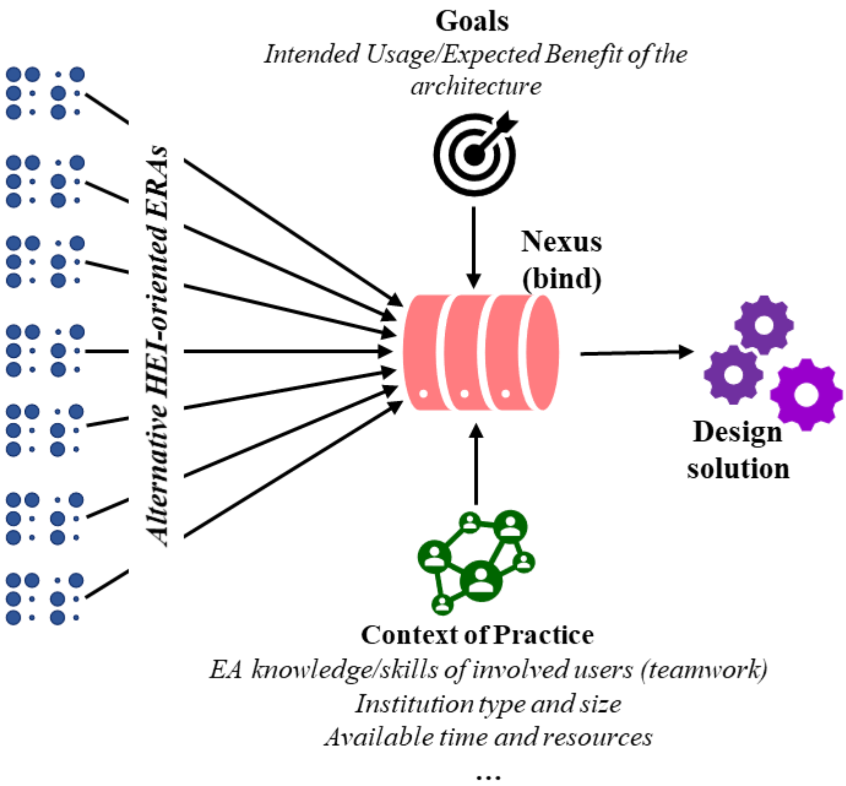

Figure 36 – A Preliminary Vision of a Hypothetical *design theory nexus* for Choosing and Applying Enterprise Reference Architectures in Higher Education Oriented Contexts of Practice

Source: Own elaboration, based on (Pries-Heje & Baskerville, 2008) and (Buckl et al., 2010)

5.6. Research Communication

According to the (Hevner et al., 2004)'s foundational contribution fixing the postulates of DSR in the IS arena, resulting knowledge of any DSR research endeavour should be effectively communicated to the corresponding target audience. This is precisely the main goal of the last *communication* stage of the nominal sequence of activities within the DSRM methodology adopted for this thesis.

In our particular case, and despite this thesis has been written as a monolithic work, several publications [P] and dissemination activities [DA] have been conceived and materialized, respectively, aiming to describe, communicate and disseminate the main results and outputs achieved during the investigation. In the successive sub-section, we provide brief additional details about them.

5.6.1. Publications

Throughout its contents, the present report contains various references to (part of) research publications [P] contents written during the research project. These research pieces have been published in different media and formats, ranging from peer-reviewed conference papers, to journal articles or book chapters. An enumeration about all the (co-) authored research pieces resulting from the thesis is presented in the following list, grouped by typology of publication. The full contents of all them are integrally reproduced in the complementary annex ("*Volume II – Annex of Publications*") associated to the present report.

Conference Papers and Proceedings (8 items)

[P1] Sanchez-Puchol, F., & Pastor-Collado, J. A. (2017a). Focus Area Maturity Models: A Comparative Review. In M. Themistocleous & V. Morabito (Ed.), *Information Systems: 14th European, Mediterranean, and Middle Eastern Conference, EMCIS 2017, Coimbra, Portugal, September 7-8, 2017, Proceedings* (p. 531-544). Springer International Publishing. https://doi.org/10.1007/978-3-319-65930-5_42

[P2] Sanchez-Puchol, F., & Pastor-Collado, J. A. (2017b). A First Literature Review on Enterprise Reference Architectures. *Proceedings of the 11th Mediterranean Conference on Information Systems (MCIS 2017)*, 1-12. http://aisel.aisnet.org/mcis2017/15

[P3] Sanchez-Puchol, F., Pastor-Collado, J. A., & Borrell, B. (2017). Towards an Unified Information Systems Reference Model for Higher Education Institutions. *Procedia Computer Science (Special issue CENTERIS 2017 - International Conference on ENTERprise Information Systems)*, *121*, 542-553. https://doi.org/10.1016/j.procs.2017.11.072

[P4] Sanchez-Puchol, F., & Pastor-Collado, J. A. (2018). Los Modelos de Madurez como Instrumentos de Calidad para la Educación Virtual: Hacia un Catálogo de Referencia [in Spanish]. *XV Foro Internacional Sobre la Evaluación de la Calidad de la Investigación y de la Educación Superior (FECIES 2018)*, 1350-1358. https://www.ugr.es/~aepc/FECIES_16/CapitulosFECIES2018.pdf

[P5] Sanchez-Puchol, F., Pastor-Collado, J. A., & Borrell, B. (2018a). A Critical Review on Reference Architectures and Models for Higher Education Institutions. In A. P. Abraham, J. Roth, & G. C. Peng (Ed.), *Proceedings of the International Conferences Big Data Analytics, Data Mining and Computational Intelligence 2018; Theory and Practice in Modern Computing 2018; and Connected Smart Cities 2018—Part of the Multi Conference on Computer Science and Information Systems (MCCSIS 2018)* (p. 113-120). http://www.iadisportal.org/digital-library/a-critical-review-on-reference-architectures-and-models-for-higher-education-institutions

[P7] Sanchez-Puchol, F., Pastor-Collado, J. A., & Casanovas, J. (2018a). Theoretical Comparison of Universitary Quality Assurance Maturity Models. In J. Berbegal-Mirabent, F. Marimon, M. Casadesús, & P. Sampaio (Ed.), *Proceedings book of the 3rd International Conference on Quality Engineering and Management, 2018* (p. 401-419). http://blue.dps.uminho.pt/icqem/2018/icqem18_proceedingsbook.pdf

[P8] Sanchez-Puchol, F., Pastor-Collado, J. A., & Casanovas, J. (2018b). What is that Thing Called Internal Quality Assurance System? In *Excellence in Services. 21st International Conference. Conference Proceedings* (p. 593-612). http://sites.les.univr.it/eisic/wp-content/uploads/2018/11/43-Sanchez-Pujol-Pastor-Collado.pdf

[P9] Sanchez-Puchol, F., Pastor-Collado, J. A., & Guàrdia, L. (2018). Maturity Models for Improving the Quality of Digital Teaching. In J. M. Duart & A. Szűcs (Ed.), *10th EDEN Research Workshop. Conference Proceedings (Towards Personalized Guidance and Support for Learning)* (p. 238-253). https://upcommons.upc.edu/bitstream/handle/2117/133380/RW10_2018_Barcelona_Proceedings.pdf?sequence=1&isAllowed=y

Journal Articles (2 items)

[P6] Sanchez-Puchol, F., Pastor-Collado, J. A., & Borrell, B. (2018b). First In-depth Analysis of Enterprise Architectures and Models for Higher Education Institutions. *IADIS International Journal on Computer Science and Information Systems*, *13*(2), 30-46. https://doi.org/10.33965/ijcsis_2018130203

[P11] Sanchez-Puchol, F., & Pastor, J. A. (2021). An In-depth Case-Study on the Practical Use of Enterprise Reference Architectures in the Public Tendering of a Universitary Information System [Unpublished manuscript].

Book Chapters (1 item)

[P10] Sanchez-Puchol, F., & Pastor-Collado, J. A. (2019). Internal Quality Assurance Systems for Higher Education Institutions: Perspectives, Opportunities and Guidelines for a New Maturity Model. In J. Maxwell (Ed.), *Higher Education Institutions: Perspectives, Opportunities and Challenges* (p. 1-90). Nova Science Publishers, Incorporated.

Doctoral Consortiums (2 items)

[P12] Sanchez-Puchol, F. (2017). *Towards a Focus Area Maturity Model for Improving Internal Quality Assurance Systems In Higher Education Institutions*. Presented at the Doctoral Consortium of the 12th International Conference on Design Science Research in Information Systems and Technology (DESRIST 2017), Karlsruhe, Germany, 30 May - 1 June 2017.

[P13] Sanchez-Puchol, F. (2017). *Towards a Focus Area Maturity Model for Internal Quality Assurance Systems In Higher Education Institutions*. Presented at the Doctoral Consortium of the 11th Mediterranean Conference on Information Systems (MCIS 2017), Genoa, Italy, 4-5 September 2017.

5.6.2. Other Dissemination Activities

In addition to the earlier publications [P], during our research efforts we had also the opportunity to participate in different professional and non-professional (dissemination) activities and events [DA] that, in some or another way, have also been fruitful to contribute to the widespread of the results achieved in the thesis or just to create awareness and interest among different HEI-oriented stakeholders about our research aims and aspirations. In addition, and up to a point, they also served as a marketing platform of the professional services offered by industrial partner of the thesis. In the following, we synthetize the most outstanding ones of them – a more detailed and specific list of activities performed can be found in the corresponding *Activity Record* report associated to the thesis –.

Professional consulting work (3 items)

[DA1] Participation as a HE consultant in several projects at *SEIDOR Learning Services* strategic business unit (2015-2019).

Providing support as an internal HE consultant in the development of several projects related with HE topics, including the bid for a contest made up for a leading on-line European university, developing the main principles of a local government's framework for regulating the accreditation of competences in Information and Communication Technologies, the conceptualisation of a proof-of-concept (i.e., software prototype) for developing a monitoring system of non-official degrees of the *Catalan Universitary System* based on blockchain technology. Being involved in such activities also entailed the realisation of several workshops and professional speeches.

[DA2] Member of the External Audit Panel for the procedure of the Accreditation of an undergraduate and master programme on Computer/Informatics Engineering of one local Catalan University (2015).

The procedure was conducted according to the regulations established by the Framework for the validation, monitoring, modification and accreditation of recognised degree programmes of the *Catalan University Quality Assurance Agency* and to the European Standard and Guidelines (ESG). Furthermore, it was also consistent with the requirements for accreditation defined by the Accreditation Agency Specialized in Accrediting Degree Programs in Engineering, Informatics, the Natural Sciences and Mathematics (ASIIN e.v.), since the institution opting to the accreditation was interested in obtaining the Euro-Inf® label according to the international criteria established by the European Quality Assurance Network for Informatics Education (EQANIE).

[DA3] Participation in different working groups of the research project leaded by the Edutech Cluster aimed to build and develop a new reference *Digitalization Framework* for educational services and products (2018-2019) [86].

The EduTech Cluster was born in 2013 as a group of companies in the IT-enabled education industry creating products or offering technology-based services aiming to improve the competitiveness of IS/IT in the education. Today, the cluster brings together more than 60 companies and organisations making the capacities and resources of its parents visible and promoting the creation of scenarios that favour its growth.

Between the 2018-2019 period, one of the main strategic initiatives of the cluster was the sponsorship and coordination of participatory research project aiming at defining, designing and developing a holistic reference *Digitalization Framework* integrating into a unified view the whole catalogue of products and services offered by the sector to educational centres. The project was devolved through a rather consortium-oriented approach, involving both practitioners and academics, including companies forming part of the cluster. During the initial stages of the framework's development, we had the opportunity to participate as field experts in several activities conducted (follow-up meetings, committees, focus groups, etc.) representing *SEIDOR Learning Services*.

[86] The following information has been extracted from the Edutech Cluster Web Portal: https://edutechcluster.org/web/noticias/

Associative collaborative activities (2 items)

[DA4] Collaboration as full member of the Advisory Committee of the Catalan University Quality Assurance Agency (2017-2019).
The committee advises the Agency on the definition, development and implementation of strategies, improvement procedures and proposals for action to underpin quality assurance in both the *Catalan Universitary System* as well as in the own Agency's activities, in accordance with international standards and guidelines. It is composed of academics from Spain and abroad of recognised standing and international experience, students from universities in Catalonia and representatives of the main labour organisations in Catalonia, who must also be academics.

[DA5] Collaboration as full member of the *UOC*'s *Psychology and Education Science Student's Course Committee*, the *UOC's Student Council* and the *UOC's University Council* (2016-2018) [87].

The function of the *UOC*'s Student's Course Committees is to channel student participation in the routine functioning of the courses. They are in charge of bringing student's requests to the attention of the pertinent bodies.

The Student Council is the students' highest body of representation, deliberation, consultation and counselling. It represents students as a whole before the University's governing and participatory bodies, and also in the inter-university liaising and coordination bodies where students are represented. The Council advice students, protect their interests, and listen to and resolve on issues raised by their representatives. The Student Council brings together the student representatives chosen by vote and is also responsible for designating a student representative for the University's Governing Council, and also for designating student representatives for each of the *UOC*'s faculties that are members of the University Council.

The University Council is the *UOC*'s community's highest representative body, chaired by the president, and including representatives of different stakeholders of the university (management and academic staff as well students). Its functions are to debate the University's strategic directions and aims; to raise opinions on issues that affect the University and propose those initiatives deemed necessary; to debate those aspects that affect the professional careers of the academic and administrative staff; to have a voice in the selection of presidents before their formal appointment, and to deal with any issues raised by the president, Governing Council or Executive Board.

Participation in International conference events (1 items)

[DA6] Participation as a speaker and attendant to several international conferences on Information Systems, Higher Education and Quality Management (2017-2018).

Including events as the *Mediterranean Conference of Information Systems* (MCIS), the European, *Mediterranean and Middle Eastern Conference on Information Systems* (EMCIS), the *Conference on ENTERprise Information* (CENTERIS) or the *Multi Conference on Computer Science and Information Systems* (MCCSIS), the *Assurance European Agencies in Higher Education & Accreditation Standards for Academic Staffing* (QAA), the *International Conference on Quality Engineering and Management* (ICQEM), the *Excellence in Services International Conference* (EISIC) – known in the past as *Toulon-Verona Conference* – or the *EDEN Research Workshop*.

Further, we also attend and collaborate supporting the local organisation team of the 15th *International Conference on Business Process Management* (BPM 2017) hosted by the Polytechnic University of Catalonia (UPC).

[87] The following information has been extracted from the *UOC*'s Web Portal: https://www.uoc.edu/portal/es/universitat/organitzacio/organs-coordinacio-representacio/index.html

Participation in other professional events

[DA7] Participation as an attendant in several seminar, workshops and meetings promoted by the Catalan University Quality Assurance Agency (2015-2018)

Aimed primarily at the university community and the Catalan Administration, these events represent spaces for the exchange of knowledge with the aim of promoting and deepening the culture of quality and the continuous improvement of the *Catalan Universitary System*.

Examples of events in which we took part can be *"La professionalització de la qualitat a l'Educació Superior: el llarg camí cap al reconeixement d'una nova professió*"; "*Com incorporar l'evidència a la presa de decisions*"; "*Com millorar la formació dels enginyers i les enginyeres de l'àmbit industrial i la logística?*" or "*L'avaluació externa de la qualitat: per a què serveix?*".

[DA8] Participation as an attendant in several seminars, workshops and meetings promoted by different actors in the HE sector in Catalonia, as for example, the *Cercle Tecnològic de Catalunya*, the *Associació Catalana d' Universitats Públiques* or the *Consorci de Serveis Universitaris de Catalunya* (2015-2018).

In general, these events were directed towards fostering and exchanging professional experiences and collaborations among IT-oriented professionals working on the local HE sector.
Examples of events in which we took part could be the participation in the "*New Models for Research Assessment*" seminar, several editions of the "*Trobada dels Serveis Informàtics de les Universitats Catalanes*" or the "*Jornades d'Innovació TIC*" and other more specific open sessions on "*Impactes socioeconòmics de les universitats públiques i recerca pública de Catalunya*" or on "*University Rankings, Methodology and Results -The Times Higher Education Ranking*".

Finally, at this point we also want to point out that, together with my doctoral thesis supervisor Dr. Joan A. Pastor-Collado, we were glad to accept the invitation formulated by the Government of the *Generalitat de Catalunya* to all partners of this project to participate on the *Ceremony of Recognition to the 1st Promotion of Industrial Doctoral Students*, held in Barcelona on July 2017.

[DA9] Collaboration in the promotion of the Industrial Doctorates Plan of the *Generalitat de Catalunya* (2015-2017)

Participation in several networking events directed to promote and disseminate the *Industrial Doctorates Plan* to different audiences, especially future suitable companies and potential doctoral students. These events included, among others, the participation in an event sponsored by the *UOC* for promoting *Industrial Doctorates* in the Social Science sphere, several promotional videos for the institutional web of the plan as well as press reports showing the daily work of an Industrial Doctorand student.

Figure 37 – Ceremony of Recognition of Industrial Doctorands

Source: Doctorats Industrials Web Page: http://doctoratsindustrials.gencat.cat/es/posts/view/117

Finally, in line with (Hevner et al., 2004)'s paper recommendations, , in the following Figure 38 we plot all publications [P] and dissemination activities [DA] conducted during the research into a bidimensional matrix considering the (i) *nature of the item* – academic publication vs. practitioner-oriented publication – , and (ii) the *target audience to whom is devoted the contribution* – technically-oriented audience vs. management or educational-oriented audience). The relative impact (*importance*) of each item in terms of the research outputs and results attained is represented by the intensity/darkness of the symbol used to represent it.

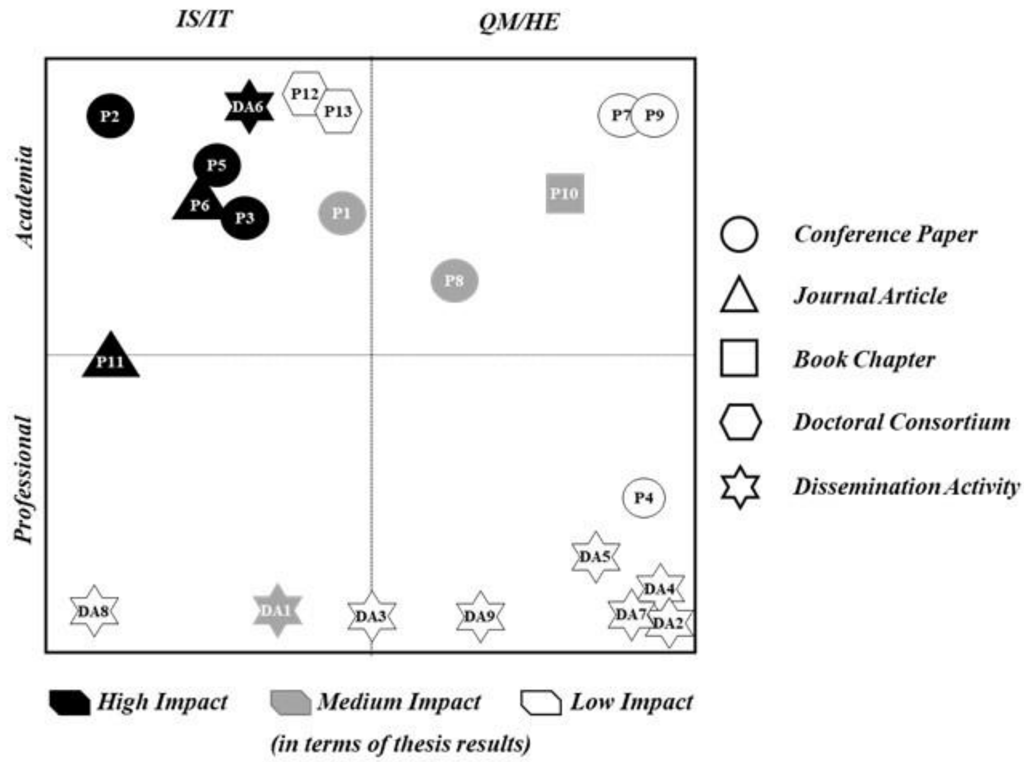

Figure 38 – Publications and Dissemination Activities Conducted During the Thesis

Source: Own elaboration

5.6.3. Measuring the Impact of the Research Conducted

Measuring the impact of a research conducted can be done from several different perspectives. In a simple way, it could be measured in terms of two main dimensions. On the one hand, the *temporal scope* – ranging from short, middle and long-term temporal span – in which the potential advantages (or drawbacks) derived from research can be materialized. On the other hand, a *cost/benefit analysis* – considering both the tangibility or intangibility – of the results achieved could also be used. However, *monetarizing or quantifying the* previous aspects not always is easy or trivial, especially for intangible benefits that tend to be difficult to quantify in monetary terms. Moreover, the farthest temporal scope for benefit materialisation, the hardest to get an accurate and un-risky economical estimation. All this rationale obviously also applies to results/ outputs achieved during the present thesis.

An easier alternative to measure and monitor (in some way) the impact of conducted research can be by means of an analysis of publication's [P] indicators. In part, this can be viewed as a rather biased approach, since the impact of the dissemination activities [DA] conducted cannot be explicitly evaluated. Nonetheless, we believe it is enough for the purposes of the present epigraph.

There is a plethora of publication indicators providing a relatively acceptable estimation of the "*goodness*" or the "*quality*" of a publication (Okubo, 1997), which in turn can be viewed as an (indirect) indicator of the impact of the research results exposed within publication contents. Here, we just limit our analysis to the publication's *number of citations*, which probably represents the simplest possible indicator for a published item. In this regard, an important mediating factor for its calculus (i.e., the number of times that the item has been cited by others work) is the year of publication of the piece: the older the publication's date of the research piece, the more likely it would have been cited a greater number of times.

In table 45, we provide the total number of citations and auto-citations of the incurred publications in the present thesis – as stated at December 2020 – in three major citation electronic databases. According to the information compiled by the table, our major "impact" has been achieved by publications [P3] – "*Towards an Unified Information Systems Reference Model for Higher Education Institutions*", [P1] – "*Focus Area Maturity Models: A Comparative Review*" and [P2] – "*A First Literature Review on Enterprise Reference Architectures".* Among the several factors that may explain the impact of this publications it can be argued that all 3 them include a more or less structured literature revision (which is usually considered as a casuistic that fosters possibilities of being cited) as well as the understandability and accessibility of the articles' content (tone and style of the text, intensive use of graphics and tables, inclusion of practical implications derived from the conclusions, etc.).

Table 45 – Number of Citations for Thesis Publications in Major Electronic Databases

Publication	**Year**	**Electronic Database**			
		Google Scholar	***Web of Science***	***Scopus***	
		#Number of Citations			**#Autocitations**
[P1]	2017	6	3	3	0
[P2]	2017	6	Not ranked	Not ranked	0
[P3]	2017	24	4	14	0
[P4]	2018	0	Not ranked	Not ranked	0
[P5]	2018	1	Not ranked	0	2
[P6]	2018	2	1	Not ranked	3
[P7]	2018	Not ranked	Not ranked	Not ranked	0
[P8]	2018	1	Not ranked	Not ranked	0
[P9]	2018	0	Not ranked	Not ranked	0
[P10]	2019	Not ranked	Not ranked	Not ranked	4
[P11]	2021	Unpublished	Unpublished	Unpublished	0
[P12]	2017	Not ranked	Not ranked	Not ranked	0
[P13]	2017	Not ranked	Not ranked	Not ranked	0

Source: Own elaboration (as stated at December 2020)

Another way for measuring impact of publications can be the number of accumulated downloads by the electronic version of a publication in certain research-oriented document's repositories. In this sense, the web portal of the Association for Information Systems (AIS) provides a central repository of research papers and journals articles relevant to the IS community, including an interesting feature to monitor their number of downloads. Unfortunately, only one of our publications belong to the spectrum of AIS related papers stored in their t repository and, therefore, the following information is only circumscribed to publication [P2] – "*A First Literature Review on Enterprise Reference Architectures*".

The AIS Electronic Library includes an *Authors' Dashboard* that provides simple statistics allowing the monitorisation of the number of downloads of a determined publication. Particularly, it offers information on the geographical precedence and the organisation type associated to the Internet user that downloads a determined publication. In this sense, caution should be taken on the statistical information provided by the AIS Electronic Library 's repository since several (many) iterative download (i.e., in different temporal moments) of a determined publication and by the same user are computed, introducing therefore, certain bias on the statistics provided. Whatever the case, the statistics reported by the AIS's platform certainly provide interesting insights on the (approximate) impact of a determined contribution in terms of the aggregated number of computed downloads.

For the particular case of our [P2] publication, a total of 247 downloads had been computed until January 2021. The aggregated information of such downloads is presented in the following Tables 46 and 47. On the one hand, Table 46 provides information of the total number of downloads of the referred publication segmented by the type of organisation associated to the user that effectively downloaded it. From the 247 effective downloads computed, the AIS platform was only able to capture meta-information related with the organisation type downloading the publication in 86 cases, which represents a 35% of the total downloads occurred. In this sense, 53 different organisations proceed to download the article, from which the 64,15% were educational institutions and the 28,3% commercial institutions. Government-oriented and other types of institutions only are representative of less than the 1% of the downloads computed.

Table 46 – Downloads Registered by the AIS Repository Platform for Publication 2, Segmented by Organisation's Type

Institution Name	Type	#Downloads
Universitaet Rostock	Education	8
Westfaelische Wilhelms-Universitaet Ziv	Education	7
Universiteit Maastricht	Education	5
Universitaet Duisburg-Essen	Education	4
Universitaet Hamburg Campus Net	Education	3
Universidade de Sao Paulo	Education	3
Delft University of Technology Network	Education	2
Danmarks Tekniske Universitet	Education	2
Technische Universiteit Delft	Education	2
Universitaet Wuerzburg	Education	2
University of Macedonia	Education	2
Islamic Azad University	Education	2
SHV Holdings N.V.	Commercial	2

Institution Name	Type	#Downloads
Friedrich-Alexander-Universitaet Erlangen-Nuernberg	Education	2
Universitaet Des Saarlandes Saarbruecken	Education	2
Universidade Federal de Pernambuco	Education	1
Technische Universiteit Eindhoven	Education	1
Universiteit van Tilburg	Education	1
Western Illinois University	Education	1
Research Network University of Ghent	Education	1
Bilkent University	Education	1
University of Innsbruck	Education	1
Zuercher Hochschule fuer Angewandte Wissenschaften ZHAW	Education	1
Ecole de Technologie Superieure	Education	1
Tampere University of Technology	Education	1
Royal Melbourne Institute of Technology	Education	1
Dhaka Communications	Commercial	1
Sahyadri Institute of Technology	Organisation	1
Technische Hochschule Deggendorf	Education	1
Hogeschool van Utrecht	Commercial	1
Aalto University	Education	1
Statens Seruminstitut	Government	1
Hochschule fuer angewandte Wissenschaften	Commercial	1
Statens IT	Commercial	1
Meteor	Commercial	1
Technische Universitaet Darmstadt	Education	1
Kiannet Nic co	Commercial	1
Dutch organisation for applied scientific research	Organisation	1
MAMPU Pool IP	Commercial	1
Habib Al Mulla & Co	Commercial	1
Ministerio do Planejamento Orcamento e Gestao	Government	1
RTP LAN	Commercial	1
Duale Hochschule Baden-Wuerttemberg Stuttgart	Commercial	1
Universitaet Siegen	Education	1
Pishgaman Toseeh Ertebatat Company (Private Joint Stock)	Commercial	1
University of Jyvaskyla	Education	1
Universitaet St. Gallen	Education	1
Urmia Medical Science Univetsity	Commercial	1
CSIR - Council for Scientific and Industrial Research	Commercial	1
ETECSA s	Commercial	1
Dublin City University	Education	1

Institution Name	Type	#Downloads
Westfaelische Wilhelms-Universitaet Muenster	Education	1
Akademska mreza Republike Srbije - AMRES	Education	1
TOTAL DOWNLOADS CAPTURED		***86***

Source: AIS Electronic Library Authors' Dashboard (as stated at January 2021)

Similarly, and on the other hand, Table 47 reports the same information that the precedent one but segmented by the geographical origin of the downloader of the article. Geographical meta-data was captured by the AIS platform for 242 downloads, a 98% of the total 247 downloads computed. European downloads represented the 68,6 % of the total amount of downloads, followed by Asian (14.46%) and American (11,2%) ones. If we circumscribe to the more fine-grained country-oriented perspective, downloads of readers from Germany (22,3%), Spain (14,5%) and the Nederland's (7%) have been the more common ones.

Table 47 – Downloads Registered by the AIS Repository Platform for Publication 2, Segmented by Geographic Origin

Country	Region	#Downloads
Germany	Europe	54
Spain	Europe	35
Netherlands	Europe	17
Iran, Islamic Republic Of	Asia	13
France	Europe	9
Brazil	Americas	9
Denmark	Europe	7
United Kingdom	Europe	7
Finland	Europe	6
United States	Americas	6
Greece	Europe	5
South Africa	Africa	5
Australia	Oceania	4
Canada	Americas	4
Switzerland	Europe	4
Indonesia	Asia	4
Malaysia	Asia	4
Norway	Europe	4
Peru	Americas	4
China	Asia	3
Ireland	Europe	3
India	Asia	3
Liberia	Africa	3

Country	Region	#Downloads
Russian Federation	Europe	3
Austria	Europe	2
Lithuania	Europe	2
Portugal	Europe	2
Serbia	Europe	2
Bahrain	Asia	2
United Arab Emirates	Asia	1
Bangladesh	Asia	1
Belgium	Europe	1
Chile	Americas	1
Colombia	Americas	1
Vanuatu	Oceania	1
Ghana	Africa	1
Kazakhstan	Europe	1
Moldova	Europe	1
Mexico	Americas	1
Qatar	Asia	1
Singapore	Asia	1
Syrian Arab Republic	Asia	1
Turkey	Europe	1
Viet Nam	Asia	1
Cuba	Americas	1
TOTAL DOWNLOADS CAPTURED		***242***

Source: AIS Electronic Library Authors' Dashboard (as stated at January 2021)

Several interesting insights could be derived from this information provided by the AIS platform. For example, it may come as no surprise the number of German downloads, since it is probably one of the countries with a longest tradition in DSR-oriented research as well as in research within the EA discipline, including a great number of EA communities of practice (Österle et al., 2011; Schelp & Winter, 2009; Winter, 2008). On the other hand, or geographical origin and affiliation might also explain well the number of downloads from Spain. Finally, for the particular case of the Nederland's, the interest in our research could be related with the fact that the Dutch HORA's National HEI-oriented ERA is probably the most important existing exemplar of this type of architectures worldwide – see again Section 3.2.2 –. In this sense, readers could also note that other countries in which there have been executed comparable initiatives devoted to conceive similar architectures (e.g., the United Kingdom, Finland or Australia, to cite a few) also appear in the top positions of the list provided by Table 47.

Figure 39 – Worldwide Map of Downloads Registered for Publication 2 by the AIS Repository Platform

Source: AIS Electronic Library Authors’ Dashboard

5.7. Final Note and Concluding Remarks

This chapter brings to an end the activities carried out during our thesis developments by summarizing the main findings and results achieved. Despite other researchers have already contributed to the particular research stream of *EA artefact usage*, the present study puts the emphasis on ERAs, since they represent one of the most under-researched artefacts by literature to date. Hence, the present thesis extends existing knowledge on the EA field by developing greater understanding on this specific EA artefacts, and in particular, those ones targeted to the application domain of HEIs.

Although *EA artefact usage* is assumed to be a precedent for all benefits that EA could provide to organisations, the effective achievement of such potential benefits has been proven to be complicate in practice for not so many organisations. In other worlds, EA artefacts "*are useless from the benefits point of view if they are not properly used*" (Niemi & Pekkola, 2019, p. 594). This is especially relevant for ERAs due to their inherent structural complexity (Greefhorst et al., 2006, 2009, 2008; Muller & van de Laar, 2009; ten Harmsen van der Beek et al., 2012), which jeopardizes their complete understanding by practitioners since they "*do not collectively have a consistent notion of what constitutes a Reference Architecture*" (Cloutier et al., 2010, p. 14). As a consequence, this misunderstanding also compromises their subsequent adoption and usage by practitioners in their daily activity work (Banaeianjahromi & Smolander, 2019; Brosius et al., 2018; Dang & Pekkola, 2017; Weiss et al., 2013).

Considering that *EA success* (i.e., benefit/value realisation) has proven to be a context dependent issue depending on technical, socio-cultural and organisational factors – e.g., firm's industry type and size, existing legislation and regulations , quality of currently implemented EA practices, etc. (Gong & Janssen, 2019; Lange et al., 2016; Niemi & Pekkola, 2019; Shanks et al., 2018; Tamm et al., 2011) –, the study of ERAs tailored for HEIs seems a promising and appropriate research topic given the idiosyncrasy of HEIs as well as the fact that HE has historically be one of the sector/industries with the poorest relative EA maturity and success ratios (Luftman & Kempaiah, 2007; Roeleven, 2010; Alamri et al., 2018).

To cope with all this background, after clarifying the concept of ERAs and giving a panoramic view of the current landscape of existing HEI-oriented ERAs, this thesis proposes an artefact framework to facilitate practitioners the use/application of HEI-oriented ERAs in their own specific practical settings. The purpose of the framework is to support practitioners when preparing and conducting the necessary adjustments and parametrisations to these architectures in order to be successfully used/applied for their specific needs. Thus, the artefact framework provides complementary assistance to enable and empower practitioner's autonomy during their architectural practice by guiding them during the process of reflecting and asking themselves the right questions to capture, understand and systematically document all the implicit knowledge needed for their efficient usage/application of this architectures.

Given such aims, the proposed artefact framework embeds and enumerates a series of generic USs in which HEI-oriented ERAs could be used in practice by different HEI-oriented stakeholders to achieve several different potential benefits. However, and since *EA artefact usage* is a context-dependent issue which entails many different dilemmas complexities that should be foreseen in each specific situation, the framework cannot render all the detailed *tips and hints* for giving specific answers to every particular USs of HEI-oriented ERA.

For instance, and despite proposing several pragmatic guidelines to cope with such existing obstacles, the proposed artefact framework only provides generic guidance for addressing them. Thus, when planning and conducting their particular usage in practice of a specific exemplar(s) of existing HEI-oriented ERA(s), practitioners still need to adequately instantiate (i.e., adapt, translate) the information and recommendations proposed by the artefact framework in order to enable its actionability in their respective particular context of practical usage.

All in all, we hope that, besides getting one step further in achieving a better understanding of HEI-oriented ERAs, our investigation would guide and inspire practitioners in HE to regularly use them in their daily practices in order to take advantage of the many possibilities their can offer. Beyond that, we also believe that our investigation might be interesting for academics/researches wishing to incorporate EA contents in their IS courses.

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