Enterprise Transformation Projects-A Mathematical Models' based Enterprise Refinement Concept (ETP-ERC)

ANTOINE TRAD
IBISTM,
Courbevoie,
FRANCE

Abstract: - This article presents analyzes the possibility and the risks related to the implementation of an Enterprise Transformation Project (ETP), which can be assisted by an Enterprise Refinement Concept (ERC). The ERC is based on the author's Applied Holistic Mathematical Model (AHMM), to implement a Digital Transformation (DT) process, which is ETP's first major step. The DT is a very critical process and it decides if the ETP will succeed or fail. ETPs are of strategic importance for the business enterprises or organizations (simply an *ENT*), but they are unfortunately, very complex and have very high failure-rates. The mentioned major complexity constraints, need a risk based strategic concept that uses a Polymathic-holistic approach, which in turn uses and integrates the AHMM for the ERC (AHMM4ERC). The AHMM4ERC can be used to evaluate ETP's progress (or regression). The ERC is sets of extraction, conversion, and refinement operations that are executed on various *ENT's* levels and on its legacy resources. An *ENT* can include: 1) A group of stakeholders; 2) Executive managers; and 3) A set of organizational units or business units (simply a Unit), where each Unit has its own (1 or more) Unit system(s) or PLatform(s) (UPL). The application of the ERC on the *ENT*, refines and transforms all its Units and its UPL(s); to deliver reusable Building Blocks (BB). ERC generated BBs can be assembled and combined in Composite BBs (CBB); and CBBs are used to reorganize *ENT's* APplication Domain's (APD) business and common functions, Units, UPLs, and all their dependencies. The AHMM4ERC insures *ENT's* generated BBs, Units, and UPLs integrities; and that they can be used in the ETP.

Key-Words: - Enterprise Transformation Projects, Enterprise architecture, Enterprise Refinement Concept, Artificial Intelligence, Mathematical Models, Strategic and Critical Business Systems, Business transformation projects, Critical Factors, Performance Indicators, and Strategic Visions.

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1 Introduction

As already mentioned, ETPs are complex to finalize, because of various reasons, and the most common reason is ETP's implementation phase(s). The implementation phases rely on the success of the ERC's generated and refined BBs and CBBs. Where a BB is a set of Reusable Micro-Artifacts (RMA), and where an RMA can be: 1) A code archive or library; 2) Data-sources objects, like a set of tables or files; 3) Business resources like Business Processes (BP); or any other type of object. The ETP must take into account, that ERC's Unbundling Process (UP) capability to deliver pool(s) of extracted and refined BBs, is the most critical success factor and a major risk. Different types of generated BBs are combined, in order to offer reusable CBBs, which in turn are combined to deliver Organizational BBs (OBB). OBBs are used to implement, (re)build, and optimize *ENT's* Units and its UPL(s). In this article, the optimization and reorganization of Units takes into account mainly intangible and non-financial objectives, because it adopts a non-business oriented approach. An ERC is a sequence (or a set) of UPs which execute Refinements operations on the UPL (RUPL). RUPL's goal is to disassemble *ENT's*: 1) Legacy Units' archaic structure(s); 2) Organizational processes; 3) Information and Communications System's (ICS) management; 4) Information system's administration; 5) Resources/objects, Applications/Modules; 6) Working models; and 7) Components; into dynamic reusable CBBs which can be (re)used in standardized or In-House-Implemented (IHI) OBBs; where a Unit is a set of OBBs and different Units can share common OBBs, and hence BBs and CBBs. In actual ETPs, the conversion/refinement of legacy Units and their subsystems, need an IHI Methodology like the Domain, and Technology Common Artefacts Standard (MDTCAS), that can inter-map and combine existing BBs, CBBs and OBBs. When generating RMAs, the ERC can face major difficulties because of *ENT's* heterogenous human profiles/cultures, system parts, ETP's Resistances (ETPR), managers/stakeholders exaggerated financial ambitions, and project's limited time/budgets. In this article the author uses an adapted version of the AHMM4ERC, [1], to support ERC's and RUPL's feasibility. The ETP starts with an initial phase's pool of secured BBs that result from the UP and its sub-processes, known as the Automated Refine Processes (ARP). A Unit is a set of refined OBBs and a Transformable *ENT* Organizational Model (TEOM) is a set of refined Units; and finally, an *ENT* is a set of TEOMS. ETP's success depends on the initial implementation phase and the success of the ARP/UP based ERC. Refined and stored CBBs are instantiated to offer sets of OBBs, which are used as organizational classes to transform an *ENT*. The ARP/UP based ERC can face difficulties because of the *ENT's* heterogenous technology, human skills, various types of resistances, and business engineering/modelling activities; and the AHMM4ERC can help in supporting the abstraction of such an issue, where it checks its feasibility and ETP's integrity. Unfortunately, the ERC and RUPL are used to achieve immediate tangible financial profits, and such approaches make ETPs fail at the rate of more than seventy percent. This article presents the possibility to implement an IHI RUPL Strategy (RUPLS) which avoids the financial-only locked-in strategies and ensures success and avoids ETPR. The main point is to define the levels of granularity and mapping concepts for the MDTCAS, which enables the reuse of existing or newly refined RMAs, BBs, CBBs and hence OBBs (simply Artefacts).

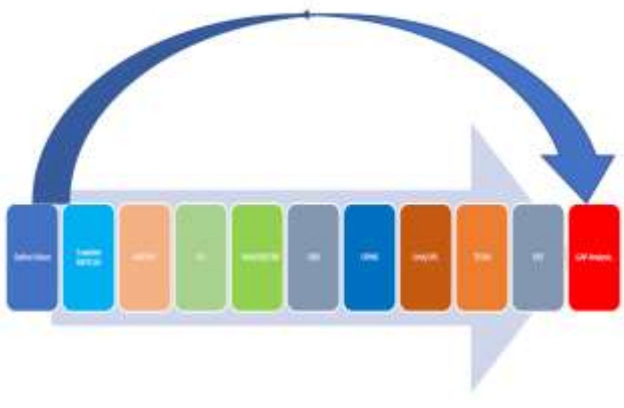

Fig. 1: ETP*'s* phases

As shown in Figure 1, the RUPLS follows the ARP/UP phase and if that step fails because of various types of resistances (like the ETPR) and difficulties, then a new RUPLS is to be implemented. Otherwise, the ETP can move to the next step and can consider another major achievement was done. The ERC and RUPLS can choose an initial Unit (and its modules) to be converted by using the ARP/UP, in order to prove that the ERC/RUPLS approaches are feasible and to try to convince *ENT's* managers (and staff) to continue/proceed the ETP and TEOM, which are this article's scope. The TEOM uses the Organizational Process/collaboration Models (OPM) System (OPMS) based Units' transformation technics. And an *ENT* is simply a set of TEOMs. Various *ENTs* and their APDs, have critical ETP requests, and the very quick evolution of business requirements, concepts/methodologies and ICS/technologies; can create major and even fatal ETP problems. Such problems are mainly due to encountered gaps between ICS/technologies' evolution and ETP's progress; where similar gaps can very wide ones. Knowing that an ETPs can take long time to terminate, and on the other hand business and ICS/technology fields have a hyper-evolution cycle. That implies that there is a need to implement a holistic MDTCAS to support ETP's evolution and independent of all business and technological evolutions. The MDTCAS based RUPLS is an important factor for the success of ETPs, because ERCs unify CBBs and OBBs management, in order to support the reorganization of Units. CBB/OBB based RUPL is a risky ETP's phase, because of limited and complex ERC. In this article, the author proposes that a RUPLS supports ETP Managers (or simply *Managers*) and his transformation team(s), in extracting and reusing CBBs and OBBs. The ERC is not just a process of disassembling (and reassembling) of CBBs and OBBs, but it is a structural and coherent reorganization of Units, and hence *ENTs*. A CBB reuses models diagrams/documents, RMAs, BBs, and Architectural BBs (ABB). So the ERC can be considered as a *reengineering* discipline, which delivers well-engineered/architectured BBs, CBBs and OBBs, which are used in next ETP*'s* phases, as shown in Figure 1.

Fig. 2: The ETP*'s* construct

In many ETPs, ARP/UPs and ERCs operations are underestimated and their complexities are ignored; and that causes ETP*'s* failure(s). Therefore, ERC's success is mandatory for ETP's next phases. ERC's activities and its transformed/generated IHI CBBs and OBBs, are independent of a specific brand, methodology, tool, or other locked-in strategy. In this article the author uses an adapted version of the AHMM (to offer the AHMM4ERC, [1]), in order to support the RUPLS, which uses ARP/UP to extract the design of Artefacts. This article selected keywords show ERC's complexity and the need for a Polymathic-holistic concept; that can be supported by a generic Enterprise Architecture (EA) methodology based RUPLS that can be used in any APD. ERC's objective is to reengineer common OBBs and the RUPLS can be done in consequent steps. The ERC uses the Polymathic-AHMM4ERC, to test Artefacts' integrity and ETP's integration capacities and feasibility. ETP's feasibility, depends on the complexities that are related to ICS' and UPL's heterogenous approaches, but it is mandatory for the *Entity's* business sustainability, [4], [5], [6]. The AHMM4ERC supports iterative ETP's activities like the RUPL of legacy sub-systems. The RUPL uses the Transformation Development Methodology (TDM) based MDTCAS to implement and integrate existing internal and standard concepts and methodologies, like The Open Group's (TOG) Architecture Framework's (TOGAF) Architecture Development Method (ADM), [7]. The ICS' related ERCs and hence ETP use agile cyclic/iterative TDM's implementation phases, which include ARP/UPs. ERCs are performed mainly for creating and managing OBBs that include: 1) Organizational refinement technics; 2) Development and Operations for ERC (DevOps4ERC); 3) Automated tests, qualifications, and deployment procedures; 4) Extracting BBs/CBBs based OBBs; and 5) CBBs/OBBs design and modelling activities. The RUPLS proposes the efficient use of the ERC, which faces complexities that are mainly due to the following facts: 1) The implementation of complex, and heterogenous Artefacts based Units; 2) ICS/Technologies' and methodologies hyper-evolution, mainly is due to financial objectives; 3) The incapacity to establish an adaptable MDTCAS; 4) Resistance for Change (R4C) that is the ETPR's origin of central types of critical problems, which should be checked with the an optimal Readiness to Transform (R2T); and 5) Maintenance difficulties, [8]. In this article the RUPLS uses a Proof of Concept (PoC) and a related Applied Case Study (ACS). The ACS descries a leading *European Bank's* (simply EUBank) ARP/UP based ERC. The mentioned ETP was mainly used to support an ERC for EUBank's legacy framework and Units structure, which was based on Unified Modelling Language (UML), EA, TDM (that abstracts ADM), ArchiMate, Mainframe and Integrated Development Environments (IDE) environments. The ADM based TDM, managed underlying design modelling, refinement, DevOps4ERC, and governance procedures. As shown in Figure 2, such a ETP needs a qualified and experience *Manager* (or Architect of Adaptive Business Information System-AofABIS), ERC specialists, and a capable team. And in this ETP, the team was the main weakness and generated R4Cs and ETPRs, which proves that the ERC is a critical phase, mainly because of the human incapacity and resistance factors. The TDM managed the implementation of the *ENT* refactored CBBs/OBBs/OBBs and storied them in *ENT's Enterprise Continuum,* [4], [5]. There were three types of CBBs: 1) Common CBBs/OBBs; 2) Mixed CBBs which include ABBs and Solution BBs (SBB), and create OBBs' libraries, [7]; and 3) Imported CBBs/OBBs. As shown in Figure 2, RUPLS' interaction includes: 1) Decision Making System (DMS) for ERC (DMS4ERC); 2) Knowledge Management System (KMS) for ERC (KMS4ERC); 3) Critical Success Factors (CSF) (and areas Critical Success Areas-CSA) Management System (CSFMS); and 4) An IHI RUPLS. To prove RUPLS' feasibility, the author implements a PoC and Research and Development Process (RDP) for ERC (RDP4ERC) concepts.

2 The RDP for ERC

2.1 AHMM's Basic Elements

The RUPLS identifies and assesses strategic and critical ETP's risks, in order to guaranty ERC's operations' coherency, by using the AHMM4ERC. AHMM4ERC's basic elements are:

- ***a*** for atomic
- ***m*** mapping operator
- ***i*** instance of
- ***R*** $\bigcup$ of Requirements
- ***C*** $\bigcup$ of Constraints
- ***V*** Valuate function, $\bigcup$ of ***H***
- ***St*** $\bigcup$ of States
- ***T*** $\bigcup$ of Sts
- ***S*** $\bigcup$ of Solutions
- ***F*** Function
- ***A*** $\bigcup$ of Actions/***Fs***
- ***P*** $\bigcup$ of Problem.

- *GID* *or GUID, is a* ***unique identifier*** *for all AHMM4ERC's objects.*
- *FTR* *is a* ***feature,*** *of an ENT.*
- *ART* *is an* ***artefact****, ...,*
- *CNT* *or* ***C's element,*** *is a* ***constraint,*** *of an ENT, Enterprise,* ETP*, ICS…*
- *RUL* *is a* ***rule,*** *of an ENT, Enterprise,* ETP*, ICS…*
- *REL* *is a* ***relationship or association, …*** *Which can be three dimensions [TYPE][GID][CSA/APD].*
- *PRB* *is an ETP or ERC* ***problem.***
- *REQ* *is an ETP* ***requirement.***
- *CLS* *is a* ***structure****, class, method-part,…*
- *OBJ* *is a* ***CLS instance****.*
- *SRV* *is a* ***service***
- *DIA* *is a* ***Diagram****, UML, TOGAF,…*
- *APP* *is an* ***application.***
- *WGT* *is a* ***Weighting.***
- *SOL* *is a* ***solution.***
- *GAP* *is a* ETP ***gap*** that results from ERC.
- *TSK* *is an* ETP or ERC ***task.***

ICS basics:

ART	= ***m*** SRV	(I1)
ART	= ***m*** DTB	(I2)
ART	= mcArtefact	(I3)
SRV	= ⋃ mcArtefact	(I4)
CLS	= ⋃ FUN ***or*** SRV + ⋃ VAR + ⋃ REL	(I5)
OBJ	= ***i*** CLS	(I6)
DIA	= ⋃ CLS + ⋃ REL	(I7)
DIA	= ⋃ OBJ + ⋃ REL	(I8)
SCR	= ***i*** DIA	(I9)
BB	= ⋃ DIA	(I9)
ABB	= ⋃ DIA	(I9)
SBB	= ***i*** SCR	(I9)
APP	= ⋃ SCR	(I10)
CMP	= ⋃ APP ***or*** IEL ***or*** DST	(I11)
ICS	= ⋃ CMP	(I12)
CLD	= ⋃ ICS	(I13)
EST	= ⋃ CLD	(I14)

Requirements:

mcREQ	= ***m*** KPI	(R1)
mcMapping mcArtefact/mcREQ	= mcArtefact + ***m*** mcREQ	(R2)
FTR	= mcREQ	(R3)
PRB	= ***m*** PRB	(R4)
REQ	= ***m*** CSF = ⋃ mcREQ	(R5)
REQ	= ⋃ FTR + ⋃ RUL + ⋃ CNT + ⋃ DIA + ⋃ REL	(R6)

Fig. 3: AHMM4ERC's nomenclature

AHMM4ERC's nomenclature is presented in Figure 3. Moreover, AHMM4ERC's basic elements are used to present ERC artefacts:

- *MVC* = ⋃ DIA + ⋃ REL (A1)
- *MVC* = ⋃ MVC + ⋃ REL (A2)
- *BB* = ⋃ SRV + ⋃ REL (A3)
- *SBB* = ⋃ ***i*** SRV + ***i*** ⋃ REL (A4)

A ETP has various Viewpoints, like "O" for organizational, "S" for Security… In this article the Viewpoint "U" (for Units) is the central section of the applied Polymathic approach.

2.2 A Polymathic Approach

ARP/UP and ERC for legacy Units' components has created a paradigmatic shift in ETPs, where these archaic components use sets of heterogenous structures, ICS/technologies, and methodologies. The transformation of such components in the form of CBBs/OBBs is supported by an adapted the RUPLS. As shown in Figure 4 and Viewpoint "O", the RUPLS focuses on refactoring of Unit's components. The main Viewpoint: "O" or Organizational elements are:

- RMA = ∑ aBB + ∑ sBB + ∑ aMVC (C1)
- BB = ∑ ARP/UP+ ∑ RMA + ∑ OPM (C2)
- CBB = ∑ BB + ∑ ABB + ∑ SBB (C3)
- OBB = ∑ CBB (C4)
- Unit = ∑ OBB (C5)
- ERC = ∑ ARP/UP (C6)
- TEOM = ∑ ERC (C7)
- RUPL = ∑ TEOM (C8)
- Unit= ∑ RUPL (C9)
- *ENT*(O) = ∑ Unit (C10)

Transformed Artefacts are identified, classified in repositories and are classes and objects that interact using GIDs, where Artefacts has its GID.

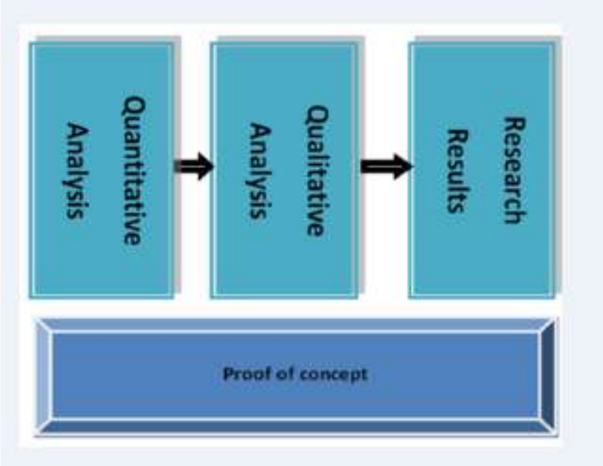

Fig. 4: ETP*'s* Polymathic research approach

The RDP4ERC proposes the RUPLS to support *Managers* and ETP teams, in refining *ENT's* Unit's platform components. ERC's main activity is to extract domain scenarios and relate them to Artefacts. The RDP4ERC presents the author's configurable research methodology and the implementation of the related ACS and PoC (which are based on the already mentioned EUBank). Figure 5 shows the Polymathic-holistic approach used by the ERC based ETP for EUBank. RDP4ERC's first step was to establish the Research Question (RQ) and achieve an in-depth Literature Review Process (LRP) for ERC (LRP4ERC).

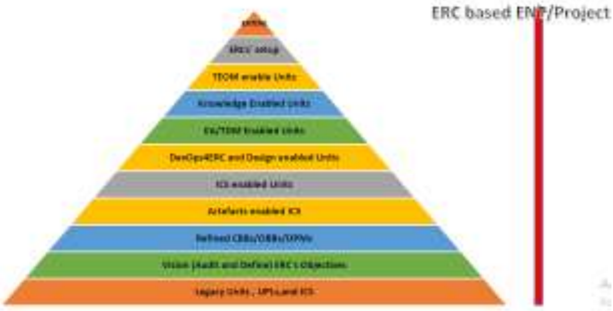

Fig. 5: ERC based ETP's Holistic Approach

2.3 The RQ and LTR4ERC

The RDP4ERC's RQ is: "Can the RUPLS support the implementation of ERC for Units?". Where this article's auxiliary RQ is: "How can Artefacts support ETP's ERC?". The RDP4ERC uses: EA inspired TDM, AHMM4ERC, CSFMS, and the DMS4ERC. LRP4ERC's processing and analysis showed that there are no similar concepts and approaches to the author's Transformation Research Architecture Development framework (*TRADf*), that includes: TDM, ARP/UP, ERC, and AHMM4ERC, RDP4ERC, … *TRADf* just shows how to implement an IHI transformation framework and that is no need for a long list of expensive products. But there are a small number of relevant industry and scholar usable resources that are related only to the ETP and ERC; and they limited. Like TOGAF, which is can considered as usable framework, but it is very limited and a simplistic cookbook, which tackles minor ETP topics, like EA. Therefore, the AHMM4ERC based RDP4ERC related author's works, are pioneering, innovative and covers an important gap, between ERC and existing complex refinement solutions. Such works can irritate major locked-in drivers, but *TRADf* persists in this approach. ETP related gaps and the high failure rates were again confirmed by the LRP4ERC, [9]. These failures are mainly to the intentional lack of a Polymathic-holistic approach to ETPS and RUPLS; and the related ERC operations, which today are done manually or by the use of commercial products, which intend to resell the same concepts again and again with having the same failure rates. The LRP4ERC used the following resources: 1) Articles and resources related to ERC, RUPLS, OPM, ICS reengineering, and ETPs; 2) The author's RDP/LRP works, TDM, and *TRADf*; 3) ERC's feasibility and capacities; 4) Initial sets of CSAs/CSFs; and 5) RDP4ERC's use of the Empirical Engineering Research Model for ERC (EERM4ERC). All the author's works are based on *TRADf*, AHMM, TDM, ARP/UP, and RDP; which are today mature and can be applied in various transformation domains like the ETP and related ERC*'s* risk management. The RDP4ERC proved the existence of an immense gap and the necessity to deliver ERC and RUPLS recommendations. The main gap is due that there nothing similar to the ERC; but there are primitive *ENT* refinement approaches that concern exclusively software (code-sources), and which are manual processes. As shown in Figure 6, the next step is to select and classify the sets of CSFs and CSAs in the CSFMS.

2.4 CSAs and CSFs Management System

A CSA is a set of CSFs where in turn a CSF is a set of Key Performance Indicators (KPI). A KPI maps (or corresponds) to a single common ETP and ERC requirement, feature, or Artefact. For a given requirement or ERC problem, the *Manager* (or enterprise architect), identifies the starting sets of CSAs, CSFs and KPIs, to be used by the Heuristics Decision Tree (HDT) based DMS4ERC and maps them to the sets of Artefacts and requirements. Hence the CSFs are important for the mapping between the requirements, knowledge constructs, ERC, Artefacts, Units, and DMS4ERC/KMS4ERC, [10]. Therefore, CSFs reflect constraints/goals that must be met in the RUPLS. *TRADf* offers evaluations and measurements methods, which are offered by *TRADf*, which is able to estimate each ETP's CSA, in which CSFs can be: 1) ETP, ERC, or RUPLS' status; 2) Mapping ERC's levels of resulting Artefacts; 3) ETP's and ERC's gap analysis; and 2) DMS4ERC/KMS4ERC requests serving in real-time, as shown in Figure 6. KPIs can be integrated in Artefacts as concrete source-code variables or attributes, so HDT's evaluation engine can automatically estimate the values of CSAs, CSFs, and KPIs (simply Factors), [11], [12].

Fig. 6: The ERC and CSFMS' integration with RDP4ERC, [1]

As shown in Figure 6, Factors and ETP's risks estimations can have the following characteristics, [13]: 1) Understanding and estimating ERC activities; 2) Factors based TDM implementations' complexity estimations and problems' solving; 3) ETP's risk mitigation strategy; 4) Factors are key elements that are linked to concrete ICS variables; and 5) CSAs, CSFs, and KPIs are configured and tuned by the ETP team members, by using *TRADf*. Sets of Factors are rated and weighted by the DMS4ERC/KMS4ERC to offer sets of solutions for a concrete ERC or RUPLS problem. The HDT-based DMS4ERC is used in all of *TRADf's* modules. RDP4ERCS' phases are: Phase 1 (represented in decision Tables), forms the empirical part of the RDP4ERC. Which checks the following CSAs: 1) The RDP4ERC, which is synthesized in Table 1; 2) The Methodology and MDTCAS, which is synthesized in Table 2; 3) The CBBs and OBBs based OBBs approach, which is synthesized in Table 3; 4) The Polymathic ERC model, which is synthesized in Table 4; 5) The RUPLS based ETP, which is synthesized in Table 5; and 6) This article's RDP4ERC outcome, which is synthesised in Table 6. *TRADf* based RUPLS delivers a set of (managerial and technical) recommendations and solutions, and a strategy for a ETP and UPL.

2.5 ERC's Integration with *TRADf*

As shown in Figure 7, *TRADf*, TDM, and its new module, the ERC, support the transformation of legacy Units and their UPLs, into agile Artefacts. These Artefacts are designed, generated/assembled, and implemented by using the MDTCAS. Such an implementation is independent of the types of: 1) ICS/technologies; 2) APDs; 3) Unit (re)structures; and 4) Methodologies of formalisms. The MDTCAS ensures that *ENT's* ETPs are not locked-in by global actors or by the hyper-evolution of business technics, methodologies, and ICS/technologies, [14].

Fig. 7: *TRADf's* implementation interface

The ERC is complex and risky, that is due to the unviable, heterogenous, and archaic UPL's and ICS' components siloed integration formalisms which are chaotic. These facts make the automated extraction of Artefacts very complex. ERC's Polymathic-holistic approach supports complex Unit and UPL's integration activities, [15]. The use of the ERC in various APDs, automates and refactors Unit modules, components, and structures. The ERC is a part of *TRADf's: Software engineering or the Implementation module* (Im), and *Architecture module* (Am). It is recommended that an *Entity* builds a similar IHI framework and TDM, which can be based on TOGAF's ADM or any other methodology. The TDM based ERC supports the DevOps4ERC, to extract and manage Artefacts, which circulate through its implementation phases. The Artefacts are related to the selected sets of Factors. The RDP4ERC reuses the author's works like *TRADf*, LRP4ERCs, Artefacts' management, which are used to assist in solving this article's RQ. Therefore, the author's research is an iterative research process and all related topics are only referenced, because otherwise it would be tedious to understand this work. The RDP4ERC is a non-conventional and pioneering concept, in the fields related to the ETP. The ERC and RUPLS are Polymathic and are founded on a genuine and the EERM4ERC in turn are based on *TRADf*, HDT, ERC, DMS4ERC/KMS4ERC, TDM/EA, RP, and ICS concepts, [7].

2.6 EERM4ERC's Usage

The EERM4ERC based RDP4ERC is optimal for ETPs and uses *TRADf* (where it applies a multi-level mixed research by using the HDT) that can be considered as different from conventional research models ,[11], [12], [16]; and *TRADf* includes: 1) Pseudo heuristics-Basic reasoning; 2) Quantitative Analysis for ERC (QNT4ERC); 3) Qualitative Analysis for ERC (QLT4ERC) research methodologies, to deliver empirical methods and concepts as a possible approach for complex tuned mixed methods research; and 4) A Learning Process based on the HDT for ERC (LP4ERC), which was inspired by Action-Research oriented LP4ERC, [11].

Fig. 8: RDP4ERC's environment

TRADf can interface any existing research methodology, and the main differences between different research methodologies, are just in the scope and depth of the applied research model. Empirical research validity, checks if the RDP, like the RDP4ERC, is acceptable as an important contribution to existing scientific (and engineering) knowledge and to convince the reader(s) that the presented recommendations and PoC (or engineering experiment), are valid and reusable for various types of ERC or RUPL operations. In engineering, a PoC is a software prototype of a testable RQ (and hypothesis) where one or more Factor (or independent variables, in theoretical research) are processed to evaluate their influence on RDP4ERC's dependent variables. As shown in Figure 8, PoCs support the evaluation (with precision) of Factors and if they are related, whether the cause–effect relationship exists between these CSFs and CSAs. The TDM based ERC and RUPLS are transformation centric and use existing standards, [7]. ERC and RUPLS' author's related works are: 1) Using Applied Mathematical Models for Business Transformation, [1]; 2) Applied Holistic Mathematical Models for Dynamic Systems (AHMM4DS), [17]; 3) Business Transformation ETPs-The Role of a Transcendent Software Engineering Concept (RoTSEC), [4]; 4) Business Transformation ETPs-The Role of Requirements Engineering (RoRE), [5]; 5) Business Transformation ETPs based on a Holistic Enterprise Architecture Pattern (HEAP)-The Basic Construction, [2]; 6) Integrating Holistic Enterprise Architecture Pattern-A Proof of Concept, [3]; 7) A Transformation Framework Proposal for Managers in Business Innovation and Business Transformation ETPs-Intelligent atomic building block architecture, [18]; 8) A Transformation Framework Proposal for Managers in Business Innovation and Business Transformation ETPs-An Information System's Atomic Architecture Vision, [19]; 9) Organizational and Digital Transformation ETPs-A Mathematical Model for Building Blocks based Organizational Unbundling Process, [6]; and 10) Organizational and Digital Transformation ETPs-A Mathematical Model for Enterprise Organizational Models, [20]. ETPs' *Managers* should not underestimate ERC's complexity, which is due to a long and complex process; and which needs R2T based transformation readiness checks.

2.7 ERC's Transformation Readiness Checks

The ERC is complex and is the major cause of ETP's failure is due to ARP/UP's complexities, which generate various types of technical problems, [21], [22], like the ones presented in *The Chaos Report*, produced by the Standish Group over the last fifteen years; they assert that: … *only about 29% of transformations come in on time and budget*… ERCs use ARP/UP refactoring processes are the main ones, and they need skills, IHI tools, synchronized extraction processes, and TDM capabilities. ETPs with successfully finalized ERCs, had similar: Strategies, Legacy organizational and ICS (by configurations), Structures, APDs/discipline, Skills, Decision model, and Transformation roadmap for localizing needed skills. The ERC supports various types of refinement action, that are used to restructure legacy Unit's structures, Application/Components portfolio, to align ETP's transformation management plan, and defined requirements' mappings. The ERC and RUPLS needs the following types of skills, [7]: 1) TDM based ERCs and generated Artefacts support *Business Transformation Readiness Assessment* capacities; 2) Supports ERCs' executions; 3) Establishes execution capacities; 4) DMS4ERC based LP4ERC, to build ERC experiences; 4) To build a MDTCAS;

and 5) Design and implement OPM System (OPMS) and TEOM.

2.8 RDP4ERC's CSFs

Based on the AHMM4ERC, LRP4ERC and DMS4ERC, this CSA's CSFs/KPI were weighted and the results are shown in Table 1. This CSA's result of 9.25, which is high, is mainly due to the fact that the iteratively used RDP4ERC is mature and that the ARP/UP to deliver BBs was successful, [6]. But that does mean that the ERC is feasible. As the RDP4ERC's CSA presented positive results, the next CSA to be analyzed the role and evolution of MDTCAS compatible methodologies.

Table 1. This CSA has the average of 9.25

Critical Success Factors	KPIs	Weightings
CSF_RDP4ERC_Polymathic_Approach	Proven	From 1 to 10. 10 Selected
CSF_RDP4ERC_Factors_Integration	Proven	From 1 to 10. 10 Selected
CSF_RDP4ERC_RUPLS_Integration	Complex	From 1 to 10. 08 Selected
CSF_RDP4ERC_EERM	Feasible	From 1 to 10. 09 Selected
CSF_RDP4ERC_Transformation_Readiness	Feasible	From 1 to 10. 09 Selected
CSF_RDP4ERC_Needed_Skills_Profiles	Feasible	From 1 to 10. 09 Selected
CSF_RDP4ERC_IHI_TRADE	Possible	From 1 to 10. 09 Selected
CSF_RDP4ERC_LTR4REC	Proven	From 1 to 10. 10 Selected

valuation

3 The Role of MDTCAS for ARTEFACTS

3.1 The Role of Digital Transformation

The ERC and RUPLS are mandatory and they are critical to all ETP's phases. ERC's main goal is to create a common platform of reusable Artefacts, services, and resources for a sustainable *ENT's* OPMS, UPL, and ICS based business platforms. Artefacts are instantiated in order to support agile Digital Transformations (DT), which intend to improve *ENT's* Time-to-Market (TtM) and to adapt to ever changing APD requirements. ARP/UP based ERC enable dynamic DTs (simply digitization), which is a strategic objective and that implies that the need for the high-adoption rate of ICS/digital technologies, is of high importance for an *ENT*. Unfortunately, ETP based digitization are complex and more than 70% of such projects fail, due to team members' concerns, which results in fatal R4Cs. The ERC breaks down *ENT's* UPL and ICS silos into a dynamic and digitized ICS. Digitization processes use TDM and MDTCAS experts in order to integrate agile APD models and to define overall DT's strategy, [23].

3.2 DT's Strategy

DTs based TEOMs are managed by the TDM to face various types of ETP challenges, where the goal is to digitally transform Artefacts, OPMs, SRVs, and resources. The TDM synchronizes *ENT's* ERC, RUPLS, UPL, and ICS operations and the DT serves as a digital platform for future business activities, [24]. DTs are difficult to define and manage, because they depend on the type of the targeted APD, OPMS/TEOM implementations, and MDTCAS' incorporation capacities. A successful DT supports ETP's ERC and future APD's functions and (re)organization, which enhances functional performances. Artefacts based APD models' development needs a stable DT strategy, in order to process business transformation activities concerning, [25]: 1) Legacy UPLs and underlying OPMS; 2) To coordinated Artefacts based choreographies; 3) DT based OPMS/TEOM, which makes an *ENT* capable of conquering new business markets; 4) Units' (re)structuration, is done by redefining needed ETP skills, OPMS/methodologies, and capabilities; 4) The capacity to execute ERCs for all APD's sub-domains; 5) To adopt an all-inclusive DT based ERC, RUPLS and MDTCAS/OPMS, with an optimal ETP plan; and 6) Include legacy Units' reengineering skills to enable DTs to be the basis of Units' restructuring processes.

3.3 Legacy Units and the MDTCAS

A ETP must define an IHI MDTCAS, which is a minimal mix of existing methodologies and (internal and external) practices, which can be used by the ERC and RUPLS. The MDTCAS can include Object Oriented (OO) Methodology (OOM) concepts and traditional legacy methodologies, like the Structure Analysis and Structured Design (SA/SD). In the case of legacy implementations, ERCs can use the following technics: 1) ERCs to transform legacy-modules into SA/SD compatible; 2) To implement the MDTCAS that is mainly based on OOM concepts; 3) To adapt MDTCAS to (popular and dominant) UML generated models; 4) To interface MDTCAS with EA methodologies like ADM based TDM and TOGAF; and EA modelling languages, like ArchiMate [28]; 5) To offer an Artefact based OPMS; and 6) To interface MDTCAS with decision notation languages like the Decision Making Notation (DMN). The ERC recommends avoiding the very risky conversion of legacy ICS components, directly into EA methodologies' oriented Artefacts, like TOGA and ADM; which was EUBank's case major failure.

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Instead it should have used an IHI MDTCAS and ERC generated Artefacts based OPMSs; which ensure an IHI non-locked-in approach for the ETP. MDTCAS is crucial to transform existing ETP models/diagrams-based components into well-designed/mapped UML/Choreography models, using classes, sequences, communication models, Entity Relationship Diagrams (ERM), and OPMs/BPs and their Models (BPM) diagrams. For the MDTCAS the OOM is the central methodology, which is used to support ERC's generated Artefacts.

3.4 OOM based MDTCAS support for Artefacts

MDTCAS is used to interface standard methodologies and ERC generated Artefacts by using OOM concepts, which mainly are based on OO features, that are inherited from three OOMs, namely Rumbaugh, Booch, and Jacobson methodologies. These methodologies are the fundaments of the most known architecture, modelling/ICS standards, the UML, [26]. The MDTCAS' Implementation is presented in Figure 9. All known methodologies, like the ADM, are developed using an UML profile or metamodel, which makes OOM a generic concept. OOM was influenced by various OO streams like Booch's methodology, which focuses on OO Analysis (OOA) and OO Design (OOD) phases which are used to implement ETP's pools of Artefacts. The ADM based TDM can manage DevOps4ERC's activities. The Use Case (UC) diagram modelling concept, can help the ERC in the analysis and extraction of useful Artefacts. Where a UC diagram can include: OOM diagrams, non-formal source-code, Events flows, and Actors. OOM based MDTCAS and UCs are the basis of the actual EA modelling languages that are used to implement Artefacts, which can be used by the TEOM. Like ArchiMate, which has many artefacts, diagram types, views, and that is why in this article only its UC View (UCV) will be presented, to show how MDTCAS can include common Artefacts, OPMS, and EA/ArchiMate diagrams.

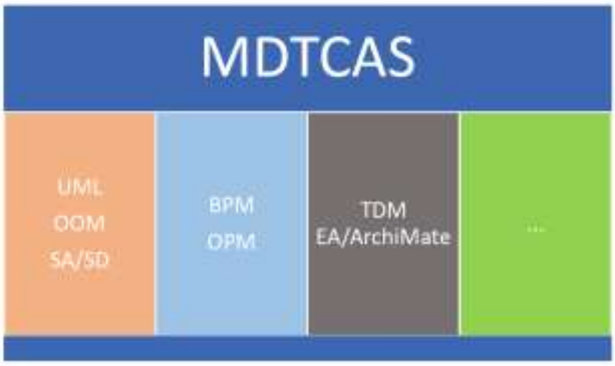


Fig. 9: MDTCAS' Implementation

Combining Artefacts and OPMS with the TDM in complex ETPs, can be supported by the MDTCAS. The ERC and RUPLS use Artefacts to support the OPMS and TEOM, in ETP's *Business Architecture* phase, [27]. ArchiMate's UCV can be incorporated in an Artefact to be used for analyzing APDs' scenarios from the functional perspective [28]. Artefacts can map to *Application Services* or SRVs. Architecture diagrams can be elements of an Artefact, which can represent the behavior of an OPM. The ETP needs a TDM, to implement an OPMS and to provide dynamic business models, EA models, -OPMs have a key role in developing APD competencies, and where *Business Architecture* and ICS architecture are vital. As shown in Figure 10, the key to linking these two EA domains are OPMs which are subsets of an *ENT* process architecture(s). An *ENT* process architecture supports APD's Finance, Human Resource, Supply chain,- can also have interdependencies with other Units and external *ENTs*. Analyzing APDs requirements in a siloed manner can have negative impacts on the ETP and there a need to have a Polymathic-holistic approach in order to capture interdependencies, and for that goal the ERC has to build Artefacts with various elements that influence the OPMS. A Polymathic-holistic overview across all CSAs, helps ETP *Managers* and implementation teams, to predict serious problems, [27]. The OPMS coordinates BPs, OPMs, and BPMs and their incorporation in Artefacts based TEOMs.

3.5 BP, BPM, OPMS based and TEOMs

To align BPs, BPMs, and OPMs (simply *Model*) with TDMs, Artefacts, and Units, there is a need to use ADM based TDM's implementation life-cycles. The ERC generates: 1) Common and generic Artefacts for the MDTCAS; 2) BP Architecture (BPA) usage concepts; 3) EA and *Models'* tools; 4) TDM and DevOps4ERC synchronization; 5) Test scenarios' management; 6) Best practices; 7) Units' control; and 8) An *ENT* Security concept, [29]. For the ERC and hence TEOM, the role of an *ENT* Polymathic security concept is important. Such a security concept uses measurable security and governance security risks CSFs, which are mitigated and tuned, in order to ensure ETP's successful evolution and to block Cyber or classical misdeeds. The actual exponential rise of Cybercrimes has become a major concern for *ENTs*; and that obliges ETPs to integrate Polymathic-holistic security strategies.

3.6 A Holistic Security Strategy

ENT's resilience, control, and security concepts are insufficient and concentrate only on platforms' infrastructural aspects. Global crimes are closely related to global events and phenomenas, like financial greediness, insecurity, conflicts, … The holistic security strategy proposes that the ERC: Interfaces existing security standards, Promotes internal ENT architecture blueprints, Automates business and application's engineering activities, Supports multilevel Artefacts' interoperability, and the optimal usage of ARP/UP operations. Secured ETPs are very complex to finalize, because of various transformation related problems, and they depend on ERC's capacities. The *ENT's* structure depends on secured Artefacts, which are stored in pool(s). Secured composite Artefacts are used to [6], [20]: 1) Reorganize secured Units and takes into account intangible objectives. A security concept avoids locked-in strategies; 2) Use a secured MDTCAS and TDM to integrate standard methodologies, like TOGAF and the Sherwood Applied Business Security Architecture (SABSA), [30]; and 3) To use a secured ICS'.

3.7 Methodologies' CSFs

Based on the AHMM4ERC, LRP4ERC and DMS4ERC, this CSA's CSFs/KPI were weighted and the results are shown in Table 2. This CSA's result of 8.0, which is low, and is mainly due to the fact that MDTCAS' implementation is complex. But that does mean that the MDTCAS is impossible to implement. As this CSA presented negative results, the next CSA to be analyzed is ERC's approach for transformations.

Table 2. CSFs that have the rounded average of 8.0

Critical Success Factors	AHMM4ERC enhances: KPIs	Weightings
CSF_MDTCAS_ERC_DT_Implementation	Complex	From 1 to 10. **08 Selected**
CSF_MDTCAS_DT_Strategy	Complex	From 1 to 10. **08 Selected**
CSF_MDTCAS_Legacy_Units	Complex	From 1 to 10. **08 Selected**
CSF_MDTCAS_Support_Artefacts	Complex	From 1 to 10. **08 Selected**
CSF_MDTCAS_OPMS_TEOM	Complex	From 1 to 10. **08 Selected**
CSF_MDTCAS_Security_Strategy	Complex	From 1 to 10. **08 Selected**

valuation

To organize various types of generated CBBs (and SBBs) there is a need to adopt the ERC and CBB based approach.

4 ERC based Approach

4.1 Artefacts based Vision

The TDM needs a directed vision, on how to integrate generated Artefacts. The ETP and ERC must establish an Artefacts based Architecture Vision (AAV), as shown in Figure 11, in order to support: ERCs, RUPLS, ABBs, and to reuse AAV principles. An adaptive UPL/ICS is based on various ERC generated atomic resources like Artefacts, Services (SRV), Model View Control (MVC) which are managed in various TDM phases to support: 1) Artefacts' integration; 2) To apply AAV patterns; 3) Control and monitoring activities; 4) Interaction of MVCs (Palermo, 2012); 5) Relate AAVs to CSFs, 5) Viewpoints, like: Unit, Process management, Stakeholders reporting, CBBs' usage in TDM models, and ICS' standards application; and 6) DMS4ERC to quantify vision's applicability by using the following CSFs:

- Coalition for the Vision: (CSF_VIS_CSV).
- AAV's Adoption: (CSF_VIS_CVA).
- ERC's Capacities : (CSF_VIS_RPC).
- Time for Execution: (CSF_VIS_T4X).
- Tooling Adoption: (CSF_VIS_TAD).
- CBB's adoption : (CSF_VIS_CBB).
- MVC adoption : (CSF_VIS_MVC).
- Control/Monitoring: (CSF_VIS_PCM).
- Transaction/Capability: (CSF_VIS_TCA).
- Strategy for Resistances: (CSF_VIS_SRE).
- PoC's capabilities : (CSF_VIS_PCC).

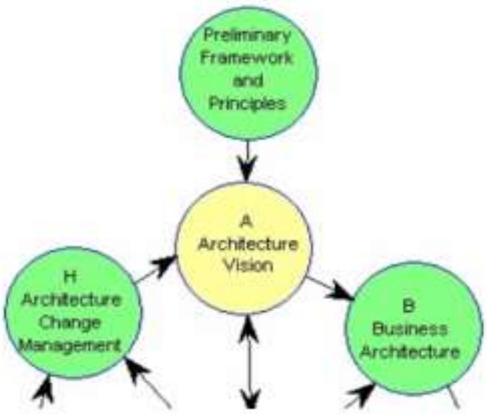


Fig. 11: ADM based TDM's vision phase

The AAV supports the interaction of the ICS, SRVs, AAVs and CBBs; where the TDM manages AAVs and uses the following TDM/ADM's phases: 1) Preliminary, that aligns ETP*'s* vision with AAV; 2) Phase "A", establishes the AAV(s) and relates them to CBBs/OBBs and UPL/ICS; 3) Requirements engineering, ensures that collected requirements are managed accordingly to AAV, where a requirement is linked to an instance of a Artefacts; 4) Phase "B", develops APD Diagrams (DIA) based on Artefacts; 5) Phase "C", develops implementation DIAs based on MVC, and Artefacts; 6) Phase "D", develops technical DIAs based on MVC, and Artefacts; 7) Phase "E" uses the HDT based DMS4ERC to estimate TDM's iteration's GAP value and to offer possible solutions/opportunities; 8) Phase "F", delivers migration plans; 9) Phase "G", analysis ETP's plans and defines governance mechanisms; and 10) Phase "H", manages requested changes. A TDM iteration generates sets of refined Artefacts.

4.2 Refined Artefacts

A CBB is a set of BBs that has a AAV that is based on a mapping-patterns that are managed by the TDM/EA [15]. ETP*s* apply CBBs driven implementation which needs specific implementation skills and a)n Artefact based model-first or a Pseudo-Bottomup-Approach (PBA), where Artefacts are built on IHI modules and resources, in order to support OPMs' integration, modelling strategy, methodology, and productivity environment.

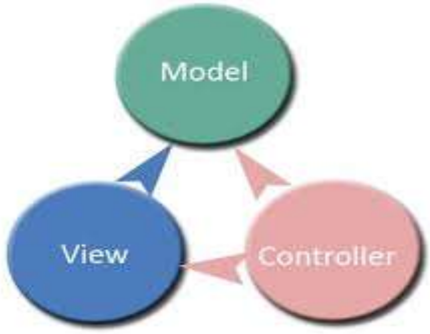


Fig. 12: The Model-View-Control pattern, [31]

RUPLS supports upstreaming of Artefacts that are generated by the ERC and re coordinated by the MVC pattern, as shown in Figure 12.

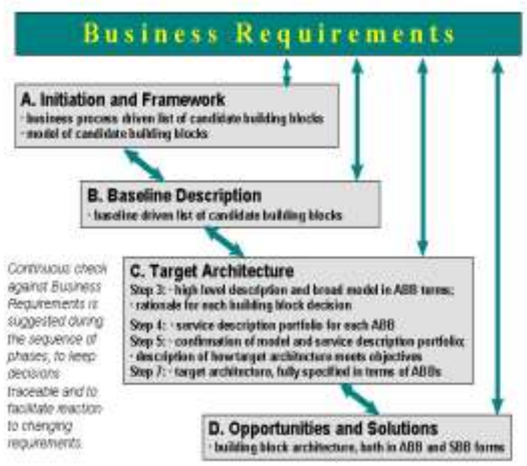


Fig. 13: ADM's phases at which Artefacts are managed, [32]

The TDM manages ERCs, where Artefacts are used as templates for instantiating SBBs. The TDM manages AAVs which provide conceptual and logical views of SRVs across various APDs. The ERC uses generic BBs, and a set of internal BBs to compose new Artefacts, where a BB has the following characteristics, [32]:

- Packages requirements, functionalities, and Artefacts to meet APD's needs.
- Standardizes interfaces to access all its resources and functionalities.
- Interoperable with other Artefacts.
- Defines functionalities that will be implemented and facilitates requirements' capture.
- It is technology aware, standardized and is used as a template to build SBBs.
- Aggregates with other Artefacts.
- Has a GID, respects the "1:1" mapping concept and enables interoperability.

- An Artefact is a set of BBs.

An Artefact corresponds to an APD Transaction (ATR) or a Cybertransaction. The way in which ATR's functionalities and resources are combined into an Artefact vary between APDs. The TDM/ADM manages the implementation CBBs as shown in Figure 13, to serve SBBs, [32]. An SBB has the following characteristics:

- Defines which SRVs and Artefacts will implement APD's functionality.
- Uses implementations of Artefacts.
- Fulfils ATR's or Cybertransaction's requirements.
- Is traceable and interoperable.
- Enables dynamic implementations and supporting Artefacts Reference Models (CRM).

The TDM depends on: Defined requirements, Artefacts, ATRs architecture which supports the related SRVs, interfaces, and standards that satisfy APD needs, [33]. The ERC and RUPL follow technology trends which drive ETP's vision. The ERC tries to reengineer/refine AAVs, to ensure that the ETP succeeds. Because it aligns: Requirements, (re)Structure/governance Units, and UPL/ICS. The ETP uses the ERC for:

- Breaking-down legacy Unit components into a set of classified unique Artefacts based ATRs. An Artefact *is just another business brick in the wall...* Resulting Artefacts are offered as templates to instantiate SBBs.
- To use alignment technics on the base of the "1:1" mapping concept; which needs an IHI format or a standard one, like the eXtensible Markup Language (XML) Interchange (XMI).
- All the mentioned features enable the development of IHI Artefacts.

4.3 IHI Artefacts

The MDTCAS includes common and coherent sets of IHI Artefacts to compose SBBs. The ERC generates feasible Artefacts, which can also emerge from *the best architecture & modeling practices*. ERCs has to apply *architecture & modeling extraction techniques*, which can fail because it causes: 1) Bad design, and is unmaintainable; 2) Lacks evolution and scalability; and to 3) Artefacts are un-usable. ERC generated sets of Artefacts for modeling, designs and implementation activities, and the PoC checks their feasibility. Artefacts instances can be used to create generic types of *Models*. Artefact instances are stored in an SBB, which is suitable for implementing various ETP architectures; and can interface standard methodologies like TOGAF, UML... Artefacts map to different types of ETP constructs, [7], which need the reduction of silos' complexities and the adoption of a PBA. The PBA is based on a "1:1/1:n" mapping concept. The MDTCAS needs Artefacts to interface existing standard OPMS by using, [6], [34]: 1) Quick support by offering sets of Artefacts to be used by the TDM/ADM, Enterprise continuum, CRM, Catalogs, ….; 2) Domain logic patterns; 3) Data-source architectural patterns; 4) Enterprise Service Bus (ESB) patterns; 5) Enterprise Application Integration (EAI) patterns; and others… There are many redundant categories of standard and internal Artefacts, which makes the ERC difficult to implement. That is why the MDTCAS must support a set of transcendent patterns-based Artefacts, like the MVC and intelligent Artefact-based Data BBs (DBB).

4.4 Artefacts and DBBs Interaction

ERCs redesign and restructure a Unit, by extracting various types of complex data structures/patterns to form DBBs, like: 1) Business Data or Interaction Modeling Patterns, that extract business data and offer interaction models, which are indepenednt of databases types. Atomic data services for business activitities, which focuses primarily on the encapsulation of data and offer behavior schemas; whih are the basis of the *Business Knowledge Management Pattern,* [35]; 2) Business Knowledge Management Pattern, includes *Models*, which persist forms of knowledge classes; and 3) A combination of data Artefacts' assembling model.

4.5 Artefacts Assembling Model

Artefacts' assembling model includes: 1) The Requirements Integration Pattern (RIP) that is used by ERCs to extract types of common Artefacts to be used and mapped to the ETP*'s* requirements and the needed Artefacts/SBBs. The extracted Artefacts are orchestrated by the AHMM4ERC's actions that process the refinement processes. ERC actions map requirements to the various Artefacts and *Models*, which are located in a specialized repository, [7]; 2) The Code Blocks Integration Pattern (CBIP) is complex pattern and the CBIP based ERC, uses the MDTCAS, which minimizes Artefacts' overhead. The CBIP based ERC determines critical process/resources regions, and then applies refinement processes, [36]; 3) Supports TEOMs' implementation; and 4) The ERC and RUPLS support IHI predefined ERC models. ARP/UPs generate basic BBs and ERCs extract standard/common Artefacts (and *Models*) to be included in the MDTCAS. As there are many standards and types of artefacts, the Object Management Group's (OMG) DMN will be presented; and it is used for modeling operational decisions. DMN's decision models are shared between different systems and the MDTCAS interfaces DMN's implementation environments to: 1) Refine and map DMN patterns which are similar to *Models*, [37]; 2) Use diagrams and elements like the: Decision Requirement Diagrams, Artefacts, *Models*, Business Knowledge Model, and Decision Tables, similar to *TRADf's* Tables that are used in this RDP4ERC; 3) ERCs processing results in a set of MDTCAS elements and *Models*; 4) ERC models' building include the following steps: Defining MDTCAS main artefacts and basic *Models*, Transforming. legacy-code-base to deliver Artefacts by using BPM, UML, TDM/TOGAF/ADM, and to integrate DMN; and 5) ERC and RUPLS have to avoid that the ERC delivers Artefacts' hairball, and it has to use the PBA to offer a set of Artefacts based choreographies to be included in MDTCAS, [34].

4.6 Artefact-based Approach CSFs

Table 3. CSA's average is 8.40.

Critical Success Factors	AHMM4ERC: KPIs	Weightings
CSF_Artefacts_Vision	Feasible	From 1 to 10. 09 Selected
CSF_Artefacts_Refinement_Extraction	Complex	From 1 to 10. 08 Selected
CSF_Artefacts_DBBS_Generation	Complex	From 1 to 10. 08 Selected
CSF_Artefacts_Assembling	Complex	From 1 to 10. 08 Selected
CSF_Artefacts_Persistence	Feasible	From 1 to 10. 09 Selected

valuation

Based on the AHMM4ERC, LRP4ERC and DMS4ERC, for this CSA's CSFs/KPI were weighted and the results are shown in Table 3. This CSA's result of 8.40, which is just a limit value, and that is due to the fact that the Artefacts-based SBBs concept is difficult to integrate. And that does mean that an Artefacts based concept is impossible to implement. To improve this fact the author will propose a Polymathic ERC approach.

5 A Polymathic ERC Approach

5.1 Evolution and Risk for ETPs

Fig. 14: Quadrant for ETP risk management, [38]

The refinement and evolution of ERC generated Artefacts, which are used to build components, take a very long time. On the other hand, UPL's and ICS evolutions are extremely fast, therefore there is a need to find a Polymathic methodology that respects the median to coordinate these two evolutions. The AHMM4ERC based ETP uses various mathematical domains to deliver a unique mathematical pattern, [1]. As shown in Figure 14, the ETP must select an optimal ETP's risk mitigation concept, which is based on the following types of risks: 1) Risk avoidance and prediction; 2) Risk reduction; 3) Offers AHMM4ERC actions to reduce risks; 4) Actions to transfer risks to third parties; and 5) Risk acceptance, like in the case of R2T. ETP and ERC risks' estimations include, [38]: AHMM based analysis, Remediation, Compliance, Coherent/Synchronization, User experiences, Reporting, Basic-advanced integration, Digital asset discovery, and Real-time control based assessments. Risk mitigation artefacts are linked to the Polymathic AHMM4ERC basic elements. AHMM4ERC's nomenclature is presented in a basic form to be understandable by the readers. The AHMM4ERC based ETP and its main artefacts and characteristics are:

- ERC actions = supports ARP/UP operations, DevOps4ERC activities, for finalizing the ERC.
- ETP parts = ∑ ERC(S) (for the UPL, ICS, Artefacts, and its infrastructure/networks).

- ERC = transformation of ETP*'s* parts + the defined goals of ETP operations.
- ERC = includes ETP's parts + ∑ ERC.
- APD's (AHMM) = ∑ ERC.

5.2 ENT's ERC based Model

As shown in Figure 14, the symbol ∑ indicates summation of all the relevant ERC elements, while the indices and the set cardinality have been omitted.

The Generic AHMM's Formulation

TDM	is a ***Transformation Development Method***, which can be ADM based...	
AHMM	= ⊔ TDMs + ⊔ DMMs	(G1)

AHMM's Application and Instantiation for a Domain

Domain	= ⊔ APD	(G2)
AHMM4(*Domain*)	= ⊔ TDMs + DMMs(*Domain*)	(G3)

Fig. 15: The AHMM4ERC main formulas

The summation should be understood in a generic sense, more like a set. The AHMM4ERC uses services model to support the ERC and is represented in a simplified form. The ERC interfaces are based on the TDM and uses services to enable the Polymathic transformation model. The AHMM4ERC based TDM is the combination of TDM and AHMM4ERC as shown in Figure 15.

5.3 The Polymathic Transformation Model

The AHMM4ERC based TDM model:
AHMM4ERCbTDM = AHMM4ERC(TDM) (G4).
The ERC transformation model is the combination of an AHMM4ERCbTDM and *IterationGap* that can be modelled using the following formula:
ETP = AHMM4ERCbTDM(*IterationGap*) (G5).
The ETP*'s* model is based on the extraction of choreographies or *Models*.

5.4 Extraction of Artefacts based Models

The ERC depends on the results of ARP/UPs' operations, which extract *Models* (or BPM/choreography). The extracted *Models* are based on the HDT that uses Artefacts to support TEOMs. The AHMM4ERC is composed of large number of interconnected nodes, to solve ERC types of problems. ERC generated Artefacts are connected to each other, like nodes of the HDT and there is a WGT (a real number) and CSFs.

5.5 The Model's CSFs

Based on the AHMM4ERC, LRP4ERC and DMS4ERC, for this CSA's CSFs/KPI were weight and the results are shown in Table 4. This CSA's result of 9.60, which is high, and that is due to the fact that the Polymathic ERC approach is based on the AHMM which is a mature model; and that it can be used.

Table 5. CSA's average is 9.60

Critical Success Factors	AHMM enhances: KPIs	Weightings
CSF_AHMM4ERC_Elements	Proven	From 1 to 10. **10 Selected**
CSF_AHMM4ERC_Risks	Possible	From 1 to 10. **09 Selected**
CSF_AHMM4ERC_ARP/UP	Proven	From 1 to 10. **10 Selected**
CSF_AHMM4ERC_TDM	Possible	From 1 to 10. **09 Selected**
CSF_AHMM4ERC_Choreography_Models	Proven	From 1 to 10. **10 Selected**

valuation

The AHMM4ERC and MDTCAS' artefacts are used to support the ERC and RUPLS based ETPs.

6 ERC and RUPLS based Projects

6.1 The Strategy and the Decision Model

The ERC and RUPLS are supported by a predictive the KMS4ERC based DMS4ERC, which depends on the selected CSFs, like the types of ERCs activities, types of ETP risks, R2T, financial situation, types of BPMs, skills, … A ETP should be adapted to a ERC and RUPLS that can offer complex designs and eventual problems, which can be the source of risks and failures... ERC problems can be measured and weighted, where the ETP*'s* risks are not easy to measure. This explains the difficulty of estimating ETP*'s* risks related to consequential sets of ERCs operations. The DMS4ERC and selected weightings are used to deliver a set of possible RUPLS actions. Weightings' DMS4ERC concept supports the ERC and RUPLS to deliver solutions in the form of recommendations. The DMS4ERC used the HDT to solve ETP and ERC types of problem(s). The ERC adopts a holistic-systemic approach, which makes the ETP robust and the Artefacts management subsystem the basis of a successful ETP. Artefacts are managed .by the MDTCAS based TDM, which provides support for refined components and the ERC synchronizes ETP's plans. The TDM supports interactions between strategies, global processes, services, and ICS' platform. The DMS4ERC controls ERC and RUPLS risks to implement Artefacts pools to support the implementation of TEOMs. The ERC and RUPLS contains the following concepts: 1) Agile DevOps4ERC for ERC, to managed Artefacts; 2) MDTCAS structures sets of artefacts; 3) TDM's interfacing capabilities;

4) Mapping MDTCAS elements; 5) Artefacts' granularity; and 6) Requirements mapping to Artefacts. ERC and RUPLS' capabilities to integrate emerging avant-garde domains, like *Models*, AI, EA, Refine techniques, and scalable UPLs/ICS platforms, [39].

6.2 The MDTCAS and Avant-garde Domains

MDTCAS supports the ERC and its capacity to refine legacy *Models*. Refined Artefacts can be used with existing standards by implementing the MDTCAS and its TDM. The ERC uses Artefacts-based Models to deliver ABBs that instantiate Unit parts. ERC is able to reuse refined Artefacts and existing ERC initiatives have the tendency to *reinvent the wheel* when creating Artefacts. The ERC delivers refined Artefacts for architecture/modeling, designs, and implementation constructs for the reengineering of TEOMs. Mixing Artefacts that can be mapped by the TDM and the ETP, must implement generic Artefacts, [7]. Using MDTCAS enables the reduction of complexities and the adaption of a PBA cycle based on a "1:1" mapping approach. The ERC applies standardized: 1) Methodologies; 2) Business or APD architecture; 3) *Models*' choreography; and 5) Mapping *Models*. Applying the mentioned standards and the classification of behavior and interoperation of Artefacts, has positive impacts on ETPs. The ERC relies on the mentioned standards to deliver an adequate MDTCAS which is based on: 1) The evolution and stability of *Models* and enables TDM based agile management activities; 2) BP Integration (BPI) enables the integration of refined *Models* by the use of EAI's infrastructure; 3) APD's documents standards, like XML; 4) Governance standards are important for control operations; 4) Avant-garde methodologies, applications and technology standards: 5) ERC's stack standard that includes various levels of APD and ICS resources and Artefacts; and 6) The IHI TDM supports the ERC to implement TEOMs. Technology evolves faster than ETP's evolution, and it is difficult to finalize the ETP with its initial goals and existing defined UPL/ICS structure. That is why it is important to define MDTCAS elements that are transcendent to time and to all ETP*'s* iterations. As already mentioned, the MDTCAS for avant-garde domains includes: 1) *Models,* UML/OOM basics and other; 2) DIAs, like OPM/collaboration, UC or DMN diagrams; 3) Delimiters, actors and interfaces; 5) Circular implementation methods, like DevOps4ERC or TDM; and 6) SRVs' technologies, abstracted by Artefacts. TDM's integration with the ERC, which enables the automation and auto-generation of MDTCAS' Artefacts. These Artefacts go-through TDM's phases which uses cyclic iterations. The ERC is generic and its interface with the TDM supports legacy-components refinement, mapping, and integration. That all enables APD's integration and inter-operability.

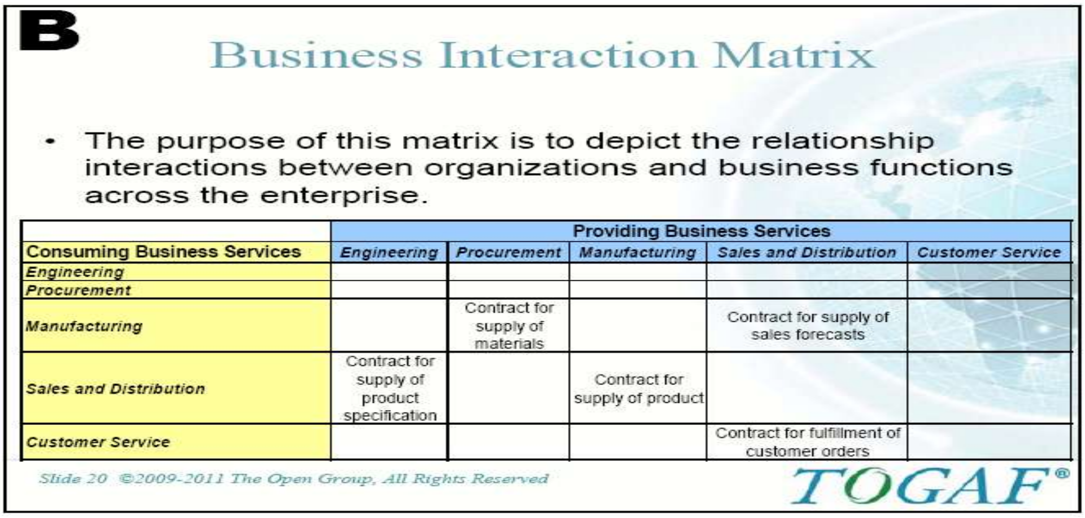


Fig. 15: The Business Interaction Matrix, [40]

6.3 APD's Integration and Inter-operability

Artefacts' integration and inter-operability capacities have the following characteristics: 1) Supports the integration of refined Artefacts and installs long-term compatibility, by using the following elements: *Models'* inter-operability, TDM's interfacing, An anti-locked-in strategy, MDTCAS' artefacts exchange, A generic inter-operable APD communication layer; 2) APD's inter-resources operability that is supported by the XML based on XMI or any *Model* format which can be IHI; 3) ETP management and *Models* serialization in standardized or IHI format files, like the *business interaction matrix* shown in Figure 18, which shows the mapping between APD's services and functional domains. APD's integration/inter-operability depends on CSFs, like APD's UPLs. Managing UPLs by the ETP team, implies that they transform it into an agile cloud platform. The ERC and RUPLS manages Artefacts to create *Models* which are deployed on UPLs. This is needed for the management of Artefacts repository that are to be used by the ETP to use OPMS/TEOMs for Unit's reorganization.

6.4 Models based Unit Reorganization

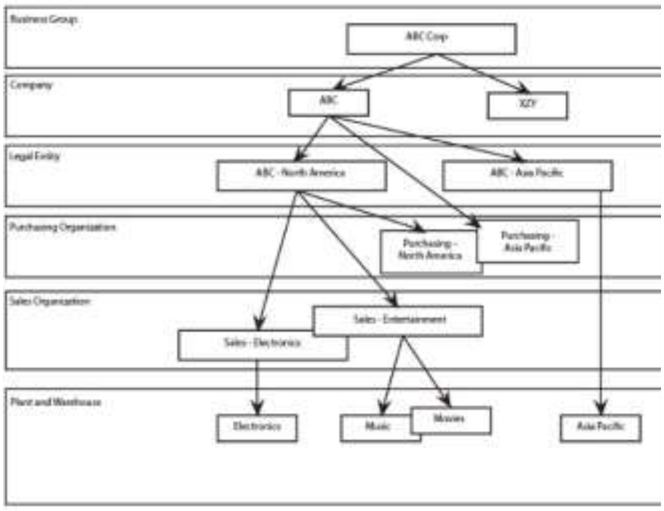


Fig. 16: Typical organization model, [42]

The OPMS explains various types of inconsistencies and uses the AHMM4ERC based DMS4ERC to take the decisions that contain the optimal set of actions to be used in order to reorganize Units. Using the right sequence of ERC and RUPLS actions, can determine ETP's success. Such actions are based on *organizational routines* or *known actions*, knowing that there are various types of reorganizational *Models,* [41]: 1) The Rational Actor *Model* (RAM), in which decisions (or sets of actions) of a large *ENT,* are under central control; the RAM can be an OPM actor; 2) The OPM, examines *ENT's* actions of an *ENT* as a whole and these actions are considered as an output of a subsystem that is based on organizational routines. The OPM depends on the critical Management's Political *Model* (MPM); and 3) The MPM focuses on the group of important decision makers and it considers actions as bargaining activities, in order to take policy decisions. The MPM decisions are a result of negotiating among stakeholders. The ARM, OPM, and MPM support organizational modelling (org TEOM) of an *ENT*. *ENT's* (re)organization represents an enterprise, department, cost-center, division, sales-unit or any other Unit. As shown in Figure 16, typical *ENTs* are as follows: Business Group, Company, Legal *ENT*, Sales Organization, Purchasing Organization, Plant and Warehouse, [42]. Artefacts and Models support TEOMs' building or (re)assembling.

6.5 TEOM's Building or (Re)Assembling

The ERC support *ENTs* to work efficiently and there are various manners to implement TEOMs, and they depend on the ETP*'s* goals. A TEOM has the following characteristics, [43]:

- It visualizes an *ENT* and distinguishing between its *operating* and *support* activities; it also clarifies relationships between Units' *support* functions and implemented TEOMs.
- It shows how employees report to their management and helps depict how TEOM based Units are structured.
- *ENT's* goal is to bring together employees with a common objective and TEOM can help it with defining: 1) The scope of the group of employees and predict R2T; 2) The formal relationships between employees and reporting lines; 3) The functional role for each employee; and 4) The interfaces between Units' functions.
- Has the following TEOM elements: 1) Types like value chain, units, matrix, functionally-oriented objects, market-oriented objects; 2) Roles which define skills and responsibilities; 3) Interfaces (interactions) between Units; 4) Organizational or TEOM charts; and 5) Influencers are employees who manage information, direct, and generating advice/recommendations.
- Support work includes: 1) Policy that has sets rules and governs Units; 2) Champion that proposes work TEOM actions' optimizations; 3) Shared TEOM services support customer/supplier relationships; and 4) Core-resources provide support for Units.

- There are different ways to structure the Unit's operating work that include the following TEOM types: 1) Value chain; 2) Matrix; 3) Functionally-oriented; and 4) Market-oriented.
- TEOM based Units are a form of *ENT's* robotization which may provoke R2T.

6.6 R4C and Related Topics

ETPs in general and ERC specially can face ETPR and/or R2T, that is why the *Manager* must implement a R4C in the ETP*'s* vision. R4C can be evaluated in all TDM's phases.

Fig. 17: Integration of SABSA with TOGAF, [44]

R4C must be integrated in a Secured EA (SEA). The TDM needs the AAV, to support: SEA, ERC, and Artefacts reusability principles. An adaptive ERC is based on various secured ARP/UPs which are coordinated by the secured ADM based TDM phases as shown in Figure 17. The ERC also generated applications' cartography.

6.7 ERC and RUPLS CSFs

Based on the AHMM4ERC, LRP4ERC and DMS4ERC, for this CSA's CSFs/KPI were weight and the results are shown in Table 5. This CSA's result of 7.20, which is very low, and that is due to the fact that the ERC is very complex to implement and would probably fail.

Table 5. CSA's average is 7.20

Critical Success Factors	KPIs	Weightings
CSF_ERC_Project_Strategy	Complex	From 1 to 10. 08 Selected
CSF_ERC_Project_MDTCAS_Avant_Domains	VeryComplex	From 1 to 10. 07 Selected
CSF_ERC_Project_APD_Inter-Operability	Complex	From 1 to 10. 08 Selected
CSF_ERC_Project_Units_Reorganization	VeryComplex	From 1 to 10. 07 Selected
CSF_ERC_Project_TEOM_Assembling	Complex	From 1 to 10. 08 Selected
CSF_ERC_Project_RelatedTopics	VeryComplex	From 1 to 10. 07 Selected
CSF_ERC_Project_cross-ENTs_Models	VeryComplex	From 1 to 10. 07 Selected

valuation

All the presented CSAs can be verified in the PoC's implementation.

7 The PoC's Implementation

7.1 ERC's Basic Preparations

The first step PoC's step is to prepare environment by setting-up the AAV, MDTCAS/TDM, and the ERC extracted Artefacts, as shown in Figure 18 [6].

Fig. 18: PoC's preparations

This PoC uses various author's previous works and PoCs that are related to the ARP/UP and ERC, which focus on the extraction of Artefacts, [6].

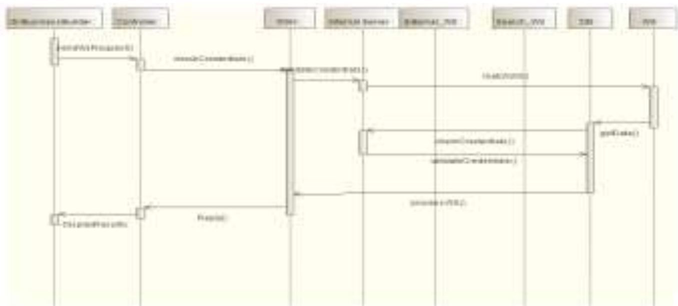


Fig. 19: The ATR's activity diagram

BBs are assembled to build Artefacts. And another PoC's part was used from a previous PoC, in which a BB and Artefacts based Transaction was experimented, it also proved that the granularity level/approach can be used to refine the "1:1" mapping, [45]. A logical view of a series of Artefacts based ATRs is presented in Figure 19, and their consumption of SRVs, in the form of an activity diagram in which all the events are exchanged between various nodes, require encryption which is defined in the TDM. The ATR uses a set of BBs which are assembled in an Artefact as presented in Figure 20. The ADM based TDM phases B and D, implement the needed ATRs.

UPL-APD Environment	Provide APD Artefacts
Controller	Passes a SRV request
Find Artefacts/SRVs	Execute
Data Source	Return information

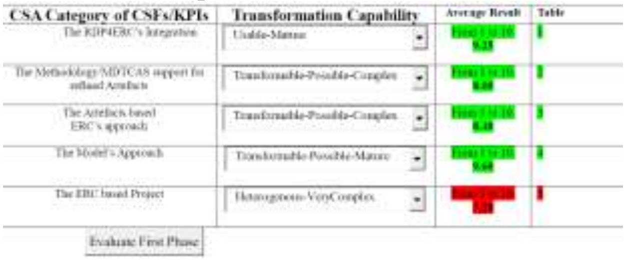
Fig. 20: ATR's elements

7.2 ERC's Design and Implementation

PoC's essential constraint is to use existing standards in a reduced form, what corresponds to MDTCAS' main objective. In this case the MDTCAS transcendent Artefacts, and diagrams are used. These standards include Artefacts to be used to integrate Models and TEOMs in the existing Units.

7.3 PoC's Phase 1

Table 6. PoC's phase 1 outcome is (rounded) 8.50.



CSA Category of CSFs/KPIs	Transformation Capability	Average Result	Table
The RDP4ERC's Integration	Usable-Mature	[illegible]	1
The Methodology/MDTCAS support for refined Artefacts	Transformable-Possible-Complex	[illegible]	2
The Artefacts based ERC's approach	Transformable-Possible-Complex	[illegible]	3
The Model's Approach	Transformable-Possible-Mature	[illegible]	4
The ERC based Project	Heterogeneous-VeryComplex	[illegible]	5

Evaluate First Phase

To identify the initial sets of CSAs' CSFs and test whether the RQ's of CSFs affect ERC' or RUPLS' integration. The PoC uses the HDT based mixed qualitative and quantitative method. The CSF's analytical process is illustrated in Figure 21. The PoC in the beginning uses Phase 1 that is mainly based on the HDT tables, which use WGTs. Phase 1 is used to weight the relative importance of CSAs and CSFs for the usage of ERC or RUPLS and that is done using a decision-tables, [46]. LRP4ERC's outcome proves the existence of a major knowledge gap and it's (or Phase 1's) outcome supports the RQ's credibility, by the use of the LRP4ERC and *TRADf*'s archive or knowledge-base, of an important set of references, previous author's works, documents, and links. After selecting the ERC's Factors, they are linked to various HDT scenarios. The PoC is based on the CSFs' binding to specific RDP4ERC resources, where the ERC and RUPLS were prototyped using *TRADf*. The HDT represents the relationships between this RDP4ERC's RQ/requirements, Artefacts, and selected Factors. PoC's interfaces were achieved using Microsoft Visual Studio .NET environment and *TRADf*. The ERC uses calls to resulting Artefacts, to execute HDT actions related to ERC requests. CSFs were selected and evaluated (using WGTs, HDT, and DMS4ERC) and the results are illustrated in Table 6, which shows that the ERC is a central phase and not an independent one. In fact, it is essential for the ETP*'s* risk concept. HDT's main constraint is that CSAs having an average result below 7.5, will be ignored. This fact, leaves the ERC's CSAs (marked in green) effective for RDP4ERC's conclusion(s); and drops the CSAs marked in red. Phase 1, shows that the ERC part of the ETP will probably fail and is a very complex one because of the ERC's and RUPLS' complex refinement operations. The PoC can proceed to Phase 2.

7.4 PoC's Phase 2

Starts with MDTCAS/TDM's setup and Factors selection. Phase's 2 setup includes: 1) Sub-phase A or the AAV and Architecture Vision phase's goals, establishes a ERC approach and goals; 2) Sub-phase B or the Business Architecture phase establishes RUPLS' target TDM/EA and related ERCs' activities; 3) Sub-phase C shows and uses the Application Communication Diagram to describe ERCs activities; 4) Sub-phase D or the Target Technology Architecture shows the needed ERC and RUPLS' optimal infrastructure landscape; and 5) Sub-phases E and F, or the Implementation and Migration Planning, presents the transition AAV based architecture, which proposes intermediate situation(s) and evaluates ERC's and RUPLS' statuses. Artefacts and HDT based DMS4ERC has mappings to *ENT's* resources and the ERC defines relationships between Artefacts, MDTCAS' artefacts, and Requirements/PRBs.

7.5 PRBs Processing in a Concrete HDT Node

The DMS4ERC solves ERC and RUPLS' PRBs, where Factors link to specific ERC PRB type and has a set of actions that are processed in a concrete HDT node. For this goal, the action *CSF_ERC_or_RUPLS_Extraction_Procedure* was called and delivered SOL(s). Solving PRBs involves the selection of actions and possible SOLs for multiple ETP activities. The HDT is on mixed quantitative/qualitative and has a dual-objective that uses the following steps:

- In Phase 1, *TRADf's* interface implements HDT scripts to process the selected CSAs. And then relates PoC's resources to *CSF_ERC_or_RUPLS_Extraction_Procedure*.
- The DMS4ERC is configured to weight and tuned to support the HDT.
- Link the selected node to HDT to deliver the root node.
- The HDT starts with the *CSF_ERC_or_RUPLS_Extraction_Procedure* and proposes SOL(s) in the form of ERC actions/improvements.

HDT scripts support AHMM4ERC's instance that are processed in the background to deliver ERC or RUPLS risk value(s). The AHMM4ERC based DMS4ERC uses Artefacts to deliver recommendations; which are a set of ERCs actions.

8 Conclusion and Recommendations

Legacy systems' unbundling is the major cause of ETPs' failures and their success rates can be improved by using Artefacts and AAVs based strategies. AAVs uses an optimal approach and the PoC proved its application's complexities, [15]. The ERC and RUPLS support Artefacts and *Models* based AAVs concept, to facilitate Units and UPLs' reorganizations. The proposed PBA is an optimal approach for the ERC and RUPLS, which supports ETP's well-architectured unbundling activities; and the LRP4ERC presented a knowledge gap, that is mainly due to the fact that are no similar research approaches and that there is a lack of a Polymathic-holistic approach. There are limited-manual refinement technics for legacy ICSs and OPMSs, but the ERC presents the possibility to implement an IHI concept, [8].

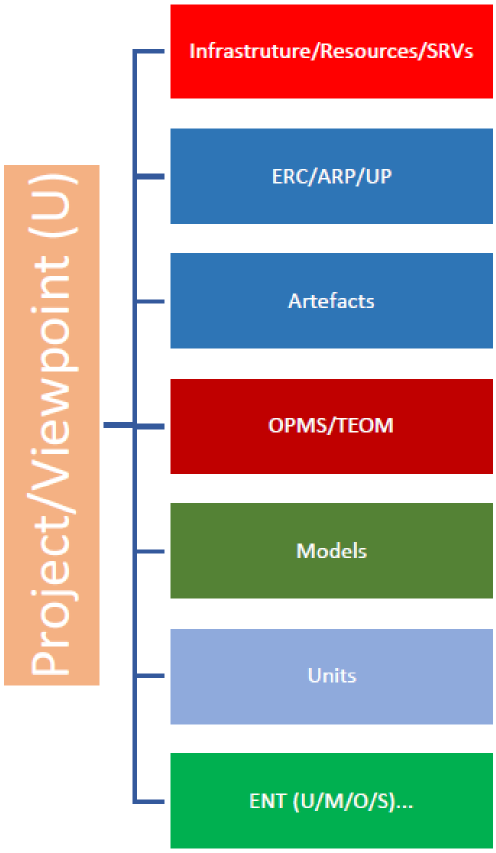


Fig. 21: Viewpoint's "U" evolution roadmap

The RDP4ERC is a part of a series of publications on ETPs, ERC, TDM/EA, Polymathic models… The ERC uses the HDT and CSFs/CSAs to support RUPLS activities. The ERC focuses on evaluating the complex ARP/UPs and synchronizes a structured relationship between: refinement, risks, TDM/EA, constraints, and HDT based SOLs. ERC's most important recommendation, is that the *Manager* must be skilled to manage ERC activities. The PoC's Table 6 result of (rounded) 8.50 that used CSFs' binding to a RDP4ERC resources, the DMS4ERC/KMS4ERC, RQ, and Artefacts, shows that the ERC is very complex due to the risky ARP/UP operations. The ERC should be an IHI process, methodology and framework. In this article, the author proposes the following set of facts and managerial recommendations:

- This article proved the possibility to implement an IHI ERC which tries to avoid locked-in strategies and ensures success.
- The MDTCAS based ERC fits with the TDM.
- TDM's integration in the ERC enables the automation of all its activities.
- ERC constraints are controlled and monitored by the UPL and ICS.

- *ENTs'* sustainability is orthogonal to its ERC capacities.
- To avoid any form of locked-in scenario the *ENT* must build its own ERC and RUPLS.
- The ETP can face ETPR or R4C, which should be predicted by using the R2T.
- APDs high demand for ETPs' and the hyper evolution of technologies, create fatal problems because of the differences in their evolution's rate.
- All author's works are based on *TRADf*, AHMM, TDM, and RDP; which are today mature and can be applied in various APDs.
- ERC like the ARP/UP, is a ETP*'s* critical phase.
- A ETP must build a holistic TDM and MDTCAS to support the ERCs activities.
- The ERC unbundles the legacy-OPMs to support Units, UPLs, which can face problems in the alignment of various refined Artefacts.
- Each *ENT* constructs its own IHI ERC and RUPLS.
- The ERC replaces legacy environments using conversion concepts in order to ensure ETP*'s* success.
- RUPLS interface *ENT's* TDM and delivers the pool of Artefacts based DIAs.
- The ADM based TDM, manages design, ERC, DevOps4ERC, and governance activities.
- TDM's and DevOps4ERC' integration with the ERC and RUPLS, enables the automation of all ETP*'s* ERC activities.
- *ENT's* Artefacts stability and coherence are crucial for its evolution.
- Artefacts can be (re)used in an IHI Models; where a Unit is a set of TEOMs and different Units can share Models, and hence TEOMs.
- Artefacts are used in OPMs based TEOM.
- Unit's transformation needs an IHI Methodology, Domain, and MDTCAS that manages Artefacts.
- To avoid consulting firms and to build internal ERC mechanisms.
- ERC and RUPLS are very complex and will very probably face failure.
- Each *ENT(S)* constructs its own IHI security strategy.
- The ERC unbundles legacy system and modules to support Artefacts, Models and TEOMs, which form new Units; and this an *ENT(U).*
- Viewpoint's "U" presents a structured evolution's roadmap for Units, as shown in Figure 21.

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