A Relational DataBase based Enterprise Transformation Projects

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Abstract: - Enterprise Transformation Projects (ETP) are important for ensuring long-term business sustainability and operational excellence, but these projects are complex to finalize and have a high failure rate. Transformation complexities are related to various concurrent factors like the use of sets of uncoherent commercial tools/products, simplistic gap estimations, status evaluations, needed cross-functional skills, and many others. Therefore, there is a need to implement an In-House Implemented (IHI) methodology and framework to support ETPs. But such IHI solutions take a long time to be implemented and to be tested; and this article tries to propose a realistic solution that is based on DataBase (DB) or more precisely Relational DBs (RDB). RDB-based IHI solutions and concepts can be gradually built on the usage of internal information systems without the need for continuous colossal investments in external products. The proposed RBD concept tries to show it can support an ETP because the RDB is a component that is used in all ETP operations and subsystems. RDBs contain all the needed information, structures, integrity check mechanisms, and applied mathematical constructs. The proposed RDB-based ETP (RDBbETP) concept adopts a Polymathic-holistic approach, which used iterative change and implementation phases. The RDBbETP uses the author's Applied Holistic Mathematical Model (AHMM) to interface and manage the RDB (AHMM4RDB).

Keywords: - RDB, ETP, Integrity Checks, Refinement, Enterprise Architecture, Development and Operations, Decision-Making Systems, and Knowledge Management Systems

I. INTRODUCTION

The enterprise's (simply the *Entity*) transformation and Refinement Processes (RP) are used to migrate to a fully integrated and automated RDBbETP. An RP is a sequence (or sets) of integrity checking, extraction, and conversion operations that are done on various parts of the traditional or existing Information and Communication System (ICS). An *Entity* is a set of organizational Units (simply the *Unit*), where each *Unit* has one or more *Unit* Platform(s) (UnP). An RP on the *Unit's* level refines and transforms this structure and its UnP(s); and the AHMM4RDB checks each iteration's integrity, by using classical existing RDB mechanisms, [2]. An RDBbETP can be applied to any APplication Domain (APD), *Units*, and all its functions. *Entity's* functions are RPed into Building Blocks (BB) which can be reused to (re)engineer the ICS, *Units*, and *UnPs*. *Units* are then (re)assembled and checked by the AHMM4RDB, to deliver a transformed *Entity*. As already mentioned, ETPs are complex and they depend on RP's successful terminations, [1]. To optimally use RPs on the existing ICSs, *Units*, and *UnPs*, there is a need to establish an IHI Methodology, Domain, and Technology Common Artefacts Standard (MDTCAS) that in turn uses an RDB to map to any existing ICS component, methodology or resource. The IHI MDTCAS interfaces and manages RP's basic elements, which are: BBs, Composite BBs (CBB), Organizational BBs (OBB), and Micro-Artifacts (MA). The RDB is used to map the AHMM4RDB an ICS' various parts and components like: 1) Networks and nodes; 2) Various types DBs and data sources; 3) Applications, software components, and libraries; 3) Methodologies, like the: Unified Modelling Language (UML), Archimate language, Object Oriented Methodology (OOM), and other; 4) Interfaces, Gateways, Application Programming Interfaces (API), and other; 5) Processes, Scenarios, Transactions, and other; 6) Security, Governance, Audit, and other; 7) Actors, delimiters, or other; 8) Decision-Making System (DMS), Knowledge Management System (KMS), or other; 9) Control, Monitoring, Tracing, or other; 10) Applications and data services; and any other ICS' part. BBs, CBBs, OBBs, and MAs (simply the *Artefact*) can be (re)used in standardized, external, or IHI *Unit's* Process/collaboration Models (UPM). As shown in Fig. 1, ETP's success depends on *Entity's* structure, which is in general siloed and that makes them complex to be finalized, because of many reasons, and they mainly depend on RPs' feasibility and the usage of ETP's Viewpoints. The ETP has various types of Viewpoints, like: "O" for organizational, "S" for Security, "F" for

Financial, "I" for Integrity checking… The RDBbETP is mainly an integrity-checking transformation project, which adopts primarily Viewpoint "I"; and "O" as the second objective.

Figure 1. RDBbETP's phases

To prove this Research and Development Project's (RDP) and RDBbETP's feasibility, the author uses the RDP for ETP (RDP4ETP) and his Proof of Concept (PoC).

II. THE RDP4ETP

A. A Polymathic Model

Figure 2. The Polymathic RPD4ETP

The RDBbETP proactively localizes and mitigates strategic, operational, and critical risks to guarantee its operations' coherency, by using the AHMM4RDB. For each ETP requirement (and/or problem type), the author's AHMM4RDB-based DMS sets up and tunes the first phase's sets of Critical Success Factors (CSF), Critical Success Areas (CSA), and related Key Performance Indicators (KPI) (simply *Factors*), to be applied by its internal Heuristics Decision Tree (HDT). The Polymathic RDP4ETP maps the selected *Factors* to requirements and the RP-generated sets of *Artefacts*. All RDP4ETP are shown in Fig. 2, where the transformation of such components is in the form of *Artefacts* to support the ETP. And in this article, the emphasis is on Viewpoint "I". The first RDP4ETP's actions were to hammer the Research Question (RQ) and to process an in-depth Literature Review Process (LRP) for the RDBbETP (LRP4ETP).

B. The RQ and LTR4ETP

This article's or RDP4ETP's RQ is: "Can the RDBbETP support complex *Entity's* transformation projects and can it deliver global integrity checking mechanisms?"; and an auxiliary RQ is: "How can it also support the synchronization of various domains which use ICS and RDBs?". Knowing that the RDP4ETP uses Enterprise Architecture (EA), RDB-related concepts, AHMM4RDB, Transformation Research Architecture Development framework (*TRADf'*), and DMS. The RDB4ETP uses an adapted EA, which is the Transformation applies Development Method (TDM). LRP4ETP's analysis showed that are no similar approaches that use: IHI Framework (like *TRADf'*), RP generated *Artefacts*, AHMM4RDB, Polymathic RDP4ETP,... And there is a small number of relevant scholarly resources that are related only to basic RDB integrity checking and the implementation of EAs. Therefore, the RDBbETP-related works, are pioneering, and innovative and cover an important RDBbETP gap. ETP-related gaps and high failure rates were confirmed by the LRP4ETP, [3]. Today is a lack of a Polymathic-holistic approach to RDBbETPs and to integrity-checking operations which can be done to some ICS parts. The LRP4ETP uses the following resources: 1) Academic works, Software PoCs, Articles, and resources related to RDBs, RP, ICS reengineering, and ETPs; 2) Previous author's RDP/LRP works, PoCs, and *TRADf'*; 3) ETP's feasibility and risks mitigations; 4) The setting and tuning of default sets of CSAs/CSFs; and 5) RDP4ETP's use of the Empirical Engineering Research Model (EERM). The RDP4ETP proved the existence of an immense gap and the necessity to deliver RDBbETP solutions and recommendations. The gap is due to that there is nothing similar to the proposed approach; but there are some basic approaches that concern exclusively RDBs.

C. The EERM and RDP4ETP Phases

RDP4ETPS' phases are: 1) Phase 1 (includes decision tables' evaluations), forms the empirical part of the RDP4ETP; which evaluates this article's CSAs, which are: a) The RDP4ETP, which is evaluated and presented in Table I; b) The RDB4ETP's initial setup, which is synthesized in Table II; c) The ERDB's integration, which is synthesized in Table III; d) ERDB's specific solutions, which is synthesized in Table IV; and f) RDP4ETP's global outcome, which is synthesized in Table V. *TRADf'* supports RDBbETP's successful integration and to offer a list of (managerial, EA/AI, and technical) recommendations and solutions, and an adapted strategy; and 2) Phase 2, solves a concrete RDB4ETP problem instance, by the use of the of *TRADf'* and HDT. RDP4ETP's usage of EERM, is optimal and *TRADf'* applies a multi-level mixed-research by applying the HDT; which is very different from conventional research models, and it includes, [4], [5]: 1) Heuristics and rules-based learning processes; 2) Quantitative analysis; 3) Qualitative analysis research concepts capable of supporting empirical approaches like mixed methods research concepts; and 4) An HDT based

Learning Process, which was mainly inspired by Action Research (AR) learning processes.

D. The AHMM4RDB

AHMM4RDB is formalized in a simple form and the RDB4ETP uses the AHMM4UP which is formalized as follows:

- ICS Unbundling actions = supports RP operations, Implementation activities, and finalizing the UnPs.
- ETP parts = ∑ UnP (for the ICS, *Artefacts*, and other ICS components).
- RDB4(Categories) = Transformation initiatives of ETP's parts + the declared objectives of ETP operations.
- RDBbETP(Iteration) = includes ETP's parts + ∑ RDB4(Categories).
- AHMM4RDB(APD) = ∑ RDBbETP(n).
- TDM(APD) = TDM + AHMM4RDB(APD).
- ETP = TDM(APD) + GapAnalysis(Iteration).

E. The RDP4ETP Factors' Evaluations

TABLE I. This CSA's average is 9.63

Critical Success Factors	KPIs	Weightings
CSF_RDP4ETP_Polymathic_Approach	Proven	From 1 to 10: 10 Selected
CSF_RDP4ETP_Factors_Integration	Proven	From 1 to 10: 10 Selected
CSF_RDP4ETP_RP_Integration	Complex	From 1 to 10: 08 Selected
CSF_RDP4ETP_EERM	Feasible	From 1 to 10: 09 Selected
CSF_RDP4ETP_AHMM4RDB_Usage	Feasible	From 1 to 10: 09 Selected
CSF_RDP4ETP_RDB_Mechanisms	Proven	From 1 to 10: 10 Selected
CSF_RDP4ETP_IHI_Framework_TRADf	Possible	From 1 to 10: 09 Selected
CSF_RDP4ETP_LTR4ETP	Proven	From 1 to 10: 10 Selected

Valuation

Based on the AHMM4RDB, LRP4ETP, and DMS, for this CSA's CSFs/KPI were weighted and the results are shown in Table I. This CSA's result of 9.63, which is very high, is due to the fact that the RDB simplifies RDP4ETP and it is possible to be implemented. And the next step is the RDB4ETP's initial setup.

III. RDB4ETP's Initial Setup

RDB4ETP's initial setup understands the following steps: 1) RP processes were successful and that generated *Artefacts* are ready to be used; 2) To Define and implement an IHI MDTCAS; 3) Using a confirmed EA and an Architecture Development Method (ADM) based TDM, [7], and 4) Setting up an Etalon RDB (ERDB) to support transformation operations, which can be any type of RDB or a software application.

A. RP Processes Successful Termination

RDB4ETPs depend on the critical BBs-based Unbundling Process (UP). The *Entity's* UP, which is a set of RPs, disassembles its Legacy *Units*' structures, System's administration, Resources, Applications, UPMs, Working models, and components; into dynamic reusable OBBs. RPs face difficulties because of the *Entity's* heterogenous human profiles/cultures, ICS' parts, managers' financial ambitions, and ETP's limited time/budgets. Another major problem is that transformation and innovation technics have been monopolized for achieving only immediate tangible goals like business and financial aspects/profits, where the intangible complex technical aspects are simply ignored. Such approaches generate major ETP issues and high rates of failures that today are above seventy percent. It is important to define ETP's levels of granularity and mapping concepts for each MDTCAS application. That enables the reuse of existing or newly generated *Artefacts*. After the successful UP (and its RPs' terminations), the ETP can move to the next step and can consider that a major achievement was done, [6]. Refined *Artefacts* that are used in UPMss support *Entities* work by: 1) Visualizing operating and support activities; 2) Showing how employees report to higher Managers and how UPM based *Units* are transformed ; 3) Fixing goals that bring together employees with a common *Entity's* objectives; 4) Supporting interfaces (interactions) between *Units*; 5) Restructuring *Units'* operations; and 6) Using the ERDB for integrity checking operations.

B. MDTCAS' Implementation

- It is vital to build an IHI framework to support the ETP, MDTCAS, and the TDM that is based on the ADM, [7].
- The RDBbETP breaks down *Entity's* monolithic silos. ETPs use the TDM and MDTCAS to model APD models and to define its scopes, [7]. The TDM synchronizes ETP's activities and UP (and its RPs) are difficult to scope because they depend on the APD and MDTCAS' incorporation capacities. The ERDB supports ETPs and future APD's functions for (re)organization operations, which enhance functional performances. An *Artefacts*-based UPM that can be used in APD models' development, which needs a Polymathic-holistic approach to transform Legacy *Units*, [9].
- The RDB4ETP uses the MDTCAS to synchronize and adopt an IHI methodology that can map to any existing methodology or technology. The IHI MDTCAS manages RP-generated *Artefacts*, and that is why there is a need to find a transcendent MDTCAS-based ETP. That ensures that ETP's evolution is independent of all domain/business and technological hyper-evolutions. MDTCAS' usage is an important factor for the success of ETPs and it unifies *Artefacts'* management.
- The AHMM4RDB supports iterative UPs and their RPs of the *Entity's* legacy systems, by using the MDTCAS and TDM to integrate standard methodologies, like The Open Group's (TOG) Architecture Framework (TOGAF) and the ADM, [7]. The MDTCAS is a combination of actual standard methodologies and practices like: OOM, UML, legacy methodologies (like the Structure Analysis and Structured Design-SA/SD), Archimate, Decision Making Notation (DMN), and others. MDTCAS can support conversion initiatives like the following case of: 1) Mainframe legacy subsystems conversion to SA/SD models;

2) Then to structures that correspond to OOM/UML entity-classes; 3) To change and transform legacy OOM/UML models/diagrams based modules/components into robust designed/mapped UML/Choreography models, using classes, sequences, communication models; 4) Entity Relationship Diagrams (ERM), and UPMs/Business Processes (BP) and related Models (BPM) diagrams; 5) Implement a light-version of Spiraled/UML, TOGAF, and ADM based TDM development cycles; 6) Recycle processes into *Artefacts*; and 7) Adopt basic DMN like elements, such as requirements diagrams and Tables' evaluations that are done by the DMS. For all mentioned methodologies, the OOM is central for the MDTCAS and *Artefacts*, which is shown in Fig. 3.

C. Adapting EA, ADM, and TDM

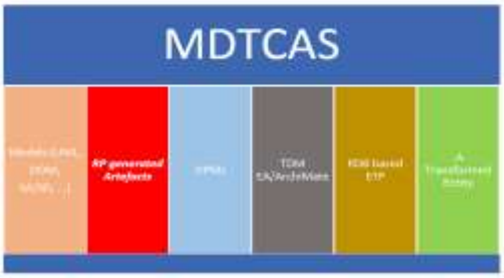

Figure 3. The IHI MDTCAS

The ERDB supports the integrity of ETP operations, like the case of the generation of *Artefacts*, and it offers EA's capacities to Assess Readiness for ETP (AR4ETP). The AR4ETP estimates *Entity's* readiness to be transformed. ETP's assessment is ensured by the ADM-based TDM and *TRADf'*. Outcomes of *TRADf'*s readiness assessment values are added to ETP's capabilities and risk mitigations. These important risks are related to the strategic vision, where the default levels are: catastrophic, critical, marginal, or negligible. *Factors*-based risk mitigation controls are integrated by applying the TDM that enables the automation of ETP's transformational actions. The TDM uses iterations, in which all ETP operations/actions are logged in an RDB. The ETP is APD polymathic, generic, agnostic, and ICS-independent. EA and TDM's integration in the RDB4ETP has the following characteristics: 1) Real-time RDB-based integrity checks, mapping, and *Artefacts'* management; 2) Improvement of ICS' robustness/performance, and availability; 3) The application of existing methodologies like UML, ArchiMate or other; and 4) The integration of tests and agile implementation approaches. The EA, ADM, and TDM link to *Entity's* and ETP's ICS cartography (resources and applications). ETP and RP classify applications by: 1) Using EA capacities like TOGAF and its Application Communication Diagram (ACD), which presents models and mappings related to the communications between ICS elements like applications, resources, and modules, to offer an *Entity's* and ICS metamodel. It also shows applications, components, and user interfaces (between various modules and components); 2) Interfaces may be associated with data classes, and applications can be linked to *Artefacts*; 3) ACDs can also show legacy applications' cartography or a logical architecture of the transformed ICS and end-business-system. *Artifacts*-based EA is privileged; 4) *Entities'* ICS contains hybrid-technologies based applications, RDB-based storages/repositories, and new *Artefacts*-based EA; 5) To achieve *Artefacts*-based applications and components, they should be reorganized according to their functionalities, used technologies, origin/nature and adopted EA level; 6) *Artefacts* based ICS and ETP components, are linked to services, by using connectors; 7) A view of applying applications' cartography can be the use of the TDM; 8) An ERDB can be used to deliver ICS' application's cartography; and 9) As shown in Fig. 4, the EA (and in turn ETP) concept is layered, where the inter-layer interaction proposes that the component layer is on top, process-based components are to be stored in the middle layer, and that the *Entity's* components are on the bottom. The TDM has the duty to superpose architecture standards, like TOGAF, as shown in Fig. 4. *TRADf'* enables the adoption of TOGAF (by the use of MDTCAS) and at the same time imposes a just-enough EA concept, which has the following layers used: 1) Business Architecture; 2) Data Architecture; 3) Application Architecture; and 4) Technology Architecture, [7], [8].

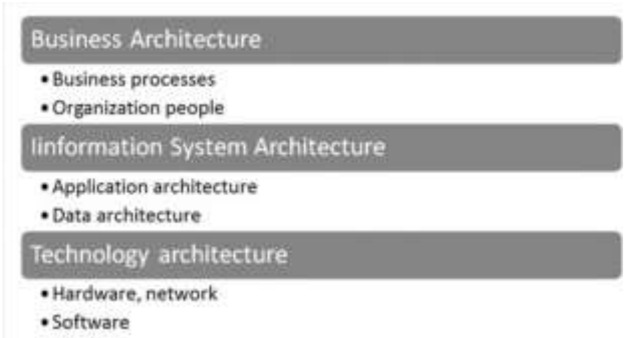

Figure 4. The used EA concept is layered

D. The IHI Methodology-TRADf'

The ETP and RDP4RDP need an IHI Methodology and Framework, and for this article and its PoC, the user presents his *TRADf'*, which any *Entity* can implement a similar one, avoid expensive products; and use RDB's qualified integrity rules which are, [14], [15], [17]: A complex/multidimensional conceptual and EA view, *Entity* wide Transparency, Accessibility, Robust consistent reporting on performance, Client/server implementation and architecture, Generic scalability and dimensionality, Dynamic sparse matrix handling, Multi-user management and support, Unrestricted polymathic cross-dimensional operations, Intuitive and structured data manipulation, Flexible/dynamic reporting, and Unlimited dimensions by using aggregation levels. Where the AHMM4RDB uses these empirical rules.

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E. Setting up the ERDB for the ETP

There are many concepts that can be used to abstract and unify a view on various DBs and data sources like the Extract, Transform, and Load (ETL), Enterprise Service Bus (ESB), or a services-oriented model. The ETL (and other similar solutions) are mainly a data integration process that combines data structures (like datasets) from multiple DBs and data sources into a single data viewpoint or an ERDB; which is a consistent data store that can be interfaced by any ICS component or tool, [10]. Besides ETL there are many other concepts that can support an ERDB.

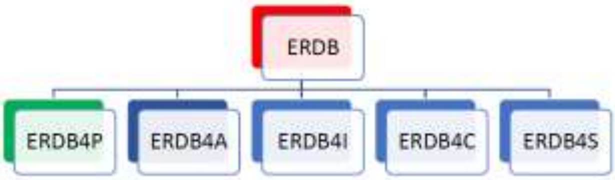

Figure 5. The ERDB

As shown in Fig. 5, the ERDB is used to abstract and interface/map the following ICS categories: 1) ERDB for Platforms (ERDB4P), which includes: Networks, DBs, and nodes; 2) ERDB for Applications (ERDB4A), which includes: Applications, Software (components and libraries), BPs/Scenarios, Transactions, Methodologies (like UML, Archimate, OOM, and other); 3) ERDB for Interfaces (ERDB4I): Interfaces, Gateways, API, Actors, Delimiters, and other; 4) ERDB for Control (ERDB4C): Security, Governance, Audit, Monitoring, Tracing, or other; and 5) ERDB for Intelligent Systems (ERDB4S): like DMS, KMS, BPM based systems, or other.

F. The RDB4ETP Initial Setup Factors' Evaluations

Based on the AHMM4RDB, LRP4ETP, and DMS, for this CSA's CSFs/KPI were weighted and the results are shown in Table II. This CSA's result of 8.60, which is in a limit zone, is due to the fact that PRs are very complex and that RDP4ETP's initial setup is a difficult phase. And the next step is ERDB's integration.

TABLE II. This CSA's average is 8.60

Critical Success Factors	AHMM4CIII enhances: KPIs	Weightings
CSF_Initial_Setup_RF_Termination	Complex	From 1 to 10. 08 Selected
CSF_Initial_Setup_MDTCAS_Implementation	Feasible	From 1 to 10. 09 Selected
CSF_Initial_Setup_TDM/ADM/EA	Feasible	From 1 to 10. 09 Selected
CSF_Initial_Setup_IIII_Framework	Feasible	From 1 to 10. 09 Selected
CSF_Initial_Setup_ERDB_Setup	Complex	From 1 to 10. 08 Selected

Validation

IV. The ERDB Integration

A. Setting up the ERDBP

The ERDB4P serves the ETP by reflecting the status of the progress of the transformation of various ICS components or elements like the following ones: Networks, DBs, and platform nodes.

Figure 6. The ERDB4P

The ERDB4P or the logically integrated platform DB, is the fundament of an ICS integrated Network Management System (NMS), which offers the requested interfaces between all actions/functions of the NMS and ICS nodes. The platform DB management system manages the needed levels of availability and delivery of needed information. It also supports real-time data logging from various ICS devices (and subnetworks, analysis functions, and transaction processing). The platform DB is distributed over the ICS and can be an RDB or any other type of DB, [11]. Concerning DBs, the ETL logging subsystem can deliver the needed persistence mechanisms. This article presents the ERDB4P as shown in Fig. 6. The creation and maintenance of NMS' resources database, will support the persistence of the information associated with the network components. As shown in Fig. 7, the NMS database persists information related to ICS' components and networks, needed for the proper operation of the ICS, [13].

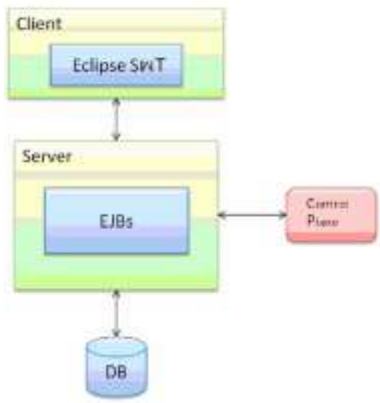

Figure 7. The ERDB4P and NMS interfaces, [13]

B. Setting up the ERDBA

The ERDB4A serves the ETP by reflecting the status and progress of the transformation of various ICS components or elements like: Applications, Libraries, BPs/Transactions, Methodologies, and others. The ERDB4A uses two DB concepts, which are 1) Classical Read, Write, Update, and Delete (RWUD) operations, which are standard data access operations, and all ERDB categories' elements use the RWUD operations; and 2) Modelling and architecture activities, where the resultants diagrams, models and other are stored in case tools DBs. For these two DB concepts, the ETP can use ETL or any other DB unification and integration concepts.

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Concerning architecture and modelling resultant elements can be mapped to MDTCAS equivalents and kept in a specific repository. This section presents the ERDB4P as shown in Fig. 8.

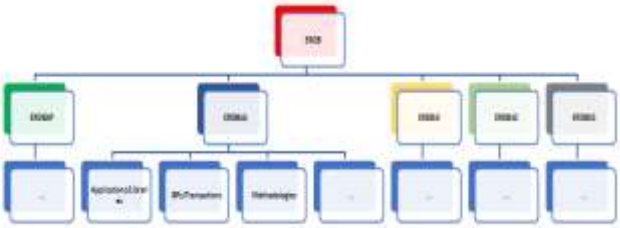

Figure 8. The ERDB4A

C. Setting up the ERDBI

The ERDB4I serves the ETP by reflecting the status of the progress of the transformation of various ICS components or elements, like: Interfaces, Gateways, APIs, Actors, Delimiters, and others. The ERDB4I uses also the two already mentioned DB concepts. For these two DB concepts can use ETL or any other specific integration concept, like API platforms. Which is a platform that supports the access, distribution, control, and analysis of APIs, that are used by ETP engineers. API platforms benefit RDB4ETPs by offering centralizing control of API pools and ensuring that they are continuously secured and available, [16]. Concerning architecture and modelling resultant interface elements can be mapped to MDTCAS equivalents and kept in the ETP central repository. This section presents the ERDB4I, as shown in Fig. 9.

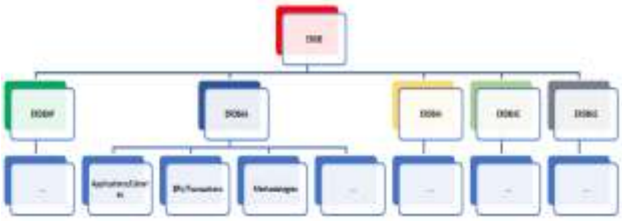

Figure 9. The ERDB4I

D. Setting up the ERDBC

The ERDB4C serves the ETP by evaluating the status of the progress of the transformation of various ICS components or elements like: Security, Governance, Audit, Monitoring, Tracing, and others. The RDB4ETP uses EA and TDM, which facilitate Sherwood Applied Business Security Architecture's (SABSA) integration, [17]. That supports security, which depends on *Entities* and the selected CSFs, and there are established sets of best practices that can influence the ERDB4C, like the ones offered by the National Institute of Standards and Technology (NIST). The NIST has created the necessary steps for an *Entity* to self-assess its ERDB4C preparedness and to apply adequate control measures. These principles are built on the NIST's five pillars of a security framework. Another framework that can be used by the ERDB4C, is the Cloud Security Posture Management (CSPM) which is designed to tackle common ICS flaws, [18]. The use of control frameworks, like SABSA, facilitates ERDB4C interfacing. The ERDB4I uses two already mentioned DB concepts. For these two DB concepts can use ETL or other DB integration concepts. Concerning architecture and modelling resultant elements can be mapped to MDTCAS equivalents and kept in a specific repository. This section presents the ERDB4C as shown in Fig. 10.

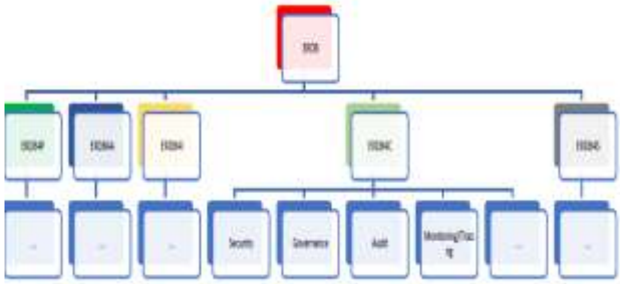

Figure 10. The ERDB4C

E. Setting up the ERDBS

The ERDB4S serves the ETP by reflecting the status of the progress of the transformation of various ICS components or elements like: DMS, KMS, BPM-based systems (BPMS), and others. The ERDB4S uses the two already DB concepts, which use ETL or other DB integration concepts that can serve complex systems like the BPMS. The BPMS manages tasks and processes related to the ICS; and it includes: 1) A process designer and implementer; 2) A process engine that manages BP tasks; 3) Data management tools; and 4) A reporting engine for monitoring BP activities. The BPMS supports BPMs' implementation by the ICS team(s), [19]. The ERDBS architecture and modelling elements can be mapped to the IHI MDTCAS equivalents and they can be kept in the *Entity's* repository. This section presents the ERDB4S as shown in Fig. 11.

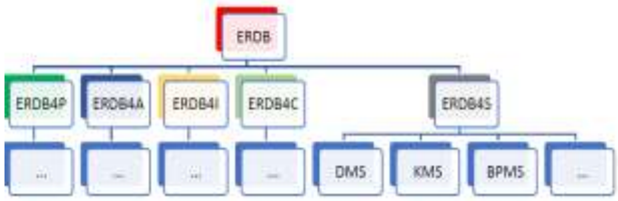

Figure 11. The ERDB4S

F. The ERDB Integration Factors' Evaluations

Based on the AHMM4RDB, LRP4ETP, and DMS, for this CSA's CSFs/KPI were weighted and the results are shown in Table III. This CSA's result of 9.0, which is in high result, is due to the fact that the ERDB facilitates the integration and that not a difficult phase. And the next step is to analyze ERDB's specific solutions.

TABLE III. This CSA's average is 9.0.

Critical Success Factors	AHMM4CBB: KPIs	Weightings
CSF_ERDB_Integration_Setup	Feasible	From 1 to 10. 09 Selected
CSF_ERDB_Integration_P	Feasible	From 1 to 10. 09 Selected
CSF_ERDB_Integration_A	Feasible	From 1 to 10. 09 Selected
CSF_ERDB_Integration_I	Feasible	From 1 to 10. 09 Selected
CSF_ERDB_Integration_C	Feasible	From 1 to 10. 09 Selected
CSF_ERDB_Integration_S	Feasible	From 1 to 10. 09 Selected

valuation

V. ERDB's Specific Solutions

A. Setting up Factors

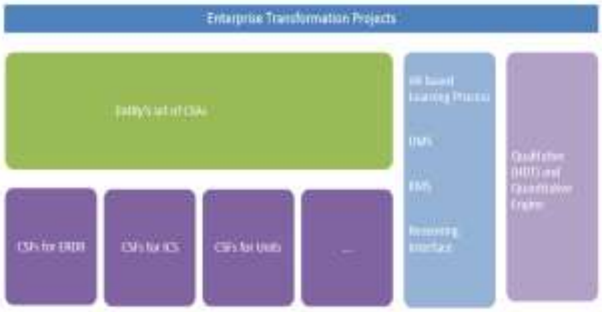

Figure 12. The ERDB4S

As already mentioned, an ETP CSA is a category (or list/set) of CSFs that are tuned and selected by the ETP team, as shown in Fig. 12. A CSF is a set of KPI, where a KPI corresponds to an ETP requirement and/or feature. A KPI can be related to a software (or application) variable or ERDB/RDB attribute. For an ETP requirement or problem, the ETP team selects the default sets of Factors, to be used by the HDT-based DMS. The Factors map to the RP-generated sets of Artefacts. Therefore, ETP CSFs are crucial for the mapping between the requirements/problems, knowledge constructs, Artefacts, OPMS/OBBs, Units, and DMS, [20]. The selected Factors have to meet the strategic ETP goals. Applied measurements technics are offered by *TRADf*, which evaluates the performance of each CSA, where CSFs can one of the following: 1) The status; 2) Mapping mechanisms of refined Artefacts; 3) Gap evaluation; 4) TDM phase's integrity; and 5) DMS requests calls. KPIs can be integrated into Artefacts, so HDT's processing and evaluations can automatically estimate the values Factors (CSAs, and CSFs), [6]. Factors are tuned by the ETP team by using the ERDB and sets of CSFs/CSAs are weighted by the DMS to offer sets of possible solutions for a problem.

B. Using Entity Logging Mechanism

An *Entity* can implement an enterprise-wide ERDB-based logging server (Logserver), to support monitoring, diagnosing, and troubleshooting activities. Such activities are key activities for the *Entity's* ETP and TDM lifecycles, and logging is the core part of these activities. Through the Logserver all ICS activities are traced in real-time. ICS components deliver messages to the Logserver. Such logging mechanisms can be adapted to ICS' requirements with varied degrees of complexities; and can have different levels of importance, like: ERROR, WARN, INFO, and DEBUG, as shown in Fig. 13. The ETP must be capable of sending logs to various destinations, likes: consoles, files, DBs/RDBs, specific servers, or messaging queues. The ERDB can support the sending to various destinations and that needs the implementation of an IHI Logging framework, [12].

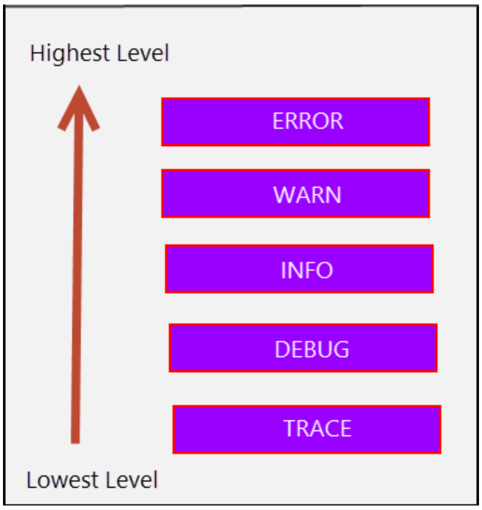

Figure 13. The Logserver levels, [13]

C. Gap's Evaluations

The ERDB enables to execution of Gap analysis on various ETP levels and on various ICS components. That will show in each TDM's phase, whether an improvement was done or regression. For example, in the case of RP, Gap analysis can report how many Artefacts were generated and if the ETP has a sufficient level of integrity; by simply using RDB technics and tables' differential technics.

D. The ERDB's Specific Solutions Factors' Evaluations

Based on the AHMM4RDB, LRP4ETP, and DMS, for this CSA's CSFs/KPI were weighted and the results are shown in Table IV. This CSA's result of 9.50, which is a high result, and that is due to ERDB's possibility to adapt to various solutions and this is not a difficult phase. And the next step is to execute the PoC.

TABLE IV. This CSA's average is 9.50

Critical Success Factors	HMM enhances: KPIs	Weightings
CSF_Specific_Solution_Factors	Proven	From 1 to 10. 10 Selected
CSF_Specific_Solution_Logserver	Possible	From 1 to 10. 09 Selected
CSF_Specific_Solution_Gap_Analysis	Proven	From 1 to 10. 10 Selected
CSF_Specific_Solution_TDM	Possible	From 1 to 10. 09 Selected

valuation

VI. The PoC

A. Basic Preparations

As shown in Fig. 14, the first step is to prepare the PoC's environment by setting up the Vision, MDTCAS/TDM and extracted *Artefacts* generated by the RPs. And afterward, start the phases of ERDB's integration.

Figure 14. The PoC's basic preparation steps

Many of this PoC's modules were already used in previous *TRADf'* related development and PoCs, [6]. The RPs-based UP enables the RDBbETP's integrity and feasibility checks.

B. Integrity and Feasibility Check

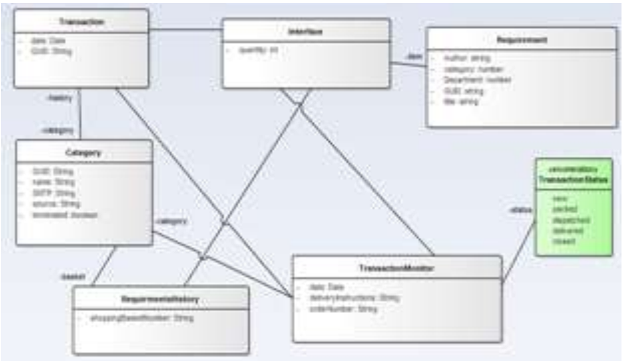

Figure 15. PoC's Artefacts' based cATR ClsD

This PoC uses *TRADf*'s mature modules (mainly the author's previous work that is related to the UP, which presents the extraction of Artefacts) and verified external solutions. Artifacts are assembled to build complex Transactions (cATR) and OBBs. The cATR Class Diagram (CLsD) is presented in Fig. 15. The CLsD optimally maps to an Entity Relational Diagram (ERD). The Artefacts-based cATR is designed using a UML activity diagram, which optimally matches the CLsD and ERD; that is a main MDTCAS constraint and it also proved that defined granularity constraints to support RP and mapping actions, [21]. A logical view of the cATR is presented in Fig. 16, and its consumption of Artefacts is in the form of an activity diagram in which all cATR events (which are transmitted between nodes), need to be encrypted and managed by the TDM.

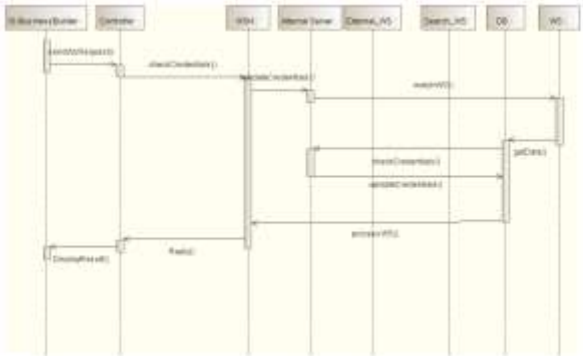

Figure 16. cATR's activity diagram that respects the CLsD and ERD

The cATR uses a set of *Artefacts* which are assembled in an MDTCAS (that maps to UML and Archimate's elements). The ADM-based TDM's phases B and D are used to implement the needed MDTCAS-based cATRs.

C. RDB4ETP's Integration and Implementation

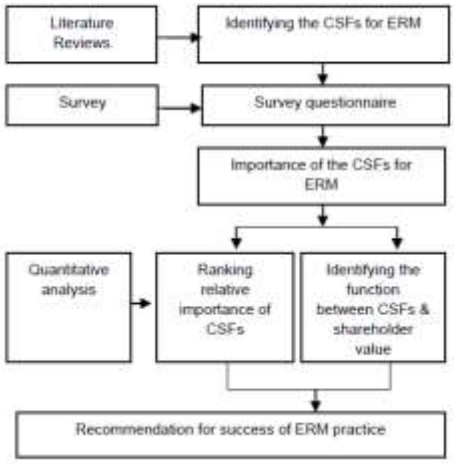

Figure 17. RDP4ETP's similar Factors' flow, [22]

An ETP and PoC's strategic goal and constraint (or CSF) is to reuse existing ICS standards and *Entity's* resources in a reduced manner, which corresponds to the MDTCAS and simplifies ETPs. In this case, MDTCAS transcendent *Artefacts based* MDTCAS, and diagrams are used. The IHI MDTCAS includes *Artefacts,* ERD/RDB, *and resources* to be used to integrate basic design models. To select and tune the default list of Factors that are associated with the RQ, PoC, and RDBbETP; there is the need to use the HDT-based mixed method (qualitative and quantitative). CSFs' HDT-based processing is presented in Fig. 17. The PoC initially launches Phase 1, which mainly uses the HDT-based decision tables, by using *TRADf*'s rating-weighting concept. Phase 1 weighs the importance of CSAs, CSFs, and KPIs in relation to the MDTCAS, ERDB, and RDB4ETP, [22].

D. PoC's Phase 1

TABLE V. This CSA's average is 9.43

CSA Category of CSFs/KPIs	Transformation Capability	Average Result	Table
The RDP4ETP's Integration	Usable-Mature	From 1 to 10: 9.63	1
RDB4ETP's Initial Setup	Transformable-Possible-Complex	From 1 to 10: 8.00	2
ERDB's Integration	Transformable-Possible	From 1 to 10: 9.8	3
ERDB's Specific Solutions	Transformable-Mature	From 1 to 10: 9.50	4

Evaluate First Phase

This research article and the LRP4ETP's outcomes proved that there is an important RDBbETP integration and knowledge gap; and the (or Phase 1's) outcome supports RQ's solutions and credibility. The application of the LRP4ETP and *TRADf*'s knowledge archive (or knowledge base), includes an important set of resources, references, previous author's works, documents, recommendations, and links.

E. Selecting RDB4ETP's Node

Factors (CSA/CSFs) are linked to various HDT-based DMS scenarios. This article's PoC uses Factors (CSFs') to bind to selected RDP4ETP Artefacts and resources, where the RDBbETP was implemented and prototyped using *TRADf'*. The HDT represents the relationships between this RDP4ETP's: RQ/requirements, sets of problems, *Artefacts*, and selected Factors (CSAs/CSFs/KPIs). PoC's interfaces were implemented by using Microsoft Visual Studio .NET environment and *TRADf's* environment. The RDBbETP uses calls to refined *Artefacts*, MDCATS, in order to execute HDT-selected sets of actions that are related to ERDB requests. Factors and especially CSFs were selected and evaluated (using Ratings-Weightings, HDT, and DMS mechanisms) and the results are presented in Table V, which shows that the DMS is feasible due to RDB's AHMM capabilities and maturity. In fact, RDBs are essential for the DMS' risk mitigation concept(s). HDT's defined constraint is that selected CSAs must have a minimum average of 7.5, otherwise, the CSA will be ignored. This constraint accepts RDB4ETP's CSAs (that are marked in green) and which are effective for RDP4ETP's recommendations and conclusion(s); and drops all the CSAs that are highlighted in red. Phase 1, clearly shows that the DMS will most likely succeed and that the proposed ERDB can be Integrated and implemented. And that enables this PoC to proceed to the nest Phase (or Phase 2).

F. PoC's Phase 2

Phase 2 contains the followings steps and stages: A) MDTCAS/TDM's Setup-integration and CSFs' Selection and tuning, where the following EA responsibilities are: 1) Sub-phase A (or the Architecture Vision phase's) goals, establish ERDB's approach and strategic goals; 2) Sub-phase B (or the Business Architecture phase), establishes DMS' target ADM based TDM and related RP activities; 3) Sub-phase C, shows, applies, and uses the ACD to describe RP operations and ERDB concepts and activities; 4) Sub-phase D (or the Target Technology Architecture), describes the needed DMS' optimal ICS infrastructure and landscape; and 5) Sub-phases E/F (or the Implementation and Migration Planning), presents the transition ERDB based EA models, which propose default intermediate ETP situation(s) and evaluates its statuses, by using the DMS. The HDT-based DMS has mappings to *Entity's Artefacts, and* resources and defines the relationships between used *Artefacts, MDTCAS/Models*, MDTCAS' elements, and Requirements/Problems; B) ETP's problems' processing in a concrete situation (or HDT Node), uses the DMS to solve RDB4ETP's Problems, where CSFs link to selected ERDB or a defined problem type, that has a defined set of actions that are processed. For the request, the selected action *CSF_RDB4ETP_Extraction_Procedure* was called and has delivered a set of solution(s). Solving ETP problems involves the selection and tuning of actions, which deliver possible sets of solutions for multiple ETP activities. The HDT is a mixed method (quantitative/qualitative) and has a dual objective that uses the following steps:

- In Phase 1, *TRADf's* interface implements HDT scripts to tune and process the selected CSAs. And then relates PoC's Artefacts and resources to *CSF_RDB4ETP_Extraction_Procedure*.
- The DMS was configured to rate, weight, and tune to support the HDT.
- Linking the selected node to the HDT to deliver the default root node.
- The HDT starts with the *CSF_RDB4ETP_Extraction_Procedure* and proposes a possible solution(s) in the form of ERDB actions/improvements.

G. Solution Nodes

The implemented HDT scripts support AHMM4RDB's instance that runs in the background to deliver RDB4ETP risks' mitigation value(s). The AHMM4RDB-based DMS uses *Artefacts* and the ERDB to deliver concrete actions.

VII. CONCLUSION

Legacy ICS' unbundling is complex and causes failures and success rates can be improved by using *Artefacts* based MDTCAS and ERDB. RDB4ETP uses a just-enough approach and the PoC proved its application's complexities. The RDB4ETP support *Units* based *Entitie*s and the proposed ERDB is an optimal approach for unifying implementation, integrity checking, and feasibility activities. The RDB4ETP supports transformation activities; and the LRP4ETP presented a knowledge gap, which is mainly due to the fact that is no similar research approaches and that there is a lack of a Polymathic-holistic approach. The RDP4ETP is part of a series of publications on ETPs, RP-based UP, ADM-based TDM, Polymathic models. The RDB4ETP uses the HDT and CSFs/CSAs to support ERDB activities. PoC's Table V result of (rounded) 9.40 that used CSFs' binding to RDP4ETP resources, ERDB categories, RQ, and MDTCAS, shows that the RDB4ETP is feasible due RDBs' maturity but the RP-based UP is risky.

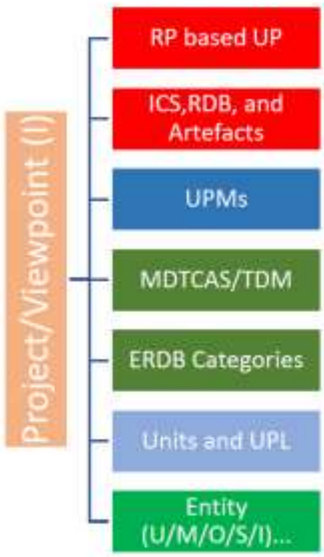

Figure 18. RDP4ETP's similar Factors' flow, [22]

The set of *RDB4ETP*'s architecture, refinement, technical, and managerial recommendations:

- ETPs are important for ensuring long-term sustainability and operational excellence.
- This article presents the possibility to implement an IHI RDB4ETP and MDTCAS which avoids the financial-only locked-in strategies and ensures ETPs' success.
- The RDBbETP concept adopts a Polymathic-holistic approach, which used iterative change and implementation phases.
- The RDB4ETP proposes a realistic solution that is based on RDB to transform *Entities*.
- Each *Entity* constructs its own IHI RDB4ETPs.
- RPs' bases UPs are ETP's most critical phase.
- *Entity's Artefacts'* stability and coherence are crucial for its evolution.
- The UP unbundles the legacy ICS into *Artefacts* to support the *Unit*'s *UnPs* and the *Entity*.
- *Unit*'s transformation needs an IHI Methodology, Domain, and MDTCAS that manages *Artefacts* and *Models*.
- An ETP must implement a TDM and MDTCAS to support ERDB's activities.
- The MDTCAS-based ERDB fits in the TDM.
- TDM's integration in the RDB4ETP enables the automation of all ERDB's activities.
- The ERDB is used to abstract and interface/map the following ICS categories: ERDB4P, ERDB4A, ERDB4I, ERDB4C, and ERDB4S.
- RDB4ETP interface *Entity's* TDM and delivers the pool of *Artefacts*-based ERDB categories.
- Avoid consulting firms and build internal ERDB mechanisms.
- RDB4ETP is *feasible* and will very probably succeed mainly due to RDBs' maturity and cross-functional capabilities.
- Viewpoints "M", "O", "S", and "I" present a structured evolution roadmap, as shown in Fig. 18. And in this article, the focus is on Viewpoint "I".
- APDs high demand for ETPs' and the hyper-evolution of ICS-related technologies, create serious problems because of the differences in their evolution rate.
- All author's works are based on *TRADf'*, AHMM, RP-based UPs, ADM-based TDM, and RDP; which are today mature and can be applied in various APDs.
- RDBs have already various mechanisms for persistence, integrity checks, and relating various ICS modules.
- The ERDB can use various technologies and concepts to unify an ICS-wide RDB concept.
- CSAs evaluation results are very high, and that is due to the fact that the RDB simplifies RDP4ETP and it is possible to be implemented.

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Conflict of Interest

The authors have no conflict of interest to declare.