- 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 ADPbETP uses EA and TDM, which facilitate the integration of the Sherwood Applied Business Security Architecture (SABSA), [12]. That supports security, which depends on *Entities* and the selected CSFs, and the established sets of best practices that can influence the ERDB4C, [19]. The use of control frameworks, like SABSA, facilitates ERDB4C interfacing. The ERDB4C uses two already mentioned DB concepts. Concerning the ADP, the models can be mapped to MDTCAS equivalents and kept in a repository. The ERDB4I supports and persists the EADP's EA modelling views like ArchiMate's Risk and Security View Pattern, [18].
- The ERDB4S supports the EADP by reflecting the status of the progress of the transformation of various systems like: DMS, KMS, BPM-based systems (BPMS), and others. 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), [20]. The ERDB4S uses two already mentioned DB concepts. Concerning the ADP, the models can be mapped to MDTCAS equivalents and kept in a repository. The ERDB4S supports and persists the EADP's EA modelling views like ArchiMate's Relation of the Value Stream and the Business Process, [18].

4.2 Integrating Advanced ERDB for EADP

The advanced ERDB capacities serve the ETP by reflecting the status of the progress of the transformation of various EADP modules, patterns, *Artefacts*, and components or elements like the:

- The ERDB4G supports the EADP by reflecting the status of the progress of the transformation of various systems like: DevOps, Agility, and others. DevOps activities, which emphasize the collaboration of ETP development and operations, infrastructure is supported by software engineering and BPs. The ERDB4G uses two already mentioned DB concepts. Concerning the EADP, the models can be mapped to MDTCAS equivalents and kept in a repository. The ERDB4G supports and persists the EADP's DevOps views like the EADP model maintenance deployment pipeline, [21].
- The ERDB4M supports the EADP by reflecting the stats of the progress of the transformation of various systems like: Project management, Audit, and others. The EADP can be used to model the management of ETP changes. The EADP of the migration process from a legacy construct (EA's current state) to a future situation (EA's target state) can have important consequences on the *Entity*. Where the EADP takes into account: 1) Implementing *Entity*-wide EA; 2) ICS remains operational through the ETP; and 3) The used ICS components can be unstable and heterogeneous. The ERDB4M uses two already mentioned DB concepts. Concerning the EADP, the models can be mapped to MDTCAS equivalents and kept in a repository. The ERDB4G supports and persists the EADP's Project Viewpoint, [18], [22].
- The ERDB4Z supports the EADP by reflecting the status of the progress of the transformation of various systems like: API platforms, Specific interfaces, and others. API platforms benefit ADPbETPs by offering centralizing control of API pools and ensuring that they are continuously secured and available. Concerning architecture and modeling resultant interface elements can be mapped to MDTCAS equivalents and kept in the ETP central repository. The EADP supports the API Viewpoint Modelling, which integrates ArchiMate and UML, [23], [24].
- 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 as shown in Fig. 8, 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 the ETL or any other DB unification and integration concepts. Concerning architecture and modeling resultant elements can be mapped to MDTCAS equivalents and kept in a specific repository.

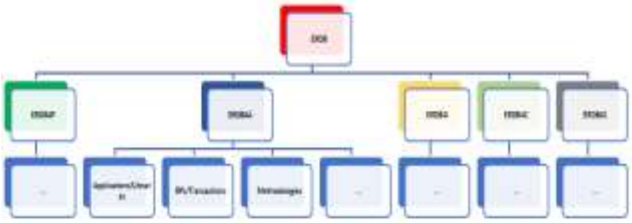

Fig. 8. The ERDB4A structure

The EADP Integration Factors' Evaluations

Table 2. This CSA's average is 9.0.

Critical Success Factors	AHMM4CBB: KPIs	Weightings
CSF_ERDB_based_EADP_Integration_Setup	Feasible	From 1 to 10. 09 Selected
CSF_ERDB_based_EADP_RDB_Mechanisms	Feasible	From 1 to 10. 09 Selected
CSF_ERDB_based_EADP_Basic_Capacities	Feasible	From 1 to 10. 09 Selected
CSF_ERDB_based_EADP_Advanced_Capacities	Complex	From 1 to 10. 08 Selected

valuation

Based on the AHMM4ADP, LRP4ADP, and DMS, for this CSA's CSFs/KPI were weighted and the results are shown in Table III. This CSA's result of 8.75, which is in high result, and is due to the fact that the EADP facilitates the integration and that is a feasible phase. And the next step is to analyse EADP's specific solutions.

5 EADP's Specific Solutions

5.1 Setting up Factors

Fig. 9. The EADPbETP Factors management.

As already mentioned, an *Entity's* (or ETP) CSA is a category (or set) of CSFs that are selected by the ETP implementation team, as shown in Fig. 9. A CSF is a set of KPI, where a KPI corresponds to an ETP requirement and/or feature. A KPI can be related to an EADP module (or application) concrete variable or ERD attribute. For a concrete EADPbETP requirement or problem, the team identifies the initial sets of Factors, to be used by the HDT-based DMS. The Factors map to the EHRP-generated sets of *Artefacts*, which include ABBs/SBBs. Hence the CSFs are important for the mapping between the requirements, knowledge constructs, *Artefacts*, patterns, ABBs, OBBs, Units, and DMS, [25]. Therefore, Factors support strategic EADPbETP goals; which need measurement technics, that are provided by *TRADf*, can be used to evaluate each CSA's performance, where CSFs can relate to: 1) EADP's status; 2) Mapping levels of EADP's *Artefacts*; 3) Gap analysis; 4) TDM phase's integrity; and 5) DMS' requests. KPIs can be integrated into *Artefacts*, so HDT's based evaluation processes can automatically estimate the values of Factors, [6]. Factors are tuned by the ETP team by using the EADPbETP and they are weighted by the DMS, in-order to offer possible solutions for a given EADPbETP problem.

5.2 Using Entity Logging Mechanism

An *Entity* can implement an enterprise-wide Log Server (LS) for EADP (LS4EADP), to support persistence, Gap analysis, monitoring, diagnosing, and troubleshooting activities.

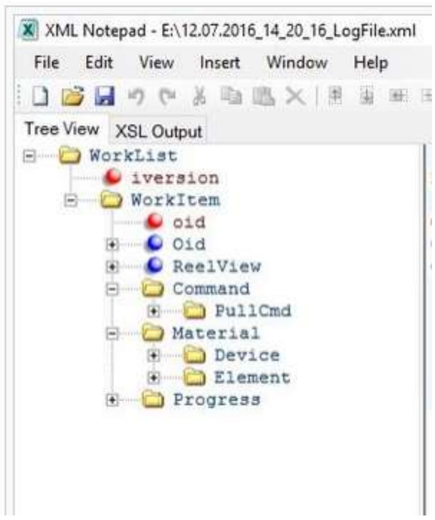

Fig. 10. XML log file, [17], [26]

Such activities are key activities for the *Entity's* ETP and TDM lifecycles, and logging is the core part of these logging activities. EADP module components deliver messages to the LS4EADP. The LS4EADP sends logs to various ICS' RDB destinations that connect to all nodes. An eXtensible Markup Language (XML) format is used for LS operations. As shown in Fig 10, the XML record includes: Timestamp, Nodes' settings, Status, Files/directories info, and Errors/warnings info. The LS4EADP can support the sending to various destinations and that needs the implementation of an IHI LS framework, [26], [27]. LS' operations can be improved by using atomic *Artefacts* (*aArtefacts*) based on atomic BBs (aBB).

5.3 aBBs' Integration

aBBs resources the TDM, wherein each phase they are refined and that gives the EADPbETP a unified view of the development cycles that consists of: 1) Unified pool of aBBs; 2) aBBs based EADP loose modules; 3) Unique identifier; 4) Optimal level of granularity; and 3) A scalable and secured ICS infrastructure. aBBs' integration needs an optimal architecture concept that needs: 1) EA business architecture pattern, 2) TDM-based MDTCAS; 3) Anti-locked-in tools; and 4). EADPbETP uses aBBs, and atomic Solution Blocks (aSB) to be used by optimized tooling and modelling environments, which are based on the Model View Control (MVC) pattern. There is a need for an atomic Architecture Vision (aAV) to support aBBs. aAV's is crucial importance for TDM's implementation phases and also for operations activities which comes after the finalization of the implementation phase. The aAV manages the implementation of autonomous aBB-based transactions, [28], [29]. aBBs are assembled in ABBs, aSBs, and SBBs.

5.4 ABBs and SBBs

The EADPbETP uses standards and for that goal, *Artefacts* are aligned by using: TDM, aBBs-based ABB concept, UML, or ArchiMate languages. The aBB concept is based on TOGAF's ABB and SBBs. There isn't a definition of services architecture, but there are common characteristics around the ABBs, SBBs, and EADP, which depend on the EHRP, [32]. The EHRP delivers the pool of aBBs, where an ABB is a set of aBBs. aBBs can be interfaced by using the API approach that is based on, [33]: 1) Modelling APIs with UML/Archimate; 2) A schema model is a contract between the EADPbETP and an actor; 3) A schema model is a contract describing what the API is and how it works; and 4) Uses an agile strategy. ABBs and SBBs are assembled to offer EA deliverables. The dimensions of EA and EADPbETP are scoped to ETP's boundaries, which integrate heterogeneous types ICS components, [7], [15]; and are supported by: 1) Applying an EA strategy; 2) Defining EADPbETP's and EA's interactions; 3) Applying *Artefacts* integration; and 5) Defining deliverables in the form of EA Patterns (EAP).

5.5 EAP's Usage and Integration

The usage of *Artefacts,* ABBs/SBBs, EAPs, and EADP can be confusing because an EAP can contain ABBs/SBBs and *Artefacts*. At the same time, an ABB can contain EAPs, and that depends on ETP's strategy that is proper to the *Entity* and that is why there is a need for an MDTCAS. The EAP enriches the MDTCAS Common Denominator Patterns (CDP), and it manages: 1) ERDB's concurrent access; 2) the Applications' user interface; and 3) EHRP activities. EAPs include the following patterns: 1) Domain Logic; 2) Data Source Architectural; 3) Object Relational Behavioural; 4) Object-Relational Structural; 5) Object-Relational Metadata Mapping; 6) Web Presentation; 7) Distribution; 8) Offline Concurrency; 9) Session State; and 10) Base Patterns. EAPs and CDPs are parts of the MDTCAS, which use OO relationship types. Relationships interconnect EAPs that use AMEFF or IHI Interchange Formats (IF), [34], [35].

5.6 IF-based EADP

The MDTCAS contains an IHI IF that maps to the common elements of the following methodologies and standards: OOM, UML, Archimate, and ERD/ERM. This implies that EA tools outputs are transformed to MDTCAS' IF and these files are persisted in EADP's repository, which supports Gap's Analysis and Evaluations (GAE).

5.7 GAE's Implications

The EADP enables GAEs on various ETP levels and various EA and ICS components. A GAE shows in each TDM's phase, whether an ETP made improvements or regressions. Concretely GAE's implication is: 1) In the case of EHRP, it shows how much *Artefacts* were generated and if the ETP has a sufficient level of integrity; by simply using ERDB technics and tables' differential technics; 2) Did the ERBD improve ETP's cohesion; and 3) Did the EADP improve EA's and DevOps integrations.

5.8 The ERDB's Specific Solutions Factors' Evaluations

Based on the AHMM4ADP, LRP4ADP, and DMS, for this CSA's CSFs/KPI were weighted and the results are shown in Table IV. This CSA's result of 8.7, is a sufficient result, and that is due to EADP's complexities to adapt to various solutions and this is a delicate phase. And the next step is to execute the PoC.

Table 3. This CSA's average is 8.70

Critical Success Factors	HMM enhances: KPIs	Weightings
CSF_EADP_Specific_Solution_Factors	Proven	From 1 to 10. **10 Selected**
CSF_EADP_Specific_Solution_LS	Possible	From 1 to 10. **09 Selected**
CSF_EADP_Specific_Solution_aBB	Complex	From 1 to 10. **08 Selected**
CSF_EADP_Specific_Solution_ABB_SBB	Complex	From 1 to 10. **08 Selected**
CSF_EADP_Specific_Solution_EAP	Complex	From 1 to 10. **08 Selected**
CSF_EADP_Specific_Solution_IF	Possible	From 1 to 10. **09 Selected**
CSF_EADP_Specific_Solution_GAE	Possible	From 1 to 10. **09 Selected**

valuation

6 The PoC

6.1 Basic Preparations
As shown in Fig. 11, the first step is to prepare the PoC's environment by setting up the ADP's vision, MDTCAS/TDM and extracted *Artefacts* generated by the EHRPs. And afterward, start the phases of ERDB-based EADPbETP's integration. This PoC uses mainly Archimate environment (Archi) and its given project Archisurance which was modified as this PoC's Applied Case Study for TRADf (ACS4TRADf), [36].

Fig. 11. The PoC's basic preparation steps

Many of PoC's modules were already used in previous *TRADf*-related RDPs and PoCs, [9]. The EHRPs and ERDBs enable ADPbETP's integrity and feasibility checks, [1].

6.2 ERDB-based Integrity and Feasibility Check

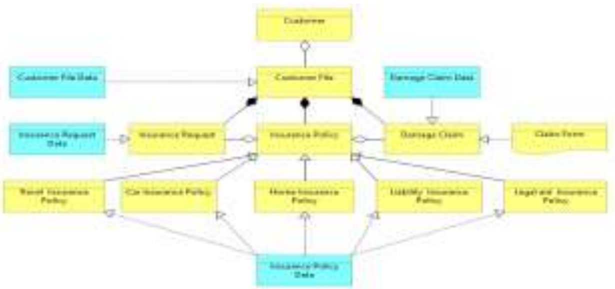

Fig. 12. PoC's Artefacts' based cATR ClsD, [36]

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. *Artefacts* are assembled to build ABBs, OBBs, and complex Transactions (cATR) shown in Fig. 12. The cATR Class Diagram (CLsD) is presented in Fig. 12. The CLsD optimally maps to an ERD.

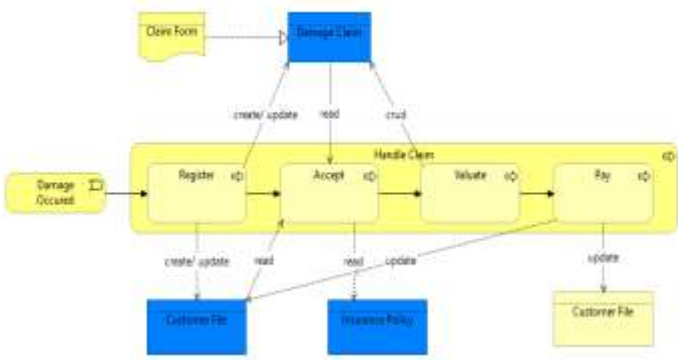

Fig. 13. cATR's activity diagram that respects the CLsD and ERD, [36).

The *Artefacts*-based cATR is designed using a UML activity diagram (translated into a BP), which optimally matches the CLsD and ERD; that is a main MDTCAS constraint and it also proved that the granularity level can be used to refine the "1:1" mapping, [30]. A logical view of the cATR is presented in Fig. 13, and its consumption of *Artefacts*, in which all events are exchanged between various nodes, requires encryption which is defined in the TDM. 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.

6.3 ADPbETP' Design and Implementation
An essential constraint for the PoC is to use of existing standards in a reduced form, which corresponds to the MDTCAS and simplifies EADPbETP's integration. In this case, MDTCAS transcendent *Artefacts* and diagrams are used. The IHI MDTCAS includes *Artefacts*, ERD/RDB, *and resources* to be used to integrate basic architecture and design models. To identify the initial sets of Factors that are related to the RQ and ADPbETP's integration. The PoC uses HDT-based mixed qualitative and quantitative methods. The CSF's analytical process. The PoC in the beginning uses Phase 1 which is mainly based on the HDT decision tables, which use *TRADf's* weighting concept. Phase 1 is used to weigh the relative importance of CSAs and CSFs for the usage of MDTCAS, ERDB, and EADPbETP and that is done using a decision-tables, [22], [31].

6.4 POC's Phase 1

Table 4. This CSA's average is (rounded) 8.73.

CSA Category of CSFs/KPIs	Transformation Capability	Average Result	Table
The RDP4ETP's Integration	Usable-Mature	From 1 to 10. 8.63	1
RDB4ETP's Initial Setup	Transformable-Possible-Complex	From 1 to 10. 8.60	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

LRP4ADP's outcome proves the existence of a major ADPbETP knowledge gap and its (or Phase 1's) outcome supports RQ's credibility. The use of the LRP4ADP and *TRADf*'s archive or knowledge-base, of an important set of references, previous author's works, documents, and links.

6.5 Selecting ADPbETP's Node

Factors (CSA/CSFs) are linked to various HDT-based DMS scenarios. The PoC is based on the Factors (CSFs') binding to specific RDP4ETP resources, where the ADPbETP was prototyped using *TRADf's*. The HDT represents the relationships between this RDP4ETP's RQ/requirements, *Artefacts*, and selected Factors (CSAs/CSFs). PoC's interfaces were achieved using the Archi tool, Microsoft Visual Studio .NET environment, and *TRADf's*. The EADPbETP uses calls to resulting *Artefacts*, MDCATS, to execute HDT actions related to EHRP, EADPbETP, and ERDB requests. CSFs were selected and evaluated (using Weightings, HDT, and DMS) and the results are illustrated in Table V, which shows that the DMS is feasible mainly because of EADP maturity. In fact, it is essential for the DMS' risk concept. HDT's main constraint is that CSAs having an average result below 7.5, will be ignored. This fact leaves the EADPbETP's CSAs (marked in green) effective for RDP4ETP's conclusion(s); and drops the CSAs marked in red. Phase 1, shows that the DMS will probably succeed and that the ERDB-based EADPbETP can be implemented, but is complex. The PoC can proceed to Phase 2.

6.6 PoC's Phase 2

This phase includes the following steps:

- MDTCAS/TDM's Setup and CSFs' Selection: The Phase 2 setup includes: 1) Sub-phase A or the Architecture Vision phase's goals, establishes the EADP approach and goals; 2) Sub-phase B, or the Business Architecture phase establishes DMS' target TDM and related EHRP activities; 3) Sub-phase C shows and uses the Application Communication Diagram to describe EHRP and EADP activities; 4) Sub-phase D or the Target Technology Architecture shows the needed DMS' optimal ICS landscape; and 5) Sub-phases E and F, or the Implementation and Migration Planning, presents the transition EADP based architecture, which proposes intermediate situation(s) and evaluates DMS' statuses. The HDT-based DMS has mappings to *Entity's* resources and defines relationships between *Artefacts*, MDTCAS (models and elements), and requirements/problems.
- Problems Processing in a Concrete HDT Node: The DMS solves ADPbETP's problems, where CSFs link to specific ERDB or ADPbETP problem types and has a set of actions that are processed in a concrete HDT node. For this goal, the action *CSF_ADPbETP_Extraction_Procedure* was called and delivered Solution(s). Solving Problems involves the selection of actions and possible Solutions for multiple *Project* activities. The HDT is mixed quantitative/qualitative and has a dual-objective that uses the following steps: 1) In Phase 1, *TRADf's* interface implements HDT scripts to process the selected CSAs. And then relates PoC's resources to *CSF_ADPbETP_Extraction_Procedure*; 2) The DMS is configured to weigh and tuned to support the HDT; 3) Link the selected node to HDT to deliver the root node; and 4) The HDT starts with the *CSF_ADPbETP_Extraction_Procedure* and proposes Solution(s) in the form of EADP actions/improvements.
- Solution Nodes: HDT scripts support an AHMM4ADP instance that is processed in *TRADf's* background to deliver ADPbETP risks' mitigation value(s). The AHMM4ADP-based DMS uses *Artefacts* and the ERDB to deliver concrete actions.

7 Conclusion

Legacy ICS' UPs are very complex and can cause ETP failures and success rates. ETP's success rates can be improved by using *Artefacts*-based MDTCAS and ERDB. ADPbETP uses a just-enough approach and the PoC proved its application's complexities. The ADPbETP support

Units based *Entities* and the proposed ERDB is an optimal approach for unifying implementation, integrity checking, and feasibility activities. The ADPbETP supports transformation activities; and the LRP4ADP 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. The RDP4ETP is part of a series of publications on ETPs, EHRP-based UP, ADM-based TDM, Polymathic models… The ADPbETP 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 ADPbETP is feasible due RDBs' maturity but the EHRP-based UP is risky. The set of ADPbETP's architecture, technical and managerial recommendations:

- EADPbETPs are important for ensuring long-term sustainability and operational excellence.
- This article presents the possibility to implement an IHI EHRP, ADPbETP, and MDTCAS which avoids the financial-only locked-in strategies and ensures ETPs' success.
- The ADPbETP concept adopts a Polymathic-holistic approach, which used iterative change and implementation phases.
- The ADPbETP proposes a realistic solution that is based on ERDB to transform *Entities*.
- The ERDB is used to abstract and interface/map the following ICS categories: ERDB4P, ERDB4A, ERDB4I, ERDB4C, and ERDB4S.
- ERDBs 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.
- Each *Entity* constructs its own IHI ADPbETPs.
- The UP unbundles the legacy ICS into *Artefacts* to support the *Unit*'s *UnPs* and the *Entity*.
- *Entity's Artefacts'* stability and coherence are crucial for its evolution.
- EHRPs' bases UPs are ETP's most critical phase.
- *Unit*'s transformation needs an IHI Methodology, framework (like *TRADf*), Domain, and MDTCAS that manages *Artefacts* and *Models*.
- An ETP must implement a TDM and MDTCAS to support ERDB-based EADP's activities.
- The MDTCAS-based EADP fits in the TDM.
- TDM's integration in the ADPbETP enables the automation of all ETP's activities.
- *Artefacts* include ABBs and SBBs.
- ADPbETP interface *Entity's* TDM and delivers the pool of *Artefacts* based EADP categories.
- Avoid consulting firms and build internal ERDB-based EADP solutions.
- ADPbETP is *feasible* and will very probably succeed mainly due to ERDBs' and MDTCAS's maturities and *TRADf's* cross-functional capabilities.
- Viewpoints "M", "O", "S", "I", and "A" present a structured evolution roadmap, as shown in Fig. 14. And in this article the focus is primarily on Viewpoint "A". And on Viewpoint "I" is a second priority.
- APDs high demand for ETPs' and the hyper-evolution of ICS-related technologies, create serious problems because of the differences in their evolution rate. And MDTCAS can avoid such cases of desynchronization.
- All author's works are based on *TRADf*, AHMM, EHRP-based UPs, ADM-based TDM, and RDP; which are today mature and can be applied in various APDs.

CSAs evaluation results are very high, and that is due to the fact that the ERDB-based EADPbETP simplifies RDP4ETP and it is possible to be implemented.

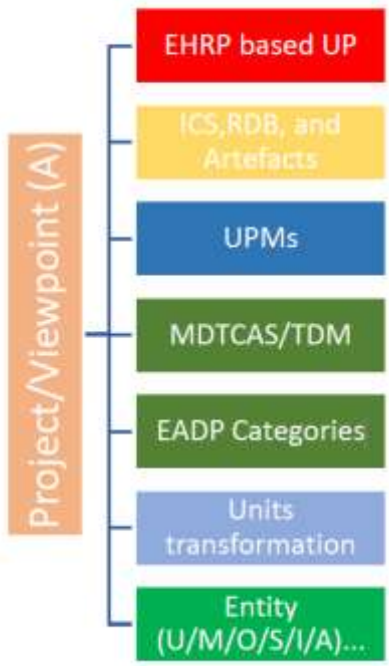

Fig. 14. RDP4ETP's similar Factors' flow, [31].

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Conflict of Interest

The authors have no conflict of interest to declare.