Enterprise Transformation Projects-The Applied Polymathical/Holistic Mathematical Model for Enterprise's Business Process Modelling (AHMM4EBPM)

ANTOINE TRAD
Business and Common Transformation Architecture and Projects
IBISTM
Paris-FRANCE

Abstract: The Applied Polymathical/Holistic Mathematical Model for Enterprise's Modelled Evolution (AHMM4EBPM) supports Enterprise's transformation projects (simply Project). The AHMM4EBPM is a set of interrelated Mathematical Models (MM), transformed artefacts, critical success factors (or calibration-factors), and adapted Enterprise Architecture (EA) Models (EAM). MMs, artefacts and EAMs use a standardized and holistic set of names-conventions, mapping concepts, unbundled-services, relations, to model the transformation and validity-checking of any part of the Enterprise, Project, Data-storage(s), or the Information Communication System (ICS). EAMs, pool(s) of unbundled services, relationships, and other can be exported to MMs via eXtensible Markup Language (XML) format. Exported MMs are combined to generate the AHMM4EBPM that can be used for Project's integrity-checking, gap-analysis, financial analysis, risk-management, and many other types of strategic enterprise operations. MMs are based on DataSets (DS) that are interrelated and use a mixed-research method(s) that are supported by qualitative and quantitative research module. This module is the central reasoning engine based on the qualitative Heuristics Decision-Tree (HDT). And this article's main objective is to support Projects [1].

Key-Words: Business Processes Modelling, Polymathical mathematical models, Business and common transformation projects, Enterprise architecture, Artificial intelligence, Qualitative and quantitative research, and Critical success factors/areas.

Received: March 19, 2024. Revised: October 6, 2024. Accepted: November 9, 2024. Published: December 12, 2024.

1 Introduction

This article illustrates the Polymathical and generic AHMM4EBPM that can be applied in Entity's or Organization's (simply Entity) continuous transformations or in the contexts of a Projects. A Project is supported by the In-House Implement (IHI) Polymathic Transformation Framework (IHIPTF), various types of critical success factors, existing-standard methodologies, various categories of MM symbols and nomenclature. In the context of Projects, the AHMM() can predict various types of problems and propose proactive solutions; and the AHMM4EBPM is a specialization for Business Processes (BP) and their Modelling (BPM). So the AHMM() can be used for various Project's sub-domains.

Before reading this article, the valuable reader can consult IHIPTF related guides, and Projects fundamental works, like:

- The AHMM4PROJECT [1].
- The IHIPTF Guide [2].
- The IHIPTF Glossary [3].

AHMM4EBPM's main goals and characteristics are [1,2,3]:

- To manage Unbundling for BPM(s) (U4BMP), and its embedded Refinement Processes (RP).
- U4BPM and its RPs (simply Disassembling), transform legacy BPs and services to deliver unbundled-BPs.
- Offers modelling principles and integrity-checking for BPMs by relating and matching specialized MMs.

- MMs and their related BPMs are persisted in Data-Sets (DS).
- The AHMM() and MM's fundaments, basics, symbols, and notations are presented in the AHMM4PROJECT guide [1].
- The AHMM(),AHMM4EBPM, and hence the IHIPTF, are the first transformation environments that offer a Mathematical Notation (MN) for Polymathic Transformation Initiatives/Projects (MN4PTI) [11,12].
- Dissembling and transformation activities deliver sets of interrelated MMs, transformed resources/artefacts in the form of MM based blocks, Critical Success Factors (CSF, used for optimization and tuning activities), and generated Enterprise Architecture (EA) Models (EAM).
- BPMs, MMs, Blocks, CSFs, and EAM are IHI methodology's main elements.
- The IHI methodology is the the Methodology, Domain, and Technology Common Artefacts Standard (MDTCAS), which incorporates various elements from standard-existing methodologies and resources-artefacts, like the BPM Notation (BPMN).
- The AHMM() is a set of MMs and they all treated and presented in the AHMM4PROJECT work [1]; but in this article the focus is on MM for BP (MM4BP) and its intersections with other MMs. Other MMs will be treated in future articles.
- The AHMM() and hence the AHMM4EBPM goals is to predict XHFRs and investigate their origin, which in most cases is related to uncertainties and complexities…
- Uses the Research and Development Project's (RDP) to support AHMM4EBPM's integration, evaluation, and execution. And it is this article's first Critical Success Areas (CSA).

2 RDP

2.1 The Research Question

This RDP's and article's Research Question (RQ) is: "Which AHMM4EBPM characteristics, elements, and structure are requested to enable mainly BPM and services-based Projects and Entity's sustainable evolution(s)?" The RDP's Polymathic Resources and Literature Review (PRLR) uses IHIPTF's knowledge, PoCs, and articles repository, and gives advantages to the authors' relevant works and professional consulting-projects, like:

- The AHMM4PROJECT(s) [1].
- The Business Transformation and Enterprise Architecture Framework-The Applied Holistic Mathematical Model's Persistence Concept (AHMMPC) [4].
- An Applied Mathematical Model for Business Transformation and Enterprise Architecture-The Holistic Mathematical Model Integration (HMMI) [5].
- Using Applied Mathematical Models for Business Transformation [6].
- The Transformation and Enterprise Architecture Framework: The Applied Holistic Mathematical Model for Geopolitical Analysis (AHMM4GA) [7].
- The Polymathic approach for Projects that use a Meta-Model [8].
- Trad, A. Enterprise Transformation Projects-A Mathematical Models' based Enterprise Refinement Concept (ETP-ERC) [9].
- Enterprise Transformation Projects-The use of the Polymathic Rating and Weighting Concept (PRWC) [10].
- Applied Holistic Mathematical Models for Dynamic Systems (AHMM4DS) [41].
- The Business Transformation Framework and Enterprise Architecture Framework for Managers in Business Innovation-An applied holistic mathematical model (AHMM) [42].
- … and many others.

2.2 The Set of MMs

The AHMM() can include one or more of the following MMs:

- MM for U4MP (MM4UP) which supports unbundling.
- MM for Object Orientes (OO) (MM4OO) which structures on the base of OO paradigm.
- MM for Factors (MM4FC) which structure and checks Factors.
- MM for GAPA (MM4GP) which supports GAPA's estimations.
- MM for PRWC (MM4PR) which supports PRWC's estimations.
- MM for Expectations and Constraints (PEC) (MM4PE) which structures PEC.
- MM for Complexities Management (MM4CM) which tries to contain complexities.
- MM for MetaModels (MtM) (MM4MM) which is base for MtM.
- MM for Polymathic Enterprise MtM (PEMtM) (MM4PM) which is base for PEMtM.
- MM for BP (MM4BP) which supports and checks BP, BPMs, and choreographies.
- MM for Methodologies and ICS (MM4MD) which supports and checks OOM/UM, Archimate, and other.
- MM for MDTCAS (MM4MT) which supports and checks MDTCAS.
- MM for APDs (MM4AD) which supports and checks APDs and its problem-types.
- MM for Agile Project Management (APM) (MM4AP) which supports and checks APM, and PM.
- MM for Intelligence (MM4IN) which supports and checks AI and decision-making.
- MM for AHMM() (MM4AH) which constructs the for a specific topic .

2.3 Hypothesis

The RDP uses a set of hypotheses (or assumptions) which correspond to Project's CSA and the article's main researched topic corresponds to the central CSA and to the RQ. RQ's scope and feasibility, and RDP's credibility dependent on a set of established hypotheses (and assumptions). Where this article's RQ's main hypotheses (or assumptions) depend on the following transformational-activities and phases, which were successfully finalized:

- Project's start, contracting, goals, vision, and roadmap development were convened and documented.
- Project's budget was estimated and accepted.
- There is the needed a sufficient level of political support.
- The Entity has a quality, and longterm RDP.
- Disassembling and automated BPM(N) choreographies' strategies were implemented.
- Disassembling processes terminated successfully and delivered the pools of BMPs, Blocks, services, and other MDTCAS artefacts.
- The Entity and Project have successfully implemented MDTCAS, Factors Management System (FMS), PRWC, HDT, and IHIPTF.
- The Project uses the DB Centric Concept (DBCC) (or DB first) for data operations.
- The Project's members have experience and advanced BPM, EAM, services modelling skills.
- The Project and Entity have defined AHMM() and MM's fundaments,

Symbols (or Notations), and AHMM()'s interactions [1].

- A hypothesis (or assumption) corresponds to a CSA, and the article's main topic corresponds to a CSA and the RQ.

2.4 The PRLR and FMS

This article and RDP localized a research-gap due to: 1) There isn't anything similar to the AHMM() and MMs, and IHIPTF; 2) XHFRs' proactive identification; 3) There isn't a mixed method similar to the Quantitative-Qualitative Research Mixed Model (QQRMM); 4) A real-world Weightings (Wgt) PRWC and FMS related to GAP-Analysis (GAPA), MMs, ICS and IHIPTF; and 5) The use of CSA Decision-Tables (CSA_DT) to qualify Project's CSAs. As shown in Fig. 1. GAPA is applied to all CSAs, but in this article only one GAPA/CSA_DT will be presented.

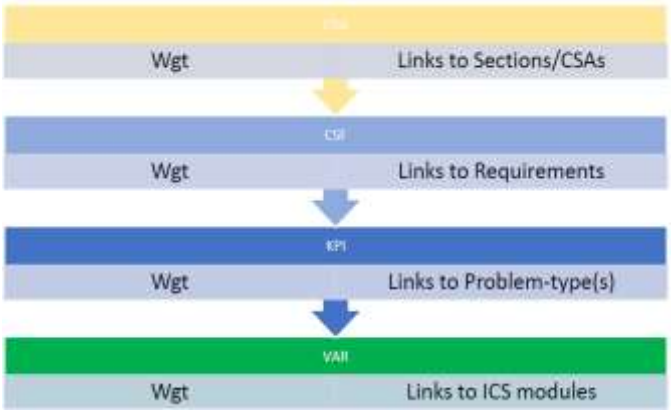


Fig. 1. The evaluations for IHIPTF and AHMM(EBPM) that process CSA_DTs.

The AHMM4EBPM relates to the MM for Factors (MM4FC) which idetifies, and relates initial-sets of Factors; and includes AHMM equations FC01 to FC21, in which CSFs, and KPIs are constraints that are needed for Project's basic-evaluations, rescheduling, and auditing. AHMM() and MMs have MetaModels (MtM) and their relations and aggregations in the context of a Polymathic Enterprise MtM (PEMtM) gives the Entity the capacity to perform validity-checking. Validity-checking uses the FMS and underlying Factors which offer [13,14,15,16]:

- They can be used in Natural Programming Languages (NLP) scripts.
- The FMS incorporates CSAs, CSFs, Key Performance Indicators (KPI), and concrete ICS VARiables (Var) (simply Factor).
- A CSA maps to a set of CSFs (and Project's resources/services), and a CSF is a set of KPIs.
- The Team manages and tunes the initial-sets of Factors.
- A KPI maps to a unique requirement and problem-type.
- CSFs are used for solving problem-types, in Decision Making System (DMS)/Knowledge Management System (KMS) (simply Intelligence), and other.
- FMS ensures that: 1) A CSA maps to an Entity APD (or a common functional-domain); 2) A CSF maps to a set of requirements (and directly linked problem-types); and 3) A KPI maps to a ICS' item-variable or Var.

2.5 The PRWC, CSA Evaluation and GAPA

The PRWC interacts with the FMS and Intelligence to offer [18]:

- A standard evaluation method like the Decision-Making Notation (DMN).
- The AHMM4EBPM and MM for PRWC (MM4PR) are supported by the PEMtM.
- Is used to evaluate Project's integrity.
- Uses the FMS that includes: Factors like VARs.

GAPA evaluates Projects and their components statuses; by using HDT based

Intelligence to eliminate gap(s). The PEMtM enables GAPA's processing in all Project's phases which are synchronized by the Transformation Development Method (TDM). The TDM uses The Open Group's Architecture Framework (TOGAF) and its Architecture Development Method (ADM).

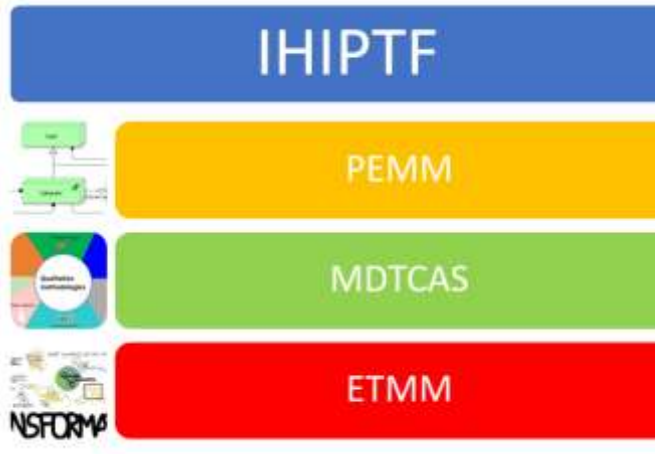
GAPA uses Factors like CSFs which can be one or more of the following: 1) Project elements/resources such as requirements; 2) Mapping and Disassembling outcomes; 3) PRWC's interfacing and outcomes; 4) Results persistence and analysis; 5) TDM's synchronization; 6) Intelligence's outcomes; and 7) Use of KPIs to link VARs to concrete ICS components. Project's management and evolution depend on GAPA, which also supports the Project's long-term strategy. GAPA is a generic mechanism which predicts XHFRs. CSAs are evaluated using CSA_DTs, where a CSA corresponds to a Project topic. CSA_DTs deliver RDP's final Phase's 1 evaluations which constitute Project's DT (Prj_DT). And APDs' evaluations depend on Project's CSAs, and these evaluations use Factors, PRWC, and GAPA. The generic MM for APDs' (MM4AD) supports CSA_DTs and Prj_DT evaluations and integrity checking.

Fig. 2. The IHIPTF's relations with other blocks.

As shown in Fig. 2. The IHIPTF offers a PEMtM, MDTCAS, and Entity Transformation Mathematical Model (ETMM). That enables the IHIPTF to support different types of methodologies and formalisms. Projects can have uncoherent objectives and Factors, which can influence: 1) Requirements engineering (or R) which use a pool of services; 2) Establishing granularity of resources and services; 3) Management of BPMs; 4) Mapping concept; and 5) Various levels of complexities. The IHIPTF is used for various types of Projects, and APDs. The IHIPTF accesses the PRWC to estimate: 1) GAPAs (Project-status); 2) To assist the MDTCAS and PEMtM, which abstract EAMs; and 3) Tune the ETMM. Because of IHIPTF's limitations (and its modules: MDTCAS, PEMtM, and ETMM) will be presented through the use of DS, Object Oriented Methodology (OOM), and BPM… Where the BPM has a central role.

3 Fundaments

3.1 The Role of Methodologies



3.2 DataSets and OOM

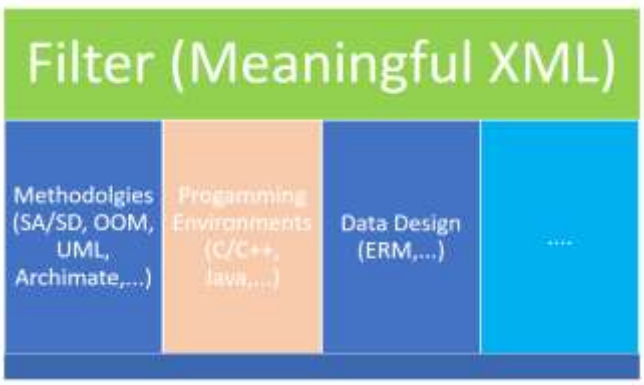


Figure 3. Using meaningful XMLs.

All ICS and APD domains, use DSs which is a common media, that offers the following characteristics [18,19,20]:

- Can be structured, unstructured, or hybrid (which can be structured and unstructured data).
- Standardize data-formats to be used by all APDs like analytics, Intelligence, and other.
- Can be conceptualized as columns and rows (like in Entity Relationship Diagrams-ERM tables and spreadsheets).
- To manage various formats like, Comma Separated Values (CSV), JavaScript Object Notation (JSON), and other to support standard-structures.
- They can be: Numerical, Bivariate, Multivariate, Categorical, and Correlation.
- They support Correctness, Performances improvements, and Usability.
- Are used for various domains like statistics, Machine Learning (ML), and other.
- Is used as a common buffer-collection, where anything can be exported to DSs.
- MDTCAS can be used a methodology which uses an IHI Common DS (IHICDS).
- IHICDSs can be interrelated to represent relationships (or R) and use GUIDs for unique identifications.
- IHICDSs are exported to XML formats, as shown in Fig. 3. Exported XML-files are used for MDTCAS, "Δ"/GAPA operations.
- They support MMs to construct AHMM variants like the AHMM4EBPM; which includes QQRMM or the HDT.
- EAMs, OOMs, (and other), unbundled services, relationships, and other, are exported to DSs.
- MMs can access (or import) such DSs or XML-files. Therefore, MMs and XML-files operations can be automated.

DSs and XML-files interactions with MMs and AHMM4EBPM, is presented for a limited set of methodologies, like the OOM, BPM, and MDTCAS. Where OOM uses DSs and XML-files to support [21,22,23, 24]:

- XML based OOM models or sub-systems as the base convention for a Project.
- Reverse engineering based on XML-files into OOMs.
- The reversed OOMs are persisted in formats like : Binary (BIN), and XML-DTD.
- Support MtMs to implement a PEMtM.
- Importing and exporting OOMs into XML is done by using the Metadata Interchange (XMI). XMIs are imported to a higher-level methodology like Unified Modelling Language (UML).
- XMI can be used to exchange OOM, UML or other between different case-tools.
- OOMs are mapped to Object Relational Mapping to synchronize with ERMs.
- ERMs map OOMs and UML Diagrams.

3.3 Technologies, EAMs, Methodologies

Refining and extracting services and resources in Projects simplify changes' requests; but that needs automated-generation of Blocks and models, and other. Automated-generation include [25]:

- The IHIPTF which enables automated-generation of EAMs, OOMs, and other types of artefacts and interfaces.
- Interfaces support links to various domains like, EAMs, Traditional management, AI-modules, external MMs, and other. Generated models and cartographies include: Networks, Data-sources, Components, Methodologies,

Interfaces, Application Programming Interfaces (API), Transactions, and other.
- Guarantees Entity's long-term sustainability.
- Supports PEMtM that automates the extraction of Blocks, BPs, and EAMs.
- Supports Polymathic analysis and design, and roadmap building.
- Implements an MDTCAS as a central methodology.

3.4 Implementing MDTCAS

MDTCAS uses MMs, Blocks, PEMtM, EAMs, Naming-conventions, Mapping-mechanisms, refined-services, relations, and other… MDTCAS models Projects and is also used for their validity-checking. The modelling considers the Enterprise structure, Project management, Data-storage(s), or the ICS and its cloud. Project's modelling operations are supported by MDTCAS and ADM based TDM. MDTCAS enables Entity's restructuring, transformational models' implementation, and Viewpoint(s) (V) selection. The TDM is used to synchronize Project's implementation and modelling operations and phases.

3.5 The Project's Operations and Phases

The Project and AHMM4EBPM use a Polymathic approach and Vs [26,27]:

- Projects need generic Polymathic Learning Processes (GLP).
- Frequent changes create huge sets of actions that in turn generate problems, which need GLP based solutions.
- Intelligence combined with GLPs, HDT, and PRWC, offer automated decision-making.
- The HDT uses: Tree-nodes, GLPs, AHMM4EBPM (and MMs), and AR.
- Intelligence is applied to all Project's operations/phases, processes, and components.
- FMS and PRWC based Intelligence, is used to select and calibrate Factors, which are used for orchestration in NLP scripts or BPMs.

4 Advanced Topics

4.1 UML, Archimate, and MDTCAS

This article focuses on BPM's usage in Projects and AHMM(). The MDTCAS that focuses on the BPM, has the following characteristics, and constraints [8,28,29,30]:

- Combines of existing and legacy methodologies, like the Structure Analysis and Structured Design (SA/SD) to be converted to BPMN.
- Relates ERMs to BPMs.
- Adapts MtM or PEMtM for: BPMs integrity-checks, Aligns Disassembling, and Used as a pattern for BPM usage.
- Adopts the right granularity-level and complies with the Artefacts Mapping Concepts (AMC) [31].
- The TDM synchronizes all BPMs implementation-operations and their evolution.
- The AHMM4EBPM supports BPMs' implementation-operations by using MDTCAS, PEMtM, and TDM to respect standards.
- BPMN can integrates common artefacts, Blocks, relationships, events…
- MDTCAS helps BPMNs to interface (other) BPM(N)s, XML-models, OOM/UML-models, Real-Time Object-Oriented Modeling (ROOM), Archimate-models, DMN-models, Process/collaboration Models (UPM), and others.

- For all mentioned the methodologies and concepts, OOM and BPM can the fundament for the MDTCAS and Blocks' design, as is shown in Fig. 4; and MMs support EAMs and AHMM4EBPM to finalize transformational-operations.
- These operations include, automated-generation of EAMs and other types of Models/Diagrams, Blocks/artefacts, catalogues, and matrixes.
- The TDM synchronizes/controls Project's BPM bases implementation-operations activities.
- The OOM and BPM use the MM for MDTCAS (MM4MT).

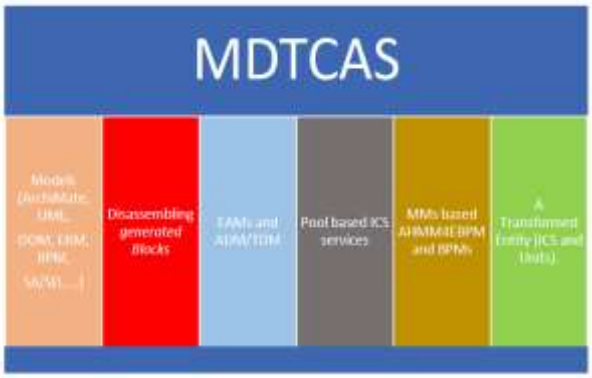


Fig. 4. MDTCAS, BPMs and AHMM4EBPM.

4.2 The Use of BPM

BPMs use and interface DSs, OOM/UML, and hence XML-files to support the following [32]:

- Projects use BPMs, and services.
- Extraction of BPMs (or choreographies) depends on Disassembling processes.
- Services are based on Service Oriented Architecture (SOA), MicroServices Architecture (MSA), or other.
- Services are consumed by BPs, and are reusable, and classified by functional properties.
- BPM Language (BPML) used to express BPs, and has the forms of high-level block-Diagram (and/or an XML standard-code). BPML is a specialization of BP and it supports the definition and description of tasks assigned to participants, and Intelligence's activities.
- BPM symbols are: Task, Sub-process, Transaction, Call, event, Message, Timer, Escalation, Conditional, Link, Error, Cancel, Compensation, and other.
- BP based Transactions (BPT) use reflection-mechnisms (automated extractions) of APD's and common services, artifacts, where a BP can map to OOM/UML's Activity Diagram.
- BPTs have the following characteristics: Interaction, Function, and Self-description.
- BP Integration (BPI) supports the usage of unbundled BPs and services in BPTs.
- BPTs support APD's transformation and ICS' inter-operability, and offers: 1) Integration of unbundled-scenarios; 2) XMI based APD's inter-operability; 3) Mapping between BPs (and its services) and EAMs/functional-domains.
- Mapping between DS and OOM; and OOM/UML with BPMN, as shown in Fig. 5.

Model Element in BPMN	Model Element in UML
A pool	A class with «service» with the same name. (whitespace characters are removed.)
A task	A method with the same name (whitespace characters are removed and the first character is decapitalized.)
A message flow	A class with «connector» with the name of *flownameConn* A class with «messageExchange» with the name of *flownameEx* A class with «message» with the name of *flowname* (where *flowname* refers the name of a message flow)
An outgoing message flow from a pool	An association role 'source' against a message exchange
An incoming message flow to a pool	An association role 'sink' against a message exchange

Fig. 5. OOM/UML mapping [32].

4.3 The BPM and MMs

Project's ICS Blocks/artefacts or EAMs/BPMs are converted to MMs which are based on Petri-Nets Model (PNM). PMN is a 4-tuple C=(P,T,I,O) model/approach as shown in Fig. 6, and has the following characteristics [33]:

- P = { p1 , p2 , ... , pn } is a finite-set of places/positions.
- T = { t1 , t2 , ... , tm } is a finite set of transitions.
- I : T → P* is an input function.
- : T → P* is an output function.
- The sets of places/transitions which are disjoint: P ∩ T = Φ.
- The value of the I (it) function, is a collection of input-places of the it transition.
- The # (pi , I(it)) notation is the number of occurrences of the pi-place in the I (it) collection.
- The value of O(it) function is the collection of output-places of the it transition.
- The #(pi , O(it)) notation is the number of occurrences of the pi-place in the O(it) collection.
- Graph's nodes are linked using directed-arcs, so that, no-two places and no-two transitions are connected directly.
- A PNM is a Work-Flow (WF or BPM) if: 1) There is "one" source-place i ∈ P such that •i=∅; 2) There is one sink-place o ∈ P such that o•=∅; and 3) For every node x ∈ P ∪ T is on a path from i to o.

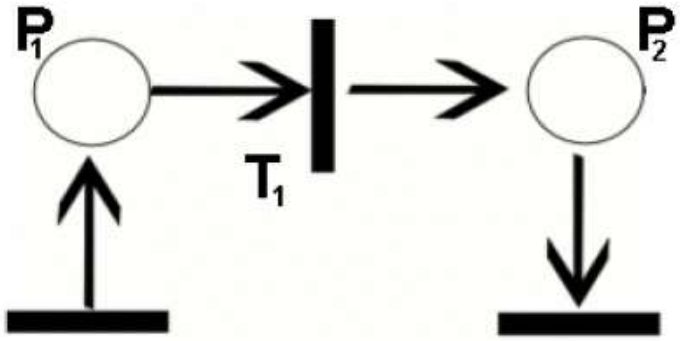


Fig. 6. A Petri-Nets Diagram [33].

The OOM and BPM use the following MM4BP generic characteristics:

- Uses consecutive Iterations (Itr).
- Uses BPM Events (Evt).
- Uses modelling Relations (Re).
- A BPM has Tasks (Tsk).
- Uses evaluation (eval).
- BPM maps to Activity-Diagram (AD).
- Uses Weightings (W).
- ….
- Extends the MM4FC, MM4PM, MM4GP, MM4PR, MM4CM, MM4AD, and MM4OO.
- The MM4BP is BPM/BML's structure and integrity-checker.
- ….
- For an Itr, eval(BPM-gap) (1.1).
- Tsk (Itr)= ∑Tsk (1.2).
- Sub-BPs (Itr)= ∑ Tsk (Itr) (1.3).
- BPT (Itr)= ∑ Sub-BPs (Itr) (1.4).
- Call (Itr)= ∑ BPT(Itr) (1.5).
- …..
- BPMs(Itr)=∑BPM+∑Evt (1.6).
- AD(Itr)= ∑AD+∑ Re (1.7).
- Δ(BPMs(itr))=∑CSF(i)*W(i) (1.8).
- G=GAPA(Itr)-GAPA(Itr-1) (1.9)
- GAPA(PRWC)=G (1.10).

BPMs, EAMs, pool(s) of unbundled-services, relationships, and other artefacts are

exported to MMs via XML-format based DSs. As already illustrated a Project uses OOM/UML, BPM, MDTCAS (and other) diagrams that are fed in DSs, MMs, and hence in XML-format (for import and export operations). The AHMM() is a set of MMs, and the AHMM4EBPM is a set of MMs that are needed by the BPM.

5 The AHMM4EBPM

5.1 A Specific Mixed-Method

The use of simplistic quantitative-analysis, is limited and the AHMM4EBPM needs a qualitative method that enriches the GLP. BPM relevant MMs are combined (and synthesized) to offer the AHMM4EBPM that is for Project's BPM-modules integrity-checking, modelling support, GAPA, financial/risk-analysis, , and other types of critical operations. As already mentioned, MMs are based on DSs that are linked-interrelated and they also include mixed-research method or QQRMM. The mixed-research method is supported mainly by a qualitative/HDT method which calls to quantitative methods. The AHMM4EBPM has a composite-structure that includes [34]:

- A statical-view, which presents basic definitions, Blocks, Diagrams, and Relations.
- A behavioral-view that is an instance of the statical-view.
- Is the skeleton of the IHIPTF and BPM based Project's modules.
- Defines BPM patterns (and interfaces) to other technologies and frameworks.
- Includes definitions for APDs.
- Integrates the QQRMM and defines the initial set of Project problem-types and their related Factors.
- The HDT inputs various sets like: Constraints, Rules, Data-sets, Configurations, and other, which are stored in IHIPTF's repository.
- The QQRMM based HDT evaluates problem-types, to detect violations (uses constraints and rules).
- AR based GLP is optimal for Projects, because it persists experiences and knowledge. AR uses processes to deliver solutions for problems-types.
- The QQRMM based HDT and related AR based GLP enhance the Project's and AHMM() transformational capacities.

5.2 The AHMM

The Polymathic AHMM() Transformational structure, as shown in Fig. 7. embeds the QQRMM and various MM domains like Boolean algebra and other.

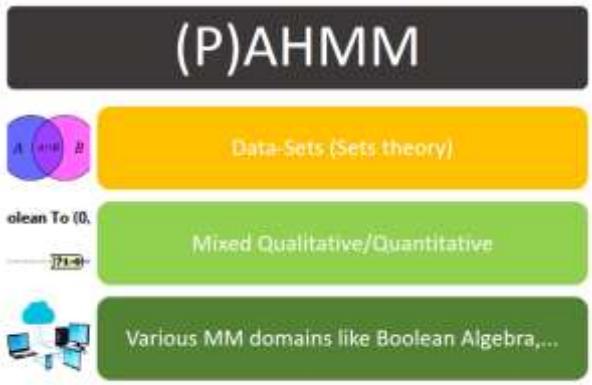


Fig. 7. The PAHMM structure.

The AHMM4EBPM's or AHMM(EBPM) transformational capacities depend on [35,36,37,38,39,40]:

- The FMS and PRWC identify and assess the Project's strategic Factors and supports its risks' management; in order to guaranty Entity's business integrity. Integrity is checked and maintained by the (P)AHMM(), which also constitutes its basic structure.
- A Project uses an MMs holistic, and Polymathical transformational model (and structure), where the (P)AHMM()

and variants (like the AHMM4EBPM), is a set of inter-related MMs and hence DSs.

- For any Project or APD, and common requirement(s) (or problem-type(s)), the (P)AHMM() based Intelligence identifies initial-sets of Factors and their corresponding sets of actions, to be executed by the HDT based GLP.
- Actually there is a huge lack of a Polymathic-holistic concept for Projects, that was proven by the PRLR and XHFRs, and that is why this the reason that this article proposes the (P)AHMM().
- The (P)AHMM() uses and interfaces to the following IHIPTF's artefacts and resources: 1) Various articles and resources related to Projects and FMS/PRWC, and other; 2) The author's works, and IHIPTF; 3) Project's and (P)AHMM()feasibility; 4) Initial sets of Factors; and 5) RDP's use of the Empirical Engineering Research Model (EERM).
- The (P)AHMM() is a subset of real-world system's structures, behaviours, and capabilities, where it is a description of a limited, modelled, integral, and accurately defined reality, that abstracts the Project and its modules.
- The (P)AHMM() offers abstractions (or MMs or Patterns) of a real-world construct or physical system.

5.3 The (P)AHMM() Construct

A Project's evolution is a series mathematical transformations (V(T)), that has the following characteristics:

- MDTCAS is the glue for Project's components.
- Extends the MM4FC, MM4PM, MM4GP, MM4PR, MM4CM, MM4AD, MM4OO, MM4BP, MM4MT, MM4PE, MM4UP, MM4MM, MM4MD, MM4IN, and MM4AH.
- P is for a Pattern.
- Qn() is a quantitative function.
- Qu() is a qualitative function.
- W is a weigting.
- ….
- MM=∑V(module)+∑P+∑MDTCAS (2.1)
- AHMM(Domain)=U MMs (2.2)
- MM4AH(Itr) as an instance = Intelligence(Itr) + other modules (2.3)
- ….
- The Generic AHMM's Formulation
- AHMM()=U ADM+U MM4AH(Itr) (2.4)
- ….
- AHMM's Application and Instantiation for an APD
- Domain=PRWC (2.5)
- PAHMM4(Domain)=U ADMs+ MM4AHs(Domain) (2.6)
- ….
- The AHMM() can be modelled using the ETMM formula that abstracts a Project.
- W1 and W2 are delivered by the AHMM().
- AHMM()=W1*AHMM()_Qn+W2*AHMM ()_Qu (2.7).
- AHMM()=∑MM() for Project(Itr) (2.8).
- ….
- ETMM = ∑ AHMM() instances (2.9).
- ETMM's OF optimization is done by using constraints and extra variables that need to be tuned (2.10).
- ….
- Prj=∫ F(ETMM(Itr)) x GAPA(Itr) (2.11).
- mc E=U RPrj (2.12)
- E=∑ mc E (2.13)
- E=U OUs (or Sectors) (2.14)
- E=U Prj + ∑ ICS + … (2.15)

6 The PoC

6.1 Basic Preparations and Setup

This PoC uses the IHIPTF and the AHMM4EBPM which use sets Factors. The

Factors are used to process CSA_DTs. Factors are linked to specific Project and Intelligence mechanisms, where the AHMM4EBPM makes calls to NLP scripts. The AHMM4EBPM maps relationships between ICS, requirements, Project's Blocks, identifiers, and CSAs. The PoC starts-up IHIPTF's client development environment-interface, which is shown in Fig. 8. IHIPTF client-interface enables NLP development activities.

Fig. 8. IHIPTF client-interface.

The NLP client-interface implements scripts to process Projects CSAs. Intelligence uses the AHMM4EBPM that offers HDT actions to offers solutions.

6.2 Phase "1"

Preparing DSs and their import/export interactions XML-files. These XML-files are used by the AHMM4EBPM and its MMs, as well as MDTCAS, OOM, BPM, and other diagrams and artefacts. In this PoC and its related Applied Case Study (ACS), shows an AHMM4EBPM based transformation where BPMs, MMs and DSs the main constructs. A DS is used by various types of methodologies and technologies. BPMs use DSs during the implementation phase that is coordinated by the IHIPTF a transformation framework is needed [42].

The AHMM4EBPM interfaces Intelligence and PRWC/Factors which are shown and evaluated in Table 1, and using the CSA_DT's Tables Weighting and Rating Enumerator (CTWRE) that is shown in Figure 9. The AHMM4EBPM maps to MMs, Project's resources and the PRWC defines relationships between the Project, FMS, and Factors.

CTWRE Label	Limit's Value	Description	Color
Proven, Mature	9.01-10.00	Success	Green
Possible, Feasible	8.51-9.00	Success	Green
Risky	8.01-8.50	Important Risk	Yellow
Complex	7.01-8.00	Unclear	Red
VeryComplex	5.01-7.00	Will probably fail	Red
Impossible	0.00-5.00	Failure	Red

Fig. 9. The CTWRE's values.

The APD that is the usage of BPMs and the used CSA_DTs contain the evaluation of a Project CSA, where a specific CSA corresponds to a concrete Project-topic. RDP's final Phase's "1" evaluations are the synthesis of all CSA_DTs or Project's (PRJ) DT (PRJ_DT). APDs' evaluations use FMS, PRWC, and Factors to enforces Intelligence's processing and to avoid regressions or XHFRs. IHIPTF Enumerators are applied to all CSAs/CSA_DTs and PRJ_DT's processing and final-findings, where:

- CSA_DT=AVG(∑CSF_KPI) (3.1).
- PRJ_DT=AVG(∑CSA_DT) (3.2).
- Phase_1=PRWC(PRJ_DT) (3.3).

CSA Category of CSFs/KPIs	Transformation Capability	Average Result	Table CSA_DT
The RDP's Integration	Mature	9.0	
The DSs and OOM	Possible	8.20	
The Role of MDTCAS, EASD...	Possible	8.00	
The Role of PRWC and FMS	Possible	8.0	
The Role of IHIPTF and its modules	Complex	7.0	
The Role of BPM	Possible	8.0	
The Role of AHMM4	Complex	7.0	
Phase's 1 Outcome (AHMM4EBPM)	VeryComplex	6.0	

Evaluate First Phase

Table 1. The RDP's outcome is 8.6.

After initializing the IHIPTF and its modules, main-client, Factors/CSFs were linked to a selected HDT node. Table 1 presents Phase's 1 results and that shows that the AHMM4EBPM

is “Feasible”. AHMM4EBPM’s main constraint to implement the PRWC is that CSAs having an average result below 8.0 will be ignored. As Phase 1 is Feasible.

6.3 The ACS and Applied BP(M)s

PoC’s uses the ArchiSurance ACS which is an insurance management system that has a legacy ICS (includes a mainframe), and Intelligence (KMS/DMS). For the AHMM4EBPM, the ArchiSurance-ACS is optimal, because it applies the merger of business system’s landscape which is siloed, which causes major data and ICS redundancies, functional-overlaps and archaic maintenance/integration activities. This ACS analyses the transformation of the “claim files service, customer file service” [43]. For the AHMM4BPM the Business Process View (BPV) (Baseline) (BPVB) is relevant, where an ArchiMate BP groups-behaviour based on ordering of activities that produces a set of products (or services). BPM based EAMs takes into account the most important BPs (and their relationships), but does not show all the details their flows. This PoC uses a BP Viewpoint which shows a high-level structure and composition of (1 or n) BPs (in TOGAF it is referred to as the Process Flow Diagram (PFD)). Fig. 10, presents 2 central BPs of ArchiSurance, with their sub-BPs: 1) Issue new-policy; and 2) Handle claim.

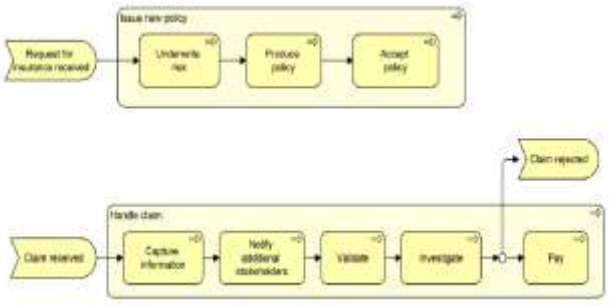


Fig. 10. The BPVB [43].

The Application Behaviour View (ABV) (Target) (ABVT) of ACS’ data-warehousing architecture that is shown in Fig. 11. Customers use these data that is processed to create customer-specific-profiles that are in-turn used for calculation of their insurance-premiums. This data is processes and aggregated to offer new insurance-products and to adjust Entity’s risk-exposures.

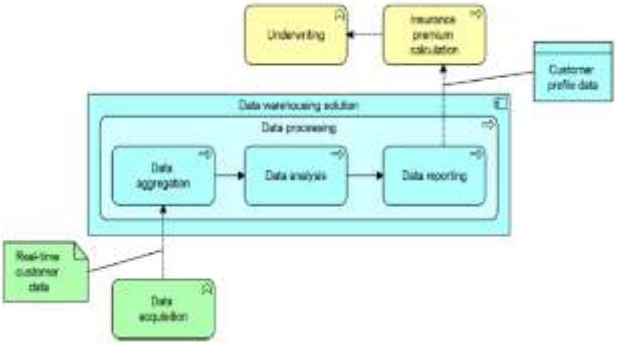


Fig. 11. The ABVT [43].

6.4 MDTCAS and BP(M)s’ Inter-Operability

MDTCAS that includes BPM(N), can support BMPs’ inter-operability by [44, 45]:

- Import/exporting XML formats.…
- Exchanging BPMN models, where serialized XML-files contain both the model’s semantics and the diagram-interchange information.
- BPMs conversions to OOM/UML activity diagrams using the eXtensible Stylesheet Language Transformations (XSLT).
- Because of tools’ limitations and efficiency an Activity diagram is more adapted.
- It should tool independent and the use of XML metadata

interchange representation of both models (as input and output) and by using XSLT for transformation.

6.5 MDTCAS and TDM

For this PoC, a Polymathic approach is tested by setting-up the ADM based TDM phases that look as follows:

- Phase A (Architecture Vision) establishes a BPM and MDTCAS based development cycles; and setting-up constraints and goals.
- Phase B (Business Architecture) establishes Project's target-architecture which realizes key Project's requirements.
- GAPA phase uses the Application Communication Diagram that shows the transformed and modelled BPMs based ICS and the target application-landscape.
- Phase D (Target Technology Architecture) presents ICS' transformed infrastructure.
- Phases E and F (Implementation and Migration Planning) presents the transition-architecture and intermediate solutions/situation.

6.5 Phase "2"- Solving a Problem-Type

Intelligence solves problem-types, where Factors have related sets of actions that are executed in a given HDT-node. And for that the action CSF_AHMM4EBPM_Feasibility_Procedure (from the PRJ_DT) was executed and delivered a set of solutions. Solving problem-types includes the execution of actions and offering possible solutions for various Project's operations, where each action can recreate a new Problem-instance and that creates the AR based HDT-tree. The HDT uses the QQRMM that contain objective-functions which: 1) In Phase 1, the AHMM4EBPM, implements NLP scripts to process CSA_DTs, and related PoC's constraints like the CSF_AHMM4EBPM_Feasibility_Procedure; 2) Intelligence is configured and uses the PRWC and FMS to support the HDT; 3) Links HDT-node to data-structures; and 4) The HDT executes the CSF_AHMM4EBPM_Feasibility_Procedure to deliver solutions. Solution-nodes activities are: 1) NLP-scripts are called-executed by IHIPTF's modules like the GAPA, FMS, and PRWC; 2) These NLP-scripts are executed in the background to offer values; and 3) These resultant-values are converted into actions, conclusions, and recommendations.

7 Conclusion

In this article the focus is on AHMM() and its AHMM4EBPM variant; where the AHMM4EBPM analyses and supports BPM based Projects (or Project's BPM components). The RDP offers the following list of BPM, common, business, EA, technical and managerial conclusions and recommendations:

- The RQ is: "Which AHMM4EBPM characteristics, elements, and structure are requested to enable mainly BPM and services-based Projects and Entity's sustainable evolution(s)?"
- As mentioned for reading this article, it is recommended to refer to IHIPTF's related guides, and Project's fundamental works, which are: 1) The AHMM4PROJECT [1]; 2) The IHIPTF Guide [2]; and 3) The IHIPTF Glossary [3].
- The major managerial finding-recommendation that was generated by the previous research phases was that the business transformation manager must be an architect of adaptive business systems.

- This RDP is based on QQRMM which uses Factors is used by the AHMM4EBPM.
- A Project starts with the U4BMP, which uses RPs; which in-turn delivers services and resources. These processes are automated for the generation of Blocks and EAM/EBPM models.
- BPMs integrate, use and interface DSs, OOM/UML, (and therefore XML-files) to support: 1) EAMs, and services; 2) Extracts BPMs (or other choreographies); and 3) Services (SOA, MSA or other).
- The MDTCAS focuses on BPM(N)s, which combines of existing and legacy concepts and methodologies.
- BPM related MMs are used to support the AHMM4EBPM that is used for BPM-modules' integrity-checking, modelling, GAPA, and other critical activities.
- The AHMM() (and its AHMM4EBPM variant) concept, strategy, and implementation is feasibility.
- The AHMM4EBPM applies qualitative approach that enriches the GLP.
- The AHMM4EBPM relates various selected BPMs, EAMs, Factors, and MMs that are inter-related.
- The AHMM4EBPM, as well as all ICS and APD domains, use DSs which is a common artefact/media, that can be generalized.
- AHMM4EBPM based Intelligence replaces obsolete legacy DMS.
- The PoC uses the IHIPTF and Factors and the he final outcomes deduces that the proposed AHMM4EBPM is complex but feasible.

Acknowledgement:

The AHMM4EBPM is the MM to be independently implemented the other MMs well be implemented in the near future. These MMs will serve for the development of the following articles: 1) The AHMM4EBPM based Processing Computer System; and 2) The AHMM4EBPM based AI-Subdomains Integrator.

References:

[1] Trad, A. The Applied Polymathical/Holistic Mathematical Model for Enterprise Transformation Projects (AHMM4PROJECT). IBISTM. France. EU. 2024.

[2] Trad, A. The In-House Polymathic Transformation Framework (IHIPTF)-The Guide. IBISTM. France. EU. 2024.

[3] Trad, A. The In-House Polymathic Transformation Framework (IHIPTF)-The Glossary. IBISTM. France. EU. 2024.

[4] Trad, A. The Business Transformation and Enterprise Architecture Framework-The Applied Holistic Mathematical Model's Persistence Concept (AHMMPC). WSEAS. 2019.

[5] Trad, A. & Kalpić, D. An Applied Mathematical Model for Business Transformation and Enterprise Architecture-The Holistic Mathematical Model Integration (HMMI). Journal: IGI Book. 2019.

[6] Trad, A., & Kalpić, D. Using Applied Mathematical Models for Business Transformation. IGI Complete Author Book. IGI Global. USA. 2020.

[7] Trad, A. The Transformation and Enterprise Architecture Framework: The Applied Holistic Mathematical Model for Geopolitical Analysis (AHMM4GA). Book: Responsible AI and Ethical Issues for Businesses and Governments. Pages 80-127. IGI Global. USA. 2021.

[8] Trad, A. POLYMATHIC APPROACH FOR ENTERPRISE TRANSFORMATION PROJECTS-IMPLEMENTING A BUSINESS META-MODEL THAT RESPECTS ENVIRONMENTAL SUSTAINABILITY (PETP-IBMMES). SCF. Journal Article. 2024.

[9] Trad, A. Enterprise Transformation Projects-A Mathematical Models' based Enterprise Refinement Concept (ETP-ERC). Journal: International Journal of Applied Mathematics, Computational Science and Systems Engineering. Volume 5. Pages 30-51. 2023.

[10] Trad, A. Enterprise Transformation Projects-The use of the Polymathic Rating and Weighting Concept (PRWC). IGI-Global. USA. 2024.

[11] Cuemath (2024). Math Symbols. https://www.cuemath.com/numbers/math-symbols/

[12] MathVault (2024). Mathematical Symbols. MathVault. https://mathvault.ca/hub/higher-math/math-symbols/

[13] Myers, B., Pane, J., & Ko, A. Natural programming languages and environments. ACM New York, NY, USA. 2004.

[14] Lankhorst, M. Enterprise Architecture at Work Modelling, Communication and Analysis. Springer, Berlin, Heidelberg. Germany. 2009.
[15] Peterson, S. Why it Worked: Critical Success Factors of a Financial Reform Project in Africa. Faculty Research Working Paper Series. Harvard Kennedy School. 2011.
[16] Putri, N., & Yusof, S.M. Critical success factors for implementing quality engineering tools and techniques in malaysian's and indonesian's automotive industries: An Exploratory Study. Journal Proceedings of the International MultiConference of Engineers and Computer Scientists. Volume 2. Pages 18-20. 2009.
[17] Trad, A. Business, Economic, and Common Transformation Projects-The Polymathic Ratings and Weightings Concept for AI (PRWC4AI). IGI-Global. USA. 2024.
[18] Holistics. Dataset's Best Practices. Holistics. 2024. https://docs.holistics.io/docs/datasets/best-practices
[19] Sheldon, R. What is a data set? 2024. https://www.techtarget.com/whatis/definition/data-set
[20] Siman, E. What Is a Dataset? Definitive Guide. BrightData. 2024. https://brightdata.com/blog/web-data/what-is-a-dataset
[21] Trad, A. & Kalpić D. Building an extensible markup language (XML) based Object Mapping System (OMS). Journal: ITI-IEEE. 2001.
[22] SAP. The PowerDesigner XML Model File Format. SAP. 2010. https://infocenter-archive.sybase.com/help/index.jsp?topic=/com.sybase.infocenter.dc38628.1530/doc/html/rad1232022061467.html
[23] SAP. PowerDesigner-Object-Oriented Modeling. SAP. 2016.
[24] Bird, L., Goodchild, A., & Halpin, T. Object Role Modelling and XML-Schema. Distributed System Technology Center (DSTC), University of Queensland, AUSTRALIA. DOI: 10.1007/3-540-45393-8_23. 2000. https://www.researchgate.net/publication/221269041_Object_Role_Modelling_and_XML-Schema
[25] Burke, P. THE POLYMATH A CULTURAL HISTORY FROM LEONARDO DA VINCI TO SUSAN SONTAG. YALE UNIVERSITY PRESS. NEW HAVEN AND LONDON. 2020.
[26] Clark, M., Fletcher, P., Hanson, J., Irani, R., Waterhouse, M., & Thelin, J. Web Services Business Strategies and Architectures. Apress. USA. 2013.
[27] Trad, A. Enterprise Transformation Projects-The Polymathic Enterprise Architecture Based Generic Learning Processes (PEAbGLP). IGI-Global. 2024.
[28] The Open Group. Introduction to the Architecture Development Method (ADM). The Open Group. USA. 2011.
[29] The Open Group. TOGAF 9.1. The Open Group. The Open Group. USA. 2011.
[30] Trad, A. A Relational DataBase based Enterprise Transformation Projects. Journal: International Journal of Mathematics and Computers in Simulation. Volume 17, Pages 1-11. Publisher: NAUN. 2023.
[31] Trad, A. Organizational and Digital Transformation Projects: A Mathematical Model for Building Blocks-Based Organizational Unbundling Process. Book: Global Perspectives on Robotics and Autonomous Systems: Development and Applications. Pages 206-239. IGI Global. 2023.
[32] Wada, H., Suzuki, J., & Oba, K. Leveraging Early Aspects in End-to-End Model Driven Development for Non-Functional Properties in Service Oriented Architecture. Journal of Database Management 22(2):93-123. DOI: 10.4018/jdm.2011040104. 2011.
[33] Osuszek, L. Converting BPM Models to a mathematical model-BPM optimization, Part 3: Application of Petri Nets to XPDL Workflow Optimization. IBM. 2012.
[34] Hine, G. S. C. The importance of action research in teacher education programs. In Design, develop, evaluate: The core of the learning. environment. Proceedings of the 22nd Annual Teaching Learning Forum, 7-8 February 2013. Perth: Murdoch University. 2013. http://ctl.curtin.edu.au/professional_development/conferences/tlf/tlf2013/refereed/hine.html
[35] Morawski, R. An application-oriented mathematical meta-model of measurement. Elsevier. Journal Measurement: Volume 46, Issue 9, November 2013, Pages 3753-3765. https://doi.org/10.1016/j.measurement.2013.04.004. 2013.
[36] Easterbrook, S., Singer, J., Storey, M., & Damian, D. Guide to Advanced Empirical Software Engineering-Selecting Empirical Methods for Software Engineering Research. F. Shull et al. (eds.). Springer. 2008.
[37] Polderman, J., & Willems, J. Introduction to Mathematical Systems Theory: A Behavioral Approach. (Texts in Applied Mathematics) 2nd Edition. Springer Verlag. Germany. 1998.

[38] Hinkelmann, K. Modelling in Enterprise Architecture. University of applied sciences northwest Switzerland. Business School. Switzerland. 2016.
[39] Syynimaa, N. Enterprise Architecture Adoption Method for Higher Education Institutions. Doctoral Thesis. Informatics Research Centre Henley Business School University of Reading. UK. 2015.
[40] Giachetti, R. A Flexible Approach to Realize an Enterprise Architecture. Department of Systems Engineering, Naval Postgraduate School, Monterey, CA USA. Presented: New Challenges in Systems Engineering and Architecting. Conference on Systems Engineering Research (CSER). St. Louis, MO. Elservier. 2012.
[41] Trad, A. Applied Holistic Mathematical Models for Dynamic Systems (AHMM4DS). Journal: International Journal of Cyber-Physical Systems (IJCPS). Volume 3. Issue 1, Pages 1-24. IGI Global. USA. 2021.
[42] Trad, A., & Kalpić, D. The Business Transformation Framework and Enterprise Architecture Framework for Managers in Business Innovation-An applied holistic mathematical model (AHMM). IGI Journal of Science and Technology. IGI-Global. USA. 2019.
[43] Jonkers, H., Band, I., Quartel, D. & Lankhorst, M. ArchiSurance Case Study. The Open Group. 2016.
[44] Sparx. Exchanging BPMN Models. Sparx Systems Pty Ltd. 2024. https://sparxsystems.com/enterprise_architect_user_guide/17.0/modeling_languages/bpmn_20_xml.html
[45] Macek, O., & Richta, K. The BPM to UML activity diagram transformation using XSLT. Conference: Proceedings of the Dateso 2009 Annual International Workshop on DAtabases, TExts, Specifications and Objects, Spindleruv Mlyn, Czech Republic, April 15-17, 2009.