Enterprise Architecture Governance of Excellence

Peter Hillmann[a], Mario Kesseler, Diana Schnell, Goran Mihelcic and Andreas Karcher
Universität der Bundeswehr München, Department of Computer Science,
Werner-Heisenberg-Weg 39, 85577 Neubiberg, Germany

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Abstract: Every organization has an architecture that must be adapted to the given circumstances and future needs in order to stay competitive. Particularly in the case of federated structures, there is a high degree of complexity in terms of both business and IT. For a smooth process and a goal-oriented management, this should be done as proactively as possible in an orderly manner. To make this possible, the principles of governance have to be applied. This forms the organizational basis for *Enterprise Architecture Management*. It creates high-quality information that is used for strategic and operational decisions. The challenge we address is the lack of *Enterprise Architecture Governance* with focus on a federated environment. Our goal is a detailed and applicable concept for *Enterprise Architecture Governance*. For this purpose, the several components are examined more closely and detailed explanations are given in a compact form. The evaluation is based on practical examples in both industry and government.

1 MOTIVATION FOR GOVERNANCE

Every company and every organization has an *Enterprise Architecture* (EA), regardless of whether one is aware of it. So, EA is always in the area of tension between unstructured ad-hoc adaptation and planned, structured change. This is where *Enterprise Architecture Management* comes in for a controlled development. We define *Enterprise Architecture Management* (EAM) in line with definition of EA (Buckl et al., 2010) as follows: *EAM is a continuous and iterative discipline for the structured further development, adaptation, and improvement of an organization. The goal is to align the company and their operation as a whole on the basis of a strategy, taking the environment into account. This includes the areas of governance and compliance, finance and risk, roles and processes as well as IT. It is essential that they are coordinated with each other with goal of Business-IT-Alignment.*

EAM requires a framework with a coherent set of methods and principles for designing the organizational structure, business processes, information, applications, systems and infrastructure. It relies on an adequate organizational form with adapted processes, roles and responsibilities as well as functioning committees (Inge, 2022; Tiemeyer, 2023).The high importance of structured business planning through EA methods is reflected in the regulations and decrees of several governments. In the USA, the Clinger-Cohen Act mandated the use of EAM for all U.S. federal agencies (U.S. House, Committee on National Security, 1996; U.S. Federal Government, 2012). A well-known example of non federated usage is the U.S. Department of Veterans Affair (U.S. Department of Veterans Affairs, 2023).

Therefore, we need governance to establish the organizational structures for an EAM. It ensures up-to-date, complete, and high-quality information that is used for strategic and operational management. We define *Enterprise Architecture Governance* (EAG) as follows: *EAG is used to define goals and strategies. It encompasses the control, administration and monitoring of architecture-related work to achieve required business outcomes by evaluation of risk and chances. This includes establishing frameworks with rules, processes, actions, roles, and control mechanisms for structuring, managing and maintaining EA. It ensures that EA is effectively implemented, sustained and regulated. It enforces compliance with standards, guidelines and best practices to assure*

[a] https://orcid.org/0000-0003-4346-4510

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control, transparency and accountability within an organization.

Governance can be divided into different areas (Schelp and Stutz, 2007). The all-encompassing level is thereby described by the corporate governance. This also includes federal associations. A subset of this is the actual EAG, which is divided into the areas of business architecture governance and IT governance. The challenge we address is a detailed description for EAG and the missing link for *Enterprise-IT-Governance* with focus on federal environments, see Figure 1. Our goal is a detailed and applicable concept for EAG, which goes in line with the large frameworks of COBIT, TOGAF, and ITIL.

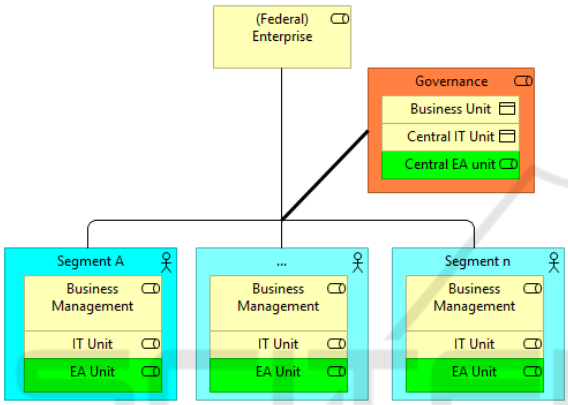

Figure 1: Abstract structure of Enterprise-IT-Governance for coordination and management in federal cooperations.

Separation of process, content, and context is critical to successful governance. This allows for the description of governance matters without reciprocal influence. The content-independent approach ensures flexible applicability. According to COBIT (ISACA Germany, 2019), functioning governance helps to identify and address problems at an early stage. We see it as an proactive as well as reactive discipline. By describing the components and their relationships that constitute the whole enterprise, it provides a road map for business and technological change (Rybaric, 2020). An enterprise architecture is a structured process for the implementation of an organisation's vision and strategy for effective change. It links the strategy to the execution by bringing the decision makers and the technical teams closer together and providing them with the information they need. This is done by creating, communicating and improving the key principles and artefacts that describe the future state of the enterprise and enable it to evolve.

2 PROBLEMS AND REQUIREMENTS

Our example comprises a conglomerate of companies focusing on energy systems, mobility solutions and medical technology. Business units are given a degree of autonomy in their development because they know best how to evolve their capabilities. There are various inter-dependencies between the business units in terms of internal processes and reuse of existing products. All units require, among other things, human resources and financial management as well as other functions. In addition, sub-products from the energy systems are used in mobility solutions, for example. In order to make targeted use of these synergy effects between the business units as a joint company, this federal structure requires holistic coordination. The goal is to improve cooperation and integration. The approaches of EAG are suitable for this purpose, whereby these are to be transferred into a federal context.

We see the following challenges for EA in general and especially for collaborations on a federated EA level:

- **Lack of Clear Purpose:**
  Imprecise overall organizational goal of EA in managing and maintaining the relation between business innovations and complexity of growing IT systems.
- **Stakeholder Acceptance:**
  Missing understanding and support about the usefulness of EA in business development and establishment of business collaborations for preplaned, structured and organized procedures.
- **Lack of Oversight:**
  Missing continuous overview and thus of the connection from the upper business level to the lower IT-technical realization level aligned with the strategic goals for proper governance and management.
- **Heterogeneous Structures:**
  Ingrained procedures and legacy systems create diversity and complexity, particularly in federal alliance with different approaches.
- **Different Frameworks:**
  Usage of multiple EA frameworks and other approaches require alignment and dedicated application descriptions.
- **Difficulty in Integration:**
  Challenging interplay of EA approaches with other management disciplines like project and change management for gaining synergy of holistic thinking and consistent planning.

Therefore, the following research questions will be addressed:

1. How could a federated enterprise structure be organized for an efficient collaboration?
2. What structure of *Advisory Boards* are needed and how they should they be organized to make appropriate decisions?
3. What kind of architecture resources and skills are recommended?
4. How should *Multi-Portfolio* controlling be handled?
5. What kind of interfaces can occur and how could they be approached?

In summary, we obtain the following main requirements for an EAG of federated enterprise management:

- **Collaborative Work Possibilities:** Support employees work and interaction to achieve a common goal in ways that benefit the enterprise.
- **Coordinated Processes:** Guiding the overall business and EAM process towards a meaningful goal between interdependent processes in terms of syntax and semantic through the entire life cycle.
- **Handling of Enterprise and Projects Artefacts:** Holistically structured and controlled architectures with homogenization and generalization to reduce complexity for overall simplification.
- **Transparency and Integration:** Clear presentation and easy access to agreed results with version and variant traceability for all stakeholders.
- **Synchronization and Conflict Management:** Alignment of artifacts and processes for a cooperative approach and integrated collaboration via working groups.
- **Artefact Maintenance and Maturity:** Regular review of results for relevance and timeliness to achieve higher sophistication.

3 RELATED WORK

In the area of governance, the frameworks of TOGAF (The Open Group, 2022), COBIT (ISACA, 2019), and BTS (Business Technology Forum, 2019) provide initial information. All ot them have a large scope and offer only abstract high-level descriptions. So these are not practical, especially with regard to small companies.

The compact approach of Hanschke (Inge, 2022) and Behara (Behara, 2022) aims directly at governance concerns. Similarly, Tiemeyer (Tiemeyer, 2023) provides a description for modern architectures. While these designs list the essential areas, it does not offer specific suggestions and structures.

For EAM, ADOIT offers an *Airport Case Study* (BOC Academy, 2017) with detailed explanations. However, these cannot be adapted to a federated governance approach.

With the goal of stakeholder management, Kurpjuweit (Kurpjuweit, 2009) provides a structured approach. Furthermore, Obermeier (Obermeier, 2014) and the Federal Republic of Germany (Beauftragten der Bundesregierung für Informationstechnik, 2022) provide a specific approach for public administration. Both also describe best practices and guidelines for creating artifacts. These are included here and kept compatible.

ITIL (AXELOS, 2019) offers more in-depth information on governance with version 4. However, these have an IT specific focus and do not provide concrete suggestions. An interaction with the ITIL specific *Service Knowledge Management System* is planned.

A deep insight into EAG is provided by the University of Columbia (University Columbia, 2023). Suitable parts are abstracted and adapted. Subsequently, the extension for the federal context takes place.

Especially in the focus of a federated environment considered here, none of the comparable frameworks provides a suitable approach.

4 CONCEPT OF EA GOVERNANCE FOR FEDERATED ENTERPRISE MANAGEMENT

For an efficient interaction of a federally structured Enterprise, different domains have to be addressed. Figure 2 shows an overview of the essential domains and their interrelationship for a functioning EAG. The interrelationships extend to horizontal and vertical domains, anchoring a holistic approach across the entire organizational structure. Our integrative approach using EA fosters the collaboration of the federated grouping. Only through their more precise design can a goal-oriented EAM take place. In particular, our concept reveals the expected interfaces and transition points that need to be addressed. With this concept, corresponding methods and coordination demands are identified. Requirements for processes, transfer points and information become apparent, whereby a kind of workflow chain or network is created. For this purpose, corresponding workflows,

communication channels and formats have to be coordinated in order to realize a professional exchange in a federal context. Therefore, we describe operational interoperability with unified management structures. Application to multiple segments generates a multiplier effect with regard to an emergence across the federal structure.

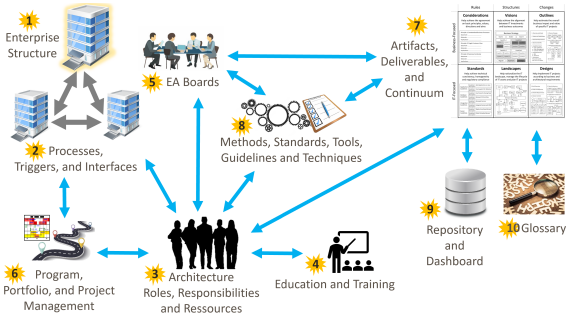

Figure 2: Essential domains and their interrelationship for a functioning EAG.

4.1 Enterprise Structure

Within the federal affiliation, we have developed a generic basic structure that can be adapted to a respective enterprise. Figure 3 shows the reference model with the goal of structured governance. Based on the design, this reveals interfaces between the business units where coordination is mandatory.

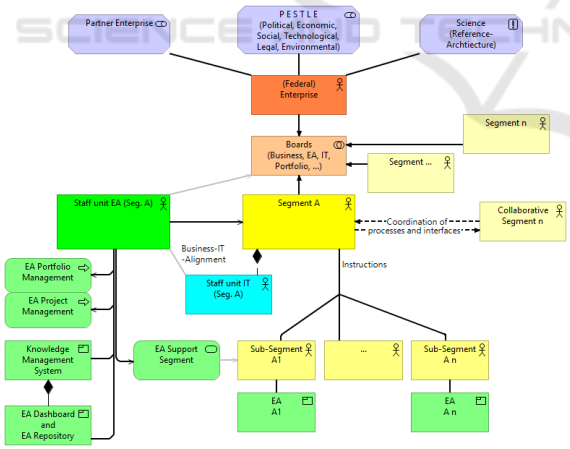

Figure 3: Reference model for structuring of *Federale Enterprise Architecture* (according to *ArchiMate*, colors self-selected with regard to grouping).

We start from Segment A in the middle, which belongs to a larger enterprise, but can itself have several sub-segments. The federated enterprise is externally influenced by other cooperation partners and *PESTLE* (Aguilar, 1967) aspects as well as by science and research. In particular, reference architectures are listed here in the context of EA. On the same level as the considered Segment A, there are further segments in the federated context. These cooperation is managed via boards. According to the *Business-IT-Alignment*, Segment A includes an IT staff unit. This unit is in collaboration with an IT unit at enterprise level via coordination bodies. Our focus is on the associated EA staff unit from Segment A. It supports Segment A in its daily business and also coordinates with the higher-level enterprise and the sub-segments as well as IT. For the cooperation in the superordinate federal enterprise, corresponding boards are to be established for the various topic complexes, such as architectures, IT and portfolio integration. The same applies, if necessary, to the subordinate business units. In accordance with the hierarchical structure, instructions and directives can be made here from top-down. For the cooperation of segments on the same level, interfaces are created with the objective of collaboration. Here, no direct specifications can be made on the basis of the hierarchy. Therefore, individual coordination of products, processes and interfaces is required and mandatory support is provided by the EA staff unit.

We see three main cases for interfaces between segments. If the segments use the same EA approach, then the cooperation should be easily possible. If the segments maintain different EA approaches, the interface and alignments has to be coordinated. In the last case, a segment has no EA approach at all, so it has to be covered primarily by the superordinate structure.

The following areas and tasks are to be covered by the EA staff unit. Project and portfolio management is to be located here. The portfolio management serves as an overview and takes over the holistic coordination of existing as well as new artifacts. Project management coordinates and supports dedicated projects. In relation to TOGAF ADM, support is provided in particular in Phase F and G, although the previous Phases A-E should also be considered. In addition, a knowledge management system is required for inventory administration. This also goes hand in hand with the ITIL approach, in particular for cooperation between Segment A and its IT staff unit. All artifacts are to be managed accordingly in an EA Repository. In addition, there is a support department for EA, which serves as a resource pool. In particular, this provides support for the creation of artifacts and the implementation of EA for the subordinate segments of Segment A. This has to be planned for the sub-segments on a case-by-case basis depending on whether a sub-segment requires its own EA staff unit or not.

The structure can be extended upwards and downwards in the layers by focusing on a business unit as

the segment under consideration. Particularly in the case of downward chaining, a decision must be made as to whether detailing within the framework of enterprise architecture still makes sense or other methods shall be applied instead. In general, the coordination along the vertical axis for a parent enterprise with its segments is carried out by means of boards. To collaborate along the horizontal axis, individual coordination between the collaborating segments is required. A segment *n* can simultaneously belong to the supporting enterprise via boards and collaborate with another segment.

4.2 Processes, Triggers, and Interfaces

The key aspects for governance processes are shown below with a focus on EAM. Figure 4 shows an overview of the essential tasks that are to be addressed by processes. These are divided into the three levels: governance processes, main achievement processes (performance processes) and support processes. The governance processes also include the management activities of the Board of Directors. The main achievement processes are further subdivided into Plan, Do, Check, and Act activities. The various processes must be customised and adapted to the needs of the company, so that no details are provided here. An essential process for EA is the application of the TOGAF ADM, whereby this extends with its phases A-H over all sub-areas. In the case of a federated consortium, the various processes and communication plans must be coordinated and harmonized with the federated partners. The representation typically takes place in several EA artefacts. This highly effects the interfaces between the artifacts for chaining. We suggest to double the interface from the prior process output as input of the following process, so disconnection becomes visible. Starting points of processes and activation of the bodies are called triggers and can be of various kinds. For a holistic view of the interrelationships, an example sequence is visualized in Figure 4.

4.3 Architecture Rolls, Responsibilities, and Training

As part of EA governance, we see at least the following role categories to ensure the basic areas of activity. These are described with their respective areas of responsibility and adequate training. The roles and their authoritative relationship is shown in the Figure 5.

- **Enterprise Manager:** Planning and further development of the enterprise and the IT landscape

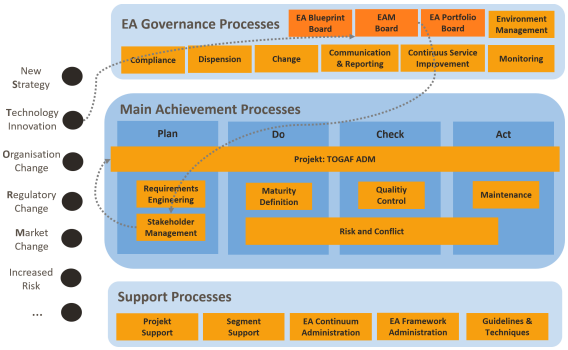

Figure 4: Overview of general EA processes for governance and management with example workflow.

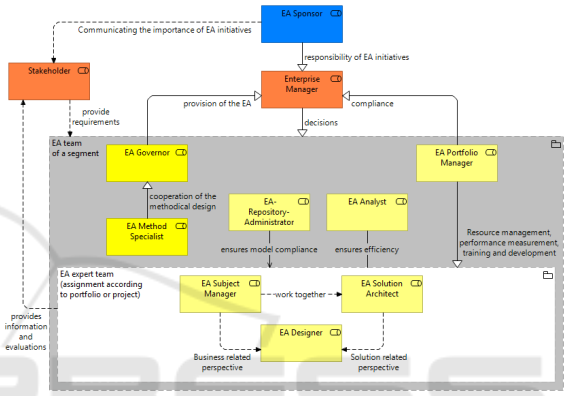

Figure 5: EA Governance roles and their relevant relationships.

in specific areas; link between business area and enterprise architects; responsibility for the content design; interpretation and documentation of requirements and content design decisions.

- **EA Sponsor:** Responsibility for the EA initiative, consistency with corporate objectives, provision of resources.
- **EA Governor:** Overall responsibility for the application; preservation of economic aspects and EA capabilities; strategic development; risk and change management; strategically develop and refine an enterprise architecture strategy that supports long-term goals of the business; identification of drivers and translation into architectural requirements.
- **EA Portfolio Manager:** Coordinates, synchronizes and controls architecture management; assurance of interoperability; resource management; maintaining architecture capability; overview and knowledge management, including the repository; communication of architecture concepts to non-technical stakeholders; quality assurance; performance and optimization management.

- **EA Subject Manager:** Responsible for the architectural knowledge of the subject area; coordinates, synchronizes and controls architecture management in specific areas; content design of architectures in compliance with the specifications of the responsible business and solution architects; part of subject matter expert network; responsible for the EA continuum of EA artifacts and reference architectures of the subject area.
- **EA Solution Architect:** Are *Subject Matter Experts* and work closely with the project teams; responsible for architectural knowledge in specific areas; technology assessment and administration of reference architectures; creation and communication of architecture concepts to stakeholders; governance implementation; following a cyclic approach of Plan-Do-Check-Act Cycle: analyze requirements, develop solutions, integration testing, and documentation; supported by *EA Designer* to realization.
- **EA Designer** (Optional)**:** Responsible for architecture descriptions that conform to specifications; creation and maintenance of architectural artifacts; capture all relevant information and interrelationships between the various architectural elements; prepare documentation; compliance with references, standards and best practices; ensuring Guidelines of Modeling (Becker, 1995; Ambysoft Inc., 2022) for accuracy, consistency and completeness in relation to aesthetic representation.
- **EA Analyst:** Evaluate architecture models with respect to specific and substantive issues; make recommendations to various audiences, including executive management, IT teams, and stakeholders.
- **EA Method Specialist:** Develop and maintain the methodologies, models, and frameworks to design and manage enterprise architecture; customization and integration of policies and standards for usage; training and support for successful application across the enterprise; quality assurance of EA artifacts; identification and promotion of best practices; continuous improvement in relation to life cycle management and maturity model.
- **EA Repository Administrator** (Optional)**:** Responsible for EA artifact management; takes care on version and variant control; does configuration management of the *EA Repository*; set up access control to the *EA Repository*.

In addition, there is also the important role of the stakeholders. We see this only indirectly as part of EA governance, here. Their interests are manifold and can vary greatly. Appropriate stakeholder maps must be maintained for them with concerns, views and relations. It is essential to be clear who the stakeholders are, before an artifact is created.

According to these roles for the EAM, we have to address the specific areas and domains of application. This is especially important for the subdivision of the role of EA Solution Architect, EA Designer and EA Analyst. A more fine-grained subdivision depends on the size of the federated enterprise, especially in the diversification to specialized subject areas. In relation to the hierarchical structuring of EA artifacts and EA continuum, the following topics have to be addressed: business; application and technology; information and data; infrastructure; process; security; risk; demand.

We highly suggest that the *EA Governor* maintains a RACI-VS Matrix for the responsibility of each roles and person. It show the conjunction with their services and function with respect to all the service areas and associated functions performed by the EA organization. This matrix is an EA artifact by itself and has to be maintained in the *EA Repository*. Furthermore, a flat hierarchy as a tree with two to three level is recommended.

4.4 EA Boards

We see as least the following three boards for discussions and decision making. Each board consists of up to seven members. In practice, larger boards are perceived as ineffective and should perhaps be structured via additional hierarchies. These boards exist at the federal level for vertical, superordinate alignment. If necessary, these also exists at the segment level for horizontal, inner coordination. The roles described exist at each level with their own staff unit EA. Associated to the boards are in each case the mentioned role of the higher segment (level *n+1*) and the same roles of the lower, parallel segments (level *n*). In addition, the management of the federation should be involved, as EA is an integral part of the management culture and thus an effective cooperation is designed here.

- **EA Blueprint Board:** Ensure a coordinated and consistent approach to the development, implementation and application of EA methodologies within the federated enterprise. EA methods include the tools, techniques, processes, and standards used to design, manage, and optimize the enterprise architecture. It is responsible for monitoring the appropriateness, viability, sustainability, costs, and benefits of the EA approach, especially for Governance and Compliance. Con-

duct reviews of EA artifacts to ensure architectural alignment. Build standards, patterns, templates, and reference architectures. Involved roles of EA subdivisions: EA Governor or representative EA Method Specialist or EA Portfolio Manager. Informed business role of the federation staff: CIO.

- **EAM Board and Strategy Council:** Coordinate and direct strategic decisions and votes regarding the enterprise architecture on a federal level. Ensure that the various subdivisions and departments are in harmony with the overall corporate goals. Jointly develop EAM concerns and capabilities; share a vision and best practices, establish strategic direction for the EAM effort; set goals for project portfolio management; recommendations with regard to the further EAM project as well as the development of the IT landscape to maximizing ICT's effect. Involved EA roles of divisions and subdivisions: Enterprise Manager and EA Portfolio Manager or representative EA Subject Manager. Informed business role of the federation staff: CEO.
- **EA Portfolio Board:** Controlling the project portfolio, evaluating and prioritizing project proposals and demands. Thus, it is defining and managing the portfolio of the EA artefacts. Projects are also started, stopped and paused, and investment decisions are made accordingly, if necessary, to ensure the company's long-term efficiency, flexibility and innovation through appropriate EA initiatives. The focus is based on product areas and products. It takes care of the user and business owner perspectives. Involved EA roles of divisions and subdivisions: EA Portfolio Manager or representative EA Subject Managers, if required EA Sponsor. Informed business role of the federation staff: CTO.

Beside these, every enterprise has to address additional, not direct EA governance related boards, e.g. *IT and Security Council*. It must still be coordinated and guided with typical perspectives of holistic ICT-service, -application and -technology architecture (Raad, 2023).

4.5 Program, Portfolio, and Project Management

This unit represents the operational power center. Here, the coordination of strategic intentions takes place within the framework of programs and projects. The activities in the portfolios of all projects must be coordinated with each other, especially with regard to dependencies, interconnections, and interfaces. This includes prioritizing projects and planning resources. It involves monitoring of budgets and progress. In the event of difficulties, appropriate escalation is to be made to the various boards. Depending on the size, a separate unit for controlling can be created or a division for the different programs can be installed. The managing role is the *EA Portfolio Manager* and should be centralized in one person if possible. For support and reliability, a deputy should be appointed, who is always informed and up to date. Typical artifacts for this are: Strategy Map, Program and Portfolio Roadmaps with dependencies, Project Working-Plans and Gantt-Charts with milestones, and Gap-Analyses. They represent the knowledge center and maintain an overview. A holistic expertise of the *EA Repository* is required in order to provide precise information. Comprehensive communication of results and interim information is essential for the success of the entire EA approach. Within the framework of the federal cooperation, a horizontal as well as vertical exchange has to take place. The contact persons for this are the respective *EA Portfolio Manager* or the corresponding board. For this purpose, an appropriate reporting system with time, format, scope, and medium has to be coordinated.

4.6 Artifacts, Deliverables, and Continuum

Architecture artifacts can have a high degree of diversity. This ranges from simple catalogs and matrices to structures and models to roadmaps and diagrams (Roth et al., 2014; Kotusev, 2019). In the context of governance, this must be taken into account when creating artifacts. Therefore, the federated parties should agree in advance on the methods, standards, and guidelines for designing. The *EA blueprint board* is particularly useful for this purpose. It is recommended that the category or a specific type of an artifact shall be determined appropriately according to the purpose (Bundesministerium des Inneren und für Heimat, 2022; Bundesministerium des Innern, 2007). This promotes cross-cutting collaboration by narrowing down the multiplicity, eliminated ambiguity, and reduce complexity. Thus creating a uniform understanding and a common approach. When artifacts are created, key design decisions are to be tracked in a table with justification. This supports the application and also serves in the context of further development for new versions and diverse variants. Especially, variants enable the adaptation to one's own specifics in a federal cooperation. In this context, compatibility with the reference must be en-

sured (Ascher et al., 2022).

Efficient implementation of variant creation requires precise coordination across the *Architecture Continuum* following *TOGAF*. Here, a clear separation between solution-independent architectures and the realization-dependent solutions must be ensured. These two types of artifacts must always be created, maintained and linked to each other. This is important in relation to the innovation cycle of technologies (Hillmann et al., 2021), e.g. for a change of concrete solutions. A respective gradation of each type from foundation to organization-specific should take place as required. The additional effort involved should be weighed up in advance in relation to the benefits. Basically, artifacts of the federated enterprise describe the highest level of abstraction. These have a comprehensive view of the cooperation with often reduced details. Segment level artifacts are more detailed in terms of programs, portfolio and projects. These include both business and IT. Domain-specific artifacts and specific designs describe concrete services, systems, or effects for basic activities and projects. The use of *Architecture Building Blocks* (ABB) can reduce the effort for both EA and implementation, preferably using Model-Driven-Architecture. For effective reuse in federated collaboration, these ABB and artifacts should be made available transparently via a register.

For the use of ABB and in variant formation, we see two possible uses in the federal domain:

- Take-Over: An artifact is adopted by a federal segment and is applied accordingly. Various techniques can be used in this process: Copy, Analogy, Specialisation, Inheritance, Instantiation, Configuration, Parametrisation (vom Brocke, 2018).
- Joint use: A segment uses an artifact offered by another segment without changes. This can be done as reuse like a value chain or as aggregation of ABBs into a higher value benefit.

In both cases, the interfaces must be precisely defined, harmonized and coordinated so that the artifacts can interact across areas. This can be done via the *EA Portfolio Board*. The goal here is *Day Zero Interoperability*. The results of coordinated interfaces shall be tracked as artifacts, e.g. as in Federated Mission Networking [1]. Furthermore, all artifacts have to be validated and verified, before these are released for fit for purpose by an *EAM-Board*.

Independently of this, the responsible role or person must also be determined for each artifact in the federal cooperation. In the last instance, this is always performed by the *EA Portfolio Manager* and, if necessary, delegated. This person is then responsible for maintenance and quality assurance. All members are always responsible for use and compliance, whereas the *EA Governor* is supervising the process.

4.7 Methods, Standards, Tools, Guidelines and Techniques

The methods, standards, tools, guidelines and techniques used for EA must be harmonised as part of governance. A combination of frameworks can be used to address the interests of stakeholders at both business and IT level. Our approach follows *The Open Group* and is based on the frameworks of *TOGAF* and *ArchiMate* in conjunction with *ITIL*. In addition, the use of a grid according to *Zachmann* for the EA artefact organisation provides an overview.

Within the framework of federated architecture management, our focus is on common principles and best practices for collaboration. Establishing best practices is an essential part of limiting degrees of variety in the design of EA artifacts. In addition, it gives the EAM direction for decisions and thus defines a basic order for all partners. The principles are documented classically using the following data: ID, Name, Statement, Rationale, Implication. For better clarity, it is advisable to categorize the principles according to their area of application or roles. For one area, a set of smaller than 30 principles has proven to be practically usable. These can grow organically and adapt to the needs of the enterprise. For the federal context, we see the following overarching principles in focus on a smooth cooperation:

1. EA pursues the goal of value creation, which must be evident in every deliverable.
2. Before an EA artifact is designed, the stakeholder has to be identified to be role concentrated.
3. For each EA artifact, a clear maturity level is addressed.
4. Each EA artifact is self-contained.
5. Every Design follows the Service-Oriented-Architecture (SOA) principle with clear defined interfaces for input and output in relation to interoperability and modular extensibility.
6. Extensive usage of standards, reference designs, interoperable open architecture, and glossary wherever possible.
7. Every EA artifact has an identified owner for clear responsibility.

[1] https://www.act.nato.int/activities/federated-mission-networking/

8. EA artifacts follow the basics of proper modelling approach (Becker, 1995; Bundesministerium des Innern: Referat IT-Steuerung Bund, 2011) and fullfil visualization guidelines.
9. Establishing a culture of digital information transfer.
10. Establishing a welcoming culture for innovations and suggestions for improvement.

4.8 Repository

The repository serves as a central knowledge base of information by storing all artifacts. This also includes the EA artifacts of the EA governance. The goal is to make EA usable, widely available and comprehensively transparent. It is managed by the *EA Repository Administrator* or by the *EA Portfolio Manager*. In the context of federal cooperation there are two possibilities for the realization of the data library:

- Common Archive: The federal community maintains one central data repository, which is shared between all parties. This has the advantage that the contents can be directly linked with each other and reduces the administrative effort.
- Multiple directories: Each party of the federal enterprise maintains its own data repository. Relevant EA artifacts have to be made available to the other parties (Heiland et al., 2021), preferably via linking. For this purpose, *Linked Data* approaches are suitable using HTML iFrames, REST, AMQP, OSLC, RDF, or CSD. Here, the sovereignty over the data obliges by the individual party.

Regardless of this, the principle of *Single Source of Truth* must be adhered to avoid synchronization and integration conflicts of shadow copies in different versions and variants (Zenz et al., 2023). We recommend a common archive as *Single Point of Information* in the context of a federated enterprise. This avoids synchronization and conflict handling problems from the outset.

As a realization, we use a web-platform to ensure easy access for all stakeholders and employees (Gidey et al., 2022; Pöhn and Hillmann, 2021). A detailed design of an *EA Repository* is referred to this work (Hillmann et al., 2022). To enable a broad use, all approved and released EA artifacts should be accessible by everyone. This ensures full transparency. We see at least the following categories for the organization of EA artifacts. These are not considered exclusive, rather they serve as tags within the metadata.

- Governance and Methodologies Artifacts, Authority Structures
- Business, Strategies and Capability Artifacts
- IT Architectures (Is-Plan-Goal)
- Processes and Data
- Portfolio and Project Architectures
- Reference Architectures, Building Blocks, Blueprint and Service Architectures
- Standard Elements, Specifications, and Regulatory Requirements

4.9 Dashboard

The dashboard serves on the one hand as a live overview and on the other hand as an entry point to the *EA Repository*. It offers the entry into the EA world of experience, as seen in the example Figure 6. For a clear start there is an interactive live grid with the different aspects and subjects. For the management of the portfolio and the running projects a graph is used, where clockwise color notations serve as progress indicators [2]. The Gantt chart provides a roadmap of deadlines and project dependencies (NATO Training Architecture Framework, 2019). Current information and changes can be found in the news feed and in the change log. This includes objectives, drivers, and history graphs. Metrics and alerts are displayed for monitoring purposes (Office of VA Enterprise Architecture, 2016). In addition, it provides a wiki like tool for: Reference Models, Requirements (Heiland et al., 2023) , Baseline Documents and the Glossary.

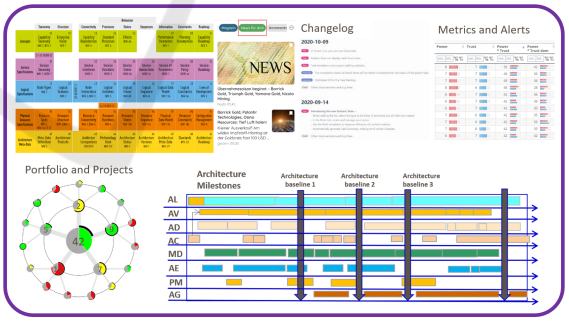

Figure 6: Example of an EA Dashboard as entry point of the EA Repository.

4.10 Glossary

A common understanding of terminology is essential for cooperation in a federal context. This is particularly important for discussions within the boards. For this purpose, a cross-company glossary must be established and maintained. The glossary itself represents an EA artifact and is to be kept in the *EA*

[2]https://principiamentis.com/de/main

Repository. A deep integration enables glossary elements to be referenced within EA artifacts through the tool landscape. This allows to provide further information in a targeted manner. In addition, linking via ontology is recommended, as this makes it easy to identify inconsistencies. The machine-processable format enables comprehensive analyses, especially if links to the EA artifacts are traced. If standardized glossaries or ontologies already exist for a domain, these should preferably be used, such as *NATO C3 Taxonomy* (NATO Consultation, Command and Control Board (C3B), 2021) or *Ontology for simulation, modeling, and optimization* (Horsch et al., 2022). In the context of EA artifact creation, always unique designations shall be used where possible. To avoid confusion, the singular and a gender neutral form should always be used.

5 PRELIMINARY IMPRESSIONS

The concept was transferred to a multidisciplinary company, like *Siemens AG*. This company is structured as follows. Our considered segment is the production division for *Medical Devices*, e.g. MRI systems. Parallel segments are e.g. *Finance*, *Energy*, *Industrial Automation*, *Drive Technology*. We cooperate with these parallel segments on a horizontal level. This relates in particular to the handling of finances and the development of components. Our *Medical Devices* segment is further subdivided into digital twin, radiology and training, among others.

By means of a table-top exercise, the presented approach is validated as a whole. For this purpose, the roles were assigned to different persons. Everyone is given a general overview and specific instructions on their tasks and responsibilities. Boards are formed by all participants, with the main responsible role being the moderator. Starting point for the processes are done by randomly selecting different triggers on a card deck that typically occur in EA like technology innovations or market changes. Through these, the defined processes are triggered. The processes are manually replicated and tracked using pen and paper. One hurdle is initiating the right process and linking a suitable path across several processes. Each role must act according to its area of responsibility and create its necessary EA artifacts. The project specific EA artifacts are mapped using puzzles, dominoes or Lego bricks. Here, a single piece symbolizes an ABB with defined service interfaces. Figure 7 shows a factual example of the overarching interaction.

Experience has shown that our EAG concept works both for individual companies and in a federal context. The processes support a structured workflow and responsibilities can always be identified.

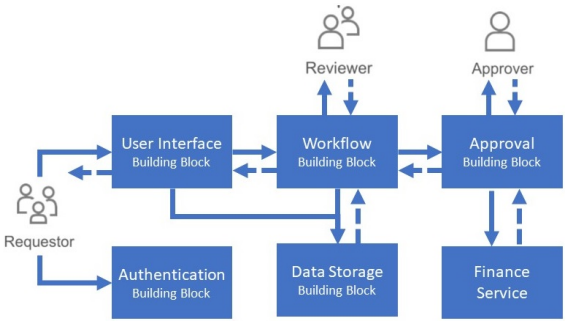

Figure 7: Example *Solution Concept Diagram* with usage of *Architecture Building Blocks* and services for the creation of project specific EA artifacts.

6 SUMMARY

In summary, our presented concept describes all essential components for EA governance in a federated context. This approach is independent of the specific established EA frameworks, so that each partner can continue to use its own EA framework. It builds on top of theirs and regulates necessary coordination, processes and interfaces in federated collaborations. Thus, our concept enables a goal-oriented control by means of EAM. It highly supports the workflow by clear command and control. It has been shown that our framework can be adapted to individual specifics. All activities and decisions concerning the architecture are aligned with the concerns of the company and the context. The resulting architecture collections meet the expected business needs of the enterprise and its stakeholders.

In the future, we will extend our concept in dealing with EA artifacts. In addition, a detailed analysis of the different EA processes with regard to governance will be performed.

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