ENTERPRISE ARCHITECTURE, A BLUEPRINT FOR ENTERPRISE LOGISTICS ROLLOUT

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Abstract In this paper it is proposed that Enterprise Architecting in principle develops the Logistic Support model for systems on System Hierarchical Level 6 and higher. The Enterprise architectural model is a blue print, like the DNA for biological systems, on how to organize an enterprise for operations.

1 Introduction

Enterprise Architecture (EA) is the holistic approach that aligns and integrates the four architectural domains of Business -, Applications -, Data - and Technology Architecture to implement strategy and deliver business value. The dependency of these four domains elements are visualised in the TOGAF's (The Open Group Architecture Framework) Content Metamodel, which relates the components of the four domains with each other. The function of enterprise architecting is towards the implementation of business strategy with the integrated provisioning, maintenance, support and operations all the components in the enterprise as depicted on the Content Metamodel.

The enterprise architecture is defined in horizontal layers of detail as Zachman (1987) proposed from a contextual, conceptual, logical, physical and out-of-context representation that are necessary to describe the enterprise in terms of the six questions: What (Data), How (Function), Where (Network), Who (People), When (Time) and Why (Motivation) that vertically intersect with the horizontal layers. Change to the TOGAF EA Content Metamodel content is complex as it ripples to all architectural domains, on various levels of detail.

The logistics support is to ensure that the operations, as well as effect of change and the impact on the architectural domains and levels are managed. The "change" not only affects the individual components, but also the impact of the direct and indirect relationships of all the components and as such must address logistic concerns on all levels: From technical data and documentation, Training, Lifecycle considerations (All components, Applications, WH, Spares, Data, Organization, etc.), facilities, scheduling, interfaces, etc.

2 Logistics Engineering

Traditionally, logistics engineering was performed after a system has been designed and it has been seen through the years as a profession that rectifies the errors of the systems engineers. Various definitions for logistics exist. Blanchard (2004) gives a detailed overview of the definitions, which has a military origin, as the part of military science dealing with the procurement, distribution/transportation, maintenance and replacement of materiel, facilities and personnel. In the past, Logistics was a defined enterprise on military projects and the integrated logistic support for a new system only needed to take into account how the new system can be integrated into the current enterprise of the military to support military doctrine and strategy.

Blanchard (2004) cites a more recent definition of logistics, known as acquisition logistics, from MIL-HDBK-502 of May 1997 as *"a multi-functional technical management discipline associated with the design, development, test, production, fielding, sustainment, and improvement modifications of cost-effective systems that achieve user's peacetime and wartime readiness requirements. The principal objectives of acquisition logistics are to ensure the support considerations are an integral part of the system's design requirements, that the system can be cost effectively supported throughout its life cycle, and that the infrastructure elements necessary to the initial fielding and operational support of the system are identified and developed and acquired*."

It is clear from this definition that logistics engineering is not an after the fact design exercise in modern system development anymore, but the logistics engineer forms part of the integrated product development team (IPDT) from the start, i.e. logistic engineering is involved from the requirements analysis sub-process of system development with reference to ISO 26702.

Today, outsourcing and globalisation challenge the traditional logistics enterprise (Blanchard 2004). With commercial of the shelve (COTS) products widely in use, and suppliers delivering from all over the globe, the current trend is to outsource partially or in some case fully, some of the functional elements of logistic (Blanchard 2004). The functional elements of logistics are (Blanchard 2004):

- Logistics, maintenance, and support personnel.
- Supply support – spares/repair parts and inventories.
- Technical data, reports and documentation.
- Packaging, handling, storage/warehousing, and transportation (distribution).
- Logistics information.
- Test, measurement, handling, and support equipment (resources).
- Maintenance and support facilities and utilities.
- Computer resources (hardware and software).
- Training and training support.

In a logistics enterprise with outsourced functions, the control over the information regarding the various functional elements is crucial to ensure the integrity of the integrated logistics support for a system. Thus, a logistics enterprise information system must keep track of all the elements, relationships and information flows to be able to produce the necessary reports to manage the logistics enterprise successfully.

Just as COTS has lead to generally lower cost systems with lower risks involved, one can ask if a commercial enterprise model can be used for the logistics enterprise. Commercial companies went through various cycles of downsizing, outsourcing and right sizing through the years. Some closed down in the process, but stronger more agile enterprises, some with a very strong global presence, emerged in which information is shared amongst clients and competitors alike. The emergence of the learning enterprise resulted during the last decade of the previous century. The economical environment for this to happen is that of trust and the coding of information in standardised frameworks so that the cost per transaction is low and learning is high (Lundvall 1992).

The driving down of costs in a globalised market lead to the situation today where noncore business services are outsourced and commercial enterprises have started to converge to a common framework of describing their business infrastructure, called enterprise architecture. Enterprise architecture started at IBM in the 1980's with Zachman developing the first version of his architecture framework for enterprise architecture (Zachman 1987).

Today, several enterprise architecture frameworks exist, with The Open Group Architecture Framework (TOGAF) one of the widely used frameworks in the world. TOGAF was first published in 1995 and was based on the US Department of Defense Technical Architecture Framework for Information Management (TAFIM) with successive versions released at regular intervals (https://www2.opengroup.org/ogsys/catalog/g116).

3 Systems Hierarchical Model

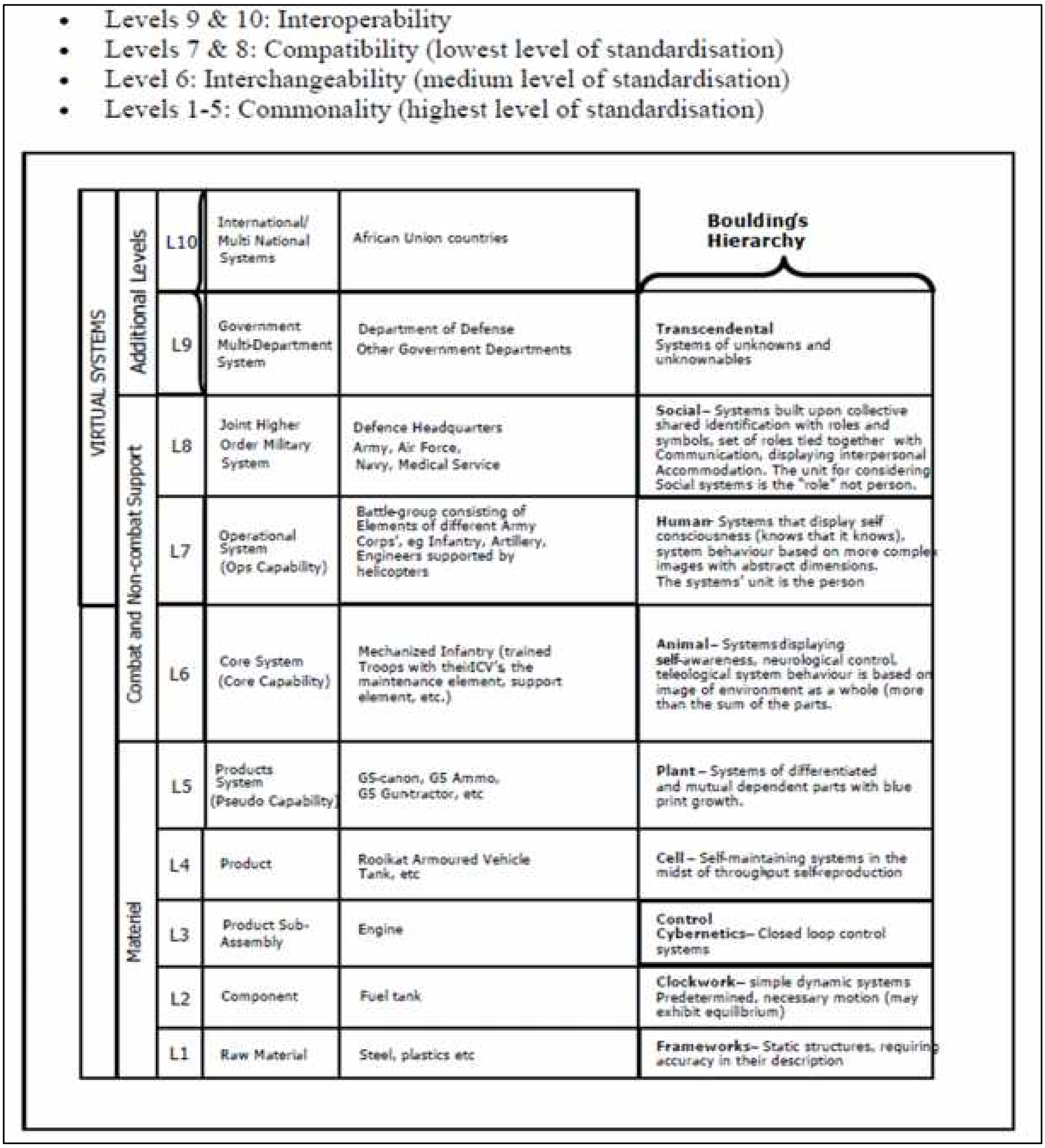
TOGAF 9 is used to describe a logistical support model that could apply to the Systems Hierarchy as generally accepted in the South African Department of Defence. De Waal and Buys (2007) describes fundamentally the systems hierarchy levels as used in the South African Department of Defence as shown in Figure 1.

In terms of this paper, one can refer to the Logistics Enterprise Architecture as that information architecture that is developed to depict the ontology of all information on elements of logistics to be able to enable management and support of the design, development, test, production, fielding, sustainment, and improvement modifications of cost-effective systems that achieve user's business requirements and expectations.

The Systems Hierarchy becomes increasingly complex to the higher levels as a result of the configuration in which levels of components are used to construct the whole system or enterprise to achieve the goals identified. The complexity is a result of the individual components logistical requirement over its lifecycle, i.e. from idea inception through design and implementation up to becoming redundant. The lifecycle stages include all the components (People, Process, Technology) in creating, operating, maintenance and support of the component and composites.

The interoperability/interchanging ability of components further contributes to the complexity of the systems optimal performance and availability. The lower levels of the hierarchy can be designed for a defined purpose and constraints, a L1-L5 Materiel component can be swapped with the exact same component without affecting the total operation. Middle levels to interact with the environment regarding inputs, processing and outputs. The highest levels in the hierarchy is a set of components that must work in unison, but the inputs are not a finite list of possibilities, processing is based on human (a specific individual and his perceptions, background, etc.) decision when interacting with the environment, and the output could be to an undefined interface, such as a verbal command to another human. This implies that the level of standardization is less on L6-10 levels than the lower levels.

The value (fit for purpose and fit for use) of the components is increasingly more difficult to guarantee on the higher levels and the measurements and metrics become increasingly subjective. The timeliness of the event feedback on composite higher levels is also further away from the occurrence of an event that must be managed.



- Levels 9 & 10: Interoperability
- Levels 7 & 8: Compatibility (lowest level of standardisation)
- Level 6: Interchangeability (medium level of standardisation)
- Levels 1-5: Commonality (highest level of standardisation)

					Boulding's Hierarchy
VIRTUAL SYSTEMS	Additional Levels	L10	International/ Multi National Systems	African Union countries	
VIRTUAL SYSTEMS	Additional Levels	L9	Government Multi-Department System	Department of Defense Other Government Departments	**Transcendental** Systems of unknowns and unknownables
VIRTUAL SYSTEMS	Combat and Non-combat Support	L8	Joint Higher Order Military System	Defence Headquarters Army, Air Force, Navy, Medical Service	**Social** – Systems built upon collective shared identification with roles and symbols, set of roles tied together with Communication, displaying interpersonal Accommodation. The unit for considering Social systems is the "role" not person.
VIRTUAL SYSTEMS	Combat and Non-combat Support	L7	Operational System (Ops Capability)	Battle-group consisting of Elements of different Army Corps', eg Infantry, Artillery, Engineers supported by helicopters	**Human** Systems that display self consciousness (knows that it knows), system behaviour based on more complex images with abstract dimensions. The systems' unit is the person
	Combat and Non-combat Support	L6	Core System (Core Capability)	Mechanized Infantry (trained Troops with theirICV's the maintenance element, support element, etc.)	**Animal** – Systems displaying self-awareness, neurological control, teleological system behaviour is based on image of environment as a whole (more than the sum of the parts.
	Materiel	L5	Products System (Pseudo Capability)	GS-canon, GS Ammo, GS Guntractor, etc	**Plant** – Systems of differentiated and mutual dependent parts with blue print growth.
	Materiel	L4	Product	Rooikat Armoured Vehicle Tank, etc	**Cell** – Self-maintaining systems in the midst of throughput self-reproduction
	Materiel	L3	Product Sub-Assembly	Engine	**Control Cybernetics** – Closed loop control systems
	Materiel	L2	Component	Fuel tank	**Clockwork** – simple dynamic systems Predetermined, necessary motion (may exhibit equilibrium)
	Materiel	L1	Raw Material	Steel, plastics etc	**Frameworks** – Static structures, requiring accuracy in their description

Figure 1: Systems Hierarchy (De Waal & Buys: 2007)

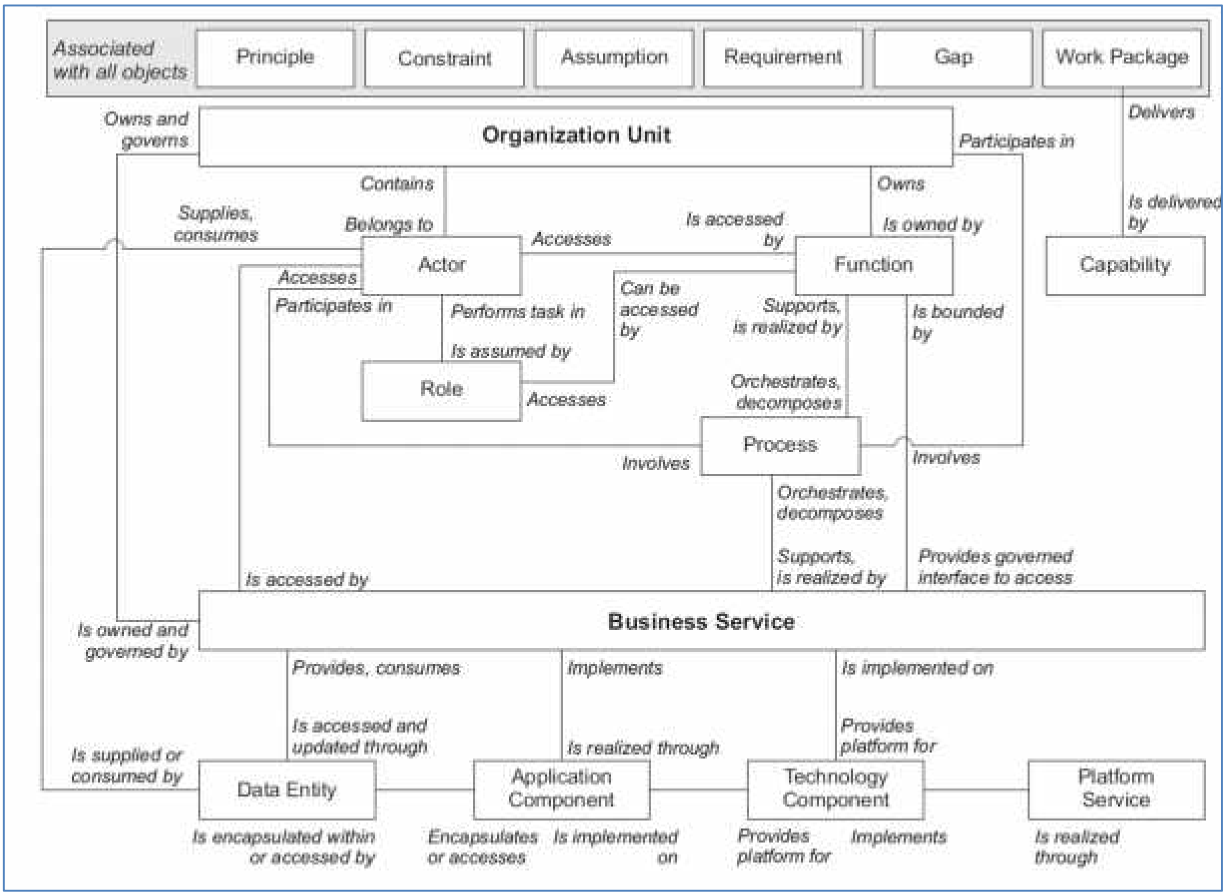
4 Enterprise Architecture

Enterprise: The Open Group (2011) defines ''enterprise'' as any collection of organizations that has a common set of goals. The term ''enterprise'' in the context of ''enterprise architecture'' can be used to denote both an entire enterprise — encompassing all of its information and technology services, processes, and infrastructure — and a specific domain within the enterprise. In both cases, the architecture spans multiple systems, and multiple functional groups within the scoped enterprise (The Open Group 2011).

Architecture: ISO/IEC 42010 (2007) defines ''architecture'' as: ''*The fundamental organization of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution*.''

The TOGAF Content Metamodel is the structure in which the deliverables/products of the development method is maintained and operated. It is a conceptual data model that relates the core entities of which all enterprises are composed of (The Open Group 2011).

This model of components and their inter-relationships describes the current reality formally, and when combined with a future model (to-be architecture) provides a roadmap for change (Formal Gap-Analysis) and governance model to implement change on all four architectural domains (Business, Data, Applications and Technology) (The Open Group 2011).



Source: The Open Group (2011)

Figure 2: TOGAF 9 Content Metamodel – Core Entities

Multiple definitions and viewpoints of Enterprise Architecture exist and could be explained using the four architectural domains in TOGAF (The Open Group 2011):

- Business Architecture: The motivation of the enterprise existence and the organizational structure, people and processes to enable the enterprise vision – how will data, applications and technology realize the objective.
- Data Architecture: What information is required, on all components of the enterprise, to successfully deliver on internal and external demands on the business – who will use it, to what end, who will be the custodian thereof, etc.
- Application Architecture: Which applications are needed to manage the data and ensure end-to-end business integration (process) across the internal and external functional areas – what are the business rules it will enforce, what data is needed, who will use the application to fulfil which role and to manage which process, etc.
- Technology Architecture: What is the hardware, software and connectivity requirements to ensure the applications provide the information and automation to the business to fulfil its goals.

All of the core entities (objects about which information is stored) are maintained in catalogues that are extended with metadata that allows analysis of the information. Examples of metadata include a classification scheme and categories of the content in the catalogue, ownership, state and modes, and unique attributes that applies to a specific entity.

None of these domain architectures operate in isolation. The architecture is defined by mapping entries of an entity to entries from other entities (As the lines in **Figure 2** show: e.g. Role/System Matrix). These matrixes manage the relationships and the grouping of related entity entries to define capabilities in the organization. The inter-dependencies of entities within, and between architectures, define the whole enterprise (The Open Group 2011).

Each of the entities in the TOGAF Content Metamodel potentially is in a different stage in its lifecycle (e.g. idea inceptions, requirement stage, design, development, deployment, operation, decommissioning, retirement) and the length of the lifecycle stage is different for each entity (e.g. application) as well as each instance of an entity.

In addition to the catalogues and matrices, diagrams are used to render content metamodel information in an ordered way so that it can be processed to meet the stakeholder needs.

Business services, as depicted in the centre of the Core Content Metamodel, associate the Data-, Application and Technology architecture domains with the Business architecture. The Business architecture predominantly relates to the L6-10 system hierarchy levels, whilst the L1-5 levels are mainly associated with the other three architecture domains. A business services has the following characteristics and purpose: (TOGAF 9)

- allows an organization to differentiate between definition of business capability, the fulfilment of business capability, and the consumption of business capability

- defines the services that the enterprise and each enterprise unit provide to its customers, both internally and externally.
- a business service has a defined, measured interface and has contracts with consumers of the service.
- a business service is supported by combinations of people, process, and technology.
- business services are explicitly identified and tied to ownership, usage, and business value.
- supports business capabilities and functions through an explicitly defined interface and is explicitly governed by an organization.
- business services are consumed by actors or other business services
- the granularity of business services should be determined according to the business drivers, goals, objectives, and measures for this area of the business.

Matrices across the architecture relate applications to business service, business function, data, process, etc. This differentiation allows the organization to consider sourcing, procurement, federation, centralization, and channel exposure in a much more flexible way, prioritizing investment and focus in areas that are core differentiators, whilst cost controlling and divesting areas that are considered to be context to the business.

Enterprise change is complex because of:

- the combination of boundary of the enterprise,
- touch-points and overlaps with other enterprises,
- components from the four architectural domains that enable the enterprise objectives,
- maturity of product and enterprise,
- changes regarding the individual instances of the solution and
- the unpredictability of human behaviour in adopting change.

Enterprise Architecture is about the understanding of the current environment, agreement of the future environment and the implementation execution (based on agreed governance factors) over time as changes in each component are foreseen and implemented to ensure effective and efficient utilization of all enterprise resources.

Many Enterprise Architecture Frameworks exist. TOGAF, FEA (Federal Enterprise Architecture), Gartner and even vendor specific such as Oracle EA have their own concise definition of “Enterprise Architecture”. They all share the desire to implement strategy by aligning business and technology from an existing baseline to a desired baseline in incremental and logical phases in the most effective and efficient manner. The Gartner Group has a good general definition: “*Enterprise Architecture is the process of translating business vision and strategy into effective enterprise change by creating, communicating and improving the key requirements, principles and models that describe the enterprise's future state and enable its evolution*”

Logistic Support is involved in the acquisition of all of the Content Metamodel entities individually, as well as collectively, in the designed levels of assembly to provide a service, but also in the operational support of each instance of the solution during its lifecycle (evolution).

5 Enterprise Architecture Practice

The TOGAF Content Metamodel also illustrates the creation of capabilities. A capability is the ability that an organization, person, or system possesses. Capabilities are typically expressed in general and high-level terms and typically require a combination of organization, people, processes, and technology to achieve the goals of the enterprise. Example capabilities include King III/Sarbanes-Oxley compliance, Electronic Commerce, Marketing, customer contact, or outbound telemarketing.

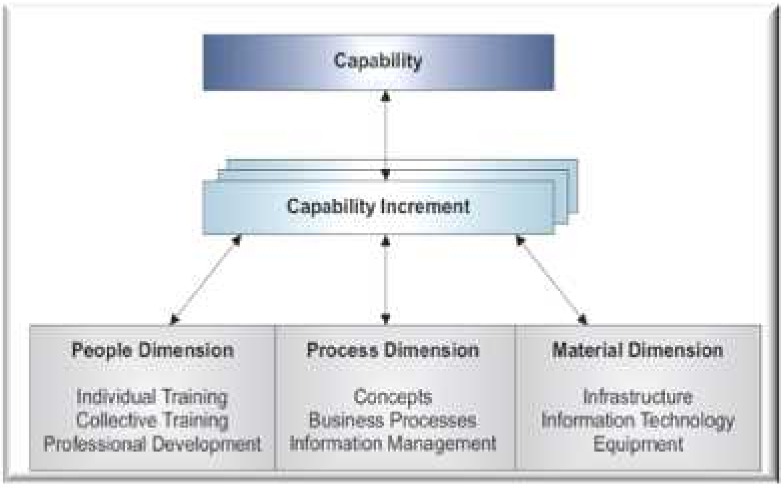


Figure 3: TOGAF 9 Capability Increments and Dimensions

The dimensions of the TOGAF Capability concept relates to the Systems Hierarchy levels and a Capability-Based-Planned approach that combines the various dimensions are aligned to the in-time provisioning of services to fulfil the logistic objectives of an enterprise on the different hierarchical layers.

Depending on the boundaries that are defined for the “enterprise” the scope of the engagement could be a business unit within the organization or the total enterprise extended to the external stakeholders. To ensure continuous value delivery from the enterprise architecture within a changing environment it is highly probable that the whole enterprise will not be architectured at once. The structures that is proposed by TOGAF allows for multiple reference models and architecture building blocks to be defined over time. These building blocks could be horizontal as new organizational units or functions are included in the architecture, as well as vertical as more detail in a scoped area is modelled as defined in the systems hierarchy levels or Zachman framework (Strategic, Segment, Capability or Contextual, Conceptual, Logical, Physical and out-of-context) (Zachman 2008).

As the definition of the enterprise grows, in depth and breadth as well as the understanding of the current (As-Is) and future (To-Be) definition, a consistent repository is required to ensure the integrity and management of the architecture as it evolves over time, to enable the realization of the future architecture.

Capability architectures are typically managed in products and methodologies that suite that specific level of control. An example is the ITIL® (Information Technology Infrastructure Library) with a CMDB (Configuration Management Database) that has processes to manage the physical ICT infrastructure in the organization (www.itil.org). Other examples include a Human Resource solution that manages inter alia individuals, roles and skills, or a Manufacturing System that manages products, components and assembly. This collection of solutions manages some of the current/As-Is entities in the overall architecture. It is therefore beneficial to have a federated approach to manage lower level components of the architecture with the optimal resources suite for that purpose. Classification schemes is required to roll this content up to the strategic or segment level of detail required to model the enterprise on that level.

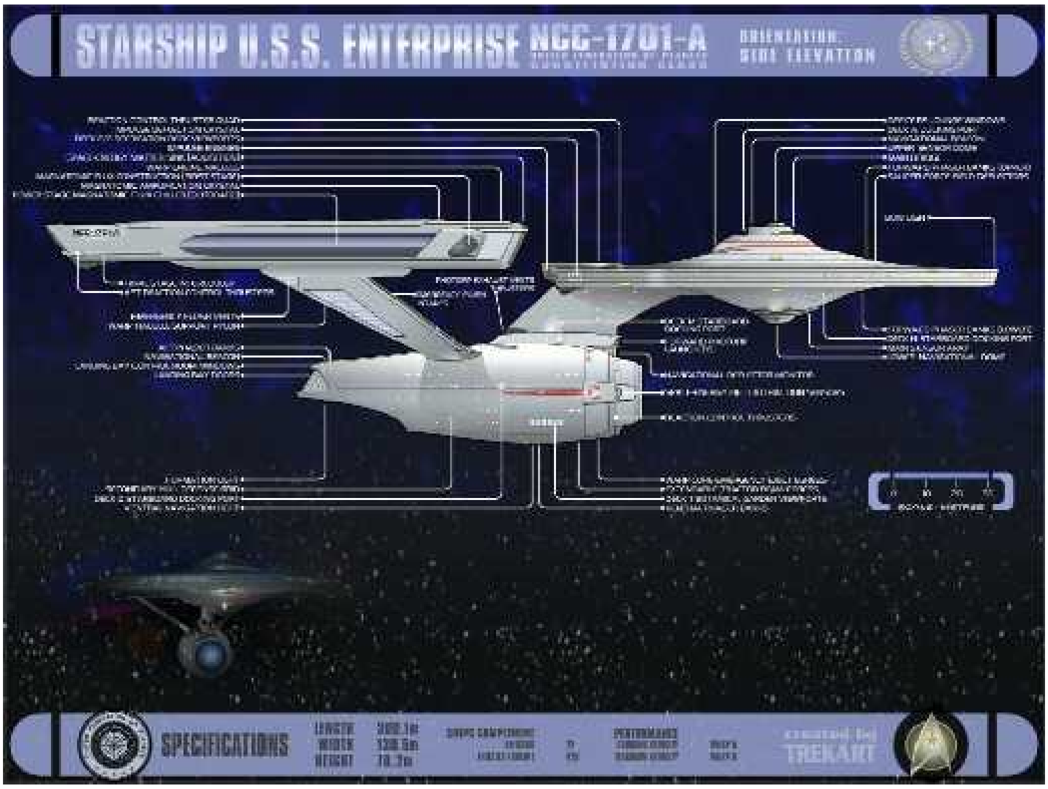
The different viewpoints of all the stakeholders in the enterprise must be understood on the levels of architecture detail required. The integrity of the information must be assured on the level of abstraction but also in terms of the federated nature of layers of detail. The collective viewpoints (the view) then provide planning capabilities regarding the operational support of the current implemented architecture as well as the roadmap of transitions to ultimately implement the desired architecture. The roadmap is a result of the differences identified between the current and future landscapes and the capabilities required to implement the incremental steps. The creation/modification of these capabilities, in relation to its own lifecycle stage and the lifecycle stage of each of its components, subject to architectural governance, is closely aligned to the definition of Acquisition Logistics.

Federations must ensure that the implementation of the strategy is translated into the language and frame-of-reference in the lower levels of systems hierarchy – traceable through relationship and measures on the organizational/systems levels- made operational on all levels, right down to the supply change of the level 1 components of the architecture (not to be confused with the systems hierarchy levels in Figure 1). Visualization of architecture – beyond the catalogues of services and the matrices of dependencies – diagrams to include analysis attributes to ensure communication is effective on the system level where the stakeholders operate.

Enterprise Architecture is continuous, it grows horizontally to larger enterprise inclusion, vertically to levels of detail and change over time as the future is realized or requirements change that impacts a component in the architecture (logical and/or physical). It becomes the metadata of the enterprise that allows the analysis of change requests to determine impact and is not restricted to a specific system level. All levels must be relatable in terms of traceability of requirements in decomposing structures that support the higher levels solutions by complementing metrics that checks the behaviour change that is expected from the measurement.

Thus: Enterprise Architecture and Systems Hierarchy Levels 6-10 require that all the core content Metamodel entities being present – thus including organizational component. All entities are important, but Data Entity and its relationships – in support of Boundaryless Information Flow™ (The Open Group 2011), are especially pertinent on System Level 6-10.

System levels do not indicate the "enterprise" scope (see enterprise definition "any collection of organizations that has a common set of goals"). The Starship USS Enterprise in Figure 2 is a level 5 system, but if the core content Metamodel entities are added, it becomes an "enterprise" on level 6. Thus the fielding (location/ remoteness / communication/ independence / #-of-starships or continued existence of Earth/ etc.) is determinant on whether this is a system level 5 or level 6 or higher. The same physical components is elevated from level 5 to the higher levels because of the business application of the component when people and process to achieve operational objectives are added.



Source: http://qbits.me

Figure 2: Starship USS Enterprise

When talking about system levels an assumption is made on the stakeholders that contribute to the requirements (problem) that the system must resolve. It also speaks to the level of abstraction and the perception of capability that exist (As-Is) and the capability that needs to be created. The capability may be conceptual and not influenced by practical constraints – the need for bottom-up information to facilitate the planning for rollout is critical. It creates the project portfolio for lower level investigation and design to complete the roadmap. Organization Levels 6 and higher focus mainly on the direction, management and control activities in an enterprise as directed by the ecosystem in which it operates.

6 Logistic Support Model

Enterprise Architecture starts with a comprehensive inventory/portfolio/catalogue/ configuration of the architectural components from all the architectural domains. The items are then related to an implemented or desired configuration that aids to an understanding of motivation for change (why, when, who, where, what and how). Performance metrics exist to monitor the current architecture and is designed (adapted or new) to test the performance of the future architecture during commissioning and operations.

Operational logistics are more applicable to the lower systems levels (capability architectures), but continuous improvement initiatives feed into higher levels of planning activities and influence the lifecycle stage of components. The combination of operational improvement and revision of strategic direction results in change. The impact of change and the complexity of the underlying interaction between components in the four architectural domains require careful consideration.

This "consideration" includes the lifecycle considerations as provided in Blanchard (2004) Acquisition Logistics definition. The system refers to an entire enterprise that requires a synchronized lifecycle management of each component in relationship with all other direct and indirect related components in the enterprise. The ability to synchronize requires forward planning, current implementation governance and continued support of the product/services individually, as well as the integration channel between them.

Key to the roadmap for change, and the acquisition of factors that affect the change, is:

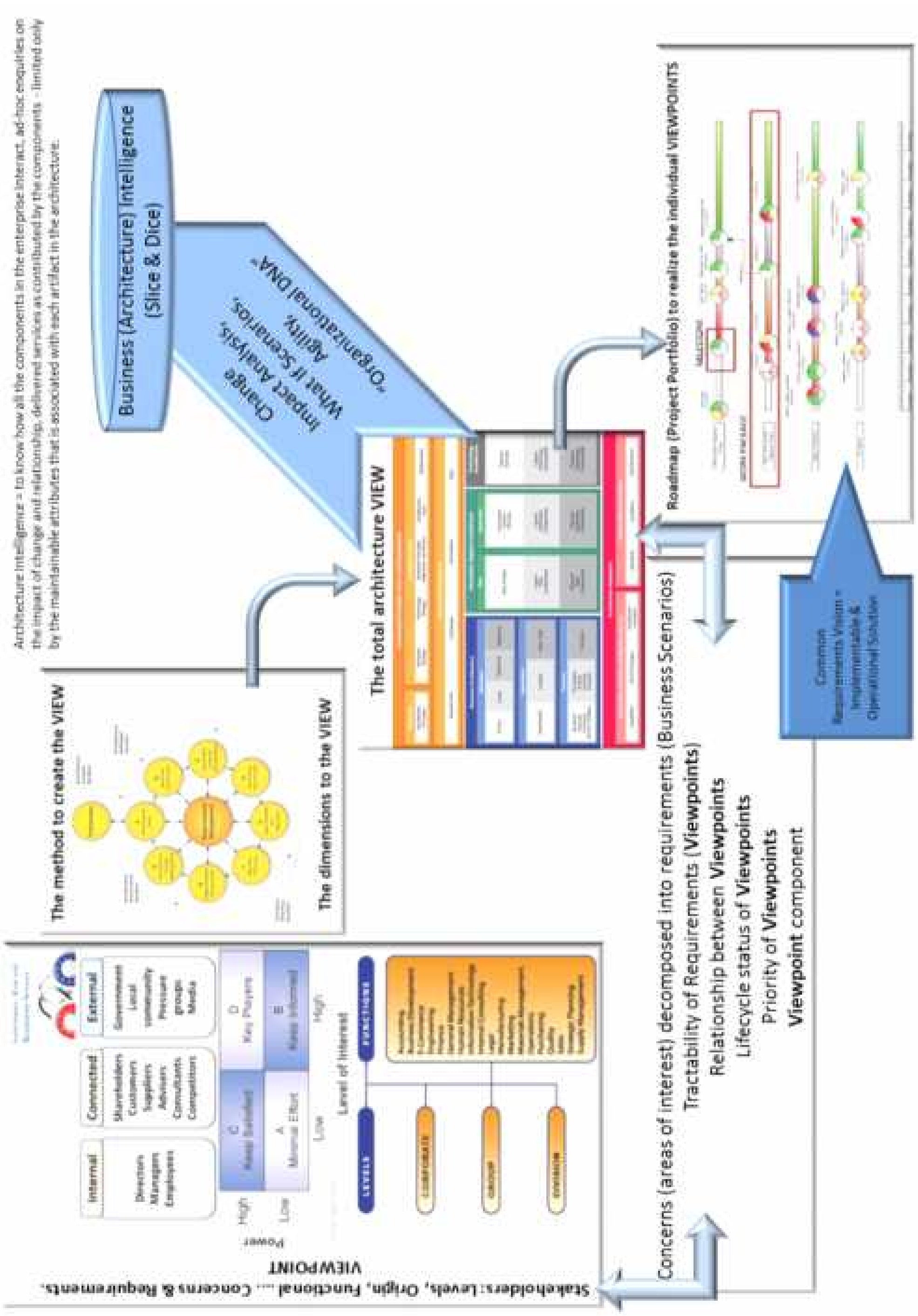
- Understanding of the gaps and work-packages to achieve the change outcome
- The project plan and milestones in achievement (Including quality, time and cost)
- The lifecycle and lifecycle status of the all components affected by the change
- Scope of change (Support requirements as integral part of the design requirements): Impact analysis – cost of change, effort of change, duration of change, risk of change, benefit of change, traceability of change and roll-back of change. What is least risk, least cost, least disruptive and most productive during the change as it impact on the four architectural domains combined.
- Development & rollout: what is the future configuration, what is required to establish the future, what will be required to support in terms of capabilities (People, Process, and Material)?
- Support – what is the configuration, what is needed to support the current configuration, effective & efficient support evaluation - Metrics and Measurements for continual improvement?
- Retirement – what is end-of-life (irrespective of reason), what is needed to decommission the configuration items and the relationships that are impacted, what will replace the retired component and whether it is a one-on-one replacement or a one-to-many (many-to-one) impact on architectural/configuration items.

- How the change impact on the viewpoints of the identified stakeholders.

Figure 4 illustrates the concept of a Enterprise architecture development method (TOGAF ADM) that creates a single view of all the stakeholder concerns (including Logistics) into a single multi-layered model from were changes can be depicted on a roadmap that will include the concerns of all to facilitate the execution of the project and resulting inclusion of artefacts in the lifecycle support configuration.

7 Conclusion

Enterprise Architecture solutions are bounded by principles that cover business-, data-, applications- and technology domains. The principles (DNA) of the design, the checklist to evaluate the cause and effect of change request results in a formal approach to ensure a plan. The cause of change is via change in requirements and traceability thereof, while the effect is determined via an integrated content Metamodel. The plan provides for the identification of all necessary resources to craft the change, implement and operate the resulting architecture.



Source: Based on The Open Group (2011)

Figure 4: Viewpoints translation to Project portfolio for implementation

Enterprise Architecture, as a framework to implement strategy, defines the current and future architectures of the enterprise, assess the gaps, identify alternatives and solutions to address the gap and plan the transition of the various projects to move towards the future architecture. The alternatives, solutions and migration plan ensure that the whole enterprise is considered when the solutions are designed to ensure that the implemented phases are ready for utilization when implemented and operational support is aligned with implementation.

The operation and maintenance processes of the architecture are managed by practices that are designed for those lower system levels. The fit of solutions into the current architecture is ensured by the enterprise architecture that ensure that the selection and/or design of architectural content took into consideration the current practices and that a smooth transition is planned to the next stage and that the next stage is fully operationally supportable when implemented.

Enterprise Logistics is underpinned by support and project management principles, TOGAF only provides framework of the requirement scope and compliance criteria to execute the project. The TOGAF ADM as a project template includes the “soft” issues (organizational design, role & responsibilities of resources) but also the establishment of “hard” issues to automate the process and the reporting from the critical success factors to ensure the enterprise is successful.

The enterprise operation in a system level is thus not the only determining factor for enterprise architectures ability to plan logistic rollout. Rather, the presence of human interaction in the system and the non-deterministic result of human behaviour in a given situation greatly determine the ability for logistic rollout.

All of this complexity for logistics enterprise architecture is to get the right reports on the required elements so that the right managers can make informed decisions to sustain business into the future.

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9 Biography

Johan Coetzee has experience of more than 20 years in the full system development lifecycle of bespoke and COTS business applications with experience in ICT projects and IT service management. He received his B.Sc. (Computer Science) degree from University of Pretoria and is TOGAF 9 Certified. He is a Principle Enterprise Architect at the CSIR since 2012.

Louwrence Erasmus worked for 20 years in academia, national and international industries on multi-disciplinary projects. He is a registered professional engineer with ECSA and a senior member of IEEE and SAIEE. He serves on the management committee of INCOSE South Africa. He is an advisory board member of Third Circle Asset Management. He received the B.Sc., B.Eng., and M.Sc. degrees from the PU for CHE and the Ph.D. degree in 2008 from the NWU. He is a Principle Systems Engineer at the CSIR since 2013.