Enterprise Architecture Driven Approach for Digital Transformation of Modern Organization

Thesis by
Sunil Mysore Kempegowda
MSc (Info Sys), TOGAF, ArchiMate, PMP, CSM, ITIL

In Partial Fulfilment of the Requirements for the
Degree of Doctor of Philosophy at the
Graduate School of the
University of Technology Sydney

University of Technology Sydney
New South Wales, Australia
November 2018

Dedicated to my Father M. K. Kempegowda, Mother B. Susheela and Wife Rashmi Thimme Gowda,

Who always believed in me, due to their sacrifice, encouragement and support I was able to achieve this incredibly memorable milestone.

Statement of Originality

I, Sunil Mysore Kempegowda, declare that I am the author of this thesis and that I have not used material in part or whole from other sources without proper acknowledgment, and that theories, results and designs of others that I have incorporated into my report have been appropriately referenced and all sources of assistance have been acknowledged.

I also certify that any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in this thesis.

This research is supported by the Australian Government Research Training Program.

Production Note:

Signature: Signature removed prior to publication.

Date: 2nd November 2018

Acknowledgments

"It is the supreme art of the teacher to awaken joy in creative expression and knowledge."

- Albert Einstein, Theoretical physicist, developed the theory of relativity.

Completing this Ph.D. is a milestone in my life, to achieve this accomplishment many people have given their support, but I am able to mention only a few. I am personally grateful to Dr. Zenon Chaczko for trusting me, his guidance, encouragement, vision; Dr. Christopher Chiu for his advice, support and Dr. Mehran Abolhasan for his motivation.

I started my research on how to manage projects based on emerging technologies. As I did my research I realized its more critical to meet the organization's changing goals. That is achievable considering the whole of the enterprise rather than an individual department or project. As my research based on practical projects, i.e., action based, changed my profession from Solution Architect to Enterprise Architect(EA). I am ever grateful for Vish Viswanathan for providing an opportunity to work in EA space. I always believed like Medical Professor an IT professional must work in projects and at the same time share the knowledge. I want to extend my gratitude for Dr. Daniel Chandran for giving an opportunity to teach in UTS and motivate me to join the Ph.D. programme. I am indebted to the staff of UTS particularly Faculty of Engineering and IT (FEIT), for their support in achieving my objective.

I was able to achieve this significant milestone due to the encouragement and confidence from my Parents: M. K. Kempegowda, B. Susheela; Brothers: M.K. Satyanarayana, M. K. Lokesh Babu & M. K. Rajesh, and my wife Rashmi Thimme Gowda. Ph.D. requires many sacrifices especially for a married person working a full-time job. Appreciate Rashmi and my children Bhumika Sree Gowda and Dhivyen Gowda for their understanding even though I did not spend much of time with them while doing my research. Finally, for all the stakeholders in the projects I have worked, their valuable inputs that have contributed to shaping this research. Some of the project's information has been used to validate my research.

Thankful for the Almighty for this beautiful life and the great opportunity given to me. This research learning can increase the success rate of digital transformation projects that will contribute to making a better world.

"Families are the compass that guide us. They are the inspiration to reach great heights, and our comfort when we occasionally falter."

- Brad Henry, An American lawyer and politician.

Abstract

The acquisition of real-time data is only possible if systems are end-to-end connected across an entire organization. To generate effective real-time information, organizations need to streamline their business processes, rationalize their applications and deploy technologies that address the needs of the organization rather than individual departments. Hence, it is critical for organizations to embrace the Enterprise Architecture (EA) best practices, open standards, architectural design patterns, proven methodologies and architectural frameworks. Furthermore, the trend towards the model and architecture driven design that addresses disruptive technologies and needs of the business will continue. A non-sustainable option is to stick with spaghetti-like architectures.

This research explores the impact of applying The Open Group Architectural Framework (TOGAF) methodology on the digital transformation of business organizations. The core components of methodology that use open standards and best-practices are evaluated from the business perspective. Several, real-life and industry-based action research studies are elaborated on, and both pitfalls and merits of the architectural approach are discussed.

Massive amounts of data collected and analyzed to benefit this research originate from large scale, and actual industrial projects. The data collection for the research was executed while the real projects were running using surveys, questionnaires and observation notes both before and after the project. The data collected were compared and validated with the theoretical model. Validation of various architectural models and methods was performed using an action studies approach. Enterprise Architecture practice takes a rather long time to realize real benefits. Therefore, a Qualitative approach supported by statistical analysis was performed as a part of the experimentation that confirmed the validity of the initial hypothesis. A critical approach to a priori data collection at the beginning of the project and posteriori data collection after project execution was applied. Also, an adaptive model of Archers Morphogenesis was used for identification and validation of the selected categories and attributes of the research outcomes.

The key projects that contributed the relevant data used in this research originate from such domains as: education, health, logistics, utility and financial sectors. The results obtained confirm that a successful, digital transformation needs to be EA-Driven. It was also found that for EA practice to be successful, maturity assessment should be done across all stages of the Architecture Development Methodology (ADM) cycle. Hence, it's critical to use a suitable EA tool to perform this task.

The investigation has justified the merits of using the EA Approach for Digital Transformation. Notably, the proposed extended Comprehensive Capability Maturity Model (CCMM) Assessment framework represents the research contribution of the thesis. The model enables to capture a realistic estimate of cost, time and efforts to match the business objectives. Organizations can get the actual value of digitization by choosing the best breed of methodologies to obtain optimal results. Using proposed sophisticated enterprise architecture tools is validated in action studies, allows to capture real-time information that is required to perform the advanced impact analysis to assist decision making and foster organizational innovation.

Table of Contents

List of Figures

List of Tables

Nomenclature

AA	Application Architecture
ABB	Architectural Building Blocks
ACMM	Architecture Capability Maturity Model
ADM	Architecture Development Method
AGA	Australian Government Architecture Framework
AI	Artificial Intelligence
APM	Application portfolio management
ARM	Application Reference Model
ASCII	American Standard Code for Information Interchange
BA	Business Architecture
BABoK	Business Analysis Body of Knowledge
BMM	Business Motivation Modelling
BPMM	Business Process Maturity Model
BPMN	Business Process Model and Notation
BYOD	Bring Your Own Device
Capex	Capital Expenditure
CERM	Cloud Ecosystem Reference Model
CMM	Capability Maturity Models
COBIT	Control Objectives for Information and Related Technologies
DoC	US Department of Commerce
DoDAF	Department of Defense Architecture Framework
DRM	Data Reference Models
EA	Enterprise Architecture
EAO	Enterprise Architecture Office
ENIAC	Electronic Numerical Integrator and Calculator
FEAF	Federal Enterprise Architecture Framework
IAF	Integrated Architecture Framework
ICT	Information Communications Technologies
III-RM	Integrated Information Infrastructure Reference
IoT	Internet of Things
IRM	Infrastructure Reference Model
IT	Information Technology
ITIL	Information Technology Infrastructure Library
LAN	Local Area Network
LIS	Land Information Systems
MAN	Metropolitan Area Network
MDA	Model Driven Architecture
MoDAF	British Ministry of Defence Architecture Framework
NSW GEA	NSW Government Enterprise Architecture
OOP	Object-Oriented Programming
Opex	Operational Expenditure
OSI	Open Source Initiative
P3M3	Programme and Project Management Maturity Model

PaaS	Platform as a Service
PMBoK	Project Management Book of Knowledge
PMI	Project Management Institute
PRM	Performance Reference Model
RA	Reference Architecture
RM	Reference Model is
ROI	Return on Investment
SBB	Solution Building Blocks
SOA	Service-Oriented Architecture
SOA-RM	Service-Oriented Architecture Reference Model
SRM	Security Reference Model
SysML	Systems Modelling Language
TA	Technology Architecture
TCO	Total Cost of Ownership
TOGAF	The Open Group Architectural Frame
TRM	Technical Reference Model
UML	Unified Modelling Language
UNIVAC	Universal Automatic Computer
WAN	Wide Area Network
WWW	World Wide Web
1 to 5 G	1st to 5th Generation mobile network

PART I
Research Theory and Concepts

1. Introduction

1.1 Purpose

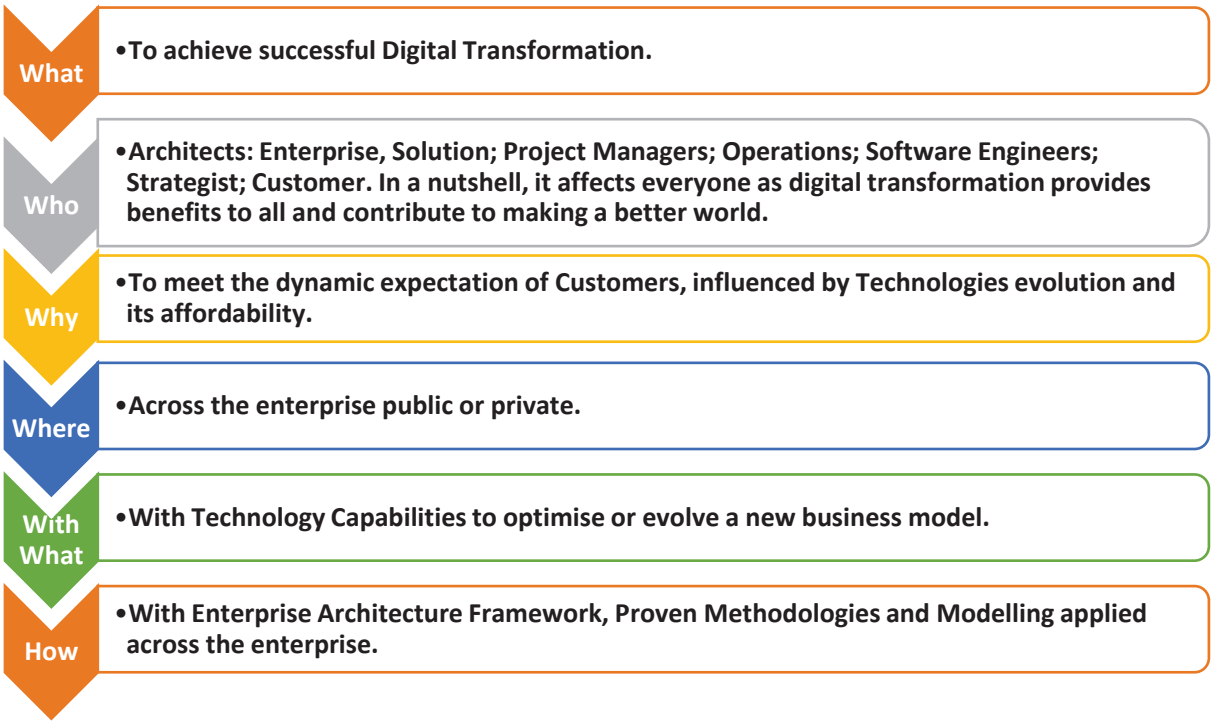


Figure 1 Research Strategy

The objective of this research is to show that the Enterprise Architecture (EA) approach is critical to the success of an organization's digital transformation.

What is Digital Transformation?
Digital Transformation is the adoption of technology to digitize their organizational assets to get insights of an organization in real-time as much as possible. This is to assist the organization to be dynamic to address the changing needs of the customer.

Figure 2 Digital Concept

The ideal approach proposed for the EA practice to be successful is as follows:

- Perform maturity assessment of the organizational practices.
- Determine frameworks & methodologies and customize as per the organization.
- Use the EA tool that links to other organization practices.

1.1.1 Motivation

To increase the success rate of organizations' digital transformation with an Enterprise Architecture Driven Approach.

1.1.2 Scope

For a successful digital transformation, the key aspects are People, Process and Technology.

This research covers:

- **Process**: Enterprise Architecture framework in detail and overview of related complementary methodologies.
- **People**: Stakeholder engagement, a high-level overview
- **Technology**: Emerging disruptive technologies, a high-level overview.

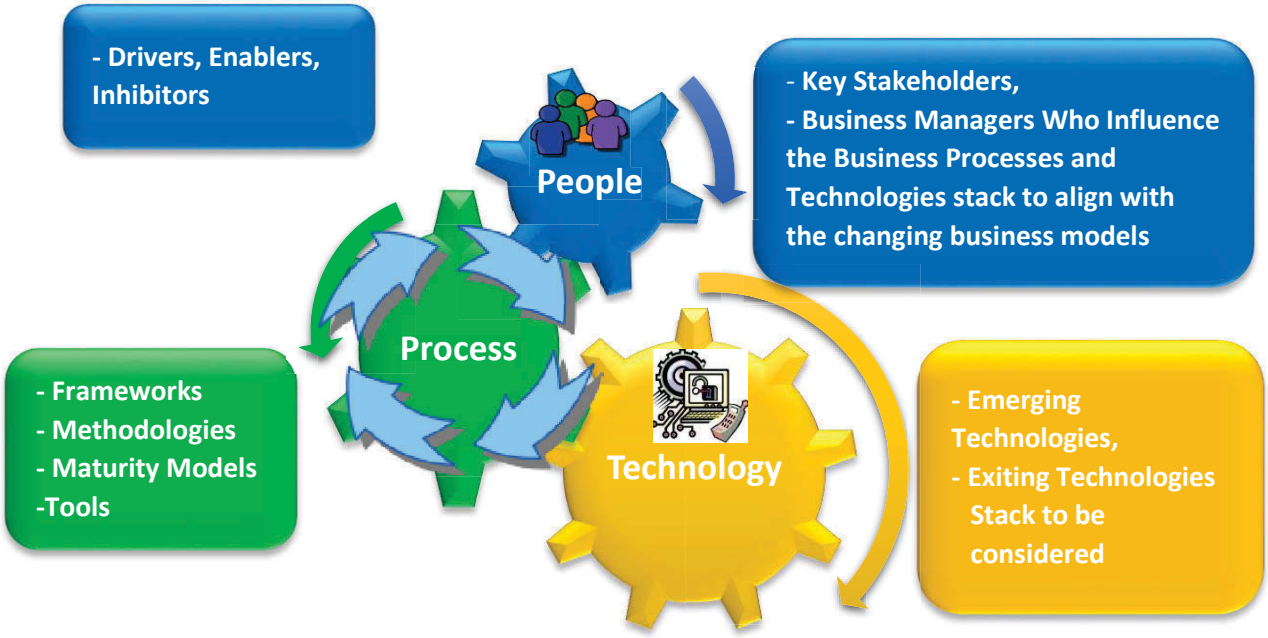


Figure 3 Research Scope: People, Process, Technology

1.1.3 Outcomes

Frameworks and methodologies that acts as a reference for practitioners, that can be tailored based on the organization domain, context, and business needs. In addition, it will increase the success rate of organization digital transformation. The proposed frameworks and methodologies are based on:

- Standards bodies,
- Product vendors,
- Government agencies
- Based on open standards

1.1.4 Research Questions

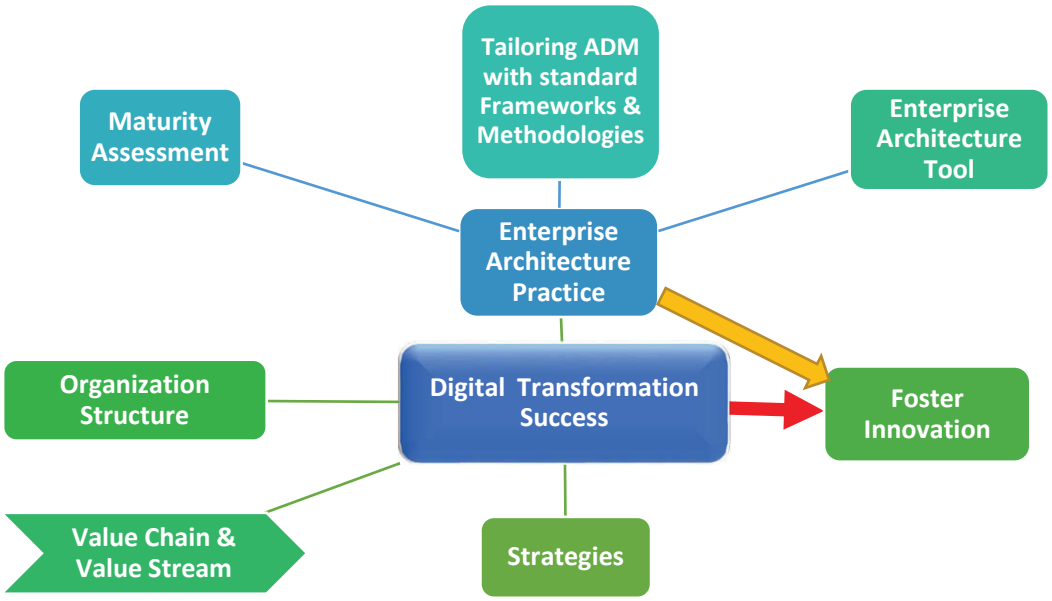


Figure 4 Research Questions Map

1.1.5 Primary Research Questions

The main objective of the primary questions are to validate the research outcomes:

Question	Primary Research Questions	Description
RQ 1	Does Enterprise Architecture approach increase the success rate of digital transformation?	Addressed in: ***Chapter 2: Literature Review;*** Covers Technology adoption of Organizations. Build the case why EA is necessary and addressed in, **Module: 2.3.3 Project Success Analysis.**
RQ 2	Does maturity assessment applied across the Architecture Development Method contribute to the success rate of digital transformation?	Addressed in: ***Chapter 4: Enterprise Architecture Stack; Module: 4.4 Capability Maturity Model***
RQ 3	Do customized Architecture Development Method, inclusive of other frameworks and methodologies, enhance the success rate of digital transformation?	Covered in, ***Chapter 4: Enterprise Architecture Stack; Module: 4.5 Complementary Framework & Methodologies for TOGAF,*** also, in: ***Module: 4.6.1 Complementary Modelling, Frameworks and Methodologies, and Chapter 3: Research Approach and Methodology; Module: 3.3 Frameworks referred to identify the attributes to measure Research Outcome.***
RQ 4	Does Enterprise Architecture tool aid the success of digital transformation?	Addressed in: ***Chapter 4: Enterprise Architecture Stack; Module: 4.6 Enterprise Architecture Tool.***

Table 1 Primary Research Questions

1.1.6 Supplementary Research Questions

Supplementary questions were identified while doing the research work. It further provides additional value-add that can be incorporated to increase the success rate and endorse the real finding of digital enterprise, i.e. innovation.

Research Question	Complementary Research Questions (CRQ)	Description
RQ 5	Does Project Management Office managed by Enterprise Architecture Office, contribute to the success of Enterprise Architecture Practice?	Covered in: ***Chapter5: Research Action Study;*** ***Module: 5.3.8.1 Proposed EA positioning across the ministry.***
RQ 6	What strategies will aid the success of organization digital transformation?	***Chapter 6: Proposed Enterprise Architecture Approach for Digital Transformation of Modern Organization.***
RQ 7	Does Enterprise Architecture practice in an organization foster innovation?	***Chapter 5: Research Action Study; and*** ***Chapter 6: Proposed Enterprise Architecture Approach for Digital Transformation of Modern Organization.***

Table 2 Supplementary Research Questions

1.2 Hypothesis

1.2.1 Proposition

The success of digital transformation can be measured using Enterprise Architecture practices and maturity models.

1.2.2 Formulation

The Organizational types considered are private and government bodies that are from medium to large sizes, which are transforming into digital enterprises. The transformation is converting manual or semi-manual business processes to automated business processes. The technology used as an enabler to be identified through Enterprise Architecture practice.

1.2.3 Validation

Though business transformation exists from the early 90's, there is no proven way of doing it successfully. As technology evolves, it displaces the business models that will trigger Organizations to adopt new technologies. Historically, technologies obtained was on a need-by-need basis; there was no focus, holistically across the Organization. In consideration of these factors, Qualitative research based on Action based methodology is practical to test the hypothesis.

1.3 Research Drivers

1.3.1 Factors contributing to Organizational Transformation

- Ever increasing mobile network speed,
- Mobile devices are replacing computers,
- Cloud computing service model,
- Organizations acceptance of Social media for business and work,
- Bring your own device, a norm in organizations,
- Change in business model from Capex to Opex,
- Affordable information technology services,

- Tech savvy well informed demanding customers.

1.3.2 Embracing Emerging Technologies and its Hurdles

- Challenges to find the resource with the right technical skills,
- Utilization of evolving technologies which contribute to high risk.
- Resistance from the business to embrace digital capabilities,
- Risk aversion of organizations,
- Difficulties to find the right vendors.

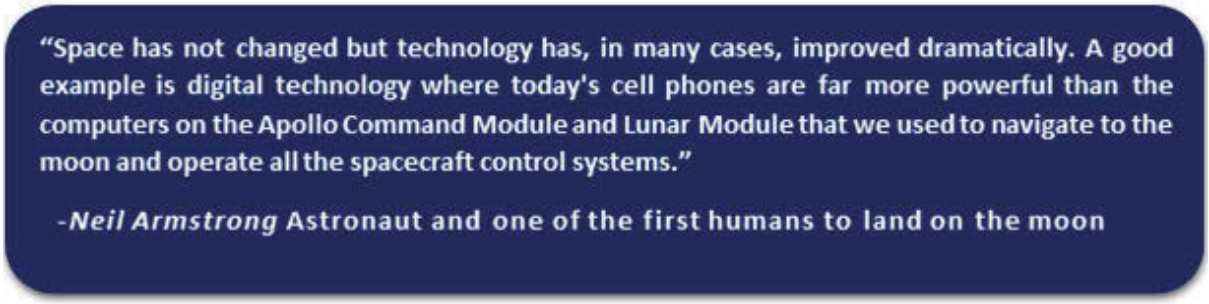
1.3.3 Impact on Organizations due to Evolving Technology

- How to identify the technologies that are right and relevant to an Organization?
- How to future-proof technologies? (A million-dollar question)
- How to choose the technologies stack that meets the objectives of the business needs?

1.3.3.1 This research covers:

- Emerging technologies that are evolving, the current technologies stack of a typical enterprise and factors that contributed to the current technologies stack.
- Enterprise Architecture Stack: Conceptual model and Framework.
- Overview of Capability Mature Model and its significance for EA success.
- Overview of different methodologies and its importance for EA practices.
- Enterprise Architecture tool and its value for EA success,
- As this is action-based research, an overview of the projects that contributed to this thesis is covered.
- Proposed Digital Transformation Strategy based on EA approach.
- Limitation of the current research, Conclusion, and Envision of the Future Work.

1.4 Research Background



Technology has evolved a long way from the inception of the first commercial computer costing US 1.6 Million in 1951 (Berger 2001) to 10,000 times its configuration, that cost less than US$100 today.

The First Digital Computer Electronic Numerical Integrator and Calculator (ENIAC) was built between 1943 and 1946. It occupied 1,800 square feet space, consisted 18,000 vacuum tubes and weighed 59 tonnes. Also, the cost of making this computer was enormous.

Universal Automatic Computer (UNIVAC 1) is the first commercial computer commissioned on June 14, 1951, for US Census Bureau, built by Unisys for $US1.6 million. The configuration of the UNIVAC 1 computer was 12MB of data with processing speed of 0.008 MHz, occupying 952-cubic feet of space. Comparing to the current smartphone which is few thousand times higher specification costing less

than US$100/- with Quad Core processor of 1.2GHz, Android Operating System, Memory (Internal): 4GB ROM + 512MB RAM.

Comparing the cost of technology which was too expensive in late 90's, purchased only by developed countries and Fortune 500 companies. The present pay as you go (a.k.a. service model), technology is a commodity affordable by small business as well.

The advent of affordable smartphones, reliable mobile networks and the proliferation of social media has made humanity more dependent on technology. The technology stack consists of Cloud, Social Media, Internet of Things, Analytics Platforms, Artificial Intelligence, Big Data, Machine Learning Deep Learning, Robotics Software, Block Chain, Software defined Virtual Systems & Networks and Physical Hardware. It is inevitable for the organization to embrace technologies, for the following objectives:

- To improve the offered products and services efficiency,
- To be competitive by reducing the cost of the services or products offered,
- To get real-time insights to enhance services or products,
- To provide services or products that meet the changing expectations of the customer,
- To retain employees by reducing the redundant (monotonous) task by utilising technology and improving employee's productivity.

Considering companies such as Motorola, Nokia and Kodak (Lucas & Goh 2009), it has been proven that organizations have lost their market leadership or perished if they do not embrace technologies for the betterment of their services or products offered. Therefore, it is critical for organizations to adopt technologies, for their survival and existence.

1.4.1 Technology Affordability

Government organizations and Fortune 500 Enterprises have embraced Information Communications Technologies (ICT) at various timelines to meet the business needs, adhere to regulatory requirements and technologies as they evolved. ICT have evolved from standalone mainframes to multi-tier systems to the current virtualised environment where the infrastructure stack is a software code (Nelson-Smith 2013) rather than physical hardware. To manage the information communications technologies adequately and efficiently various frameworks and methodologies have evolved.

An organization has utilised technology as it evolved, by introducing Applications such as: Financial Management, Rostering Systems, Accounting Systems, Customer Relationship Management, Human Resource Management, Payroll, Enterprise Resource Planning, Real-time insights of services offered and so on. The systems acquired were more tactical to address the need of the Organization, though it was strategically considered to buy the products. The products procured from various vendors based on different technologies that resulted in the spaghetti of systems as shown in Figure 5 Spaghetti Network, below.

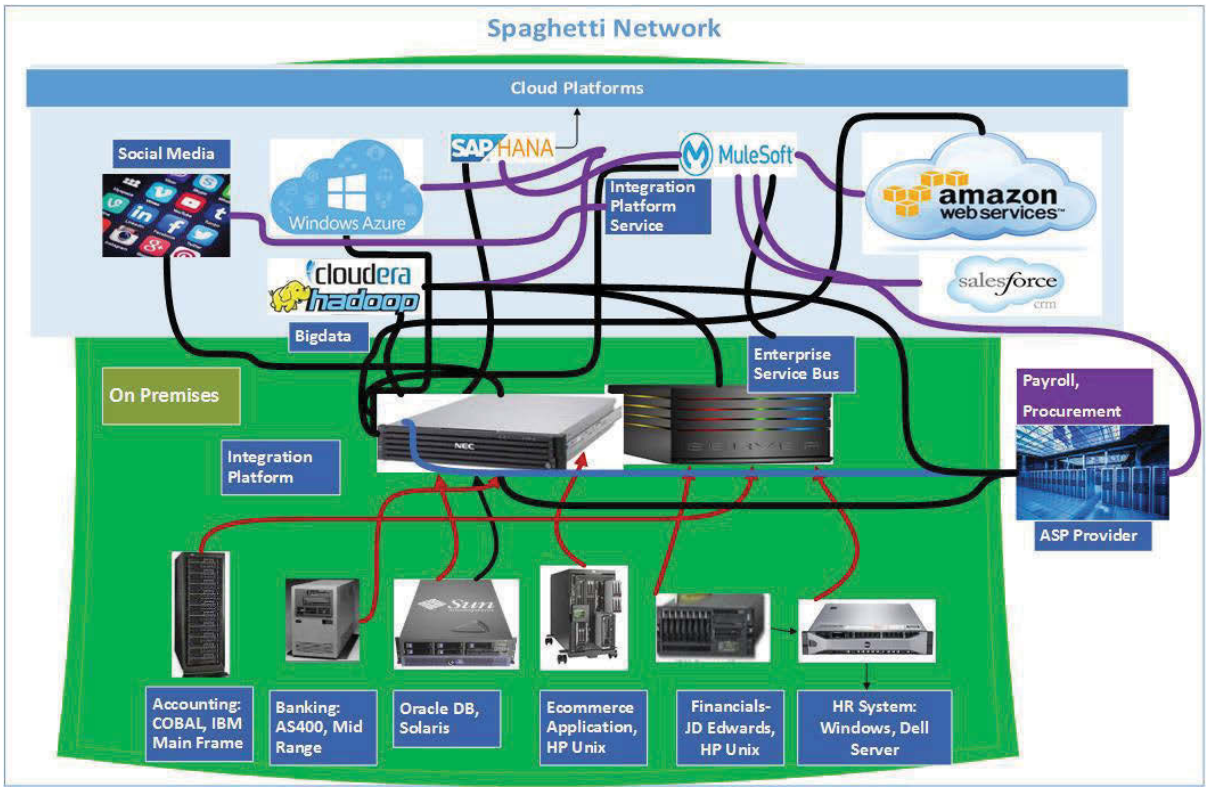


Figure 5 Spaghetti Network

1.4.2 Emerging Technologies

Innovative organizations generally prefer to embrace cutting-edge technologies that are either matured or evolving. This cutting-edge technology also known as Emerging technologies lack a universal consensus of what is emerging? The five key (Kempegowda & Chaczko 2016) attributes of emerging technologies are the "radical novelty, relatively fast growth, coherence, noticeable impact, uncertainty and ambiguity" (Rotolo, Hicks & Martin 2015).

Though technologies evolve continually, specific technology such as Mainframes, Windows Desktop, Client-Server, Internet and Multi-Tier Web have changed the business model, lifestyle of people and reduced the cost of services drastically.

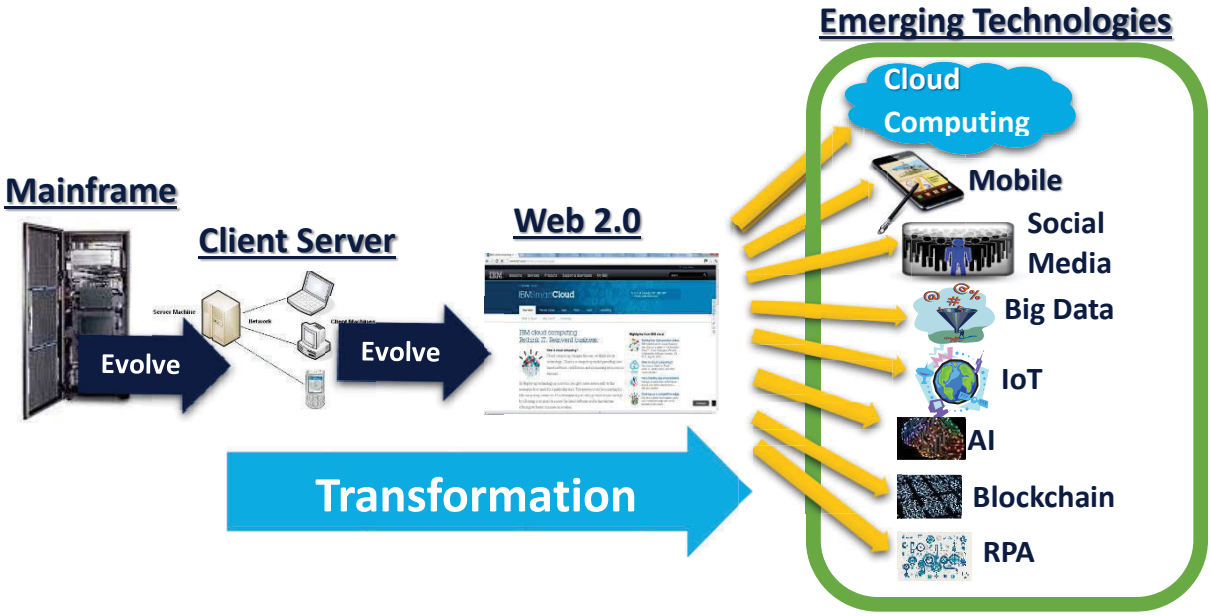


Figure 6 Technologies Evolution

Emerging technologies such as Mobile, Cloud (public and private), Social Media, Big data, Machine Learning, Internet of Things (IoT), Artificial Intelligence, Robotic Process Automation(RPA), Blockchain, and so on which are still evolving will drastically disrupt the existing business model and give the path to new business models that have not been envisioned yet.

- **Mobile**: Enabled users to communicate fuelled by 3G, 4G powered by the smartphone that can use internet creating enormous amount data. As mobility is not specific to one department that needs to be addressed enterprise-wide.
- **Cloud Computing**: Enabled Organizations to rapidly provision infrastructure, enabled sufficient computing power to the business, that too based on the need basis. Infrastructure procurement and provisioning consideration are across the organization.
- **Social Media**: Allowed the users to communicate at free in real-time and share events as their picture, activities, upcoming events, advertising themselves. Organization jumped at the opportunity of profiling the user's behaviours and their buying patterns, changing the business model that Organizations forced to address. To understand the customer's needs and expectation across the enterprise to get real benefit.
- **Internet of Things (IoT):** Sensors backed with IPv6 enabled to monitor things in real-time creating data by leaps and bounds. Innovative organizations that have implemented IoT are reaping the benefits. As IoT matures, it's inevitable to adopt IoT, that needs consideration from Enterprise-wide focus.
- **Big Data**: The data that created due to Mobile, Social Media, and IoT needs managing, analysing to get insights. Due to Hadoop that uses commodity hardware providing massive storage with enormous processing power virtually for processing any volume of data. Big Data needs to be managed from the enterprise-wide perspective to get its optimal benefit.
- **Artificial Intelligence (AI)**: Intelligence demonstrated by machines comparable to natural knowledge of Human being and enables insights of the subject area that is not possible by human brain alone. AI will become an optimal part of an organization that needs enterprise-wide approach.
- **Blockchain**: The digital, decentralised distributed ledger with transactions recorded chronologically enables openness, transparency, reducing the cost of the operation is critical

for digitisation. It's a foundational technology that brings in transparency in the transactions that it is inevitable to be considered enterprise-wide.

- **Robotic Process Automation(RPA):** The specialized software programs known as robots that manage repeatable business process replacing humans. It is critical to have an enterprise-wide approach to reduce the repeatable tedious task to increase efficiency and decrease the cost.

Emerging Technology Effects include the following aspects:

- Provide innovative capabilities that will enable new business opportunities reducing the cost of products or services;
- Able to improve economic, social confidence that decreases poverty that contributes to political stability;
- Ability to address Global issues;
- Disrupt the existing business models with innovative business models;
- Provide affordable education to the masses;
- Increase awareness to the public, thereby they know their fundamental human rights; and
- Quality Health services at affordable cost.

1.4.3 Open Source Technology Effects

"No matter how many smart people we hire inside the company, there's always smarter people on the outside. We find it is worth it to us to open source and share our code with the outside world in exchange for getting some great advice from people on the outside who have the expertise and are willing to share back with us."
- Jared Smith Open Source Community Manager, Capital One

Free software as defined by Software Foundation (Foundation 2004) is free for users to run, copy, distribute, study, change, and improve. Organizations have benefitted by leaps and bounds using free software. Especially developing countries, academic institutions were able to use technology that was once too expensive to buy.

Open source software is available generally at no cost for anyone to use, modify and distribute. As software source code is available, this encouraged added involvement from the software developers. Collaboration from developers promoted independent peer review that enabled transparency in software. It also allowed the software to evolve with more features and even reliability. Therefore, it changed the direction of software that was profit-driven, proprietary to protect intellectual property, towards more open standards.

A Non-Profit Organization, Open Source Initiative (OSI) (Initiative 2010) reviews, validates and promotes Open source software to be used in the commercial world. Open source software validation from a standard organization fosters trust with developers, users, corporations and governments that gives the confidence to use the software. The characteristics of open source software include lower cost, reliability, higher quality, greater flexibility, and no vendor lock-in.

Open Source software due to its characteristics of transparency, collaboration, interoperability and open standards promotes technology adoption and innovation.

The notable milestones of open source that has fostered technology adoption due to its affordability, access to source code overall making a better world are listed in Table 3 Key Open Source Software fostering Technology Adoption :

Description	Purpose	Adoption
Linux	Operating System	Projects hosted estimated development cost of USD $ 16B, developers 13,594, companies 1,340 contributed to the Linux kernel since 2005 (Foundation 2018)
Mozilla Firefox	Browser	Worldwide Market Share on February 2018 is 5.5% (StatCounter 2018).
Tomcat	Application Server	Worldwide market Share on 2018 is 89.6% (iDatalabs 2018).
Apache	Web Server	Worldwide Market Share of active sites on February 2018 is 44% (Netcraft 2018).
WordPress, Drupal	Content Management System, Blogging	Widely used by Government agencies as US, Australia, Business
Android	Mobile Operating System	Global Market Share as on 2017 February is 87.7% (Statista 2017).
PostgreSQL	Database	Widely used by commercial Organizations
MongoDB	Distributed database	Fifth place in 2018 (IT 2018).
OpenOffice	Office Suite	Widely used by medium and small Organizations
Java, Python	Software Language	Default language for open source and commercial applications
Git	Version Control System, Project Management tool	Default version control for both public and private Organizations
Eclipse	Integrated development environment	The default Rapid application tool used for software development based on Java
ArcGIS	Geographical Information Systems	Widely used across the world
Xen, KVM	Hypervisor	75%+ primary cloud platform is based on Linux, KVM, Google Cloud
Docker	Container	Default container for cloud platforms
Kubernetes	Automating deployment, scaling and management of containerised applications	1,180 companies involved, the contribution from 3,000 developers for 80,000 commits (McLuckie 2018)
Hadoop	Framework for Bigdata	Underling framework for the Big Data platforms
Horton Works	Hadoop platform	100% open source, used by eBay, Mitre, Symantec, Western Digital, Samsung
Mycroft	Voice assistant	That used for simple science project to commercial applications
Hyperledger	Cross-industry blockchain technologies	Real-time information contributed by securely distributed ledger adds to safer market, increase efficiencies reducing costs used by Intel, Cisco, Visa (Data 2018).
Ethereum	Open-source based Blockchain distributed computing platform	Smart contracts are supported for online contractual agreements used by Visa, Bitcoin, Coinbase (Ethereum 2018).
OpenDaylight or OpenFlow	Software-defined networks	Standards-based, open and interoperable multivendor environments.
WSO2	Integration platform	Seamless integration enables real-time information with insights increases business efficiency fuels innovative business models.

Table 3 Key Open Source Software fostering Technology Adoption

1.4.3.1 *Open Source Contribution to Innovation*

AWS the leader in cloud computing hypervisor was Xen being open source, Google cloud computing platform hypervisor is KVM. Hadoop is used by innovative Fortune 500 companies like Yahoo, eBay and Facebook.

> **"We will start an open source project if we cannot find something we are looking for, or if the thing that we found that has worked in the past does not work for us as we are moving forward. Sometimes that is for performance reasons. Sometimes that is simply cost reasons or vendor lock-in reasons. Sometimes it is simply we are moving a bunch of our infrastructure over to more modern technologies, and some of the legacy vendors we have used in the past just aren't prepared or aren't willing to run their software in a cloud or containerised environment."**
>
> **- Jared Smith** Open Source Community Manager, Capital One

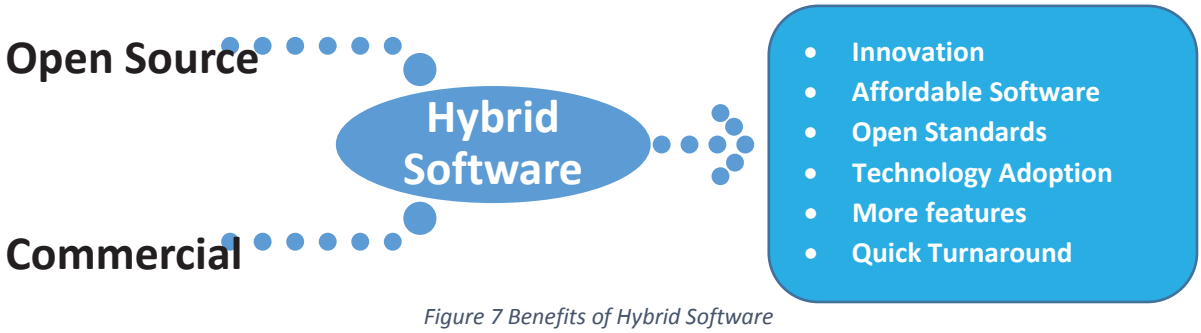


Figure 7 Benefits of Hybrid Software

Open source software is customised by commercial Organizations and bundled with their products with support options is fuelling technology adoption. As open source contributors are developers with passion rather than commercial motivation helps to foster innovation, and thus faster to market. The software industry is growing towards collaboration of open source and commercial vendors. Due to open source, commercial Organizations need to make their products based on more open standards and to keep their products on par with open source software features.

Open source software as its free to use, better features than commercial software and that is ever evolving has contributed to innovation.

1.4.3.2 *Open Platform 3.0 Model for Software Intensive Systems*

The Open Platform 3.0 (Group 2016b) enables to realise the Boundaryless information flow by defining the platform capabilities. The platform supports the emerging technologies capabilities classified as:

- Cloud Computing
- Mobility
- Big Data
- Social Networks and Social Enterprise
- The Internet of Things (networked sensors and controls)
- Technologies, that matures will be added to the platform

1.4.3.3 *Enterprise Architecture*

To manage technology changes and its complexity a proven framework is essential, that is of an open standard developed by a non-profit organization rather than the commercial entity.

According to The Open Group (Group 2011), “Enterprise is a group of organizations with shared or common set of goals.” E.g., a Government Organization, a Government Department, Multinational spread geographically across the world.

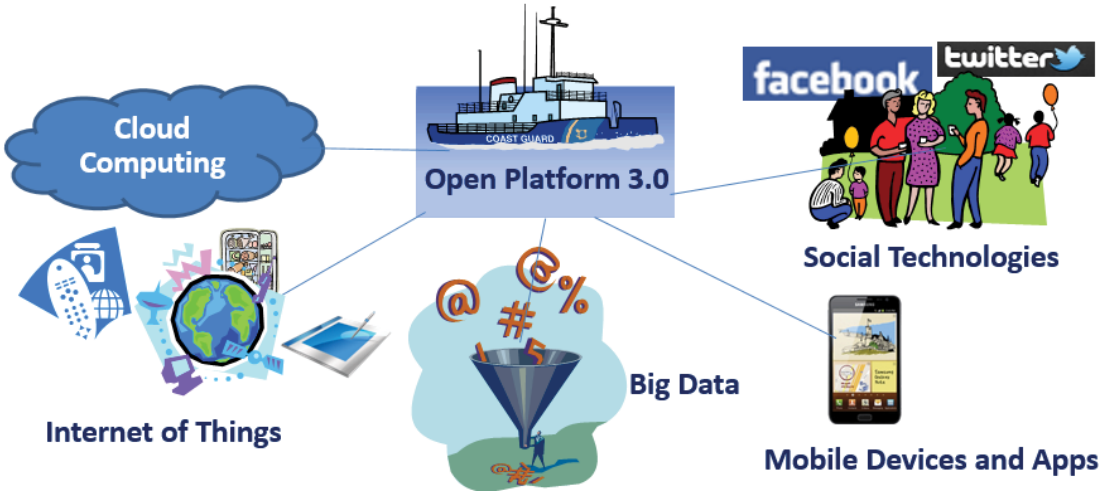


Figure 8 Open Platform 3.0

Services offered by an Enterprise enabled through systems that have Architecture.

The Enterprise Architecture of an organization realizes the organizational vision through information & technology services, business processes & functions, infrastructure and the Architecture that cuts across the multiple systems, functional groups in the enterprise.

Enterprise Architecture definition as defined by Gartner in 2008 and 2018 is shown below:

“Enterprise architecture is the process of translating business vision and strategy into effective enterprise change by creating, communicating and improving the essential requirements, principles, and models that describe the enterprise's future state and enable its evolution” as defined by Gartner in 2008 (Lapkin et al. 2008).

“EA is a discipline that proactively and holistically leads enterprise responses to disruptive forces. It does this by identifying and analyzing the execution of change toward the desired business vision and outcomes. Mainstream viewpoints of EA include:

- Business architecture, which guides people, processes and organizational change
- Information architecture, which focuses on the consistent sharing of information across the enterprise
- Solutions architecture, which develops a direction for managing the portfolio of to-be solutions
- Technical architecture, which focuses on evolving the technical infrastructure” as defined by Gartner in 2018 (Saul Brand 2018).

The scope of the enterprise architecture includes the people (who define the vision), processes (procedure to identify the business service, function, events, information), and technologies to realize the business objectives. Enterprise architects address the changing business needs by defining the artefacts, that is vendor and technology agnostic thereby future proofing as much as possible.

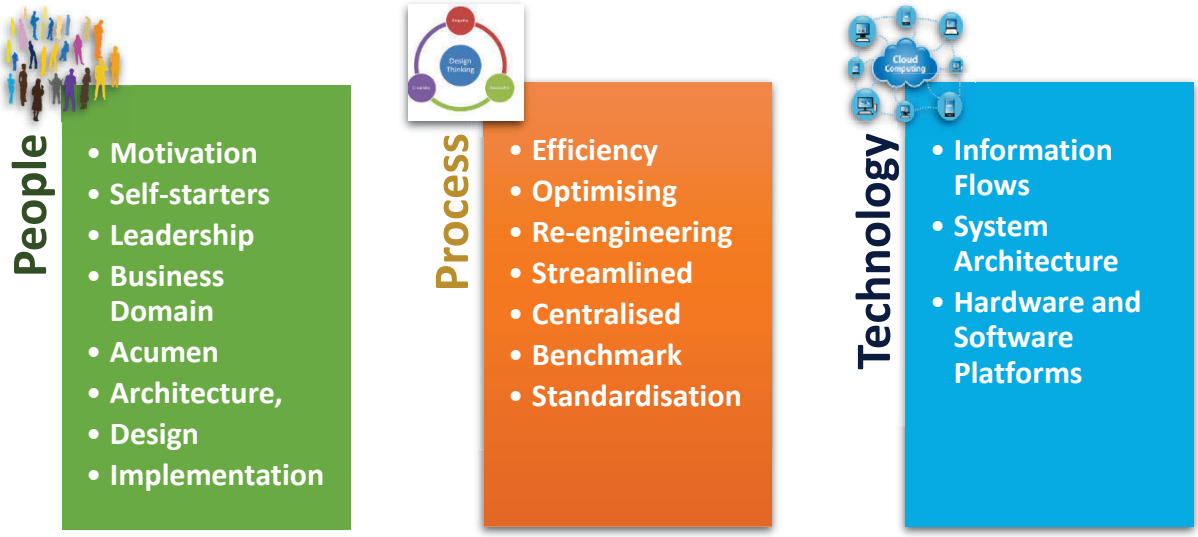


Figure 9 People, Process and Technology

1.4.3.4 Digital Transformation

Digital has various meaning based on the context, according to Oxford dictionary (Press 2016c) digits 0 or 1 that signifies data or signal are called Digital. Based on Cambridge dictionary (Press 2016a) digitise is the process of representing information as '0' or '1' that is used by Computers. Whereby (Techopedia 2017) data denoted physically is analog data such as magnetic tape, vinyl record or physical book.

Summary of Digital technology (History 2003), American Standard Code for Information Interchange (ASCII) technique is derived from binary computing system a mathematical concept work of the German mathematician, Gottfried Wilhelm Leibniz's work of the seventeenth century. Digital technology consisted of two processes where the information is stored as a binary code '0' and '1' and transported seamlessly when the telecom industry swapped from analog to digital. Furthermore, this has been accelerated by digital computers in early 2000 that changed the way people communicate, work and learn. This has given rise to numerous business models that are continuously reinventing itself to keep pace with ever-changing technology where businesses forced to embrace.

1.4.4 Digital Transformation Definition

Digital transformation has numerous definition, some of it that are relevant to the research is from:

- TechTarget (NETWORK 2017b) defines: Digital transformation (DX) is the changing of the Strategies, Process, Function and Products to derive benefits from technologies.
- MuleSoft (MuleSoft 2017)} elaborates Digital Transformation as fundamental change in the way the business operates with innovative strategy, to address the customer's needs, who are accessing the services through mobile devices, wearable technologies, or other devices.

From the above points, the summary is that an organization needs to adopt the technology that is currently proven, keep pace with the technology as it changes and innovate to take advantage of the technology. Also, the organization needs to relook at the services that are offered holistically keeping the customer as the focus and with precise strategies to embrace technology.

For digital transformation to be successful organization must be made aware of technology capabilities. Business and IT departments must work together. It is also crucial for the IT department

to understand the business domain. Then to recommend the technology capabilities to enhance the current business process or operation to increase efficiency. Also, propose how to innovate the business model to take advantage of technology capabilities as demonstrated by the digital transformation of Amsterdam Airport (Group 2017d).

Further, the 'digital transformation' is the changes to all aspects of human society achieved through the adoption of technologies. With the hyper-connected world, it is critical for the enterprise's survival to take the path of digital transformation through the adoption of technologies and to innovate.

1.4.5 Digital Transformation in Practice

Google Maps are taken as an example to relate digital transformation with innovation in the mapping and visualisation space. Google Maps is a type of digital map where the map information is stored in a digital form that can be processed and linked with other applications in real-time based on the user requirements.

Before Google Maps, users were using a static street map to travel between two locations. With Google Maps, a digital navigation tool, users can get the duration of travel between two locations in real-time based on the mode of transportation they choose.

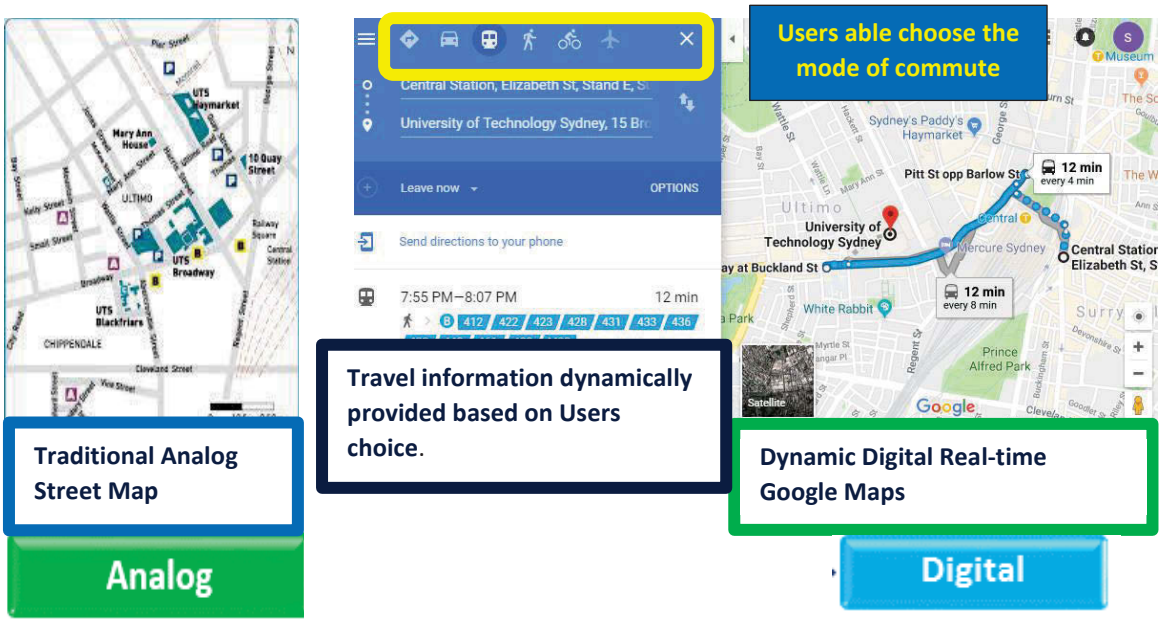


Figure 10 Google Digital Map (Maps 2017)

Google Maps (Maps 2017) provides the following services:

- **Maps**
  - Google Street View – able to embed imagery of Street Views.
  - Custom Map Styling – to customize google map.
  - Satellite Imagery – ability to render high resolution satellite imagery in app.
  - Static and Interactive Maps – to render maps as interactive maps or images.
- **Navigation**
  - Estimated Travel Times - to determine the current or future travel time based on current real-time traffic
  - Directions – to get directions for travel mode as driving, biking or walking.

- Distance Data – to send travel time & distance for location of one or more.
- Snap to Road – vehicles route determined.

- **Place**
  - Place Information – address, Names of more than 100 million places.
  - Autocomplete – auto complete suggesting locations.
  - Location Detection – to provide device location without depending on GPS.
  - Geocoding - geographic coordinates converted to address or possible to convert in reverse order too.

As of December 2017, the above services are available. Though Google Maps started in 2004 with essential features, it evolved in pace with the technology. The current features were not possible way back in 2004 due to the limitation of the technology. Currently, Google Maps (Google 2017) database consist data from 199 countries with driving directions, listings of 100 million business and Points of Interest.

Please note, an analogy of Google Maps is to give an idea of what is digital transformation. However, it's not known whether Google has followed "Enterprise Architectural Approach for Google Maps."

Digital Transformation is defined as the adoption of technologies, and its capabilities to digitize organizational assets.

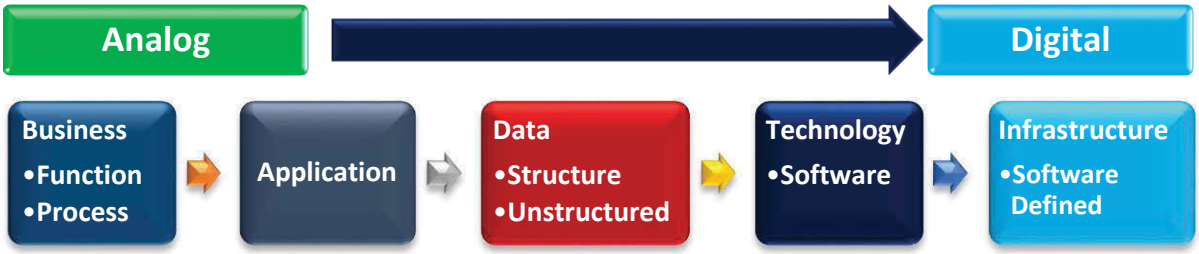


Figure 11 Analog to Digital process

Irrespective of the type of organizations, it is critical to digitize the processes that reduces the human dependency. To get insights of an organization in real-time is possible through digitization. Digitization will enable organizations to be dynamic with the ability to address the customer's changing expectations.

Service Model

Procuring technology to meet the new and evolving business model has changed due to the service model, where the business acquires services needed only on a need-by-need basis. Thereby, there is no upfront investment what is known as Capital expenditure (Capex); to only pay for the utilization this is called Operational expenditure (Opex). Also, there is no vendor lock-in, technology lock-in and due to seamless integration with the new breed of applications that have standard interfaces developed using open standards.

This evolution of technologies and changed business model, has made it affordable for large and small enterprises and the common man. The technology evolution has reduced the timeframe to implement a major IT project from few years to few months or weeks. In the hyper-connected world, social media is accepted as part of day to day life used for personal and commercial usage. Big data and analytics enable to get new insights of human behaviour. Organizations need to reinvent itself through innovation embracing technology in the Digital Age to be competitive and exist.

Some of the Notable Failures of Organizations are:

- **Kodak:** The first company to invent the Digital camera, but did not commercial the product (Anthony 2016).
- **BlackBerry:** Though introduced the first smartphone, with 50 million devices sold in 2011, did not change the original physical keyboard to the touchscreen.
- **AltaVista:** Popular search engine before google search engine, did not innovate to the expectation of end users (LISA EADICICCO 2017).
- **Siebel Systems:** A software company with products like salesforce automation, marketing, and customer service started in 1993, the market capitalisation was US 30 billion in late 90's (CLEVELAND 2014). Siebel did not change the business model as Salesforce.com, Inc. founded in 1999 based on Software as a Service model. So, Siebel Systems was sold to Oracle for US $ 6 billion in 2005, whereas Salesforce.com, Inc. in Spring 2018 as the market capitalisation of US$90 billion.

Digital transformation is not an option, but it is inevitable. Organizations have invested billions of dollars in adapting technology products to operate their business. As anything in nature has as an end of life, some of the products have reached the end of product support or technology is obsolete. It is not only expensive to maintain the products that are based on outdated legacy technologies, but also it is unable for Organizations to improve the service offered, sustain business or innovate drastically.

Consumers are More Demanding with the Expectations as:

- Access to the needed information instantaneously anytime and everywhere,
- Trusted Information where the quality is assured,
- Cost-effective to access and use the information,
- Intuitive interfaces to obtain the information

Organizations need to meet the consumers demand to digitise where ever it is applicable and possible with the efficient use of Information Technology.

1.5 Summary

It is an art and science to embrace cutting-edge evolving technologies. The harnessing of the technologies that are disruptive in nature organizations need to change the traditional business model across the organization to be successful.

An organization is a tapestry of the number of moving parts, that are of the different formats, flow paths, with old and new, tested and untested of an abstract construct of disparate elements or artefacts.

Moving forward to embrace technologies, it is critical for the enterprise to evaluate the current state of the technologies stack, identify the desired future technologies stack (Group 2011). It's like a patient assessed by the doctor before the treatment can begin. Based on the assessment Doctor may ask the patient for ad hoc or a complete end to end check-up. Generally, organizations going for digital transformation has mentioned before having embraced technology over a period. So, it's critical to have a comprehensive maturity assessment that is covered in detail in chapter 4, module 4.4 Capability Maturity Model (CMM).

Technologies are pervasive, and its affordability has reached the human masses across the globe. Human dependency on the technology for their day-to-day chores is increasing at an alarming pace.

People are connected and communicating in real-time due to affordable mobiles, high band mobile bandwidth and free social media. People are exchanging information, comparing the services provided by Government or Private Organizations. So, it is inevitable to enterprises, whether it is Government or Private, to improve the services through the adoption of emerging technologies.

Enterprises have spent millions or billions on technologies to support business in the last few decades. Though Organizations did not realise the benefits of technologies adoption as expected. Also, the technologies stack in the typical enterprise is based on proprietary and hardcoded (Gunasekaran & Ngai 2004). It is expensive to maintain legacy technology, due to vendor lock-in and costly to extend. All this is limiting enterprise to adopt the emerging technologies that fosters innovation.

Technology evolution has given rise to the service model where the organization pays for the technology services consumed. The service model has changed the capital expenditure (Capex) model where cost was paid upfront for technology services, to pay per operational usage expenditure (Opex) model. Technology affordability due to Capex to Opex is disrupting the existing business models. All this has given the possibility for the enterprise to experiment business transformation with digital capability, driven by cutting-edge technologies with minimal budget and reduced risk.

Considering all the above factors, it's essential to have an Enterprise Architecture Framework, proven Methodologies and Modelling applied across the enterprise to increase the success rate of digital transformation.

1.6 Structure

"Research is to see what everybody else has seen, and to think what nobody else has thought"
- Albert Szent-Gyorgyi 1932 Medicine Nobel Prize Winner

Chapters	Objectives
Chapter 1: Introduction to Research	Set the context, defines the background, purpose of the research.
Chapter 2: Literature Review	Covers the evolution of technology, its adoption in an organization and the process followed.
Chapter 3: Research Approach & Methodology	Introduces the research philosophy, then selecting the right framework, the methodology that aligns with the research philosophy and customising the same that is appropriate and practical for this research.
Chapter 4: Enterprise Architecture Stack	Describes Enterprise Architecture (EA) concepts, Organization influence on the enterprise architecture practice, frameworks and methodologies that assist in managing the lifecycle of EA, the core and cross-cutting domain of EA and the technology stack.
Chapter 5: Research Action Study	Discusses the projects that I have worked on and that case studies used for this Thesis.
Chapter 6: Proposed Enterprise Architecture Approach for Digital Transformation of Modern Organization	Suggest the model for digital transformation that is applicable for any domain.
Chapter 7: Conclusion	Discusses the research limitation, followed by future work and walks through the next model of digitisation business model in the insurance industry and finally the overall summary.

Table 4 Chapters & Objectives

"If I have seen further it is only by standing on the shoulders of giants"
- Isaac Newton

1.7 Publication List

The following list includes pertinent publications by the author in relation to the doctoral dissertation:

- Hybrid E-learning Platform based on Cloud Architecture Model: A Proposal – *International Conference on IEEE Signal and Image Processing (ICSIP 2010)*
  https://ieeexplore.ieee.org/document/5697535/
- Transforming the Educational System for the Digital Economy – *International Business Information Management Association (IBIMA 2012)*
  https://opus.lib.uts.edu.au/handle/10453/24047
- Adoption of Cloud Computing in Outsourcing: A New Model – *International Association for Development of Information Society International Conference (IADIS 2012)*
  http://www.iadisportal.org/information-systems-2012-proceedings
  https://opus.lib.uts.edu.au/handle/10453/121154
- Compatibility of Aligning e-learning with Emerging Technologies – *International Conference on Education and New Learning Technologies (EDULEARN 2012)*
  https://library.iated.org/view/CHANDRAN2012COM
- Adoption of Emerging Technologies established on Comprehensive Capability Maturity Model Framework: A new practical model – *International Business Information Management Association Conference (IBIMA 2016)*
  https://opus.lib.uts.edu.au/handle/10453/102559
  http://ibima.org/accepted-paper/adoption-of-emerging-technologies-established-on-comprehensive-capability-maturity-model-framework-a-new-practical-model/

2. Literature Review

> "To write using three sources is plagiarism, but with 300 sources it is science!"
> - Dagfinn Magnus

This chapter covers the evolution of technologies, its adoption in an Organization, the process followed and "Terms and Terminology" used in this thesis. The literatures review is taken from various sources:

- Standard Bodies
- Academic Research Publications
- Research Organizations
- Empirical Studies
- Product Vendors
- Case Studies
- Journal Articles
- Conferences Proceedings
- Monographs
- Computerised Databases
- Dissertations
- Historical Records
- Statistical Handbooks
- Government Reports and Legal Documents

2.1 Technology Landscape

2.1.1 Current Information Technology Landscape

Organizations started using technologies since early 1950's from the mainframe that have evolved to current open platform 3.0. The first to embrace technologies were Government Organizations in developed countries and large private enterprises. The technologies landscape of organization represents the software products acquired to meet the business needs at different timelines. That has resulted in disparate system developed with various technologies, some are proprietary, and some are based on the open standards. The systems were connected to get the real-time information that has resulted in the spaghetti network has shown in Figure 12 Technology Landscape due to Technology Adoption at Various Timelines.

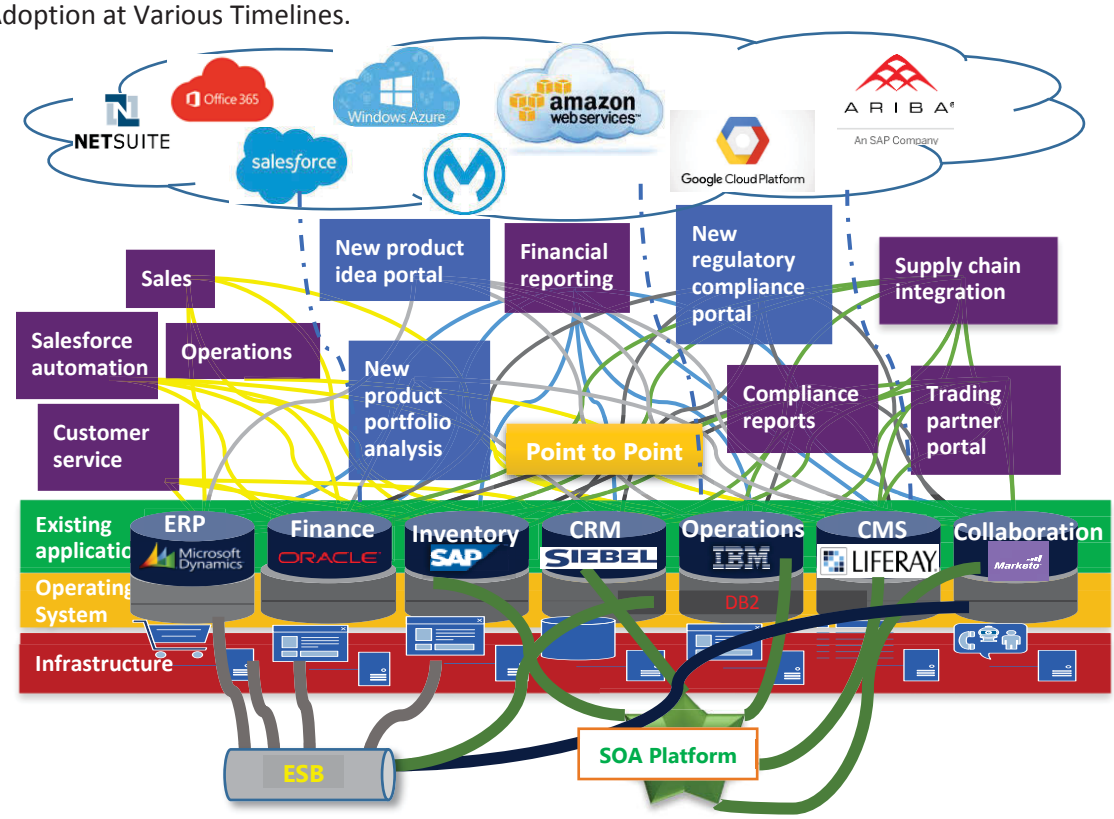


Figure 12 Technology Landscape due to Technology Adoption at Various Timelines

Without EA focus the products are procured with only specific high-level requirements to address the need of an individual or department. With EA in place, products are acquired in consideration of organization strategic perspective to future-proof the business needs.

The critical enablement to achieve future-proof the business needs is accomplished only through procuring the product based on the actual needs of the business. With enterprise architecture approach identifying the Architecture Building Block (ABB) and then by choosing products that meet the ABB.

Technology has also evolved from physical systems to virtual infrastructure, Capex to Opex that has changed its procurement.

Procurement of infrastructure for large projects based on application service provider (ASP) model, the cost is substantial with a commitment to a specified period. The service model in the software industry existed for over a decade, for example, email service, CRM from Salesforce, costing fraction of the ASP model.

Software vendors were making use of the virtual infrastructure over a decade. Technology evolution fuelled improved processes speed, enhanced network bandwidth, with the open standards the whole ecosystem of technology suite transformed to Software/ Platform/ Infrastructure as a Service model. With containers, there is no lock-in with the infrastructure vendor.

The changed business model from Capex to Opex model, technology is a commodity. It has enabled the organization to try out a new business model without long-term investment and commitment to the product.

To do the proof of concept(POC) with new technology for large organization private or public, it is possible, without months of planning to write the business case to qualify the project and request for substantial investment. It is possible to do the POC to validate the technical capability and only adopt the technology if it meets the intended business requirement.

The planning was not only needed to determine the products required but also the infrastructure to host and to the provision in an organization data centres or rent a space and manage the infrastructure in-house or managed service by an external vendor.

The new business model from Capex to Opex brings in its challenges. Business units instead of consulting the IT department are trialling or procuring service-based systems without the knowledge of IT, referred to as Shadow IT. Also, as business unaware of IT standards are exposing corporate Intellectual Property (IP), data to the external world and contributing to security breaches.

It has been critical for an organization to determine the business needs pro-actively and provide the services, which can be enabled only with the focus across the organization that is possible with Enterprise Architecture practice in place.

With the services model, it is possible to procure the services in hours for the required infrastructure services and software needed by the business. That has reduced the procurement from months to days and contributed to the project lifecycle to reduce from years to months or weeks.

Software model has evolved from intangible to tangible. Realised due to Cloud computing that has enabled infrastructure, platform, and software as a service model, that is illustrated by services offered by AWS, Google and Azure respectively in Figure 13 Amazon Web Services, Figure 14 Google Cloud Platform, and Figure 15 Microsoft Azure Services.

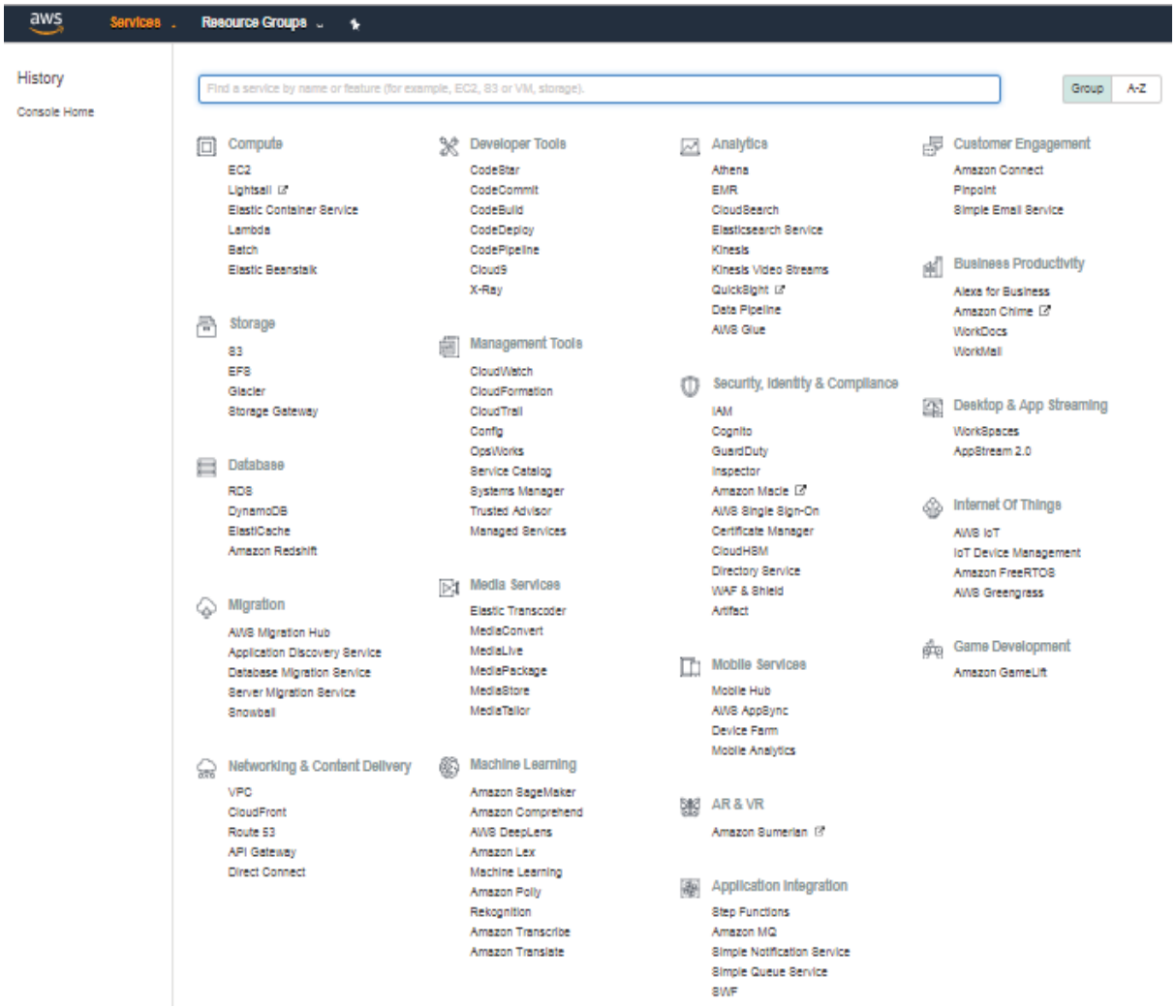


Figure 13 Amazon Web Services

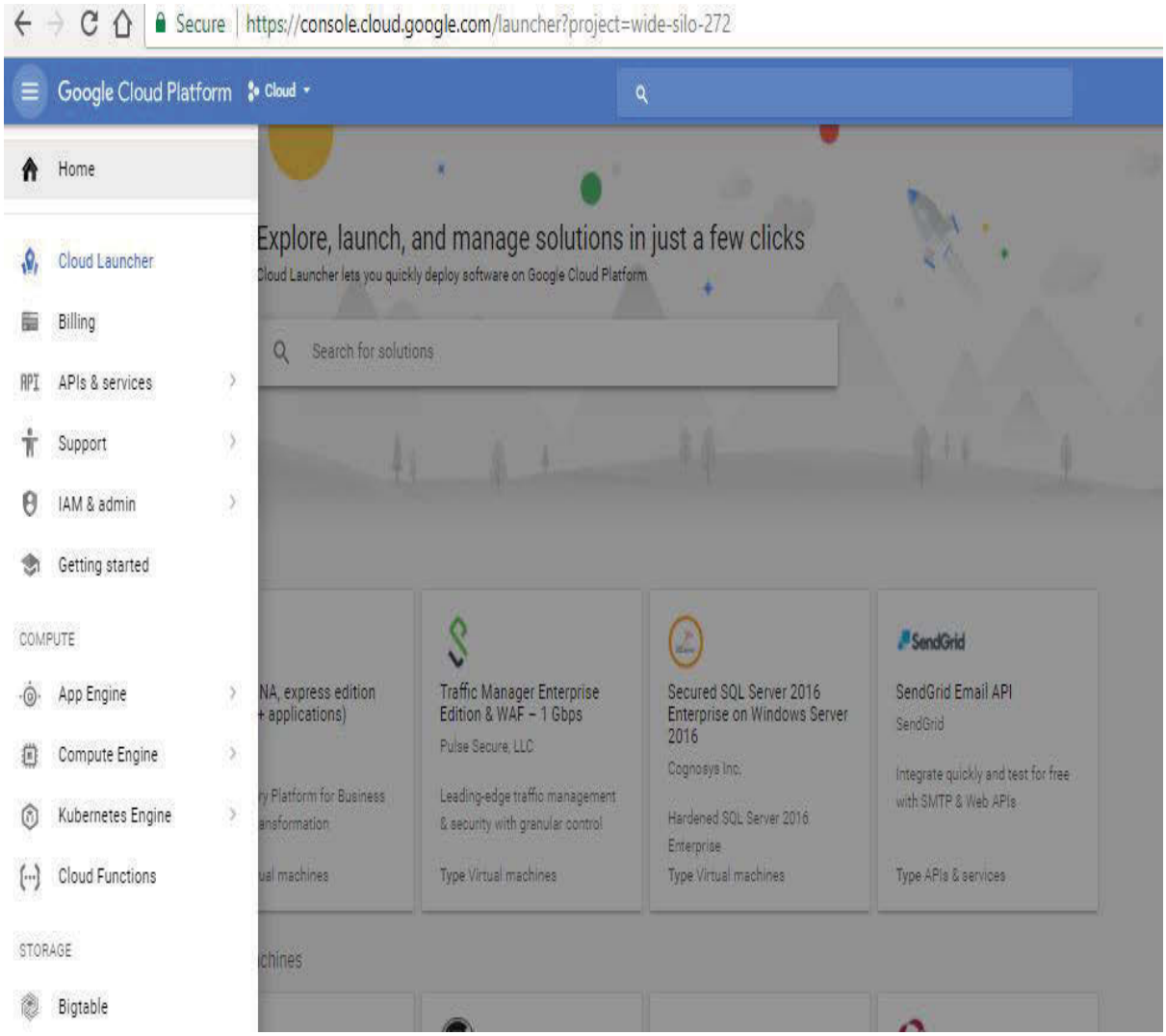


Figure 14 Google Cloud Platform

In the past to test a product it was needed to get the organization permission. Trial version of the software product had subset capabilities, followed by hardware to check the product and finally to test the product based on the vendor documentation was tedious and time-consuming.

With the Platform as a Service (PaaS) model hosted on the cloud, it is convenient to test the product. Also, as the platform service is yet evolving the PaaS companies are offering the entire product suite for anyone to examine without financial obligation. Even its possible do the trial without permission from the organization if corporate data/IP not used. PaaS products have an interactive and intuitive tutorial which helps to do the trial. For e.g. Trailhead a free online course to learn Salesforce platform from Salesforce.com (Salesforce.com 2018), Microsoft Virtual Academy a free online course to learn Microsoft products from Microsoft (Corporation 2018), Ui Path Academy a free online course to learn Robotic Process Automation from Ui Path (UiPath 2018), and so on. So, businesses are advising IT of their expectation and suggesting the products that suit them.

With Enterprise Architecture practice in place, that will proactively identify the technology that is emerging, giving the business pro and cons of the technology and aligning with the business more with the collaboration mode and advisors.

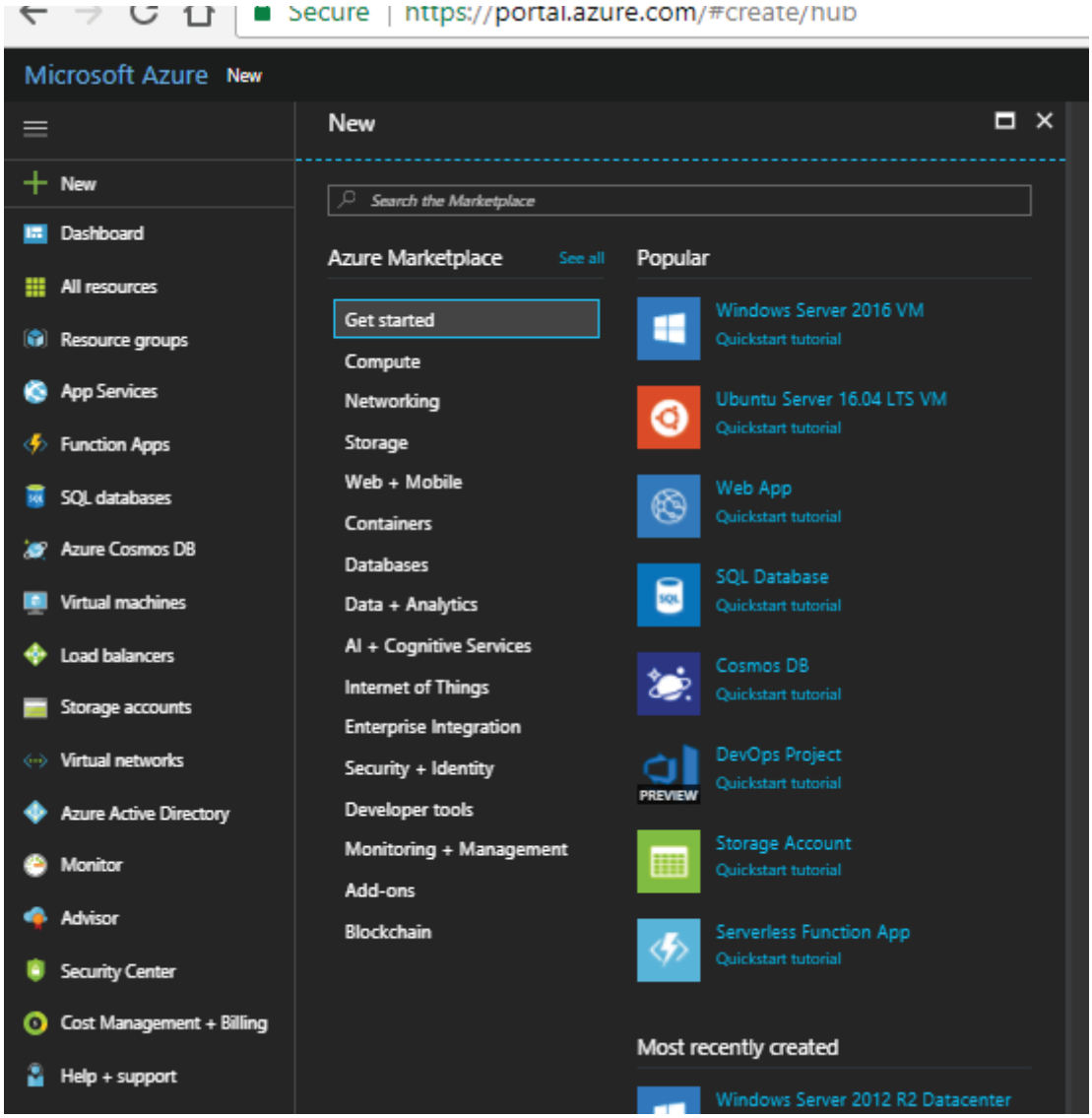


Figure 15 Microsoft Azure Services

Importance of Technology

Systems are critical for day to day to manage the business or for an individual for their personal usage. For the company to support their customer it is needed, but for an individual relying on modern gadgets to give alerts, enables automation, e.g., connected homes, Tesla car door opening automatically.

With digitisation, the intervention of human being to make the decision will reduce drastically. Digitisation enables the data in the digital format. A system can take decisions based on the set criteria without human intervention. With the technology and virtual infrastructure, it is possible to use the digitisation to make a better world.

Examples of Innovation companies disrupting the industry with evolving technology

- **Travel website**: Expedia, Kayak, Travelocity, has reduced/got rid of human travel agents.
- **Taxation Software**: XERO, TurboTax reduced the dependency of accountants eliminating tens of thousands of accounting jobs.

- **Language Translation**: Google, Microsoft Translator, with more accurate results of the speech/ text has reduced the human translator's requirement for translation.
- **Job Recruiters**: LinkedIn, Indeed.com, (MWW), have reduced the number of human resources needed as well as improving the accuracy to select the right candidate
- **Taxi Service**: Uber, Lyft, has reduced the waiting time for the taxi, reducing cost, providing real-time information of the taxi arrival and with the estimated price of the ride too. That too the company is not owning any taxis.
- **Hotel Industry**: Airbnb, HomeAway provides customers with more choice of accommodation to choose that too of reasonable price (Hayes). That too the company is not owning any accommodation facility.

2.2 Technology Adoption

> **"The Roman bridges of antiquity were very inefficient structures. By modern standards, they used too much stone, and as a result, far too much labour to build. Over the years we have learned to build bridges more efficiently, using fewer materials and less labour to perform the same task."**
>
> - **Tom Clancy** The Sum of All Fears

As the technology evolved, new products/ systems developed that were beneficial for the business to improve their services offered, reduce their overall operational cost, add additional services to be competitive. Organization procured these systems that had Architecture Building Blocks that is determined by the product vendor. Organization extended the existing product to meet their needs. As the products developed by the vendor to support audience, they expected at the design of the product.

Many product implementations by organization overshot the budget, implementation timeline and did not meet the expectation of the business as the product designed was generic and not to that specific Organization. The cost of customisation was not only expensive but also time-consuming.

Technologies have evolved from mainframe stand-alone, personal computers used for day to day, distributed layers to current Open Platform 3.0.

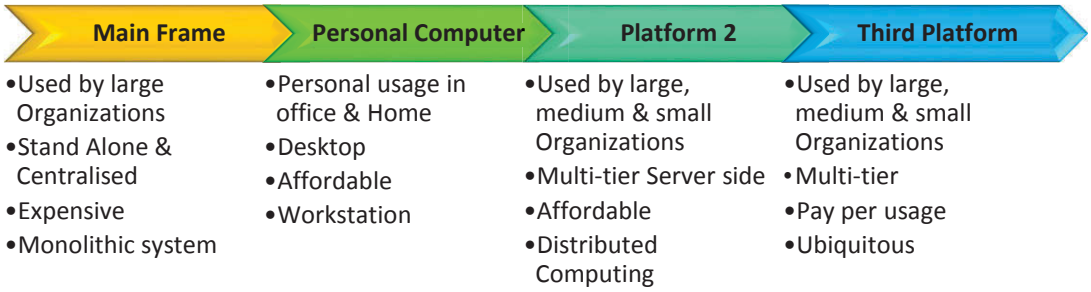


Figure 16 Technology Evolution

2.2.1 Gartner Magic Quadrant

Gartner Magic Quadrant (Gartner) provides “in-depth analyses, actionable advice, insight of market's direction, maturity, with the participants categorised” as:

- **Leaders**: Positioned well for the future with execution aligned with their vision.
- **Visionaries**: Knowledge of the market, able to influence to change the market, but their execution yet to improve.
- **Niche Players**: Execute successfully for a small segment or lack of focus to innovate.
- **Challengers**: Currently execute well or share of large segment but lack understanding of market direction.

From Gartner Magic Quadrant, its observed the market trend changes year after year, so it's not practical to choose a product based on its current features or market share only.

2.2.2 Gartner Emerging Technologies Hype Cycle

In 1995 Gartner Hype Cycle (Gartner) was Introduced, is a graphical representation of pattern as below:

- **Innovation Trigger**: A potential technology breakthrough, neither usable products exist, nor proven commercially.
- **Peak of Inflated Expectations**: Promotions contribute to many success stories followed by several failures too. With risk taking companies will adopt.
- **Trough of Disillusionment**: Results are less than expected, with less success and more failures.
- **Slope of Enlightenment**: As the technology is understood well several use cases exists that have realized the technology. Pilot kicks off as second, third-generation products come into the market.
- **Plateau of Productivity**: As it’s possible to assess the technology viability, the adoption becomes mainstream.

As each technology evolves with its own pace for mainstream adoption, hype cycle period is as below:

- Within two years period
- Two - five years period
- Five - 10 years period
- 10 years above
- Obsolete before plateau, as technology might not be commercially viable.

The Hype Cycle is the vital reference for Organizations in deciding to choose the technology that meets their needs based on their risk appetite of the Organization

Gartner Hype Cycle viewed through different lens compare to private and government Organizations. Private Organizations driven by profit may try technology at its early stages to increase their service or margin. Government agencies mainly service driven will go only after the technology is mainstream.

Hype Cycle for Emerging Technologies audience are strategic planners, IT professionals, innovation and emerging technology professionals. With Capex to Opex model, the product's lifecycle has reduced from decades to years or months based on the organization innovation and risk appetite. So, it’s critical to any IT & Business professional to understand the capabilities of emerging technologies.

2.2.2.1 Hype Cycles from 1995 to 2017

1995: Emerging Technologies Hype Cycle extracts

	Emerging Technologies
Towards Peak	Emergent Computation, Wireless Communication
Peak of Inflated Expectations	Intelligent Agents
Towards Trough	Information Superhighway
Trough of Disillusionment	Handwriting Recognition
Slope of Enlightenment	Object-Oriented Programming
Plateau of Productivity	Knowledge based Systems

Table 5 Key extracts from Hype Cycle of Emerging Technologies, 1995 (Fenn 2017)

- Wireless communication was rising towards the peak in 1995, today 4G or 5G which was not even thought of in 1995,
- Object-Oriented Programming (OOP) was at the Slope of Enlightenment, though Java launched in 1995 genuinely provided the lightweight full OOP capabilities.

1996: Emerging Technologies Hype Cycle extracts

	Emerging Technologies
Towards Peak	Cable Modems, Digital Video Clock, Java, Intranets
Peak of Inflated Expectations	Internet Terminals
Towards Trough	World Wide Web, Virtual Reality
Trough of Disillusionment	Desktop Telephony, Personal Digital Assistance
Slope of Enlightenment	Handwriting Recognition, Desktop Video Conferencing
Plateau of Productivity	Workflow Imaging

Table 6 Key extracts from Hype Cycle of Emerging Technologies, 1996 (Fenn 2017)

- Java was rising towards the peak in 1996, though it achieved the Plateau of Productivity in 1999, which has completely changed the landscape of software development
- Java is the base for Hadoop which has changed the landscape of data mining, insights, deep insights, and so on.
- Object-Oriented separated the concerns from implementation, the essential factor of not depending on the technology rather than business requirements.
- World Wide Web (WWW) was at the peak of Inflated Expectations, with unrealistic expectation. Today the WWW used by almost everyone for their day to day activities, it has ingrained in the life of common people, it can be work or home.

1997: Emerging Technologies Hype Cycle extracts

Emerging Technologies	
Towards Peak	Wearable Computers, Biometrics, DVD, E-Cash
Peak of Inflated Expectations	Netcasting/ Push Technology
Towards Trough	Smart Cards, Java – the Platform, Interactive / Web TV
Trough of Disillusionment	PDA
Slope of Enlightenment	Speech Recognition, Application Sharing, Database Mining
Plateau of Productivity	Workflow Imaging, OO Programming

Table 7 Key extracts from Hype Cycle of Emerging Technologies, 1997 (Fenn 2017)

- Wearable Computer was rising towards the peak in 1997, though it achieved the Plateau of Productivity in 2015. Smartwatches with GPS tracking, sensors, network connectivity with blue tooth to Smartphones is changing the landscape of health, that was not even thought of in 1997.
- DVD was rising towards the peak in 1997, which is obsolete now with manufacturing units closure, with millions of dollars written off and hundreds of workers out of jobs.
- E-Cash was rising towards the peak in 1997, today in 2018 without e-commerce (m-commerce, paperless transaction, contactless payment) the world will become standstill.
- Database Mining had reached Slope of Enlightenment, though data mining is achieving its glory now, due to the cloud (2006) and Hadoop (2011) that become mainstream technology at a very later stage.

"Predicting future technology and its impact with any accuracy is extremely difficult. Recognising that general patterns of technological change will persist can help governments, businesses and communities facilitate and adapt to change. Attention should be focused upon problems that need to be solved and on helping innovators find solutions".

- Technology and Australia's Future

2008: Emerging Technologies Hype Cycle extracts

	Emerging Technologies
Towards Peak	Behaviour Economics, Mobile Robots, 3D Printing
Peak of Inflated Expectations	Green IT
Towards Trough	Social Computing Platform, Solid-State Drives
Trough of Disillusionment	Corporate Blogging
Slope of Enlightenment	Electronic Paper, SOA
Plateau of Productivity	Basic Web Service

Table 8 Key extracts from Hype Cycle of Emerging Technologies, 2008 (Fenn 2017)

- Cloud Computing was rising towards the peak in 2008, though it achieved the Plateau of Productivity in 2015. Cloud computing has changed the business model from Capital Expenditure (Capex) to Operation expenditure (Opex) model where infrastructure is a commodity disrupting the entire business across the world.
- Service-Oriented Architecture (SOA) had reached Slope of Enlightenment, though SOA gave rise to microservices changing the application model from Macro to Micro, giving rise to innovative business model from 2015.

2011: Emerging Technologies Hype Cycle extracts

	Emerging Technologies
Towards Peak	Internet of Things (IoT), natural language question answering, and Big Data
Peak of Inflated Expectations	Technologies at peak: NFC payment, Activity Streams, Internet TV, Wireless Power, private cloud computing.
Towards Trough	Augmented Reality, Media Tablet
Trough of Disillusionment	Virtual Worlds, E-Book Readers
Slope of Enlightenment	Idea Management, Mobile Application Stores
Plateau of Productivity	Location Aware Application

Table 9 Key extracts from Hype Cycle of Emerging Technologies, 2011 (Fenn & LeHong 2011)

- 2011 Gartner's Hype Cycle Special Report listed 1,800 number of technologies.
    - Technologies at peak: NFC payment, Activity Streams, Internet TV, Wireless Power, and private cloud computing.
    - High-impact trends included newly: Internet of Things (IoT), natural language question answering, and Big Data.
- In 2018, IoT, Big data, Social Analysis is disrupting the business models and changing the lifestyle of people because of possibilities of real-time insight and sharing of information.

2017: Emerging Technologies Hype Cycle extracts

Emerging Technologies	
Towards Peak	Digital Twin, Quantum Computing, Edge Computing, IoT Platform, Smart Robots,
Peak of Inflated Expectations	Connected Home, Deep Learning, Machine Learning,
Towards Trough	Autonomous Vehicle, Cognitive Computing, Blockchain, Commercial UAV (Drones)
Trough of Disillusionment	Augmented Reality
Slope of Enlightenment	Virtual Reality

Table 10 Key extracts from Hype Cycle of Emerging Technologies from 2017 (Walker 2017)

- Technologies at the peak: Commercial unmanned aerial vehicles' (UAV) (Drones), Deep Learning, Edge Computing, IoT Platform, Virtual Reality Machine Learning, Serverless PaaS, Software-Defined Security.
- Edge Computing harness the power of IoT computing at the edge and transferring the processed data reducing clogging of the network.
- Serverless PaaS, redefining the service model of paying only for the usage of the functions, this will drive more innovation, and that contributes to the new dimension in services offered.

2.2.2.2 Summary of Hype Cycle for Emerging Technologies

Analysing the Gartner's Emerging Technologies Hype Cycle from 1995 to 2017, the technology landscape has changed tremendously from stand-alone Main Frame to the lightweight handheld Computer connected seamlessly through mobile network or WIFI.

Also, the technology stack has changed dramatically that was accessible by Fortune companies towards more as a commodity affordable by medium & small companies and common man too.

As the technology evolves, it is adopted by business redefining their existing models and creating new models.

Separating the concerns of business and implementation of technology is critical. Also, to keep track of the technology as business models need to be changed to harness the technology.

It is essential to define the requirements, from the business perspective, then to architect and choose the product. So, the business requirements are not tied to a technology or product, as the new product comes due to technology changes it is more convenient to switch over.

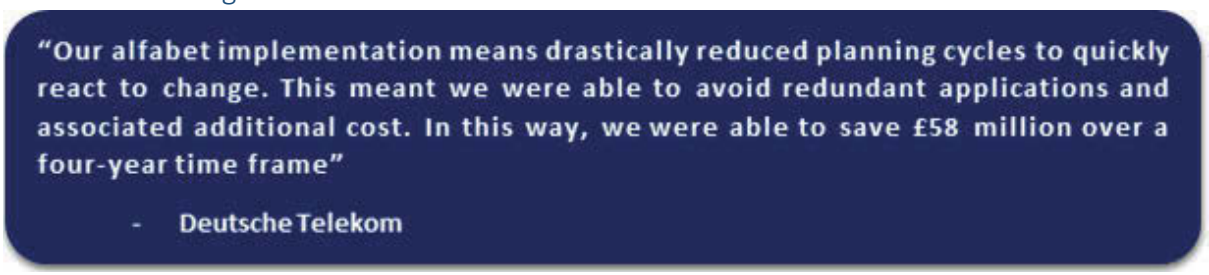
However, all these years based on the business requirements products procured. Also, the products picked was specific to a business department or fancy of an influential stakeholder. As technology is now pervasive, it is critical to follow enterprise-wide approach that where Enterprise Architecture (EA) comes. EA enables to streamline the business requirements that apply to enterprise-wide and separate the business requirements with technology and product procurement based on consensus.

2.3 Notable Organisation that have incorporated EA practice

Some of the successful projects adopting EA practice are (The Open Group 2001)

- Dairy Farm Group (Hong Kong)
- Global Financial Services
- Litton PRC (US)
- QA Consulting
- National Health Service (UK)
- NATO (Belgium)
- Police IT Organization (UK)
- Department of Social Security (UK)
- Statskonsult (Norway)
- Westpac (Australia)
- Ministry of Defence (UK)
- Global Energy Company

2.3.1 Measuring ROI of EA Practice



Alphabet company declares (Alfabet 2007) using its PlanningIT tool for EA initiatives, within a period of one to three years it's possible to recover return on investment (ROI) as follows:

- Enterprise architecture elements collection, processing, validation and reporting save 60% man-day efforts.
- Architecturally checking the projects at preparation phase, it is possible to achieve 10% increase in deliverables.
- Operation cost reduced by 10% by eliminating redundancies or excessive spending in the IT.

From the above findings, it can be argued EA practice though brings indirect benefits; there is no standard approach to justify the ROI for EA practice. To realize the benefits of EA practice it may take longer duration compare to the business-initiated tactical projects.

To illustrate EA benefits with an analogy of the indirect benefits derived from human being embracing a healthy lifestyle. That includes investing in quality food, going to a regular gym and taking a holiday break to recharge. The ROI justified indirectly as:

- Not getting sick
  - cost saved without doctors' consultation,
  - saving in medication cost,
  - loss of leave
- Being healthy
  - increase work productivity, that results for additional incentive or promotion,
  - reduced sick leaves.

Similarly, with EA practice there are indirect benefits as:

- EA reduces people, systems and infrastructure duplication approximately with 15% of cost saving of the project value
- Strategic sourcing applied through EA can save 10 to 14% saving for mid to large size organization (Hajela 2009)

2.3.2 Empowerment of People

> "There is no more effective way to empower people than to see each person in terms of his or her strengths."
>
> - **Don Clifton** Father of Strengths Psychology and Inventor of Clifton Strengths

An organization made of people, who are employees they need to be motivated, passionate about their work.

According to Gallup (Gallup 2017) employees types are of three:

1. **Engaged:** Employees of Engaged type work with passion, proud to work for the company and move the company forward while bringing innovation.
2. **Non-Engaged:** Employees of Non- Engaged type have no passion nor proud to work for the company and they work for their remuneration.
3. **Actively Disengaged:** Employees of Actively Disengaged type are unhappy about their work and destabilise the accomplishment of their engaged co-workers.

> "Successful firms will be those most adept at attracting, developing, and retaining individuals with the skills, perspectives, and experience necessary to drive a global business."
>
> - **Ulrich** People Capability Maturity Model: Guidelines for Improving the Workforce

Digital transformation is not just embracing new technology, but also innovate, that is possible only with Engaged employees. As per Gallup State of the Global Workplace Report of 2017, Worldwide, full time employed adults who are Engaged at work are just 15% in Australia and 14% in New Zealand.

Due to digitisation and automation, today's workplace is going through drastic changes in the work environment. Also, employees have information at their fingertips to compare with their peers any part of the world. For an Organization, it is essential to have Engaged employees who will assist the organization to innovate.

17% of Business units in the top quartile are more productive with Engaged employees.

Gallup (Reilly 2014) strategies for engaged employees:

- Right employee engagement survey to be used.
- Employees at Organizational and local levels to be engaged.
- Right managers to be chosen.
- Coach managers are accountable for their employees' engagement.
- Engagement goals to be defined realistically based on everyday terms.

2.3.3 Project Success Analysis

Enterprise Architecture outcome was not measured in Organizations as it took a long time to realise the benefits and it is qualitative in nature.

The research summary of "Measuring the value of Enterprise Architecture on IT projects with CHAOS Research" (KUREK, JOHNSON & MULDER 2017) analysed 28 Organizations, 3076 IT projects from 2007 to 2016, that have implemented EA practice from 2011 to 2016. The report does not address the maturity of the enterprise architecture practice, whether EA was applied across the enterprise or used for one project or used in some department only.

Summary of the analysis for Organizations after the establishment of EA practice:

- Survey respondents with Organization with EA practice
    - 10%, thought that EA would bring no value at all
    - 90%, thought EA would bring value
- Project end state, with Modern Resolution, measures the customer satisfaction.
    - an increase of 14,5%, of successful projects,
    - decrease of 26,2%, of failed projects.
- Project end state, with traditional resolution, measures the 'On Target':
    - an Increase of 11,48%, of successful projects,
    - a Decrease of 26,19%, of failed projects

2.4 Summary

In this chapter, the journey of embracing technologies in the organization was covered. It highlighted that technology is continuously evolving, so organizations must realize their strategies through Enterprise Architecture approach rather than buying the product that addresses the current need.

The skills for a Modern Enterprise practitioner to be knowledgeable in Strategy as well as technology too, so maximum benefit of emerging technology can be harnessed.

Due to service model the product lifecycle as reduced from decades to weeks, months or years.

EA is tangible as the outcome can be measured though not 100% accurate, as some of the benefits it provides are exponential and long term.

The success of digital transformation depends on staff with right attitude, who are driven by passion rather than their routine job.

3. Research Approach and Methodology

This chapter introduces the research philosophy to substantiate, Qualitative research is the right approach for this thesis. Then identifies the theories to build a theoretical model that defines the different perspectives relevant to the analysis. Next frameworks are selected to determine the data attributes that align with the theoretical model. Followed by the suitable research methodology to collect the data to validate the research. Then discusses the validation approach, analysis, and visualization. Finally, the method that is suitable to execute the project.

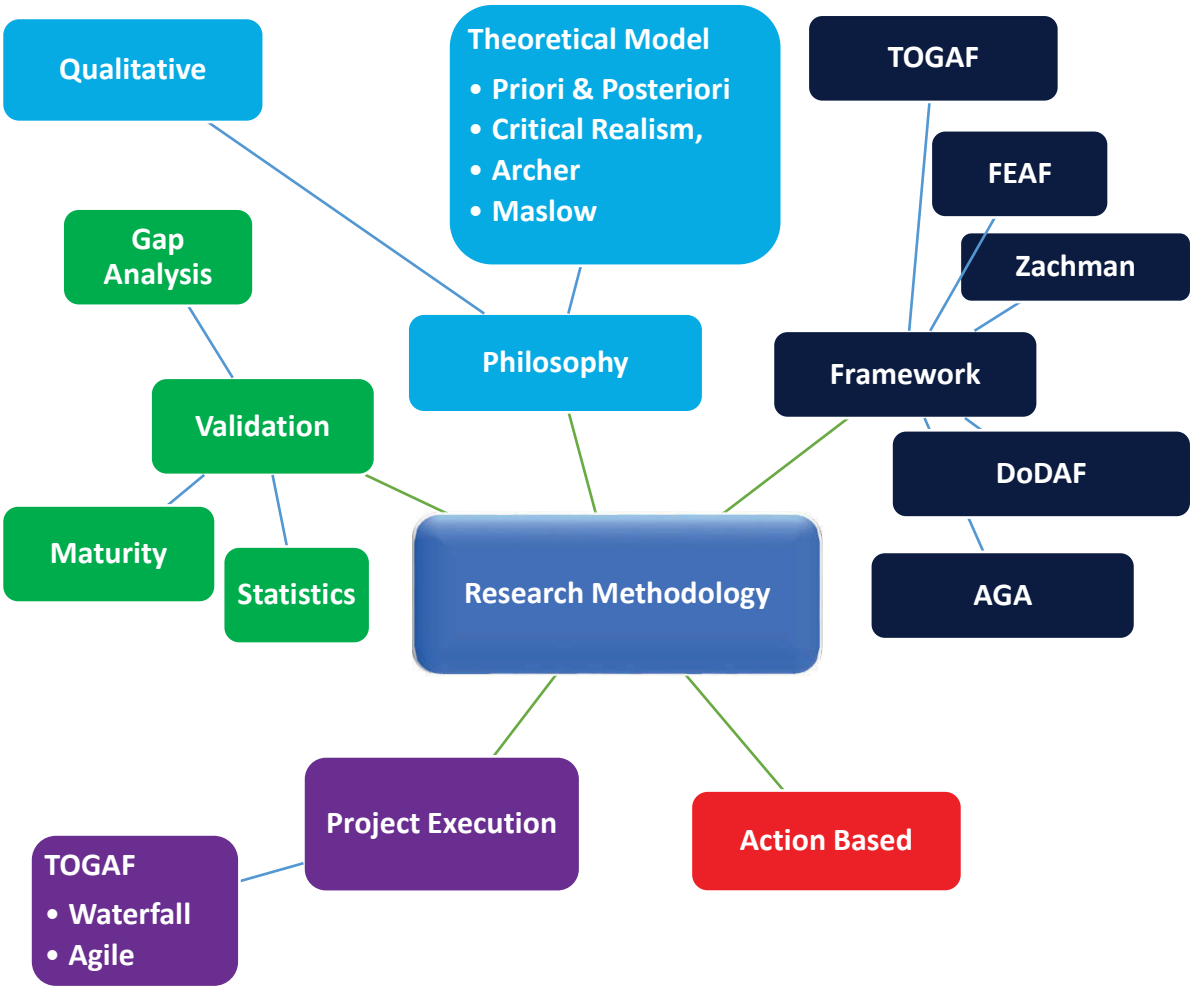


Figure 17 Research Methodology

3.1 Research Philosophy

Research philosophy assists to choose the right research methodology that will enable to identify the suitable source of data, its nature of collection and the appropriate way to analyze the data.

Enterprise Architecture and Digital Transformation are a broad subject that is influenced by the type of Organization, its employees, their attitude, and the organization culture. All this requires flexibility in collecting and categorising the data as it is not practical to do a scientific experiment to collect the data. The expected data is of semi-structured, that is narrative, and it is from observation (cirt.gcu.edu

2017). The research results explicitly is influenced by the actual context, where the data is collected (Barbour 2001).

It is not possible to get the tangible and concrete benefits of EA projects immediately after the project execution. Some of the EA initiatives may take extended period to realise the benefits. Also, due to the changing business model, users' expectation driven by technology, the outcome might not be relevant at that point in time.

According to Institute of International Affairs University of Utah (AFFAIRS 2009), Human Actors interpretation, their understanding is the basis of the scientific description in Interpretive methodologies that is one of the types of qualitative research. It further states that researcher used their experience and based on the context of the actual scenario/ project to apply the right approach that determines the outcome. As the research results are defined case by case basis, based on the actual situation, this further emphasis qualitative is the right approach for this research.

As organization and people involved in the data collection, that is influenced by the culture of an organization that impacts the human behaviour. Due to this data collected are unique, specific for the research activity conducted that is not possible to validate for another similar project in a separate/ same organization as well for the same scenario in the different timeline. Though the knowledge gained can be analysed and customised based on the organization for similar kind of situation and context.

3.1.1 Qualitative research methodology

Qualitative research definition as per USC library (libraries 2016), the word qualitative indicates the importance on the qualities of entities, the processes, and meanings that are not possible to experimentally examine or measure regarding size, volume, strength, or recurrence. Socially constructed reality is given importance. The researcher's relationship to the study is analyzed, based on the context and constraints that will shape the research. Social and Behavioural scientist use qualitative methods to investigate a research problem.

In a society how an individual thinks, feels, acts in a given situation are critical aspects to be considered, as enterprise architecture practice consists of organization and people(Council).

Qualitative Design Approach recommended by (libraries 2016) as in Table 11 Qualitative design approach applicable for the research**,** as follows:

Definition	Characteristic	Applicable for this research
Naturalistic	The approach taken by researcher is based on the actual situation	Research is based on actual project executed.
Emergent	Researcher are flexible to change their approach as the situation changes	Research approach tailored as per the needs of the project
Purposeful	The study focused is on living or nonliving that is of interest. In consideration of useful information that can be derived from observation based on judgment and context.	Performed analysis of Organization: type, its influence on the stakeholders, their authority to choose the framework and methodology.

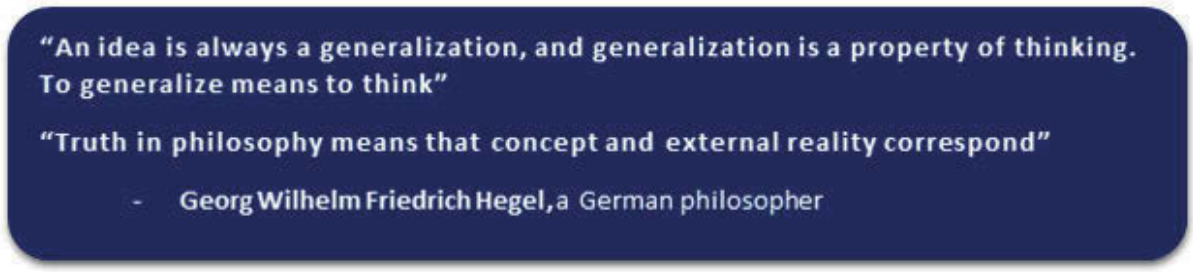
Table 11 Qualitative design approach applicable for the research

As referred by (Dudovskiy 2017) from the comparison of objective and subjective, illustrated by Cohen et al (2007) is retreived from Gree+`nfield (1975) is in Table 12 Dimensions of Comparison extended from (Dudovskiy 2017), as follows:

Dimensions of Comparison	Objectivist	Subjectivist	Applicable for this Research
Basis of Philosophical	Realism: World can be studied as it exists	Idealism: Though World exists, its studied from based perspective of people	Context influences, what is studied and how it is studied.
Role of social science	Analysing universal laws of the society and people's behaviour	Analysing the interpretation of world from people perspective	Staff role, needs, type of the organization and country they are working, influences the project outcome, to be considered.
Basic units of social reality	Organization or Society	Persons	Organization consists people, from whom requirements was gathered for the projects, subsequently for this research.
Comprehensi on methods	Studying the type and nature of relationships that allow to exist collectively	Studying subjective is of individuals execute upon their actions	Individual influence and their relationship to be considered, as it influences the outcome of the project.
Theory	Researchers perspective to explain the human behaviour	Individuals perspective to interpret their world and behaviour	It is critical to understand the stakeholder and to interpret. As their input varies based on the type of project, their understanding and their interest (vested or genuine).
Research	Experimentation or quasi-experimentation, used to Validate theory	Identify relations to establish the consequences of actions	The research data collected through people involved in the projects executed and their observation.
Methodology	Quantitative analysis with mathematical methods	Qualitative analysis based on interpretation of reality with statistical methods	Methodologies used for phases of Architecture development life cycle as deemed appropriate
Society	Achieved through set of general values, rules and regulations	Achieved based on values possessed by people with power	Enterprise Architecture practice influenced by people with power. At the initial stage Enterprise Architecture practice brings in chaos as organization needs to change the way they work. Though at later stage the benefits are realised.

Table 12 Dimensions of Comparison extended from (Dudovskiy 2017)

3.2 Theoretical model



3.2.1 Priori and Posteriori

Priori is the knowledge known without experiences. Priori assist to conceptualize the knowledge that is general or from causes to effects.

A posteriori knowledge known from experience or personal observation or facts or evidence.

The rationale for Priori & Posteriori

This research is the combination of Priori "from what is before" and Posteriori "from what is after" knowledge. As Priori philosophy "from causes to the effect," (Merriam-Webster) is applied before the starting the project to gather the information of the organizations, people who will be involved in the project, the frameworks and methodologies that can be applied.

The data gathered for the Thesis is based on the Posteriori philosophy "from effects to causes." (Merriam-Webster) from the facts by observing organization changes, people behavior changes due to the applied framework and methodologies after the project executed.

Priori probability is the statistics of the probability assigned to the parameter in advance before the event (Farlex) generally it's subjective.

Posteriori probability is the statistics of the probability derived from the parameter or observed event (Farlex) that assist in validating the observation.

3.2.2 Critical Realism (CR)

Provides philosophically informed of science and social science that assist empirical investigations a meta-theoretical approach (Margaret Archer 2016). Critical realism a philosophical, social science connects naturally with the social world, considers forms of explanation consisting ontology, causation, structure, persons.

The inquiry into the nature of things, known as Ontology is a subset of taxonomy according to Bowles (Bowles 2017). Ontology explains entities their behavior and the relationship between them. Ontological realism emphasizes that reality exists and operates independently of our knowledge or awareness of it. Sociology is a theoretical and methodological approach to study social world, that consist of society, people, structure, process, and causes.

Critical realism enables mapping of ontological character with real facts based on the events experienced or produced due to social reality. Social science assists to make sense of the real world happening which changes with time.

3.2.3 Archers Morphogenesis approach

Morphogenesis is a process that enables changes in system state resulting end-product is structural elaboration. Archer analytical dualism suggests separation of 'structure' and 'agency' and to examine them as each has different properties and powers. Also, they are dependent on each other for their

formation, continuation, and development. Also "'structure' and 'agency' operate diachronically over the time periods that are different and the structure necessarily pre-dates the actions that transform. Structural elaboration certainly post-dates those actions. Also, morphogenesis is a continuous sequential cycle of structural conditioning / social interaction / structural elaboration due to action on the structure" (Archer 2010).

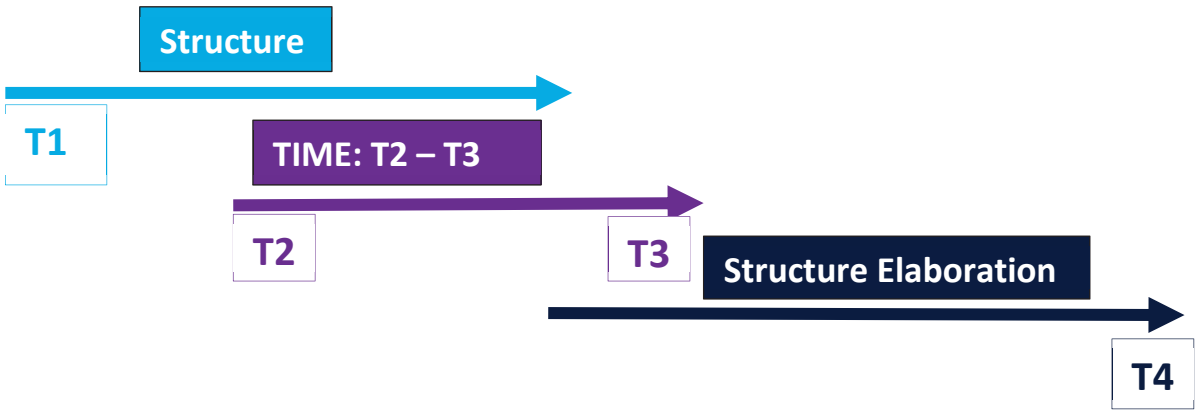


Figure 18 Archer morphogenetic approach Adopted from Archers, Source: (Archer 2010)

Archer approach customized to suit the research, with Structure mapped to Organization, People, Technology; Action is performed by people with their chosen Framework and Methodology determines the Technology, that will enable Organizational Change. As in digital transformation though there is a change in organization state, but it overlaps with the old and new state at some part of the time. Overlapping state relates to Bimodal as referred by Gartner where legacy process / technology will co-exist with the rationalized process / new technology.

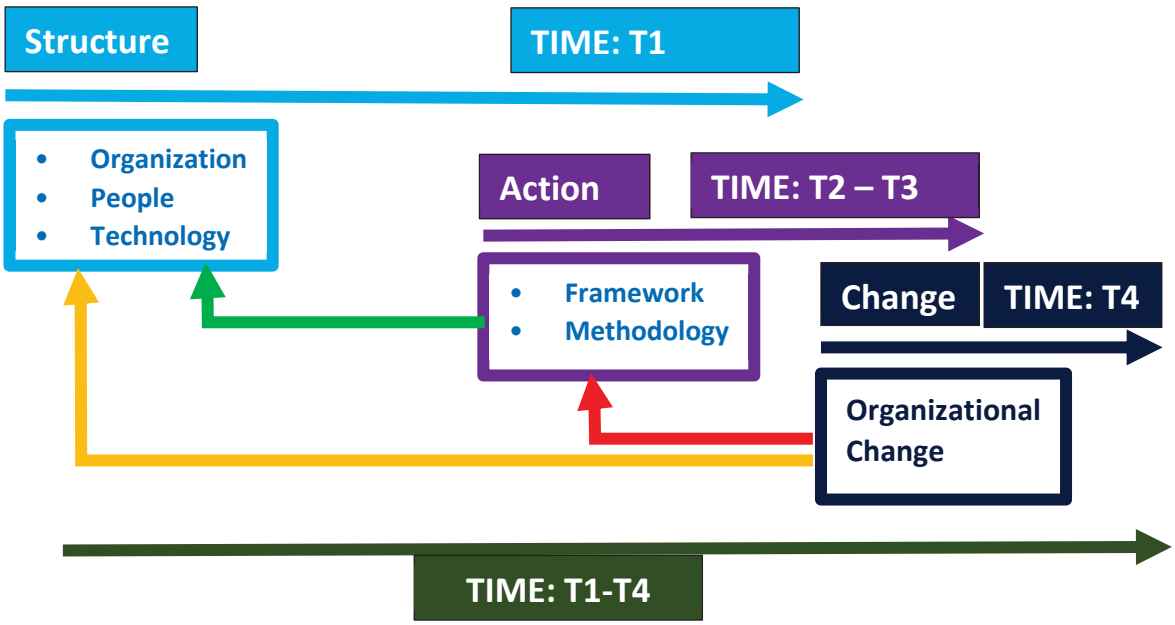


Figure 19 Theoretical model Adopted from Archers

3.2.4 Maslow's hierarchy of needs

Hierarchy of Needs motivational model was developed by Abraham in 1943; it is relevant even today to understand human motivational psychology. Hierarchy of Needs has five-stages as shown in Figure 20 Maslow's: Hierarchy of needs, Source: (Maslow 1943):

Figure 20 Maslow's: Hierarchy of needs, Source: (Maslow 1943)

The success of the digital transformation depends on people, their motivation, passion, and commitment. It's critical to understand the human psychology to determine the right people who will be involved in the transformation. Digital transformation though brings in changes at the later stages, at the initial stage there will be chaos, people need to change their working style. Transformation minimizing human involvement reduces error and brings in more transparency. There will be people with genuine as well as vested interest. Maslow theory will assist to choose the right set of people.

It's essential to choose Peoples whose basic needs have been met. They will be the right people to contribute to successful digital transformation, that will be from S4 & S5. Though S5 will be the ideal for leadership role who are decision makers.

3.2.5 Rational of theoretical model

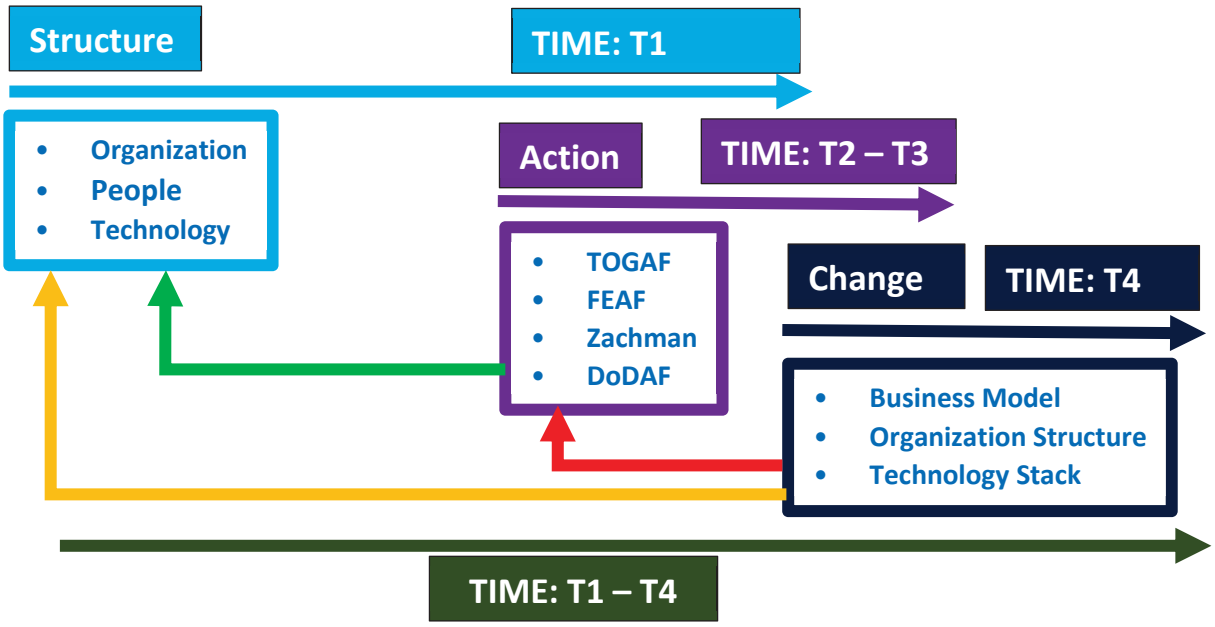


Figure 21 Identified Category of Theoretical model to measure

To justify Enterprise Architectural approach, adds value for Digital Transformation, the project outcome to be measured. The result cannot be measured as the data is qualitative in nature and the Digital transformation measurement may take few years to realize the benefits of transformation. Qualitative methodology is suggested as it can be quantifiable based on specific results rather than actual quantitative experimental data. Theoretical model assists to determine the data category with its attributes that can be measured.

3.3 Frameworks referred to identify the attributes to measure Research Outcome

Framework	Purpose
TOGAF	To develop Enterprise Architecture
FEAF	Identifies and measure the Performance of EA Projects
Zachman	Assists to identify the stakeholders of an Organization
DoDAF	To identify the various stakeholder groups and their viewpoints
AGA	Provides metrics for EA practice

Table 13 Selected Framework for action-based research

3.3.1 The Open Group Architectural Framework (TOGAF)

TOGAF is an architecture framework and methodology for developing enterprise architecture ({Group, 2011 #108} P.9), It is an iterative and incremental process to create reusable, shareable artefacts to address the changing business needs triggered due to disruptive technology and demanding customers.

Why TOGAF?

TOGAF is Architectural development method, covering the enterprise architecture lifecycle. Significant performance indicators that can be measured are from inception of EA project to execution that consists of EA current state to target state of business, application, data, technology, security, and integration.

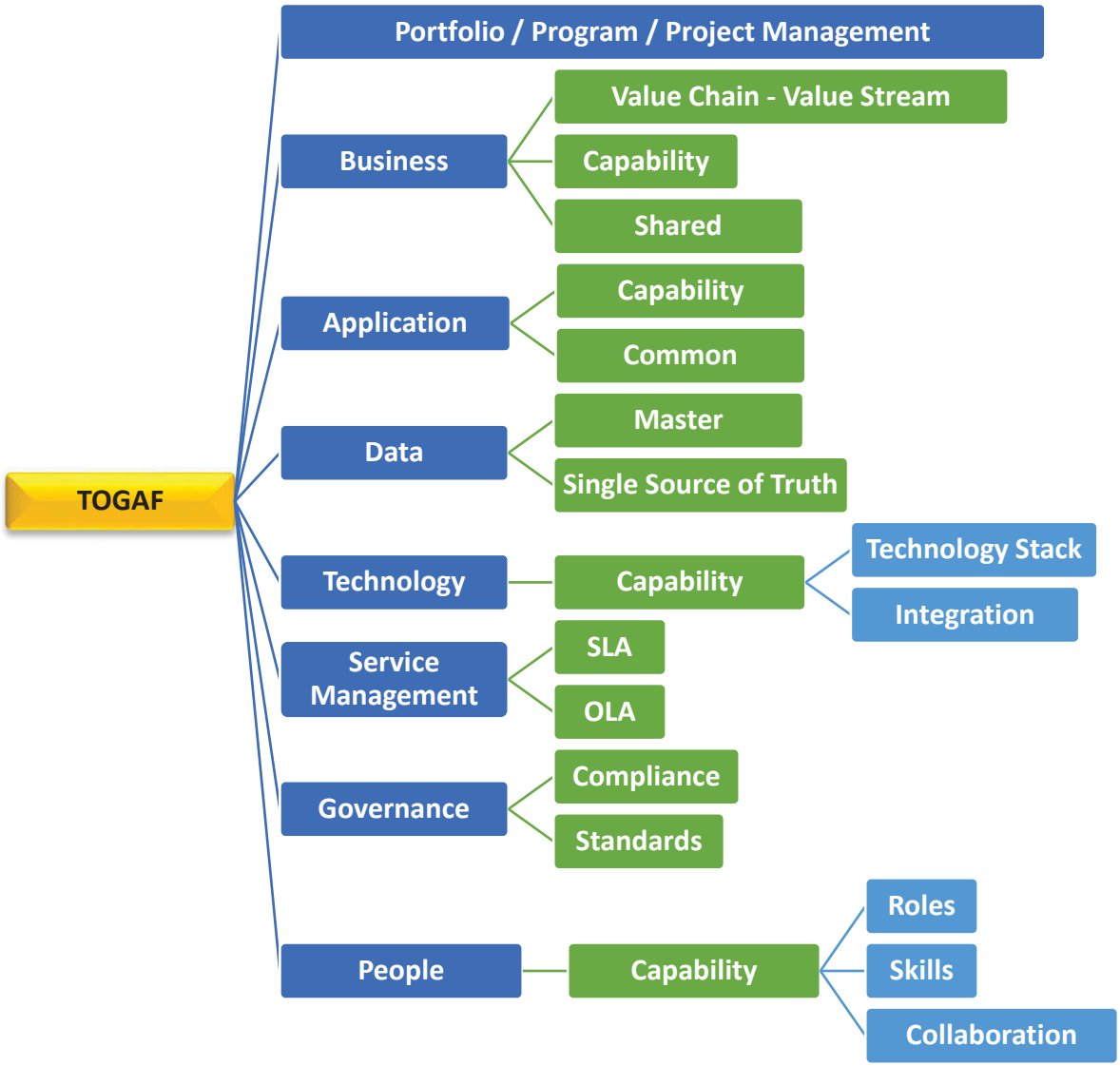


Figure 22 TOGAF Categories identified for Measurement

3.3.2 Federal Enterprise Architecture Framework (FEAF)

FEAF (House 2013) P.11, provides tools to describe and analyze investments. Tools assists to review cross-agency to identify duplicate investments, gaps, and opportunities to collaborate among themselves

Why FEAF?

There is no set standard to measure Enterprise Architecture projects outcomes. By using FEAF Performance Reference Model (PRM) it's possible to measure the impact of the investments on strategic outcomes. Achieved through linking the agencies strategies, internal business components, and investments.

The PRM provides common output measurements throughout the enterprise for measuring the performance.

Performance Reference Model (House 2013) consists of 3 areas:

1. **Goal:** To enable grouping of investments and activities by a standard and authoritative framework. That allows the identification of common performance elements across investments or activities
2. **Measurement Area:** Describes the way the investment or activity supports the achievement of the supported performance element determined by the Agency Goal.
3. **Measurement Category:** Measurement Area further refined, Goal can connect with any Measurement Category.

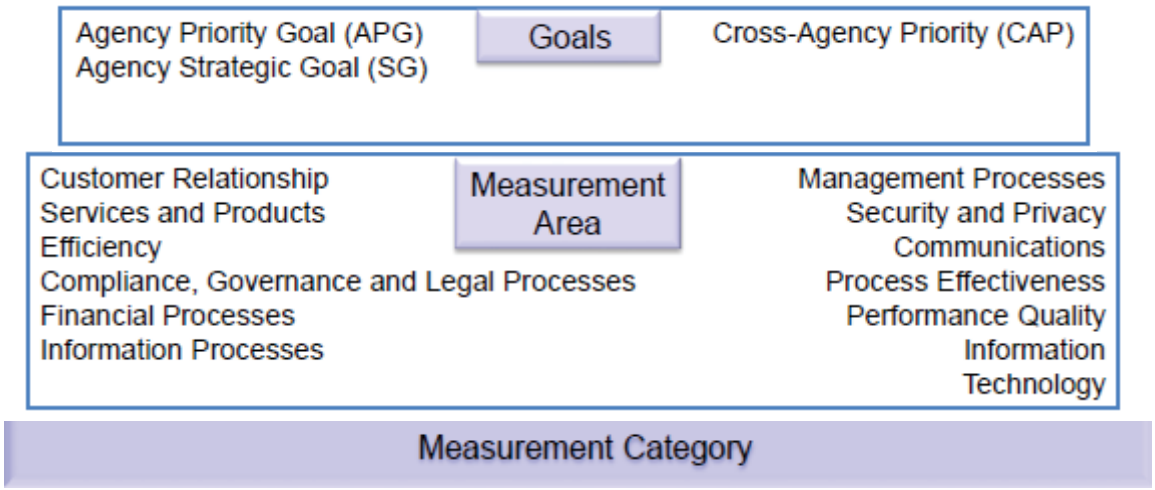


Figure 23 High Level PRM Taxonomy (House 2013)

3.3.3 Zachman Framework

An Enterprise Architecture Framework (Zachman 2016) that defines enterprise anthology. That provides a logical structure to classify the artefacts cohesively from the perspective of different stakeholders.

The Zachman Framework is a schema of two dimensional; row represents the primitive interrogatives: What, How, When, Who, Where, and Why. Row describes the enterprise from six viewpoint perspectives of the stakeholders. The columns consist set of artefacts that are the description of the enterprise. These artefacts represent the specific viewpoint of stakeholders consisting of Owners, Planners, Designers (Architects), Implementers, Sub Constructors, Users, or sometimes represented as viewpoints as: Scope Context, System Logic, Business Concepts, Physical, Technology, Component Assemblies and Operations Classes.

General Classification Structure of Design Artefacts

	What	How	Where	Who	When	Why	
Planner							**Scope**
Owner							**Concepts**
Designer							**Logical**
Builder							**Physical**
Implementer							**Technology**
Operator							**Product**
	Material	**Process**	**Geometry**	**Instructions**	**Timing**	**Objectives**	

Figure 24 Zachman Framework (Zachman 2016)

Why Zachman Framework?

Zachman framework is generic, applicable to any industry, with the architecture artefacts developed in consideration of various stakeholders from their perspective of an abstract idea to tangible, concrete product. Using Zachman framework, it is possible to identify the stakeholders at multiple stages of EA development.

3.3.4 Department of Defense Architecture Framework (DoDAF)

DoDAF (Defense 2010) is a comprehensive, conceptual model with an overarching framework. Assist to develop Architecture to enable seamless information sharing within the Departments, Joint Capability Areas (JCAs), Mission, Component, and Program boundaries. That assists the Department of Defense (DoD) managers to take informed effective decisions.

DoDAF directs architectural "data" to be collected in detail to support taking decisions. Data is represented visually such as documents, dashboards, spreadsheets, or graphs.

DoDAF Main Viewpoint

DoDAF addresses the needs of stakeholder communities by means of abstraction. Achieved by dividing the problem space into manageable pieces, conferring to the stakeholder's viewpoint. Each viewpoint address one aspect, with whole enterprise through broad summary information and narrowly focused information for a specialist purpose.

The primary objective of DoDAF to create a coherent model of the enterprise that provides effective decision-making with presentational aspects.

DoDAF (Defense 2010) Viewpoints:

- **All Viewpoint:** Overarching aspects of architecture context related to all viewpoints is described.
- **Capability Viewpoint:** Elaborates the capability requirements, delivery timing, and deployed capability.
- **Data and Information Viewpoint:** Elaborates the data relationships and alignment structures in the architecture content to assist the capability and operational requirements, system engineering processes, systems and services.
- **Operational Viewpoint:** Capabilities to support the operational scenarios, activities, and requirements.
- **Project Viewpoint:** Defines the relationships between operational and capability requirements and projects being implemented.
- **Services Viewpoint:** It is the design for solutions elaborating performers, services, activities, and their exchanges.
- **Standards Viewpoint:** Elaborates the valid technical, operational, business, and industry policies, standards, guidance, constraints, and forecasts applicable to capability and operational requirements, system engineering processes, and systems.

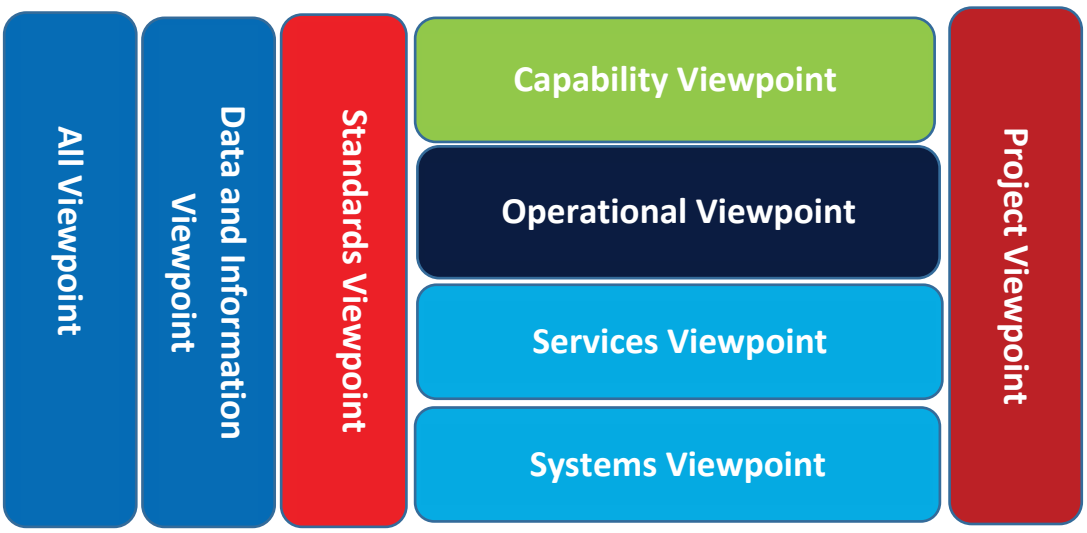


Figure 25 DoDAF Viewpoints (Defense 2010)

Why Department of Defense Architecture Framework (DoDAF)?

It's critical for digital enterprise the information needs to be abstracted based on the stakeholder at the same time giving the Big picture of the enterprise, addressed by DoDAF viewpoints. As DoDAF is from the defense that Is critical for a country, so it's considered for digital transformation to have the same precision as the military approach to increase its success.

3.3.5 Australian Government Architecture Framework (AGA)

Derived from Federal Enterprise Architecture Framework (FEAF), AGA enables ((AGIMO) 2011) to have consistent delivery with cohesive services for citizens and support cost-effective delivery of Information and Communications Technology (ICT) services through:

- Common language for agencies
- Assists in identification of duplicate, re-usable and sharable services
- Supports to describe and analyse IT investments
- Government transformation supported

Why AGA framework

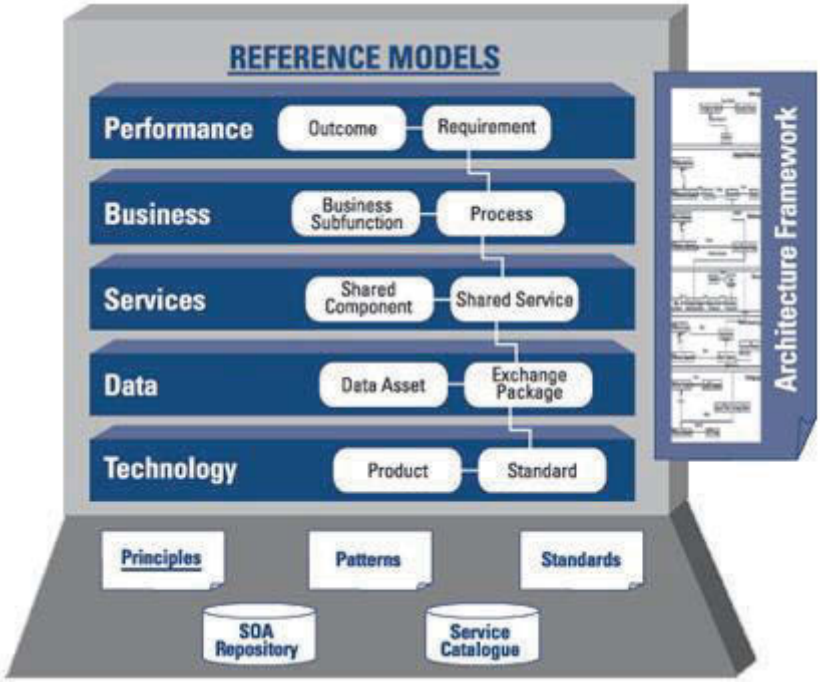


Figure 26 Australian Government Architecture ((AGIMO) 2011)

Measuring Areas of Enterprise Architecture as per Performance Reference Model (PRM) Results.

As per AGA ((AGIMO) 2011), there are five measurement domains with 14 sub-types domains.

1. Inputs domain: People, Data, Fixed Assets, Technology, Information, and Finances.
2. Work domain: Ad hoc Tasks, Processes, Projects and Operations.
3. Outputs domain: Services & Products.
4. Usage domain: Service Delivery & Product Consumption.
5. Outcomes domain: Business Outcomes & Program Outcomes

For the projects referred, some of the aspects that are applicable are referred from the Figure 27 AGA Performance Metrics ((AGIMO) 2011),

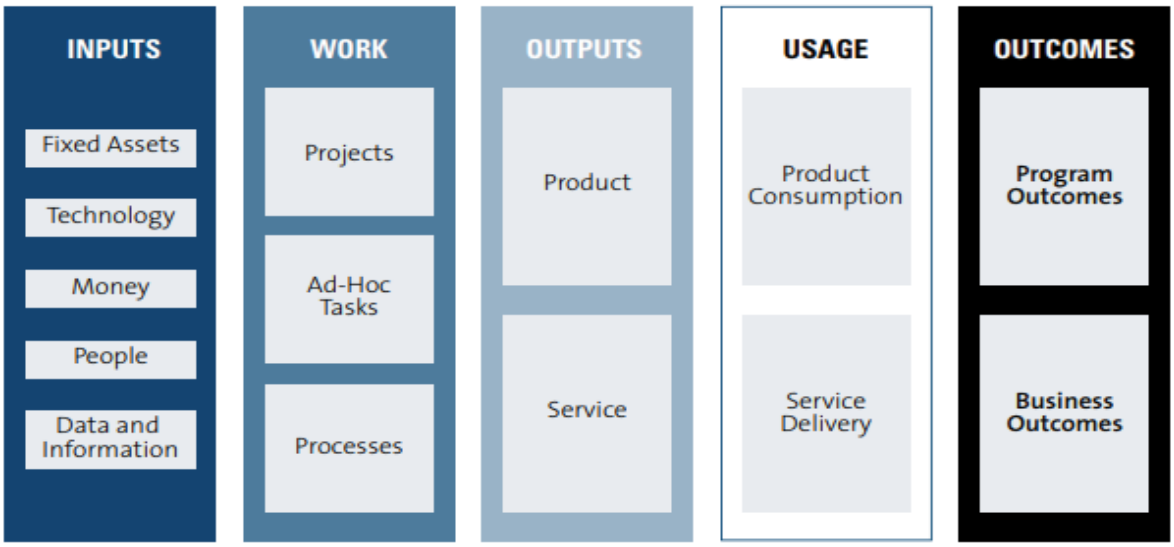


Figure 27 AGA Performance Metrics ((AGIMO) 2011)

3.4 Action Based Research

The action-based approach chosen for this research and the outcome of the projects is used to validate the hypothesis.

3.4.1 Action Research

Rory O'Brien (O'Brien 1998) suggests, to get the genuine results, action to be performed by the researcher. In real situations Action research is used, rather than in artificial, experimental studies since its prime focus is on solving real problems. This approach was followed to conduct the research and collect the data based on actual projects executed. Those acting will follow a disciplined process to conduct the inquiry. Action research enables the Researcher/Actor to improve and refine the activities based on the context.

Action research defines the incorporation of action (plan of implementation) with research (to validate the outcome of the implementation) conceived by Kurt Lewin (1890–1947).

Research implies that academics are working in isolation based on theories. Where in Action research is on real projects, working with real people in collaborative environment interacting and getting their feedback. That will assist to identify the cause of the issues that can be modified or enhanced to improve processes that benefit the project outcome.

Row	Routine Practice	Action Research	Scientific Research
1	Usual	Innovative	Resourced Original
2	Nonstop	Continual	Irregular
3	Contingency Driven: Reactive	Strategically Driven: Pro-active	Meticulously Driven
4	Specific	Involved	Combined, Shared
5	Real	Interventionalist	Experimental
6	Unexamined	Problematised	Commissioned
7	Skilled	Considered	Argued
8	Implicit	Explicit	Peer Reviewed
9	Rational	Unstated	Theorised, Explained
10	Context Specific	Generic	Generalised
11	Secluded	Disseminated	Published

Table 14 Eleven Characteristics of Action Research (Tripp 2005)

3.4.2 What is Excluded from this Research

Action research is executing real-time projects, not based on the experiments.

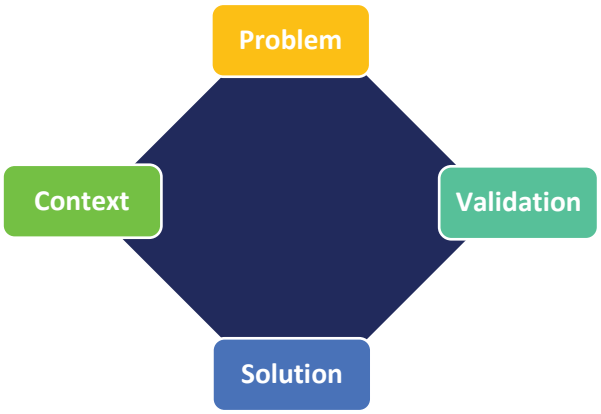
Action research is not aimed to solve a problem instead to execute a project and to find out based on the outcome (Ferrance 2000).

3.5 Validation of Research by Measuring Output on Architecture Projects

The outcome of the research is based on the lessons learned from executing actual Enterprise Architecture projects. That involves working in real projects, engaging stakeholders, adopting enterprise architecture frameworks that are applicable and methodologies that are relevant.

As the focus of this research is to prove enterprise architecture approach increases the success rate of digital transformation, the data is collected and analysed to validate the hypothesis.

The process followed to validate the research outcome as proposed by Dr Zenon (Chaczko 2018).



The above model followed to validate the research project outcome. As the research methodology is Action based, each project Problem is unique based on the Context. The Solution will be specific to the project Context and Validation needs to be tailored to align with Problem, Context, and Solution.

Raouf (Khayami 2011) has thrown light on qualitative nature of enterprise architecture and had identified few of the attributes:

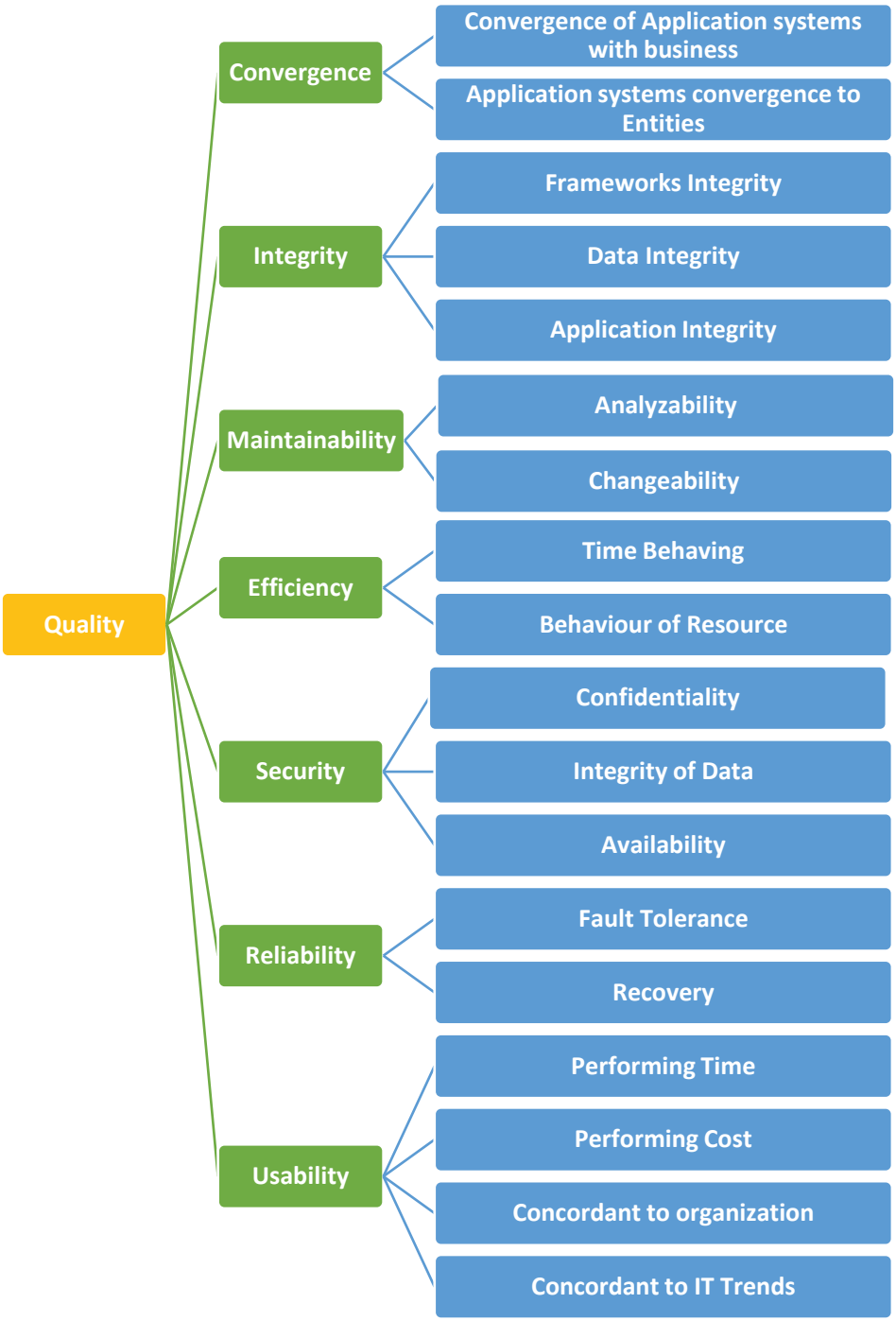


Figure 28 Quality Model of Enterprise Architecture (Khayami 2011)

In the paper "Assessment of Enterprise Architecture Implementation Capability and Priority in Public Sector Agency" (Bakar, Harihodin & Kama 2016), the authors have assessed case study of EA projects of public sector based on:

- **EA Implementation Capability:** Organization strength for developing the EA to be determined and parallel build capability in the area its lacking.
- **EA Implementation Priority:** Determine the task based on the rank, then prioritise for implementation.

Syynimaa (Syynimaa 2013) suggests, Enterprise Architecture implementation success metrics should be performed indirectly by measuring the achievement of the goals. Considerations determined from the perspective of the individual's and Organization's point of view.

B. H. Cameron (Cameron 2015) recommends defining and analysing key EA performance metrics that are mutually agreed both by IT and business that is easy to measure with accurate results.

EA applied at the strategic level, generates some measurable parameters that allow practitioners to assess and evaluate the EA program, the IT assets employed, and their significance to delivering business value for the enterprise.

At a tactical level, EA metrics are EA impact and its effectiveness across the organization — both directly and indirectly.

Brain (Cameron 2015) Suggested Steps to Measure EA Metrics

1. Identify
2. Establish
3. Assess
4. Measure
5. Monitor
6. Manage

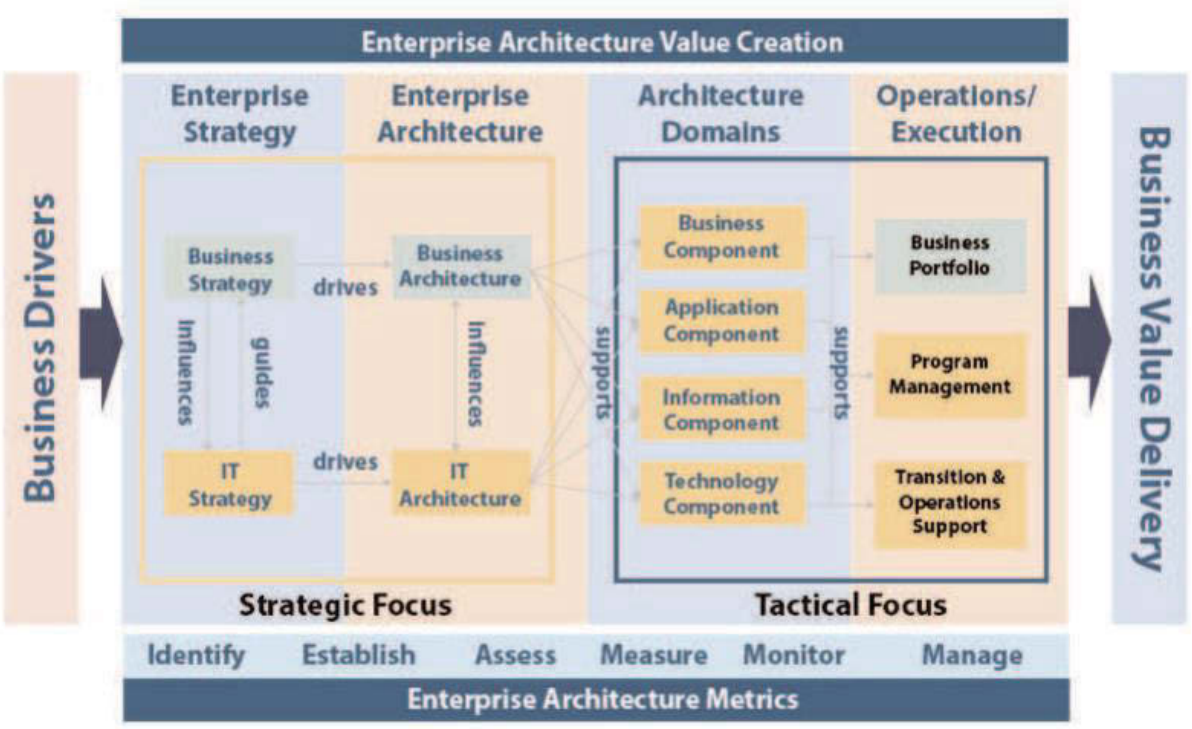


Figure 29 EA Value Creation (Cameron 2015)

3.5.1 Gap Analysis

Gap Analysis (Group 2011) is the technique to determine the differences between the current state or As Is to Target state or To Be state of Architecture.

Figure 30 Gap Analysis

Different type of Gaps

- Business domain gaps:
  - People, Process, Tools, Function, Information, Financial, Facilities gaps, and so on.
- Data domain gaps:
  - Insufficient Data, Quality, Access, Duplication, Relationship, and so on.
- Applications:
  - Core, Support
- Technologies:
  - Software, Hardware Network
- Security:
  - Authentication, Business Continuity Planning, Provisioning, Application, Technology and so on.

Item	Description
Staff skill	Knowledge of staff to follow the process
Frameworks	The frameworks used in an organization
Process	Process followed
Methodology	Applied methodology
Maturity	The current state of the existing practice assessed to determine the gap to achieve the target state
Technology Stack	Technology used
Management commitment	Support of the management team
Information Systems	Systems to support the business
Business Architecture	Blueprint of the Enterprise to realise strategic objectives

Table 15 Typical Gaps applied in the Research

3.5.2 Maturity assessment

Maturity assessment evolved as its been developed at the various timeline based on technology evolution. As organization relied more on technologies, it was critical to assess the maturity of the organization to improve the capability of people, process, and technology.

3.5.2.1 Organizational Performance to support Enterprise Goals

Gartner (Inc) measures Organizational Performance to Support Enterprise Goals considering capabilities based on the context of organization culture, behaviours and capacity of leadership.

Maturity assessments done for IT organization as a IT services provider and as a consumer of information technology. Assessed attributes are People, Practices and Process, Value and Financial Management, Technology, Relationships.

3.5.3 Statistics

Statics assists to organize, analyze and present the quantitative data. Statistics is a scientific approach for analyzing the collected numerical data that will enable to interpret and to understand data. Statistics enables to convert data into information, so the user can interpret, understand and get useful information.

The data collected through action research is by conducting focus group surveys and observation that needs to be analyzed and presented.

3.6 Project execution

This thesis is done to find evidence of Enterprise Architectural Approach for Digital Transformation of Modern organizations will increase the success rate. The framework used is TOGAF as it covers the complete life cycle of Enterprise Architecture life cycle iteratively incrementally through Architecture Development method.

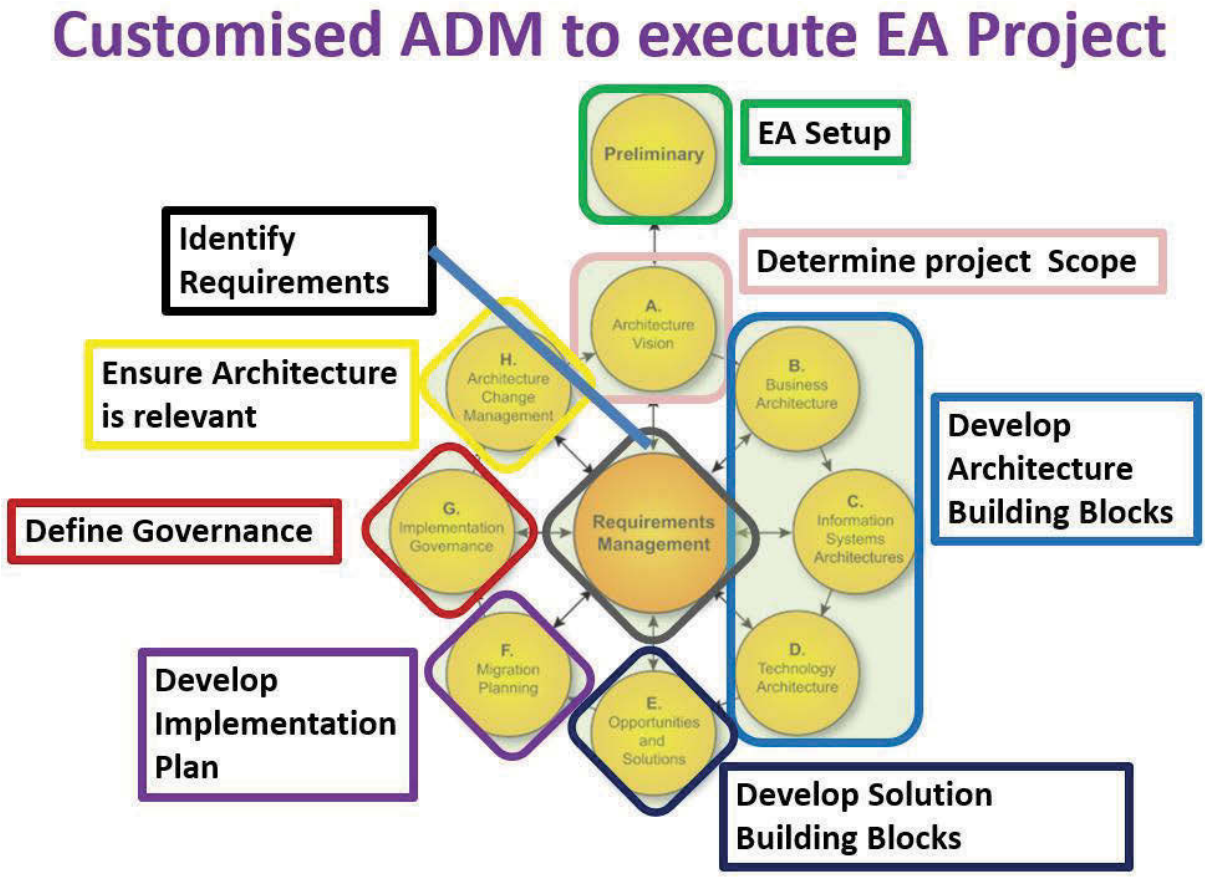


Figure 31 Customised ADM to execute EA Project

TOGAF framework aligns with our action-based research, through actual case studies based on real projects.

- **Waterfall**:
  A Linear sequential process followed to complete the research from Project selection to extract the relevant data.
- **Agile**:
  A iterative process with incremental outcome followed for each process.

3.7 Research Process

Figure 32 Research Process followed

EA practice connects the business and IT, that consist of strategic planning and tactical execution. Its explained with the following example of an organization embracing mobile-enabled workforce. The strategy to allow Bring Your Own Device (BYOD). The tactical is to enable the employee to use the corporate provided device to work remotely. Then in the long term, the BYOD will be supported.

3.8 Qualitative Attributes

Key areas that can be assessed qualitatively to validate EA practice, derived from theoretical model.

Primary Research Questions qualitative attributes

Category	Attribute
RQ 1: Does Enterprise Architecture approach increase the success rate of digital transformation?	
Enterprise Architecture	Strategy
	Governance
	Management Commitment
	Motivated & Passionate Team
	Capability Model
	Risk Management
	Business Architecture
	Application Architecture
	Data Architecture
	Technology Architecture
	Integration Architecture
	Security Architecture
	Portfolio Program Project Management
	Application Portfolio Management
	Service Management

	EA Linkage to Business
	EA Linkage to PMO office
	EA Linkage to Service Management
	Development Process
RQ 2: Does maturity assessment applied across the Architecture Development Method contribute to the success rate of digital transformation?	
Maturity Assessment	Organizational Maturity
	Organization Domain Specific Maturity
	Enterprise Architecture Maturity
	Business Architecture
	Application Architecture
	Data Architecture
	Technology Architecture
	Integration Architecture
	Security Architecture
	Portfolio Program Project Management Maturity
RQ 3: Do customized Architecture Development Method, inclusive of other frameworks and methodologies, enhance the success rate of digital transformation?	
ADM Phases	P: Preliminary
	A: Architecture Vision
	B: Business Architecture
	C: Information Systems Architectures
	D: Technology Architecture
	E: Opportunities and Solutions
	F: Migration Planning
	G: Implementation Governance
	H: Architecture Change Management
	Requirements Management
RQ 4: Does Enterprise Architecture tool aid the success of digital transformation?	
Enterprise Architecture Tool	Strategy
	Roadmap
	ArchiMate model
	BPMN model
	UML model
	Data model
	Requirements model
	Linkage across the models
	Linkage to Project Tool
	Linkage to Service Management tool
	Linkage to Software Development Tool

Table 16 Primary Research Questions Qualitative Attributes

Supplementary Research Questions qualitative attributes

Category	Attribute
RQ 7: Does Enterprise Architecture practice in an Organization foster innovation?	
Innovation	Transparency
	Openness
	Rationalized Business Function / Process
	Streamlined application
	Technology embracement
	Awareness of Risk

Table 17 Supplementary Research Questions Qualitative Attributes

3.9 Summary

This chapter discussed the philosophy, the principal reason to select the qualitative approach. Then based on the identified theories Priori to collect data before the project and Posteriori approach to collect the data after the project was chosen.

Next, Critical realism was used as it enables mapping of ontological character with real facts based on the events experienced or produced due to social reality. The Social science assists to make sense of the real world happening which changes with time.

Followed by the Archers Morphogenesis approach a process that enables changes in system state resulting end-product structural elaboration was chosen. Archer approach customized to suit the research, with Structure mapped to Organization, People, Technology; Action is performed by people with their accepted Framework and Methodology determines the Technology, that will change the organization.

The success of the digital transformation depends on people, their motivation, passion, and commitment. It's critical to understand the human psychology to determine the right people who will be involved in the transformation. To understand the human psychology Maslow's hierarchy of needs was selected.

Subsequently, EA frameworks such as TOGAF, FEAF, Zachman, DoDAF & AGA were chosen as they are all proven and based on open standards. From the selected framework data attributes were identified that align with the theoretical model.

The action-based research was chosen as this research is based on the actual projects that will be executed. The research outcome will be validated with the data collected from the execution of the projects.

PART II
Contribution to Research

4. Enterprise Architecture Stack

This chapter covers Enterprise Architecture (EA) concepts, Organization influence on the enterprise architecture practice, frameworks and methodologies that assist in managing the lifecycle of EA, the core and cross-cutting domain of EA, and the elaboration of the technology stack.

Next, an in-depth analysis of TOGAF and its components, followed by the Enterprise Architecture conceptual framework explained, followed by Logical Model of Living Enterprise Repository. Subsequently, the importance of model with the related modelling language that applies to EA practice narrated. Then the Capability maturity model, its significance with the proposed comprehensive capability model is covered. Then followed by Complementary Framework and Methodologies for TOGAF with its relevance. Followed by EA tools, the Complementary Modelling, Framework, and Methodologies covered. Finally, Enterprise Architect Skills, Roles, and Responsibilities discussed.

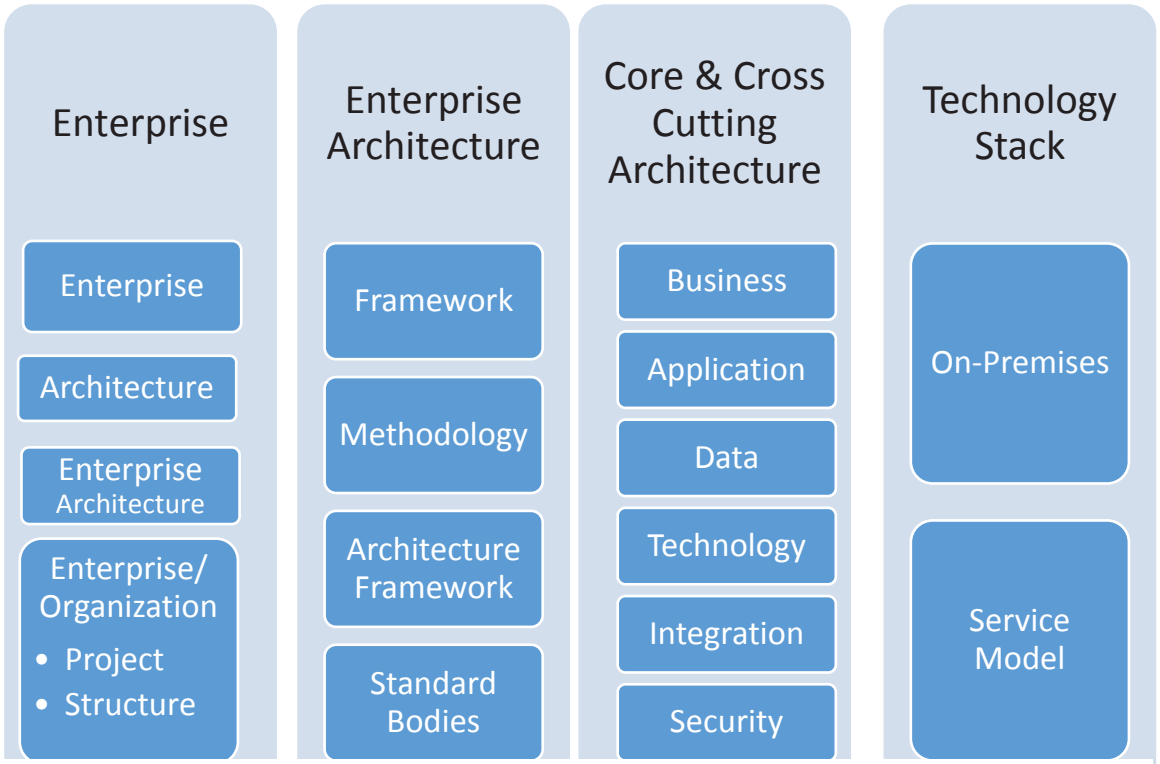


Figure 33 EA Conceptual Model

4.1 Conceptual Model

4.1.1 Enterprise, Architecture, Enterprise, Architecture definition

4.1.1.1 Enterprise

TOGAF defines (Group 2017a) P.5 “Enterprise as any collection of Organizations that has a common set of goals.” It can be a Government Organization, a Multinational Corporation spread across globally, an individual Department of Government or Private Business; but all need to have the goal in common. For example, a Government organization common goal is to provide service to the citizens, whereas a Private Organization exists due to commercial interest, so its common goal is to make the profit.

As in the current connected world and global economy organization cannot exist isolated instead they need to collaborate. The enterprise extends further to include its partners, suppliers, and customers.

Furthermore, organizations are elaborated, which has many definitions; as per (University 2016) “An ‘Organization’ is a group of individuals working together to achieve one or more objectives.” With common characteristics as:

- Consists of people in group or individuals
- To accomplish common goals
- Work on diverse functions
- Harmonised functions
- They may work independently or together

4.1.1.2 Architecture

The definition of architecture based on the discipline it has been referred. Summary of Architecture definition from Merriam Webster and Dictionary (Dictionary.com 2017; Merriam-Webster 2017) is as follows:

- Designing buildings or any artificial constructions
- The art and science of building
- Style or character of the building, e.g., Roman, Paris, Gothic architecture
- Assembly of computers components hardware or software

From the above, architecture can be defined as an artefact produced by the human being, that has some meaning, usefulness, and purpose.

Irrespective of the domain or disciplines, the architecture provides approach for solving a common problem: guaranteeing that a building, or bridge, or composition, or book, or computer, or network, or system has specific properties and behaviours when built.

“A good system architecture exhibits conceptual integrity; that is equipped with a set of design rules that assists in reducing the complexity and that to be used as guidance for the detailed design and system verification” from the book Beautiful Architecture (John Klein January 2009).

4.1.1.3 Enterprise Architecture

Enterprise Architecture encompasses the organization addressing the business requirements through architecture that assist to provisioning systems to realises business objectives and ensures the architecture is flexible to change to support the changing business model influenced by technology and evolving customer expectation. To support a dynamic architecture at the quick turnaround time is enabled through frameworks and methodologies.

4.1.1.4 Interchangeability with Enterprise and Organization

Enterprise or Organization are used interchangeably in this Thesis, as both seem the same based on our research context.

PMI defines (Institute 2013) Organizations are systematic arrangements of entities such as departments or persons aimed at accomplishing a purpose.

The purpose of the Organizations starts right from the inception of dream or aspiration of the individual or an organization to achieve something. Mission enables to realise the vision of an organization through strategy

Organization strategies, goals and objectives aligned with their mission and vision are more successful compared with an organization which did not have, as mentioned by Bart (Bart, Bontis & Taggar 2001).

"Good business leaders create a vision, articulate the vision, passionately own the vision, and relentlessly drive it to completion."

- Jack Welch former CEO of General Electric

Organizational Strategic Elements Vision to Outcomes:

Vision	Aspiration/ Dream of Organization and its Purpose
Mission	What it does or will do and who does it when
Goal	Goals are the broad primary outcomes, targets of the long-term vision of the Organization. They define the expected result and clearly outline a measurable "what" that needs to be accomplished
Objective	Outcome: What to do, how much, by when
Strategy	How (Plan, goals, sequence), A strategy is the choices taken to achieve the *goal*
Tactics	Short-term actions
Action plan	What to do, how do we know it's done
Value	Business value is of tangible or intangible.
Outcome	A result that must be achieved
Principle	A qualitative statement that sets a boundary for the architecture team for decision making.
Policies	Clear, simple statements of how the organization proposes to conduct its services, actions or business. Provides a set of principles that will guide decision making.
Procedures	Defines how each policy can be enabled in an Organization. Each procedure outlines: • Who will do what, • What steps they need to take, • Which forms or documents to use.

Table 18 Organization Vision to Outcomes

4.1.2 Enterprise Architecture

There are various definitions for enterprise architecture; relevant to the research are:

- The Open Group (Group 2017a) defines ''enterprise architecture to denote both an entire enterprise encompassing all of its information and technology services, processes and infrastructure and a specific domain within the enterprise".
    - From the above, it can be inferred that EA is coverage holistically Organization-wide or to one domain that addresses the services of business, application, and technology.
- Oracle (Network 2017a) defines Enterprise Architecture (EA) as a method with organizing principle to aligns functional business objectives and strategies in an IT strategy and execution plan
    - From the Oracle definition, it can be concluded EA must address the business objective and there must be a strategy to execute that is achieved through IT strategy. So, IT and business must work together to achieve the desired business expected result.
- Gartner (Mann 21 August 2017) has defined "business-outcome-focused enterprise architecture" as "a discipline for proactively and holistically leading enterprise responses to

disruptive forces by identifying and analysing the execution of change toward desired business vision and outcomes."

  - Based on Gartner definition of EA, its understand the key consideration is to enable the business transformation with modern technology to realise business vision focusing on outcome.
  - Also, Garner recommends adapting the modern technology organization needs to adjust the policies. E.g., Change from systems deployed in-house data centre called on-premises to cloud deployment that is a public shared infrastructure or procure application based on a platform as a service model and pay only for the services used.

- Government of NSW (DFSI 2016) definition "NSW Government Enterprise Architecture (NSW GEA) encompasses all aspects of enterprise architecture activity at the business, information, application and technology infrastructure layers across the NSW Government in support of the NSW Government ICT Strategy. Key focus points for Enterprise Architecture support of the ICT Strategy are ICT solution rationalisation and the planning, design and delivery of improved Key Service Capabilities including citizen focused services."
  - We can comprehend NSW want to realise EA across all the domain for EA such as business, information, application and technology across NSW government departments. They key focus to rationalise the process with key Citizen centric focus.

From the four different definitions of EA it can be concluded 'EA is a discipline to rationalise and improve the process across all the domain of EA such as business, information, application and technology. To realise business outcome focused on Customer or Citizen centric, that is realised through modern technology. If its necessity to change the policies to adapt the technology'.

The scope of enterprise architecture is based on the Business Operating Model of the Organization. There may exist multiples enterprise architecture in the large enterprise in federated style. But they may have shared architecture framework (Group 2017a).

Historically due to a limitation of software and hardware, it was not possible to have single architecture due to the size and location of the organization spread across in multiple locations and countries. But with the current technology, process, and tools available it's possible to have a single architecture for some of the core systems.

For example, AADHAAR a unique 12 digit ID number (UID) to all residents in India issued by The Unique Identification Authority of India (UIDAI).Unique Identification Number database store the data of citizens of India in the form of Biometric and demographics data (Society 14 March 2013).

Biometric information consists of Ten Fingerprints, Two Iris Scans, and Facial Photograph. Where Demographic data is made up of Name, Date of Birth (verified) or Age (declared), Gender, Address, Mobile Number (optional) and Email ID (optional). Aadhaar the digital and online Id provided free of cost for every resident of India that is one billion plus citizens, the largest biometrics-based identification system in the world. UID architecture is open and scalable based on open source technologies. Aadhaar Authentication serviceable handle 100 million authentications a day and scalable based on the demand (India).

4.1.2.1 Why Enterprise Architecture?

It has been mentioned earlier organization have procured system on need basis influenced by the evolution of technology that provides the business capability. That has resulted in Architecture by necessity, summarised in Figure 34 Architecture by Necessity versus Architecture by Design.

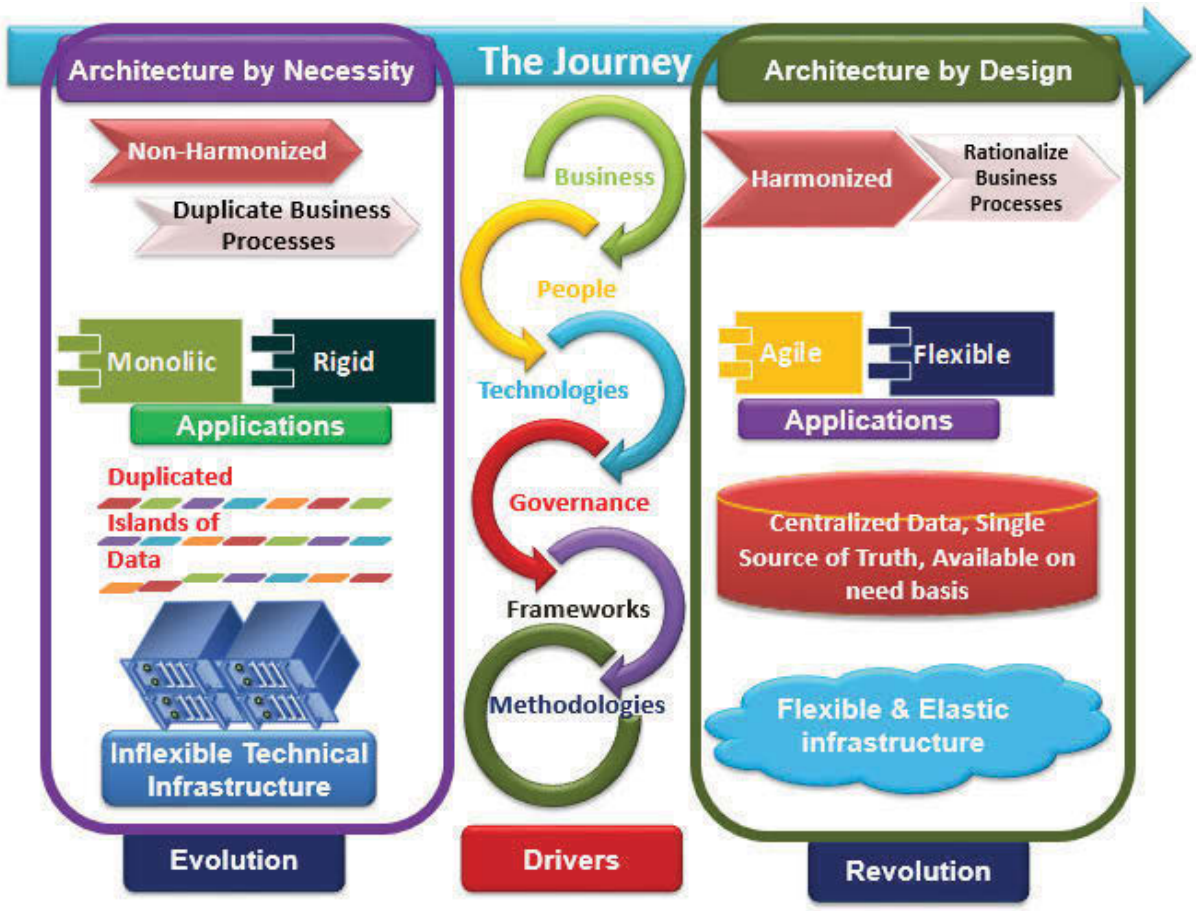


Figure 34 Architecture by Necessity versus Architecture by Design

Architecture by design based on enterprise architecture practice, it is possible to have common sharable, harmonise business process across the Organization. With the current software programming, it is possible to build agile systems. Evolution of hardware technology it's possible to provide dynamic real-time information and lastly to provide the flexible infrastructure that is elastic in nature that is possible due to cloud technology. Cloud technology offers the capability of elastic infrastructure that will dynamically expand or shrink based on the demand.

With EA practice it is possible to set up the architecture that supports business and make use of the capability of technology.

Setting up and following right EA practice it is possible to:

- Identify business processes that are common and sharable across the Organization
- Optimise and increase business efficiency
- Reduce operational cost
- Support the changing business needs and models
- Provide better service to customers
- Increase work productivity

4.1.2.2 What Type of Architecture is Enterprise Architecture?

EA is an architecture based on software that is not tangible as the construction industry but inherits the nature of software architecture that is intangible.

From Beautiful Architecture (John Klein January 2009) it is summarised software architecture consist of design decisions that are documented and maintained based on version control for auditing purpose for the decision and its rationale.

Type of design decisions broadly classified as:

- **Behavioural:**
  - *External:* defines the external exposed interfaces for user interaction or interface for other system integration
  - *Internal:* defines the interfaces between the components
- **Structural:**
  - Division of the product logical and physically components

Project: "A project is a temporary endeavour undertaken to create a unique service, product, or result" as defined by Project Management Institute(PMI) (Institute 2013) P 29. Project has the timeline with start and finish date as it is temporary. The project ended when its objectives achieved or terminated if it's not viable to continue the project.

The program consists of related projects grouped to increase efficiency and success rate.

A portfolio composed of some independent programs based on strategic perspective.

An organization vision realised through its Mission through Project or Program or Portfolio that depends on the size of the project and strategic perspective that is executed based on the Organization structure.

Organizational Structure An organization is made up of numerous departments. The employees in the units are to be managed. There need be a hierarchy of roles defined to achieve their tasks. Organization structure determines the grouping of staff and their positions that represent the reporting structure. Organization structure will identify the communication style, reporting system, assist in decision making and completion of the task assigned.
Project management institute (Institute 2013) P.48 defines the following types of organization structure:

- **Functional Organization:** In this of an Organization, the staff is grouped based on the specialty such as human resource, marketing, production, financials, engineering, accounting, and so on. Based on the type of organization domain the specialty group may be subdivided further. The reporting structure is a top-down hierarchy, with each employee having one supervisor to report. The projects are executed based on that specific department needs with the functional head having full control.
- **Projectized Organizations:** In this type of Organization, the staff is grouped into departments to manage the project, reporting directly to project manager. The projects are executed based on that specific department needs with the full authority of Project Manager.
- **Matrix Organization:** This type of organization is hybrid of Functional and Projectized organization further subdivided based on the power of Project Manager or Department functional head.
  - **Weak Matrix:** Project Manager has less authority of projects, where the Department functional head will have full control.
  - **Strong Matrix:** Project Manager have full control of projects, where the Department functional head will have less control.

- **Balanced Matrix:** Project Manager and Department functional head will share the power equally on projects.

Project Success Measurement As the project has an end date (Institute 2013) P. 61, it must meet its agreed objectives of key stakeholders such as time, cost, scope and quality within permissible parameters.

Standish Group (The Standish Group International 2015), established in 1985 specialises in project management, publishes CHAOS report since 1994 comparing projects across the world, defines project success measurement as follows:

- Projects successful are on budget, time, cost, quality with satisfactory implementation.
- Projects challenged are over budget, late, and unsatisfactory implementation.
- Projects failed are either cancelled before completion or never used after implementation.

Projects are temporary endeavour more of the tactical solution to meet the business objectives. Enterprise Architecture is an ongoing practice that exists if the enterprise exists to achieve the strategic goal. The type of organization structure suitable to meet the dynamic strategic objective is the Matrix based either Balanced or Strong, but the success rate will be high in Strong Matrix.

4.1.2.3 Framework

Framework based on the types is defined by Cambridge dictionary (Press 2017a) as:

- **System**: Have rules, ideas, or beliefs that may be used to plan or decide something;
- **Structure**: It's a framework with shape, that supports something such as a vehicle or building.

Thereby a framework acts as a tool with a standard structure to increase productivity. A framework is a static model library of taxonomy. It does 'What' but not the 'How' based on the usage (Global) and it does not mandate the order of execution of framework. Based on the user experience and context of the project the structure can be customised.

4.1.2.4 Methodology

TOGAF defines (Group 2017a) P.27, methodology as repeatable steps to address a specific type of problem, which typically focuses on a well-defined processes, that may include definition of content. Also IASA Global (Global) defines a methodology as the order of 'What' steps to perform, 'How' and reason 'Why', though it doesn't mandate the steps it provides structure and philosophy.

4.1.2.5 Architecture Framework

TOGAF (Group 2017a) P. 7 defines architecture framework as a foundational structure, that can be reused for evolving a broad range of different architectures.

ISO/IEC/IEEE 42010 (ISO/IEC/IEEE 2011) defines architecture framework as conventions, principles and practices to define architectures for a specific domain of application to address the need of community of stakeholders.

Architecture Framework (ISO/IEC/IEEE 2011) to meet the International Standard (IS) to confirm:

- Information for identifying the framework;
- To address one or more concerns of stakeholders;
- Generate architecture viewpoints to address stakeholder's concerns;
- Able to integrate the viewpoints;
- Applicability of conditions as needed;
- Framework consistency aligning with ISO/IEC/IEEE 42010 conceptual model.

There are 77 frameworks that confirms to International Standard as on 2017 (ISO/IEC/IEEE 2017).

4.1.2.6 Standards Bodies

The Law Dictionary (Dictionary 2016) defines Standard bodies as "Organization in a public or private sector, national or international that proposes, monitors, develops voluntary standards. For example, ISO, ANSI." Further TechTarget (NETWORK 2016) clarifies that standard bodies or organization as “authority to endorse official standards” that are known as De facto Standards. This ensures the standards endorsed to be trusted and that will be of open standards. Technologies that are based on standards, removes the technical barriers for trade that enables world trade, contributing economic growth due to opening of new market opportunities (OFFICE).

4.1.3 Core and Cross Cutting Architecture

4.1.3.1 Core Architecture

- **Business Architecture:** Outlines the business strategy, services, process, function, governance, and organization.
- **Application Architecture:** Describes the blueprint of the deployable applications with their interactions. Also defines the application relationships to the core business processes. **Technology Architecture:** Defines the relevant software and hardware capabilities to support the deployment of application, data, business, and application services.

4.1.3.2 Cross Cutting Architecture

The cross cutting architecture layer cutting across the core layers are:

- **Security Architecture:** All the phases of ADM to address security as its pervasive. Security Architecture consists of a set of relevant design artefacts to describe an object that to be maintained over its useful life. (Architecture 2016).
- **Integration Architecture:** Core architectures integration are: Business architecture-its function/ process; Information architecture-its disparate applications/ data, and Technology architecture-its diverse technology stack
- **Data Architecture:** An Organization's conceptual, logical and physical data assets and its data management resources is described. It identifies the structured, unstructured and hybrid data of an organization. In TOGAF - Data Architecture is core layer, where in ArchiMate its shown as cutting across all the three domains Business, Application and Technology. Also, data is required even in Integration, Security, and so on.

4.1.3.3 Consideration for Core and Cross Cutting Architecture

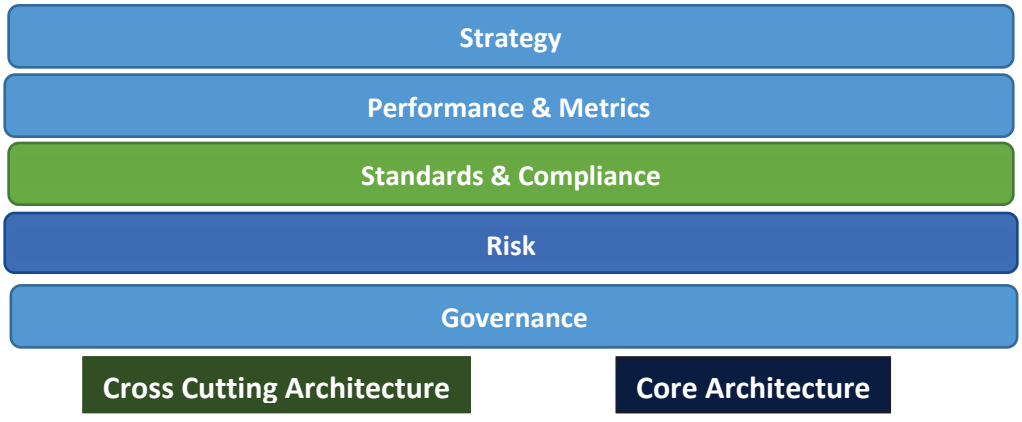


Figure 35 Additional Consideration for Core and Cross Cutting Architecture

4.1.4 Technology Stack

Architecture is realised by the technology stack, that can be provisioned as below:

- **On-Premises**:
  Physical infrastructure provisioned inside the organization data centre, or private data centre
- **Service Model**:
  Infrastructure service provisioned on the need basis with operational cost-Opex without the initial capital expenditure cost-Capex.

Due to the changes in the procurement model from Capex to Opex Organizations are embracing technology at an alarming speed. If the organization delay in providing the capability needed by business, they are giving rise to Shadow IT, where the business procures service without consulting the IT department. Adoption of enterprise architecture practice will enable to address the business needs proactively.

4.1.5 Supplemental Concerns

4.1.5.1 Strategy

A Strategy is for the longer term, and broader in scope is the essential Course of Action to achieve the goal (P 2015). Enterprise Architecture practice enables the business to realise its vision through strategies

4.1.5.2 Performance and Metrics

Assess the Current performance and determine the target that to be evaluated at the specific timeline. To assess performance, metrics are to be identified. As EA practice is qualitative in nature, it is critical to determine the performance parameters where ever applicable in EA cycle.

4.1.5.3 Standards and Compliance

A set of procedures, specifications and guidelines that ensures products, services, and systems are reliable, safe & consistent. EA practice success is guaranteed by following the standards that are applicable nationally or internationally.

An organization must be compliant with the compliance of the regulatory bodies, national or international Organization.

4.1.5.4 Risk

The risk is pervasive and inevitable, as such it's critical to identify, analyse and mitigate.

4.1.5.5 Governance

"Governance is how society or groups within it, organise to make decisions" (Governance. 2018). For EA practice to be successful, key people across the organization are to be involved, and decisions that are taken to be in consensus. Governance to be defined by industry standard as Control Objectives for Information and Related Technologies (COBIT).

4.2 Architecture Framework - TOGAF

TOGAF 9.1 (Group 2017a) P. 9, is an architecture framework developed based on Open standards. As an organization evolution is constant, so TOGAF addresses as it's an iterative process that provide methods and tools to produce reusable assets developed using proven best practices for production, acceptance and maintenances of EA in an Organization.

TOGAF was developed in 1995 by The Open Group, that was derived from DoD's TAFIM. As of 2017, 80% of Global 50 companies and 60% of Fortune 500 companies use TOGAF. It defines standardised

semantics, and processes that can be used by Enterprise Architects to align IT with the strategic goals of their Organization.

TOGAF is from The Open Group, (Group 2017b) is a technology and vendor agnostic. The Vision of Open Group to achieve seamless communication within an organization and outside with its partners. The open standards enable to achieve the interoperability. The Open Group address current and emerging requirements of an organization through defining policies and share best practices. It also supports Open Source technologies in partnership with consortia, customers, suppliers, and standards bodies.,

TOGAF describes series of steps to develop an enterprise architecture, with its prescribed tools. TOGAF is an approach to develop "rapid" architectural development with an effective governance. Models are not prescribing to represent the architecture, though it guides with the process to create architecture. We can summarise TOGAF is both a Framework and Methodology for developing an Enterprise Architecture iterative process and incremental implementation.

4.2.1 Classification of Framework and Methodology

Framework or Methodology is developed to address the problem specific to industry or domain; it evolves due to knowledge gained from implementation. A typical enterprise may use the combination of Framework or Methodology as none is complete to address the needs.

Framework and Methodologies	Purpose
Strategy	Defines process to realise enterprise Vision and Mission
Enterprise Architecture	Provides process to establish enterprise architecture practice across the organization to realise strategy
Project/Program/Portfolio	Process to implement the initiatives identified by EA to realise the strategy
Operation	Process to ensure project implemented systems are running as defined by EA
Governance	Establish policies, rules, relationships, systems, and processes. Provides a formal structure for Organizations, authority within agencies is exercised and maintained
Software Development	Defines process to develop executable software to realise the software project.

Table 19 Classification of Framework and Methodology

4.2.2 Definition of Architecture from TOGAF Perspective

TOGAF is partially based on ISO/IEC 42010: 2007 it 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.''

ISO/IEC/IEEE 15288 Annex G (ISO, 2015) (Standardization 2015) definition of system of systems, groups set of systems to do task that not possible to be accomplished by one system alone.

A typical enterprise is system of systems, consisting multiples systems having their own architecture. All system irrespective of the type have four key architecture domains according to TOGAF (Group 2017a) P.10.

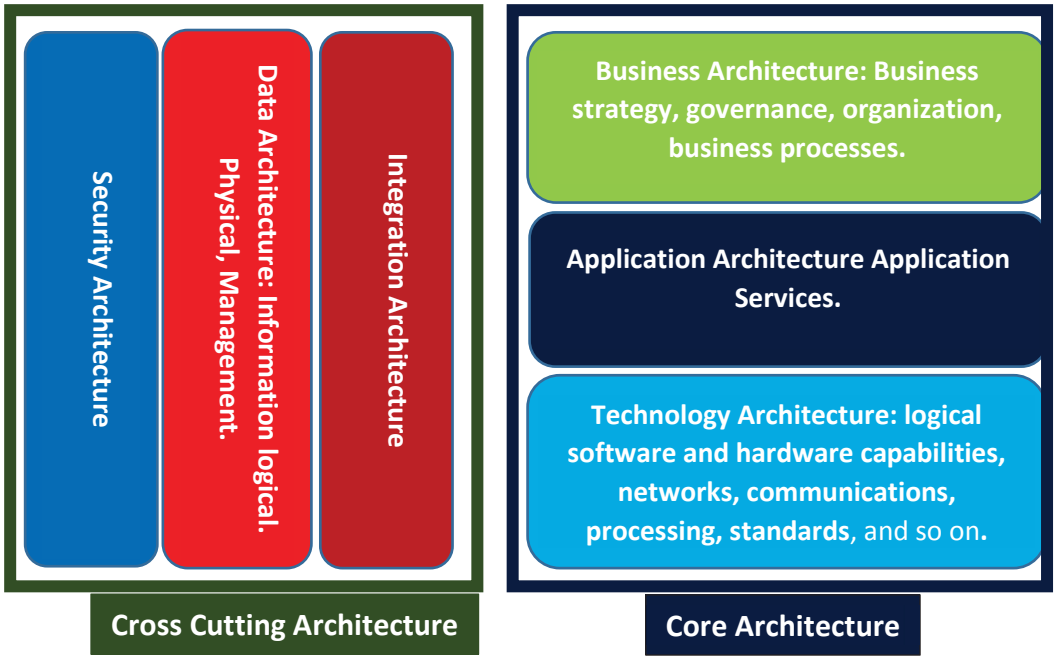


Figure 36 Enterprise Core and Cross Cutting Architecture

4.2.3 TOGAF Components

4.2.3.1 Architecture Development Method(ADM)

The core of TOGAF is ADM to develop lifecycle of Enterprise Architecture through iterative and incremental process.

TOGAF ADM has several phases, like waterfall model. As TOGAF is both a framework and methodology, it specifies the input, output, and content for each phase.

Though TOGAF ADM reflects waterfall model, with each phase connected in one direction with an arrow in a forward direction, it relates all the phases to the requirements engineering with a double-headed arrow thereby it is an agile methodology too. TOGAF is a hybrid model combining waterfall and agile methodology.

Every organization there will be an Enterprise Architecture practice and it exists if the organization exists. Depending on the organization maturity or management support EA can be dormant state or highly visible and powerful sate.

Enterprise Architecture cuts across the organization at various stages from identifying the business objective to its realisation.

The core of TOGAF is Architecture Development Method(ADM) (Group 2017a) P.48, that is extended represented in Figure 37 Architecture Development Method,

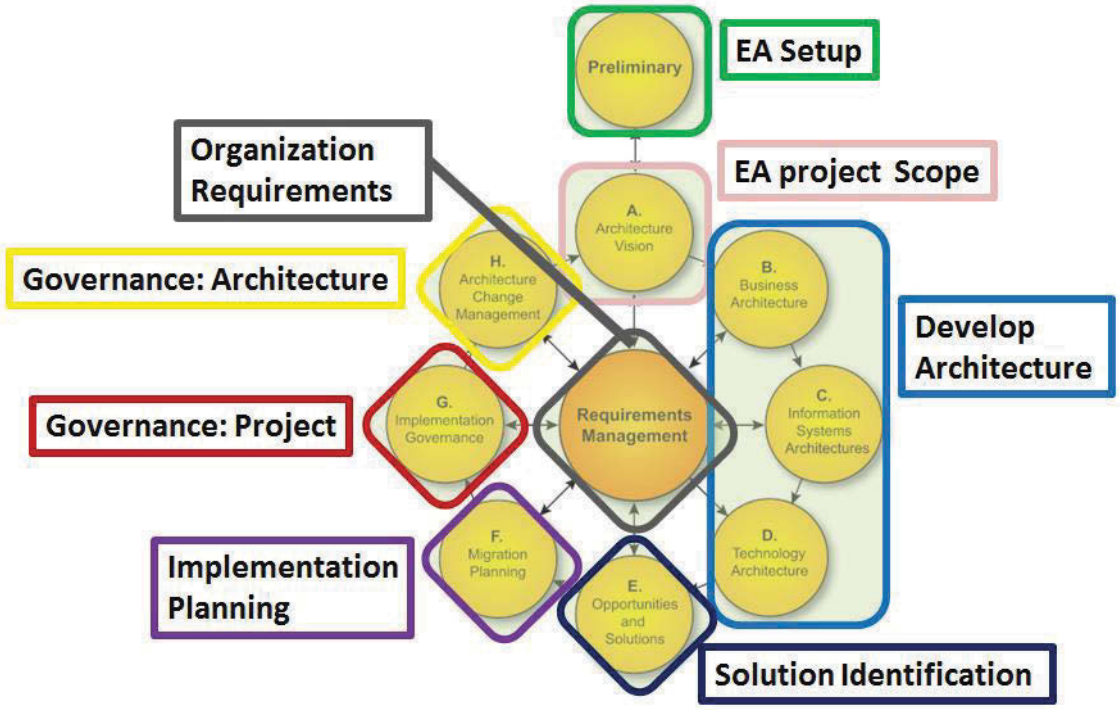


Figure 37 Architecture Development Method

Partition	Purpose	ADM Phase	Objective
EA Setup	To start the practice	Preliminary Phase	Tailor Enterprise Architecture practice as per organization constrains and requirements
EA Project Scope	Strategic & Tactical Planning	A: Architecture Vision	Defines the scope of the ADM Cycle based on the Strategic and Tactical based on organization risk appetite
Develop Architecture	Define and analyse Architecture	B: Business Architecture	Develop Business Architecture in alignment with the scope identified in Phase A
		C: Information Systems Architecture: Data	Identify the information and develop the Information Architecture
		C: Information Systems Architecture: Application	Determine the logical applications and develop Application Architecture
		D: Technology Architecture	Identify the technology and develop the Technology Architecture
Solution Identification	Determine the Solutions	Phase E: Opportunities & Solutions	Market scan and identify the Products to realise Technology Architecture
Implementation Planning	Planning to implement the qualified Solution	Phase F: Migration Planning	Select the product that aligns with the organization and develop the implementation plan
Governance	Project Governance	Phase G: Implementation Governance	Govern the EA projects and monitor the deliverables meets the identified KPI

	Architecture Governance	Phase H: Architecture Change Management	Pro-actively monitor the market condition and establish change management process to ensures the Architecture is relevant
Organization Requirements	Requirements Management	ADM Architecture Requirements Management	Track the requirements and ensures its relevant and based on the business need and addressed in the phases of applicable ADM

Table 20 ADM Cycle Partition

4.2.3.2 Guidelines and Techniques-ADM

Guideline according to Cambridge Dictionary (Dictionary) "information intended to advise people on how something should be done or what something should be".

ADM can be applied for various scenarios in a life cycle of EA practice. TOGAF provides few guidelines such as ADM Iteration, Architecture Landscape, Security Architecture, SOA, and so on.

In general, as guidelines are not mandated or enforced, there are few for reference provided by TOGAF. Based on the context guidelines from other framework or industry can be considered, if it adds value.

Technique according to Cambridge Dictionary (Dictionary), "a way of doing an activity that needs skill", further Oxford Dictionary describes technique as, "a way of carrying out a particular task".

To develop an architecture, in the ADM cycle, a task that needs specific skills to be applied. TOGAF has provided few techniques as a reference, but they are many more that needs to be considered.

4.2.3.3 Architecture Content Framework

Developing Architecture produces various types of documents such as business requirements, strategy documents, Stakeholder Map Matrix, Value Chain Diagram, Process Flows, Project Plans, and so on.

TOGAF provides as content framework (Group 2017a) P.327, that is structural model for architectural content created by architects, to be consistently defined, structured, and presented.

The output produced are categorised as:

1. **Deliverables**: The output artefacts, which is contractually specified.
2. **Artefacts**: The output produced are grouped as:
    a. Catalogues: Related output arranged as lists of things,
    b. Matrices: The relationships between output represented with a table,
    c. Diagrams: Output represented as pictures.
3. **Building Blocks**: The artefacts that are reusable and able to be combined to produce:
    a. Architecture Building Blocks (ABB): Developed to address the required capability of the Organization.
    b. Solution Building Blocks (SBB): Realises the capability adhering to the specification as per ABB through components.

The content frameworks provide the input and output for all the phases. Due to this, there is consistency in the documents produced, acts as a checklist for the type and the number of records generated. TOGAF does not prescribe the other content framework; we discuss the different content framework that is available in "Framework and Methodologies" section that will complement ADM.

4.2.3.4 *Enterprise Continuum*

Continuum (Vocabulary.com) “is something that keeps on going, changing slowly over time”, where Continuum (Press 2016b) is also, it’s a continuous sequence where the adjacent elements are not noticeably different from each other, but the extremes are quite distinct.

An enterprise is ever evolving, produces various types of digital documents such as principles, policies, strategic initiatives, standards, organizational structures, enterprise-level capabilities that needs to be organised, stored, indexed, managed, version controlled, and so on.

Enterprise Continuum from TOGAF (Group 2017a) P.461-473, perspective provides a way of organising the architecture at it evolves from generic to organization specific.

It identifies the drivers “Why” the architecture is to be developed, “What” type of architecture and “How” to develop. Such that architectural data is being generated, it can relate to conceptual model of the Enterprise data warehouse. Enterprise Continuum gives the conceptual model for the storage of data that is most relevant.

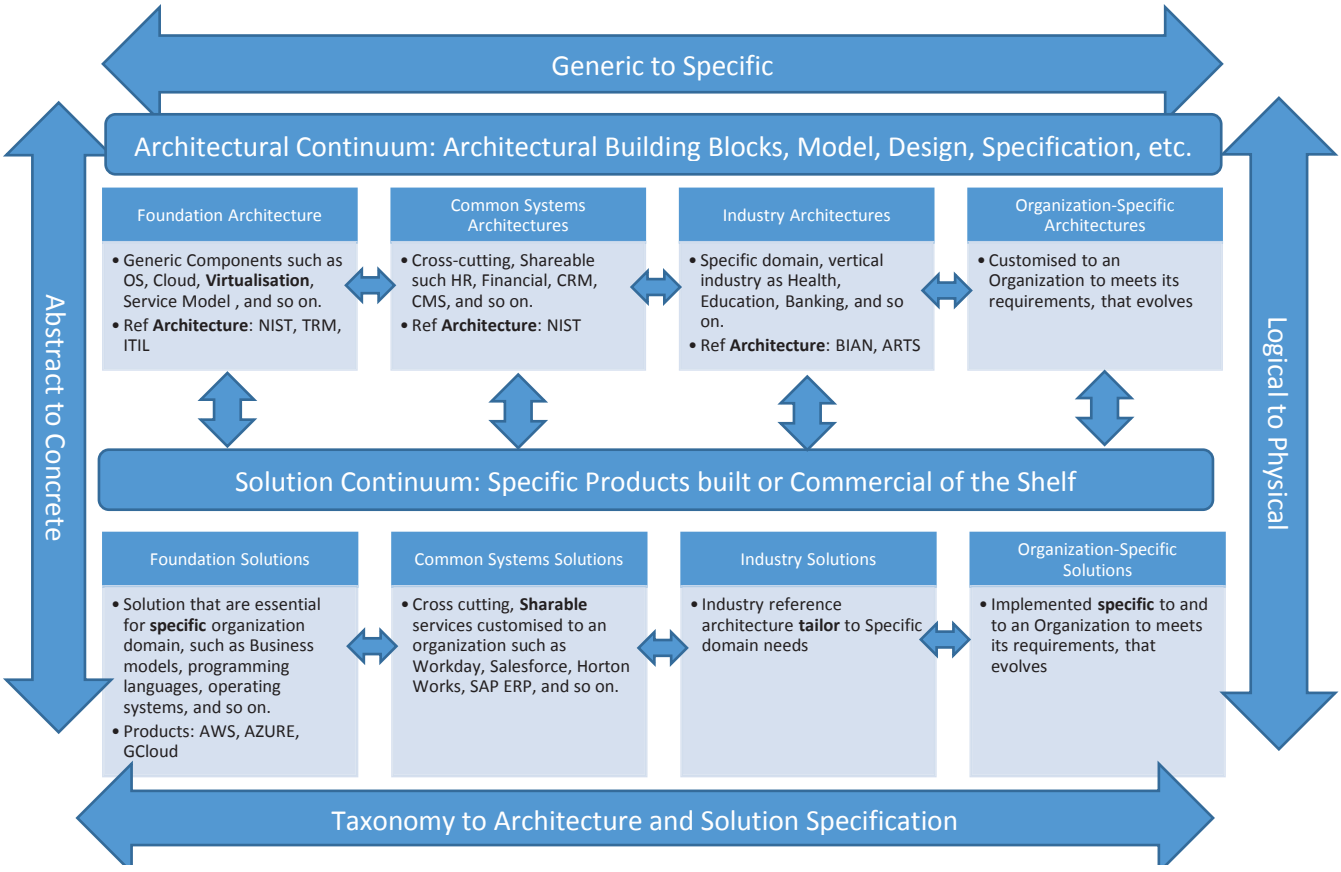


Figure 38 Enterprise Continuum in detail

Ontology a set of concepts and categories in a subject area or domain that displays their properties and the relations among them. Philosophy conceptually, specific to a domain as a central concept connects the related ideas on linearly in an intuitive way.

Taxonomy is (Press 2017b) "The branch of science concerned with classification," this includes the description, identification, nomenclature and classification of things. Taxonomy logically groups the items. A repository with proper taxonomy can manage many artefacts that are generated.

Architecture repository is a combination derived from ontology conceptually and taxonomy logically that provides the structure and relationship between the artefacts as it evolves for current and future

objects. Architecture repository is a logical model that provides the structure and relationship between the artefacts.

TOGAF Architecture repository is a structural framework as follows:

- **The Architecture Metamodel:** This is developed based on the selected architecture frameworks, with their architecture content Metamodel. Module "4.5 Complementary Framework and Methodologies for TOGAF", has covered in detail the frameworks and methodologies that are available in the market.
- **The Architecture Capability**: Provides the structure, process to assist the Architecture Repository governance.
- **The Architecture Landscape**: The assets required at various timeline as Strategic high level, Segmental in program or portfolio and Capability at the project level.
- **The Standards Information Base**: The standards that are used to comply based on industry, national and international, or whatever applicable.
- **Reference Library**: The materials referred to develop the architecture are defined such as:
    - National and International standards bodies
    - Product & Service vendors
    - Industry Forums or Communities
    - Design Patterns
    - Commercial Organization Vertical Industry references
    - Research Organizations
    - Corporately defined templates
    - Best practice known from project implementation

  Reference frameworks ensures the success of fast phase of the project execution, as there are directions to follow, that reduces the development time. Also, some of the frameworks are from practical implementation; this increases the success rate of the project.
- **The Governance Log:** The activities of the Governance are captured such as:
    - Decision Log: Decision that is important are captured that includes:
        - Selection of:
            - Framework
            - Methodology
            - Team
            - Technology selection
            - Product
            - Standard
            - Reference Architecture
        - Work assignment
        - Priority of the architecture projects
        - Reporting structure
        - Project Progress
        - Change request evaluations and approvals, and so on.
    - Compliance Assessments: This ensures the process, product or service confirms as per the standards identified and applicable, that may include
        - Progress (timeline, status, issues, risks, dependencies, and so on.)
        - Standards
        - Regulations
        - Capability Assessments.

IT projects fail as people with power take decisions, and they are not held accountable as they choices are not captured and logged. Governance log is one of the critical document for the success of the enterprise architectural projects. As the prominent activities, such are the decision, compliance assessment, project progress, and so on. are logged, thus bringing in accountability and transparency.

Architecture repository is one part of the more extensive repository that exists in an Organization. There will be various other repositories that will segment based on the activities as Project, Software, Operations, Configuration Management, and so on. Currently, based on the projects executed, have never come across where all the repositories are referenced or connected, that will show the dependencies and enables to perform impact analysis in real-time.

Repositories Identified based on the ADM Phase:

ADM Phase	Type of Content	Repository Type
P: Preliminary	Frameworks, Methodologies, Standards, Organization Model, Principles,	Frameworks,
A: Architecture Vision	Strategy, Roadmaps, Communication, Managerial Approaches	Strategy, Tactical
B: Business Architecture	Function, Process, Events	Business
C: Information Systems Architectures	Application Types,	Application Portfolio
	Data Architecture	Data
D: Technology Architecture	Technology stack: Operating Systems, Network, Infrastructure	Technology
E: Opportunities and Solutions	Products,	Products
F: Migration Planning	Project Plan, Impact Assessment, Contracts	Project, Program, Portfolio
G: Implementation Governance	Governance, Compliance, Configuration Management, Risk Audit, Code	Governance
H Architecture Change Management	Market Scan, Change	Change
Requirements Management	Requirements	Requirements

Table 21 Repositories identified based on the ADM Phase:

The repository recommended as in, Figure 39 Proposed Logical Model of Living Enterprise Repository, is possible due to current technology based on open standards, standard REST API interfaces, Open Services for Lifecycle Collaboration (OSLC) an open community to create specifications for integrating tools, XaaS model, Capability of Structured & Unstructured data and so on.

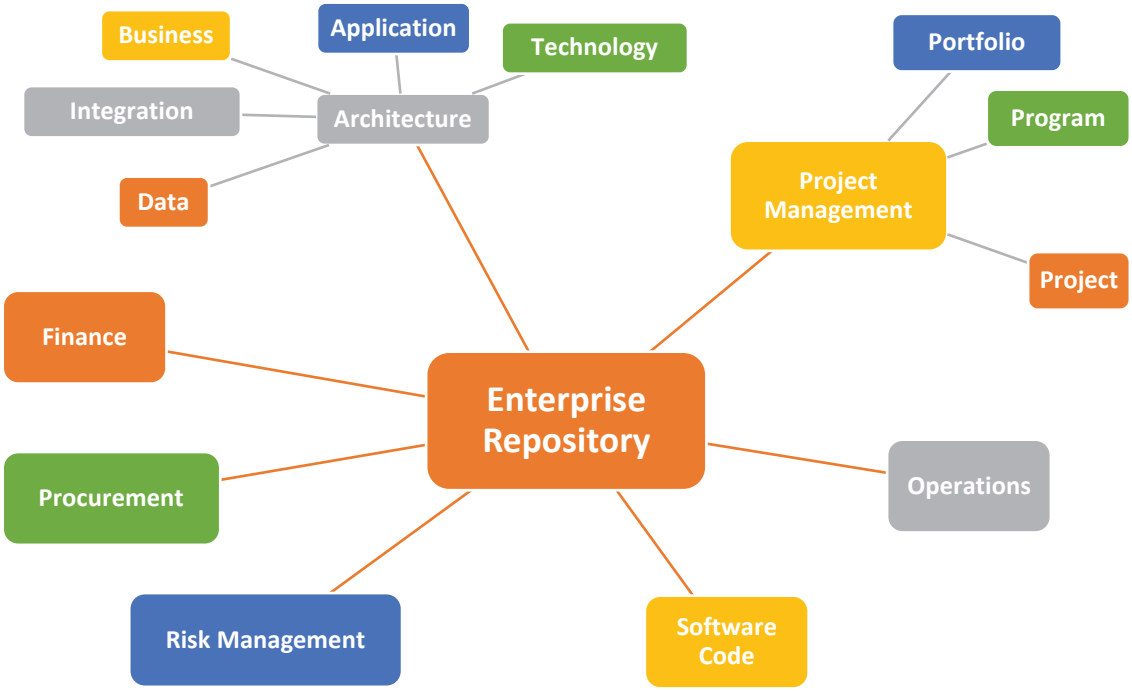


Figure 39 Proposed Logical Model of Living Enterprise Repository

4.2.3.6 Reference Models

Architecture exists in an organization sometimes explicit or implicit, where the former organization products are procured based on the design, while in the latter it's the acquired products structure architecture.

Thereby generally we extend or redo the architecture, for that we need reference model which provides the conceptual model,

A Reference model is a conceptual framework that assists to understand relationships, according TechTarget (NETWORK 2017c). OASIS (Standards 2017) defines reference model (RM) as abstract framework to understand important relationships between the entities in their environment, and to develop consistent specifications or standards to support in that environment. Also, OASIS indicates that RM is not attached to standard, technology or implementation. As per the needs of the project, RM is to be referred.

Reference model assists in the development of the conceptual model at the beginning of an Architectural project. RM represent business functions, business processes to system components, and so on, usually a full set.

4.2.3.7 Technical Reference Model

Technical reference model (Archivists 1936) is "A structured vocabulary used to ensure that technical terms in an enterprise architecture are carefully defined, related, and used consistently".

According to FEAF (House 2009), TRM provides a foundation to categorise the specifications, standards, and technologies to assist the construction, delivery, and exchange of business and application components.

4.2.3.8 TOGAF Reference Models

TOGAF 9.1, have two reference models:

1. Technical Reference Model(TRM) (Group 2017a) P.491, is a model with the taxonomy for generic services, that has two components:
    a. Taxonomy: a conceptual structure for information system that defines terminology, coherent description of the components.
    b. TRM graphic: taxonomy represented visually for easy understanding.

    TRM assists to develop the foundation architecture, mainly to address the Application Platform space. University of Birmingham had developed a comprehensive technical reference model (Birmingham 2008) based on TOGAF TRM.

2. Integrated Information Infrastructure Reference Model (III-RM) (Group 2017a) P.524, defines the Application software space and common system architecture, has two components
    a. Taxonomy, which defines terminology, with coherent description of the components and conceptual structure of an integrated information infrastructure.
    b. III-RM graphic a visual representation of the taxonomy, and the inter-relationship of the components.

TRM was developed before the internet, depending on the size of the organization systems existed in a corporate Local Area Network (LAN) connected to Wide Area Network (WAN) connected to Metropolitan Area Network (MAN).

With the advent of internet, systems can be accessed anywhere. Internet triggered and Initiated Interoperable Enterprise Business Scenario in 2001, recommending the necessity for Boundaryless Information Flow that was realised by III-RM.

Cloud computing adoption requires a complete paradigm shift; the Cloud Ecosystem Reference Model (CERM) (Group 2013b) addresses by "aligning business and technical capabilities, architectural components creation and their inter-relationships".

In addition to TOGAF, there are other Technical Reference Models that assist in developing the architecture.

Organization	TRM	Description	Purpose
The Open Group Architecture Framework	Technical Reference Model (TRM)	Services and functions, are Generic, that assist to develop more specific architectures	Application Platform space.
	Application Software space, and ''Common Systems Architecture''	To design an integrated information infrastructure that enables Boundaryless Information Flow	Application Software space, and ''Common Systems Architecture''
	Cloud Ecosystem Reference Model	Describes the relationships and dependencies between the various enterprise frameworks to manage the life cycle of Cloud Services	Cloud Computing

OASIS	Service-Oriented Architecture (SOA-RM)	To understand entities and relationships in service-oriented environment	Service-Oriented Architecture
Federal Enterprise Architecture	TRM	Describes the standards, specifications, and technologies to support exchange, secure delivery, and construction of business components of e-Gov solutions.	Federated Enterprise or Large Enterprise
Federal Enterprise Architecture (House 2013)	Performance Reference Model (PRM)	Connects agency strategy, internal business components, and investments	Ability to measure the impact of investments on strategic outcomes.
	Business Reference Model	Taxonomy to describe the type of business functions and services	Promotes cross-government collaboration, empowers business and IT leaders to determine opportunities for cost savings and new business capabilities that assists to achieve strategic objectives.
	Data Reference Models (DRM)	Standards-based framework to allow information sharing and reuse	Provides a standard way to discovery and exchange of information across Organizational boundaries.
	Application Reference Model (ARM)	Category of software, components and interfaces.	Assists in categorising applications and their components.
	Infrastructure Reference Model (IRM)	Category of IT infrastructure, facilities, network	Assist in sharing and reuse of infrastructure
	Security Reference Model (SRM)	Category of security architecture at International, National, Federal, Sector, Agency, Segment, System and Application	Assists to modify federal laws, regulations, and publications into specific policies

Table 22 Technical Reference Models

Generally, Organizations use only TOGAF TRM, to ensure the success of Enterprise Architecture practice, especially for a large Organization, it is critical to use a hybrid approach of combining the relevant Technical reference models.

4.2.3.9 Reference Architecture

A Reference Architecture (RA) is a proven template solution for an architecture in a specific domain. It takes consideration of an Organization's existing technology capabilities, the vision of the future needs and the evolutions required to provide guidance for developing new architectures,

The Reference Architecture has several Viewpoints that together provide complete blueprints of Capabilities, Processes, Information, Components, Infrastructure, and so on. Describes the architecture layers, principles, major components, and patterns used. Introduces a common vocabulary to all constituents, based on best practices within the industry and specific domains. So, it is an authentic, to the subject area which guides to apply across architectures and solutions.

The reference architecture (RA) template assists in developing reference architecture artefacts to support interoperability.

4.2.3.10 Reference Implementation

The Reference Implementation is a concrete implementation, partially at the early stage and progress to full as the project progresses:

Reference Architecture	Description	Purpose
Open Business Data Lake (O-BDL)	A set of architectural patterns, concepts, and re-usable artefacts, assists for "big data" solutions	Assists for setting "data-centric" strategy.
The Open Data Format (O-DF) for IoT	Provides information about things in a standardised way	To publish data using ordinary URL (Uniform Resource Locator) addresses
Open Data Element Framework (O-DEF)	Classification of basic units of data	For the development of interface software
The Open Trusted Technology Provider Standard (O-TTPS)	Conformance to the O-TTPS and ISO/IEC 20243	A set of best practice requirements and recommendations
Open Business Architecture (O-BA) Standard	Elaboration of strategy, implications on structure and operations	Enables to understand business vision by all stakeholders.
IT4IT Reference Architecture	A reference architecture with value chain-based operating model to manage the business of IT.	Enables it to run as a business with predictability
National Institute of Standards and Technology (Technology 2011): Cloud Computing Reference Architecture	Defines the major actors, their activities and functions in cloud computing.	Able to understand cloud computing technologies and services.
BIAN: Banking Industry Architecture Network	A banking framework consist of Conceptual, Logical, and Metadata design of the Service Domains	To create a standard semantic banking services landscape
ACORD: Association for Cooperative Operations Research and Development	Enable collaboration between insurance and financial-industry Organizations for development of data-transmission standards.	Enables fast, accurate data exchange with efficient workflows.
Australian Government Architecture (AGA)	To delivery consistent and cohesive service to citizens that support cost-effective delivery of ICT services	Defines a common language for agencies

Table 23 Reference Architecture

4.2.3.11 Architecture Capability Framework

US Department of Defense (Defense 2010) definition of capability as the ability to achieve a Desired Effect under specified standards and conditions. To achieve the result based on the context, it is required to follow the applicable standards performed by resources that have the ability that can be system or person.

Capability as defined by TOGAF (Group 2017c), a ability that an Organization, system or person possesses. The capability is overarching across the Organization, that is applied by people or system following a process.

It is critical for an organization to possess architectural capability to run architectural practice defined by Architecture Capability Framework consisting of:

- **Architecture Board:** Board set up with the broad representation from different groups of the organization to ensures the successful implementation of a strategy.
  The success of Enterprise Architecture practice is determined by, how soon the Architectural board is set up and starts functioning. Also, it's essential the board members to have a genuine interest in the success of the organization than individual vested interest.

- **Architecture Compliance:** An aspect of Architectural Governance to ensure by reviewing the projects periodically against the established architectural criteria based on standards, regulatory requirements, and so on. Based on the architectural landscape, size and complexity duration review will be determined.

  The current guidelines and checklist provided by TOGAF are before cloud computing. It is crucial to develop the guidelines and checklist based on the domain of the organization and the technology stack chosen.

  Architectural compliance to be done by an external organization annually, though there is no standard practice of auditing for EA projects like financial and accounting.

- **Architecture Contracts**: A formal signed agreement to develop enterprise architecture deliverables, with agreed specification ensuring quality between the organization and its development partners.

  As EA practice still at its infancy stage, and many of the deliverables as strategies, target architecture, cost estimation of proposed transition architectures, identified Key performance index, are not possible to validate its accuracy.

- **Architecture Governance**: As defined by TOGAF, (Group 2017c) is a practice and alignment of enterprise architectures, its management and control at an enterprise-wide level. It is concerned with change processes (design governance) and operation of product systems (operational governance).

  One the reason EA projects fail as Architecture Governance is not enforced. Though EA brings in the change that is tangible after some year as infrastructure was Capex model. With the current Opex model infrastructure, it is possible to see the benefits of EA in shorter duration, that can be more effective with effective architecture governance.

- **Capability Maturity Models (CMMs**): provide an effective method for control and improvement of change processes

  Its best practice to perform maturity assessment at the beginning of the project. Though Maturity assessment is sometimes done, covers only some aspect and that too not in detail. It is one of the reasons EA practice does not give the benefits as expected.

The current Capability Maturity Model is based on US Department of Commerce (DoC) IT Architecture Capability Maturity Model (ACMM). This maturity model was developed in 2001 and last updated on December 2007 (Commerce 2007) . Information technologies have changed leaps and bounds; the maturity model has not been updated to keep in tune with the current requirements.

There are more details about the proposed CMM practice at the section "Capability Maturity Model".

- **Architecture Skills Framework**: Enterprise Architecture practice spans across the Organization, an EA practitioner to have the diverse skillset to be an Enterprise Architect professional.
  TOGAF (Group 2017a) P.603, Skills Frameworks describes:
  - The roles for a work area
  - The skills essential by each role
  - The knowledge required to successfully fulfil the role.

  Organizations have underestimated the role of Enterprise Architect practitioner; this is one of the leading reason that contributes the failure of EA projects.

  There are more details about the Skills proposed for an EA practitioner to contribute for the success of the projects at section, " **4.7 Enterprise Architect Skills, Roles and Responsibilities**".

4.2.3.12 Logical Mapping of TOGAF Components

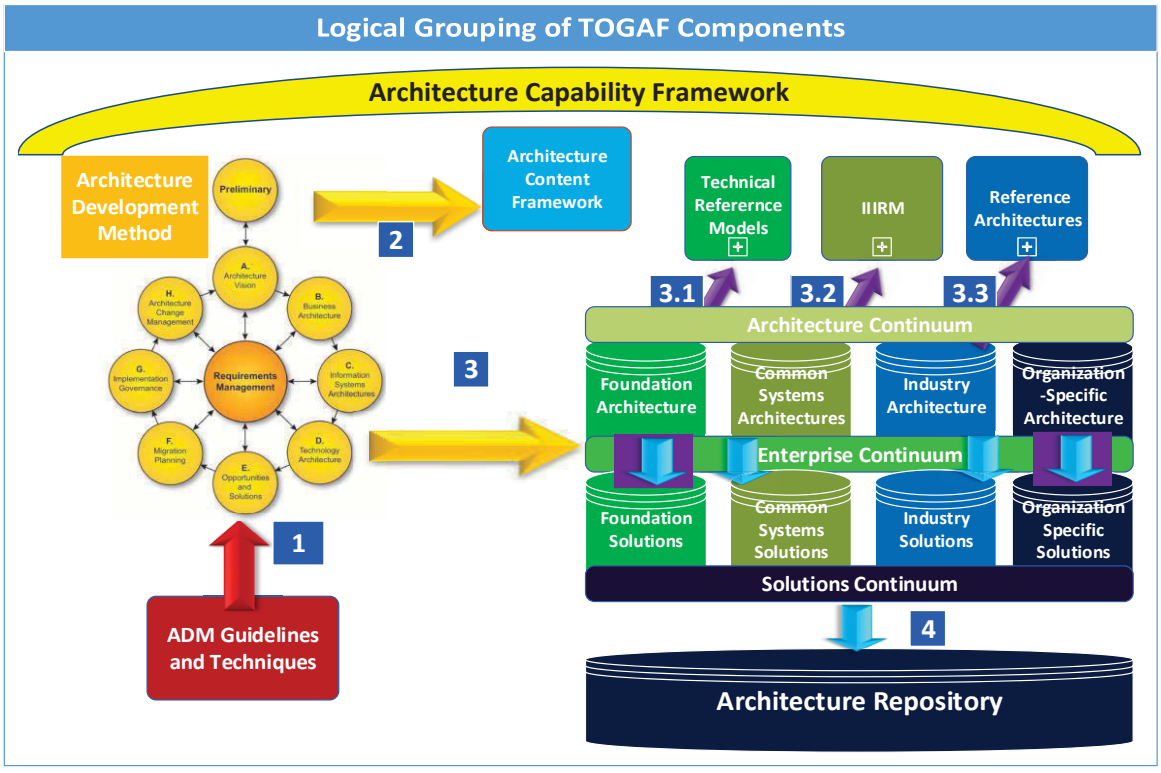


Figure 40 Logical mapping of TOGAF Components

- **Architecture Capability Framework:** Overarches all the other components, as architectural skills are essential to run an architectural practice professionally.
- **Architecture Development Method (ADM):** Is an iterative and incremental framework. ADM evolves as the organization maturity level enhanced.
  Organizations run ADM at the start of setting an EA practice and its only for reference. TOGAF ADM to be revisited as the organization business models' changes, as technology evolves and most importantly the customer expectation changes, so ADM is living if it's to be effective
- **ADM Guidelines and Techniques**: To run ADM TOGAF provides few guidelines and Techniques, depending on the other framework, methodologies and domain of the organization ADM guidelines and Techniques can be adopted.
- **Architecture Content Framework**: TOGAF is a Framework and Methodology, so there is content to be referred as an input to ADM phase and content to be produced as an output of ADM phase that is provided by the content framework.

Enterprise Continuum: The content produced is organised conceptually in a horizontal category:

- **Architecture Continuum**
  - **Foundation Architecture**: Generic components, technical components are based on Technical Reference Model
  - **Common Systems Architectures**: Common, reusable components and service based on Integrated Information Infrastructure Reference Model.
  - **Industry Architectures**: Common Industry components based on Reference Architecture / Models from standard bodies, industry, domain and research Organizations
  - **Organization-Specific Architectures**: Customised as per organization requirements
  - **Solution Continuum**: Derived from Architecture continuum, more detailed specification that assists in building or buying products to meet organization requirements.
- **Architecture Repository**: The logical model for the storage of content produced while iterating ADM cycle.

4.3 Enterprise Architecture Conceptual Framework

4.3.1 Architecture Development Stages

Architecture are developed from abstract to concrete, as in the early stages there are no much information available. That's the reason the conceptual model is developed to understand the concept, followed by logical grouping, then finally the physical model to realise the concept.

Conceptual Model	• Defines the business owner's viewpoint of the outcome expected
Logical Model	• Defines the grouping of the in a manageable manner
Physical Model	• Defines the implementers viewpoint to realise the outcome.

4.3.2 IEEE 1471-2000 Conceptual Framework for Architectural Description

ISO/IEC 42010:2007 (Engineers 2007) Defines the activities to create, analyze sustainment of architectures of software-intensive systems. To record the design, provide the conceptual framework and describes the content for architectural description.

Running ADM creates artefacts that addresses the stakeholder's concerns, that will assist to describe the system. To develop the views of various stakeholders TOGAF as adopted 'IEEE 1471-2000 Conceptual Framework for Architectural Description (Group 2011) P 373-375 as below:

- **System**: Components grouped to realize a specific function.
- **Architecture**: System's architecture consists of components with defined relationships in an environment that evolves based on the guiding principles design.
- **Architecture description**: Category of artefacts produced based on architecture views.
- **Stakeholders**: People with key roles with concerns, regarding the system.
- **Concerns**: Key interests of Stakeholders, that need to be addressed and to determine the acceptability of the system.
- **View**: Related set of concerns is represented by the whole system.
- **Viewpoint**: Stakeholder perspective from which a view is taken. Viewpoints can be reused as a template to generate the specific views. As every view has a Viewpoint.

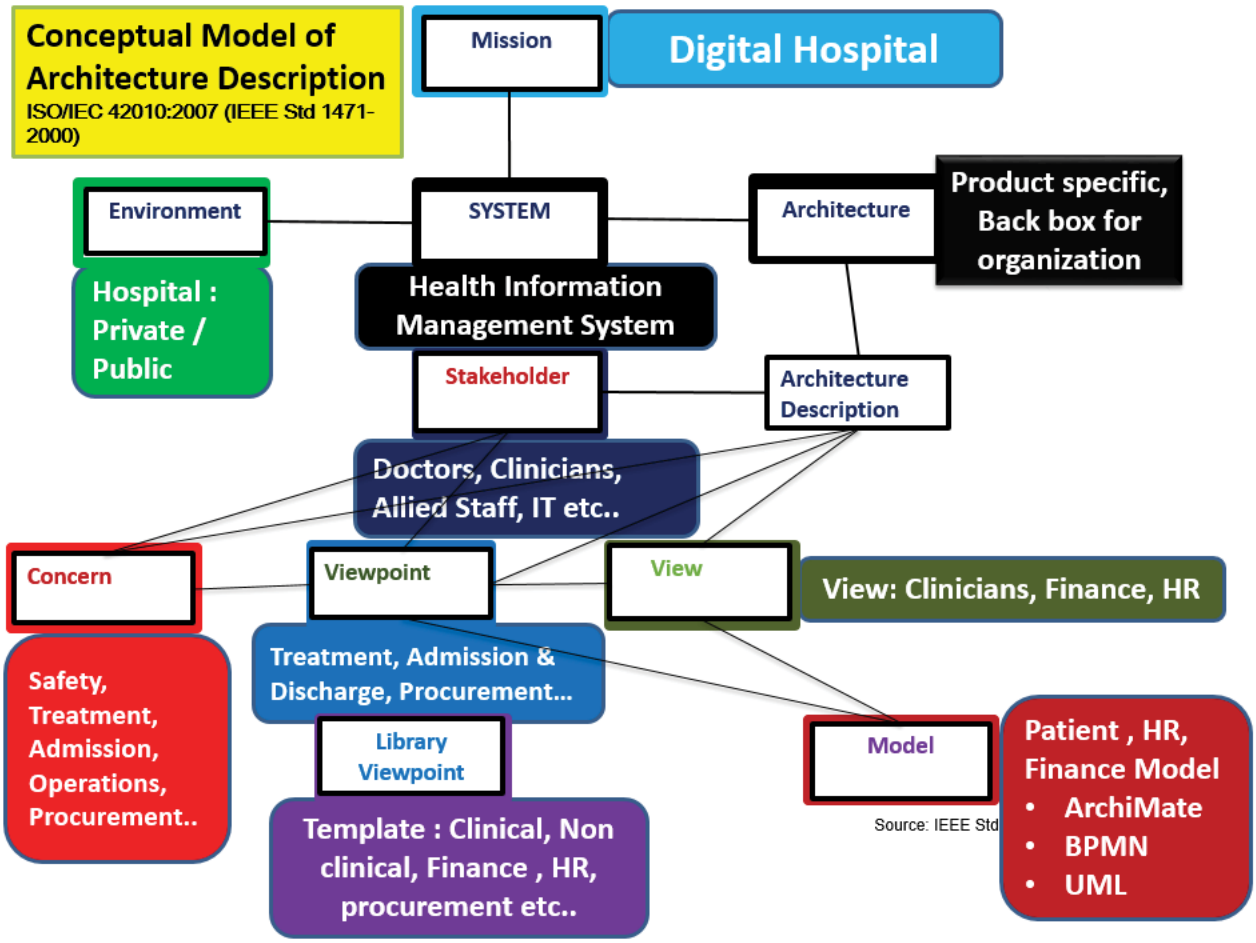


Figure 41 Architectural Description Conceptual Framework (Engineers 2007)

4.3.2.1 Current Architecture Landscape in Typical Enterprise

Current System Architecture

Every organization has an Architecture, based on the Systems procured. Product vendors build the system based on the generic requirements, and due to intellectual property rights, it will not be disclosed, thereby the architecture is a black box. Systems that are procured to meet the needs of the individual department or influential stakeholders that will not address the organization requirements. Also, the system that is purchased at various timelines as needed by the different departments or influenced by technology changes or due to compliance requirements.

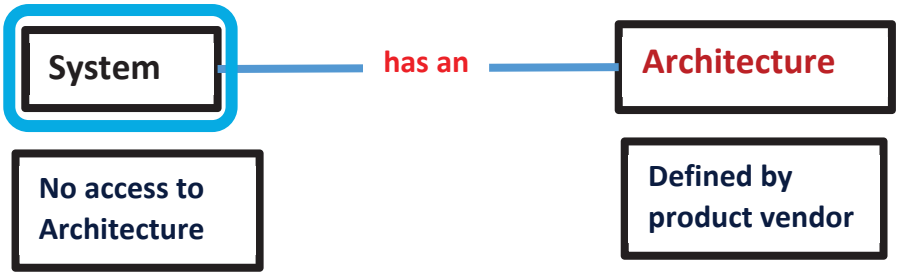


Figure 42 System Architecture

The systems procured by different vendors will be based on different architecture and technology too. That will give rise to challenges such as exposing the interfaces as required by another system, converting the data as understandable between systems. The inability of the system to communicate in real-time will limit the agility of the business increasing the cost of operations.

If the system is based on open source, the source code of the system is accessible.

Example of Hospital that Evolved without EA Practice

An example of the typical hospital that has adopted technology to enable better care for the patients. As technology, evolved systems were procured and implemented to provide better health service. In general, a typical enterprise is the system of systems, consisting multiples systems. Each system has its architecture, that is a black box for the Organization.

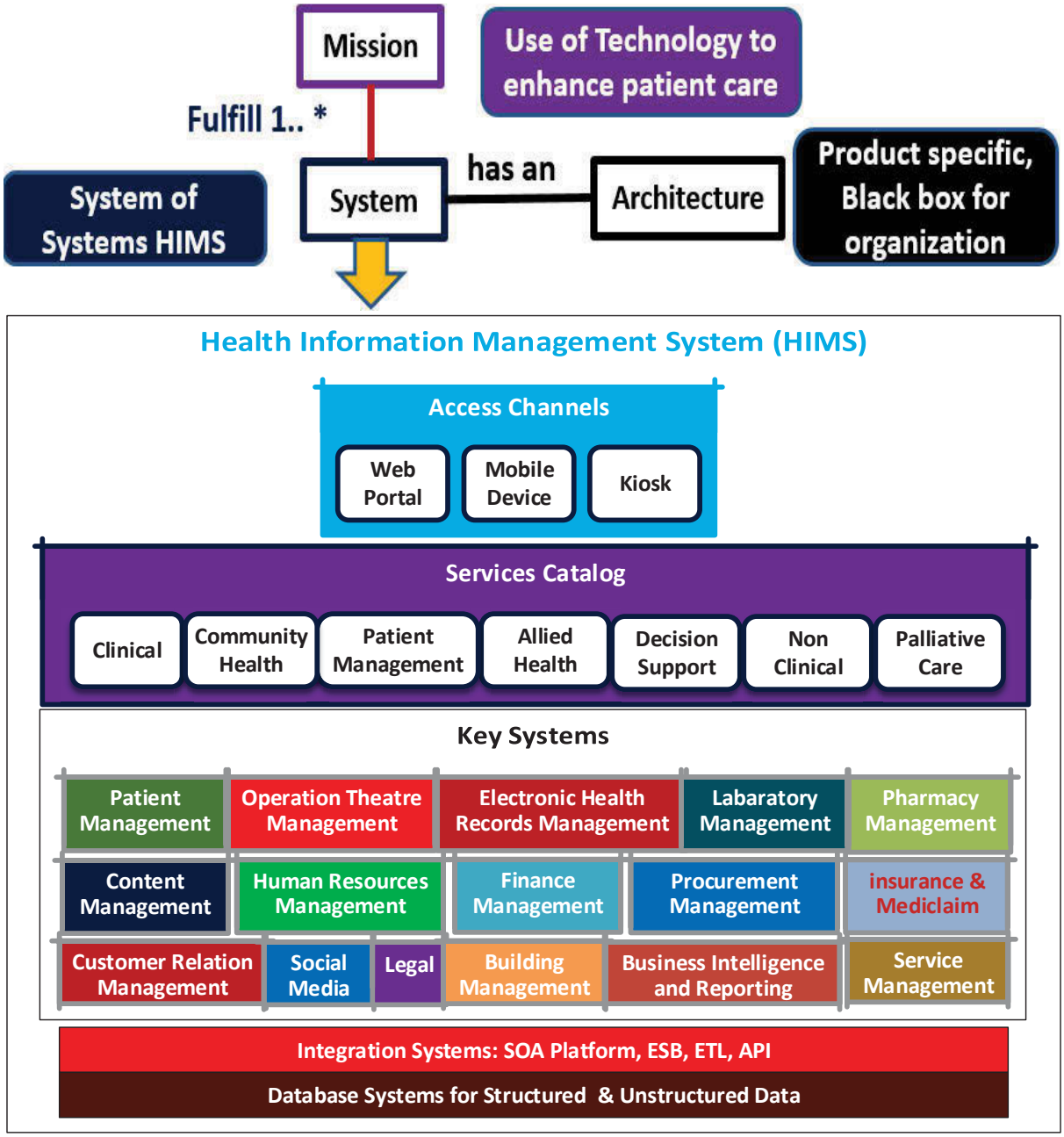


Figure 43 Example of Hospital that evolved without EA practice

Stakeholders Identification:

The system built or procured needs to satisfy the business requirements with easy to extend to meet the changing business environment, with the reduced operational cost for business and easy to manage the systems. The stakeholders contributing to the success of the projects to be identified and their concerns are to be addressed to determine the Architectural description.

For a successful project its critical to identify key stakeholders Concerns. To understand the concerns, we must take the expectation from their point of view.

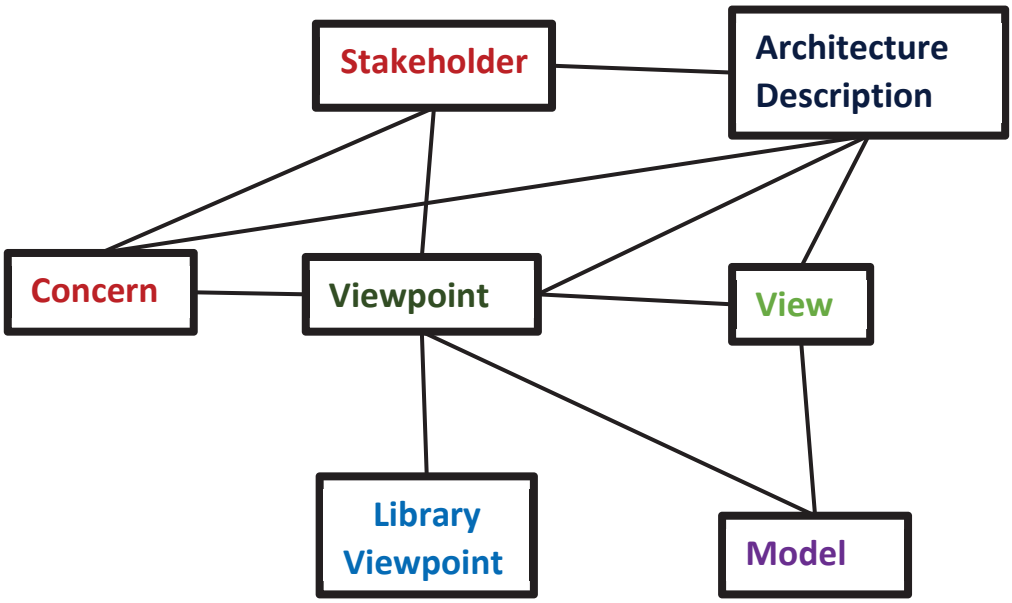


Figure 44 Stakeholders Viewpoint (Engineers 2007)

The Organization, as mentioned earlier, is a system of systems. All the systems are connected seamlessly to communicate in real-time to serve the business.

We illustrate through DHL Global portal, the concepts of Views and Viewpoints. As an end user, we see the portal view, that is addressing or concerns of various stakeholder's viewpoint that collectively represents the portal view.

For example, "Track Your Shipment" communicates with various systems such as Asset Tracking, Customer Relationship Management, Logistics, Shipment. In turn, these systems get information from other related systems, before it can give the shipment status in real-time. The module to track the shipment status is built gathering the requirements from various business departments, users and from their department perspective.

Henceforth, stakeholders to be identified at different phase of the ADM based on the role and functions of the stakeholders.

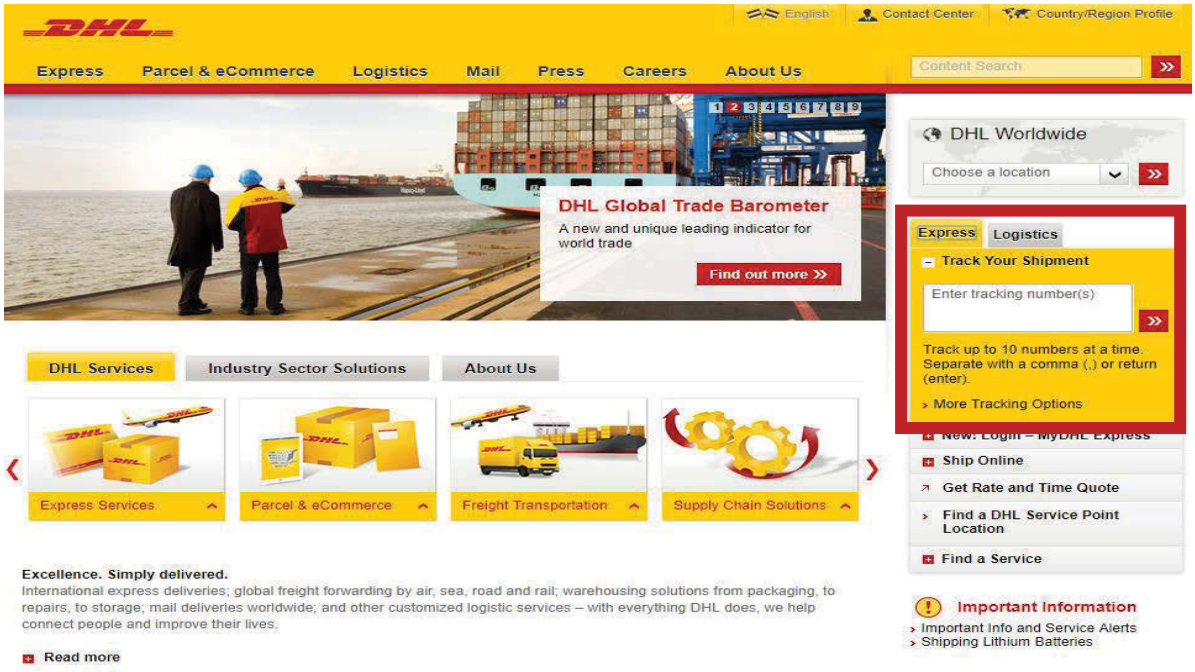


Figure 45 DHL Global Portal (DHL 2017)

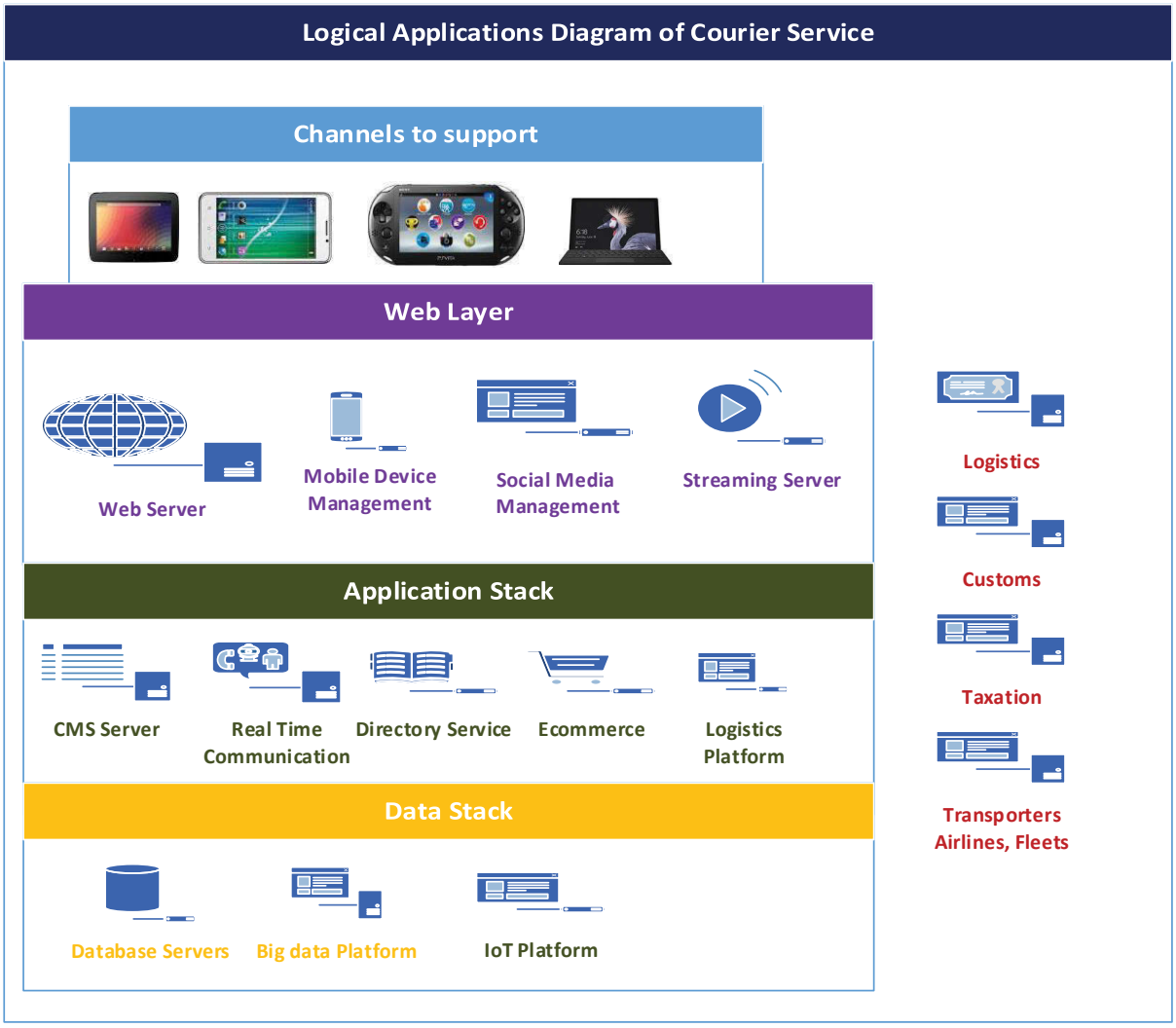


Figure 46 Logical Applications Diagram of Courier Service

4.3.2.2 Stakeholders Identified as per ADM Phase

ADM Phase	Objective
Preliminary Phase	Tailor Enterprise Architecture practice as per organization constrains and requirements
A: Architecture Vision	Department heads,
B: Business Architecture	Business Heads, Functional Subject Matter expert, Business Architect
C: Information Systems Architecture: Data	Application specialist
C: Information Systems Architecture: Application	Information specialist
D: Technology Architecture	Technology department consisting of Technology Evangelist, Infrastructure specialist
Phase E: Opportunities & Solutions	Operation, Project Management, Procurement department
Phase F: Migration Planning	Operation, Project Management, Procurement department
Phase G: Implementation Governance	Operation, Project Management, Procurement department
Phase H: Architecture Change Management	Department heads, Business Heads,
ADM Architecture Requirements Management	Requirements Manager, Product Owner

Table 24 Stakeholders identified as per ADM

4.3.3 Modelling

An enterprise consists system of systems that is becoming more complex as more systems added due to software has become a commodity, due to change from Capex an upfront investment where the cost of IT was sunk cost, to Opex model pay per usage basis.

"If I can't picture it, I can't understand it."
- Albert Einstein

As the systems become more complex it's impossible to make sense of them unless it is broken down into models to abstract the details to get a bigger picture.

Different stakeholders from business, technology, operations are required to understand their concerns. With traditional paper-based it will be too verbose and very subjective based on a standard template, documenting based on the language skills of the documenter and understanding the text based on the user interpretation of the content.

A picture is worth a thousand words; with pictorial representation comfortable to start the conversation with the users, they can understand and able to communicate their concerns.

Visual Modelling: Eclipse (Eclipse 2013) defines as to capture the requirement though semantically rich, graphical and textual design. As this enables the level of abstraction, it's possible to engage uses based on their specific concerns, that enhances two-way communication and reduces ambiguity.

Models abstract the unnecessary information and represent the simplifies view of the system from the user perspective.

Visual Models Points

- Complex systems can be easier to understand
- Provides ability to design and compare alternate design
- Enables precisely to capture requirements
- Eliminates ambiguity in communication.

Model consists two aspects as semantic information represented by notation visually (James Rumbaugh 2004)

Importance of Standard Notation

Also, due to globalisation and digitisation of enterprise its critical to have the standard notation based on international standards backed by the standard body. Standard notation eliminates ambiguity where all the stakeholders get the same message across irrespective of language, culture or country.

We relate to an example to show the importance of standard notation. A smiley face represented in various languages and symbols as referred in Figure 47 Smiley Face - Different Language & Figure 48 Smiley Face Symbol/Notation,

Figure 47 Smiley Face - Different Language

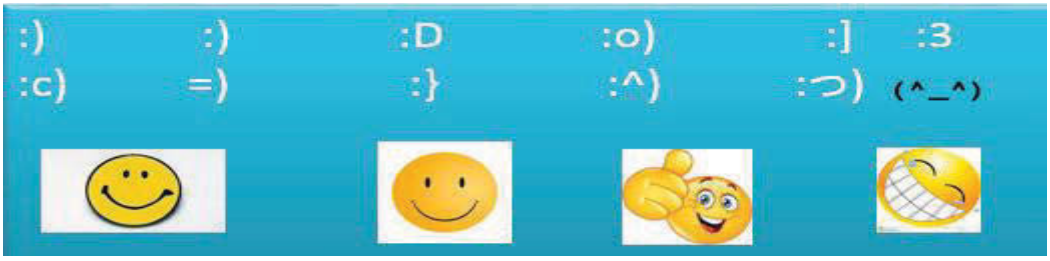


Figure 48 Smiley Face Symbol/Notation

With standard notation, the end user will get the message precisely what its conveying, for this we need modelling language.

Modelling Language

Systems or Knowledge expressed with artificial language with a structure consistent with the set of rules to define the components (Revolvy).

Types of Modelling Language:

- **Graphical modelling languages:** A diagram technique, concepts represented by symbols that are connected by lines to establish consistency and constraints
- **Textual languages:** A natural language based on specific standards that can be interpreted by the computer

A model is a clear illustration of reality, modelled by modelling language that specifies the building blocks (elements).

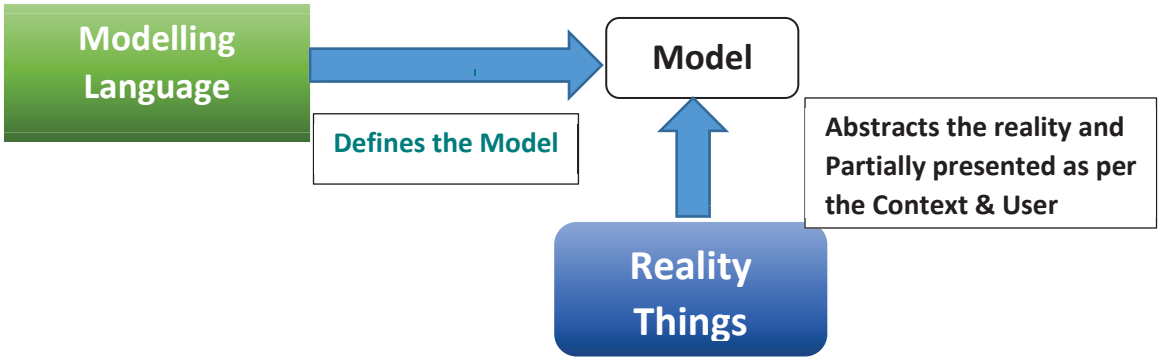


Figure 49 Relationship Model, Modelling Language and Reality Things

Unified Modelling Language (UML)

ISO/IEC 19505-2:2012 (ISO/IEC/IEEE 2012) describes UML objective of UML to support system architects, software engineers, and software. It's used as a tool for analysis, design, and implementation of software systems and business processes modelling.

Evolution of modelling language summarised from (Watson) as era before UML and after UML. Before UML there was no standard notation, which resulted in the low acceptance of modelling in the industry.

UML is a standard executable language that increases productivity as per the report by Gartner, an estimated 10 million IT professionals used UML in 2006, and by 2009 organizations worldwide were using 70% for software development

UML widely accepted by industry as illustrated by the NASA project in 2013 for "James Webb space telescope" where UML was used to design the software that enabled communication, meet stringent reliability and to achieve performance goals.

UML Taxonomy of Structure and Behaviour Diagrams

As per UML specification 2.5.1 (Group 2017a) P. 727, UML diagram structure logically represented by the taxonomy consisting two significant diagrams.

- Structure diagrams: System Static structure of objects, that abstract, real-world and implementation ideas. There are seven structure diagrams to capture the real system.
- Behaviour diagrams: System dynamic behaviour of the objects, that changes due to the time.

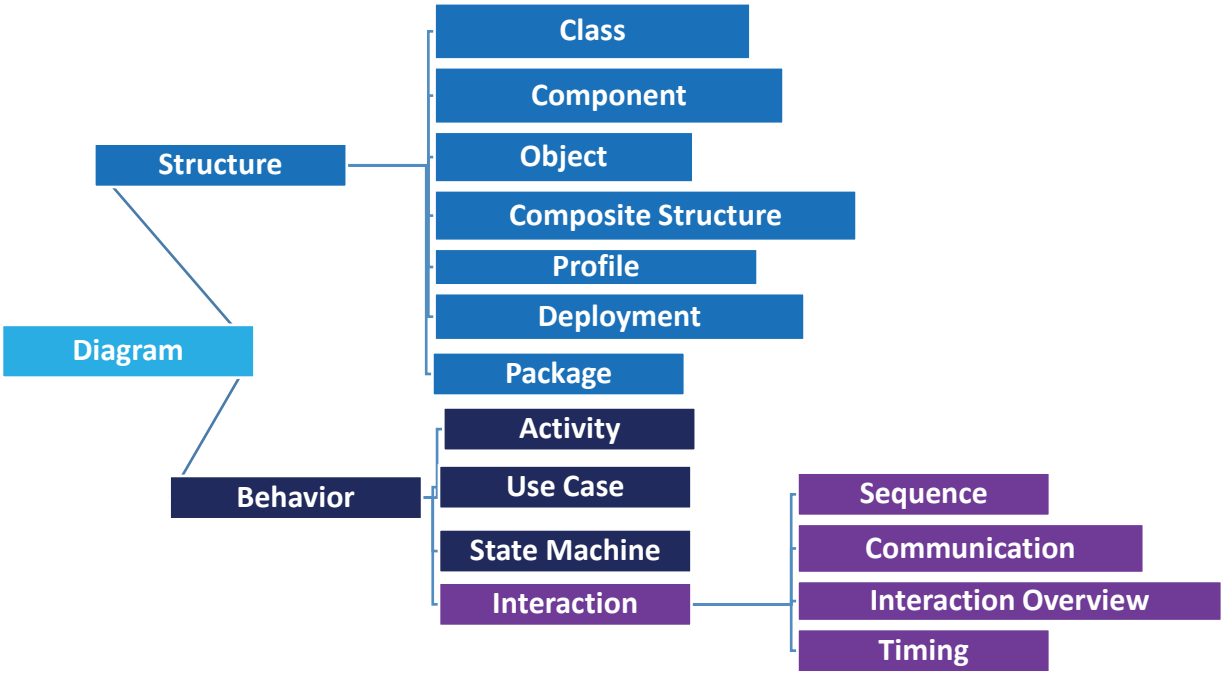


Figure 50 UML Taxonomy of Structure and Behaviour Diagrams (Group 2017a)

OMG's Model Driven Architecture (MDA)

OMG MDA (Group) is an open, vendor-neutral approach to address the challenges of business and technology change. The technology platform is logically divided for the business and application logic. Its Platform agnostic models of an application, business functionality, its behavior, built using UML.

These platform-independent models developed specifically for the domain model of the Organization. Services, process, and functionality of the business documented independently of implementing the technology. As technology evolves, business logic can be extended to take advantage, as business logic is independent of the technology.

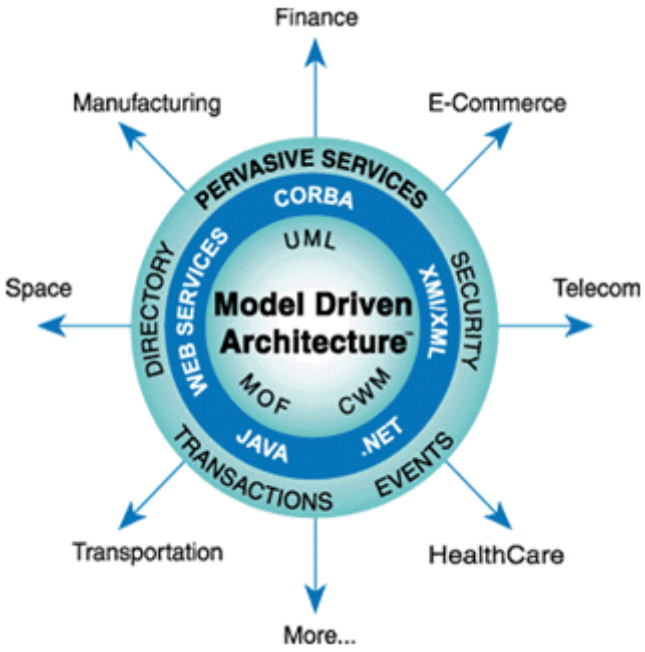


Figure 51 Model Driven Architecture Source: ((OMG®))

Benefits of MDA:

- Cost of Application life cycle reduced,
- Reduced time to develop new applications,
- Application quality Enhanced,
- Capability to take adopt emerging technology and to get benefits.
- Enhanced Return on Investment (ROI)
- Reduced Total Cost of Ownership (TCO) for technology,

There are some case studies of successful implementation of UML and MDA; illustrated by two cases that are relevant.

- Deutsche Bank demonstrated the reduced TCO: 60%, and ROI: 90%, of software costs that are designed using UML models with MDA techniques for database code .
- The resulted cost saving was 40%, in comparison with handwritten code from sketched design diagrams.

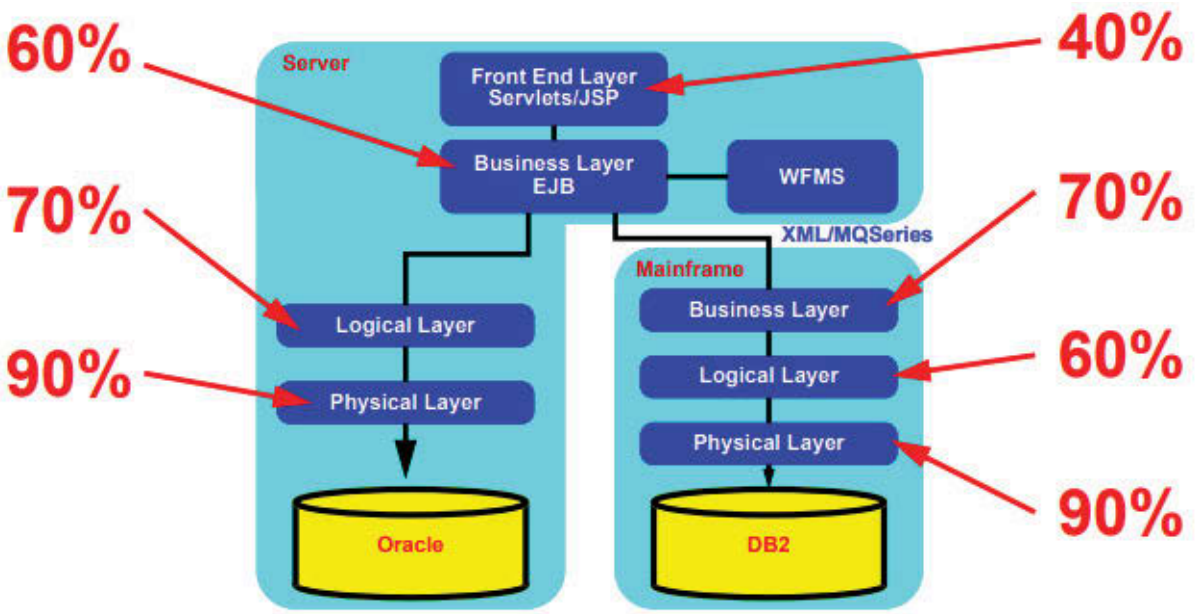


Figure 52 Code generation percentages of MDA Application, Source (Watson)

- M1 Global's (Group 2004) employed Model Driven Architecture MDA, during the design phase of the project to encapsulate their intellectual property ("The BIG Idea") into a platform independent model (PIM) of the application. The model characterized software application would do, regardless of the complexity of the application architecture.

- Model Driven Architecture MDA was used by M1 Global's (Group 2004) to encapsulate their intellectual property ("The BIG Idea") into a platform independent model (PIM). The model represented the software application would do regardless of the complexity of the application architecture.

M1 Global was able to realise the project cost of $1,007,354 with a net savings of about $1,200,000 over the project life, also with benefits as:

	HAND WRITTEN LOC	COST/LOC	TIME	TOTAL COST	PERCENT SAVINGS
Traditional U.S. Based Development	177,963	$34.83	32 Months	$6,198,812	N/A
With MDE	65,457	$34.83	12 Months	$2,280,000	272%
With MDE and Offshore	65,457	$5.66	12 Months	$1,007,354	615%

Table 25 Benefits realised by M1 Global with MDA approach

UML in Enterprise Architecture

UML developed for software projects from requirements gathering to implementation, so it is very exhaustively structured.

UML is used to (Group 2017a) P.54, model of something, generally a system for a domain. The model is used to capture the view from the perspective of user specific to their viewpoint abstracting the details of the system.

The model can be used both for existing and new system.

- **Existing System**: Modeled to analyse the system properties and behaviour.
- **Planned System**: Modelled as reference for specification and assists in the system build.

UML was developed to address the needs of the software system from requirements gathering to implementation, so it is very exhaustive with seven structures and seven behaviour diagrams in consideration of the different viewpoints of the stakeholders involved in the software system.

The stakeholder's viewpoint to be considered for enterprise architecture is from strategy to solution architecture, that is the subset of UML that is addressed by ArchiMate Enterprise Architecture modelling language.

4.3.3.1 ArchiMate Enterprise Architecture Modelling Language

ArchiMate specification (Group 2013a) emphasis that Enterprise Architecture Components to be unambiguous and the relationship among the components to be consistent and represent coherent modelling of Enterprise architecture.

As enterprise architecture overarches across the enterprise, to develop the metamodel, it must not be too detail specific to a language or very generic of the high level showing the relationship between entities.

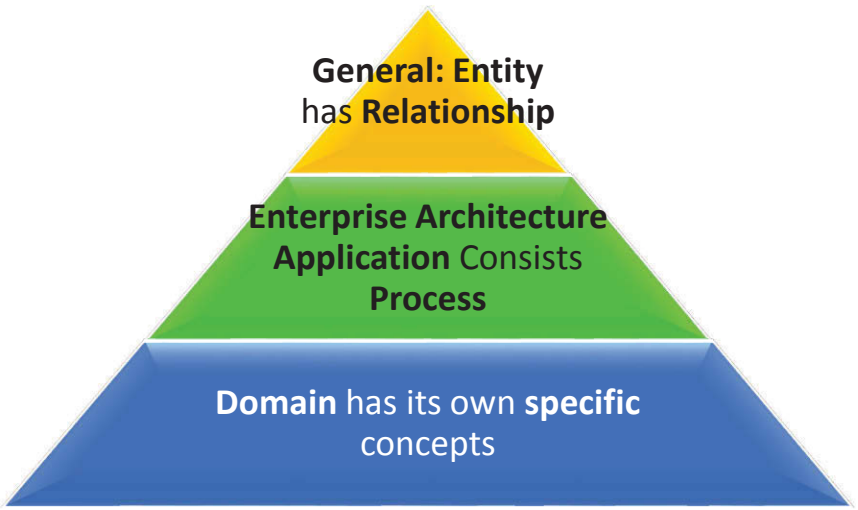


Figure 53 Metamodels at Different Levels of Specificity (Group 2013a)

The top of the triangle represents the more generic meta-model with the basic entity and their relationship. E.g., Entity represented by Department must exchange information with each other, through relationship.

The base of the triangle is more specific to a domain as UML, BPMN; and company-specific as Enhanced Telecom Operations Map (eTOM) for telecom or The Banking Industry Architecture Network (BIAN), and so on.

From Enterprise Architecture perspective consideration are for Application and process, with a lightweight language, intuitive to use. These features are supported by ArchiMate Enterprise Architecture Modelling Language that can model 80% of practical cases.

ArchiMate Enterprise Architecture Modelling Language

ArchiMate specification (Group 2016a) P.23, defines ArchiMate as, a visual style to describe, analyse, and communicate the concerns of Enterprise Architectures as they evolve with iconography. Architecture Descriptions represented with the set of entities and relationships with related iconography.

Features of The ArchiMate modelling language:

- Enterprise Architecture description through diagrams.
- Uses service-orientation to distinguish and relate Enterprise Architectures layers.
- Realisation relationships to connect concrete elements to more abstract elements across these layers.

For an organization digitisation to be successful, the critical ingredient is seamless integration between the systems in the Organization. Service-Orientation enables seamless integration. Also, Organizations are breaking down the macro services to microservices that allow the business to be more dynamic to use the services they require.

So ArchiMate language complements digital enterprise as it supports service-orientation.

To address the stakeholder's concerns, it critical to abstract the unnecessary details, that is supported by ArchiMate by:

- Separation of view external black box and internal white box
- What the system does and How it is done
- High-level conceptual level, logical grouping, and physical systems.

ArchiMate Language Structure

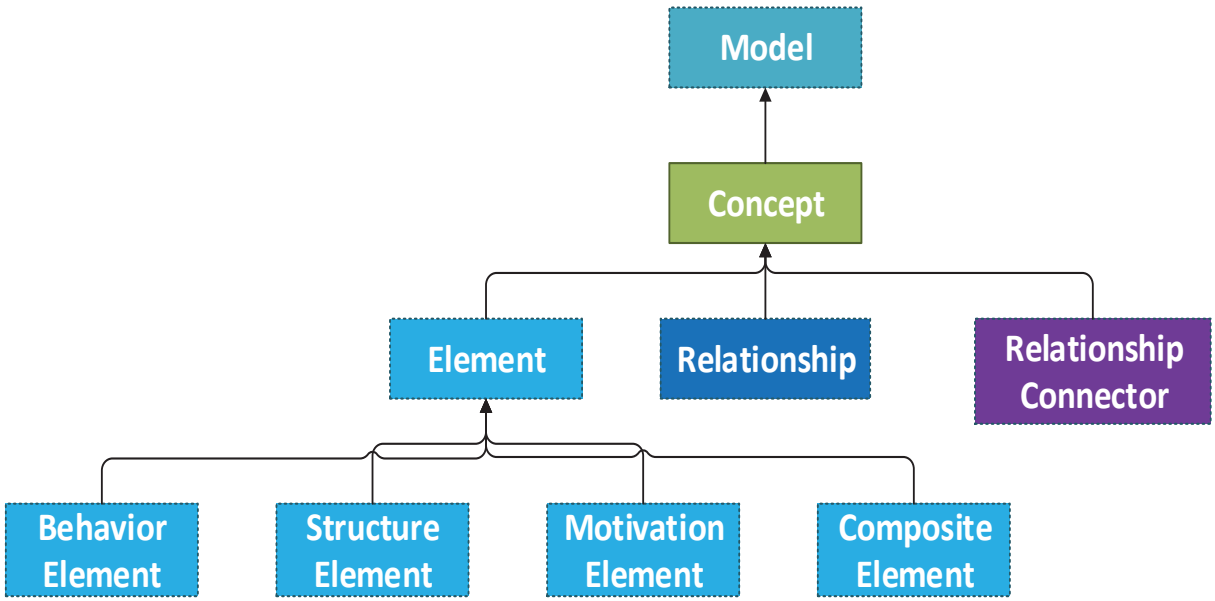


Figure 54 ArchiMate Language Structure (Group 2017c)

ArchiMate specification (Group 2017c) describes:

- Model as a collection of Concepts.
- Concept is either:
    - Basic unit of Element or
    - Relationship: ensures the consistency and meaning of the model.
- An element is either a:
    - Structure element can be related **How** the system does and **Who** does it
        - Active Structure element: Able to perform behaviour
        - Passive Structure element: Behaviour can be performed.
    - Behaviour element: Activity performed by structure elements, that is **What** the system will do
    - Motivation element, to model the motivations, or reasons, can be related to **Why** it's done
    - Composite element.

ArchiMate Core Framework

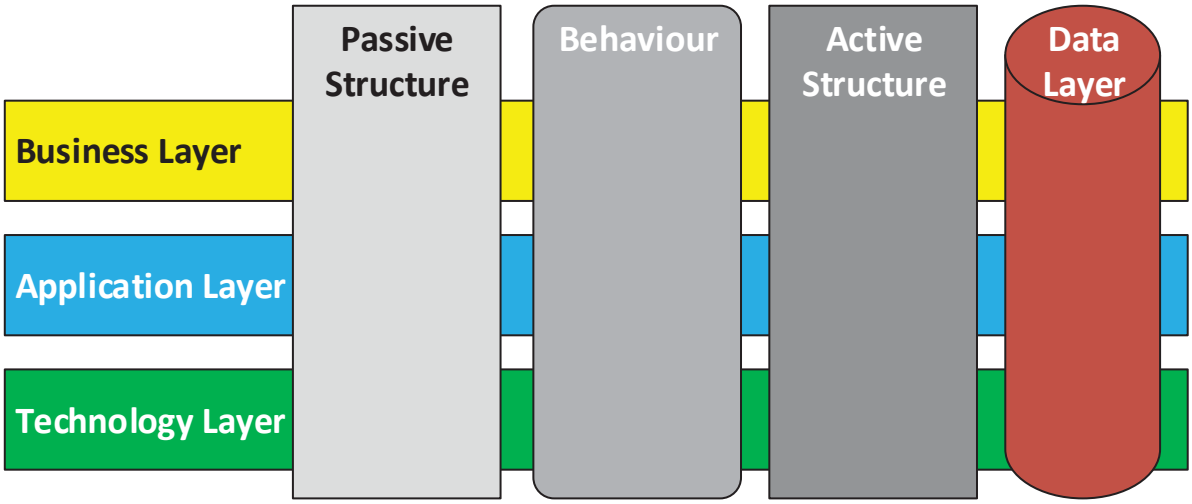


Figure 55 ArchiMate Core Framework extended from ArchiMate, Source: (Group 2017c)

The ArchiMate Core Framework

Consist of three layers horizontally and three aspects vertically cutting across the horizontal layers.

- **ArchiMate core language:**
    - **Business Layer:** Business services offered to customers.
    - **Application Layer:** Application services.
    - **Technology Layer:** Technology services.
- **Aspects**
    - **Active Structure Aspect:** The structural elements that display actual behaviour;
    - **Behaviour Aspect:** The behaviour performed by the actors.
    - **Passive Structure Aspect:** The objects on which behaviour is performed.

4.3.3.2 UML versus ArchiMate

	UML	ArchiMate
Developed by	Grady Booch, James Rumbaugh & Ivar Jacobson in 1994	Telematica Instituut from 2002-2004
Main objective	To solve the problem faced by software industry	To solve the problem faced by Enterprise
Focus Area	Framework for software Architecture Process	Language for Enterprise Architecture Process
First Publication	1995	2012
Standards	ISO/IEC 19505-2:2012	Partially based on ISO/IEC 42010
Structure	Two Diagrams (Seven Structural & Seven Behavioural)	Three Layers (Business, Application, Technology, Physical), three aspects (Active, Behaviour, Passive), two extensions (Motivation (Strategy), Implementation & Migration (Physical))
Data module	Separate	Cuts across Business, Application and Technology
Document Specification	UML 2.5.1: 796 Pages	ArchiMate 3.0: 181 Pages
Maturity	Well matured for software development lifecycle	Though address enterprise architecture practice, still evolving.

Table 26 UML versus ArchiMate

4.3.3.3 Relation Between ArchiMate and TOGAF

	TOGAF	ArchiMate
Developed by	DoDAF derived from Technical Architecture Framework for Information Management (TAFIM)	Telematica Instituut
Purpose	Framework for Enterprise Architecture Development	Modelling Language
First Publication	1995	2012
Standard	ISO/IEC/IEEE 42010: 2011 and ISO/IEC/IEEE 15288: 2015.	ISO/IEC 42010
Meta-model	Holistic single with relationships	Generic high-level with seven detailed
Concepts	Conceptual and Logical	Conceptual, Logical and Physical
Visual Representation	Catalogues, Matrices and Diagrams	Diagram
Data module	Separate	Cuts across Business, Application and Technology
Document Specification	Version 9.1: 692 Pages Version 9.2: 532 Pages	ArchiMate 3.0: 181 Pages
Certified professionals	Total: 78286 (Group 2018b)	Total: 5451 (Group 2018a)

Table 27 Relation between ArchiMate and TOGAF

4.3.4 Enterprise Architecture from Object Oriented Perspective

The real-world model for development is captured using Object-Oriented method is its greatest strength, as stated by Grady Booch (James Rumbaugh 2004), one of the creators of UML.

Ambler defines (Ambler 2002) Objects are reusable components from which systems are the development strategy of Object-Oriented (OO) paradigm. Object-Orientation key is objects that represent the actual real-world objects.

UML (Group 2017a) P.43, derived from leading three object-oriented methods (Booch, OMT, and OOSE) is modelling language to design object-oriented programming. UML used to model large-scale systems which are technology independent and human-readable.

ArchiMate is the subset of UML, though not wholly, most notations and relationships borrowed from UML. Though ArchiMate based on natural English language as the structure which can perform the behaviour, it is a part of object-orientation, it is based on objects of physical real-world that has state and behaviour. An enterprise represents a material world and reacts based on how it operates, ArchiMate is suitable for enterprise architecture modelling.

Object-Oriented Design (OOD) (Fakhroutdinov 2017) is the collection of interacting stateful objects with specified structure and behaviour to design, develop and implements software.

ArchiMate basis is structure and behaviour, so using ArchiMate it is possible to adopt OOD.

As TOGAF ADM phases represented by ArchiMate, so TOGAF has characteristics of Object-Orientation. Also, the Object of TOGAF is reusable Components that align with Object-Orientation.

So, we can say that ArchiMate is partially object oriented and can be used to design enterprise architecture development from object-orientation perspective.

Though there was some earlier proposal in 2005 (Lam-Son Lê 2005) for an Object Oriented Modelling language, it has not taken off. The main reason is as there was no formal modelling language to model Enterprise Architecture, at early stages either UML or Visio used. Also, EA itself adopted by some Fortune 100 organization and governments agencies. EA approach considered only for significant initiatives, and then Enterprise Architecture was not kept up to date as the organization evolved.

4.3.4.1 Enterprise Architecture Development Process

The *incremental* approach involves breaking a large chunk of work into smaller portions.

The *iterative* approach involves a cyclical process in refining work:

- **Waterfall**: A Linear sequential process followed for architecture development to complete the Project from inception to implementation. An *incremental* approach that involves breaking a large chunk of work into smaller portions.
- **Agile**: An iterative approach that involves refining the work with the cyclical process with incremental outcome followed for each phase of architecture development life cycle.

TOGAF Architecture Development Method (ADM) combines waterfall and Agile. ADM phases run in a sequence like the waterfall with an arrow in one direction between the phases. Also, provision to the changing business requirements some phases to be revisited as in Agile. So, its represented with all the phases connected to the central Requirements Management phase with the double head arrow.

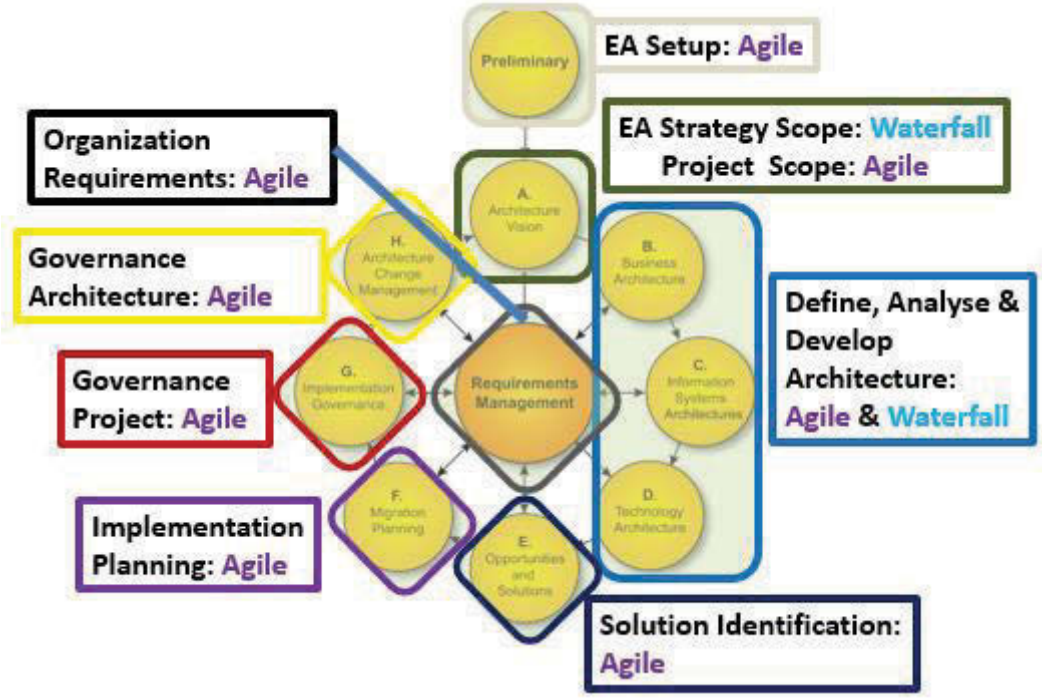


Figure 56 Enterprise Architecture development process

- **P - Preliminary - EA Setup**: This done at the beginning of the setting the practice, so it is done iteratively and revisited on occasions as organization merger, downsize or re-Organization, Agile is suitable.
- **A - Vision:** Organization vision realised through the mission that consists of
    - **Strategy**: Long term a high-level ADM cycle run through A to F following hybrid less Agile and more Waterfall
    - **Tactic**: To realise a project a high detailed ADM cycle run through A to F following combination more of Agile and less of waterfall
- **Core Architecture**: Consist of Business, Application, Data and Technology architecture-Define, Analyse and Develop Architecture. The individual phased are agile but the B to D follow waterfall
    - **B - Business Architecture:** Consist of identifying Service, Function, and Process that needs multiple iterations, so Agile is suitable
    - **C - Information System Architecture-Application**: Consist of identifying Applications that enables the business objectives needs multiple iterations, so Agile is suitable
    - **C - Information System Architecture-Data**: Consist of identifying data that needs to be continually recognised, though the domain model might not change drastically, but additional attributes or core domain extended to support the agile business requirements, that needs multiple iterations, so Agile is suitable
    - **D - Technology Architecture:** Consist of identifying the technology stack, due to the service as a model, Capex to Opex model, though the core systems might not often change, additional technology capabilities need to be identified, analysed, recommended to enable the business to take advantage of the technology, so Agile is suitable

- **E - Opportunities and Solutions** - Solution identification: Products identified and evaluated to realise the core architecture. Due to the service model, various products assessed to check its availability sometimes with Proof of concept, so Agile is suitable.
- **F - Migration Planning** - Implementation planning: The task performed are assessing the dependencies, costs, and benefits within the current or other tactic and strategic cycles, Agile is suitable.
- **G- Implementation Governance** - Governance Project: Ensures the current projects and in-flight projects across the enterprise are compliant, so Agile is suitable.
- **H - Architecture Change Management** - Governance Architect: Ensures the architecture meets the agreed business. Also, to monitor and propose changes to architecture to meet the business changes that are influenced by the changing business model due to technology changes, Agile is suitable.
- **Architecture Requirements Management** - Organization Requirements: EA intends to support the changing business needs, Agile is suitable.

4.4 Capability Maturity Model(CMM)

CMM is a process improvement approach derived from a process model, that is collection of practices that describe the characteristics of efficient processes that are proven by experience.

With CMM an organization is assessed against a scale of process maturity levels. The subject areas can be as diverse as:

- Enterprise Architecture Maturity Assessment
- The Strategic Management Maturity Model
- Business Transformation Readiness Assessment
- Business process capability maturity model
- Data Maturity model
- The Data Warehouse Capability Maturity Model
- Information technology (IT) services
- Portfolio, Programme and Project Management Maturity Model (P3M3)
- Project management,
- Organizational Change Management Maturity
- Risk management,
- Software engineering,
- Systems engineering
- System acquisition,
- Personnel management.

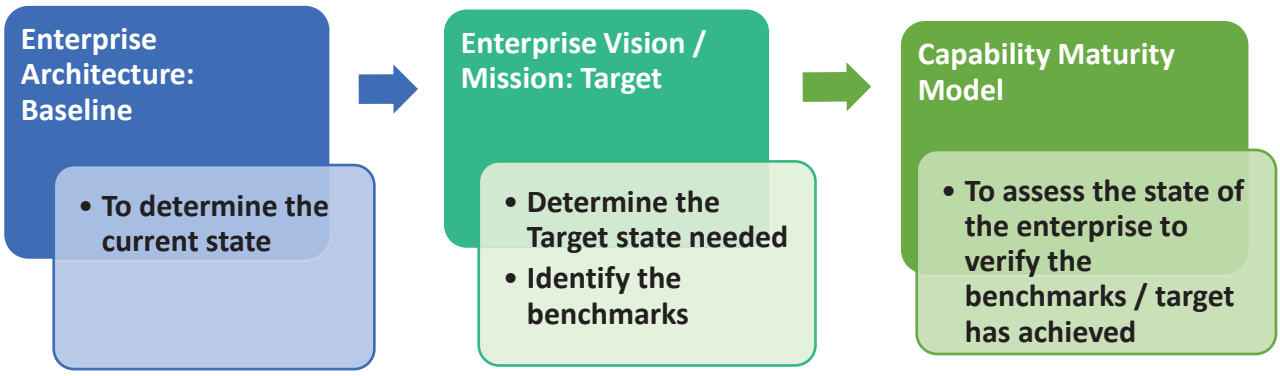


Figure 57 Capability Maturity Model overview

Maturity Model Provides

- A starting point for the assessment
- A shared vision with the common language
- Defines what does “improvement” and “maturity” means to an organization
- Framework to prioritize actions
- Provides an efficient and proven method to assess, control and improve the processes gradually.

IT strategy and roadmap development are the most complex tasks for Strategists and Executives, due to the nature of various systems implemented at different timelines. Enterprise Architectures, to address the adoption of emerging technologies. Therefore, it is essential to assess the organization maturity before starting any significant business transformation / periodically to identify the current maturity level which will help to define IT strategy to be realistic.

Current Practices Utilised for Enterprise Architecture Maturity Assessment

The current Capability Maturity Model referred in TOGAF is based on US Department of Commerce (DoC) IT Architecture Capability Maturity Model (ACMM). This maturity model developed in 2001 with the last update on December 2007 (Commerce 2007).

Information technologies have changed leaps and bounds from physical infrastructure to virtual infrastructure, on-premises systems to cloud-enabled, structured to unstructured data, mobility from 2G to 5G; the maturity model has not been updated to keep in tune with the current requirement. The DoC ACMM has three sections, six levels, and nine architecture characteristics.

The ACMM comprises three sections:

1. The IT architecture maturity model
2. Different Maturity levels of operating units' processes
3. Capability maturity model scorecard of IT architecture

The six levels are:

0. None
1. Initial
2. Under development
3. Defined
4. Managed
5. Measured

If you can't measure it, you can't manage it is; but to measure it you need to know what it is.

The nine IT architecture characteristics are:

1. IT investment and acquisition strategy
2. Business linkage
3. Architecture governance
4. IT architecture process
5. IT architecture development
6. Senior management involvement
7. Operating unit participation
8. Architecture communication
9. IT security

4.4.1 Why is Capability Maturity Model Assessment needed?

We want to provide importance of maturity assessment with a treatment of a patient. Before giving therapy to a patient, the doctor diagnoses the patient current health condition. Based on the results the treatment is prescribed to the patient.

Generally, Organizations embracing EA practice are large to medium Organizations either public or private early adopters of technology. If the organization wants to start EA practice means they have limited processes, also business and IT are not aligned.

Similarly, as patient assessment performed before treatment, the purpose of the assessment of an organization is to estimate the level of maturity of the enterprise IT architecture and to identify various improvement areas.

We can relate to humans, those who take precautions pro-actively based on the age and condition, the other who are reactive take treatment based on the ailment. Irrespective it is necessary to do the health check on the entire human body (system) to suggest a proper treatment

Similarly, it is required to do the maturity assessment in a holistic approach that covers the whole Organization. Said that it is essential to identify the existing methods, methodologies, frameworks that are in use. The assessment gives an understanding of the current working style. Based on the target state identified it is possible to recommend the appropriate framework or method or methodologies that are suitable for the enterprise.

The maturity models to be used needed for an enterprise is determined based on the domain, industry vertical, type of enterprise public or private, Country, Culture, the Technologies utilised.

So, each Capability Maturity Model is uniquely identified and tailored based on the above criteria.

1. Outline what to measure.
2. Define what can and cannot be measured.
3. Collect the data.
    A. Identify the department
    B. Group the Stakeholder
    C. where possible organise a workshop for collecting the data
    D. One to one interview
    E. Anonymous online survey
4. Organization audit reports.
5. Process the data.
6. Analyse the data.
7. Present the analysis to the users
8. Validate their feedback.
9. Present the proposed corrective action.
10. Implement the corrective action.

4.4.1.1 *Maturity Assessment Process*

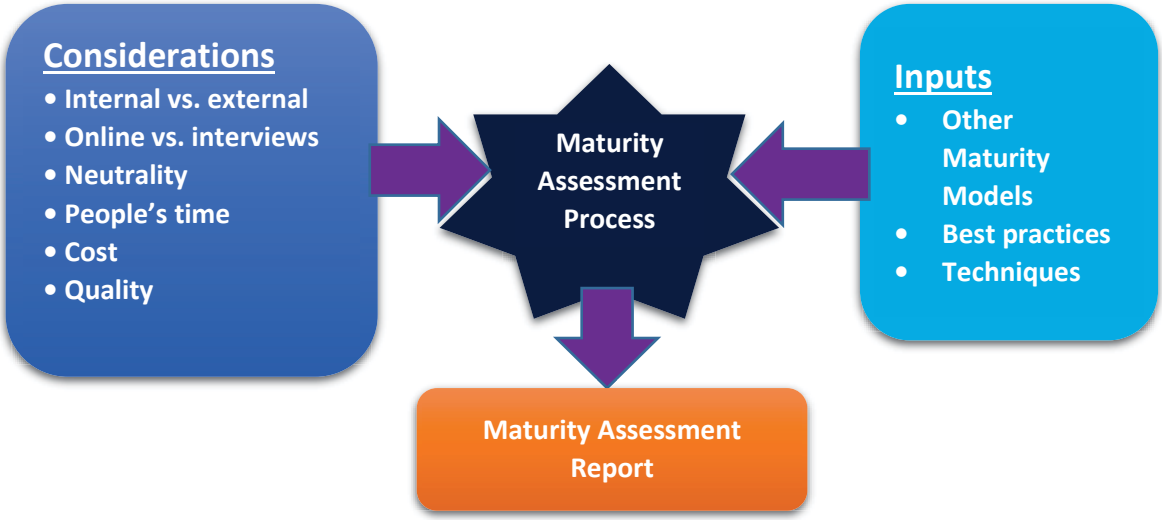


Figure 58 Maturity Assessment Process

4.4.2 Capability Maturity Model Considerations

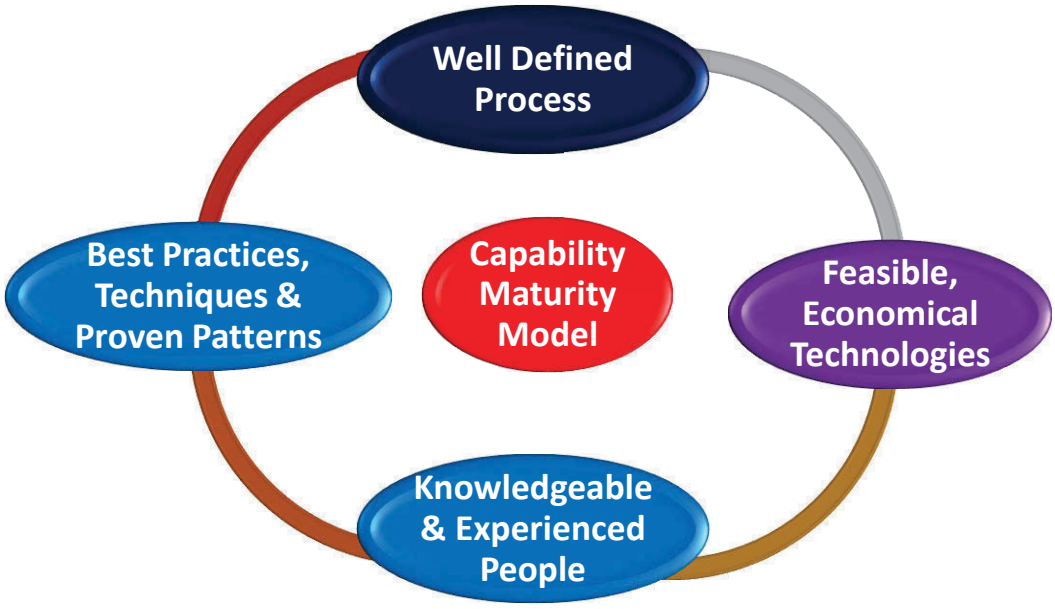


Figure 59 Capability Maturity Model considerations

4.4.3 Types of Capability Maturity Model

Maturity assessment evolved as its been developed at the various timeline based on technologies evolution. As organization relied more on technologies, it was critical to assess the maturity of the organization to improve the capability of people, process, and technologies.

From the inception of, maturity model by the US Department of Défense Software Engineering Institute (SEI) began in 1986, as now they are more than fifty-four maturity models (Wikipedia 2016). Based on domain and type of the project maturity models are chosen. Only appropriate assessment is done due to constraints of time, budget, and resources.

4.4.4 Proposed Comprehensive Capability Maturity Model

Organizations are implementing TOGAF framework for their enterprise architecture practice. Based on that we determined the critical maturity models that are relevant to each phase of TOGAF Architecture development.

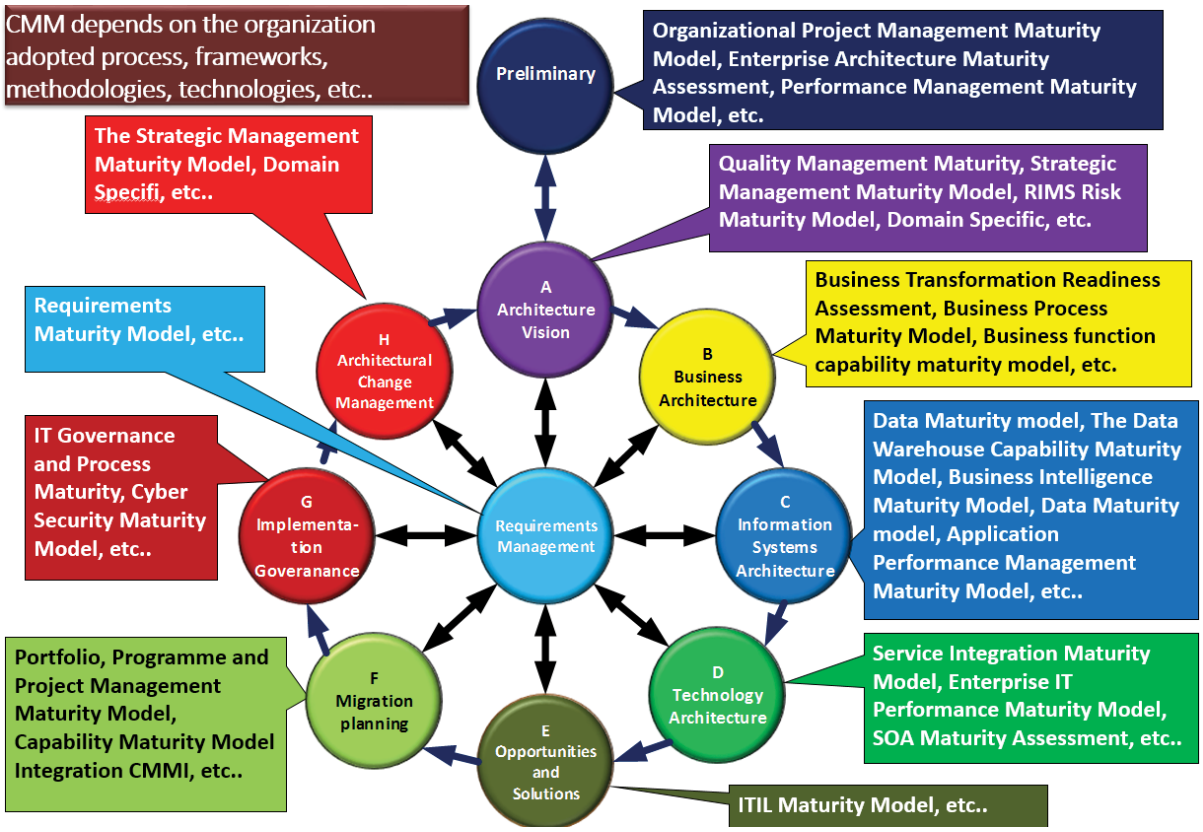


Figure 60 Proposed Comprehensive Capability Maturity Model

ADM Phase	Maturity Model	Purpose
P: Preliminary Phase	Organizational Project Management Maturity Model	Project Management
	Enterprise Architecture Maturity Assessment,	Enterprise Architecture
	Performance Management Maturity Model,	Performance
	Quality Management Maturity,	Quality
Phase A: Architecture Vision	Strategic Management Maturity Model,	Strategy
	RIMS Risk Maturity Model	Risk
Phase B: Business Architecture	Business Transformation Readiness Assessment,	Business Readiness
	Business Process Maturity Model,	Business process
	Business function capability maturity model,	Business function
Phase C: Information Systems Architectures Data & Application	Data Maturity model,	Data Model
	The Data Warehouse Capability Maturity Model,	Data ware house
	Business Intelligence Maturity Model	Business Intelligence
	Data Maturity model,	Data maturity
	Application Performance Management Maturity Model	Application Performance
Phase D: Technology Architecture	Service Integration Maturity Model,	Service Integration
	Enterprise IT Performance Maturity Model,	Information system performance
	SOA Maturity Assessment	Service-Orientation Architecture
Phase E: Opportunities & Solutions	ITIL Maturity Model,	Information Infrastructure
Phase F: Migration Planning	Portfolio, Programme and Project Management Maturity Model,	Portfolio, Programme, Project Management
	Capability Maturity Model Integration CMMI	Capability Maturity Model Integration software development
Phase G: Implementation Governance	IT Governance and Process Maturity,	Governance
	Cyber Security Maturity Model	Security
Phase H: Architecture Change Management	The Strategic Management Maturity Model	Assess Organizational Strategic Management Performance.
Requirements Management	Requirements Maturity Model	Requirements

Table 28 Maturity Models description and their purpose

4.4.4.1 Proposed Maturity Models identified based on Industry Domain

Maturity model assessment of the ADM only is not sufficient, as addresses the maturity of the Architecture development processes only. It is also necessary to determine the capability of the domain or the type of the industry, so it is essential to assess the current maturity of the organization based on the domain too. Listed below are some of the maturity models based on the industry type.

Industry	Maturity Model	Description
Health	Electronic Medical Record Adoption Model (EMRAM)	EMRAM (HIMSS 2018) is eight-stage (0 – 7) maturity model measures the adoption and utilisation of Electronic Medical Records (EMR) function required to achieve a paperless environment that harness technology to support optimised patient care.
Land management	Geographic information system Capability Maturity Model (GISCMM)	GISCMM (Association 2014)116} allows GIS operations to assess the maturity of their organization and compare them against a standardised framework and rating mechanism for enabling capability and execution ability.
Government	Gartner Digital Government Maturity Model (DGMM)	DGMM (Howard 2017) is framework for CIOs to assess where their organization stands in relation to its goals and take strategic steps to increase digital maturity.

Table 29 Maturity Models identified based on industry

Current practice of Maturity assessment in an Organization

Based on the other project reports and the projects involved, it was observed only the TOGAF proposed maturity is done. The information is collected from certain key holders, which is very subjective. Also, rarely organization do domain specific maturity assessment.

Comparison of the current maturity assessment with proposed

The current maturity model is on outdated maturity model of US Department of Commerce (DoC) IT Architecture Capability Maturity Model (ACMM). The proposed Comprehensive Capability Maturity Model (CCMM) covers the Architecture Development Method (ADM) phases, as such the assessment is more realistic and practical.

For the assessment, the relevant stakeholders are to be engaged. The complexity of the project dictates, the information for the assessment to be collected either through workshops, one to one anonymous survey or all.

Further research work carried on the proposed maturity model assessment

The identified maturity models are specific for each phase of the ADM. The techniques applied is based on the experience learned from various enterprise architecture projects implemented and through other case studies referred.

However, it is recommended to examine additional projects that are practicing EA. Then to correlate the result to identify the critical maturity models that are relevant for the project to be realized and its domain. The recognized maturity models are applicable for certain period only. Maturity models changes as technology evolve.

4.4.4.2 Summary of Maturity Model

Organizations are utilising The Open Group Architecture Framework (TOGAF) based on open standards to develop the enterprise architecture, to help in their transformation to adopt emerging technologies.

The maturity assessment suggested by TOGAF is outdated US Department of Commerce (DoC) IT Architecture Capability Maturity Model (ACMM).

From the past project experience, Comprehensive Capability Maturity Model (CCMM) to assess all the phases of Architecture development was developed. With CCMM it's possible to estimate the maturity with more accuracy.

The maturity assessment done holistic across all the phases of Architecture Development Lifecycle will assist in finding the weakest point of failure. Maturity assessment enables to prioritize the capabilities, thereby ensures the success of the project, also with reduced cost and timeline.

Maturity assessment in total will help the organization to choose the right technologies stack that serves the business needs in alignment with organization vision to realize the strategy.

Maturity measures the actual progress or the gaps to the expected at the specific milestone. In total maturity assessment performed at different phases of ADM as per the relevant maturity models at the key milestones will increase the success of digital transformation.

4.5 Complementary Framework and Methodologies for TOGAF

TOGAF is a generic framework for architectural development lifecycle applied irrespective of any industry. TOGAF ADM has not gone through drastic changes since TOGAF 9.0 version introduced in 2009. As TOGAF framework is vendor neutral and technology independent, it can be applied irrespective of the technology. Technology had transformed drastically since cloud computing becoming the mainstream after 2010. TOGAF framework complemented with other methodologies will enable the successful adoption of Enterprise Architecture practice of an Organization.

4.5.1 Current Framework and Methodologies in Organizations

Generally, in a typical enterprise TOGAF framework is used as a standalone framework. Based on the case study reviewed I have rarely come across the organization using other frameworks. Though PRINCE 2 / PMI referred in an organization for project management and ITIL for service management. TOGAF is used to realize the strategy and the default artefacts provided by TOGAF frameworks are used.

4.5.1.1 Key Reasons TOGAF is used as a Standalone Framework

- TOGAF artefacts produced, are the list of documents
- Lack of tool capabilities, to links other frameworks and methodologies
- Lack of tool usage for EA practice
- EA tool used only for ADM development
- TOGAF used only to identify the strategy to determine the cost and just for request funding,
- From TOGAF there is no linking to other frameworks like BPMN, BPEL, UML, ITIL, Data management and generally they all standalone.
- ArchiMate introduced 2013; used in few Organizations.
- Knowledge of EA practitioner limited only knowing TOGAF

4.5.2 Identified complementary Techniques, Frameworks & Methodologies

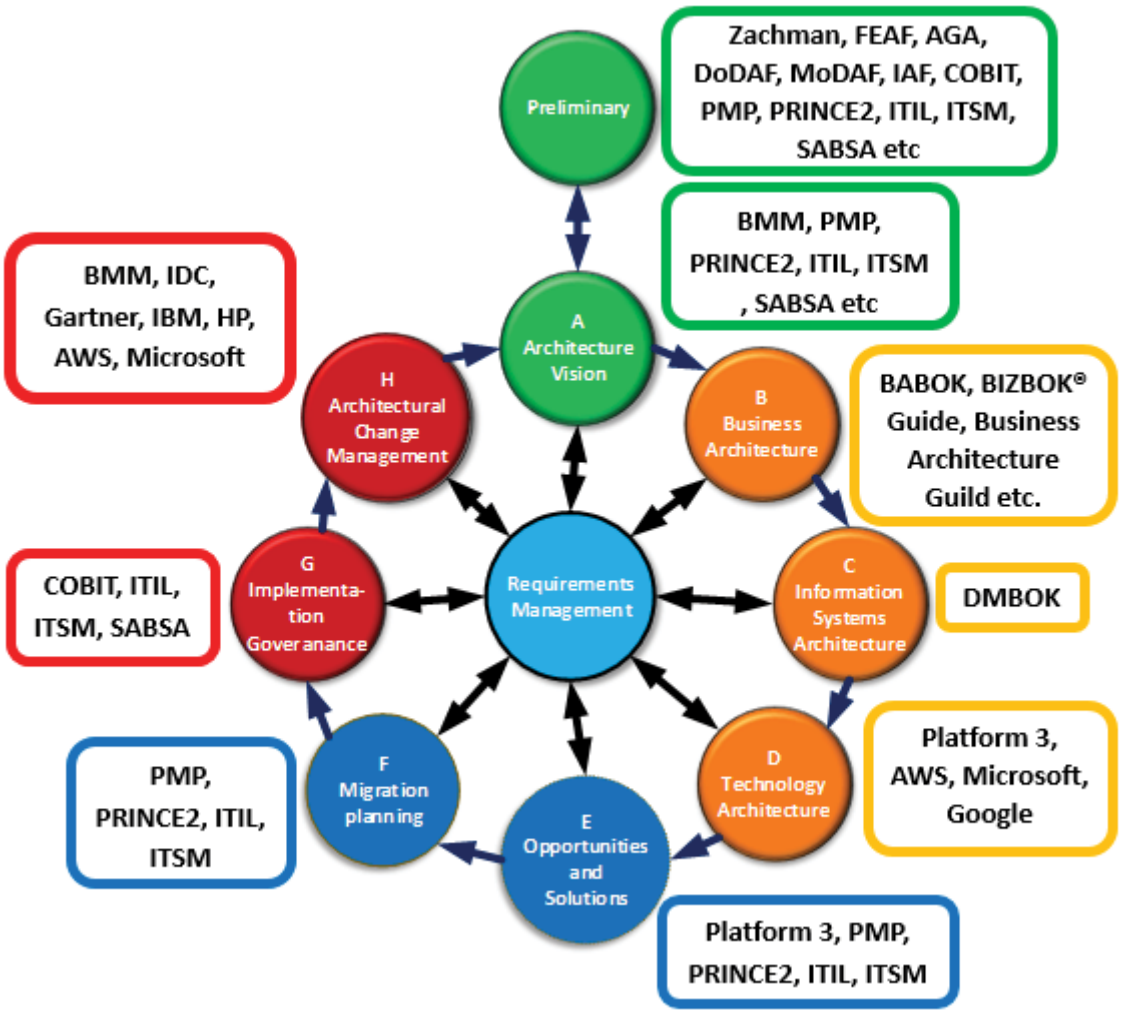


Figure 61 Proposed ADM cycle, (Kempegowda & Chaczko 2016)

4.5.2.1 *Identified Framework and Methodologies for success of Enterprise Architecture*

Have extensively used other frameworks and Methodologies that complement TOGAF. As TOGAF is a generic framework, it does not cover the in-depth of the phases. TOGAF by its nature is the generic framework, that needs to be extended with other frameworks or methodologies as required.

There is more explanation provided in the case studies covered in "Chapter 5 Research Action Study", and listed below are the main framework and methodologies applicable to phases of the ADM.

Frameworks /Methodologies	Focus Area	ADM Phase
Zachman: an architectural Framework, with logical structure to classify the artefacts cohesively to address stakeholder perspectives.	Stakeholder	P, A, B, C, D, R
Federal Enterprise Architecture Framework (FEAF): provides tools to describe, and analyse investments	Performance &investment	P, A, B, C, D, R
British Ministry of Defence Architecture Framework (MoDAF): provides models to analyze and understand the capabilities of, Systems of Systems.	Systems of Systems	P, A, B, C, D, R
Department of Defense Architecture Framework (DoDAF): a comprehensive framework and conceptual model to develop architectures.	Core Architecture	P, A, B, C, D, R
Integrated Architecture Framework (IAF): provides processes, products, tools, and techniques to create architectures.	Core Architecture	P, A, B, C, D, R
Australian Government Architecture Framework (AGA:): provides processes to analyse, identify the duplicate investments, gaps, and opportunities.	Performance & investment	P, A, B, C, D, R
Project Management Book of Knowledge (PMBoK): has set of standard terminology and guidelines for project management	Managing Projects	P, A, B, C, D, E, F, R
Project Management in controlled environment (PRINCE2): Process-based method for effective project management.	Managing Projects	P, A, B, C, D, E, F, R
Business Motivation Model (BMM Model:): a structure to develop a business strategy to realize the vision of an organization.	Strategy	P, A, B
Business Architecture Body of Knowledge (BIZBOK GUIDE): provides a practical guide to address business challenges, consist of best practices collection from numerous companies and business architecture leaders	Business Architecture	B
Business Analysis Body of Knowledge (**BABoK**): a framework that describes the business analysis tasks	Business Architecture	B
Data Management Body of Knowledge (DMBoK): a framework to manage data and mature information infrastructure,	Data Architecture	B, C
Information Technology Infrastructure Library (ITIL): a framework of best practices for delivering IT services.	Change Management	A, E, F, G
Information Technology Service Management (ITSM:): provide all the activities involved in designing, creating, delivering, supporting and managing the lifecycle of IT services.	Service Management	A, E, F, G
Control Objectives for Information and Related Technology (COBIT): framework for governance, audit, and compliance.	Governance	A, G
Sherwood Applied Business Security Architecture (SABSA:): a framework and methodology for enterprise security architecture and service management.	Governance, Risk	All the phases
Platform 3.0: provides a standard for digital platform based on the emerging technologies such as cloud computing, mobile computing, social computing, big data analysis, and the Internet of things	Strategy, Technology	D, E
Amazon Web Services(AWS), **IBM, HP, AWS, Microsoft:** XaaS model for cloud computing platform	Strategy, Technology	A, C, D, E, F
IDC, Gartner: Research Organization Frameworks	Strategy, Technology	A, C, D, E, F

Table 30 Identified Framework and Methodologies list

Summary of Complementary framework and Methodologies for TOGAF

TOGAF is a generic and descriptive framework for architecture development lifecycle. TOGAF needs to be extended to make EA practice successful. Based on the projects executed, the research has identified the frameworks and methodologies that complements TOGAF and ensures EA practice success that will contribute to the success of organization digital transformation.

4.6 Enterprise Architecture Tool

Enterprise Architecture development lifecycle generates enormous amount of content that needs to be managed. The documents generated needs be sharable and accessible across the Organization. EA practice is a collaborative work as such different team will contribute for a document.

Google Maps is used as an analogy to relate the importance of tool for EA practice. An organization having a practice of EA without a tool is like referencing a static street map. As Google Maps provides real-time information to go from place A to B with options for the user to choose. Similarly, an EA tool, if all the information is available in the repository will provide impact analysis that will assist in decision making.

The main objective of EA practice is to produce and reuse assets that are needed enterprise wide. TOGAF is a descriptive process, as such other frameworks and methodologies can be included. TOGAF as its framework and methodology specifies the input and deliverables represented in, Figure 62 EA Input and Deliverables.

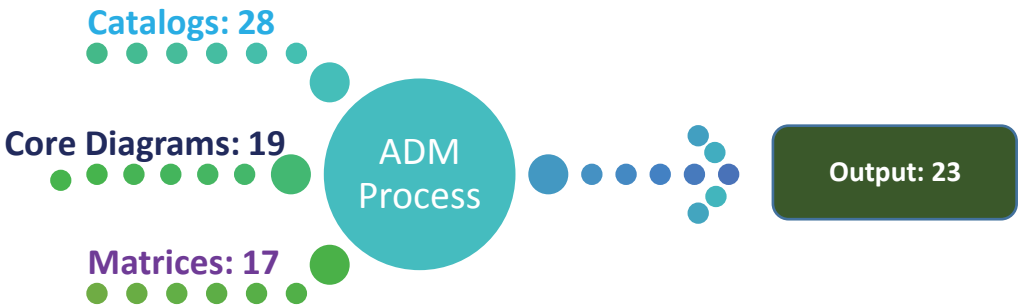


Figure 62 EA Input and Deliverables

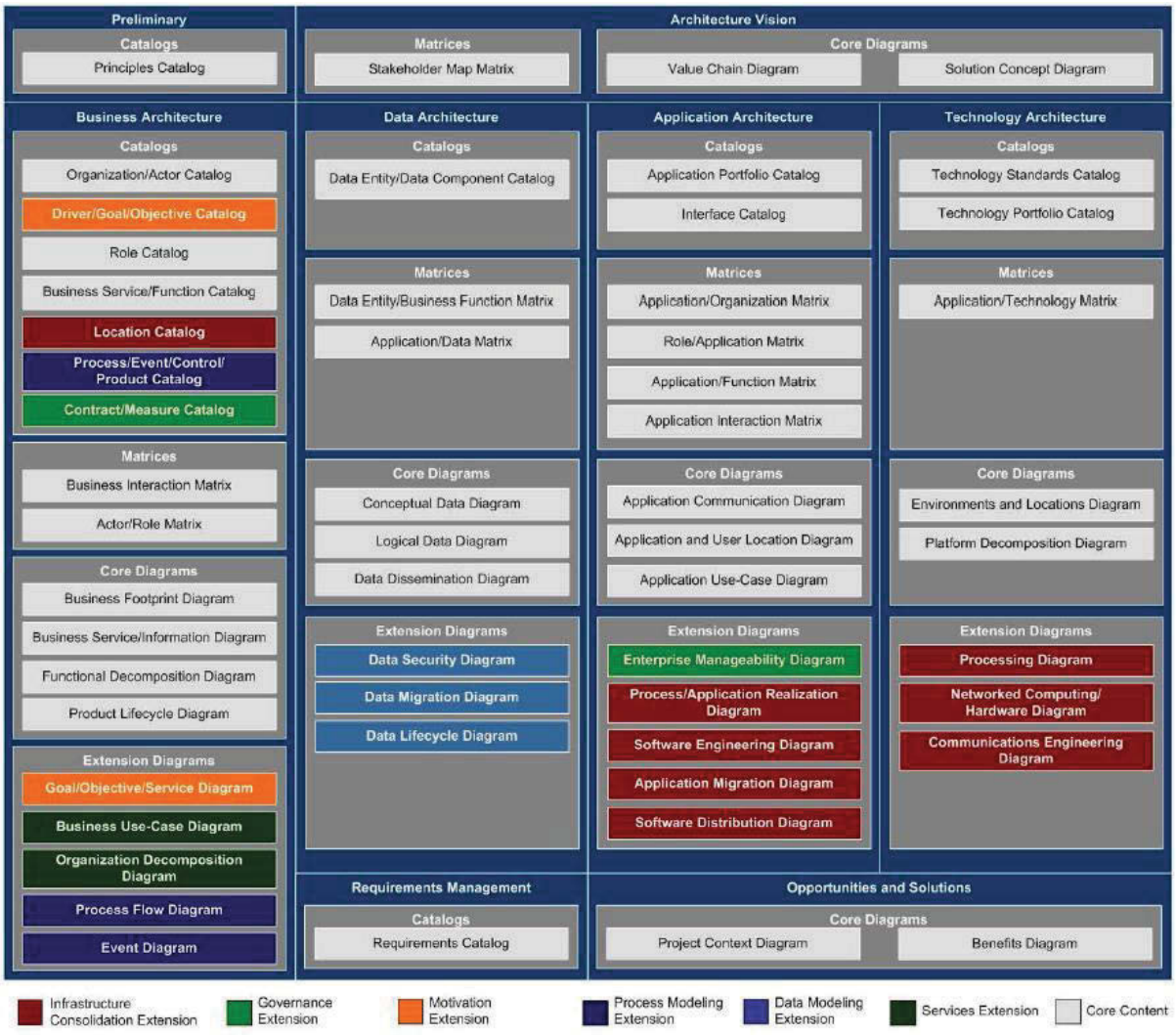


Figure 63 TOGAF Input Artefacts (Group)

The input artefacts and the output all need to be referenced as needed, which can be tedious process without a tool.

Prior to the ArchiMate notation, first released in 2012, the notations followed were based on the Tool vendors without any standard convention. The current ArchiMate 3.0 released in 2016 covers almost all the artefacts of TOGAF 9.1, that can be represented in ArchiMate notation.

The number of certified professional for TOGAF are 78286 (Group 2018b) whereas for is ArchiMate is 5451 (Group 2018a). This clearly indicates organization are not yet following ArchiMate notation and the tool if is used, it's not to its full extent.

What is Enterprise Architecture Tool?

An enterprise architecture tool captures the information based on various phases of architecture development life cycle. It supports the modelling of different stages with the relevant modelling language. All the models generated are connected, that provides the ability to analyse, understand the impact, able to create reports that provide real-time information.

An Enterprise Architecture tool facilitates collaborative modelling from a single source of truth. The artefacts can be created once that may be used multiple times, thereby avoiding duplication, errors

and reducing the time to produce the models. Also ensures consistent and accurate diagrams such as Architecture Roadmaps and heatmaps, that are used to be communicate with the stakeholders.

Why Enterprise Architecture Tool is Essential

Software development has evolved and matured from text editor to Rapid Application Development (RAD) tools. It is inevitable in software development to have at least minimum tools as RAD, version control, build tool, deployment tool, configuration tool.

Figure 64 EA Tool Essentials

Enterprise architecture documents the stakeholder requirements. Before ArchiMate there was no formal modelling language. With ArchiMate the Enterprise Architecture artefacts modelled are at the higher level. As EA practice covers the entire lifecycle of an organization from inception to implementation to business as usual (BAU), the artefacts of an organization to be modelled in much more detail. The modelled artefacts to be interconnected and be able to make real-time analysis to understand dependencies and impact.

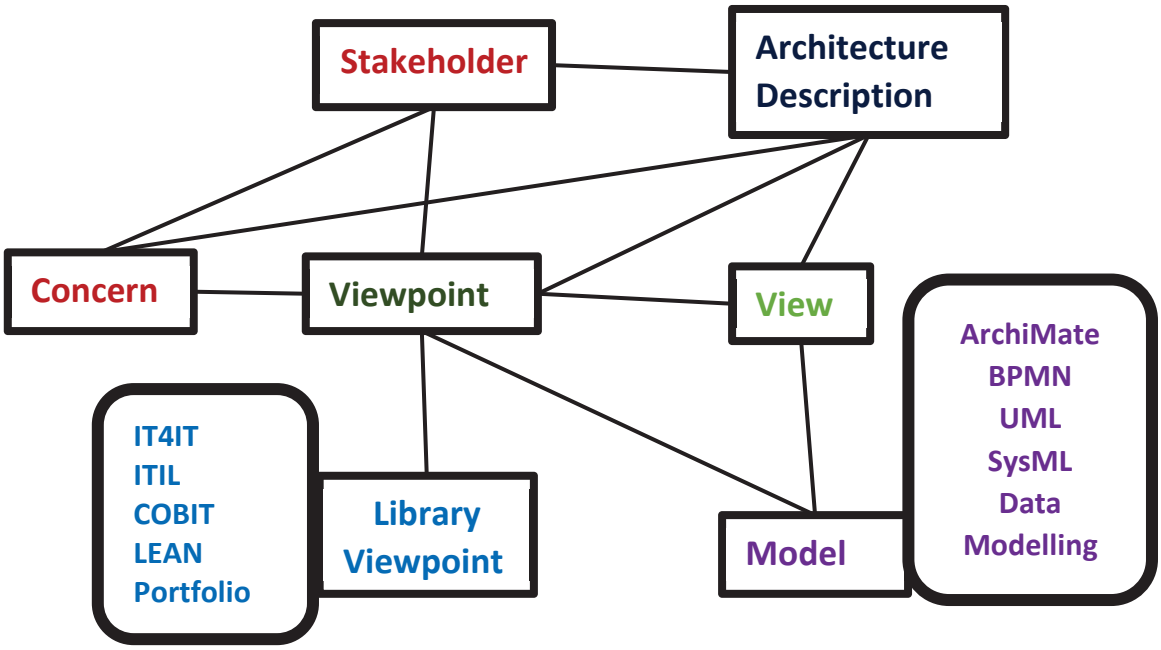


Figure 65 Complementary Modelling language for Enterprise Architecture

4.6.1 Complementary Modelling Languages, Frameworks and Methodologies

4.6.1.1 Modelling Languages

- **ArchiMate Modelling Language**: Used for Enterprise Architecture for description, analysis, and visualisation of architecture for an Organization-wide.
- **Business Process Model and Notation (BPMN)**: Used for business architecture to model business processes.
- **Unified Modelling Language (UML)**: Used for software engineering for requirements gathering, understanding the structure and behaviour of the system.
- **Systems Modelling Language (SysML)**: Used in complex engineering systems for analysis, design, and verification of hardware, software, information, personnel, procedures, and facilities.
- **Data Modelling**: Used to identify, define, analyse and model data requirements of the business.

4.6.1.2 Frameworks and Methodologies

- **Business Motivation Modelling (BMM)**: Used to model business plan with Vision, Goals, Objectives, Mission, Strategies, and Tactics
- **IT4IT**: Provides prescriptive guidance to implement IT management capabilities.
- **Information Technology Infrastructure Library (ITIL):** Provides direction to an organization to utilise IT as a tool to encourage business change, transformation, and development. Focuses on business and IT integration.
- **Control Objectives for Information and Related Technologies (COBIT):** Provides governance model that helps to understand and manage risks. Complements phase G- Implementation Governance, as COBIT has more comprehensive Governance model.
- **LEAN**: Through process improvement reducing the cost with fewer resources thereby providing more value to the Organization. As in the initial stage of EA has fewer means regarding staff and tools but also needs to exhibit benefit to the organization in short duration.
- **Application portfolio management (APM)**: Provides an inventory of organization software application with metrics that illustrate the business benefit of each application. It is very critical to replace the applications that do not provide business value essential for EA success.
- **Project Portfolio Management**: Provides centralised management of projects or portfolios that assist in achieving the strategic objective. That complements EA projects implementation with the centralised view of the projects/portfolios.

For the success of EA practice, various modelling language and frameworks to be supported, its only possible with a tool.

4.6.1.3 Enterprise Architecture Tool Key Capabilities

Selection of right tools and components are critical to the success of Enterprise Architecture. So, it is very crucial to identify the tool that complements and aligns with the overall architectural framework that meets the needs of the Organization. The tool selected, to have the minimum capabilities as listed:

- **Integration**: As Enterprise Architecture Addresses Strategy to Implementation to Business as Usual, the tool must be easy to integrate with another tool such as Portfolio management, Service management, Risk management, Governance, Content management, and so on.
- **Intuitive to use**: Easy to use with drag and drop ability with minimal learning curve.

- **Simulator**: To simulate the probability, that assists the impact analysis or Decision analysis, conclusions.
- **Publisher**: EA artefacts are required to be referred and to be used across the Organizations, so EA tool must have the capability to render an interactive website
- **Report Builder**: As Enterprise Architecture metrics is needed by the senior management to make the decisions; the tool must be able to generate dynamic reports.
- **Metamodel**: Currently they are about 78 frameworks. Also, TOGAF is a descriptive framework that supports other frameworks, such that the metamodel must be easy to extend.
- **Modelling**: Though TOGAF can be modelled using ArchiMate, it is only at the high level. So, the tool to support at the minimum BPMN for business architecture, Data modelling for data architecture and UML notations for software architecture, at the minimum
- **Configuration**: Tool must be easy to do configuration and administration.
- **Standards**: The success of enterprise architecture is the ability to follow Standards, so the tool must have the ability to support the various standards as required.
- **Linkage**: Exposed interfaces to connect with Project, Service, and Software management tools with intuitive Configuration.

Benefits of the EA Tool

- Provides the 360 views of the enterprise assets
- The ability to forecast the enterprise changes with 720 views
- Ensures consistent modelling across the Organization
- Enables collaboration across the Organization
- Includes impact analyses that will allow decision-making ability
- Assets generated are reusable
- Easy to manage compliance
- High Value, End-To-End Modelling
- Business models Simulation
- End-to-End Traceability
- Able to Model, Manage and Trace Requirements
- Document Generation
- A faster content development cycle

4.6.1.4 Proposed logical model of EA Tool

As enterprise architecture enables to realize an organization vision, so the artefacts generated from inception to implementation to be linked. The primary objective of EA is to support the business with the changing business models that need information in real-time.

In general, the different tool in organization work in isolation. The information that needed by different tools are shared manually, so the data is of not real-time. To support the business, it's critical to provide impact analysis to the initiatives; that are possible only with all the relevant process, functions and artefacts in an enterprise relate / connected to each other in real-time, as recommended in Figure 66 Proposed logical model of EA Tool

Figure 66 Proposed logical model of EA Tool

4.6.1.5 Why EA tool not extensively used in the industry

Before ArchiMate notation, tools vendors used their own notation based on the metamodel of EA framework. EA tools that were available in the market was too expensive, or tools that were affordable was not so intuitive that needed a high learning curve.

Though ArchiMate introduced in 2012, is not widely accepted, that is demonstrated by the number of certifications, in 2018 TOGAF: 78286 (Group 2018b) and ArchiMate: 5451 (Group 2018a). Other aspects were generally Enterprise Architects were seniors, the majority were from infrastructure, business, management, and so on. so, the appetite to use a modelling language and tool is limited.

Enterprise Architecture practice was not widely used prior to Opex model. Due to the cost of infrastructure and perpetual license of software, technology stack was rarely refreshed, unless deemed necessary as the system stops working or system unable to support the business anymore. So, Enterprise Architecture approach was used only for significant initiatives as ERP validation, infrastructure upgrade. Due to the above EA tool was not widely used in the industry.

4.6.1.6 Enterprise Architect Tool Summary

As Enterprise Architecture practice generates an enormous amount of documentation, that will be referred in the Organization. ArchiMate provides the notation to represent EA model at the high level. For detail modelling other notation with frameworks and methodologies are used. To manages EA artefacts that are generated from strategy to implementation to business as usual, tools are required.

So, it is critical to have an EA tool with a centralised repository to manage the artefacts, that has ability to do impact analysis to make decisions. So, it is very crucial to have EA tool that needs to be connected end to end.

Organizations are moving cautiously towards digitization path to utilize the capability of emerging technologies, service model and Opex business model. EA tool will start to take off in next one or two years as it provides transparency and real-time information that are critical for success of digital transformation.

4.7 Enterprise Architect Skills, Roles and Responsibilities

Identified Skills for an Enterprise Architect

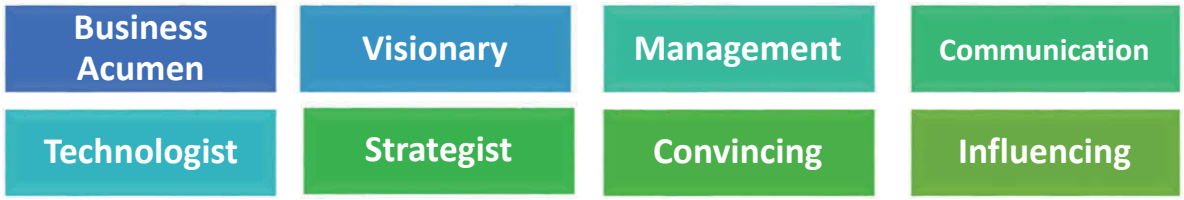


Figure 67 Skills for Enterprise Architect

Identified roles for TOGAF ADM phases

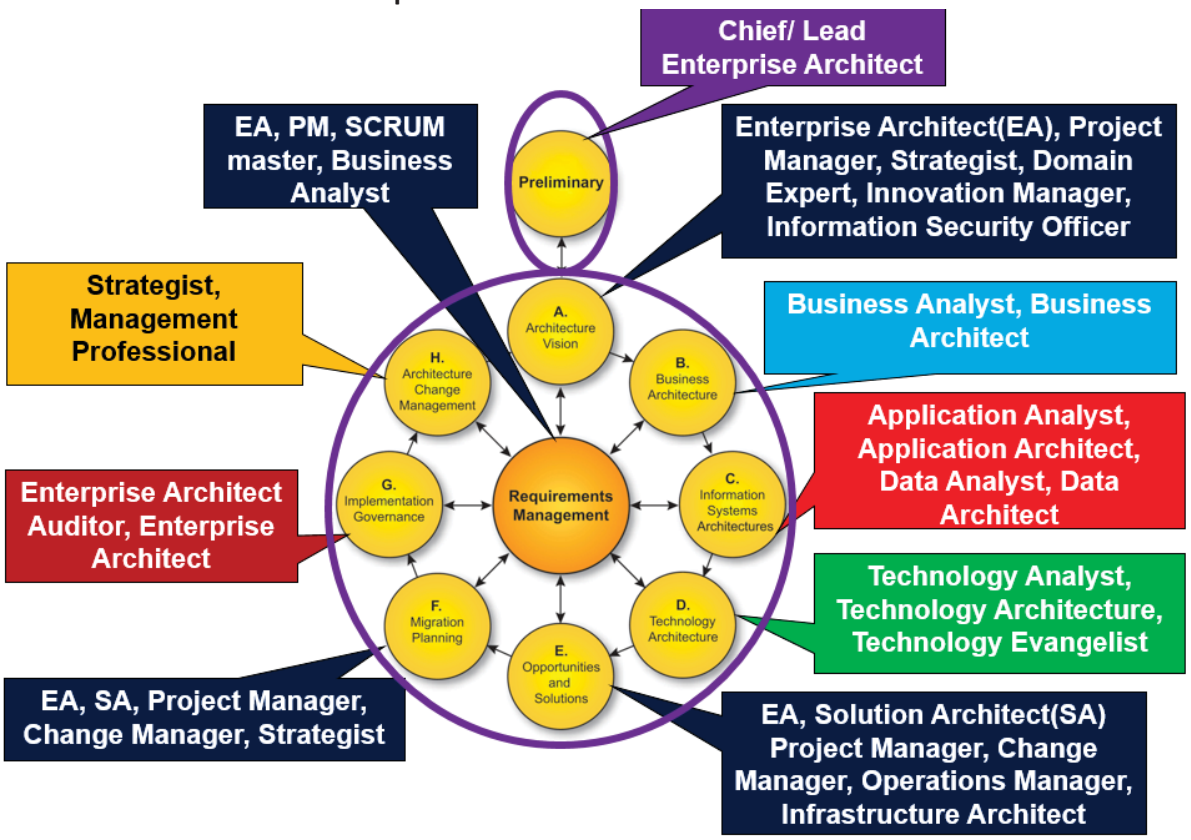


Figure 68 Identified Roles for TOGAF ADM phases

Roles and Responsibilities for effective EA Practice

The roles and responsibilities identified are mapped to the Skills Framework for the Information Age (SFIA) model version 6. SFIA is a globally accepted common language for the skills and competencies required in the digital world. SFIA is a not-for-profit organization with five corporate members - the Institution of Engineering and Technology (IET), e-skills UK, the British Computer Society (BCS), IMIS and the itSMF.

Role	Responsibilities
Chief Enterprise Architect (CEA)	• Supports the CXO to realize business vision • Sets directions for enterprise architecture practice, and manages the team.
Domain Expert	• Chosen based on the type of the industry
Enterprise Architect	• Supports CEA and manages the EA project

Information Security Officer	• Responsible for the organization information strategy and to set up security practice.
Strategist	• To formulate and implement strategy
IT Innovation Manager	• Responsible for IT Innovation
IT Innovation Specialist	• Assists the IT Innovation Manager, performs evaluations and experiments
Business Architect	• Supports the EA in analysing compliance for the Business domain
Business Analyst	• Supports the EA in workshops, analysis and articulation
Data Architect	• Responsible for organization data including Master Data Management, information management, data modelling (structure & unstructured)
Application Architect	• Supports the EA in analysing compliance for the Information Systems (Data + Application) and Technology domains
Infrastructure Architect	• Supports the SA and EA in analysing compliance for the Technology domain, focusing on infrastructure
Auditor	• Examine organizations, systems, processes, risks and controls.

Table 31 Roles and Responsibilities

4.7.1 Skills to Implement Enterprise Architecture

The role of Enterprise Architect as analysed by Amit (Unde 2008) is to realise the vision of CIO. Enterprise Architect defines the strategic architecture that aligns with Business Strategy. Define standards, guidelines and chooses the technology stack that is relevant to the Organization.

The focus of the Enterprise Architects is more on Strategy, where on Technology focus is very low. This approach was good with traditional old way of computing based on Capex, software based on a perpetual license where software can be used for ever with one-time fees, and the product lifecycle was more than ten to 15 years. Though the depreciation of technology products is 33% per annum, rarely Organizations replaced their IT systems every 3 or 4 years.

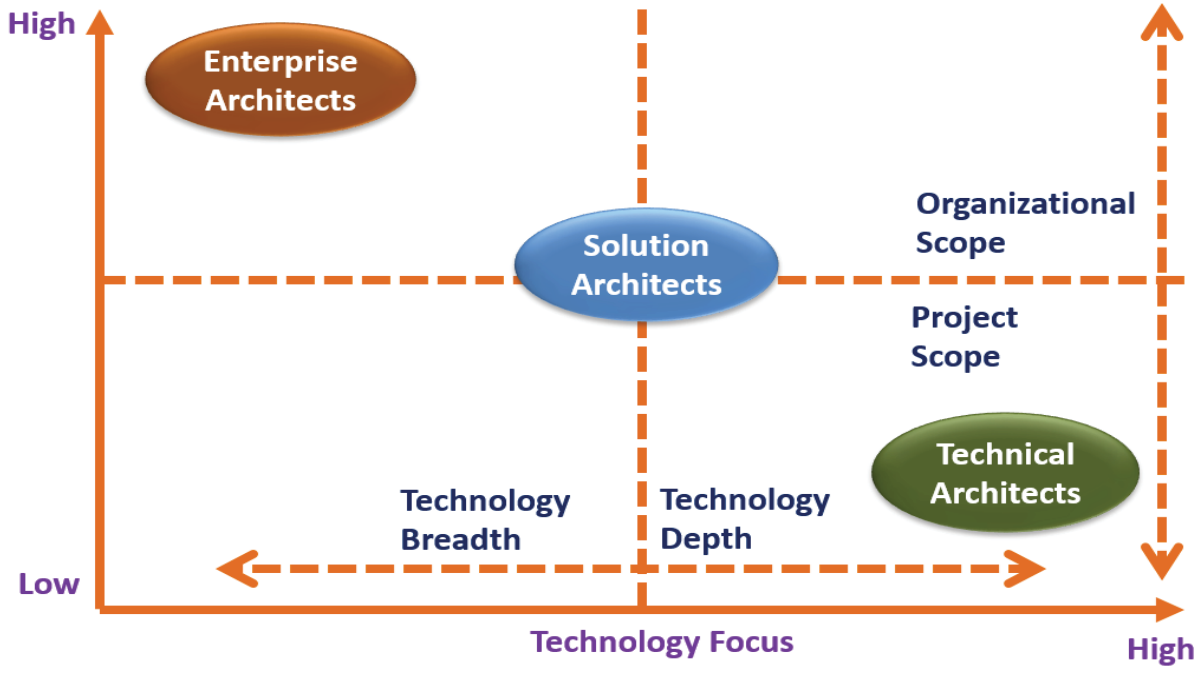


Figure 69 Traditional Enterprise Architects technology focus (Unde)

IT infrastructure and software based on service model, where the user pays for the usage have changed the landscape of IT. That has contributed technology embracement for day to day activity of everyday life. The service model enabled change in procuring IT services from Capital expenditure to Operational expenditure.

The Platform as a Service (PaaS) model Customer Relationship Management (CRM) as Salesforce will cost AU$3000 per user account, where's Siebel based on-premises CRM cost few millions.

Evolution in computer hardware, open source initiative, increase broadband, mobile capabilities as of computer, service model, all are contributing to affordable technology, irrespective of the size of the industry.

The project life cycle has drastically changed from years to months. For a considerable implementation of Enterprise Resource planning that was costing million depending on the size of the organization is now costing the fraction of the cost. Due to high cost of the project there was extensive activity involved to get the approval of the projects. As in-service model as there is no long-term commitment and pay as you go, Organizations are experimenting technology due to less risk. All the above have contributed to the project life cycle to months or weeks rather than years. Also, due to the service model, the product companies are innovating their solution, as Organizations are forced to upgrade their service and pay for it. Also, if the product companies do not innovate, Organization can switch the product due to service model, open standards there is no vendor lock-in and due to containerization its seamless for organizations to switch service providers.

As we observed from Gartner Hype cycle for emerging technologies, EA practitioner to understand bird's eye view of the technologies stack, its capabilities and the overall landscape of the emerging technologies. Only then an EA can able to advise the business to choose the right technology stack. EA practitioner to have a high focus on Strategy as well as technology too, as shown in Figure 70 Modern Enterprise Architects Technology Focus extended from (Unde 2008).

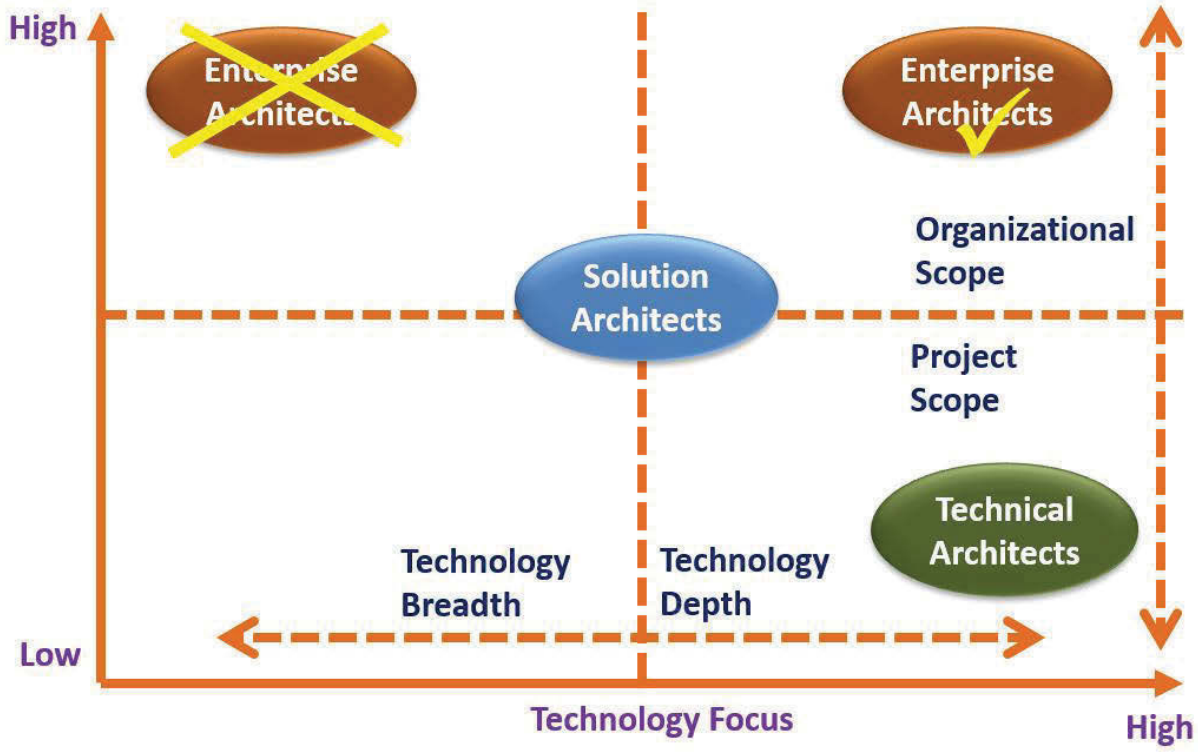


Figure 70 Modern Enterprise Architects Technology Focus extended from (Unde 2008)

4.7.2 Roles and Responsibilities aligned with SFIA

Role	SFIA 6 Alignment	SFIA reference	Comments
Chief Enterprise Architect	Enterprise and business architecture STPL/6	Level 6: Complexity, Have business understanding Able to understand complex work activities of technical, financial and quality aspects. Level 5: Able to Influences Organization, customers, suppliers, partners and peers.	Can be between 5 - 6
Domain Expert	Consultancy CNSL/5	Level 5: Ensure, Advise	
Enterprise Architect	Enterprise and business architecture STPL/5	Level 5: Able to Influences Organization, customers, suppliers, partners and peers.	5 Recommended
Business Architect	Enterprise and business architecture STPL/4-5	Level 4: Autonomy Works under general direction within a clear framework of accountability. Level 4: Business skills Selects appropriately from applicable standards, methods, tools and applications. Level 5: Influences Organization, customers, suppliers, partners and peers on the contribution of own specialism.	Between 4 - 5
Data Architect	Development and implementation / Systems development	Systems development management **DLMG**	Level 5
Application Architect	Solution architecture ARCH/4		
Infrastructure Architect	Solution architecture ARCH/4	Level: 4	
Business Analyst	Change and transformation ARCH/3	Level: 4	
Information Security Officer	Strategy and Architecture/ Business strategy and planning	Level: 3	
IT Innovation Manager	Strategy and Architecture/ Business strategy and planning	Level: 5	
IT Innovation Specialist	Strategy and Architecture/ Technical strategy and planning	Level: 5	
IT Security Services Manager	Strategy and Architecture/ Information strategy	Level: 5	

Table 32 Roles and Responsibilities Aligned with SFIA (Foundation 2017)

4.8 Chapter Summary

This chapter discussed the Enterprise Architecture (EA) concepts, Organization influence on the enterprise architecture practice, frameworks, and methodologies that assist in managing the lifecycle of EA, the core and cross-cutting domain of EA, and the elaboration of the technology stack.

Next, an in-depth analysis of TOGAF and its components were covered, followed by the Enterprise Architecture conceptual framework explained. Subsequently, the importance of model with the related modelling language that applies to EA practice was narrated.

Then the Capability maturity model, its significance with the proposed comprehensive capability model is covered. Organizations are utilizing The Open Group Architecture Framework (TOGAF) based on open standards to develop the enterprise architecture, to help in their transformation to adopt emerging technologies. The maturity assessment suggested by TOGAF is outdated US Department of Commerce (DoC) IT Architecture Capability Maturity Model (ACMM).

From the past project experience, Comprehensive Capability Maturity Model (CCMM) to assess all the phases of Architecture development was developed. With CCMM it's possible to estimate the maturity with more accuracy.

The CCMM maturity assessment if done holistically across all the phases of Architecture Development Lifecycle, will assists in finding the weakest point of failure. Maturity assessment enables to prioritize the capabilities, thereby ensures the success of the project, also with reduced cost and timeline. Maturity assessment in total will help the organization to choose the right technologies stack that serves the business needs in alignment with the organization vision to realize the strategy.

Then followed by Complementary Framework and Methodologies for TOGAF with its relevance. TOGAF is a generic and descriptive framework for architecture development lifecycle. TOGAF needs to be extended, to make EA practice successful. We have identified the frameworks and methodologies that complements TOGAF and ensures EA success based on the projects executed

Followed by EA tools, the Complementary Modelling languages, Frameworks, and Methodologies covered. As Enterprise Architecture practice generates an enormous amount of documentation, that will be referred in the organization. ArchiMate provides the notation to represent EA model at the higher level. For detail modelling other notation with frameworks and methodologies to manage EA artefacts that are generated from strategy to implementation to business as usual.

So, it is critical to have an EA tool with a centralized repository to manage the artefacts that will be possible to do impact analysis to make decisions. So, it is very crucial to have EA tool that needs to be connected end to end. As Organizations are moving cautiously towards digitization path to utilize the capability of emerging technologies, service model and Opex business model. EA tool will start to take off in next one or two years as it provides transparency and real-time information that are critical for success of digital transformation.

Finally, Enterprise Architect Skills, Roles, and Responsibilities discussed. Enterprise Architecture practice requires various skills, roles, and responsibilities. The essential skills, roles specifics to each phase of ADM, key roles, and duties were identified then mapped with the SFIA frameworks.

Furthermore, the linking of the conceptual model regarding the TOGAF Architecture Framework has been applied to the primary mode of research.

5. Research Action Study

This chapter discuss about the case studies that the author was involved with, that has been used for this chapter of the thesis.

5.1 Approach of Enterprise Architecture

For all the case studies, TOGAF is the fundamental framework,

- Though every Enterprise has "Architecture," most often it has just happened "by necessity" and not "well designed and truly architected."
- TOGAF referred as an EA Book of Knowledge and a reference document.
- TOGAF customized and enriched with other best practices.
- TOGAF as the base as it is an "inclusive "framework combined with others such as Zachman, EAP, FEAF, DODAF, and so on, as needed.
- TOGAF provides "WHAT" need to be done for each phase of ADM. To do "HOW" methodologies that are relevant to each phase are chosen, E.g., BABoK, COBIT, PRINCE 2, ITIL, and so on.
- EA is still evolving its 50% science and 50% art. The latter requires much creativity at the same time following certain scientific principles, rules, and guidelines.

5.1.1 Fundamental Framework: TOGAF

- As it is managed by the Open Group
- Based on open standards
- Clearly separates the Architectural Building Blocks that address organization capabilities from Solution Building Blocks specific to products
- Evolving from contribution of Fortune 500 companies and standard bodies
- Well defined Architecture development method that addresses
    - Planning the scope,
    - Analysing the architecture,
    - Determining the suitable products,
    - Migration planning and implementation based on the organization proven frameworks, ensuring the project implemented meets its objectives,
    - Though typically Architecture Development method is a waterfall, with its requirements management that connects all the phases of ADM, it's fully agile. So, business changing needs are addressed at whatever stage of the architectural development phase,
    - As TOGAF is a descriptive framework, it's give the ability to choose the frameworks that addresses the needs of the project and Organization,
    - Architecture Review Board consisting of Management and Business users which Proactively assess the current architecture if it addresses the business needs, if not it recommends another architecture development cycle.

General steps followed for the projects

- What are their requirements/outcomes?
- Why the organization wants to do
- What is the Opportunity short & long term.
- What is the current and the future Problem
- The best approach to achieve success
- To determine the scope of the project
- Identify & Categorize the Key stakeholders

- Determine their objectives and identify their needs based on Maslow Hierarchy
- Identify the Maturity frameworks that are relevant to the project scope
- Tailor the process to suit the project
- Perform maturity assessment
  - Determine where to do the assessment to be done in detail
  - Who to be involved in the assessment
- Identify the Suitable framework, methodology, modelling language that suits the enterprise
- Define the roadmap to improve the capability
- Define the Organization structure
- Determine the Skills to make the EA project successful.

5.2 Introduction to Case Studies

The type of case studies referred in this thesis are of the following:

- Enterprise Architecture Capability Building and Practice set-up
- Proposal for Enterprise Architecture
- ArchiMate Modelling Capability Building and Practice set-up

5.3 Case Study: Education Ministry

5.3.1 Introduction

Project type: Enterprise Architecture Capability Building and Practice set-up.

Assess and recommend Enterprise Architecture practice for an education ministry to reform its education system.

5.3.2 Organization

A Government Ministry a functional organization type, where projects were managed based on the strong matrix structure (Enterprise Architecture Office reporting to Project Management Office).

5.3.3 Background

To realize the government vision of knowledge-based economy various strategies was envisioned. Project Management Office(PMO) was set up to manage the programs. As PMO was not able to deliver the results as expected, Enterprise Architecture practice was initiated.

5.3.4 Motivation

To incorporate education to the masses and drive the nation towards a knowledge-based economy

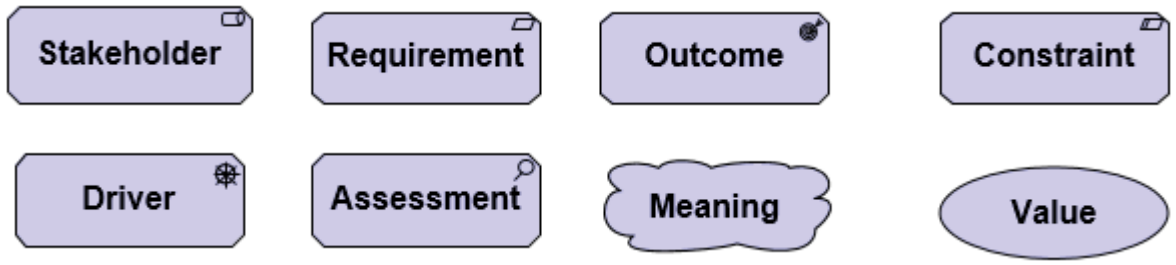


Figure 71 ArchiMate Notation Legend

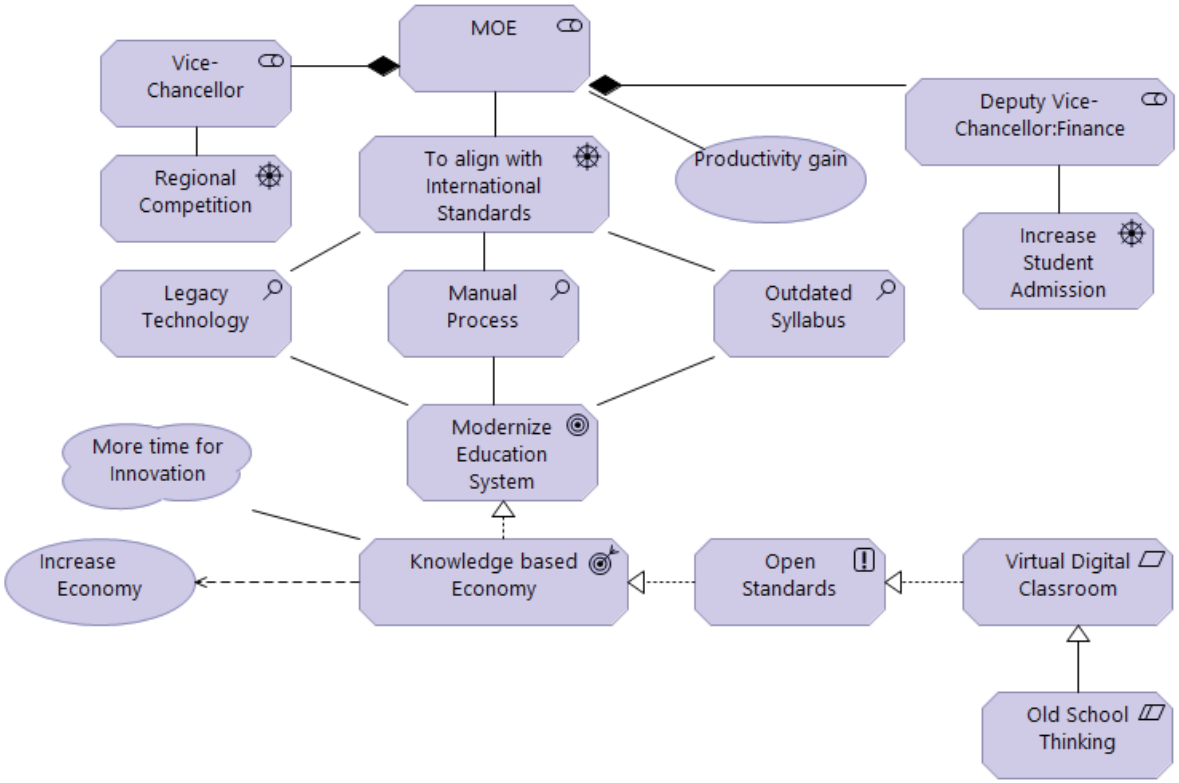


Figure 72 Drivers influencing the change

5.3.5 Objective

- A formative Enterprise Architecture maturity assessment of Ministry of Education.
- To set up Enterprise Architecture Framework based on the gap analysis.
- To hand-hold Ministry of Education to develop & implement Enterprise Architecture practice.

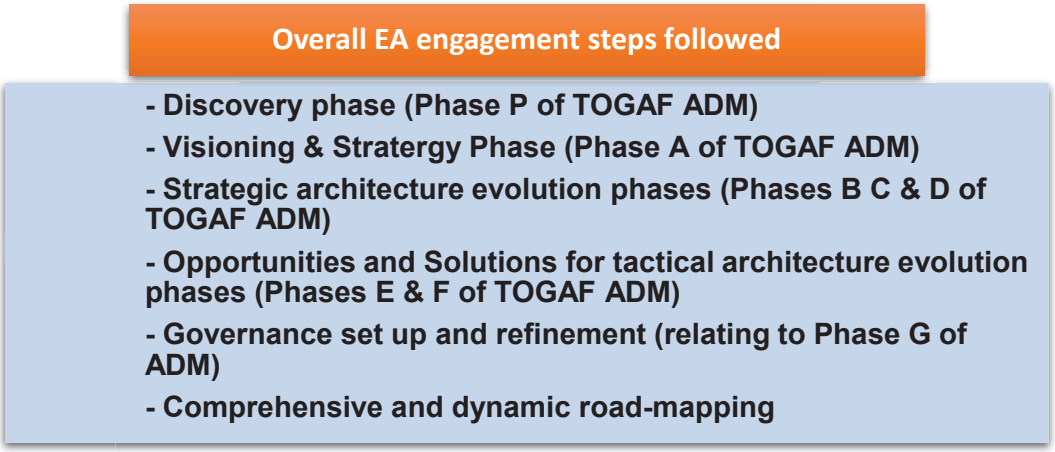


Figure 73 Overall EA engagement steps followed

5.3.6 Overall Observation and Key findings

The interview was conducted before starting the project and after completion. They were eight stakeholders involved in the project. The stakeholders had more than ten years' experience working in Information Technology with majority from Project Management background.

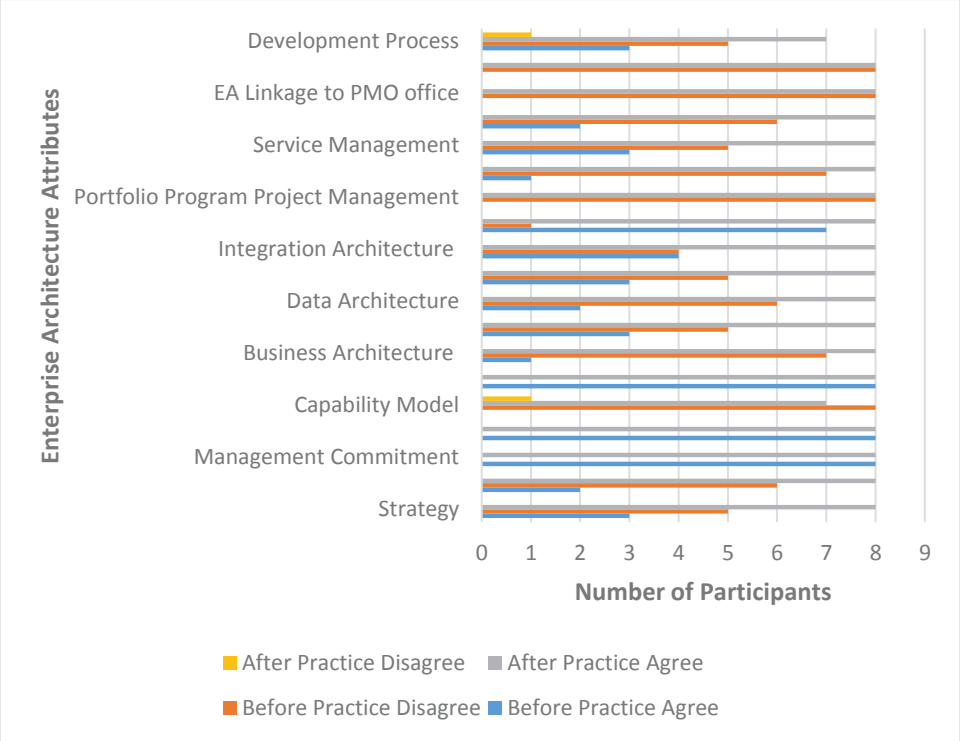


Figure 74 MOE Enterprise Architecture Approach

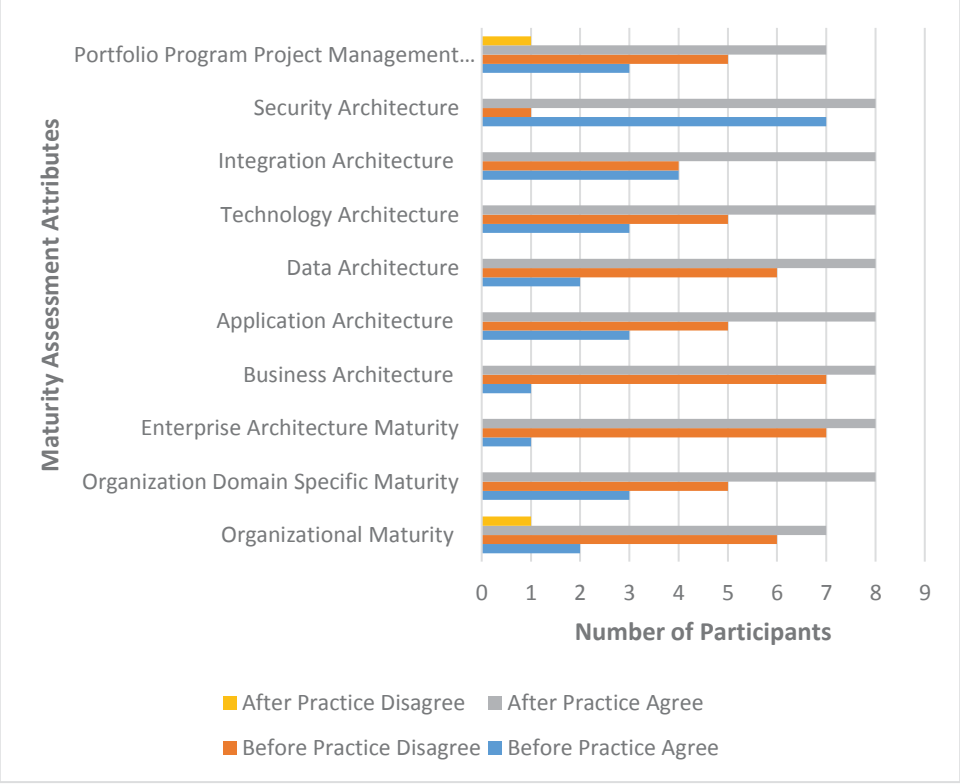


Figure 75 MOE Enterprise wide Maturity Assessment

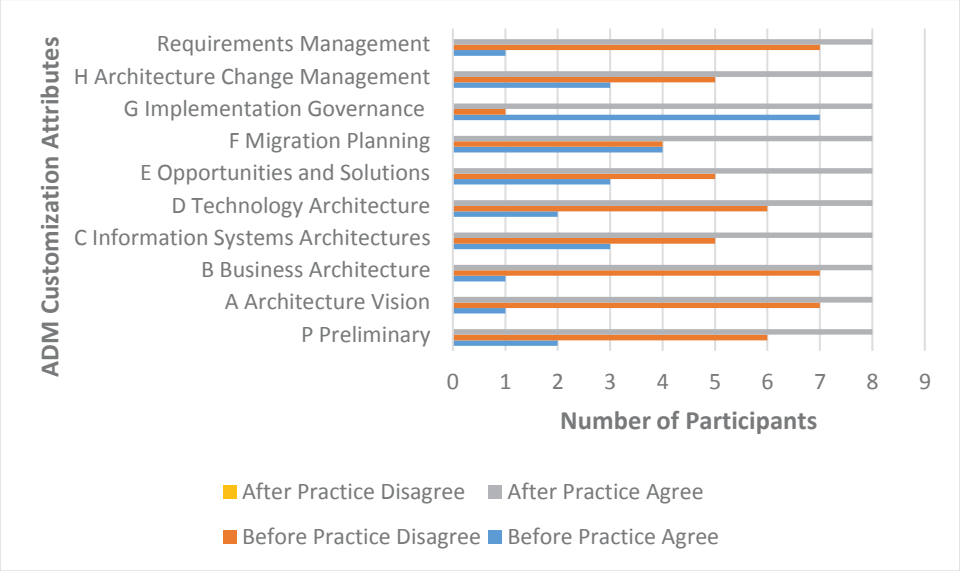


Figure 76 MOE ADM Customization

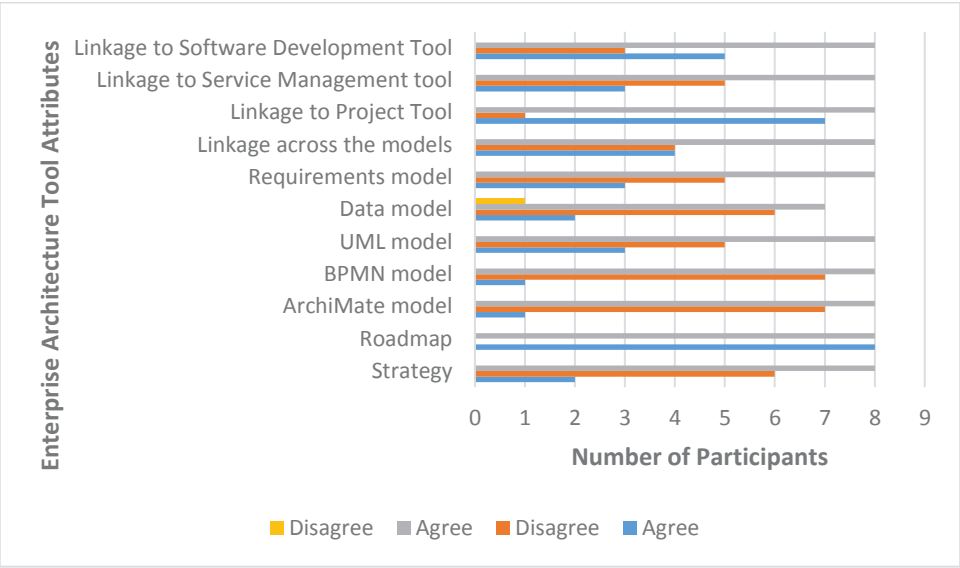


Figure 77 MOE Usage of Enterprise Architecture Tool

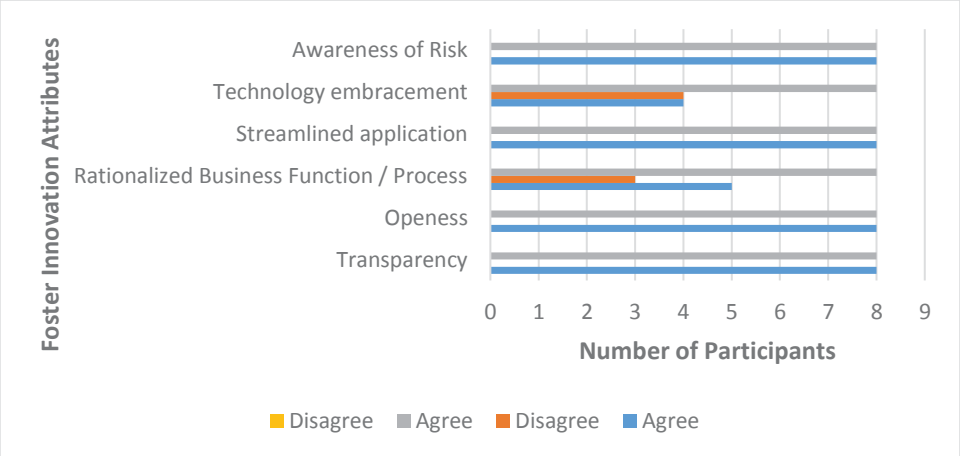


Figure 78 MOE Foster Innovation

As most of the participants were from Project Management, the initial assessment gave poor results. But after capacity building and project execution the participants realized the benefits of Enterprise Architecture, so the results were good after project completion.

TOGAF Architecture Capability Maturity Model (ACMM) tailored specifically to the project was used for maturity assessment.

5.3.7 Summary of Key Recommendations

Establishing EA as a practice with the proposed new model.

Increase maturity of PM practices

Establish ITIL as a practice

Establish Data Governance, Master Data Management as a practice

Automate Business Process through BPM tools

Figure 79 Summary of Key Recommendations

5.3.7.1 Proposed EA positioning across the ministry

The key finding was that Enterprise Architecture was managed by PMO office. The PMO that set newly, had no maturity in its process and practices. Strategic initiatives led as projects. However, projects are temporary endeavours with end date whereas strategic efforts go beyond the project lifecycle. Strategic initiatives after implementation need to be validated if objectives are met. Enterprise Architecture ensures the objectives are met, if not another programme or project is initiated.

In general, PMO wants the project completed at the earliest, yesterday. While Enterprise Architecture(EA) want to future proof that involves time and cost. As EA controlled and managed by PMO, the former had no say in the outcome of the projects. So, new structure where Enterprise Architecture Office manage PMO was recommended.

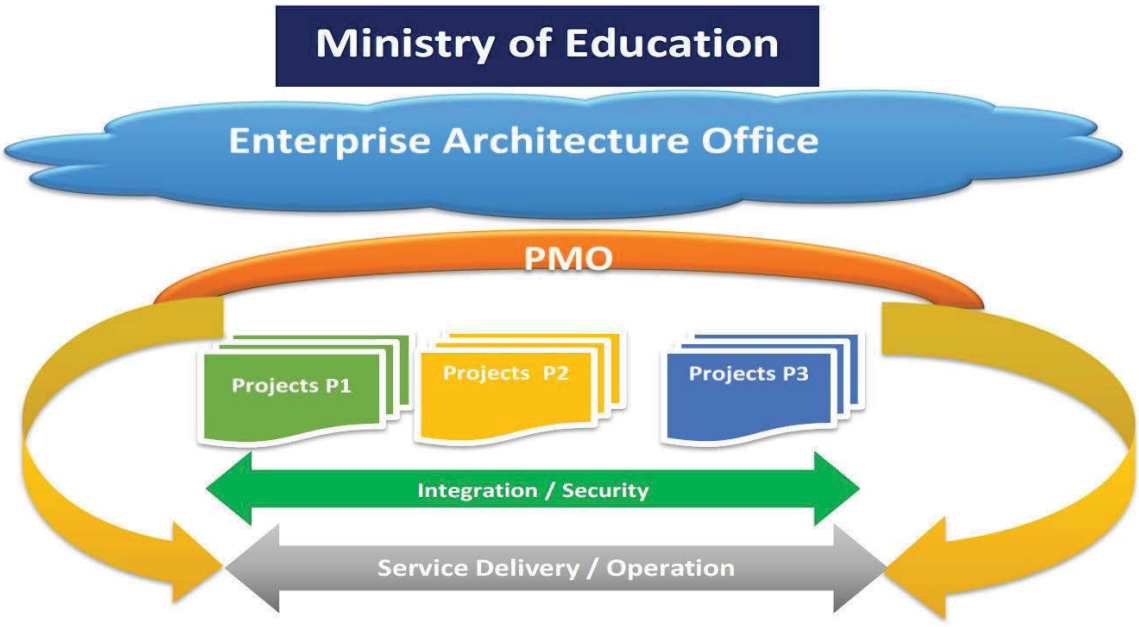


Figure 80 Proposed EA organization model

The proposed new model had the Enterprise Architecture Office (EAO) directly working and reporting to the ministry and overseeing PMO, which will ensure the success of strategic initiatives.

Also, it was proposed the EA can be successful with Whole of Government approach, rather than single ministry. As the weakest chain can break, so the process to be across the Government.

5.3.8 Conclusion

The success of the enterprise architecture is achievable with the projects implementing organization reporting to EAO or with PMO and EA working in balance organization matrix.

"Perfection is not attainable, but if we chase perfection we can reach excellence."
- Vince Lombardi

5.4 Case Study: Ministry of Health

5.4.1 Introduction

Project type: Enterprise Architecture Capability Building and Practice set-up.

Capacity Building, Assess and recommend Enterprise Architecture approach for Counterfeit Medicine eradication.

5.4.2 Organization

A Government Ministry with functional organization type, where projects managed in a weak matrix structure.

5.4.3 Background

The national e-Health strategies are to provide better services for citizens by streamlining and supporting the reuse of public sector information systems, while reducing duplication and costs. Enterprise Architecture practice was initiated to realize the strategy.

5.4.4 Motivation

Counterfeit Medicine

There was a distribution of illegal counterfeit medicines. Wholesalers were distributing substandard medication, and it subsequently sold by pharmacies. Nearly 4/5 of the medication was imported.

Due to above, health of the people getting affected, loss in the revenue for the Government and cost to treat the Citizens due to counterfeit and substandard medicine.

5.4.5 Objective

- Capacity building through TOGAF workshop
- Enterprise Architecture Maturity assessment of the current state of Ministry of Health: strategy to implementation practices.
- To build national capacity in EA
- Identify the methodology that is practical, and tailor based on the organization culture.

5.4.6 Process Followed

Stage 1: Discovery Phase: P, A, B, R

- Prepare the organization for EA projects based on TOGAF.
- Create an Architecture Capability, customizeTOGAF framework, select the tools, and define the EA Principles.
- Understand the current organization, business process (manual / automated)
- Understand the available International Standards
- Determine the scope, constraints, and expectations for the EA project. Create the Architecture Vision.
- Develop the high level Baseline and Target Architecture and analyze gaps.
- Assure each phase of a TOGAF project validates the business requirements.

Stage 2: Analysis & Develop Phase : C, D, F, R

- Analyise & Develop architectures domains: Business, Applicaion, Data, Technology, Secrity
- For each domain determine the Baseline and Target Architecture and analyze gaps.

Stage 3: Planning Phase: E, F, R

- Determine initial implementation planning of delivery for the building blocks identified in the previous phases.
- Determine incremental approach and identify Transition Architectures.
- Develop detailed Implementation and Migration Plan to move from the Baseline to the Target Architecture in alignment with the business objectives.

Stage 4: Implementation Phase: G, H, R

- Define the architectural oversight for the implementation.
- Develop and issue Architecture Contracts.
- The implementation project to conforms as per defined architecture.
- Architecture always needs to meet the changing business requirements, ensured by monitoring and implementing changes as required

5.4.7 Overall Observation and Key findings

The interview was conducted before starting the project and after completion. They were twelve stakeholders involved in the project. The stakeholders had more than ten years' experience working in Information Technology with majority from operations and few from business analysis.

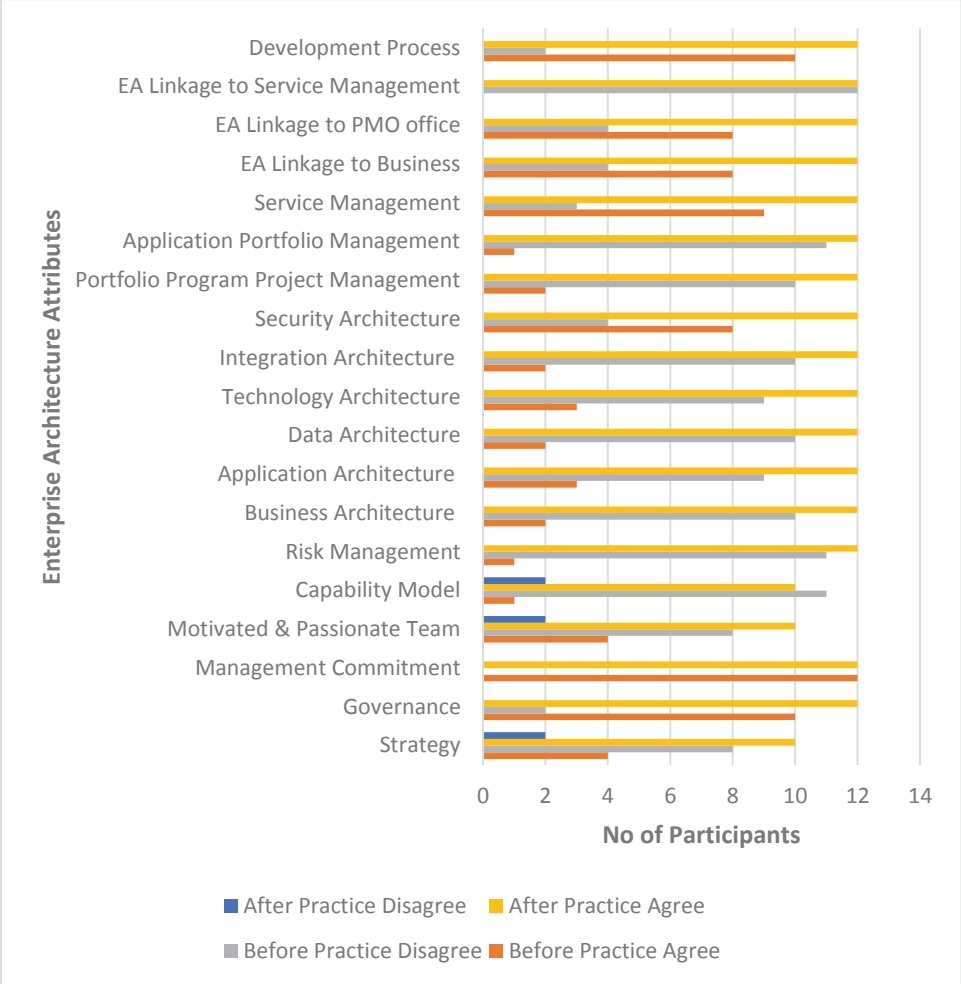


Figure 81 MOH Enterprise Architecture Approach

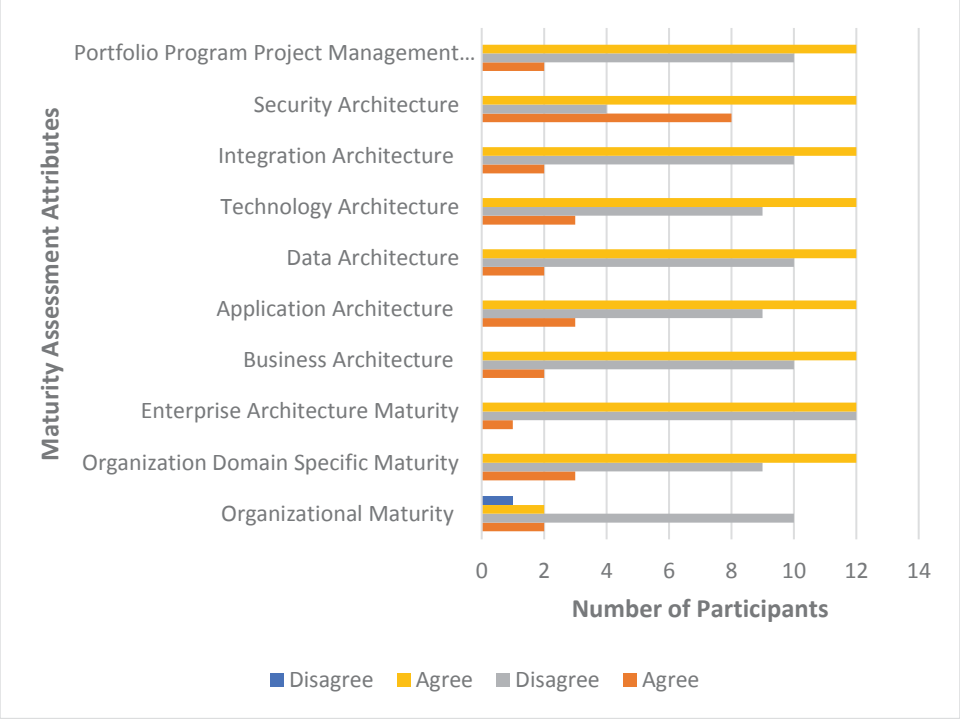


Figure 82 MOH Enterprise wide Maturity Assessment

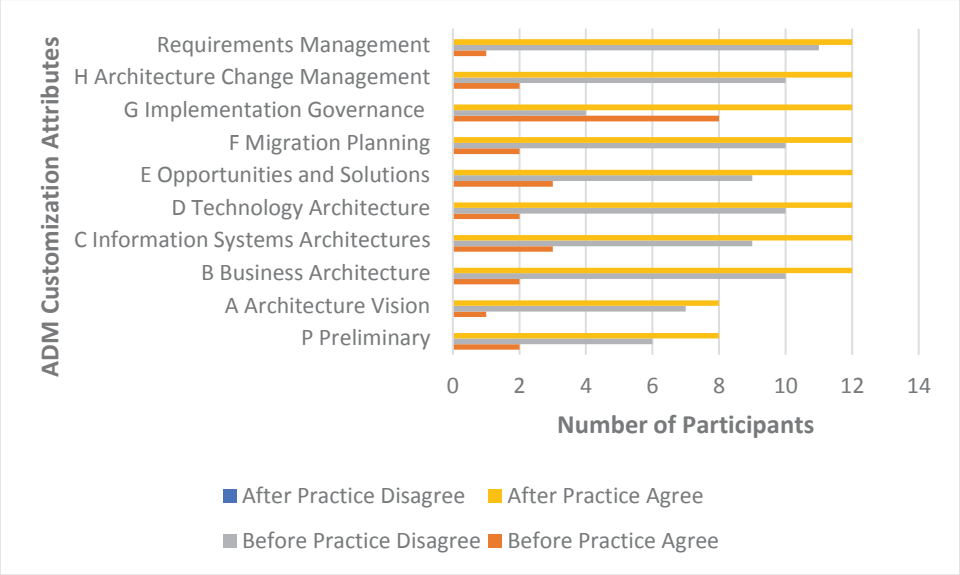


Figure 83 MOH ADM Customization

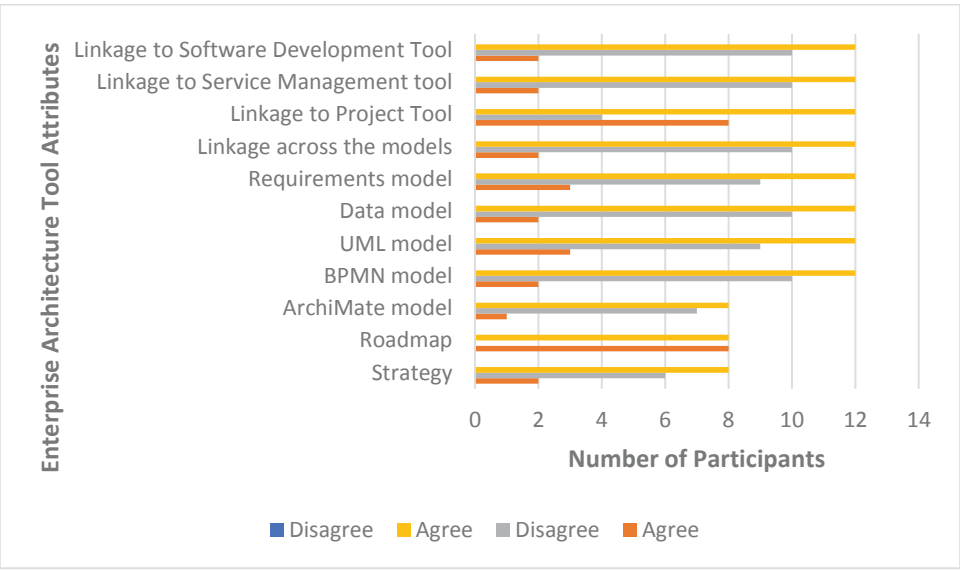


Figure 84 MOH Usage of Enterprise Architecture Tool

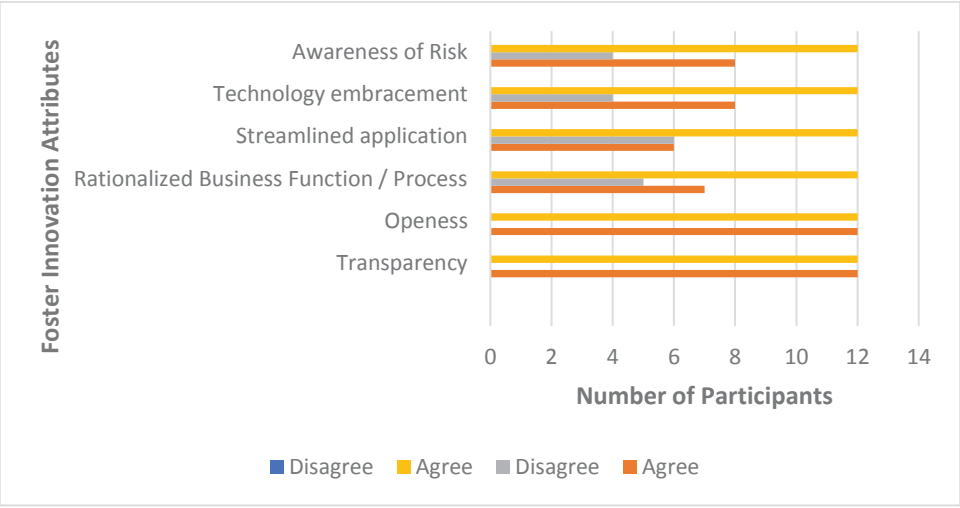


Figure 85 MOH Foster Innovation

As most of the participants were from the operation and business analysis, the initial assessment gave poor results. However, after capacity building and project execution, the participants realized the benefits of Enterprise Architecture, so the results were excellent

5.4.8 Conclusion

Proposed, Medicine Safety Information Management Suite, a centralized system to issue, manage and track medicine of the country.

Health Information Management System Suite, to maintains the record of citizens from birth to death. The information of Health Information Management System is the Single Source of Truth that needs to be interoperable with other systems of the Government.

5.5 Case Study: Financial Institute

5.5.1 Introduction

Project type: Proposal for Enterprise Architecture

Propose Enterprise Architecture approach for trading platform transformation for financial institute.

5.5.2 Organization

One of the significant financial Institute that provides financial services.

5.5.3 Background

A Financial Institute provides service as comprehensive clearing, compliance services, practice management programs, training, research for independent financial advisors and financial institutions. To revamp the current trading platform to reduce the time of service provisioning, reduce cost and increase quality through cutting edge proven technology.

5.5.4 Motivation

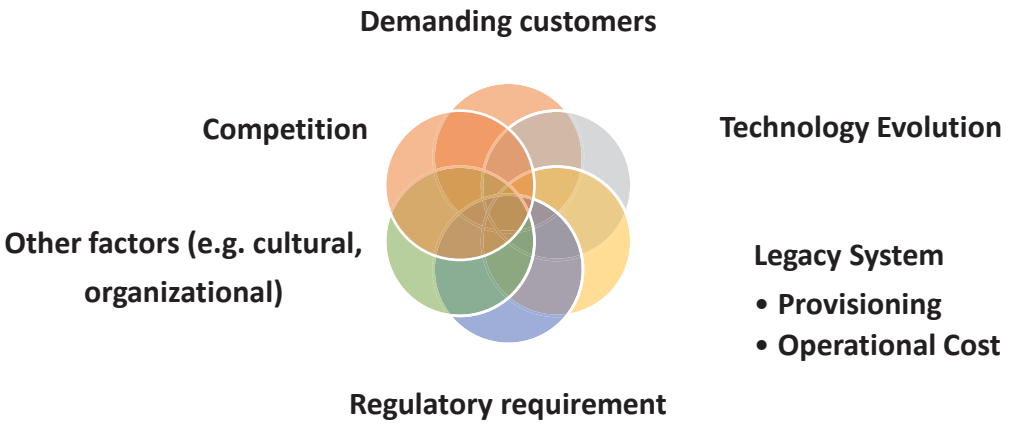


Figure 86 Drivers influencing the change

5.5.5 Objective

- Proposal for migrating to a Multi-tenancy trading platform using an Enterprise Architecture approach.

5.5.6 Process followed

Characteristics of multitenant environment, each tenant operates in a logically isolated, but physically shared environment.

5.5.7 Overall Observation and Key findings

The interview was conducted before doing the proposal. The input was taken from 5 stakeholders with majority of their experience in presales and project management. Management background. Before preparing the proposal only the interview was conducted as an input to prepare the proposal.

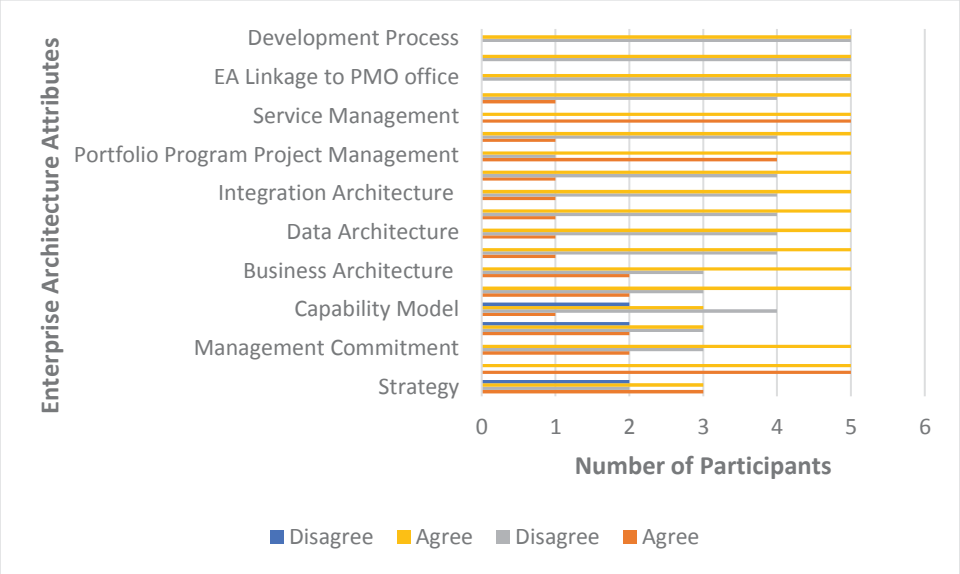


Figure 87 Finance Institute Enterprise Architecture Approach

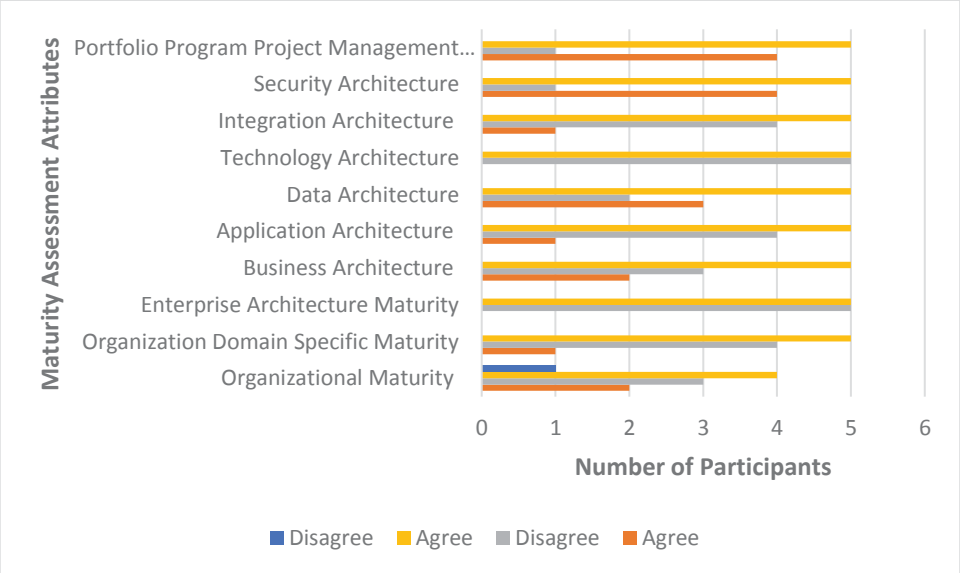


Figure 88 Finance Institute Enterprise wide Maturity Assessment

5.5.8 Conclusion

Technology is inevitable to run the business, especially for the large organization. It is not practical to upgrade the core systems in pace with the ever-changing technology. Also, it not wise to ignore to adopt the cutting-edge technology.

Enterprise Architecture approach enables to analyze business needs and recommend technology stack that suits the organization based on the culture, risk appetite, and business model,

EA approach identifies the actual building blocks from the architectural perspective, thereby reducing the risk of technology stack or vendor lock-in.

5.6 Case Study: Bank

5.6.1 Introduction

Project type: Enterprise Architecture Capability Building and Practice set-up.

Assess and recommend Data Management for a Bank, based on Enterprise Architecture Approach.

5.6.2 Organization

A leading state-owned Bank with functional organization type, wherein projects were managed in a strong matrix structure.

5.6.3 Background

The retail bank was replacing its core banking system. The data management was done by a dedicated team. Bank consisted of various banking products that had their backends composed of different types of databases. To streamline the data management, to create an awareness for large structured and unstructured data, an EA approach was initiated.

5.6.4 Motivation

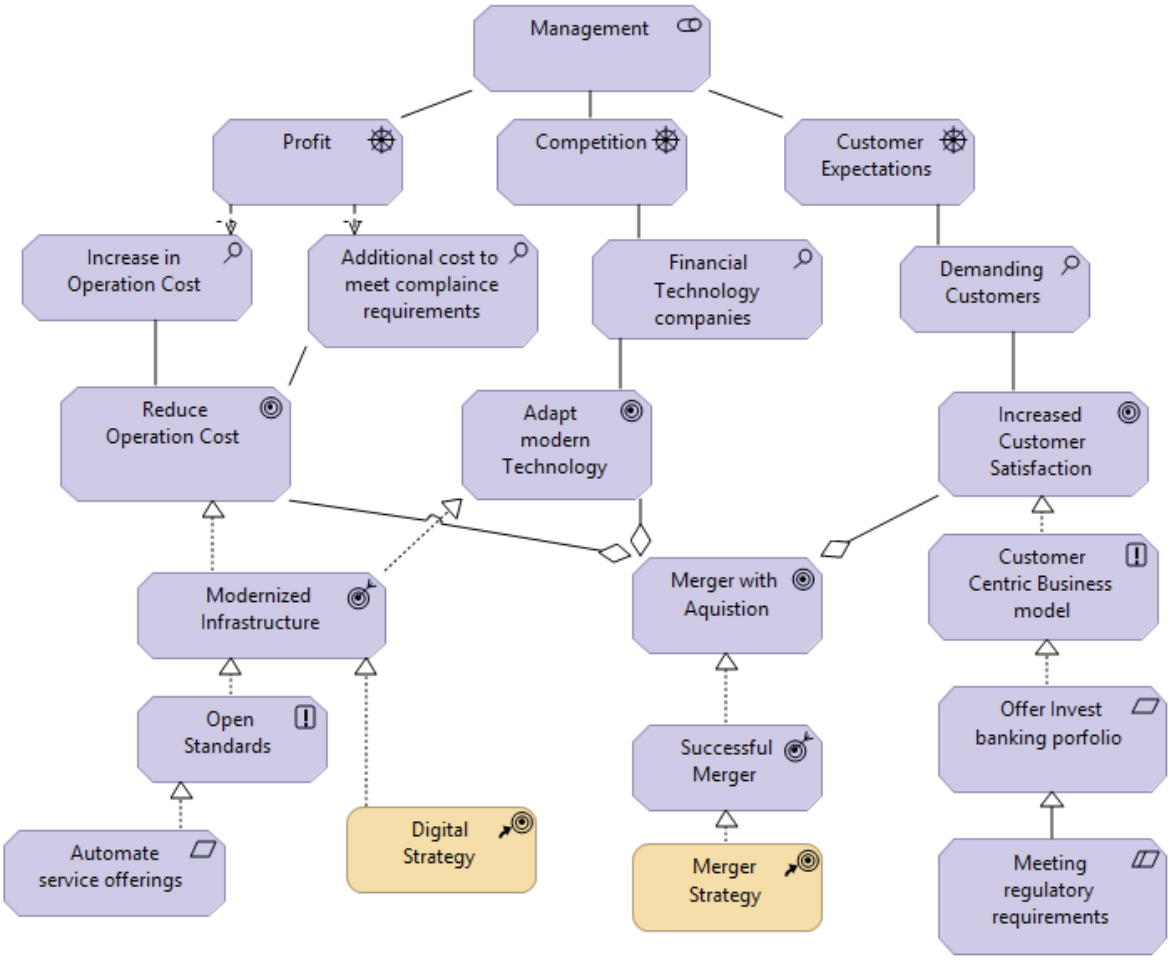


Figure 89 Drivers influencing the change

5.6.5 Objective

- To Introduction TOGAF ®. 9.1 framework, its scope, benefits and how to use it efficiently,
- To use common notation based on open standard modelling language ArchiMate,
- To standardise and rationalise use of the modelling tool across the spectrum in the bank,
- To establish common repository for collaboration,

- To introduce data architecture frameworks that are widely accepted by the banking industry,
- To build agreement for applicable & practical view of data management functions.

5.6.6 Process Followed

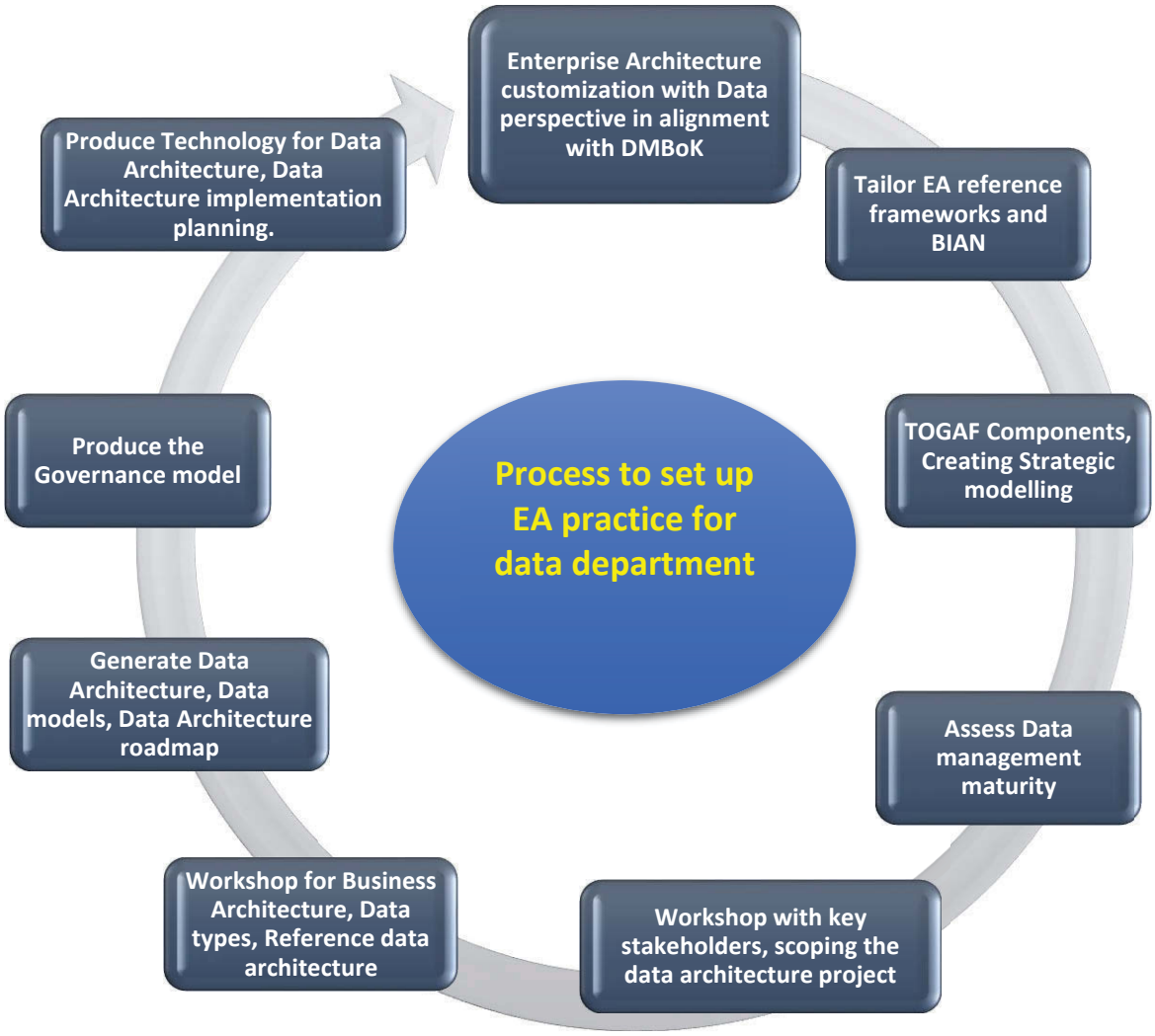


Figure 90 Process to set up EA practice

5.6.7 Overall Observation and Key findings

The interview was conducted before starting the project and after completion. They were twelve stakeholders involved in the project. The stakeholders had more than ten years' experience working in Information Technology mainly in banking domain with majority from Operation Service Management and Data Management background.

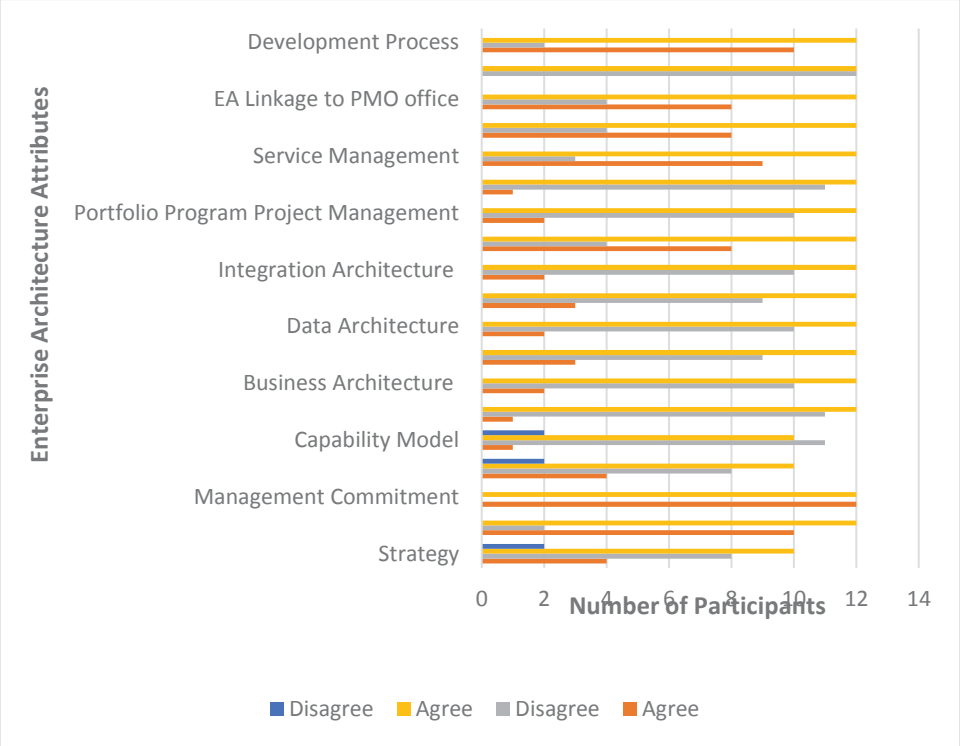


Figure 91 Bank Enterprise Architecture Approach

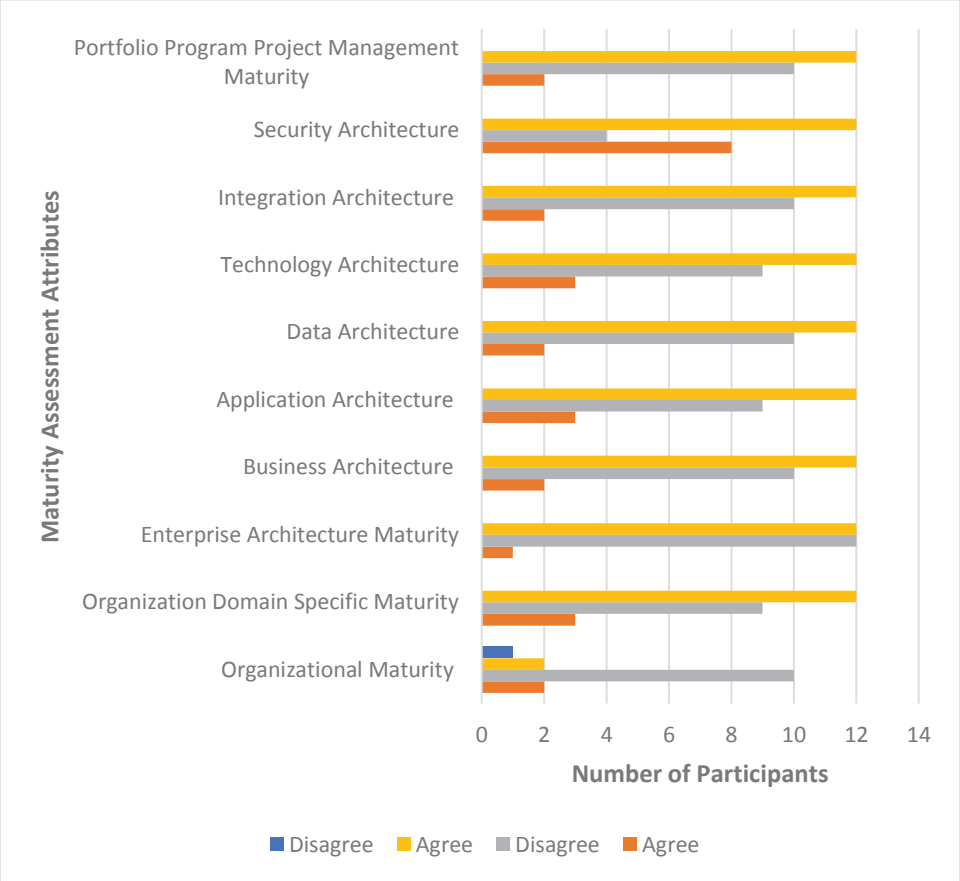


Figure 92 Bank Enterprise wide Maturity Assessment

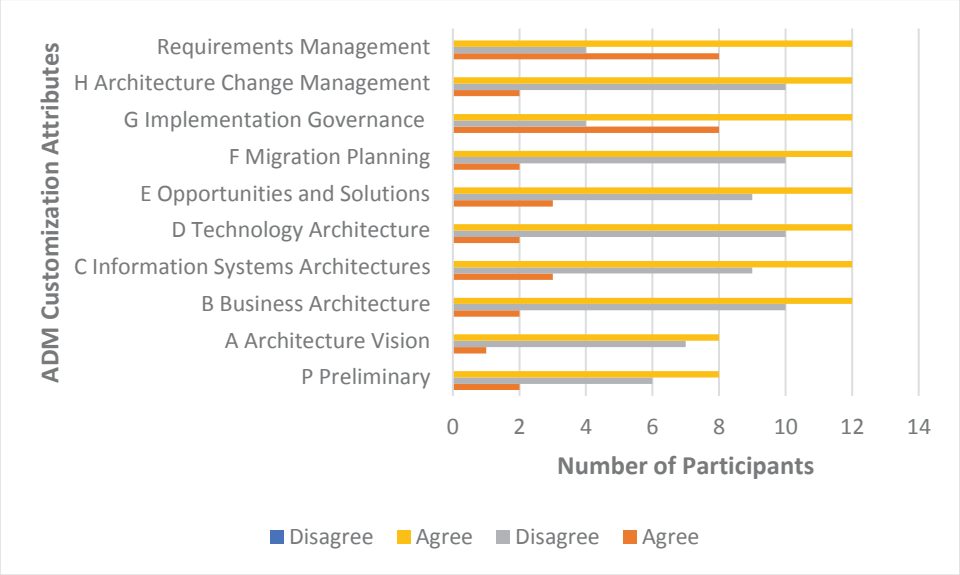


Figure 93 Bank ADM Customization

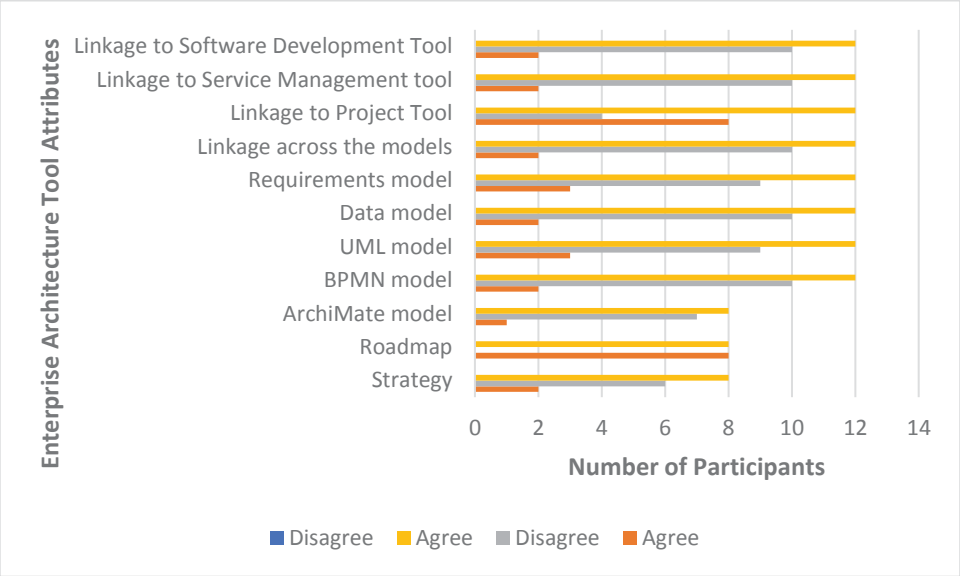


Figure 94 Bank Enterprise Architecture Tool

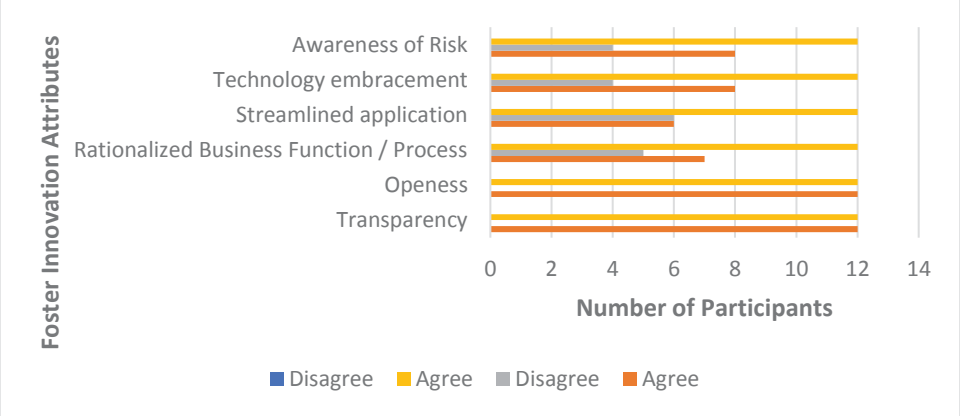


Figure 95 Foster Innovation

As most of the participants were from Operation Service Management and Data Management background, the initial assessment gave poor results. But after capacity building and project execution the participants realized the benefits of Enterprise Architecture its value that going to add to the data management, so later stage the results were good.

5.6.7.1 Conclusion

The success of the enterprise architecture is achievable with the staff understanding the importance of EA. Staff needs to be imparted with the knowledge of EA in alignment with the data management practice.

Data is the lifeblood in the digital world and especially for a bank data its vital. For a bank it is critical to have process and structure based on proven methodology. Especially for a state-owned bank though it is not profit motivated, but able to give better service to citizens with reduced cost.

5.7 Case Study: Environment Ministry

5.7.1 Introduction

Project type: Enterprise Architecture Capability Building and Practice set-up.

To establish Enterprise Architecture Practice for Department of Land Management.

"It had been estimated that 80% of the informational needs of local government policy makers are related to geographic location"
- Robert Williams

5.7.2 *Organization*

A Government department, with a functional organization type, where projects were managed based on the strong matrix structure

5.7.2.1 Background

The new land law focuses on economic, administration, with mechanisms to monitor and evaluate land usage towards building the modern, transparent and efficient land management system. It is always a challenge to authentic and sustain administration of national land resources. It adds more complexity to develop a digital Land Information Systems (LIS) to support the availability of information and efficient processing of land transactions. A holistic approach to implement LIS that can be quickly deployed and to maintain, an Enterprise Architecture practice was initiated.

5.7.2.2 Motivation

- Changes in the land law
- The land data is inconsistent and inaccurate.
- Manual and tedious, time-consuming process for land registration.
- The tedious process to manage land maps, tables of the land prices
- Overseeing the operations which are manual and time consuming
- Organization transformation from manual land registration process to semi-automated
- International standards compliances

5.7.3 *Objectives*

EA practice to realize the vision:

- Analog map to digital transformation of geographical data
- A system capable of supporting paperless land transaction

- A Centralized Multipurpose Land Information Systems for the country

The land administration and its related resources are dependent on the land information to manage it efficiently, and effectively. Land-related data needs to be integrated, analyzed, and distributed to manage the land usage efficiently

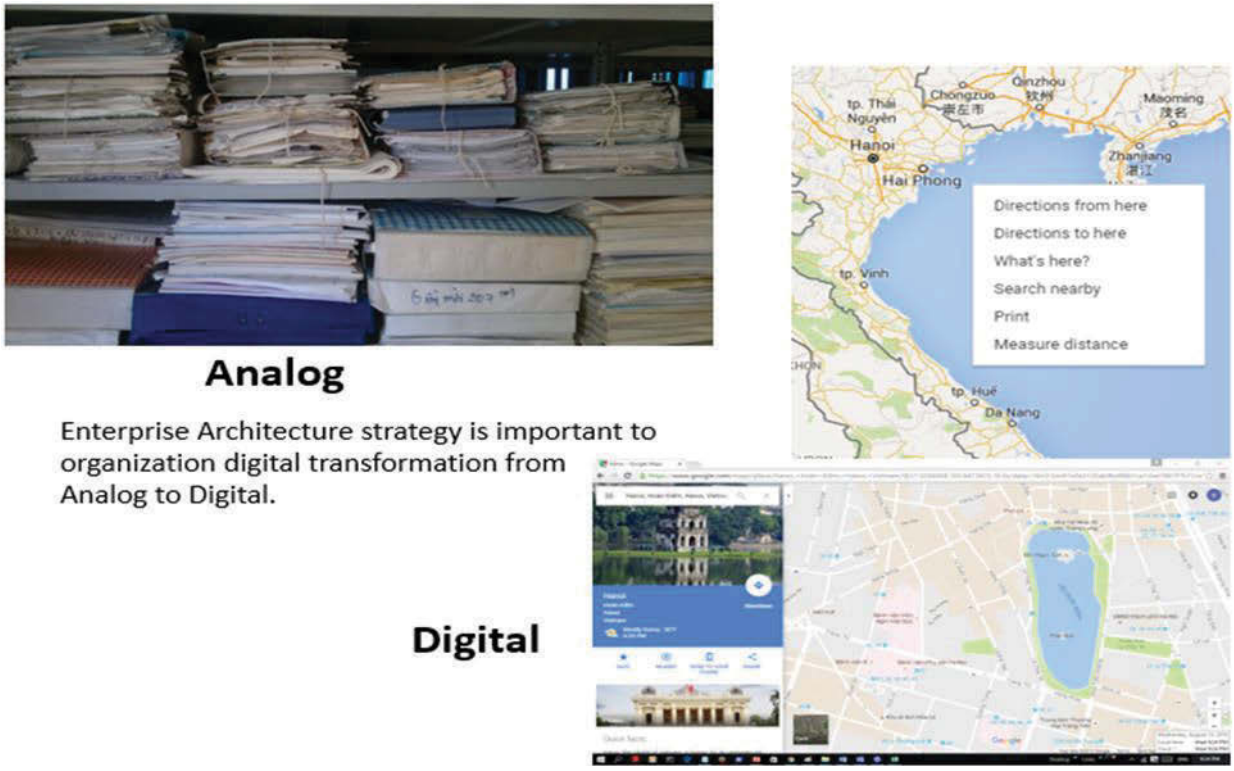


Figure 96 Analog to Digital

5.7.4 Process Followed

In the first phase participants were introduced to the concepts and benefits of EA practice. After two months, participants were trained on the ideas of TOGAF, ArchiMate with a tool based on a simple case study. Finally, after two months an EA project kicked off with the selected 15 participants consisted of Architects, project managers, business users, operations, developers and domain experts. Series of workshops conducted to understand the current As Is status of the current assets, processes. Then it was followed by understanding the land laws to get the requirements, to understand the business rules, functions, process and the service to be exposed.

Based on all the above input the target architecture was determined. To realize the target architecture roadmaps were proposed.

5.7.5 Overall Observation and Key findings

The interview was conducted before doing the proposal. The input was taken from 20 stakeholders with mixed team from operations, development, project management and domain experts from Geo Information Systems.

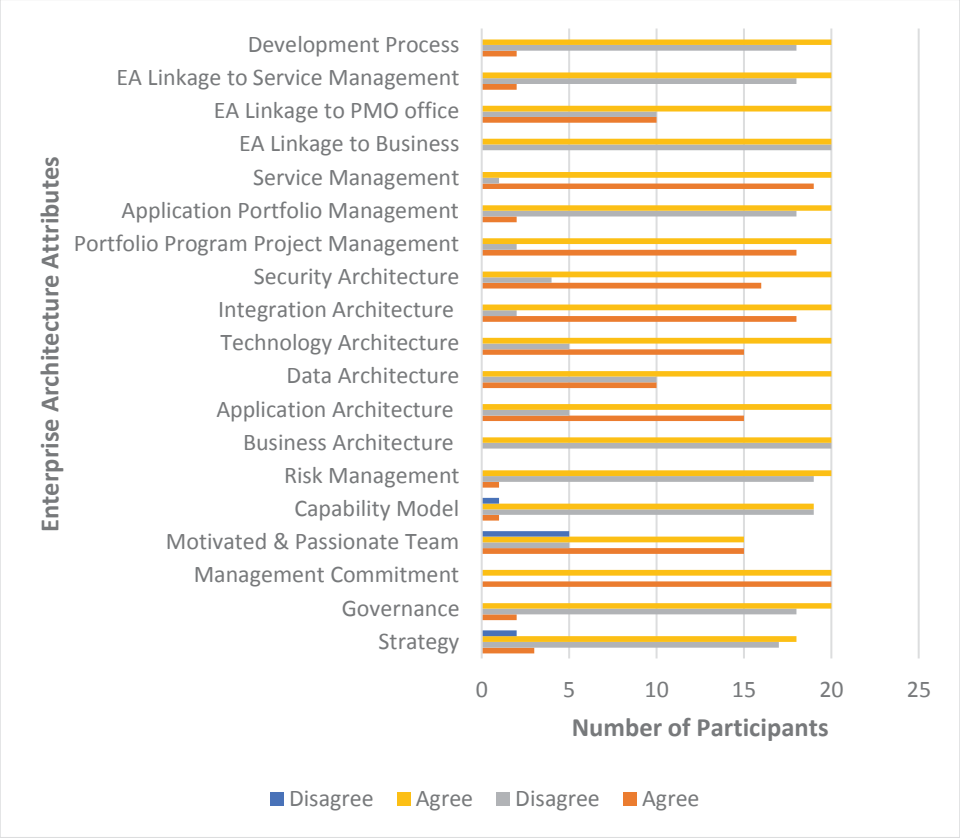


Figure 97 ENV Enterprise Architecture Approach

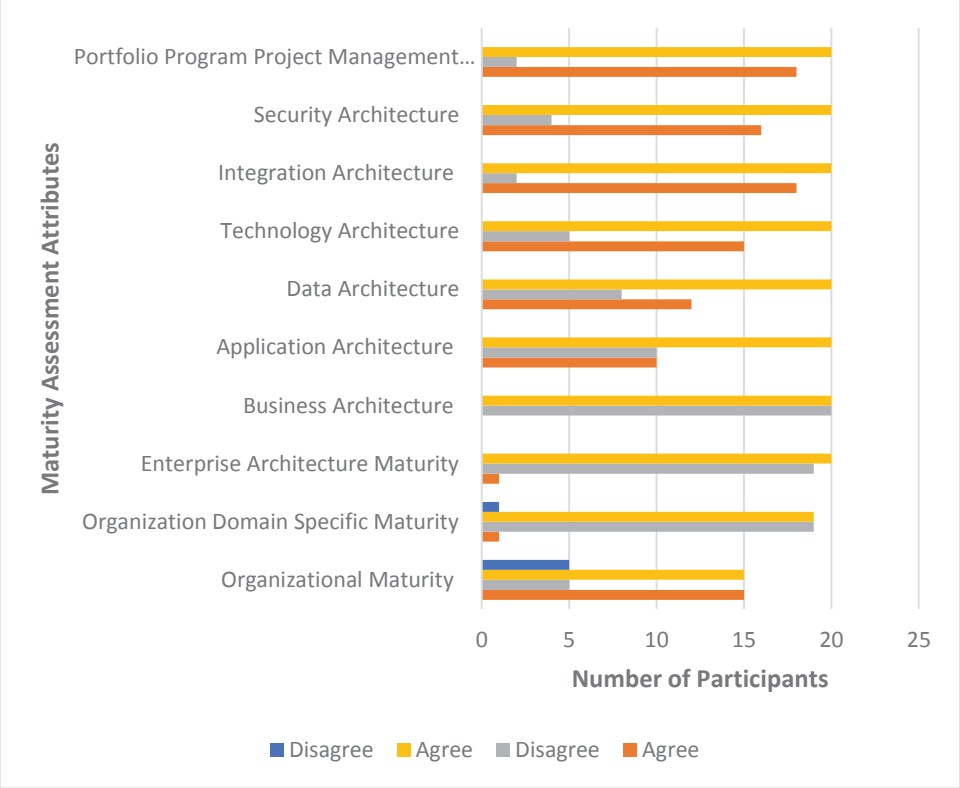


Figure 98 ENV Enterprise wide Maturity Assessment

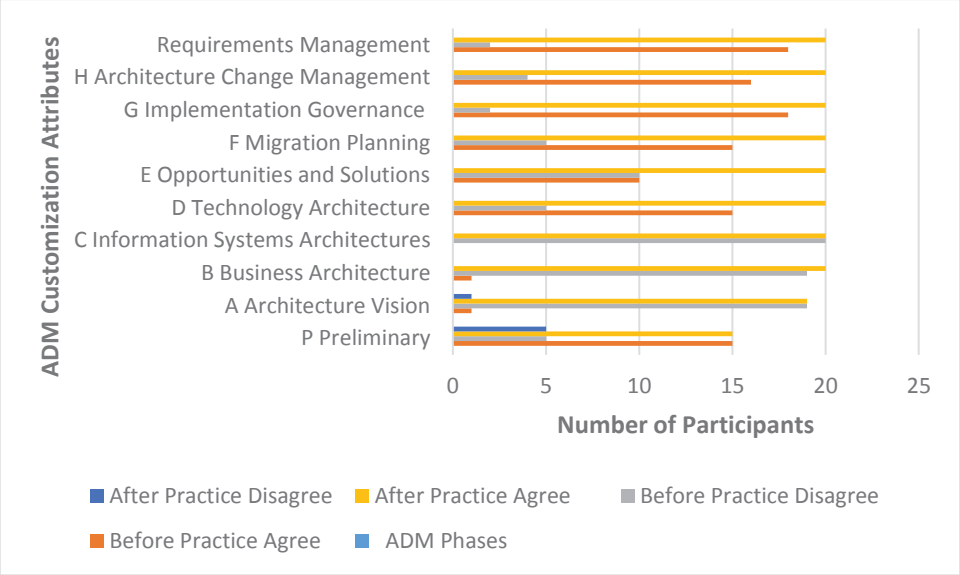


Figure 99 ENV ADM Customization

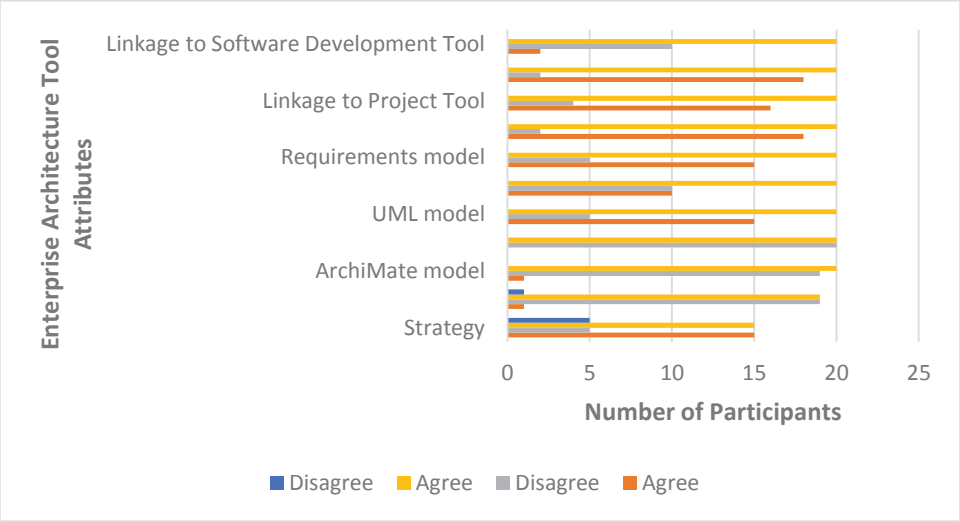


Figure 100 Enterprise Architecture Tool

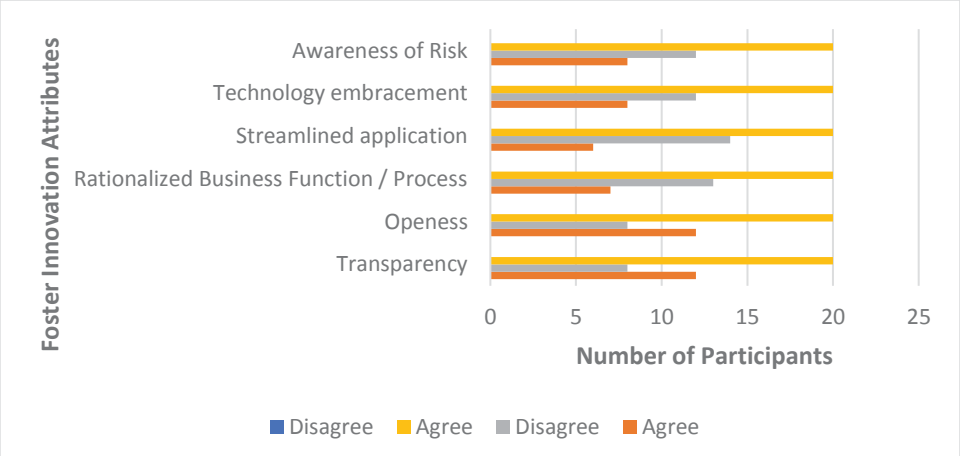


Figure 101 ENV Foster Innovation

As most of the participants were from operations, development, project management and domain experts from Geo Information Systems, the initial assessment was above average, as participants were well trained, and awareness was created of the importance of EA approach its benefits. But after capacity building and project execution the participants were able to appreciate the benefits of Enterprise Architecture, its contribution for digital transformation, with Centralized Multipurpose Land Information Systems that enables paperless land transaction.

5.7.5.1 Conclusion

EA practice is the cultural change for an organization. The staff needs to be exposed to the EA knowledge in a phased manner. The selected EA team after knowing the concepts and benefits will be able to provide valuable information. The team to consist of Architects, project managers, business users, operations, developers and domain experts. Then with the team involved to understand the As Is status, Identify the requirements, determine the target architecture. Then to realize the target architecture roadmaps were proposed.

5.8 Case Study: Utility Organization

5.8.1 Introduction

Project type: ArchiMate modelling Capability Building and Practice set-up.

Capacity Building, Assess and establish modelling approach across the organization.

5.8.2 Organization

A logistics company with functional organization type, where projects managed in a balanced matrix structure.

5.8.3 Background

An organization was upgrading the financial systems. Organization had an enterprise architecture practice, but it was not well used. The models existed were based on Visio that was modeled differently by Architects based on their perception. To standardize the modelling practice ArchiMate modelling was initiated.

5.8.4 Motivation

To standardize modelling practice and establish uniformity across the organization to minimize the ambiguity of modelling.

5.8.5 Objective

- Capacity building in ArchiMate modelling
- To establish modelling practice across the organization

5.8.6 Process Followed

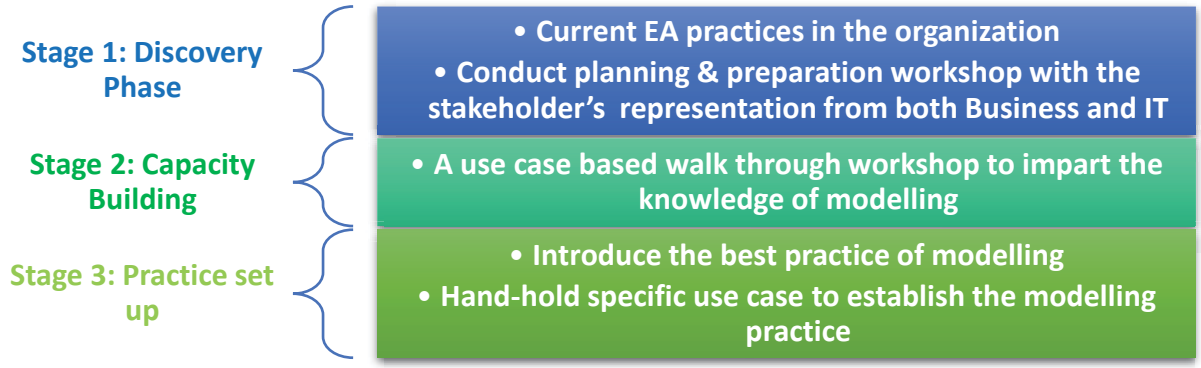


Figure 102 Utility ArchiMate Capacity Building Process followed

5.8.7 Overall Observation and Key findings

The interview was conducted before starting the project and after completion. They were ten stakeholders involved in the project. The stakeholders had more than fifteen years' experience working in Information Technology with majority from Architecture and Project Management. The initial assessment was above average as they were aware of the importance of modelling and tool.

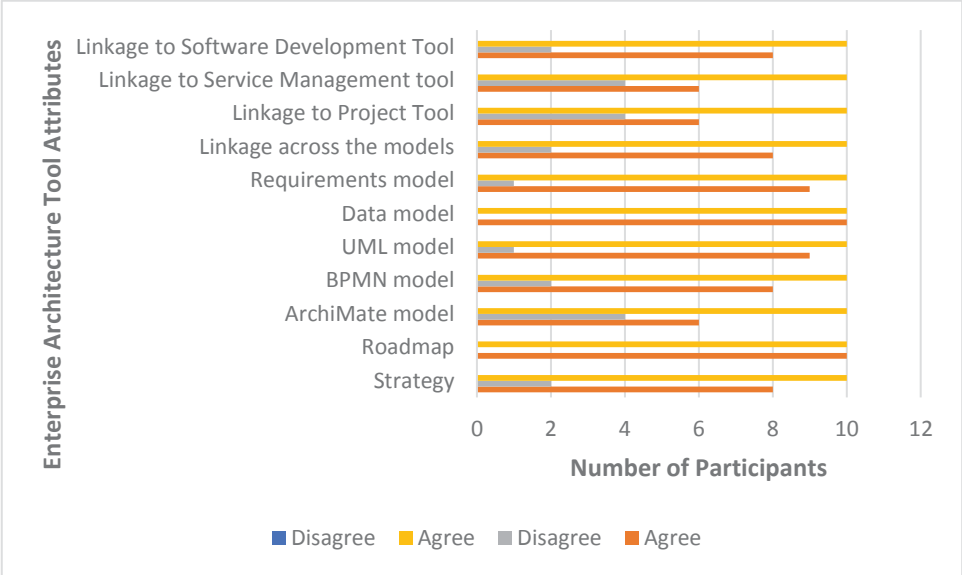


Figure 103 Utility Usage of Enterprise Architecture Tool

But after capacity building and project execution the participants were able to fully appreciate the benefits of Enterprise Architecture, so the results were good.

Proposed modelling practice

- Determine the taxonomy
- Develop the metamodel
- Create the Capability model
- Identify the existing Functions, Processes, Services connect them and then map to the capability model
- Map the stakeholders to the above model

5.8.8 Conclusion

Modelling practice using a Visio is subjective, as the models developed are from user perspective. The relationships are not enforced and due to lack of standard there is no consistency in modelling. Using a tool enforces relationship as compared to grammar that confirms the accuracy of the language. Its critical to have at a tool for the success of modelling practice.

5.8.9 Summary of the survey results.

Primary Research Questions

- RQ 1: Does Enterprise Architecture approach increase the success rate of digital transformation?
  - **Category**: Enterprise Architecture(EA)
- RQ 2: Does maturity assessment applied across the Architecture Development Method contribute to the success rate of digital transformation?
  - **Category**: Maturity Assessment
- RQ 3: Do customized Architecture Development Method, inclusive of other frameworks and methodologies, enhance the success rate of digital transformation?
  - **Category:** ADM Phases
- RQ 4: Does Enterprise Architecture tool aid the success of digital transformation?
  - **Category**: Enterprise Architecture(EA) Tool

Supplementary Research Questions qualitative attributes

- RQ 7: Does Enterprise Architecture practice in an Organization foster innovation?
  - **Category**: Innovation

Note: Majority result only represented in the table, Y or N

BEF: Before the EA practice, AFT: After EA practice set up

Question Customer	RQ 1 Enterprise Architecture		RQ 2 Maturity Assessment		RQ 3 ADM Phases		RQ 4 EA Tool		RQ 7 Innovation		
Survey	**BEF**	AFT	BEF	AFT	BEF	AFT	BEF	AFT	BEF	AFT	
Education Ministry	**N**	Y	N	Y	N	Y	N	Y	N	Y	
Ministry of Health	**N**	Y	N	Y	N	Y	N	Y	N	Y	
Financial Institute	**N**		N								
Bank	**N**	Y	N	Y	N	Y	N	Y	N	Y	
Environment Ministry	**N**	Y	N	Y	N	Y	N	Y	N	Y	
Utility Organization							N	Y			

Table 33 Summary of the survey results.

The result summary from the above table indicates:

Majority of the participants before the EA practice were disagreeing. But, after EA practice set up, as participants got the knowledge of EA, were able to realize the benefits of EA and appreciate the importance of EA practice that assists in their organization digital transformation journey.

6. Proposed Enterprise Architecture Approach for Digital Transformation of Modern Organization

This chapter discusses the suggested model for digital transformation applicable for any domain.

According to GOA (Office 2002) “An enterprise architecture provides a description—in useful models, diagrams, and narrative—of the mode of operation for an agency. It describes the agency in both:

- logical aspects, such as interrelated business processes and business rules, information needs and flows, and work locations and users; and
- technical aspects, such as hardware, software, data, communications, and security attributes and standards”.

An Enterprise Architecture addresses the logical and technical aspects of the existing current state (As Is) and the target state (To Be). To reach the target state is a journey rather than a project, that is enabled through Transition plans.

The above definition is the most relevant that applies to digital transformation, as it addresses the comprehensively regarding business and technical terms, taking into consideration of the current and future environment.

The goal of this research is to increase the success rate of organizations digital transformation.

6.1 Digital Transformation

The advancement in technology has enabled a connected world with no boundaries, that can be related to a global village. With affordable mobile devices, information is accessible, and the information is shareable through the free social media platforms globally in seconds.

Organization path for digital transformation is not an option anymore, rather than it is inevitable. Based on the complexity as discussed earlier, it’s necessary to approach pragmatically that ensures the success.

Digital Transformation is the mammoth task, especially with the organizations that are large, spread across geographically, i.e., locally or internationally. There are various stakeholders involved with different mindset, conflicting or vested interest. Also, the organization's compliance with various government or private regulation. There will be systems that have been commissioned at multiple timelines to complement business. These systems will be from numerous organizations, based on different technologies. To meet the business objectives, information from various systems are collated in real-time or nearly real-time or at predefined times. The system's communication can be the point to point or through an integration platform that collects the data centrally and will have access to systems as required.

6.1.1 The main organization goals to embrace digitisation as follows:

- To reduce the operation cost,
- Improve services,
- Increase profit,
- Increase market share,
- Acquire more customer base,
- Self service capability to business & customers and so on.

As it is mentioned earlier, digitization is converting the organization assets wherever possible to digital, reducing the manual process, automation of the organization process with specific criteria that

can be changed as needed based on the fluctuating business models, that is driven by technology and meets the expectation of the customers.

It's not possible to have downtime of systems to enhance the quality of services provided to the customers. We try to relate to an example of Telco changing the telephone network from 3G to 4G. Customers are ported from 3G to 4G segment by segment. Till all the customers are ported to 4G, both 3G and 4G network will be running in parallel. Only after all the customers are ported to 4G, the 3G network is phased out. Similarly, organizations to follow telco model to rationalize and provide quality services stage by stage to customers.

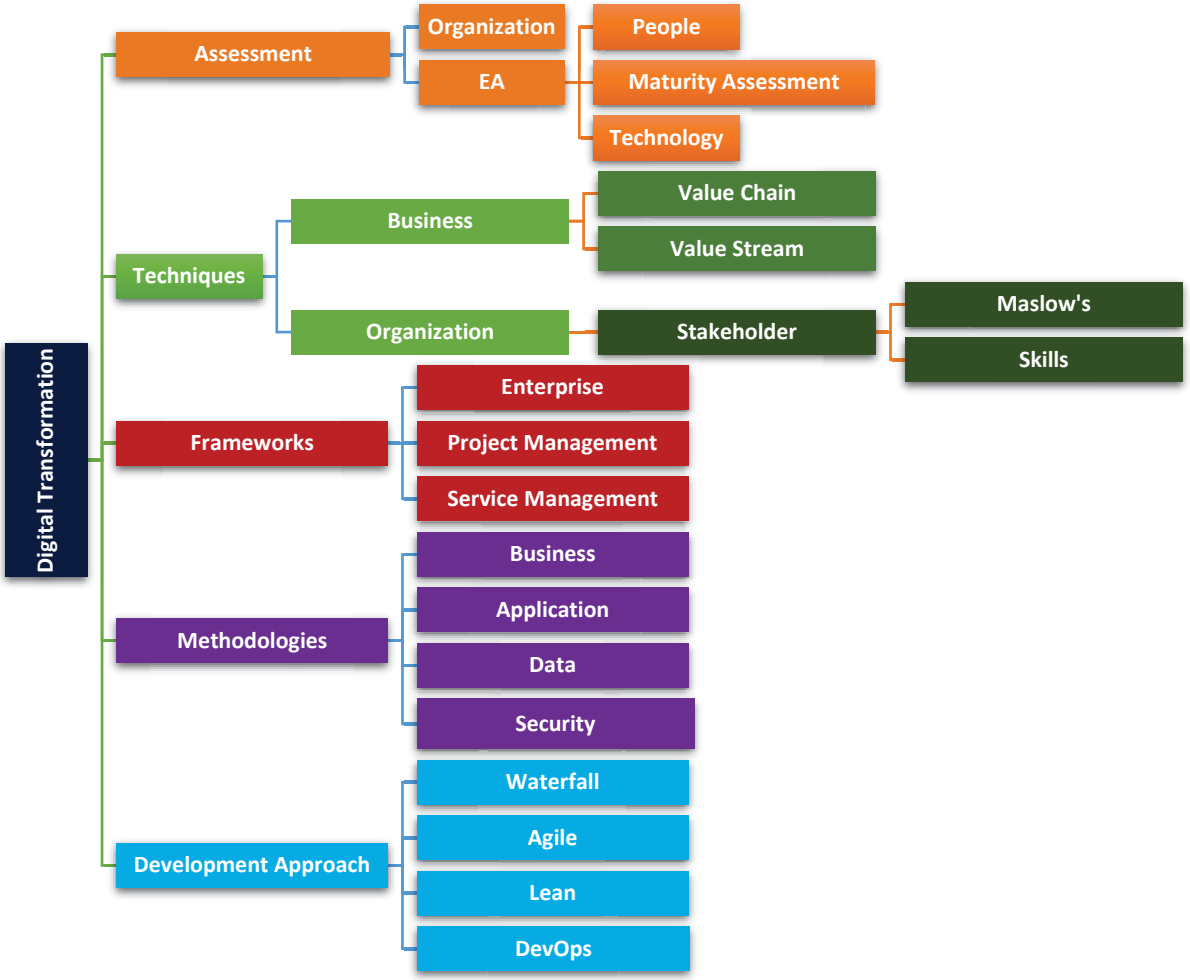


Figure 104 Digital Transformation Hierarchy

6.1.2 Where does an organization start its digital transformation?

Digital transformation is not just refreshing technology, but to minimize the manual process by digitizing the process across the organization. Digitization enables the business to be agile with essential information available in real-time as required. To gather information from various systems in real-time, its need to be connected that enables to provide the information required to take the decision.

So where does an organization need to start its business transformation to become a digital organization?

6.1.3 Proposed Digital Transformation Strategy

Figure 105 Proposed Digital Transformation Strategy

6.2 Enterprise Architecture

- Frameworks and methodologies that are proven, from a non-profit consortium, based on open standards.
    - Frameworks structure and methodologies steps to evolve with the changing technology that ensures, future proofing
    - Also, as they follow the open standards, they are transparent, and there is no vendor lock-in and able to be applied practically as per the context.

6.2.1 Why to choose TOGAF?

The core framework that has been followed is TOGAF as its derived from TAFIM developed by DoD. The internet was designed by DoD, which laid the foundation for the connected digital world. Also, the internet is non-proprietary, evolving based on open standards.

TOGAF is the framework & methodology, with the iterative and incremental delivery. An architecture of an organization evolves to address the needs of the business iteratively and embrace technology incrementally. TOGAF core is Architecture development method is hybrid as it incorporates the waterfall and agile methodology complementing the iterative and incremental delivery.

TOGAF has partially adopted ISO/IEC 42010:2007, a conceptual framework that addresses the tasks of the creation, analysis, and sustainment of architectures of software-intensive systems. The key for digital transformation is adopting technology to reduce the human intervention and automating the organization business processes wherever possible. Digitization can be achieved only with agile architecture that addresses the ever-changing perspective of stakeholders' views to build a system (typically its system of Systems).

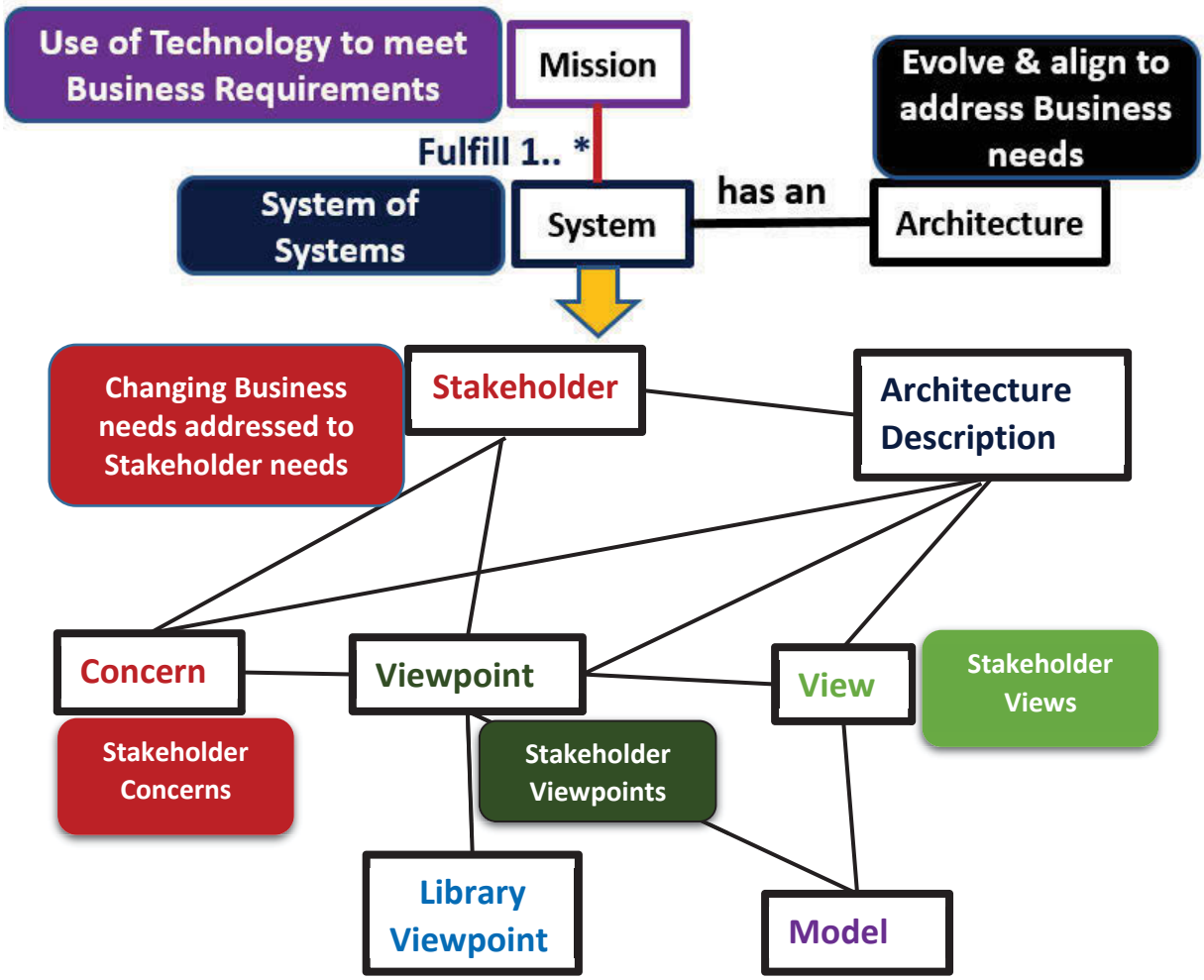


Figure 106 Architectural Stakeholder Concerns (Engineers 2007)

Systems that are built to address the Stakeholder Concerns in consideration with their views taken from the Stakeholders perspective. The stakeholder views are represented by the model that enables the unambiguous communication with the stakeholders. That will assist in developing the Architecture description with a Rational architect for the digital transformation.

TOGAF is a framework and methodology for Architecture development lifecycle; as such its descriptive of the phases, it does not enforce it. Based on the projects executed and experiences, additional frameworks and methodologies that will extend and complement TOGAF, i.e., a hybrid framework that is descriptive and prescriptive in nature is proposed.

6.2.1.1 Steps to rationalize the core architecture

- **Context to determine Target First / As Is First Architecture**
  - For any green field project, Target first architecture is suitable, as there is no existing As Is architecture (old baggage to be considered).
  - For legacy projects
    - Business Architecture: if the existing process is of importance then As Is architecture is first otherwise Target first.
    - Application Architecture: If the existing application to be migrated to higher version or virtual environment As Is Architecture first otherwise Target first.
    - Technology Architecture: If legacy application will be phased of Target first.

Value Chain & Value Stream: Determine the Value chain and identify the value stream of the core architecture and process as this will assist to streamline the process and identify the weakest link.

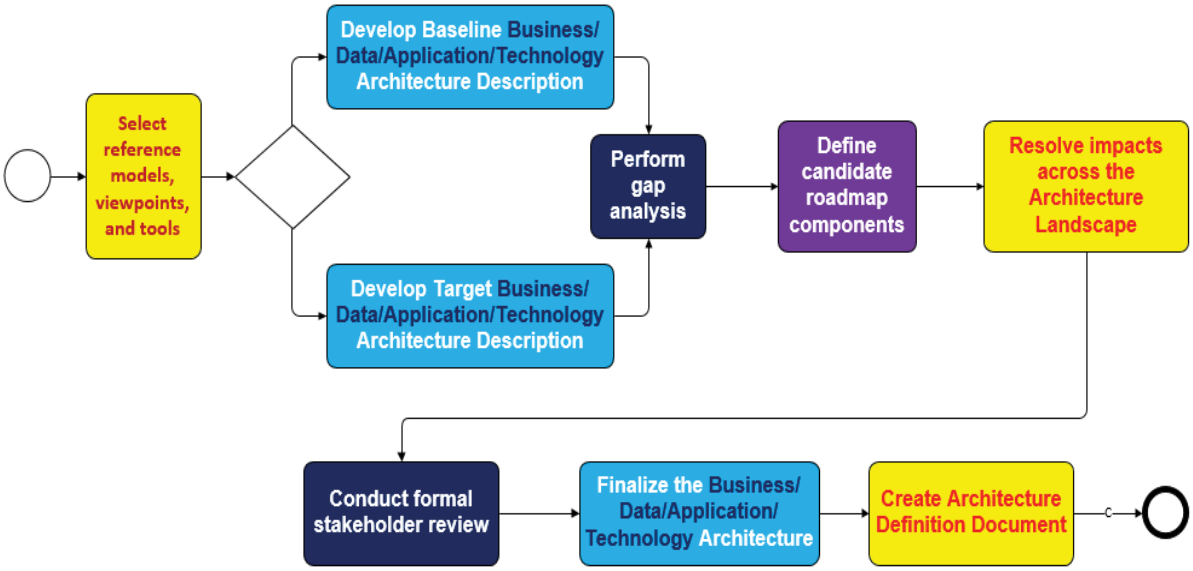


Figure 107 Context to determine Target First / As Is First Architecture

6.2.1.2 Steps to rationalize the applications

- Map the products/systems used in an Organization to the identified capability.
- Identify the business owners, the functionality of the system.
- Verify the time line of the system, the maintenance cost, the type of technology and Total Cost of Ownership of the specific system.
- Determine the products that are available in the market to compare with the current product.
- After comparing with the identified criteria determine its necessary to replace or continue with the existing product.
- Identify the process that are generic, independent and shareable to improve the process to enable micro services
- As it is not possible to make a drastic change, adopt bi model approach where two systems will be running parallel slowly replacing the legacy systems.

6.2.2 Framework and Methodology

Digitisation is driving customer centric focus, to achieve that the quality of service to be trusted, reliable and meet the needs of the customer. At the same time, it must be economical for the customer to use the service.

Frameworks /Methodologies	Focus Area	ADM Phase
Zachman: an architectural Framework, with logical structure to classify the artefacts cohesively to address stakeholder perspectives.	Stakeholder	P, A, B, C, D, R
Federal Enterprise Architecture Framework (FEAF): provides tools to describe, and analyse investments	Performance &investment	P, A, B, C, D, R
British Ministry of Defence Architecture Framework (MoDAF): provides models to analyze and understand the capabilities of, Systems of Systems.	Systems of Systems	P, A, B, C, D, R
Department of Defense Architecture Framework (DoDAF): a comprehensive framework and conceptual model to develop architectures.	Core Architecture	P, A, B, C, D, R
Integrated Architecture Framework (IAF): provides processes, products, tools, and techniques to create architectures.	Core Architecture	P, A, B, C, D, R
Australian Government Architecture Framework (AGA:): provides processes to analyse, identify the duplicate investments, gaps, and opportunities.	Performance & investment	P, A, B, C, D, R
Project Management Book of Knowledge (PMBoK): has set of standard terminology and guidelines for project management	Managing Projects	P, A, B, C, D, E, F, R
Project Management in controlled environment (PRINCE2): process-based method for effective project management.	Managing Projects	P, A, B, C, D, E, F, R
Business Motivation Model (BMM Model:): a structure to develop a business strategy to realize the vision of an organization.	Strategy	P, A, B
Business Architecture Body of Knowledge (BIZBOK GUIDE): provides a practical guide to address business challenges, consist of best practices collection from numerous companies and business architecture leaders	Business Architecture	B
Business Analysis Body of Knowledge (**BABoK**): a framework that describes the business analysis tasks	Business Architecture	B
Data Management Body of Knowledge (DMBoK): a framework to manage data and mature information infrastructure,	Data Architecture	B, C
Information Technology Infrastructure Library (ITIL): a framework of best practices for delivering IT services.	Change Management	A, E, F, G
Information Technology Service Management (ITSM:): provide all the activities involved in designing, creating, delivering, supporting and managing the lifecycle of IT services.	Service Management	A, E, F, G
Control Objectives for Information and Related Technology (COBIT): framework for governance, audit, and compliance.	Governance	A, G
Sherwood Applied Business Security Architecture (SABSA:): a framework and methodology for enterprise security architecture and service management.	Governance, Risk	All the phases
Platform 3.0: provides a standard for digital platform based on the emerging technologies such as cloud computing, mobile computing, social computing, big data analysis, and the Internet of things	Strategy, Technology	D, E
Amazon Web Services(AWS), IBM, HP, AWS, Microsoft: XaaS model for cloud computing platform	Strategy, Technology	A, C, D, E, F
Cloud Controls Matrix (CCM): A meta-framework of cloud-specific security controls.	Security	A, B, C, D, E, F
IDC, Gartner: Research Organization Frameworks	Strategy, Technology	A, C, D, E, F

Table 34 Proposed Frameworks and Methodologies list (living table, needs to be updated regularly)

To achieve this, it is essential to follow the proven framework or methodology based on the standard bodies. The enterprise architecture framework is TOGAF irrespective of the type of the organization domain. Some of the additional frameworks and methodologies are identified and mapped against the TOGAF ADM, as referred in Table 34 Proposed Frameworks and Methodologies list (living table, needs to be updated regularly). The identified frameworks are subject to change to align with technology evolution or business model changes. As some of the frameworks may be obsolete and new frameworks or methodologies will be available. The framework or methodology to be chosen based on the project and to be tailored specific to the Organization.

6.2.3 Reference Architecture

Reference Architecture	Description	Purpose
Open Business Data Lake (O-BDL)	A set of architectural patterns, concepts, and re-usable artefacts, assists for "big data" solutions	Assists for setting "data-centric" strategy.
The Open Data Format (O-DF) for IoT	Provides information about things in a standardised way	To publish data using ordinary URL (Uniform Resource Locator) addresses
Open Data Element Framework (O-DEF)	Classification of basic units of data	For the development of interface software
The Open Trusted Technology Provider Standard (O-TTPS)	Conformance to the O-TTPS and ISO/IEC 20243	A set of best practice requirements and recommendations
Open Business Architecture (O-BA) Standard	Elaboration of strategy, implications on structure and operations	Enables to understand business vision by all stakeholders.
IT4IT Reference Architecture	A reference architecture with value chain-based operating model to manage the business of IT.	Enables it to run as a business with predictability
National Institute of Standards and Technology (Technology 2011): Cloud Computing Reference Architecture	Defines the major actors, their activities and functions in cloud computing.	Able to understand cloud computing technologies and services.
BIAN: Banking Industry Architecture Network	A banking framework consist of Conceptual, Logical, and Metadata design of the Service Domains	To create a standard semantic banking services landscape
ACORD: Association for Cooperative Operations Research and Development	Enable collaboration between insurance and financial-industry Organizations for development of data-transmission standards.	Enables fast, accurate data exchange with efficient workflows.
Australian Government Architecture (AGA)	To delivery consistent and cohesive service to citizens that support cost-effective delivery of ICT services	Defines a common language for agencies

Table 35 Reference Architecture

Time is essence in digital transformation, as the organization that introduces the product first with an innovative approach will get the lead. To achieve it's important to adopt the reference architecture based on the domain of the Organization. Reference architecture for some of the major domains in the industry are identified and listed in, Table 35 Reference Architecture

The identified reference architecture is subject to change, as the organization domain is redefined due to technology, as well as the organization risk appetite in introducing new business model that encompass few domains or some niche domain that may come into existence.
E.g. Uber that redefined the transportation, Airbnb redefined paid accommodation, and so on.

6.2.4 Maturity Assessment

The key success to digital transformation, is to understand the organization health, as the weakest link can break, so it's important to get the health status of each phase of ADM. Appropriate key maturity models are identified and mapped against the TOGAF ADM.

ADM Phase	Maturity Model	Purpose
P: Preliminary Phase	Organizational Project Management Maturity Model	Project Management
	Enterprise Architecture Maturity Assessment,	Enterprise Architecture
	Performance Management Maturity Model,	Performance
Phase A: Architecture Vision	Quality Management Maturity,	Quality
	Strategic Management Maturity Model,	Strategy
	RIMS Risk Maturity Model	Risk
Phase B: Business Architecture	Business Transformation Readiness Assessment,	Business Readiness
	Business Process Maturity Model,	Business process
	Business function capability maturity model,	Business function
Phase C: Information Systems Architectures Data & Application	Data Maturity model,	Data Model
	The Data Warehouse Capability Maturity Model,	Data ware house
	Business Intelligence Maturity Model	Business Intelligence
	Data Maturity model,	Data maturity
	Application Performance Management Maturity Model	Application Performance
Phase D: Technology Architecture	Service Integration Maturity Model,	Service Integration
	Enterprise IT Performance Maturity Model,	Information system performance
	SOA Maturity Assessment	Service-Orientation Architecture
Phase E: Opportunities & Solutions	ITIL Maturity Model,	Information Infrastructure
	Portfolio, Programme and Project Management Maturity Model,	Portfolio, Programme, Project Management
Phase F: Migration Planning	Capability Maturity Model Integration CMMI	Capability Maturity Model Integration software development
Phase G: Implementation Governance	IT Governance and Process Maturity,	Governance
Phase H: Architecture Change Management	Cyber Security Maturity Model	Security
Requirements Management	Requirements Maturity Model	Requirements

Table 36 ADM Maturity Model

The identified framework is based on the experience, research and what is currently known and relevant. There might be other frameworks that I have not come across that might be relevant. Based on the evolving technologies and business models, new frameworks will come into existence. The maturity model need to be tailored based on the individual projects, as all the process of maturity model might not be applicable.

6.2.5 Modelling Language

The key ingredient for digital transformation is to reduce human intervention that reduces the error. It can be achieved by modelling the artefacts across the Organization. Modelling language that is suitable based on the phase of the ADM are mapped as referred in, Table 37 ADM Modelling Language:

ADM Phase	Models	Modelling Language
P	Drivers, Motivation, Strategy	ArchiMate
A	Drivers, Motivation, Strategy, Business Motivation Model, Conceptual Model	ArchiMate
B	Drivers, Motivation, Strategy, Business Motivation Model, Business Architecture Model, Conceptual & Logical Model	ArchiMate, BPMN
C	Drivers, Motivation, Strategy, Application Architecture Model, Data Architecture Model, Application Architecture Model, Conceptual Model, Logical Model,	ArchiMate, Entity-relationship modelling
D	Drivers, Motivation, Strategy, Technology Architecture Model, Conceptual Model, Logical Model	ArchiMate, Entity-relationship modelling
E	Drivers, Motivation, Strategy; Business, Application, Data Technology: Logical & Physical Model.	ArchiMate UML
F	Drivers, Motivation, Strategy; Business, Application, Data Technology: Physical Model.	ArchiMate UML
G	Drivers, Motivation, Strategy, Governance	ArchiMate
H	Drivers, Motivation, Strategy,	ArchiMate
R	Drivers, Motivation, Strategy,	ArchiMate

Table 37 ADM Modelling Language

6.2.6 Requirement Management

One of the success factor for digital transformation is getting the information from the right people and have their involvement in the project:

- Strategic Key Stakeholders
- Segmental: Business Owners
- Project: Business Users

Organize the requirements gathering as proposed in, Table 38 Requirements Management:

	Stakeholder	Proposed method
Strategy	**Key Stakeholders**	**One to one or Focus group workshop**
Segment	**Business owner**	**Workshop with Business Owners**
Project	**Business Users**	**Workshop with Business owner and Key Business Users**

Table 38 Requirements Management

6.2.7 Organizational Power Structure

The organization power structure is to change from Micro Management to Macro Management. Only with Macro Management, the staff can be empowered to take the decision to change the criteria of the automation without going around and consulting higher up management. With empowered independent staff will give rise to innovation.

With empowerment of more power to the staff, there must be a well-defined governance structure. The governance structure suitable for each phase is listed in, Table 39 ADM Phases Governance:

ADM Phase	Governance
P	Architecture Governance
A	Business Governance
B	Business Governance
C	Application and Data Governance
D	Technology Governance
F	Project and Change Management Governance
G	Organization, Architecture, Programme, Project Governance
H	Architecture Governance
R	Requirements Governance

Table 39 ADM Phases Governance

6.2.8 Security Considerations

Digitization of an organization will enable to digitize whatever assets that is possible in an organization. Fuelled by Cloud infrastructure, BYOD, the IOT Explosion its pervasiveness and scale, has a significant impact on the security of Enterprise Architecture. EA must address this issue in all aspects of maturity and at each stage of architectural design. Maturity assessment and verification of EA need to identify which and how architectural qualities and design drivers correlate and impact architecture vulnerabilities, risks and mitigation methods.

Security to be addressed in all aspects of EA lifecycle. Conceptual model with multi "layers" of digital services. Multi-tier architecture where the presentation, logic, storage, user interface with no dependency on each other like service-oriented architecture. Each tier can be replaced independently. Security is considered for each layer separately. The multi -Tier architecture model includes:

- the User Access Point: Bring Your Own Device(BYOD)
- the Presentation Layer,
- the Platform or Application Layer, and
- the Information of Database Layer.

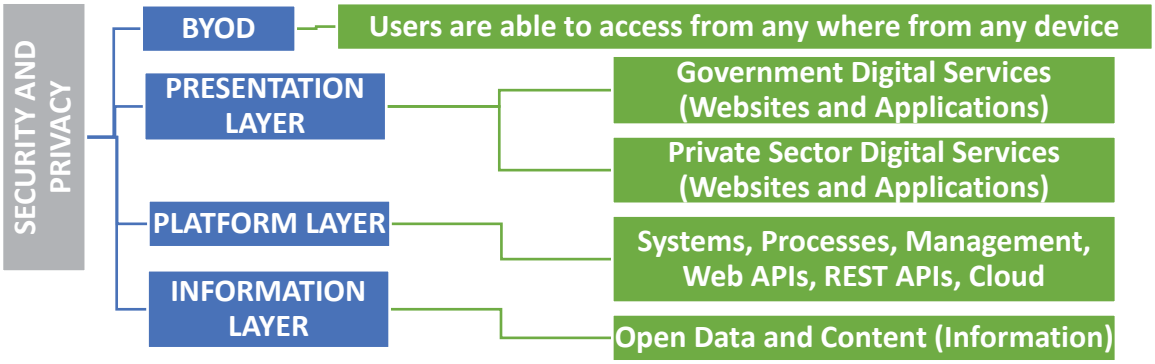


Figure 108: Conceptual Three-Layers/Tiers of Digital Services

The multi-Tier model separates information creation and presentation with the ability to create once and use multiple times as allowed.

6.2.9 Enterprise Architecture practice that enables digital transformation will Foster Innovation

- EA brings in transparency in an organization as services performances are measured, monitored, and action is taken to enhance the service.
- EA practice determines the Architectural Building Blocks and subsequently the Solution Building Blocks. Due to this process eliminates the technology & vendor lock-in and gives IT more control to choose the products that meet the business requirements.
- As decisions in EA practice is taken by a committee rather than individual, this ensures the transparency in decision making
- As EA practice address the maturity assessment across the Architecture development life cycle, the weakest link and project priority can be determined.
- Also applying value chain & value stream on the core architecture and process will assist to streamline the process and identify the weakest link.
- Due to EAO managing, PMO ensures business needs are addressed rather than delivering the project to meet the contractual obligations
- Tailoring the framework and methodology optimize the use of the resource, time thereby reducing the cost.
- The primary objective of digital transformation is to reduce human intervention and to enhance automation.
- The goal of digital transformation is to provide the self-service option to customers and to address the needs of customers and support business to utilize the disruptive technology.

Due to the above factors as transparency, optimized process, self-service enablement, utilize technology to address the business needs automatically enables innovation

6.3 Summary

6.3.1 Key Recommendation

- Business Architecture, Application and Data Architecture must be created for the capability required.
- Architecture Building Blocks must exist or to be created.
- Architecture / Solution Building blocks to be modelled.
- Solution Architecture Building blocks to be based on Architecture Building Blocks.
- Object-orientation must be followed wherever applicable.
- Architecture must follow Service-Oriented Architecture approach.
- Cloud Architecture to be utilized.
- Security to be built in for all the layers of Architecture and the application components.
- Software components to be based on Horizontal scaling to utilize the elasticity of cloud instead of Vertical scaling where hardware resources are utilized.
- Wherever applicable IT Assets considered that are programmable Resources.
- Wherever possible to follow microservice architectural style. This is by breaking single application as a suite of small services, each running in its own process and communicating with lightweight mechanisms, often an HTTP resource API i.e. REST API.
- The Micro Services end points to be REST or RPC.

- All services metrics to be identified and to monitor, to check if it meets the determined criteria.
- Software deployment only on virtual environment.
- Agile methodology must be adopted from inception to deployment.
- Development or enhancement to follow DevOps approach wherever feasible.
- Applications to be designed to self-healing wherever its possible.
- Applications must be continuously monitored and be able to proactively alert the admins if there is degradation or service outage.
- From Inception (Strategy) to Deployment (Applications running) all to be connected where ever its possible. For this EA tool that is connected to monitoring tool, Project Management, Service Management and so on.

6.3.2 Key Consideration for Digital Transformation

- Identify the organization Vision and Mission
- Map the Strategy to the organization's Vision and Mission
- Determine the type of the organization is it Functional, Matrix or Projectized this will aid to determine the key stakeholders who have the power to bring in the organization change that is required for Digital Transformation
- Identify the way projects are managed, is it Strong (Project manager controls), Weak (Functional Manager controls), or Balanced Matrix (Both Project and Functional Manager controls) organization. Determining the organization structure will assist to understand who controls and manages the project, so to determine the management style of the project that needs to be executed for the Digital Transformation.
- From the Education Ministry Case Study, it has been identified for business transformation focused enterprise wide project to be successful, Enterprise Architecture needs to manage project Management Office.
- As it was mentioned earlier as organization reduces human dependency due to digitization, there will be more automation. The decisions taken by the system are based on specific criteria with limited or no intervention by a human being. To achieve automation, the business process needs to be automated wherever possible. At the same time, there must be a control for the human being to change the criteria based on the organization needs. To achieve this business process management tool is required, as business users can change the requirements as per the business needs, without a technical team to do the job.

7. Conclusion

This chapter discusses the research limitations, then future works, next walks through the future digitisation business models in the insurance industry, and finally the overall thesis summary.

7.1 Limitations

The research covered various Capability Maturity Models, Frameworks and Methodologies from standard organizations, and reference architecture from generic to specific domains. To apply the same needs knowledge to customise and use based on the Organization. As stated earlier, the knowledge that is required to practice EA is not addressed comprehensively, though skills needed for ADM cycle is covered.

7.1.1 Limitations of Research

The research has validated the necessity of an enterprise architect to understand the entire lifecycle of architecture development; to have knowledge of Management (Financial, People, Project), Soft skills, Negotiation, Procurement, Emerging Technologies awareness, Software development practices, a Research mindset and finally the domain knowledge of the Organization. Though it is not possible for an individual to gain in-depth, knowledge stated, its essential to have an overview. Only then can an EA practitioner be able to contribute to the success of the Enterprise Architecture practice. But the research has not covered specific domain, technology skills and modelling knowledge.

Research as addressed the overview of emerging technologies that are relevant from EA perspective.

Given an overview and importance of key Stakeholders engagement that is critical for the success of EA practice.

7.1.2 Limitations in Practice

Typically, it depends on the organization maturity, knowledge of EA practitioner, selected methodologies, type of the project, scope of the project, available budget, time constraint, management awareness, business users' cooperation and support from management.

7.2 Future Work

As technology evolves, it is inevitable for an organization to embrace and to innovate to derive benefit out of technology. Organization technology adoption is influenced by the risk appetite, the staff skills and competition in the market.

- Organizations need to keep track of the technologies to adopt as needed. Choosing a disruptive technology can trigger several research topics such as "How to identify the relevant technology that suits the organization and the timeframe required to adopt."
- The methodologies and frameworks will evolve though not in pace with the technologies. To identify the right methodologies and frameworks that suits the organization may trigger few research topics. Also, to customise and tailor the framework and methodologies itself may trigger additional research topics.
- Skills that are required are influenced by the technologies, methodologies, frameworks, and process followed by an Organization, may trigger few research projects.
- Managing the employees, equipping them with right skills, motivating the employees, retaining the employees for a digital enterprise may trigger few research areas.
- Industry 4.0 Framework. Known as 'fourth industrial revolution' addresses automation, machine-to-machine and human-to-machine communication, artificial intelligence, continued technological improvements and digitalization in manufacturing. However, the same concept

can be tailored and customized to any organization or domain. A hybrid approach of TOGAF and Industry 4.0 to be further investigated.

7.2.1 Vision of the Future Insurance Business

There will be gadgets that will be able to monitor the user vital sign as Body temperature, Pulse rate, Respiration rate, Blood pressure, and so on. There is capability to know the location of the person through the mobile SIM card. User spending details based on their banking transaction. Combing the vital signs, location of the user and with the spending pattern, it is possible to get an overview of the person, his habits (sleeping, eating), time spent in a Gym or drinking an alcoholic drink and his exercise pattern.

Though users may not opt to give their personal details, but it's possible to get the social profile through social media as Facebook, Twitter, Snapchat or Professional information from LinkedIn, his associates from the social media. It is a matter of time insurance companies will woo customers with an incentive of reduction insurance premiums or providing gadgets to collect the information directly or indirectly. This will change the lifestyle of the user as well as the information shared with a hospital, that can proactively determine the future treatment that will be needed. Also, for the Government to change the policies for a healthier population.

7.3 Research Contribution

This research has validated, the problem defined, and hypothesis stated in Chapter 1, "**The success of digital transformation can be measured using Enterprise Architecture practices and maturity models**" As transformation is a complex task, additional factors that contribute to Enterprise Architecture success was validated using the theoretical model:

1. Enterprise Architecture driven approach increase the success rate of digital transformation.
    - Enterprise Architecture eliminates duplicate services which will increase efficiency of the services, a critical success factor for digitization.
    - Enterprise Architecture ensures that key stakeholders input is considered.
    - Due to EA practice, the process becomes visible that contributes to transparency, a key attribute of digitization.
2. Perform maturity assessment of the organizational practices.
    - Assessment of the organization maturity assessment at the start of project gives a realistic estimate of cost, time and effort to meet the business objectives.
    - Generally, companies follow the current Capability Maturity Model referred in TOGAF that is based on US Department of Commerce (DoC) IT Architecture Capability Maturity Model (ACMM). This maturity model developed in 2001 with the last update on December 2007 (Commerce 2007).
    - Applying the proposed "4.4.4 Proposed Comprehensive Capability Maturity Model' that covers the entire enterprise and gives a realistic maturity assessment.
    - The approach of assessing all the phases of the ADM based on "Comprehensive Capability Maturity Model' (CCMM) will assist to determine the priority of the project.
    - As the weakest link can break the chain, that is only possible to find out by the above suggested approach.
    - Organizations adopting CCMM will be able delivery projects in time, within the budget, be assured of the risk and able to meet the business & customer's needs.

3. Determine frameworks and methodologies, and Customize as per the organization.
    - As TOGAF is generally misunderstood by practitioners, they follow the process as per TOGAF specification entirely and adopt TOGAF 9 deliverables templates & artefacts that was last updated in 2010 (Group 2010).
    - TOGAF is a descriptive framework not a prescriptive, it's a complete Architecture Development lifecycle method. So, chose the frameworks, methodology for each phase of the ADM depending on the organization, domain, culture and so on.
    - Organization customizing different frameworks and methodologies are able follow proven process and select the relevant process that are practical to implement EA.
    - Digital transformation is to increase the efficiency of the process across the organization. The efficiency can be increased only by applying the methodologies and processes that are appropriate for that phase of ADM cycle and organization type.
    - Also, referring the relevant Frameworks, Methodologies and Reference Architecture listed in "Table 28: Proposed Frameworks and Methodologies list" and "Table 29: Reference Architecture", will increase the success rate of digital transformation.
4. Use EA tool that links to other organization practices.
    - The usefulness and value of EA tool is validated in the research.
    - Also, a logical model is suggested to link the organization key processes.
    - For digital transformation decisions are to be taken based on information that can be trusted and real-time as possible. Proposed Logical Model of Living Enterprise Repository that contributes to real time information.
    - So recommended tool usage can make an organization true digital enterprise. With the connected processes it's possible to get the real-time information and do the impact analysis that assist in decision making.
5. Enterprise Architecture practice in an Organization foster innovation.
    - Successful EA practice will bring in transparency as decisions are made based on consensus rather than an individual.
    - Due to transparency, there is openness across the organization
    - Due to EA practice, common process/ services/ functions are shared across the organization eliminating duplication. Business process/ services/ functions are optimized and monitored in real-time or nearly real-time to identify they performance as the identified metrics to meet the expected OLA or SLA.
    - EA practice in combination with digital transformation eliminates human dependency automating the process where ever applicable and advocates self-service for staff or customer.
    - EA advocates the necessity of IT alignment with the business needs, that enable the utilization of service model to support the business initiatives.
    - Self-service combined with service model will encourage business to experiment with a new business model, fail fast approach; all that contributes to innovation.

Through Enterprise Architecture practice and the application of Comprehensive Capability Maturity Model assessment, it was found that it is possible to obtain realistic time, cost and budget. Additionally, the approach will help to reduce project failure rates. This research identified the Frameworks, Methodologies, Reference Architectures, Modelling Language to complement success of digital transformation. Identified the necessity of EA Tools to detect the weak links in the processes that are critical for digitization. Ultimately the true value of digitization is the fact it enables effective decision making and fosters innovation. Validated the success of the enterprise architecture is achievable with the projects implementing organization reporting to EAO or with PMO and EA working in balance organization matrix.

7.4 Final Observations

Information Technology has evolved drastically in the last few decades from Mainframes - consisting of computing and storage in monolithic systems, followed by mid-range computers, then with desktop computers and finally the handheld devices combining all the computer, storage, and wireless network capabilities in a portable unit.

The computer's network has evolved from the mainframe that related to dumb terminals, followed by the Local Area Networks (LAN), Wide Area Network (WAN), Metropolitan Area Network (MAN) and finally the Internet where everything is connected.

Mainframe, midrange, desktop computers or any handheld device are generalised as computer resources that connected within an organization through LAN. Then based on the geography MAN, followed by WAN were computing resources linked to the different organization location, then the internet that enables access to the information from any part of the world.

Mobile network as evolved from 1G with 1kb speed to the present 3G network speed max of 3.6Mbps, 4G network speed max of 50Mbps and evolving 5G network speed max of 100Mbps.

The cost of compute resource as drastically reduced with mainframes costing $ 4-10 Million in the 1970's to the present mobile device costing $99 with more compute, storage and network access at your fingertips than the mainframes bought for in 1970's.

Information Technology (IT) that is based on Mainframes were used by Fortune 100 Companies, Government, Research Organizations, Universities in early 70's; with mid-range and desktops, even Fortune 1000 Companies started using IT. With the whole infrastructure stack evolving as virtual compute units, along with storage that can be purchased based on pay per usage model, have contributed usage of technology as the necessity for the survival of business irrespective of size.

Usage of information technology initially utilised in Organizations for managing their business. With internet capability complemented with affordable hand-held devices and improved wireless network gave raise to social media where users are utilising technology for social activity.

Software developed earlier by companies were shipped to the purchaser with source code. Later in early 1980's source code was not given to the purchaser.

Later organizations in early 1980's changed they model of not releasing the source code and charging for the software. Software free to use, share, modify, distribute was started by Richard Salman in 1983 with his initiation of Public License, then followed by Free software foundation founded by Richard Stallman it gained momentum, then the Open source initiative founded by Bruce Peren and Eric S Raymond in 1998 it became mainstream. Apaches software foundation incorporated in US in 1999 propelled number of popular open source projects in big-data, build management, and so on. Some of the popular open source software were backed by Fortune 500 companies such as MySQL, Hadoop, Red Hat Linux, and so on. According to recent study in 2016, open source saved $60 billion for Organizational licensing costs.

With the technology advancement information systems consisting of hardware, software has become commodity that can be purchased on the need and demand basis, changing the costing from Capex to Opex. This is causing disruptions to the business, as Organizations adopting technology effectively

can give quality economic services they offer, irrespective of the industry including health, education supply chain, banks, Government and so on.

The timeline to implement an information system project before service model was few years due to the cost of the project - driven by its approval process due its cost, procurement timeline that consisted of infrastructure & software and implementation consisting of extending and customising the software.

With the current service model complemented by minimal capital expenditure on the information systems that is available instantaneous, the implementation is reduced from years to weeks.

Due to the above Organizations are digitising their business process, documents and other non-digitised material. Wherever it is practical, organizations are rationalizing the processes to reduce their operating cost and minimize human resources, thereby to be competitive in their offering and to provide quality services.

Organizations starting their journey newly in information technology can pick and match the technologies that suit them. Also, for small and medium size organizations, it is easier to transform their business model.

But large Organizations depending on their size and necessity that have adopted technology from few decades, that consist of heterogeneous systems based on various technologies consisting of hardware, software and networking. This brings in its own challenges to transform to digitisation with their existing baggage. It's critical to follow a proper process and initiatives that addresses enterprise level across the Organization.

The focus of this research is to propose Frameworks and Methodologies, that are relevant and practical across the organization based on the Enterprise Architecture Frameworks. Assessing the maturity of the organization on various aspects based on the proposed Comprehensive Capability Maturity Model. Necessity of EA tool for digital transformation success. To identify the value chain with its value stream, which will increase the success rate of the organization digital transformation irrespective of their domain. As Organizations embrace the digital journey, they will be more insightful on the performance across different aspects. This will trigger the organization to experiment different modes to increase the service or profit through innovation.

The conclusion based on the research outcome, it was found that the Enterprise Architecture approach increases the success rate of digital transformation and subsequently foster innovation.

PART III
Bibliography

References

(AGIMO), A.G.I.M.O. 2011, *Australian Government Architecture Reference Models* AUSTRALIAN GOVERNMENT INFORMATION MANAGEMENT OFFICE (AGIMO), Australia.

(OMG®), T.O.M.G., *MDA® - THE ARCHITECTURE OF CHOICE FOR A CHANGING WORLD*, The Object Management Group® (OMG®) USA.

AFFAIRS, I.O.P.I. 2009, *WHAT IS INTERPRETIVE RESEARCH?*, THE UNIVERSITY OF UTAH, USA, viewed 10/10/2016 2016.

Alfabet 2007, *Achieving ROI on Enterprise Architecture* Alfabet, USA.

Ambler, S. 2002, *Introduction to Object-Orientation and the UML*, Ambysoft Inc. , <http://www.agiledata.org/essays/objectOrientation101.html>.

Anthony, S. 2016, 'Kodak's Downfall Wasn't About Technology', *DISRUPTIVE INNOVATION*, viewed 21/01/2017, <https://hbr.org/2016/07/kodaks-downfall-wasnt-about-technology>.

Archer, M.S. 2010, 'Morphogenesis versus structuration: on combining structure and action', *The British Journal of Sociology*.

Architecture, O.S. 2016, 'IT Security Architecture', *IT Security Architecture*, Analysis report, 2016, viewed 21 Feb 2016, <http://www.opensecurityarchitecture.org/cms/definitions/it-security-architecture>.

Archivists, S.o.A. 1936, 'technical reference model ', , Society of American Archivists, USA, viewed 15/11/2016, <https://www2.archivists.org/glossary/terms/t/technical-reference-model>.

Association, U.a.R.I.S. 2014, *Geospatial Management Competency Model*, Urban and Regional Information Systems Association, USA.

Bakar, N.A.A., Harihodin, S. & Kama, N. 2016, 'Assessment of Enterprise Architecture Implementation Capability and Priority in Public Sector Agency', *Procedia Computer Science*, vol. 100, pp. 198-206.

Barbour, R.S. 2001, 'Checklists for improving rigour in qualitative research: a case of the tail wagging the dog?', *BMJ: British Medical Journal*, vol. 322, no. 7294, p. 1115.

Bart, C.K., Bontis, N. & Taggar, S. 2001, 'A model of the impact of mission statements on firm performance', *Management Decision Management Decision*, vol. 39, no. 1, pp. 19-35.

Berger, M. 2001, 'First commercial computer turns 50', *First commercial computer turns 50*, <https://www.pcworld.idg.com.au/article/76470/first_commercial_computer_turns_50/>.

Birmingham, U.o. 2008, 'Technical Reference Model (TRM)', University of Birmingham, UK, <http://www.download.bham.ac.uk/it/TRM.htm#Data%20Management>.

Bowles, A. 2017, *Organizing Data and Knowledge – The Role of Taxonomies and Ontologies*, DATAVERSITY Education, LLC, USA, <http://www.dataversity.net/smart-data-webinar-organizing-data-knowledge-role-taxonomies-ontologies/>.

Cameron, B.H. 2015, 'Methods for Defining and Analyzing Key EA Performance Metrics', *Business & Enterprise Architecture*, <https://www.cutter.com/sites/default/files/architecture/fulltext/reports/2015/02/index/ear1502.pdf>.

Chaczko, D.Z. 2018, 'Biography', in S.M. Kempegowda (ed.)UTS, Australia, <https://www.uts.edu.au/staff/zenon.chaczko>.

cirt.gcu.edu 2017, *When to Use Qualitative Research*, Center for Innovation in Research and Teaching (CIRT), USA, viewed January 25 2017 2017, <https://cirt.gcu.edu/research/developmentresources/research_ready/qualitative/when_to_use>.

CLEVELAND, B. 2014, 'Lessons from the death of a tech Goliath', <http://fortune.com/2014/01/23/lessons-from-the-death-of-a-tech-goliath/>.

Commerce, U.S.D.o. 2007, 'Enterprise Architecture Capability Maturity Model', *Enterprise Architecture Capability Maturity Model*, Document, 12/10/2007, viewed 22 Feb 2016, <http://ocio.os.doc.gov/ITPolicyandPrograms/Enterprise_Architecture/PROD01_004935>.

Corporation, M. 2018, ' Microsoft Virtual Academy', <https://mva.microsoft.com/>.

Council, E.a.R., 'What is social science?', <https://esrc.ukri.org/about-us/what-is-social-science/>.
Data, H. 2018, 'Companies Currently Using Hyperledger', *Hyperledger*, <https://discovery.hgdata.com/product/hyperledger>.
Defense, U.S.D.o. 2010, *The DoDAF Architecture Framework Version 2.02*, U.S. Department of Defense, USA.
DFSI, N. 2016, *Priorities: NSW Government Enterprise Architecture*, NSW Government, Australia, viewed 20/8/2016, <https://www.finance.nsw.gov.au/ict/priorities/infrastructure-and-managed-services/nsw-government-enterprise-architecture>.
DHL 2017, *DHL Global Portal*, DHL, <http://www.dhl.com/en.html>.
What is STANDARDS BODIES? 2016, Black's Law Dictionary Free 2nd Ed. and The Law Dictionary, USA.
Guideline, Cambridge Dictionary, UK.
technique, Cambridge Dictionary, UK.
the definition of architecture 2017, Dictionary.com, USA.
Dudovskiy, J. 2017, *Methodology*, research-methodology.net, viewed 10/1/2017 2017.
Eclipse 2013, 'Guideline: Using Visual Modeling ', *Guideline: Using Visual Modeling* <http://epf.eclipse.org/wikis/openup/core.tech.common.extend_supp/guidances/concepts/visual_modeling_2C089766.html>.
Engineers, I.o.E.a.E. 2007, *ISO/IEC/IEEE 42010*, Institute of Electrical and Electronics Engineers, USA.
Ethereum 2018, *Build unstoppable applications*, Ethereum, USA.
Fakhroutdinov, K. 2017, *Object-Oriented Design Concepts in UML*, https://www.uml-diagrams.org/, USA, <https://www.uml-diagrams.org/uml-object-oriented-concepts.html>.
posterior probability Farlex, Inc.
prior probability, Farlex, Inc.
Fenn, J. 2017, 'Applying Lessons From 20 Years of Hype Cycles to Your Own Innovation and Forecasting Strategies '.
Fenn, J. & LeHong, H. 2011, 'Hype cycle for emerging technologies, 2011', *Gartner, July*.
Ferrance, E. 2000, *ACTION RESEARCH*, Northeast and Islands Regional Educational Laboratory At Brown University, <https://www.brown.edu/academics/education-alliance/sites/brown.edu.academics.education-alliance/files/publications/act_research.pdf>.
Foundation, T.F.S. 2004, *The Free Software Foundation*, The Free Software Foundation, USA.
Foundation, T.L. 2018, *Largest Shared Technology Investment*, The Linux Foundation, USA.
Gallup 2017, *State of the Global Workplace*, Gallup Management consulting company, USA.
Gartner, I., 'Gartner Magic Quadrant', *Research Methodologies*, <https://www.gartner.com/technology/research/methodologies/research_mq.jsp>.
Global, I., *IT Architecture Body of Knowledge 2.0*, Iasa Global, USA.
Google 2017, *Google Maps*, Google, USA, viewed 18 Nov 2017 2017, <https://enterprise.google.com/maps/products/mapsapi.html>.
Governance., I.o. 2018, 'Defining governance', <https://iog.ca/what-is-governance/>.
Group, O.M. 2017a, *OMG® Unified Modeling Language®*, formal/2017-12-05, Object Management Group, USA.
Group, T.O., *TOGAF® Version 9.1, an Open Group Standard*, The Open Group, USA.
Group, T.O. 2010, *TOGAF® 9 TEMPLATE ARTIFACTS AND DELIVERABLES, SET 2*, The Open Group, USA.
Group, T.O. 2011, *TOGAF(R) 9.1*, G116_TOGAFSpecs.PDF, The Open Group, USA.
Group, T.O. 2013a, *ArchiMate® 2.1 Specification*, The Open Group, USA.
Group, T.O. 2013b, *The Open Group Cloud Ecosystem Reference Model*, The Open Group, USA.
Group, T.O. 2016a, *ArchiMate 3.0 Specification*, C162, The Open Group, USA.
Group, T.O. 2016b, *Open Platform 3.0™ Snapshot – Platform Capabilities*, S152, The Open Group, USA.
Group, T.O. 2017b, 'About Us', *About Us*, viewed 16 /09/2017, <http://opengroup.org/aboutus>.
Group, T.O. 2017c, *ArchiMate® 3.0.1 Specification*, The Open Group, USA.

Group, T.O. 2017d, 'DIGITAL TRANSFORMATION AT AMSTERDAM'S SCHIPHOL AIRPORT: A CONVERSATION WITH AALDERT HOFMAN', paper presented to the *DIGITAL TRANSFORMATION AT AMSTERDAM'S SCHIPHOL AIRPORT: A CONVERSATION WITH AALDERT HOFMAN*, USA, <https://blog.opengroup.org/2017/10/17/digital-transformation-at-amsterdams-schiphol-airport-a-conversation-with-aaldert-hofman/>.
Group, T.O. 2018a, 'ArchiMate® Certification Program', *Directory of Certified People*, viewed 01/05/2018, <https://archimate-cert.opengroup.org/certified-individuals>.
Group, T.O. 2018b, 'TOGAF® 9 Certification', *Directory of Certified People*, viewed 01/05/2018, <https://togaf9-cert.opengroup.org/certified-individuals>.
Group, T.O.M. 2004, 'M1 GLOBAL SOLUTIONS ', *MDA SUCCESS STORY*, p. , viewed <http://www.omg.org/mda/mda_files/M1Global.htm>.
Gunasekaran, A. & Ngai, E.W. 2004, 'Information systems in supply chain integration and management', *European Journal of Operational Research*, vol. 159, no. 2, pp. 269-95.
Hajela, S. 2009, 'Making a Case for Enterprise Architecture', <https://www.cioindex.com/article/articleid/1037/making-a-case-for-enterprise-architecture>.
Hayes, A., '20 Industries Threatened by Tech Disruption', <https://www.investopedia.com/articles/investing/020615/20-industries-threatened-tech-disruption.asp>.
HIMSS 2018, *EMRAM*, HIMSS, <http://www.himss.eu/healthcare-providers/emram>.
DIGITAL TECHNOLOGY 2003, Encyclopedia.com., USA.
House, T.W. 2009, *Federal Enterprise Architecture*, The White House, USA.
House, T.W. 2013, *Federal Enterprise Architecture Framework*, The White House, USA.
Howard, A.D.M.R. 2017, 'Introducing the Gartner Digital Government Maturity Model 2.0 ', *Introducing the Gartner Digital Government Maturity Model 2.0*
iDatalabs 2018, 'Companies using Apache Tomcat', <https://idatalabs.com/tech/products/apache-tomcat>.
Inc, G., *Gartner ITScore*, pamphlet, Gartner Inc, USA.
India, U.I.A.o. 2017, *Features of Aadhaar*, vol. , Government of India, New Delhi, India, viewed 15/09/2017, <https://uidai.gov.in/your-aadhaar/about-aadhaar/feature-of-aadhaar.html>.
Initiative, O.S. 2010, *Open Source Initiative*, Open Source Initiative, USA.
Institute, P.M. 2013, *A GUIDE TO THE PROJECT MANAGEMENT BODY OF KNOWLEDGE (PMBOK® Guide) – Fifth Edition*, "Project Management Institute, Inc.", USA.
ISO/IEC/IEEE 2011, *Architecture Frameworks*, ISO/IEC/IEEE, USA.
ISO/IEC/IEEE 2012, *ISO/IEC 19505-2:2012*, ISO/IEC, USA.
ISO/IEC/IEEE 2017, *Survey of Architecture Frameworks*, ISO/IEC/IEEE, USA.
IT, S. 2018, 'DB-Engines Ranking', *DB-Engines Ranking*, <https://db-engines.com/en/ranking>.
James Rumbaugh, I.J., Grady Booch 2004, *The Unified Modelling Language Reference Manual*, Paearson Education, Inc, USA.
John Klein, D.W. January 2009, *Chapter 1. What Is Architecture?*, Safari Books Online, USA.
Kempegowda, S. & Chaczko, Z. 2016, 'Adoption of emerging technologies established on Comprehensive capability maturity model framework: A new practical model', *27th IBIMA Conference*, IBIMA.
Khayami, R. 2011, 'Qualitative characteristics of enterprise architecture', *Procedia Computer Science*, vol. 3, pp. 1277-82.
KUREK, E., JOHNSON, J. & MULDER, H. 2017, 'Measuring the value of Enterprise Architecture on IT projects with CHAOS Research', paper presented to the *21st World Multi-Conference on Systemics, Cybernetics and Informatics* Orlando, Florida, USA, viewed 22/110/2017, <http://www.iiis.org/CDs2017/CD2017Summer/papers/SA935WB.pdf>.
Lam-Son Lê, A.W. 2005, 'Definition of an Object-Oriented Modeling Language for Enterprise Architecture', paper presented to the *38th Hawaii International Conference on System*

Sciences, Hawaii, USA, viewed 22/1/2018, <https://infoscience.epfl.ch/record/55776/files/LEW05A.pdf>.
Lapkin, A., Allega, P., Burke, B., Burton, B., Bittler, R.S., Handler, R.A., James, G.A., Robertson, B., Newman, D. & Weiss, D. 2008, 'Gartner clarifies the definition of the term'enterprise architecture'', *Gartner, Inc*.
libraries, U. 2016, *Organizing Your Social Sciences Research Paper: Qualitative Methods*, University of Southern California, USA, viewed 10/10/2016 2016.
LISA EADICICCO, M.P., JOHN PATRICK PULLEN, and ALEX FITZPATRICK 2017, 'The 20 Most Successful Technology Failures of All Time', *The 20 Most Successful Technology Failures of All Time*, <http://time.com/4704250/most-successful-technology-tech-failures-gadgets-flops-bombs-fails/>.
Lucas, H.C. & Goh, J.M. 2009, 'Disruptive technology: How Kodak missed the digital photography revolution', *The Journal of Strategic Information Systems*, vol. 18, no. 1, pp. 46-55.
Mann, K.J. 21 August 2017 'Find Your True Meaning of 'Architecture' to Succeed With Agile ', *Find Your True Meaning of 'Architecture' to Succeed With Agile* 21 August 2017 <https://www.gartner.com/document/3788763?ref=solrAll&refval=195447020&qid=8dc7c24a54dbeb8f53c1b13ce108a14d>.
Maps, G. 2017, *Google Maps APIs*, Google USA, viewed 19/11/2017 2017, <https://developers.google.com/maps/documentation/>.
Margaret Archer, C.D., Philip Gorski, Daniel Little,Doug Porpora, Timothy Rutzou, Christian Smith, George Steinmetz, Frédéric Vandenberghe. 2016, 'WHAT IS CRITICAL REALISM?', *Section on Theory* <http://www.asatheory.org/current-newsletter-online/what-is-critical-realism>.
Maslow, A.H. 1943, 'A theory of human motivation', *Psychological review*, vol. 50, no. 4, p. 370.
McLuckie, C. 2018, 'Craig McLuckie on Kubernetes and its Community-Driven Path', 16/02/2018, viewed 26/03/2018, <https://www.linuxfoundation.org/blog/craig-mcluckie-kubernetes-community-driven-path/>.
a priori, Merriam-Webster, USA.
Definition of architecture 2017, Merriam-Webster, USA.
MuleSoft 2017, *What is Digital Transformation?*, MuleSoft, USA, viewed 12/5/2017 2017, <https://www.mulesoft.com/resources/cloudhub/what-is-digital-transformation>.
Nelson-Smith, S. 2013, *Test-Driven Infrastructure with Chef: Bring Behavior-Driven Development to Infrastructure as Code*, " O'Reilly Media, Inc.".
Netcraft 2018, 'February 2018 Web Server Survey', February 2018, <https://news.netcraft.com/archives/2018/02/13/february-2018-web-server-survey.html>.
Network, O.T. 2017a, 'Enterprise Architecture', *Enterprise Architecture*, viewed 10/1/2017, <http://www.oracle.com/technetwork/topics/entarch/whatsnew/index.html>.
standards organization 2016, TechTarget, USA.
NETWORK, T. 2017b, 'digital transformation (DX)', *Leadership and planning*, Article, 2017, viewed 1/5/2017, <http://searchcio.techtarget.com/definition/digital-transformation>.
NETWORK, T. 2017c, 'OSI reference model (Open Systems Interconnection)', *Definition*, Article, 2017, viewed 1/5/2017, <http://searchnetworking.techtarget.com/definition/OSI>.
O'Brien, R. 1998, 'An overview of the methodological approach of action research'.
Office, G.A. 2002, *INFORMATION MANAGEMENT- Challenges in Managing and Preserving Electronic Records*, General Accounting Office, USA.
OFFICE, I.A.A.A. 2017, *National Standards Bodies*, NIST, USA.
P, O.B.J.E.C.T.M.N.A.G.E.N.T.G.R.O.U. 2015, *Business Motivation Model*, O B J E C T MA N A G EME N T G R O U P, USA.
Meaning of "digitize" 2016a, Cambridge University Press, UK.
framework 2017a, Cambridge University Press
continuum 2016b, Oxford University Press, UK.
Definition of digital 2016c, Oxford University Press, UK.

ontology 2017b, Oxford University Press, UK.
Reilly, R. 2014, *Five Ways to Improve Employee Engagement Now*, GALLUP, USA.
Revolvy, 'Modeling language ', *Modeling language*, <https://www.revolvy.com/main/index.php?s=Modeling%20language>.
Rotolo, D., Hicks, D. & Martin, B.R. 2015, 'What is an emerging technology?', *Research Policy*, vol. 44, no. 10, pp. 1827-43.
Salesforce.com 2018, 'The fun way to learn Salesforce', <https://trailhead.salesforce.com/>.
Saul Brand, B.B., Marcus Blosch 2018, 'Avoid the 13 Worst EA Practices and Ensure Your Success in the Digital Business Era', Gartner, Inc., USA, <https://www.gartner.com/>.
Society, T.C.f.I.a. 14 March 2013, 'Unique Identification Scheme (UID) & National Population Register (NPR), and Governance', *Unique Identification Scheme (UID) & National Population Register (NPR), and Governance*, weblog, The Centre for Internet and Society India, <https://cis-india.org/internet-governance/blog/uid-and-npr-a-background-note>.
Standardization, I.O.f. 2015, *ISO/IEC/IEEE 15288:2015 Systems and software engineering -- System life cycle processes*, International Organization for Standardization, Switzerland.
Standards, O.f.t.A.o.S.I. 2017, ' OASIS SOA Reference Model (SOA-RM) TC', *OASIS SOA Reference Model (SOA-RM) TC*, viewed 16 /10/2017, <https://www.oasis-open.org/committees/soa-rm/faq.php>.
StatCounter 2018, 'Browser Market Share Worldwide', *Browser Market Share Worldwide*, viewed 26/03/2018, <http://gs.statcounter.com/browser-market-share>.
Statista 2017, 'Global mobile OS market share in sales to end users from 1st quarter 2009 to 2nd quarter 2017', <https://www.statista.com/statistics/266136/global-market-share-held-by-smartphone-operating-systems/>.
Syynimaa, N. 2013, 'Measuring Enterprise Architecture success: a tentative model for measuring success'.
Technology, N.I.o.S.a. 2011, *NIST Cloud Computing Reference Architecture*, National Institute of Standards and Technology, USA.
Analog Data 2017, Techopedia, USA.
The Open Group 2001, 'Case Studies', 2001, <http://www.opengroup.org/public/arch/p4/cases/case_intro.htm>.
The Standish Group International, I. 2015, *Resolution Benchmark Report*, The Standish Group International, Inc.
Tripp, D. 2005, 'Action research: a methodological introduction', *Educacao e pesquisa*, vol. 31, no. 3, pp. 443-66.
UiPath 2018, 'https://www.uipath.com/rpa/academy', <https://www.uipath.com/rpa/academy>.
Unde, A. 2008, 'Becoming an Architect in a System Integrator', <https://msdn.microsoft.com/en-us/library/cc505970.aspx>.
University, T.O. 2016, *Organisations and management accounting*, UK, viewed 10 Nov 2016 2016, <http://www.open.edu/openlearn/money-management/organisations-and-management-accounting/content-section-1>.
continuum, Vocabulary.com, USA.
Walker, M.J. 2017, 'Hype Cycle for Emerging Technologies, 2017', *Hype Cycle for Emerging Technologies*, viewed 19/12/2017.
Watson, A., 'Visual Modelling: past, present and future ', <http://www.uml.org/Visual_Modeling.pdf>.
Wikipedia 2016, 'Maturity model', *Maturity model*, Listing of available maturiy models, 12 February 2016, viewed 22 Feb 2016, <https://en.wikipedia.org/wiki/Maturity_model>.
Zachman, J.A. 2016, 'The Framework for Enterprise Architecture', <https://www.zachman.com/resources/ea-articles-reference/327-the-framework-for-enterprise-architecture-background-description-and-utility-by-john-a-zachman>.

Appendices

1. Research Action Study in detail

This chapter discuss about the case studies that the author was involved with, that has been used for this chapter of the thesis.

1.1 Introduction to Case Studies

The type of case studies referred in this thesis are of the following:

- Enterprise Architecture Capability Building and Practice set-up
- Proposal for Enterprise Architecture
- ArchiMate modelling Capability Building and Practice set-up

1.2 Case Study: Education Ministry

1.2.1 Introduction

Project type: Enterprise Architecture Capability Building and Practice set-up.

Assess and recommend Enterprise Architecture practice for an education ministry to reform its education system.

Organization

A Government Ministry a functional organization type, where projects were managed based on the strong matrix structure (Enterprise Architecture Office reporting to Project Management Office).

Background

To realize the government vision of knowledge-based economy various strategies was envisioned. Project Management Office(PMO) was set up to manage the programs. As PMO was not able to deliver the results as expected, Enterprise Architecture practice was initiated.

Motivation

To incorporate education to the masses and drive the nation towards a knowledge-based economy

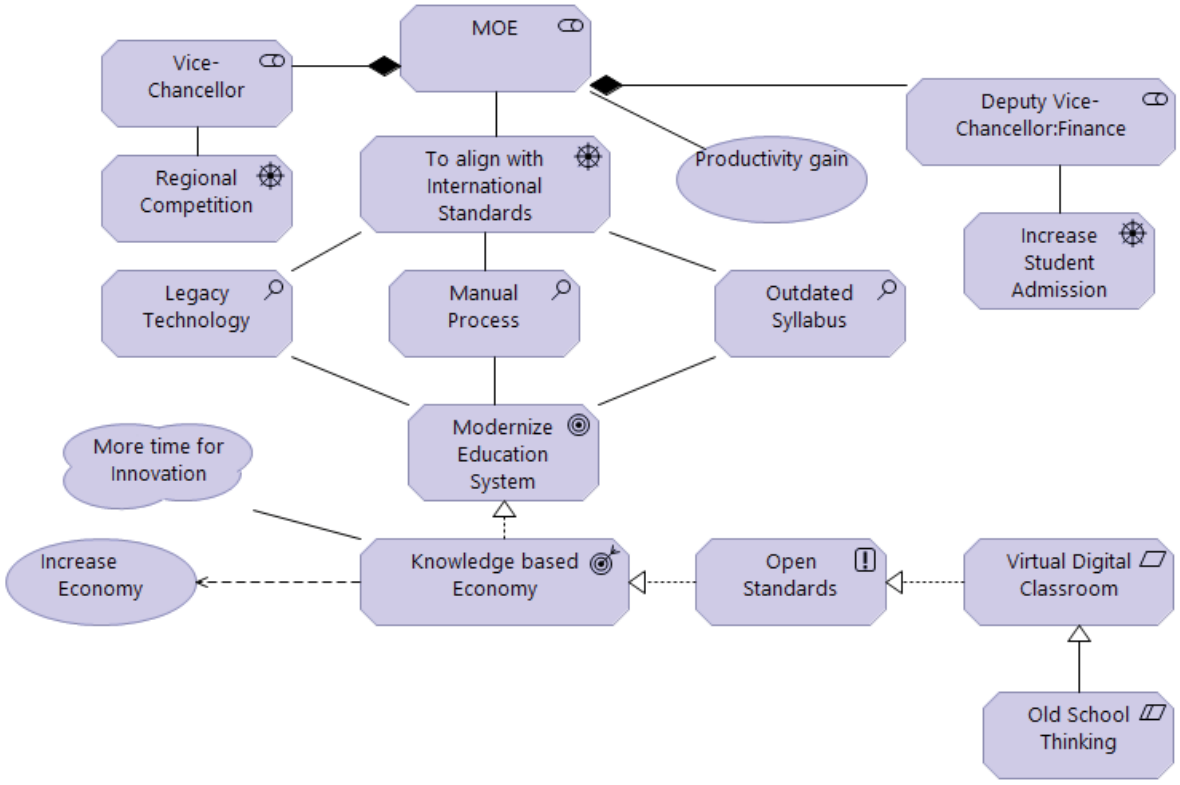


Figure 109 Drivers influencing the change

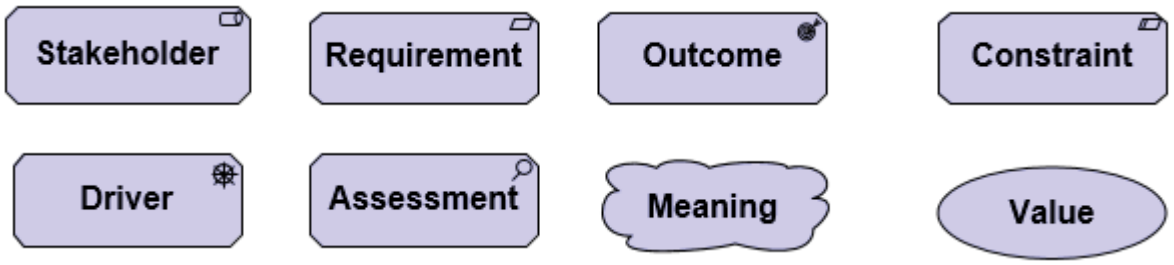


Figure 110 ArchiMate Notation Legend

1.2.2 Objective

- A formative Enterprise Architecture maturity assessment of Ministry of Education.
- To set up Enterprise Architecture Framework based on the gap analysis.
- To hand-hold Ministry of Education to develop & implement Enterprise Architecture practice.

1.2.3 Process followed

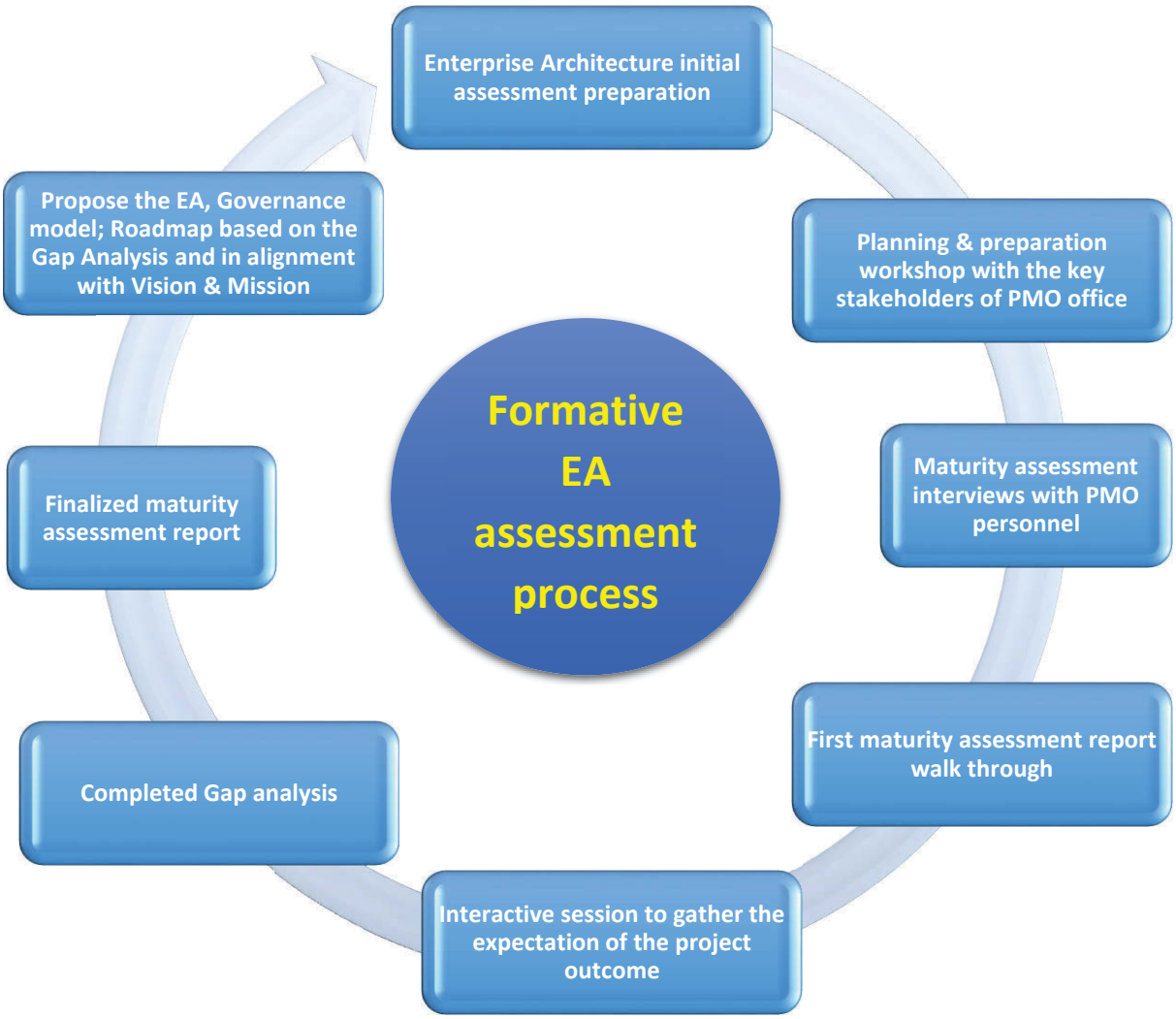


Figure 111 Framework and methodology tailored

Figure 112 TOGAF ADM customized

Overall EA engagement steps followed

- **Discovery phase (Phase P of TOGAF ADM)**
- **Visioning & Stratergy Phase (Phase A of TOGAF ADM)**
- **Strategic architecture evolution phases (Phases B C & D of TOGAF ADM)**
- **Opportunities and Solutions for tactical architecture evolution phases (Phases E & F of TOGAF ADM)**
- **Governance set up and refinement (relating to Phase G of ADM)**
- **Comprehensive and dynamic road-mapping**

Figure 113 Overall EA engagement steps followed

Highlight of the phases:

- **Discovery phase (phase P of TOGAF ADM)**: During this phase, we followed all the best practices in TOGAF. Also, we took concepts from other frameworks and best practices from within and outside of the enterprise. Also, we referred Zachman framework and "EA as a strategy"- by Jeanne Ross, Peter Weill and David Robertson in mapping a high-level positioning in the grid Standardisation vs. integration of the Enterprise.
- **Visioning Phase (Phase A of TOGAF ADM)**. Consist two parts
    - EA programme vision in the long term, and

    - EA vision in the short term to get some quick wins. We look for strategic hooks that we can plan one cycle of ADM at a time and tightly define the deliverables, key success indicators and metrics. We use TOGAF's Business Scenario workshopping techniques to the full.
- **Strategic architecture evolution phases (phases B C & D of TOGAF ADM)**: While TOGAF is a bit lose about building blocks, through our experience, have developed a clear concept of what an ABB (Architectural Building Block) is and what a SBB (Solution Building Block) is. We used ARCHIMATE as modelling language to develop the artefacts.
- **Opportunities and Solutions for tactical architecture evolution phases (phases E & F of TOGAF ADM)**: During this phase, referred Standard bodies as NIST, Open group, Object Management Group, Cloud security alliance; product vendors as AWS, Cloudera, IBM, Microsoft, to align Emerging technologies such as Cloud, Big Data, Social media, and so on, to create transitional future architectures that embrace them in a "future proof" way.
- **Governance set up and refinement (relating to Phase G of ADM):** We set up a practical and workable governance model consistent with the Organizational culture and risk profile. We linked clearly all aspects of governance all the way from Corporate Governance through EA Governance to Project governance in an integrated and transparent way.
- **Comprehensive and dynamic road-mapping**: The road mapping techniques used ensured that there is a clear two-way communication between strategy and implementation and adjustments were made continually to ensure that they are in sync.

Other frameworks used:

- **Information Technology Infrastructure Library (ITIL)**: It is critical to monitor the service provided to staff and students are available 24 X 7, 365 days. To ensure the only framework available is ITIL, which monitor pro-actively rather than reactively of the services provided
- **DAMA-DMBOK:** Data is the lifeblood of any industry, especially for education it is critical to get the statistics of the performance of staff and students that help to take the decision based on the bottleneck where the process can be improved.
- **Business Analysis Body of Knowledge (BABOK):** The primary objective of the project was to address the knowledge-based economy, for that we need to standardize, improve the efficiency of the business process.
- **The Control Objectives for Information and related Technology (COBIT):** Governance is the vital process that assures that the proper governance is in place that will assist in setting the policy to follow. It ensures the decisions taken are for the benefit of the project by the committee rather than an individual.

Education industry needs to align with international standards and compliances. It guarantees the education qualifications offered by the organization is valid and trusted across the world. With proper Governance and audit, the quality of education is on par with international standards

1.2.4 Overall Observation and Key findings

The interview was conducted before starting the project and after completion. They were eight stakeholders involved in the project. The stakeholders had more than ten years' experience working in Information Technology with majority from Project Management background.

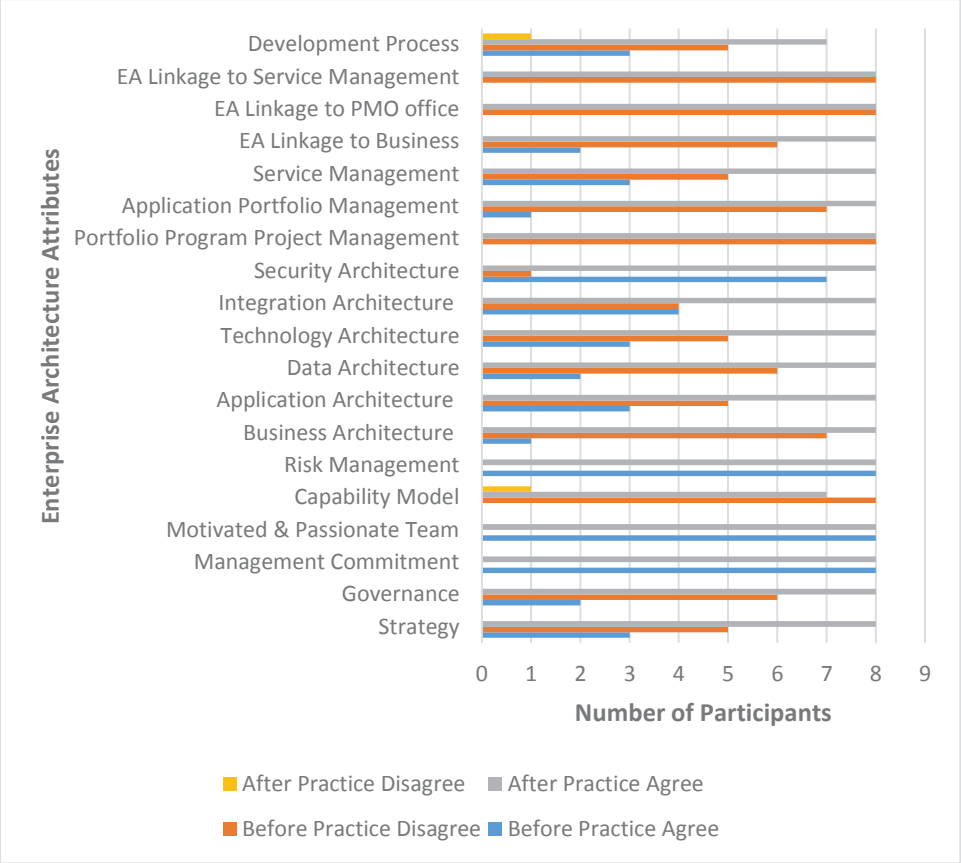


Figure 114 MOE Enterprise Architecture Approach

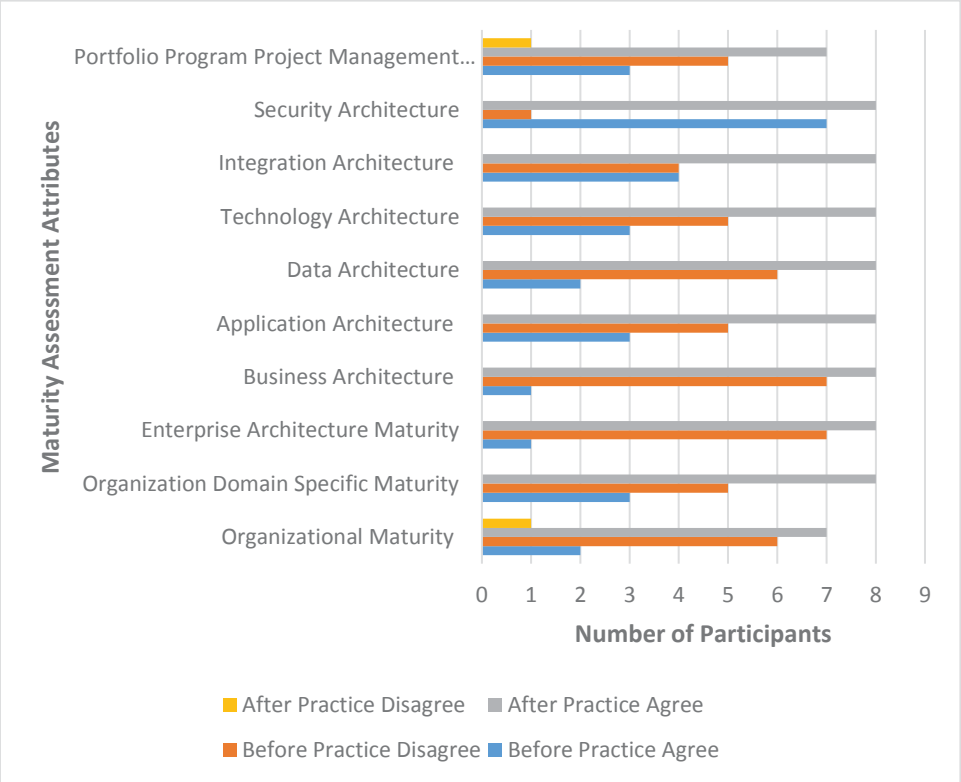


Figure 115 MOE Enterprise wide Maturity Assessment

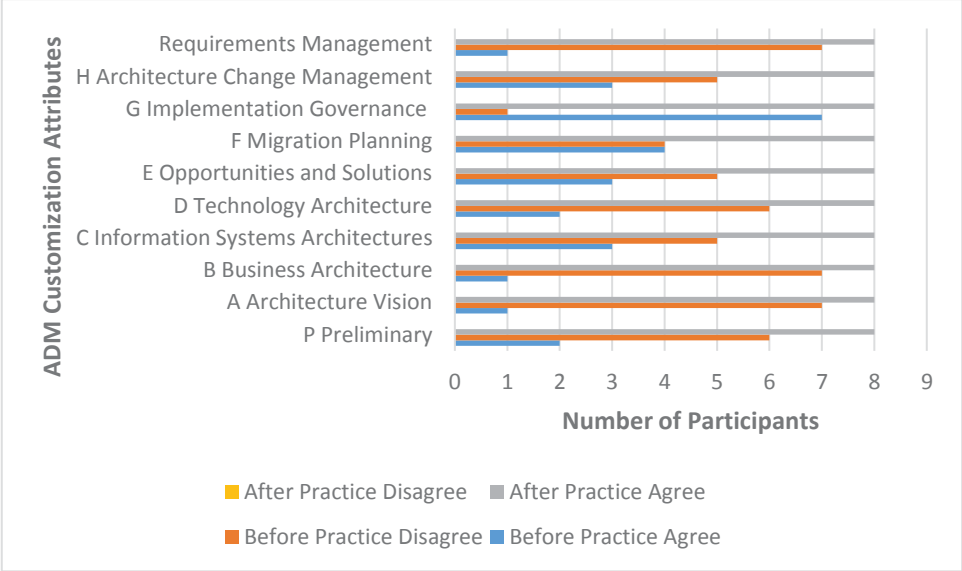


Figure 116 MOE ADM Customization

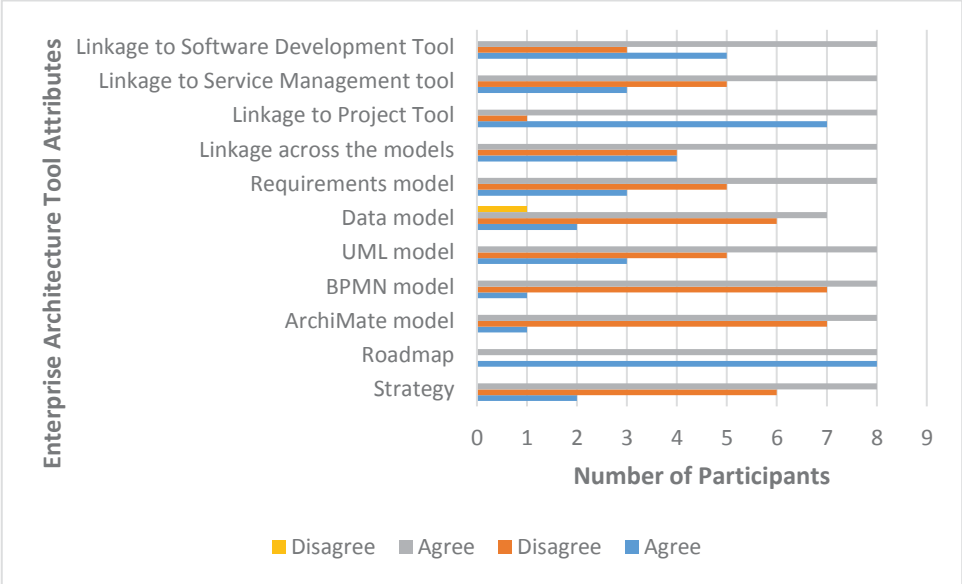


Figure 117 MOE Usage of Enterprise Architecture Tool

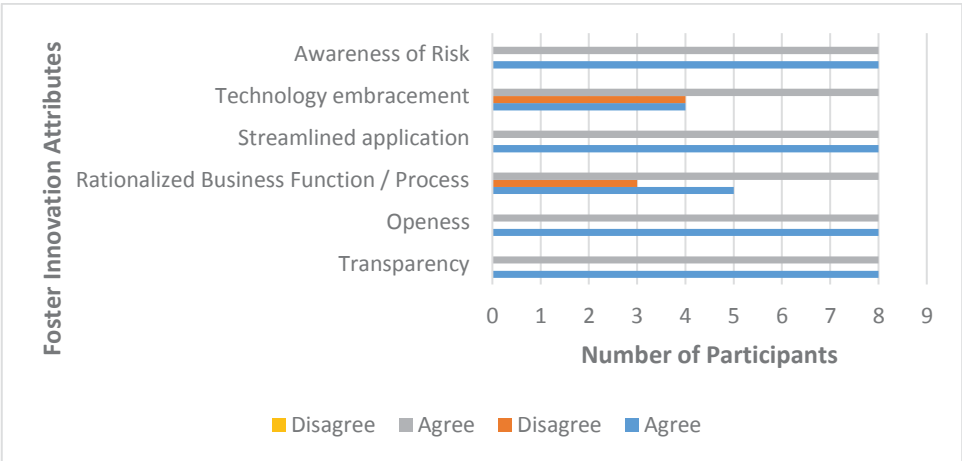


Figure 118 MOE Foster Innovation

As most of the participants were from Project Management, the initial assessment gave poor results. But after capacity building and project execution the participants realized the benefits of Enterprise Architecture, so the results were good after project completion.

TOGAF Architecture Capability Maturity Model (ACMM) tailored specifically to the project was used for maturity assessment.

People and skills related

- The Staff are enthusiastic and are keen to learn.
- Staff was performing an additional task other their designated roles.
- Staff transferred from other departments are not given induction to the role assigned.
- Staff do not have necessary knowledge for the role assigned
- Roles are not defined with clear responsibilities, thereby without KPI
- A few of the senior staff have management and strategy level skills
- A few of other staff are still only knowledgeable in their technology areas

Process related

- Requirement gathering process can be improved through usages of techniques such as, Use Cases and TOGAF business scenario.
- There is no standardised practice to capture business function and process
- Governance is generally lacking
- Though EAO set up is in progress its scope, charter and rules of engagement need to be defined.
- Project completion process need to include documenting lessons learnt and reusable assets
- Data Governance is not in place

Tools related

- No centralized Project Management tool
- No tool for EA modelling
- Lack of tools to manage project progress centrally
- Lack of centralized document management system or EA repository

Technology

- Lack of an enterprise wide EA approach has resulted in heterogeneous platform and systems.
- The cause of heterogeneous school's environment is due to initiatives coming from different directions to the schools: through different ministries, school principal having authority to choose their own systems and other Government or agencies donating systems to schools
- Enterprise wide integration and Service-Oriented approach is not in place
- Master data management or a single source of truth was not in place.

Day to day operations

- Most of the operations done manually and there is very little automation.
- The vision exists but does not reflect or connect to the day to day operations.
- Centralized configuration management system is not in place.

- Software version control system is not in place.
- Change management; release management is in the preliminary stage.

Gap Analysis (short / medium/ long term)

- **Short term gaps to be addressed:**
  1. To set up EAO charter, EA Organization, Scope, Process definitions,
  2. EA Organization:
     a. Structure, roles, linkages to other group, deliverables,
     b. Tools decision, training and implementation
     c. Repository decision
     d. Modelling knowledge: ArchiMate
     e. Business Analysis / Business Architecture
     f. To do on the Job training and hand holding for TOGAF ADM Cycles
     g. ITIL for change management.
     h. Technology scan, decision, selection and implementation strategy for
        i. Data warehouse
        ii. OLAP/ OLTP combination capability
        iii. Private cloud options
        iv. Disaster backup and recovery
     i. Requirements gathering (Business scenarios) processes
     j. Detailed Maturity model and roadmap
  3. Review of training Requirements & plan for EAO / PMO staff.
  4. Current help desk rationalization and contracts
  5. Self service
  6. Identity management
  7. CMDB to be built
  8. Virtualization of the standalone systems
  9. Initiation of Master data management

Medium term gaps- Solutions to be in place by next 6 months

1. Enterprise Architecture
   a. Governance processes, tools and reference information in place and fully operational
   b. EA change management operational
   c. Actionable EA principles
   d. Two -Way link between EA and strategic initiatives
   e. Tools implementation
   f. Functional repository
   g. Technology scan, selection and implementation strategy for
      i. Big data to harness unstructured data (E. g. Social media integration / social profiling of the students)
      ii. Social media integration with the organization
      iii. Learning Management System based on SaaS model
      iv. Customer relationship management that are based on SaaS model

v. Bring your own device management appliance for laptop, hand held devices, and so on.

2. Centrally managed software distribution license agreements (LAs).
3. Master data management in place
4. Single truth of record, as the data collected of students, staff and parents can be used by other ministries
5. Fully functioning centralized help desk support.

Long term gaps- Solutions

1. The roadmap in place to achieve Maturity of EA level to 4
2. EAO well defined and a model or showcase for other ministries to adopt
3. Effective use of modern technology as big data, internet of things
4. Business process management tools in place
5. Fully centralized information management systems

1.2.5 Summary of Key Recommendations

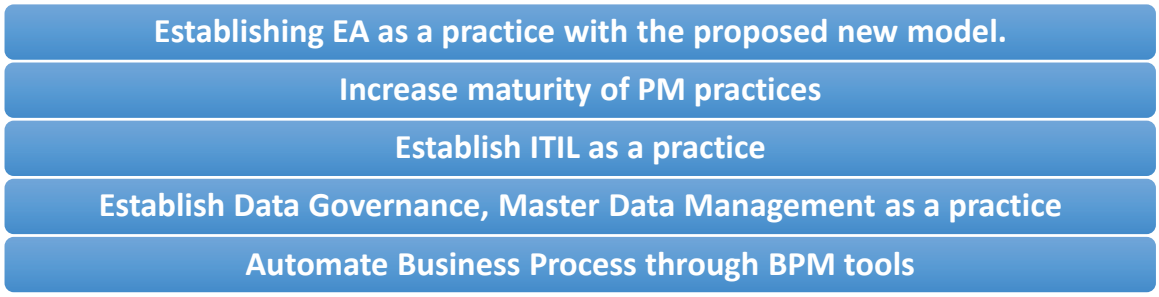


Figure 119 Summary of Key Recommendations

1.2.6 Proposed EA positioning across the ministry

The key finding was that Enterprise Architecture was managed by PMO office. The PMO that set newly, had no maturity in its process and practices. Strategic initiatives led as projects. However, projects are temporary endeavours with end date whereas strategic efforts go beyond the project lifecycle. Strategic initiatives after implementation need to be validated if objectives are met. Enterprise Architecture ensures the objectives are met, if not another programme or project is initiated.

In general, PMO wants the project completed at the earliest, yesterday. While Enterprise Architecture(EA) want to future proof that involves time and cost. As EA controlled and managed by PMO, the former had no say in the outcome of the projects. So, new structure where Enterprise Architecture Office manage PMO was recommended.

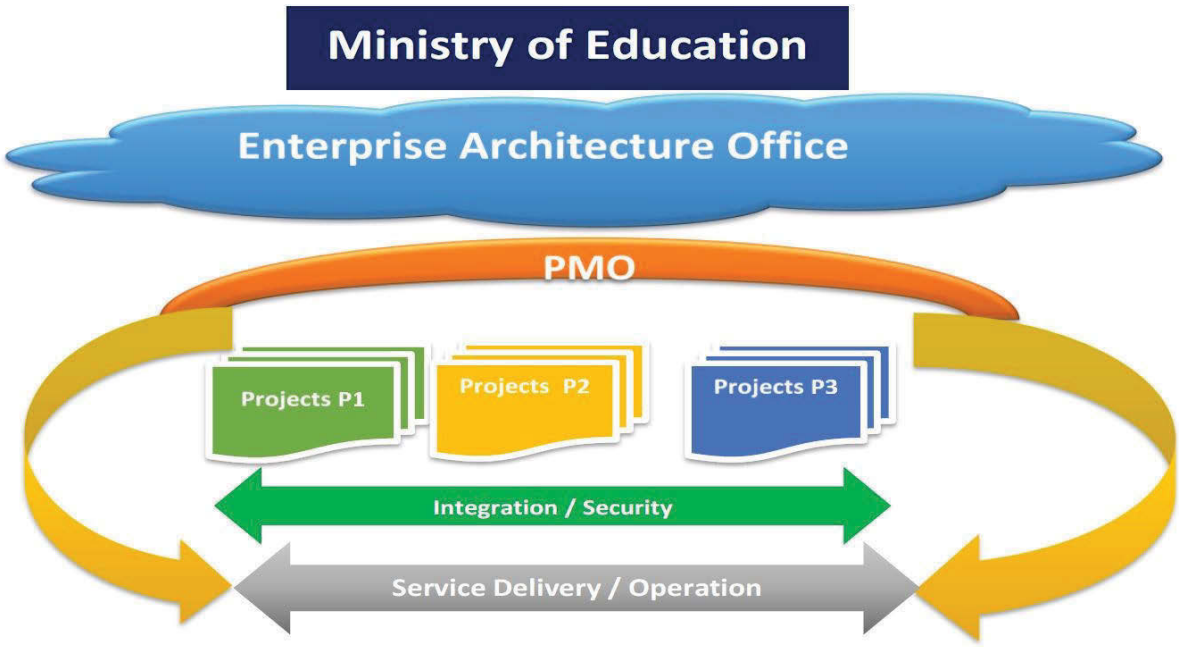


Figure 120 Proposed EA organization model

The proposed new model had the Enterprise Architecture Office (EAO) directly working and reporting to the ministry and overseeing PMO, which will ensure the success of strategic initiatives.

Also, it was proposed the EA can be successful with Whole of Government approach, rather than single ministry. As the weakest chain can break, so the process to be across the Government.

1.2.7 Proposed Digital Platform Capabilities

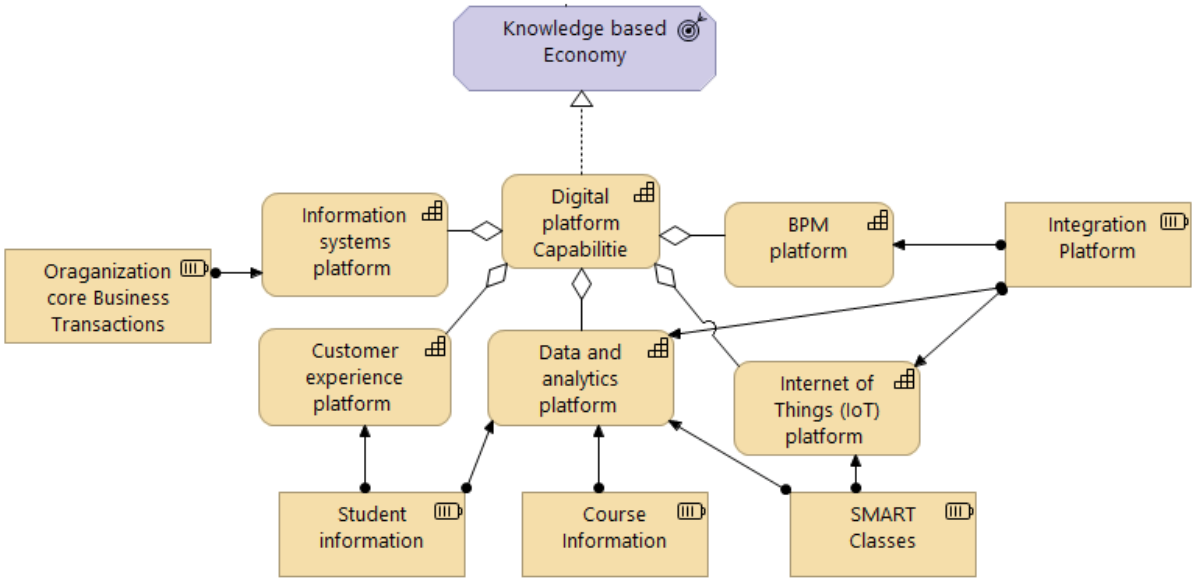


Figure 121 Proposed Digital Platform Capabilities

1.2.8 Conclusion

The success of the enterprise architecture is achievable with the projects implementing organization reporting to EAO or with PMO and EA working in balance organization matrix.

"Perfection is not attainable, but if we chase perfection we can reach excellence."
- Vince Lombardi

1.3 Case Study: Ministry of Health

1.3.1 Introduction

Project type: Enterprise Architecture Capability Building and Practice set-up.

Capacity Building, Assess and recommend Enterprise Architecture approach for Counterfeit Medicine eradication.

Organization

A Government Ministry with functional organization type, where projects managed in a weak matrix structure.

Background

The national e-Health strategies are to provide better services for citizens by streaming lining and supporting the reuse of public sector information systems while reducing duplication and costs. Enterprise Architecture practice was initiated to realize the strategy.

Motivation

Counterfeit Medicine

There was a distribution of illegal counterfeit medicines. Wholesalers were distributing substandard medication, and it subsequently sold by pharmacies. Nearly 4/5 of the medication was imported.

Due to above, health of the people getting affected, loss in the revenue for the Government and cost to treat the Citizens due to counterfeit and substandard medicine.

1.3.2 Objective

- Capacity building through TOGAF workshop
- Enterprise Architecture Maturity assessment of the current state of Ministry of Health strategy to implementation practices.
- To build national capacity in EA
- Identify the methodology that is practical, and tailor based on the organization culture.
- To perform one cycle of ADM for Medicine Safety Information Management Suite (MSIMS).

1.3.3 Process Followed

Stage 1: Discovery Phase: P, A, B, R

- Prepare the organization for EA projects based on TOGAF.
- Create an Architecture Capability, customizeTOGAF framework, select the tools, and define the EA Principles.
- Understand the current organization, business process (manual / automated)
- Understand the available International Standards
- Determine the scope, constraints, and expectations for the EA project. Create the Architecture Vision.
- Develop the high level Baseline and Target Architecture and analyze gaps.
- Assure each phase of a TOGAF project validates the business requirements.

Stage 2: Analysis & Develop Phase : C, D, F, R

- Analyise & Develop architectures domains: Business, Applicaion, Data, Technology, Secrity
- For each domain determine the Baseline and Target Architecture and analyze gaps.

Stage 3: Planning Phase: E, F, R

- Determine initial implementation planning of delivery for the building blocks identified in the previous phases.
- Determine incremental approach and identify Transition Architectures.
- Develop detailed Implementation and Migration Plan to move from the Baseline to the Target Architecture in alignment with the business objectives.

Stage 4: Implementation Phase: G, H, R

- Define the architectural oversight for the implementation.
- Develop and issue Architecture Contracts.
- The implementation project to conforms as per defined architecture.
- Architecture always needs to meet the changing business requirements, ensured by monitoring and implementing changes as required

1.3.4 Overall Observation and Key findings

The interview was conducted before starting the project and after completion. They were twelve stakeholders involved in the project. The stakeholders had more than ten years' experience working in Information Technology with majority from operations and few from business analysis.

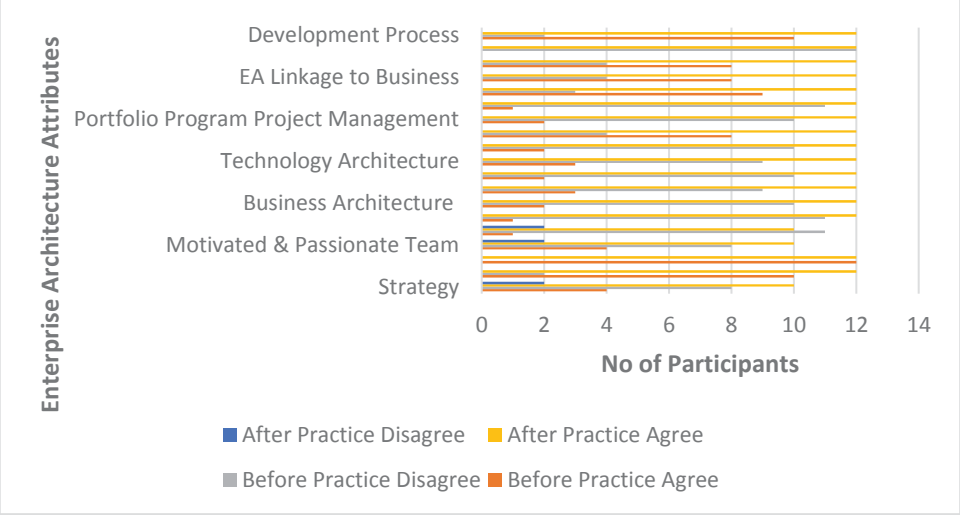


Figure 122 MOH Enterprise Architecture Approach

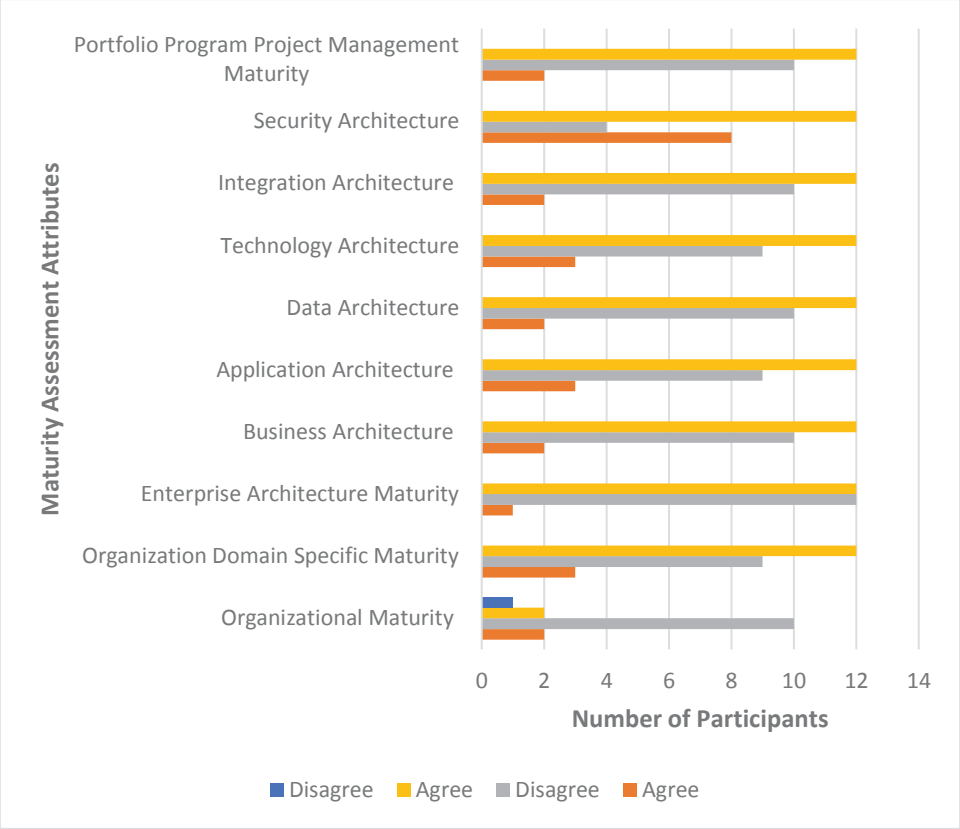


Figure 123 MOH Enterprise wide Maturity Assessment

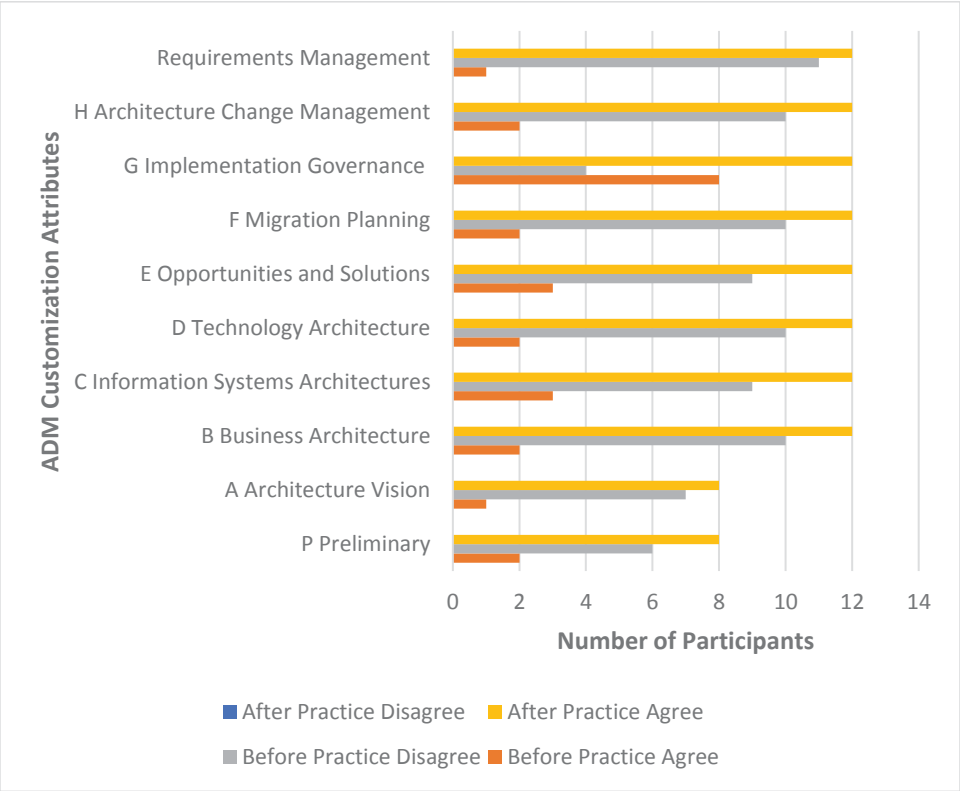


Figure 124 MOH ADM Customization

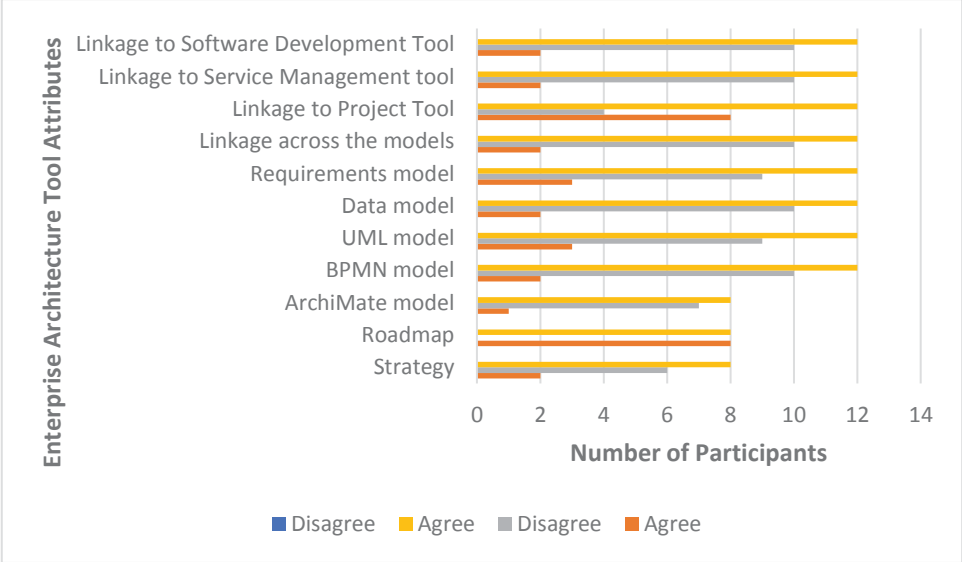


Figure 125 MOH Usage of Enterprise Architecture Tool

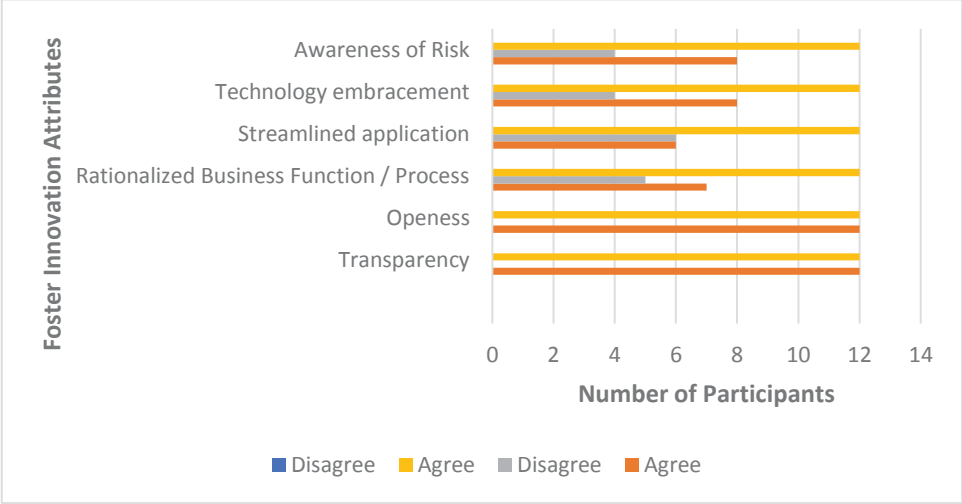


Figure 126 MOH Foster Innovation

As most of the participants were from the operation and business analysis, the initial assessment gave poor results. However, after capacity building and project execution, the participants realized the benefits of Enterprise Architecture, so the results were excellent.

Proposed EA practice Kick Off

To kick start EA practice, it is essential to identify the project that is strategically important. As 80 % of the imported medicine were counterfeit medicines, it is critical to have an automated system with the capability to manage and monitor medicine in real-time. The system should have the ability to integrate information across various departments, business units, hospitals pharmacies, and so on.

Importing medicines as raw and finished products, brings in with many challenges. Many products entering country are made or grown in non-standardized environment. To ensure their quality and safety its required to:

- Identify potential medicine safety problems before products are approved
- Ensure that medical products meet international standards.
- Monitor imported medicine raw material used by medicine manufacturers.

- To establish the process that ensures quality and monitors the products adheres to the specifications as applicable.

Key high-level process identified:

- Ensure the quality of medicines
- Manage adverse events
- Establish Standard inspections procedures
- Establish the process for Premarket Approvals
- Conduct Post-Approval Studies
- Identify Radiation-Emitting Products, listing, repository
- Manage Recall Activities
- Process for Registration & Listing
- Identify and maintain Standards
- Monitor the Total Product Life Cycle
- Establish the process for Inspections, Compliance, Enforcement, and Criminal Investigations
- Develop a process for Products Sampling procedures
- Establishment Inspections and Investigations
- Give steps for Emergency Preparedness
- Process for Inspections/Compliance
- Guide to International Inspections and Travel
- A process to respond to Foodborne Illness Outbreaks
- A process to respond to International Disasters in the local environment
- Process for Global Data Information Sharing
- Send formatted data or other nonclinical GLP study data from source collections systems into secure, controlled repositories
- Process to share data with neighbouring and collaborating countries

To achieve the above it is essential to develop a Medicine Safety Information Management Suite:

- To get medicine import statistics in real-time,
- To eliminate import of unregistered and illegal counterfeit medicines,
- To provide the population with genuine and authenticated medicines,
- To enforce issue of medicine by prescription only
- To ensure proper use of medicines
- To have price control over medicine as the price of imported medicine are 4 to 5 times higher than international standards.
- To increase the revenue to the Government and reduce the loss of income due to illegal imports.
- To reduce the long-term burden on the Government due to counterfeit medicine.

Though MSIMS is specific to the ministry, it needs to be based on International standards to comply with the International regulatory requirements and to promote knowledge sharing and reuse among other Asian countries.

The system initially targeted at drugs for human consumption. However, it can be extended further, for food, agricultural products, animal medicine, manure, pesticides import, and so on.

International Standards Compliance:

Identified relevant international standards, as per the architectural requirements, these standards need to be evaluated and adapted.

- Health Level Seven International(HL7)
- GS1 Standards of Healthcare sector
- Automatic Identification and Data Capture (AIDC)
- Digital Imaging and Communications in Medicine (DICOM)
- Systematized Nomenclature of Medicine – Clinical Terms (SNOMED CT)
- Logical Observation Identifiers Names and Codes (LOINC)
- Continuity of Care Record (ASTM CCR)
- International Classification of Diseases (ICD-9/10)
- Clinical Data Interchange Standards Consortium (CDISC)
- ISO/IEC 11179: Repository metadata
- CEN ISO/IEEE P11073: Medical device communication
- Continua Health Alliance
- Integrating the Healthcare Enterprise (IHE)
- Food and Drug Administration Safety and Innovation Act (FDASIA)
- Current good manufacturing practices (CGMP's)
- International Organization for Standards (ISO) 9001:1994

Proposed Business Process Management process

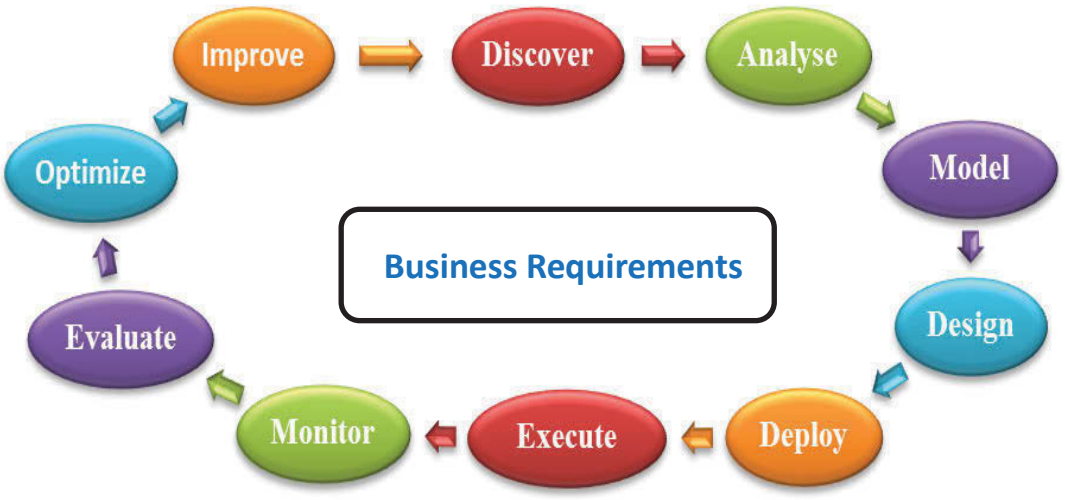


Figure 127 Proposed Business Process Management process

1.3.5 Summary of Key recommendation

To kick start EA practice, it is essential to identify the project that is strategically important. As 80 %
Proposed EA positioning for the ministry

A significant number of Enterprise Architecture (EA) projects do not to achieve all their objectives or do not realize the benefits as the team is not using the right methodology to exploit the phases.

For the success of EA based on TOGAF, it is essential to handhold the team for few phases of ADM.

As the Health Information Management System Suite maintains the record of citizens from “Cradle to Grave” or “Womb to Tomb,” the information of Health Information Management System needs to be interoperable with other systems of the Government.

- To start the engagement with other related ministries or partners to get the information that is required by the system as:
    - The drugs or ingredients that are entering the country to interact with the systems of the Ministry of Health in real-time to check the validity of the license
    - Medicine imported from the manufacturer to be traceable from the origin to destination
    - Prescription to be an issue to patients that are available to the pharmacy in real-time. So, the medication can be issued only to authorize patient.

The current EA practice is defined centrally in country or state-wide. However, there is no mandate to follow the tradition. With the current technology capability information of Citizen can be determined and all the other agencies can refer to same data. Depending on the department wise the data will be updated. A good example is a unique ID in India where all the citizens have single source truth for their identity.

The private organization with current technology using CRM combing with big data get the customer 720-degree view. Similarly, Government agency to adopt the same model where there is one CRM across the Government where the citizen information captured and explicitly updated based on individual departments as education, health, taxation. It must be mandated private organization will make the unique id of the citizen as the primary key. Unique ID will ensure the Government to get the complete data of the citizen, which will help the Government to make policies that are beneficial for the citizen and country.

1.3.6 Conclusion

Medicine Safety Information Management Suite a centralized system to issue, manage and track medicine of the country.

Health Information Management System Suite to maintains the record of citizens from birth to death. The information of Health Information Management System is the Single Source of Truth that needs to be interoperable with other systems of the Government.

1.4 Case Study: Financial Institute

1.4.1 Introduction

Project type: Proposal for Enterprise Architecture

Propose Enterprise Architecture approach for trading platform transformation for financial institute.

Organization

One of the significant financial Institute that provides financial services.

Background

A Financial Institute provides service as comprehensive clearing, compliance services, practice management programs, training, research for independent financial advisors and financial institutions. To revamp the current trading platform to reduce the time of service provisioning, reduce cost and increase quality through cutting edge proven technology.

Motivation

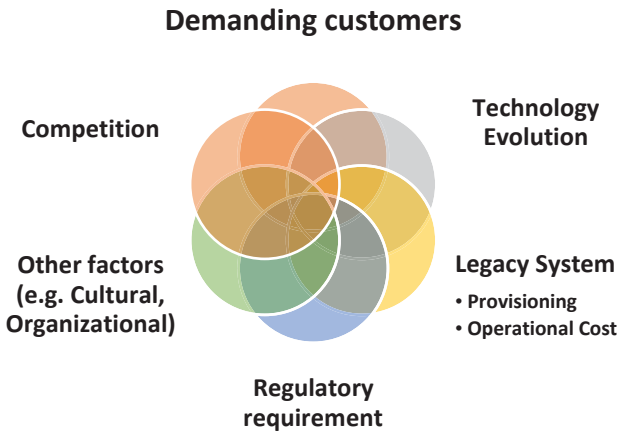


Figure 128 Drivers influencing the change

1.4.2 Objective

- Proposal for migrating to a Multi-tenancy trading platform using an Enterprise Architecture approach.

1.4.3 Process followed

Characteristics of multitenant environment, each tenant operates in a logically isolated, but physically shared environment-

1.4.3.1 The appropriate phase of TOGAF as referred from Gartner Reference Architecture for Multitenancy:

- P-Phase
    1. Tenant customization
    2. Tenant security policies
    3. Tenant elasticity policies
    4. Automatic allocation, thresholds and increments of change
    5. Tenant-aware error and disaster recovery
    6. Tenant-aware security, monitoring, management, reporting and self-service administration
    7. The ability to allocate resources to tenants dynamically, as needed and based on policy
- B-Phase
    1. Tenant process isolation — to identify and segregate business service, process and function to find characteristics such as privacy of state and error isolation
    2. Tenant self-service provisioning, administration and de-provisioning
    3. Tenant resource-use tracking Tenant billing in proportion to the actual resource use
    4. Isolation of tenant customizations and extensions to business logic
    5. Tenant resources tracking and recording per user
- C-Phase
    1. Tenant data isolation considering -privacy and integrity
- D-Phase

1. Tenant-aware version control for platform technology and application software
2. Tenant workspace isolation
3. Tenant execution characteristics isolation.
4. Horizontal scalability to support real-time addition/removal of tenant resources, without interruptions to the running environment

- E-Phase
    1. Tenant SLA policies with availability and response time
    2. Version control of Tenant
    3. Error tracking and recovery of Tenant

Framework and methodology customized

Tailoring of TOGAF in context of migration to Multi-tenancy (references are made to the multi tenancy characteristics as outlined previously)

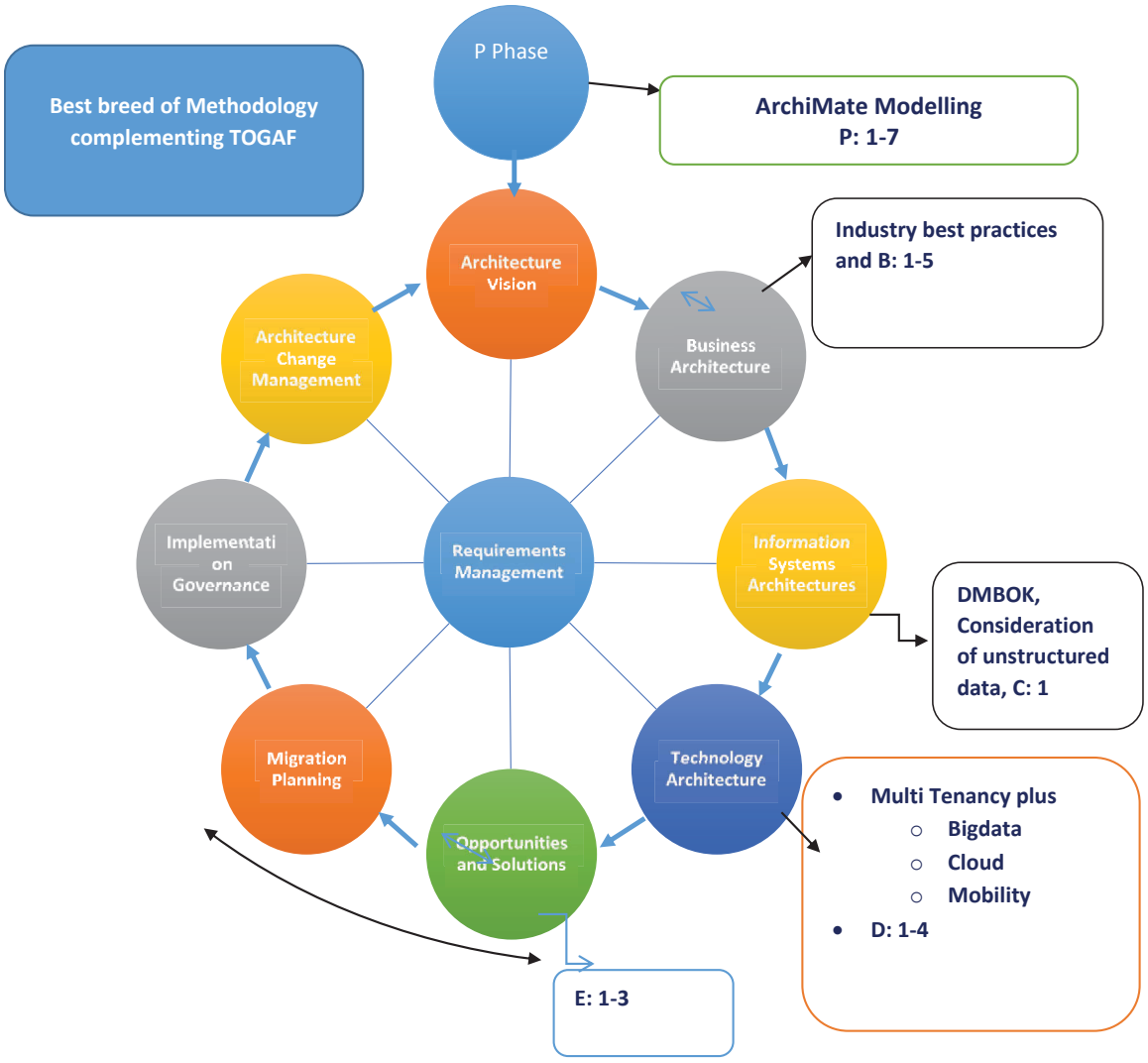


Figure 129 Framework and methodology customized

Approaches

To analyze the approach to be based on Baseline first or Target first.

As the current platform supporting thousands of financial advisors and hundreds of financial institutions, it is critical to approach based on Baseline first. In this approach, it identifies the current problems, business logic, dependencies, transition plan, and so on.

As the platform is extensively used, the platform to evolve, business as usual with the focus on:

- Assessment of physical running applications and IT infrastructure to optimize and enhance, considering its must not affect the business and its BAU operations.
- Programs, Projects their dependencies to align with the architecture.
- To realize Vision, identify the gaps that needs to be achieved to reach the target state.

1.4.4 Overall Observation and Key findings

The interview was conducted before doing the proposal. The input was taken from 5 stakeholders with majority of their experience in presales and project management. Management background. Before preparing the proposal only the interview was conducted as an input to prepare the proposal.

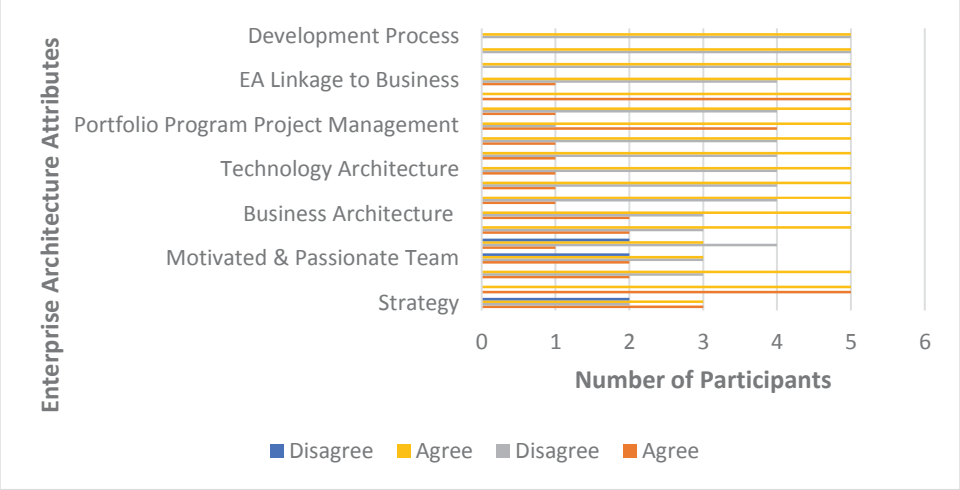


Figure 130 Finance Institute Enterprise Architecture Approach

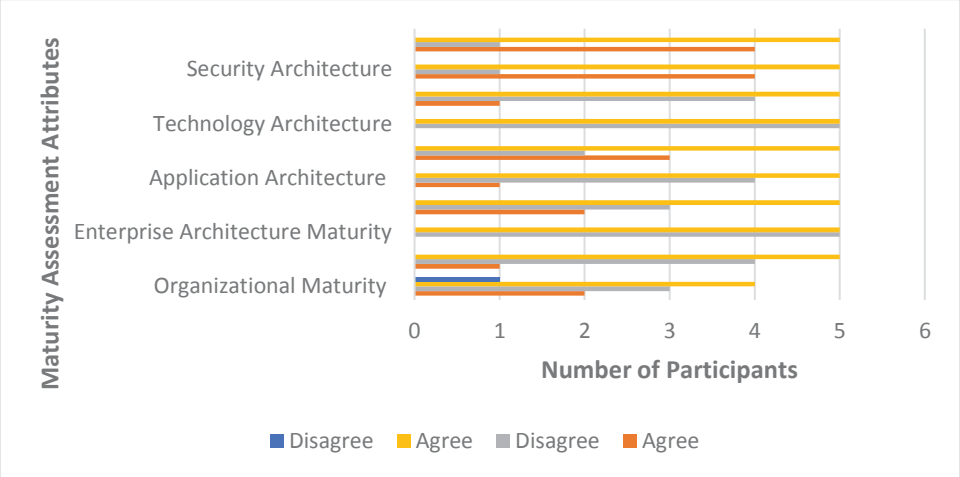


Figure 131 Finance Institute Enterprise wide Maturity Assessment

1.4.4.1 Technology

- Organization as grown astronomically, at the same time it was not possible to upgrade the platform with the technology that had evolved.
- The technology is changing at an alarming pace, it's a risk to an organization to change the core platform on a technology is yet no matured. Also, at the same time costing a huge investment.
- Technology is inevitable to run the business, especially for the large organization. It is not practical to upgrade the core systems in pace with the ever-changing technology. Also, it not wise to ignore to adopt the cutting-edge technology.
- Enterprise Architecture approach enables to analyze business needs and recommend technology stack that suits the organization based on the culture, risk appetite, and business model.

Two Common Multitenant Architecture Models:

1. The Dedicated resource models define the resource a tenant can access the shared infrastructure. Though its more secure but with less flexibility.
2. Metadata map models chart protected pathways to shared resources, allowing for increased flexibility, but less secure compare to the above.

1.4.4.2 Identified International Standards Compliance:

- Society for Worldwide Interbank Financial Telecommunication (SWIFT)
- Automated Broker Interface (ABI)
- Automated Commercial System (ACS)
- Automated Clearinghouse
- SOX Compliance
- Dodd-Frank Act
- GLBA
- AML
- Regulatory Audits (SEC, FDIC, CFPB, OTS, OCC, NCUA, FINRA)

"Organizations that have the imagination to reinvent themselves can make a decisive leap forward."
- Capgemini

1.4.5 Conclusion

Technology is inevitable to run the business, especially for the large organization. It is not practical to upgrade the core systems in pace with the ever-changing technology. Also, it not wise to ignore to adopt the cutting-edge technology.

Enterprise Architecture approach enables to analyze business needs and recommend technology stack that suits the organization based on the culture, risk appetite, and business model,

EA approach identifies the actual building blocks from the architectural perspective, thereby reducing the risk of technology stack or vendor lock-in.

1.5 Case Study: Bank

1.5.1 Introduction

Project type: Enterprise Architecture Capability Building and Practice set-up.

Assess and recommend Data Management for a Bank, based on Enterprise Architecture Approach.

Organization

A leading state-owned Bank with functional organization type, wherein projects were managed in a strong matrix structure.

Background

The retail bank was replacing its core banking system. The data management was done by a dedicated team. Bank consisted of various banking products that had their backends composed of different types of databases. To streamline the data management, to create an awareness of large and unstructured data an EA approach was initiated.

Motivation

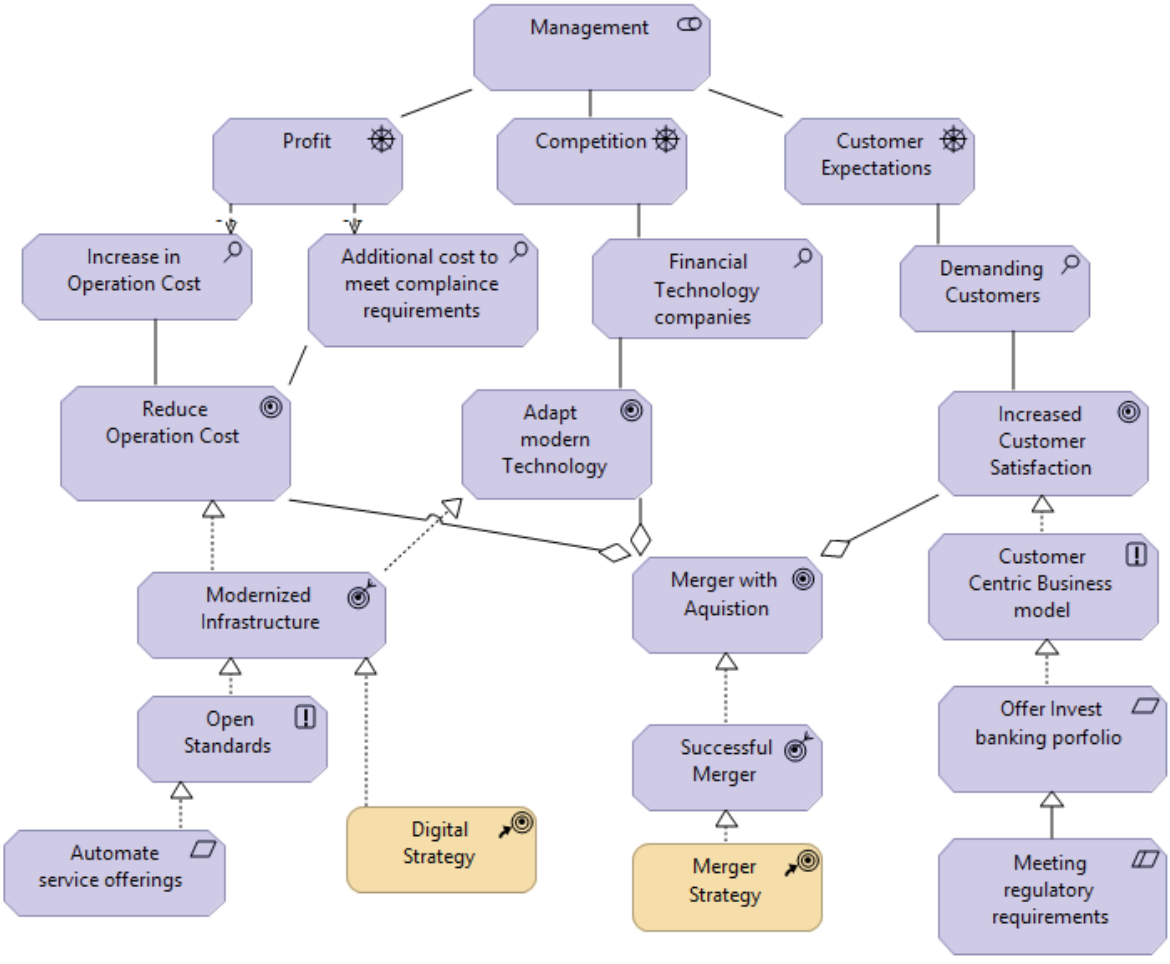


Figure 132 Drivers influencing the change

1.5.2 Objective

- To Introduction TOGAF ®. 9.1 framework, its scope, benefits and how to use it efficiently,
- To use common notation based on open standard modelling language ArchiMate,

- To standardise and rationalise use of the modelling tool across the spectrum in the bank,
- To establish common repository for collaboration,
- To introduce data architecture frameworks that are widely accepted by the banking industry,
- To build agreement for applicable & practical view of data management functions.

1.5.3 Process Followed

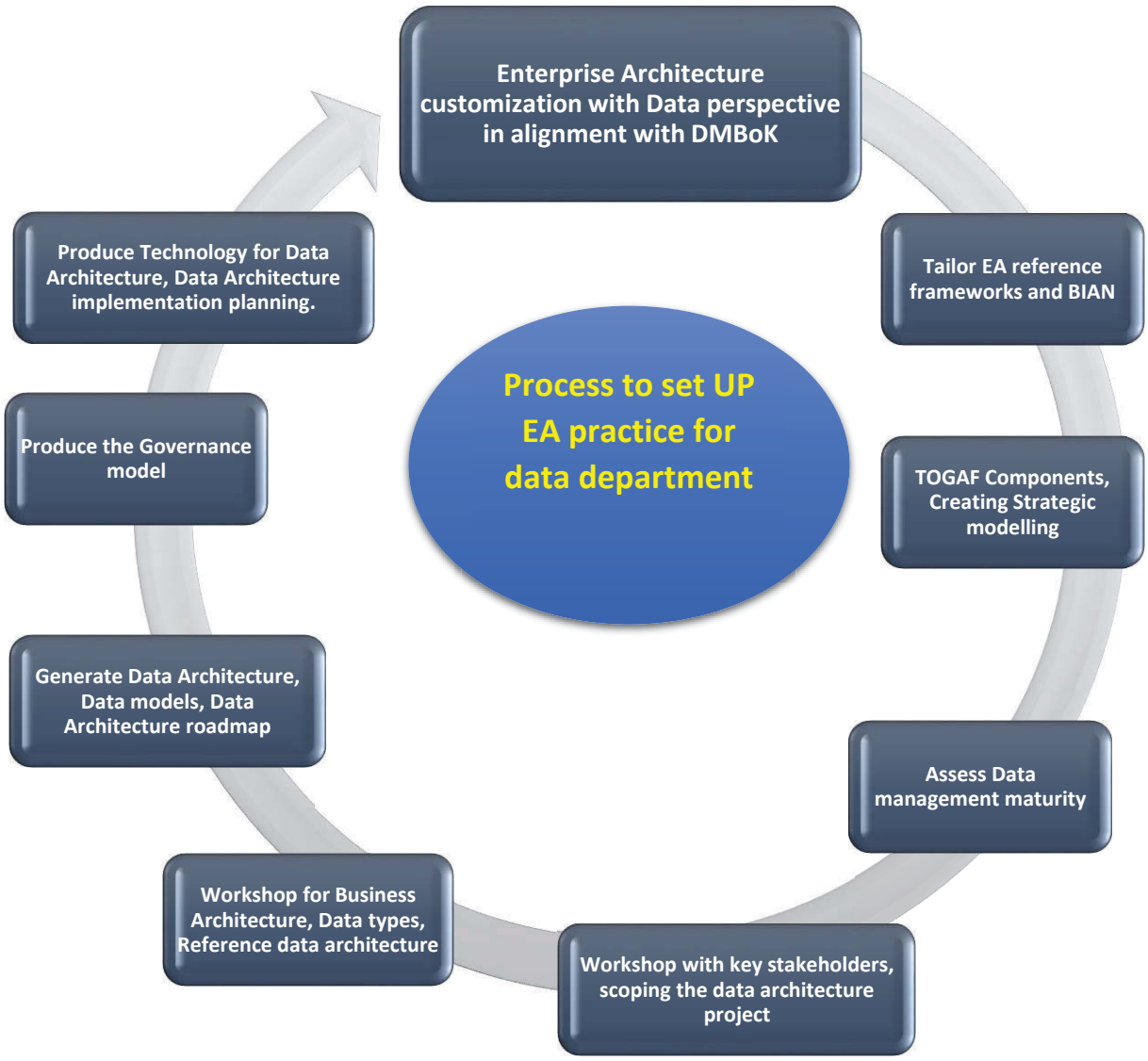


Figure 133 Process to set up EA practice

1.5.3.1 ADM steps

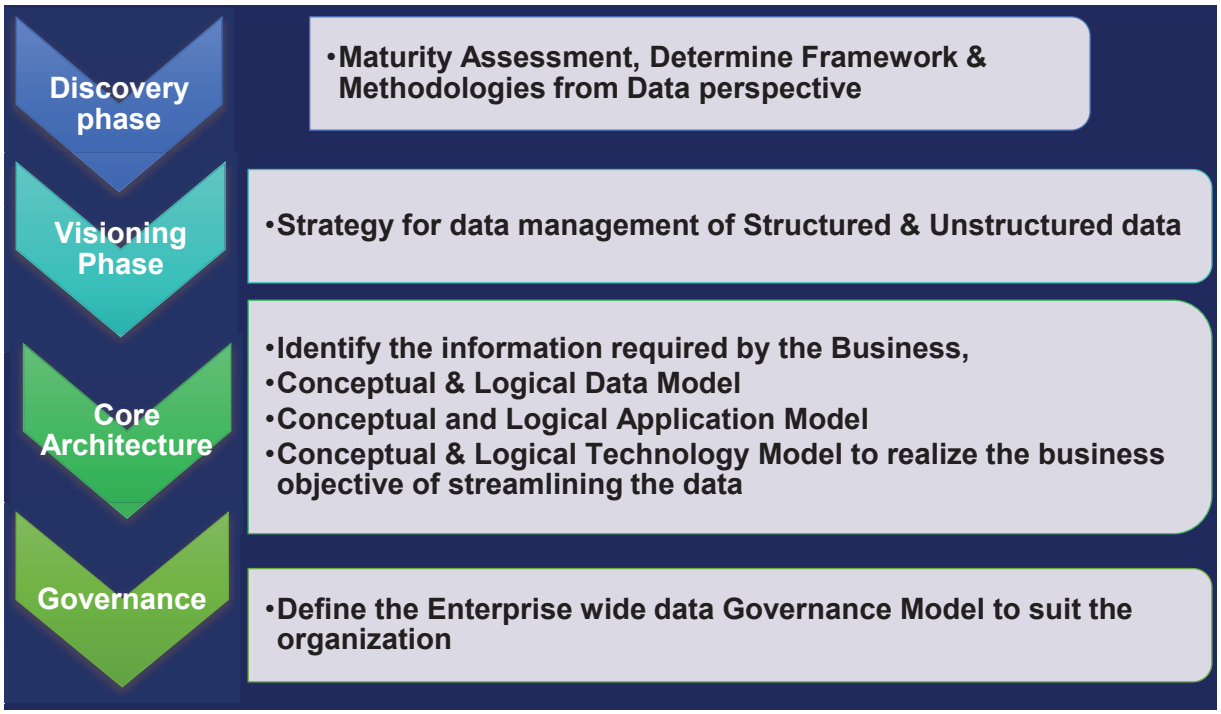


Figure 134 Overall ADM steps

1.5.3.2 Framework and methodology customized

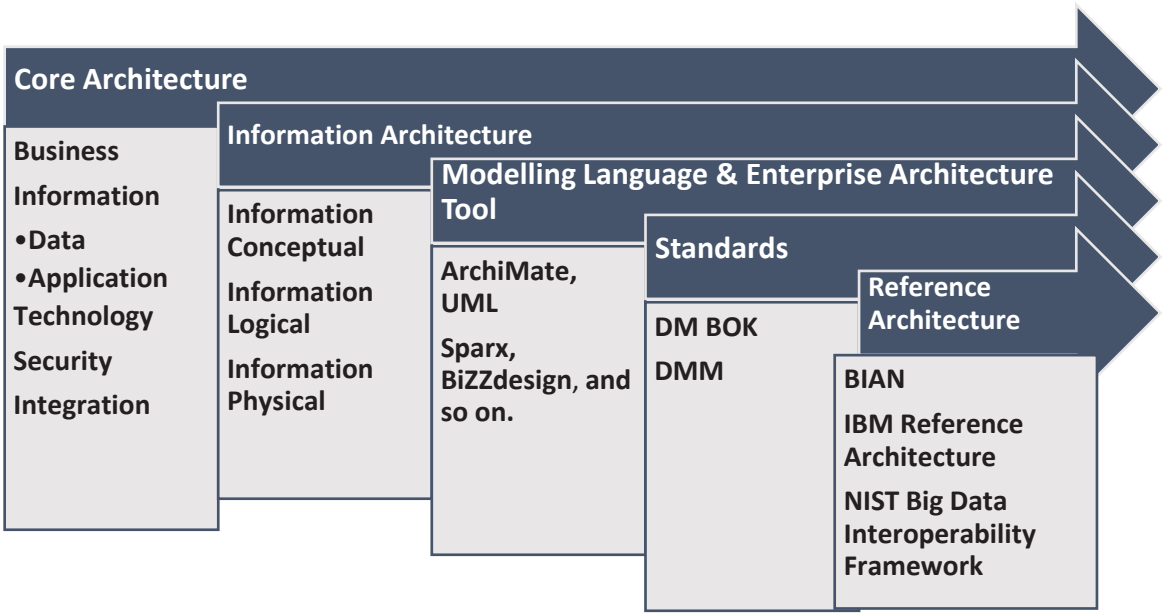


Figure 135 Framework and methodology customized

TOGAF ® 9.1: The Open Group Architecture Framework

TOGAF framework was followed and customized to suit the organization based on the culture. This scope of EA was only for data management

ArchiMate ® 2.1

As in the current practice other than DDL there was no other modelling language followed. So ArchiMate was introduced to model the high level strategic to business requirement.

Sparx Enterprise Architecture Tool

Enterprise Architect Sparx EA tool was used to as tool for EA

DMBOK: Data Management Body of Knowledge

DAMA DMBOK describes the management of data, its function, associated terminology with best practices.

Data Management Functions

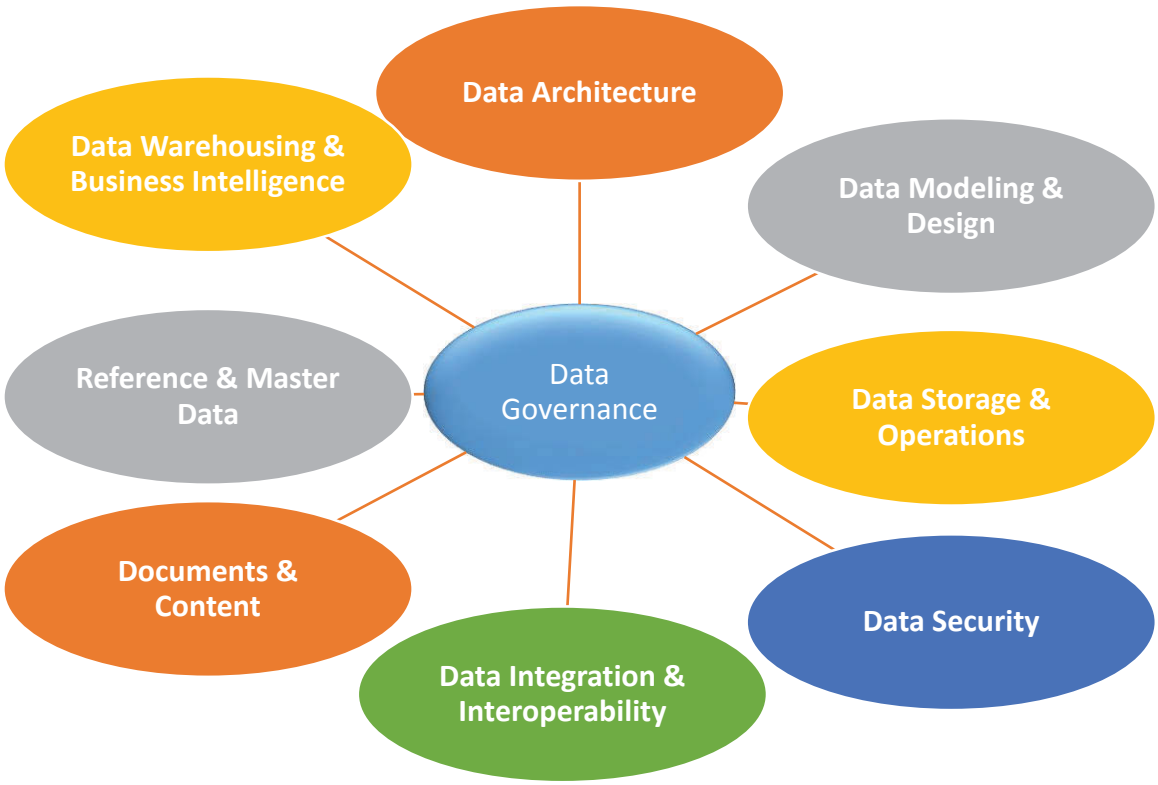


Figure 136 Data Management Functions, Source: DMBoK

DMM: Data Management Maturity (DMM) SM Model

Assesses the data maturity to identify the misalignment between business and IT.

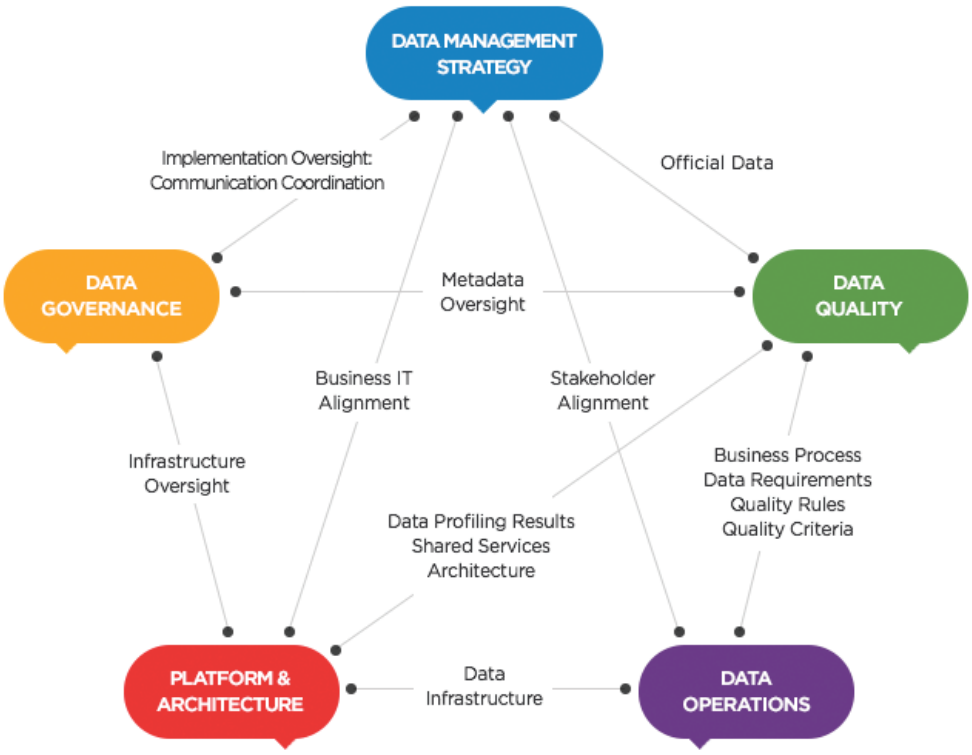


Figure 137 Data Management Maturity, Source CMMI Institute

NIST Big Data Interoperability Framework

Big Data reference framework that defines use cases, taxonomy, security with Roadmap.

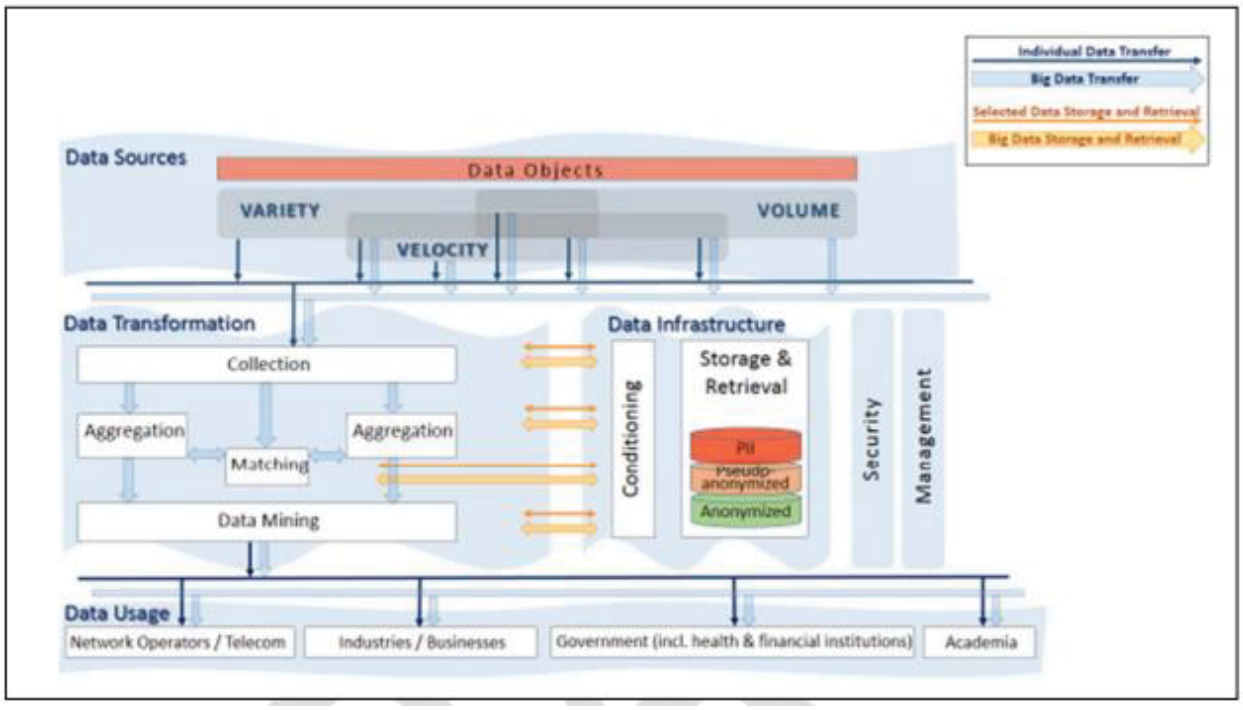


Figure 138 NIST Big Data Interoperability Framework, Source NIST

1.5.4 Overall Observation and Key findings

The interview was conducted before starting the project and after completion. They were twelve stakeholders involved in the project. The stakeholders had more than ten years' experience working in Information Technology mainly in banking domain with majority from Operation Service Management and Data Management background.

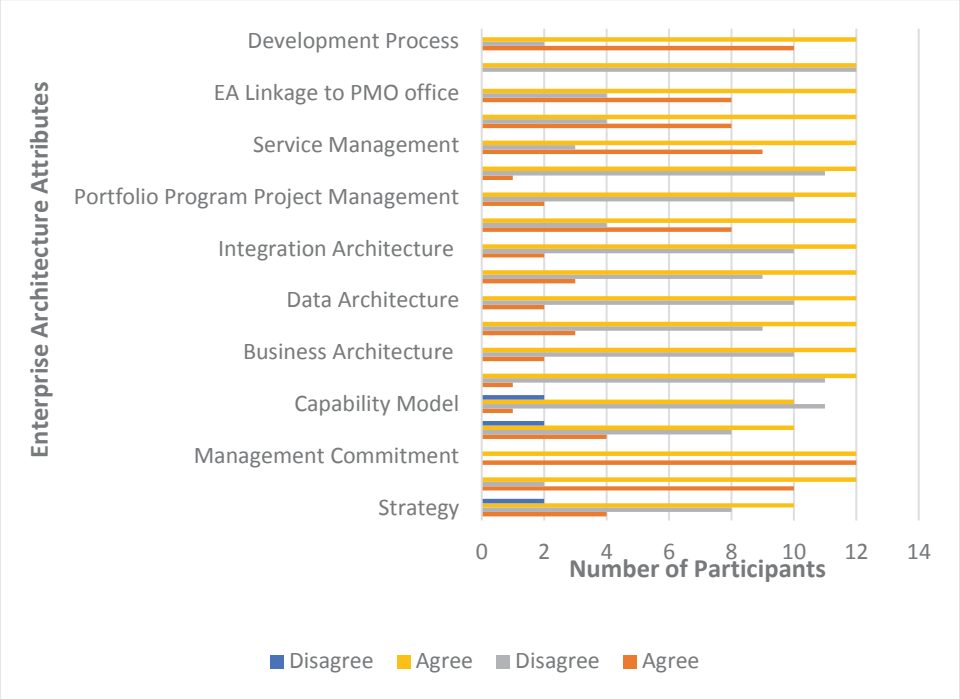


Figure 139 Bank Enterprise Architecture Approach

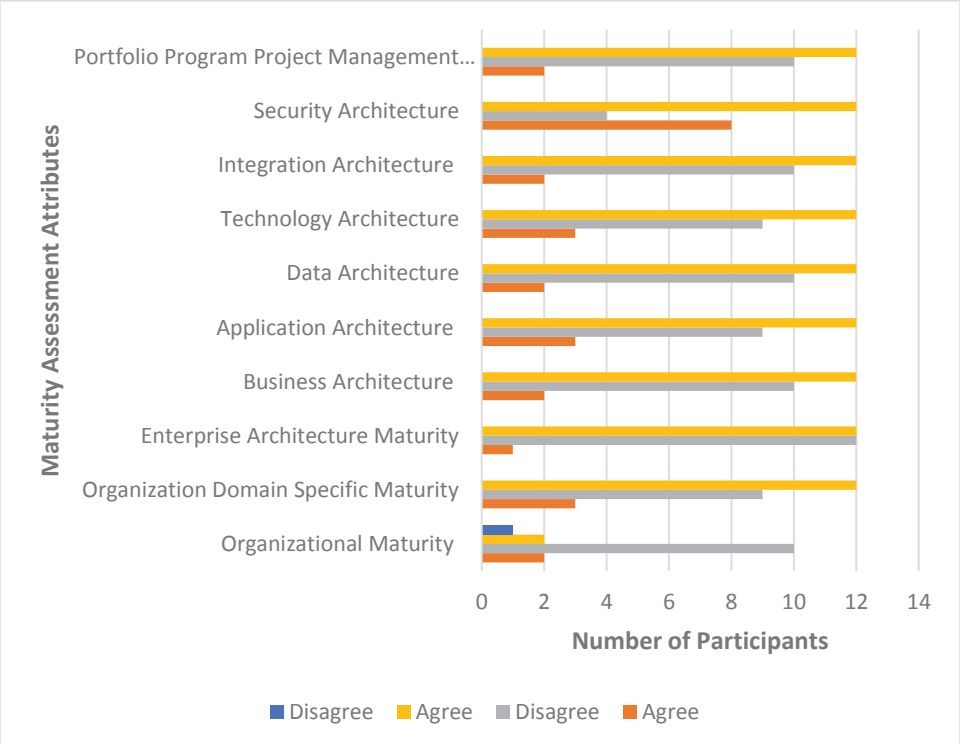


Figure 140 Bank Enterprise wide Maturity Assessment

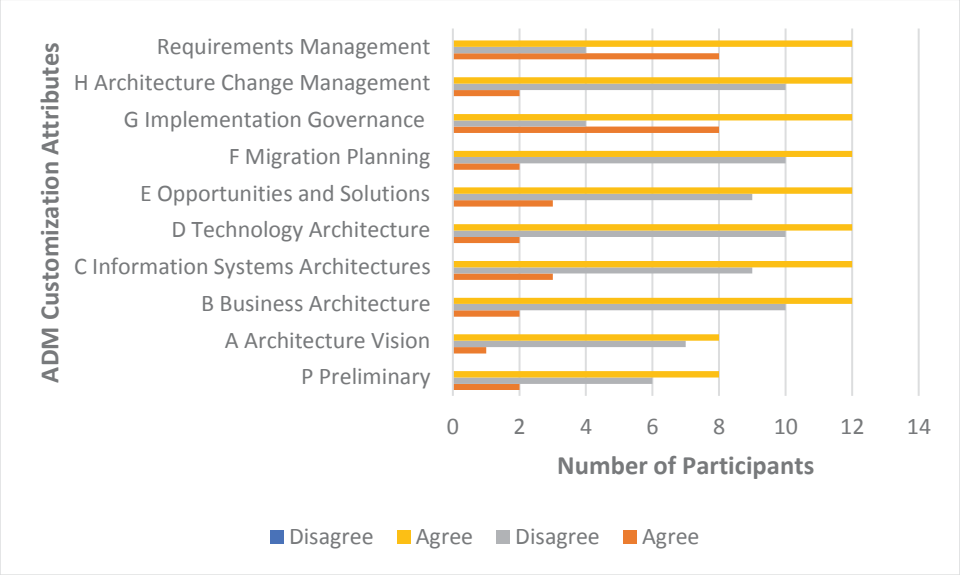


Figure 141 Bank ADM Customization

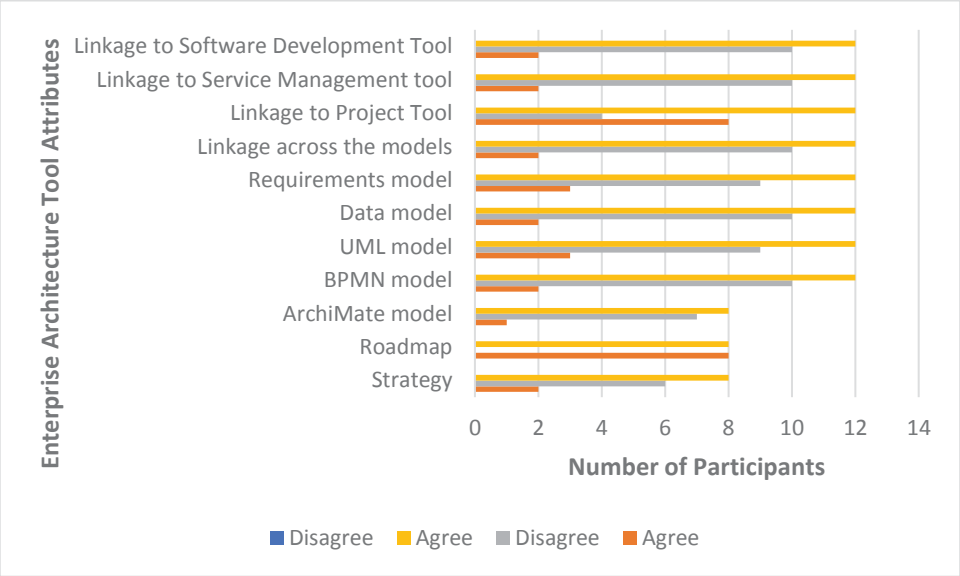


Figure 142 Bank Enterprise Architecture Tool

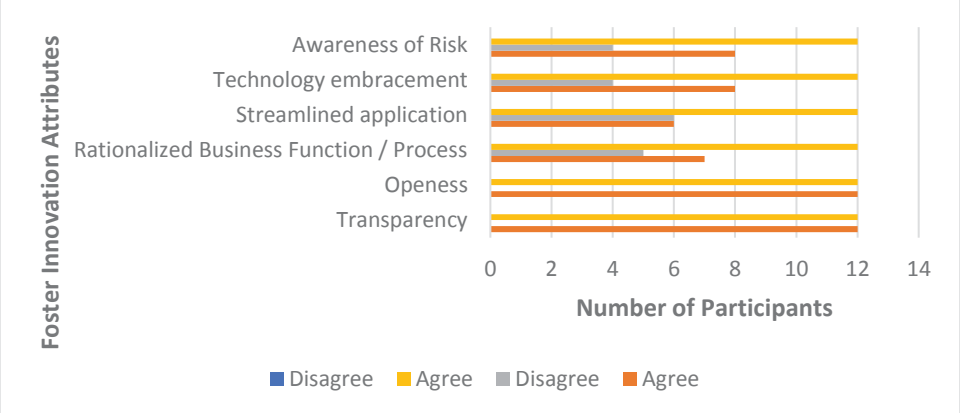


Figure 143 Foster Innovation

As most of the participants were from Operation Service Management and Data Management background, the initial assessment gave poor results. But after capacity building and project execution the participants realized the benefits of Enterprise Architecture its value that going to add to the data management, so later stage the results were good.

People and skills related

- The Staff have expertise on core banking domain
- Very good with data skills
- Very quick in grasping to identify the business process concept, the source that generates data

Process related

- There is no standardised practice to capture business function and process
- Governance is generally lacking
- Data Governance is not in place
- Lack of process to connect from conceptual to logical to physical diagram

Tools related

- No centralized modelling tool other than preliminary EDL tools Project Management tool
- No tool for EA modelling

Day to day operations

- Most of the operations done manually and there is very little automation.
- Change management, release management is in preliminary stage.

1.5.4.1 Summary of Key Recommendations

Establishing EA practice

Increase maturity of PM practices

Establish ITIL practice

Determine the Taxonomy and Data Metamodel

Establish Master Data Management practice

Automate Business Process, with BPM tools.

1.5.4.2 Conclusion

The success of the enterprise architecture is achievable with the staff understanding the importance of EA. Staff needs to be imparted with the knowledge of EA in alignment with the data management practice.

Data is the lifeblood in the digital world and especially for a bank data its vital. For a bank it is critical to have process and structure based on proven methodology. Especially for a state-owned bank though it is not profit motivated, but able to give better service to citizens with reduced cost.

1.6 Case Study: Environment Ministry

1.6.1 Introduction

Project type: Enterprise Architecture Capability Building and Practice set-up.

To establish Enterprise Architecture Practice for Department of Land Management.

> **"It had been estimated that 80% of the informational needs of local government policy makers are related to geographic location"**
> **- Robert Williams**

Organization

A Government department, with a functional organization type, where projects were managed based on the strong matrix structure

Background

The new land law focuses on economic, administration, with mechanisms to monitor and evaluate land usage towards building the modern, transparent and efficient land management system. It is always a challenge to authentic and sustain administration of national land resources including, interests in land and the use of the property. It adds more complexity to develop a digital Land Information Systems (LIS) to support the availability of information and efficient processing of land transactions. A holistic approach to implement LIS that can be quickly deployed and to maintain, an Enterprise Architecture practice was initiated.

Motivation

- Changes in the land law
- The land data is inconsistent and inaccurate.
- Manual and tedious, time-consuming process for land registration.
- The tedious process to manage land maps, tables of the land prices
- Overseeing the operations which are manual and time consuming
- organization transformation from manual land registration process to semi-automated
- International standards compliances

1.6.2 *Objectives*

EA practice to realize the vision:

- Analog map to digital transformation of geographical data
- A system capable of supporting paperless land transaction
- A Centralized Multipurpose Land Information Systems for the country

The land administration and its related resources are dependent on the land information to manage it efficiently, and effectively. Land-related data needs to be integrated, analyzed, and distributed to manage the land usage efficiently

. Land-related data needs to be integrated, analyzed, and distributed to manage the land efficiently

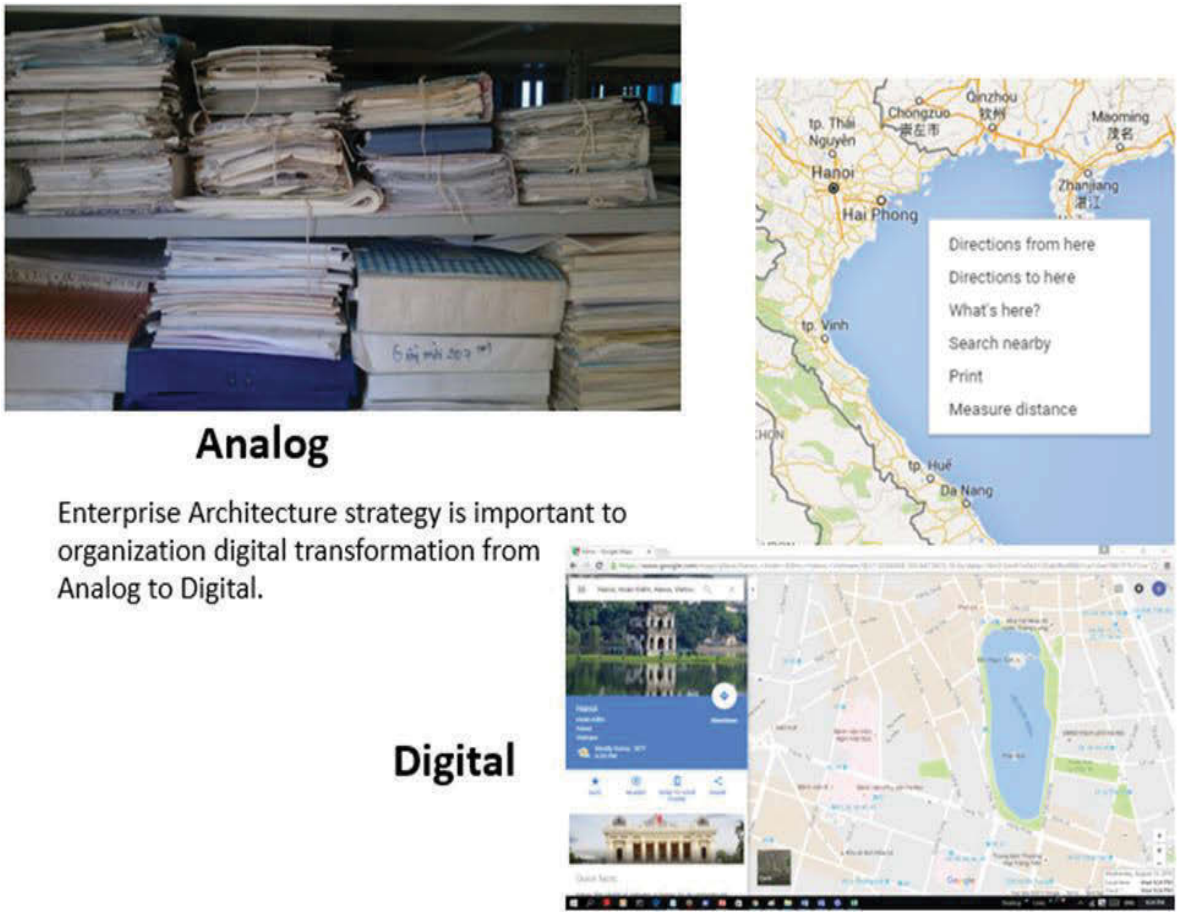


Figure 144 Analog to Digital

1.6.3 Process Followed

In the first phase participants were introduced to the concepts and benefits of EA practice. After two months, participants were trained on the ideas of TOGAF, ArchiMate with a tool based on a simple case study. Finally, after two months an EA project kicked off with the selected 15 participants consisted of Architects, project managers, business users, operations, developers and domain experts. Series of workshops conducted to understand the current As Is status of the current assets, processes. Then it was followed by understanding the land laws to get the requirements, to understand the business rules, functions, process and the service to be exposed.

Based on all the above input the target architecture was determined. To realize the target architecture roadmaps were proposed.

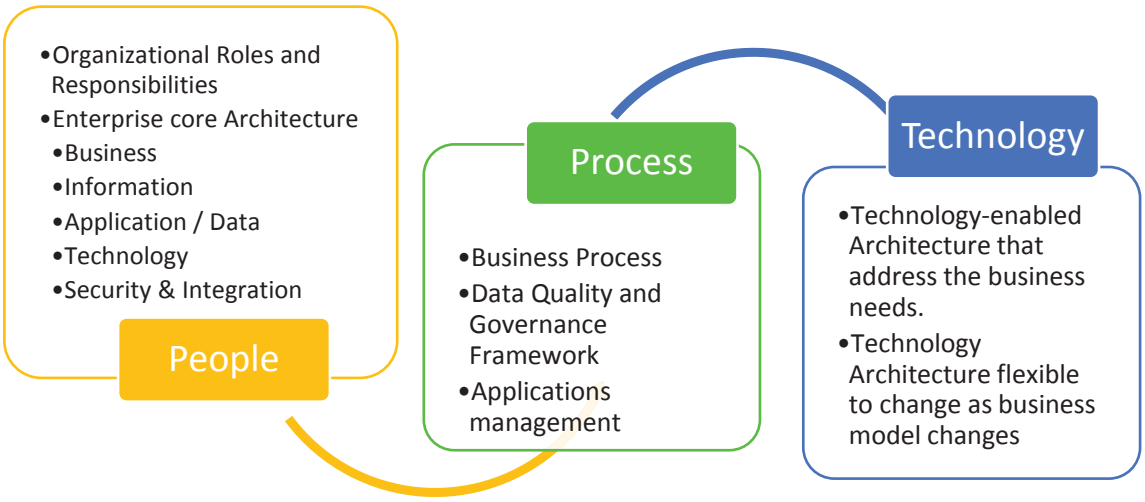


Figure 145 ENV Dependency of People, Process & Technology

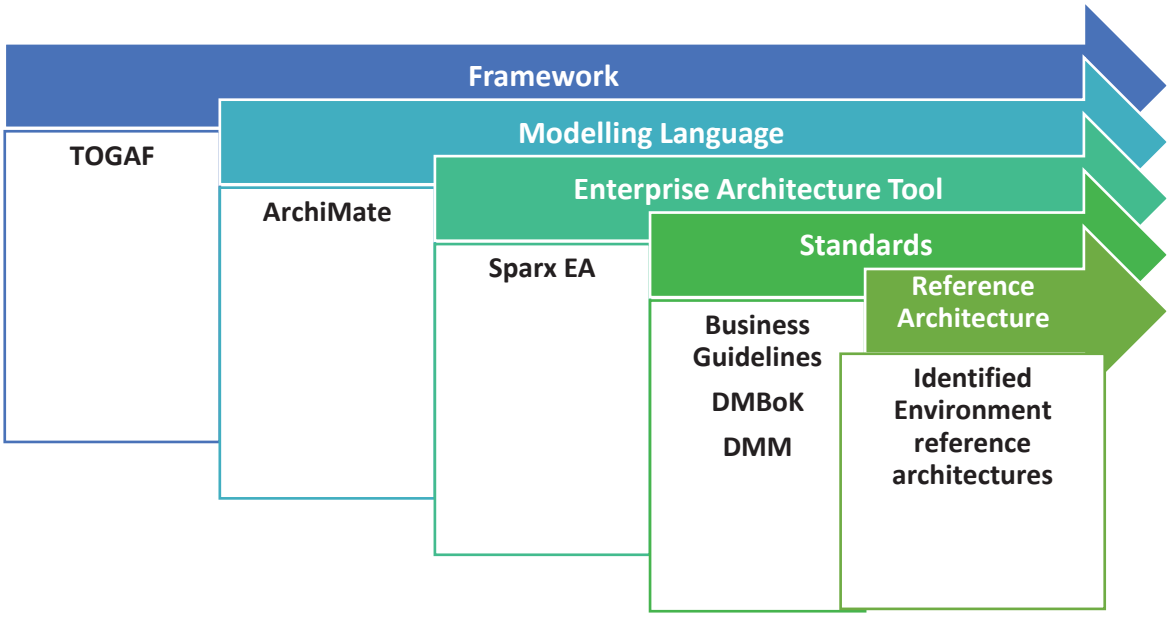


Figure 146 ENV Frameworks and Methodologies used

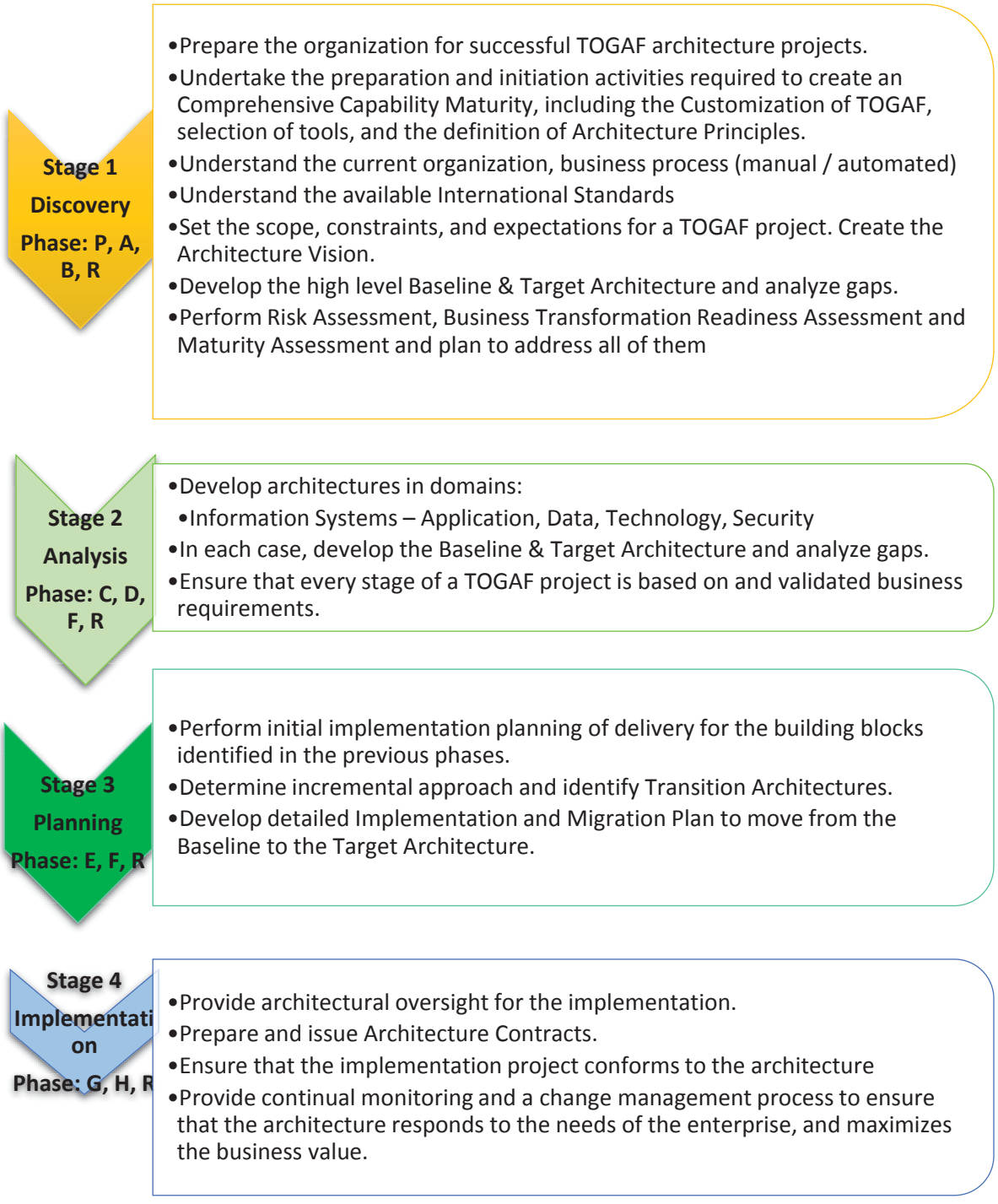


Figure 147 ENV ADM Process

To analyse the approach to be based on Baseline first or Target first.

As the current application are supporting the mission critical applications with some are developed on IBM and other vendor products, it's critical to approach based on Baseline first. In this style, an assessment of the baseline landscape is used to identify problem areas and to enhance opportunities. This process is most suitable when the baseline is complex, not clearly understood, or agreed upon. This approach is common where organizational units have had a high degree of autonomy.

- Physical assessment of baseline applications and technology infrastructure to identify improvement opportunities, typically within the constraints of maintaining business as usual.
- Impact analysis of Projects, its dependencies against the architectural landscape and to align project sequencing in a way that is architecturally optimized.
- Elaborating a vision through definition of baseline and identifying what needs to change to transition to the target.

Selecting the Reference Architecture (RA) is to:

- Provide common language for the various stakeholders
- Provide consistent implementation of technology to solve problems.
- Support the validation of solutions against proven Reference Architectures
- Encourage adherence to common standards, specifications, and patterns

The reference architecture is vendor neutral. It helps in defining capabilities, building blocks, and architecture decisions that enables to use as a model to define specific constraints, considerations, criteria and directions for implementations in a manner that maximizes asset re-use

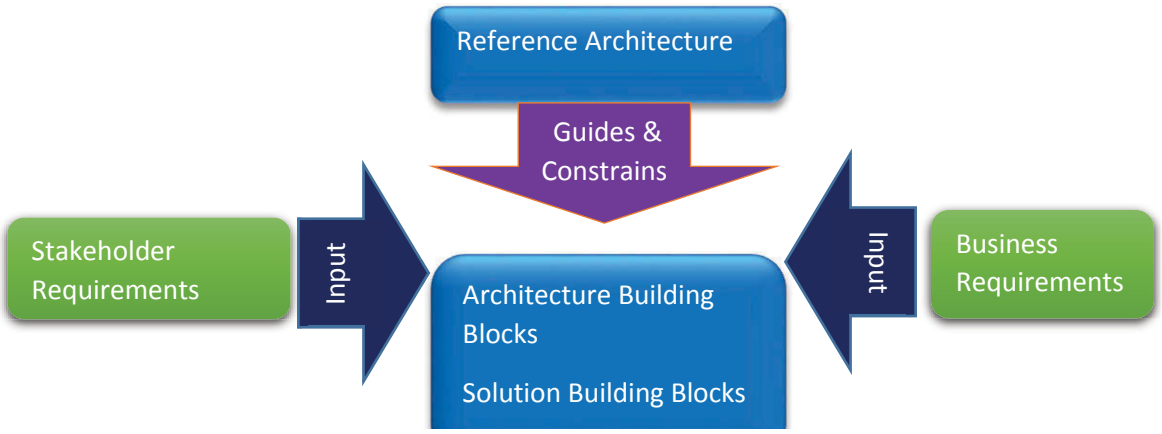


Figure 148 Solution Identification Process

In addition to be a template for defining an Architectural solution at a logical level, the RA also assists as a tool in the design of vendor-neutral solutions. The RA provides a decomposition of the problem space, which allows one to focus on those parts of a solution that are important in the context of the problem and to map the required capabilities onto vendor product capability.

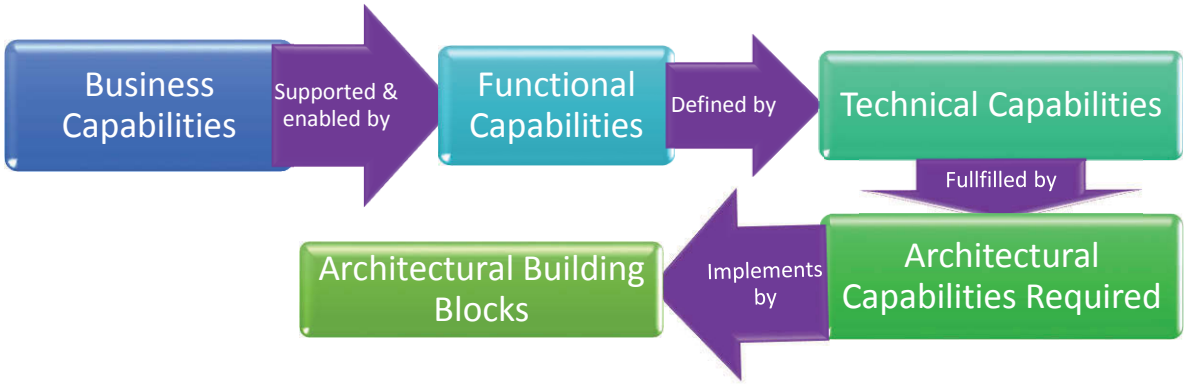


Figure 149 Business Capabilities to ABB

The RA consists of few layers that represent the key considerations and responsibilities that are involved in designing a solution. Each layer is an abstraction that encapsulates a group of architecture building blocks that define key responsibilities of that layer and support a set of related capabilities.

1.6.3.1 Reference architecture specific to Land Information Domain

Reference Architecture	Purpose	comments
Geospatial Interoperability Reference Architecture (GIRA)	Reference guide for geospatial interoperable architecture governance, design and implementation	Proposed in this project
OGC Reference Model	A framework for geospatial services, data, and applications.	Proposed in this project
Open Geospatial	List of standards for Geospatial	Proposed in this project

Table 40 Reference architecture specific to Land Information Domain

1.6.4 International standards

International Standards	Purpose	comments
Open Platform 3.0™	An interoperability standard for the digital platforms.	Proposed in this project
Open Data	Data that can be freely used, re-used and redistributed by anyone. Open government, in line with the open movement	Proposed in this project
Land Standards		
Geography Markup Language (GML)	XML to express geographical features.	Proposed in this project
ISO 19115-1:2014 Geographic information - Metadata	Defines the schema required for describing geographic information and services	Proposed in this project
International Environmental Standards - ISO 14000	A collection of voluntary standards to achieve environmental and financial gains.	Reference to be used later depending on the need
ISO 14001	Standard for Environment Management Systems.	Reference to be used later depending on the need
Geospatial Positioning Accuracy Standards		
Geographic Information Framework Data Content Standard	Supports the exchange of geodetic control data.	Reference to be used later depending on the need
The Spatial Data Transfer Standard	Defines the format to be used to transfer geodetic coordinate data.	Reference to be used later depending on the need
National Standard for Spatial Data Accuracy (NSSDA), Geospatial Positioning Accuracy Standards	Provides the statistical and testing methodology for estimating the accuracy of point coordinate values produced from maps	Reference to be used later depending on the need

Table 41 International standards

Interfaces with Governance Models and Frameworks

- Portfolio Management Framework
- Project Management Framework
- Operations Management Framework

Constraints that impact the target architecture

- Management Support
- Acceptance of Modern technology due to restriction of standards defined by “Ministry of Information and Communication”
- Staff acceptance of new system that are web based and business process driven
- Skills shortage to implement, manage and operate new technology.

1.6.5 Overall Observation and Key findings

The interview was conducted before doing the proposal. The input was taken from 20 stakeholders with mixed team from operations, development, project management and domain experts from Geo Information Systems.

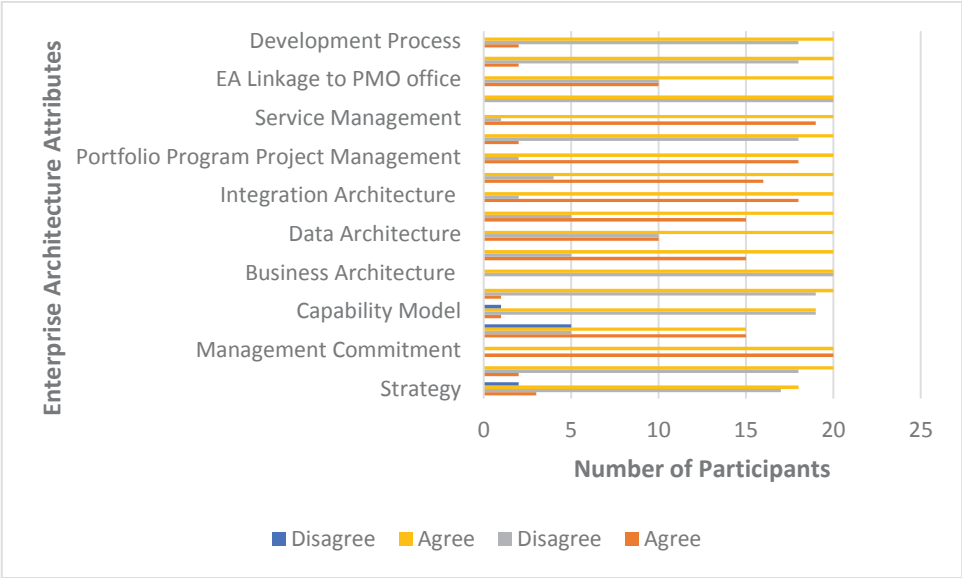


Figure 150 ENV Enterprise Architecture Approach

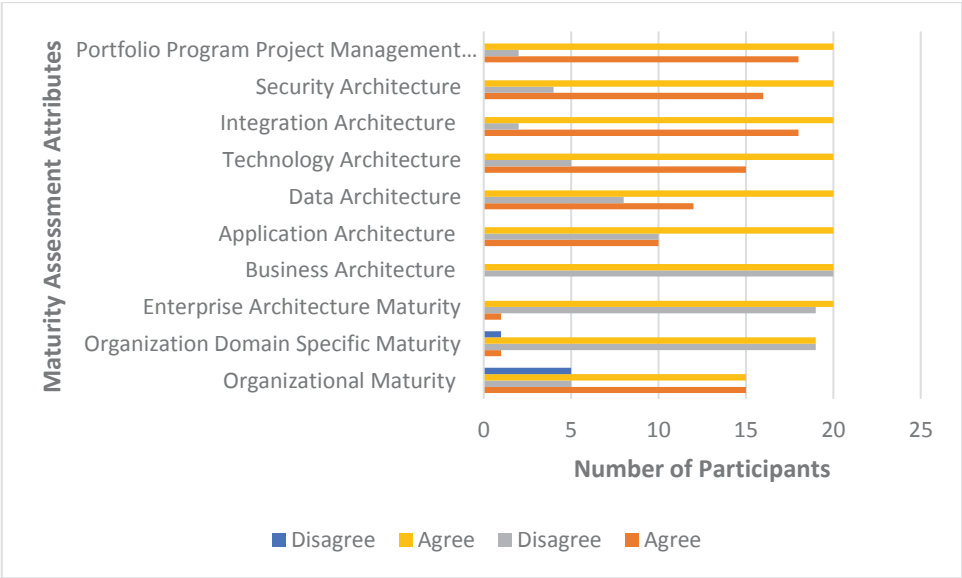


Figure 151 ENV Enterprise wide Maturity Assessment

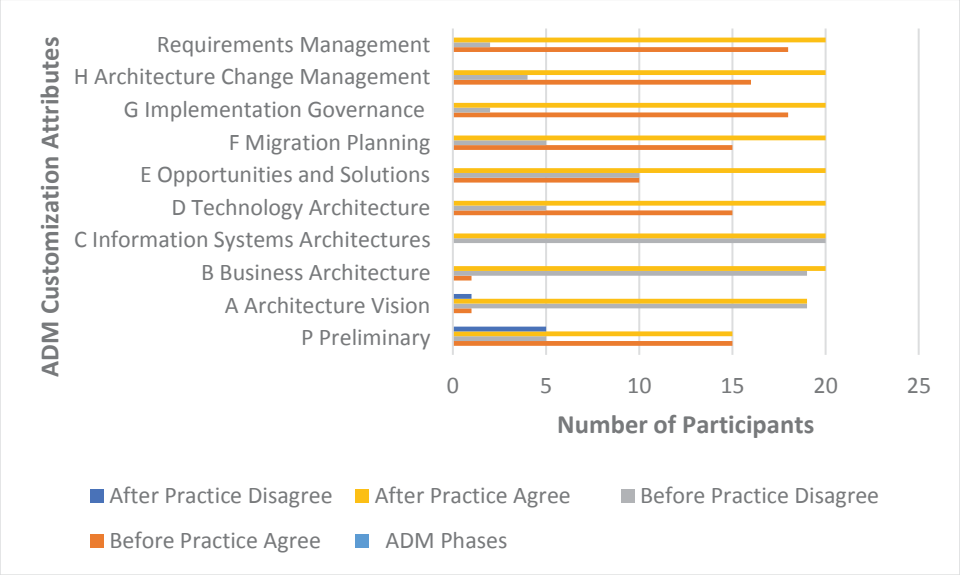


Figure 152 ENV ADM Customization

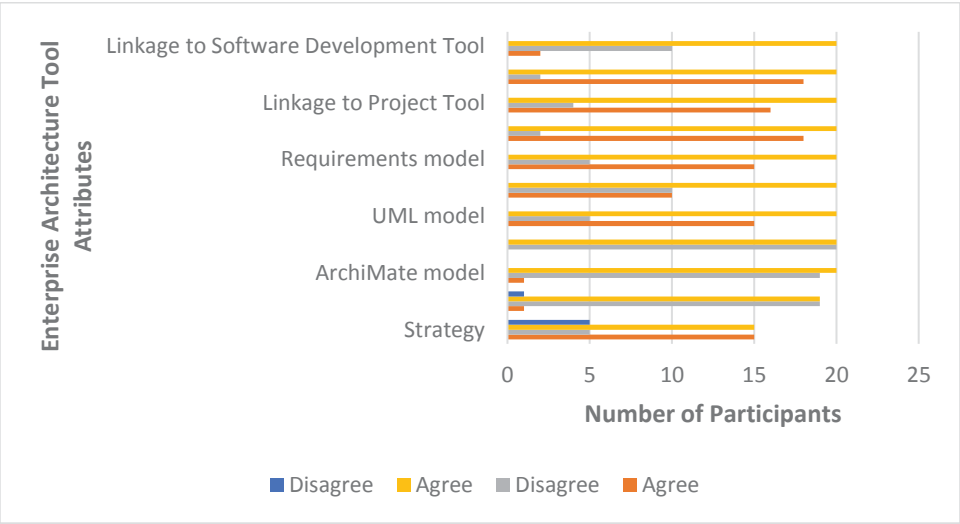


Figure 153 Enterprise Architecture Tool

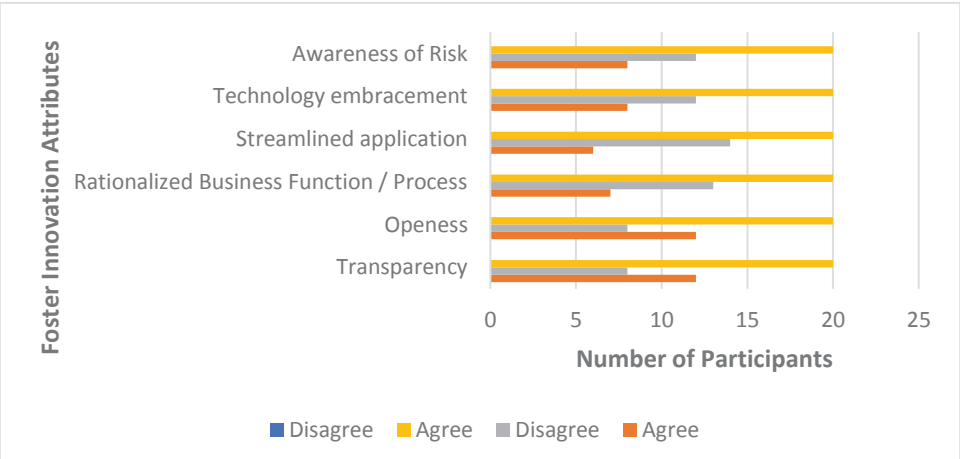


Figure 154 ENV Foster Innovation

As most of the participants were from operations, development, project management and domain experts from Geo Information Systems, the initial assessment was above average, as participants were well trained, and awareness was created of the importance of EA approach its benefits. But after capacity building and project execution the participants were able to appreciate the benefits of Enterprise Architecture, its contribution for digital transformation, with Centralized Multipurpose Land Information Systems that enables paperless land transaction.

1.6.5.1 Summary of Key Recommendations

Identified generic core capabilities

Figure 155 Identified generic core capabilities

Key Recommendation

- Business Architecture, Application and Data Architecture must be created for the capability required.
- Architecture Building Blocks must exist or to be created
- Architecture / Solution Building blocks to be modelled
- Solution Architecture Building blocks to be based on Architecture Building Blocks
- Object-orientation must be followed wherever applicable
- Architecture must follow Service-Oriented approach
- Cloud Architecture to be utilized
- Security to be built in for the application components
- Software components to be based on Horizontal scaling to utilize the elasticity of cloud instead of Vertical scaling where hardware resources are utilized
- Wherever applicable IT Assets considered that are programmable Resources

- Where ever possible to follow microservice architectural style. This is by breaking single application as a suite of small services, each running in its own process and communicating with lightweight mechanisms, often an HTTP resource API
- The Micro Services end points to be REST or RPC
- All services metrics to be identified and to monitor it, to check if it meets the determined criteria
- Software deployment only on virtual environment
- Agile methodology must be adopted from inception to deployment
- Applications must be continuously monitored and be able to proactively alert the admins if there is degradation or service outage

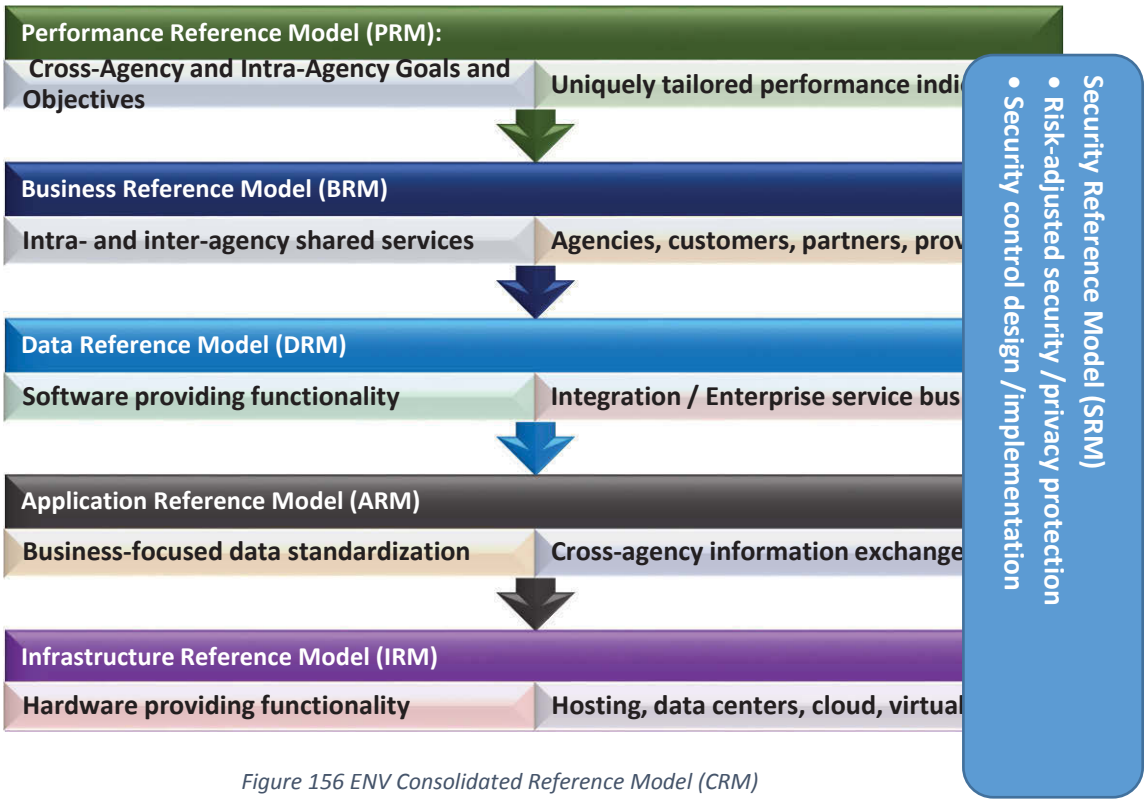


Figure 156 ENV Consolidated Reference Model (CRM)

Shared Services Implementation Process

The Implementation tasks & activities, best practices, risk areas with mitigations to consider and prepare for when implementing shared services.

Figure 157 ENV Shared Services Implementation Process

Architecture Governance

Architecture Governance is the practice of how architectures are controlled and managed at an enterprise-wide level. Governance addresses the following

- Implementing a system of controls over the creation and monitoring of architecture components and activities.
- Implementing a system to ensure compliance with internal and external standards and regulatory obligations.
- Establishing processes that support effective management of the above processes within agreed parameters

Land Information System Data Reference Model

Defines the primary considerations for describing, discovering, delivering, and sharing common data using open standards and the promotion of uniform data 4 management practices to sustain **data as a national asset**.

The main purpose / Function is to promote the common identification, tagging, sharing, and reuse of appropriate geospatial data/information resources across communities. It contributes to the mission/business Operational Requirements Documentation to determine what data inputs and assets are required to meet the functional needs of the stakeholder.

- Establish a process for base lining and documenting geospatial data inputs and datasets.
- Provide guidance for preparing data description, context, and sharing methods.
- Provide references to common operating data and other sources.

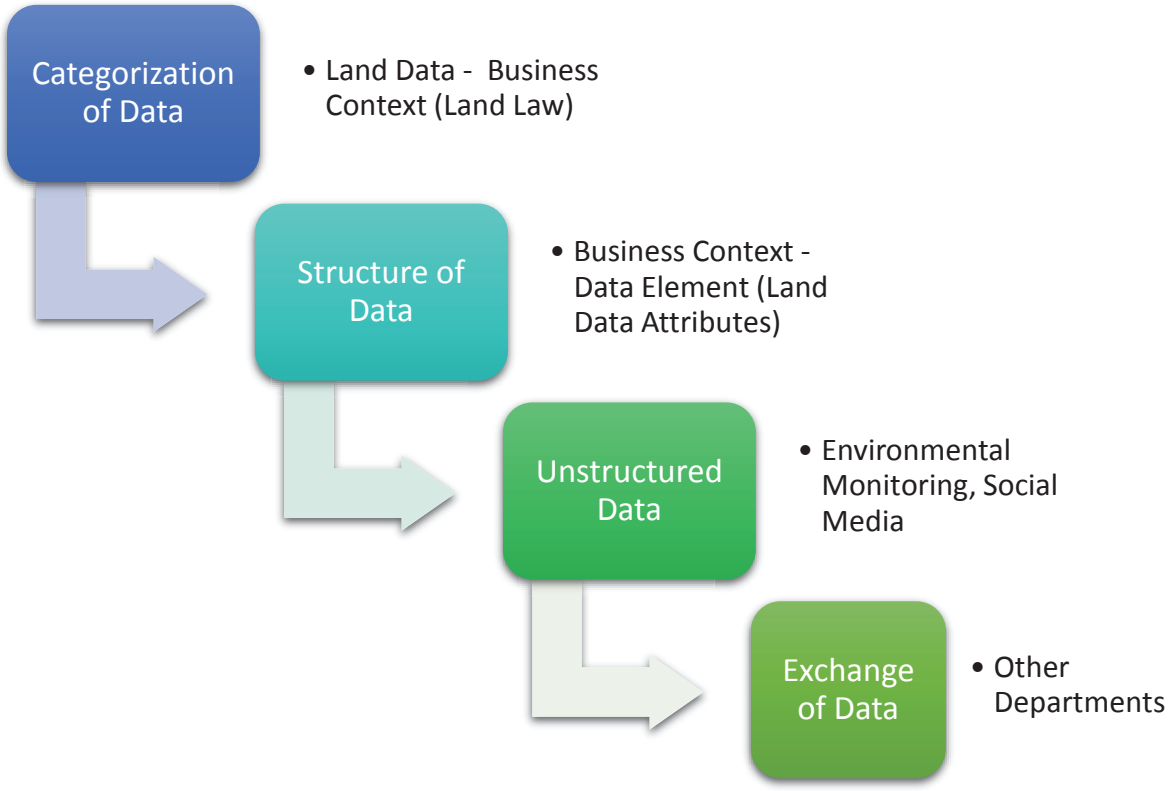


Figure 158 ENV Land Information System Data Reference Model

Figure 159 High Level Data Reference Model Taxonomy for Land Information System

Land Information System Application Components

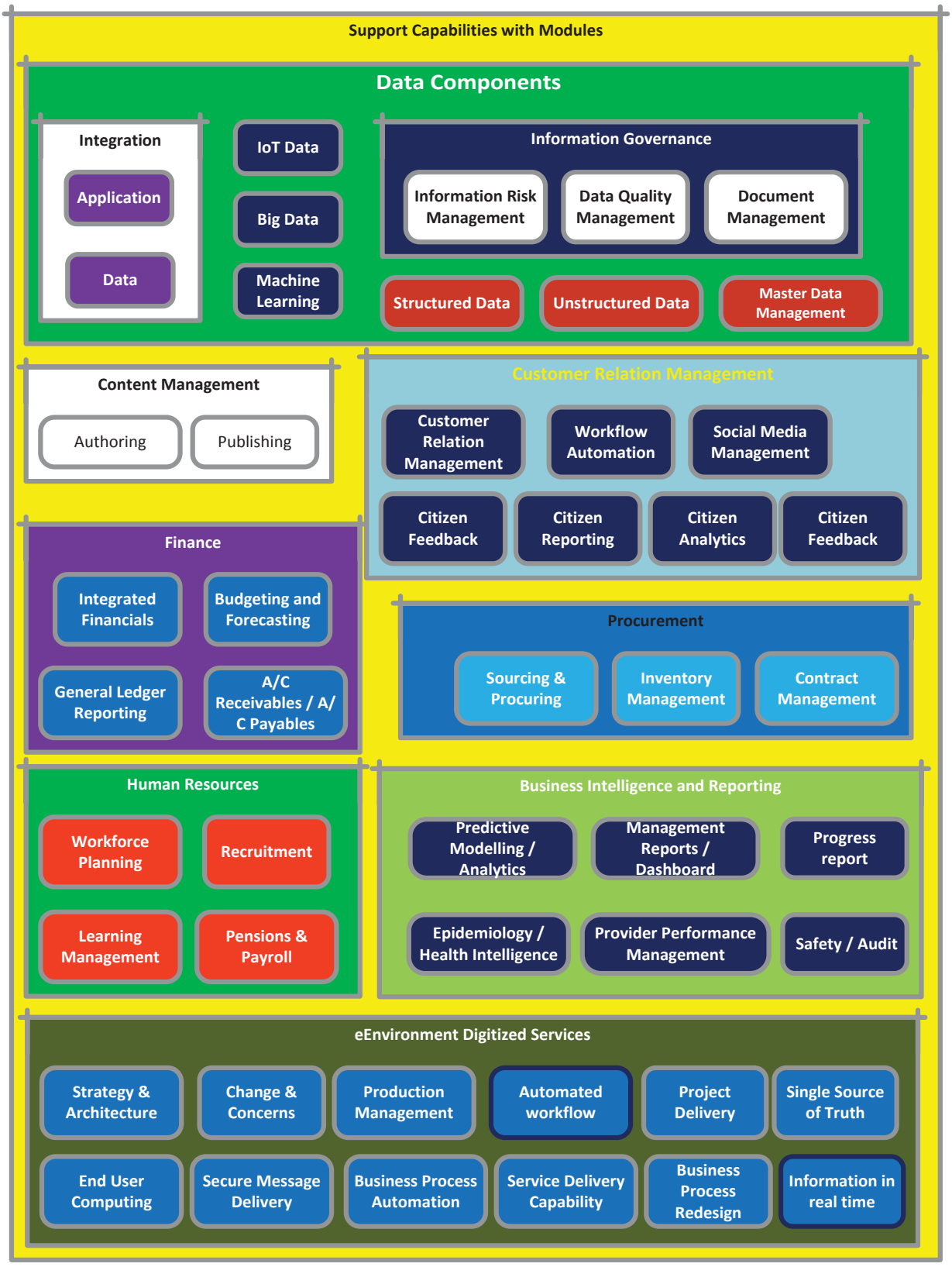


Figure 160 Support Capabilities with Modules

1.6.5.2 Summary of Proposed Roadmaps

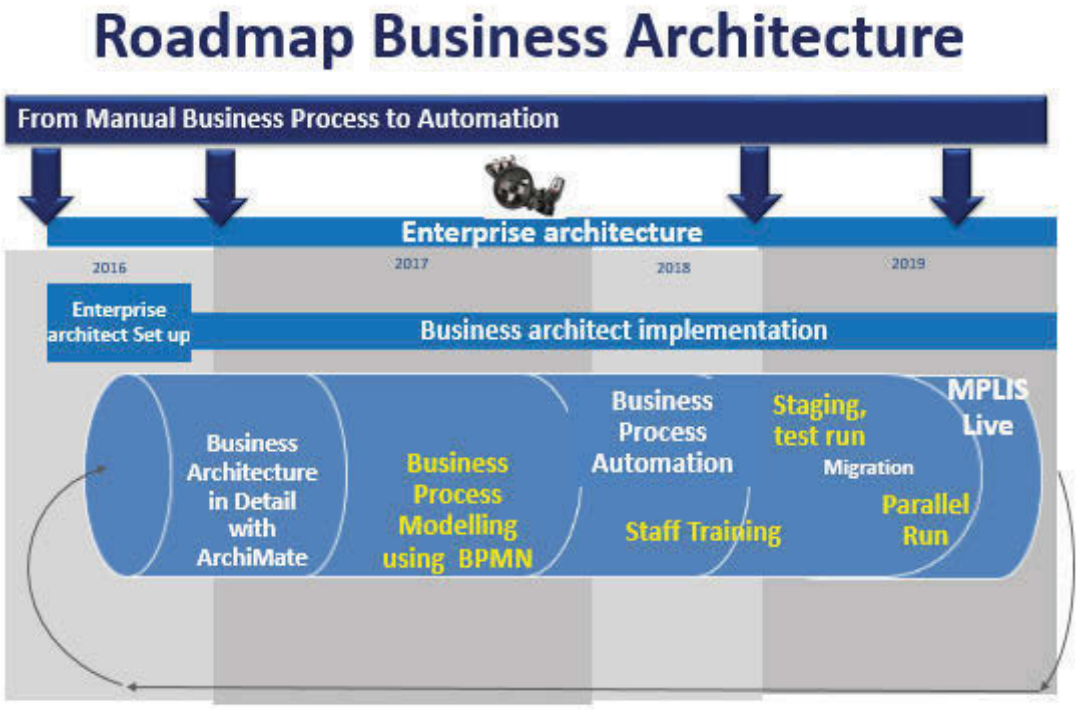


Figure 161 Roadmap Business Architecture

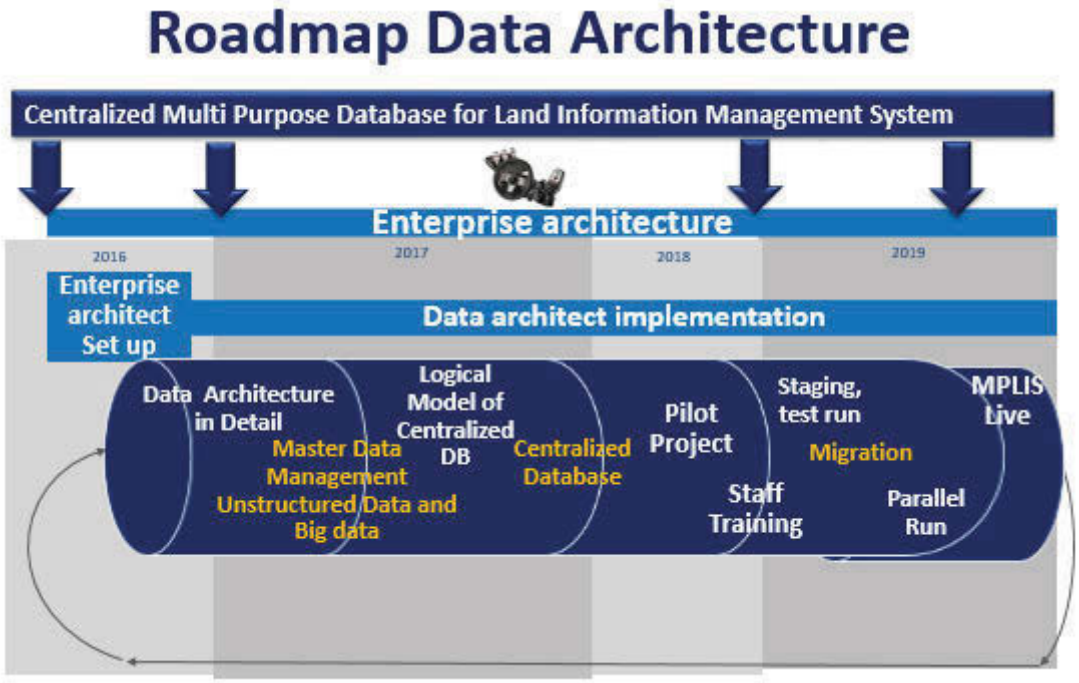


Figure 162 Roadmap Data Architecture

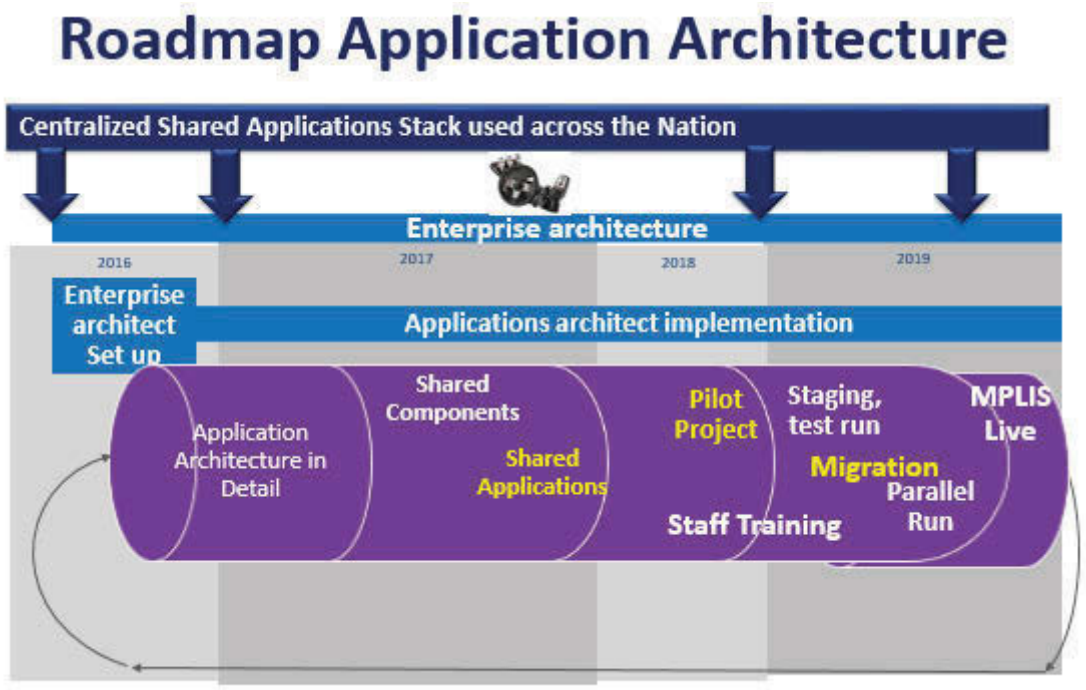


Figure 163 Roadmap Application Architecture

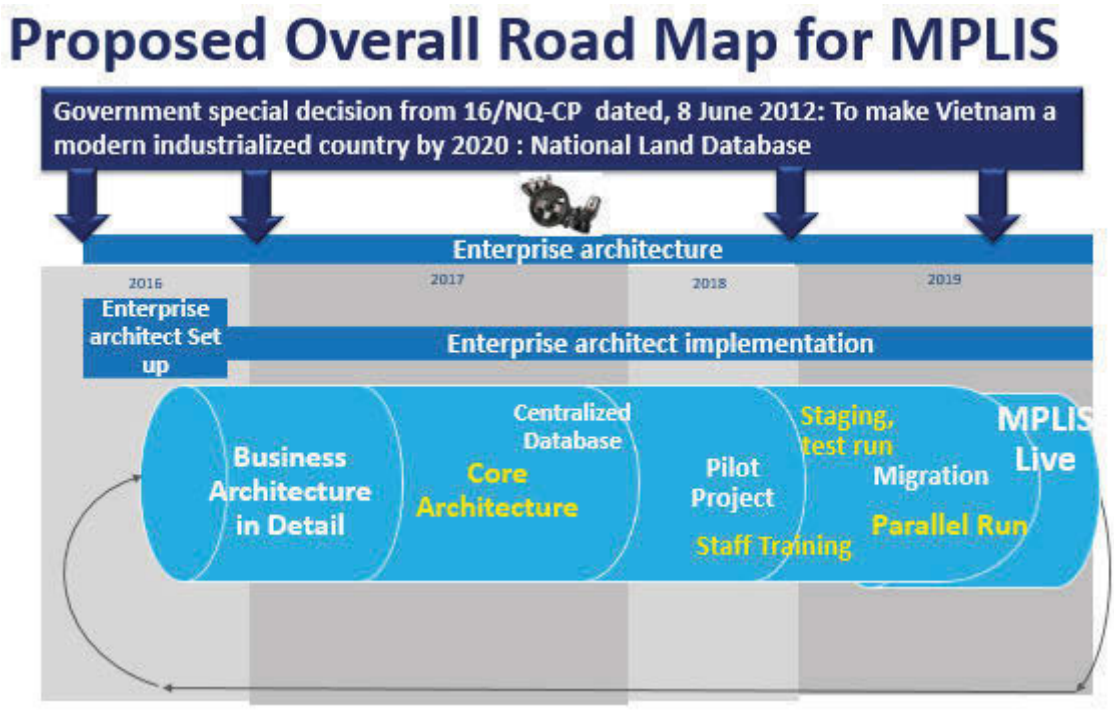


Figure 164 Proposed Overall Road Map for MPLIS

1.6.5.3 Enterprise Architecture a mandatory for Big data projects

As data that needs to be harnessed is enterprise focus rather than individual agencies, it's very critical for the success of the projects to be based on Enterprise-wide approach rather than silo approach. With EA approach the data analyzed will give hindsight and foresight that is more valuable from the organization perspective. Key factors are considered:

- There is a broader range of stakeholders in big data projects than is often apparent. Often their data is used as part of the project, or they are impacted by the findings of the project.
- As business generates data, based on EA, we analyze Business Architecture to understand the data required a top-down approach.
- In Big data based on the data we map back to Business Architecture, so it's make more relevant analysing the data holistically that can be achieved through EA
- Big Data projects combine business process and scientific research and software development.
- Information security and privacy are critical considerations in all big data projects.
- When applied to service delivery type applications, big data findings realise their full benefit when applied to improve business processes holistically across the enterprise that often involves a change in business processes.
- The possibility that the data acquired will not provide the insights sought.
- Findings and results from projects can be uncertain and counterintuitive.
- False discoveries are possible –large amounts of data can produce statistically significant results that arise purely by chance.
- During the exploratory process, data may present unexpected, positive, outcomes that may or may not be related directly to the initial issue being addressed.

1.6.5.4 IoT & Big Data Recommendation

- Choose the right project that gives immediate success rather than complicated project, as there are lot of moving parts in Big data and IoT
- A managed data lake a single place to manage the supply and demand. To incorporate rigorous, strategic data governance policies and processes. To build effective data lake is complicated, "Through 2018, 90% of deployed data lakes will be useless." Gartner predicts as it gives rise to "data swamp"
- Selecting HDFC distribution to be based on Open source Horton Works
- Integration and reporting tool based on open source: Pentaho
- IoT monitoring

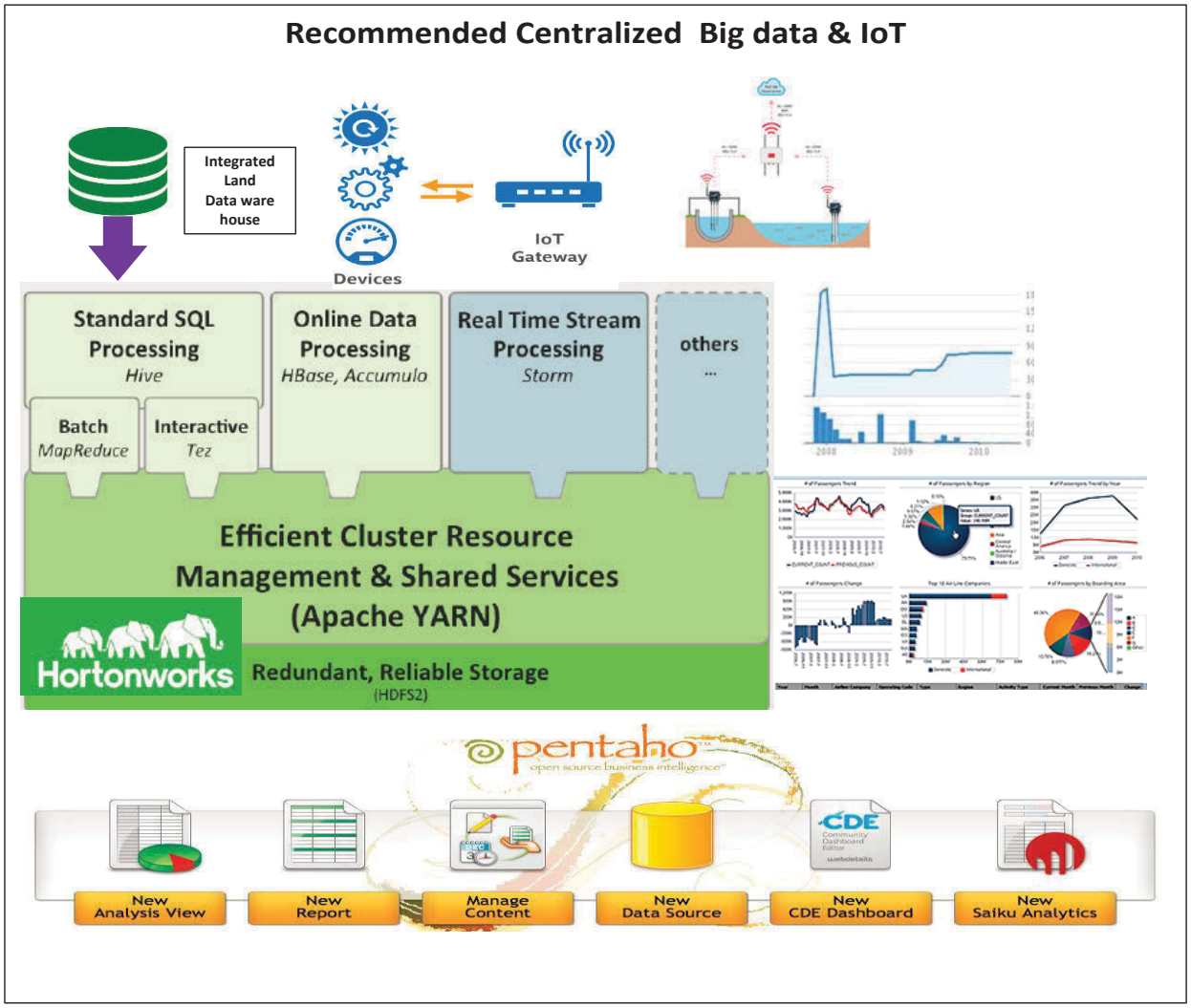


Figure 165 Proposed Solution Architecture based on open source stack

1.6.5.5 Conclusion

EA practice is the cultural change for an organization. The staff needs to be exposed to the EA knowledge in a phased manner. The selected EA team after knowing the concepts and benefits will be able to provide valuable information. The team to consist of Architects, project managers, business users, operations, developers and domain experts. Then with the team involved to understand the As Is status, Identify the requirements, determine the target architecture. Then to realize the target architecture roadmaps were proposed.

1.7 Case Study: Logistics Organization

1.7.1 Introduction

Project type: ArchiMate modelling Capability Building and Practice set-up.

Capacity Building, Assess and recommend ArchiMate modelling approach for ad hoc business requests.

Organization

A logistics company with functional organization type, where projects managed in a strong matrix structure.

Background

Business users were making ad hoc request to change or extend or alter the business processes. The project management team was required to analyze to validate the feasibility and its impact on another process. There was no real modelling available with all the functional specification was in documents. ArchiMate modelling was initiated to model the core business process that assists analysis and communication with business users as models are visual.

Motivation

To reduce the time required to analyze the business change request and enable collaboration with business through visualization where business users can understand.

1.7.2 Objective

- Capacity building in ArchiMate modelling
- To establish modelling practice for the organization

1.7.3 Process Followed

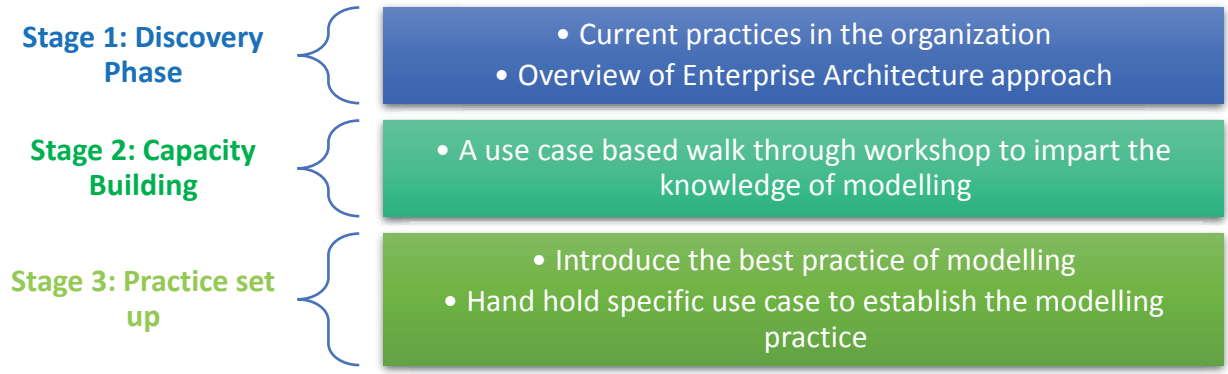


Figure 166 Logistics ArchiMate Capacity Building Process followed

1.7.4 Overall Observation and Key findings

The interview was conducted before starting the project and after completion. They were six stakeholders involved in the project. The stakeholders had more than ten years' experience working in Information Technology with majority from Business Analysis and Project Management. The initial assessment gave poor results. But after capacity building and workshop participants realized the benefits of Enterprise Architecture tool so the results are good.

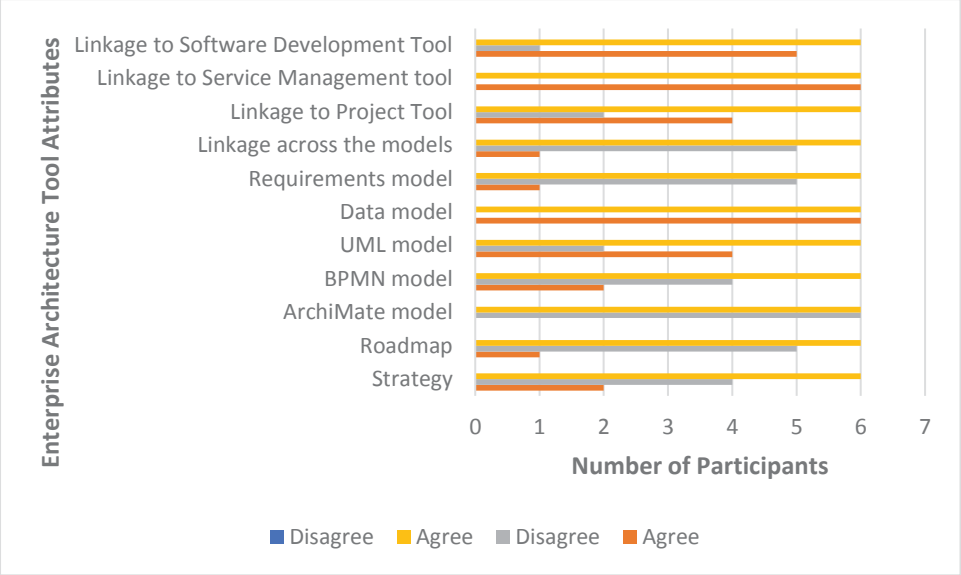


Figure 167 Logistics Usage of Enterprise Architecture Tool

Proposed modelling practice

- Determine the taxonomy
- Develop the metamodel
- Create the Capability model
- Identify the existing Functions, Processes, Services connect them and then map to the capability model
- Map the stakeholders to the above model

1.7.5 Conclusion

Modelling practice establishes good rapport between the business and IT. Business can realize the impact of their request. Modelling practice. The benefit of modelling is realized only if a good modelling tool is used.

1.8 Case Study: Utility Organization

1.8.1 Introduction

Project type: ArchiMate modelling Capability Building and Practice set-up.

Capacity Building, Assess and establish modelling approach across the organization.

Organization

A logistics company with functional organization type, where projects managed in a balanced matrix structure.

Background

An organization was upgrading the financial systems. Organization had an enterprise architecture practice, but it was not well used. The models existed were based on Visio that was modeled differently by Architects based on their perception. To standardize the modelling practice ArchiMate modelling was initiated.

Motivation

To standardize modelling practice and establish uniformity across the organization to minimize the ambiguity of modelling.

1.8.2 Objective

- Capacity building in ArchiMate modelling
- To establish modelling practice across the organization

1.8.3 Process Followed

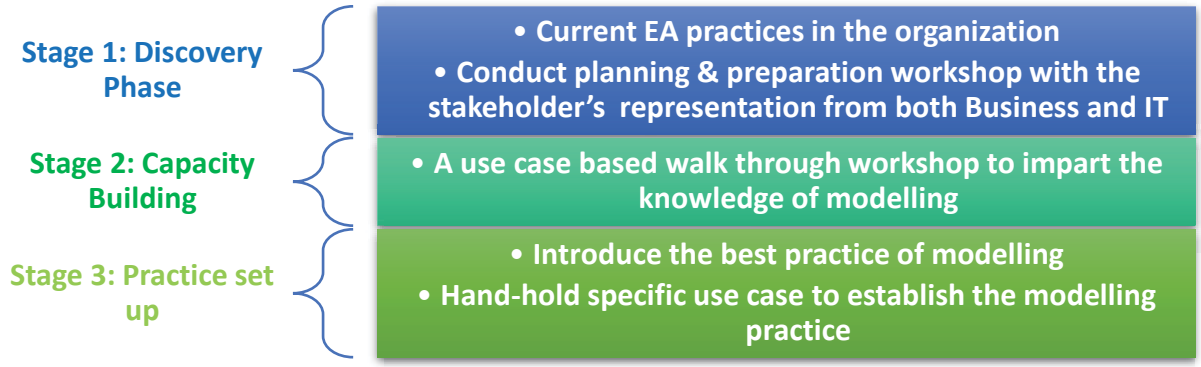


Figure 168 Utility ArchiMate Capacity Building Process followed

1.8.4 Overall Observation and Key findings

The interview was conducted before starting the project and after completion. They were ten stakeholders involved in the project. The stakeholders had more than fifteen years' experience working in Information Technology with majority from Architecture and Project Management. The initial assessment was above average as they were aware of the importance of modelling and tool.

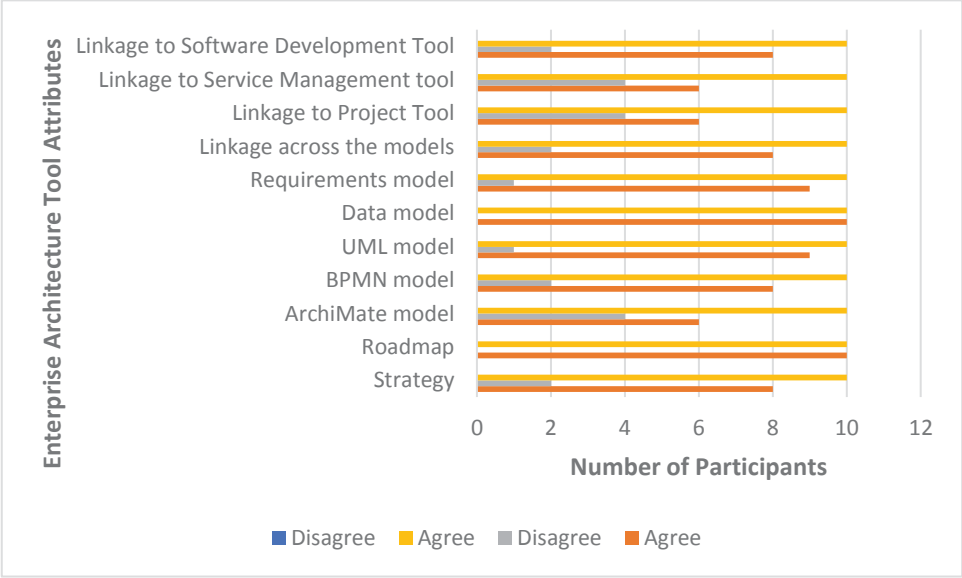


Figure 169 Utility Usage of Enterprise Architecture Tool

As most of the participants were from operation and business analysis, the initial assessment gave poor results. But after capacity building and project execution the participants realized the benefits of Enterprise Architecture, so the results are good.

Proposed modelling practice

- Determine the taxonomy
- Develop the metamodel
- Create the Capability model
- Identify the existing Functions, Processes, Services connect them and then map to the capability model
- Map the stakeholders to the above model

1.8.5 Conclusion

Modelling practice using a Visio is subjective, as the models developed are from user perspective. The relationships are not enforced and due to lack of standard there is no consistency in modelling. Using a tool enforces relationship as compared to grammar that confirms the accuracy of the language. Its critical to have at a tool for the success of modelling practice.