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1 Introduction

1.1 Background

Often compared with town-planning or urban design, Enterprise Architecture (EA) is a holistic approach to managing the complexity of IT from a business perspective. EA documents the structural and behavioural building blocks that make up the overall information system of the enterprises together with their relationships. A management tool, not a silver bullet, EA provides a blueprint for an effective IT strategy and guides the controlled evolution of IT in a way that delivers business benefit in a cost effective way.

The scope of enterprise architecture includes: the people, processes, information and technology of the enterprise, and their relationships to one another and to the external environment. This approach views the enterprise as a complex "system of systems" and applies appropriate engineering principles.

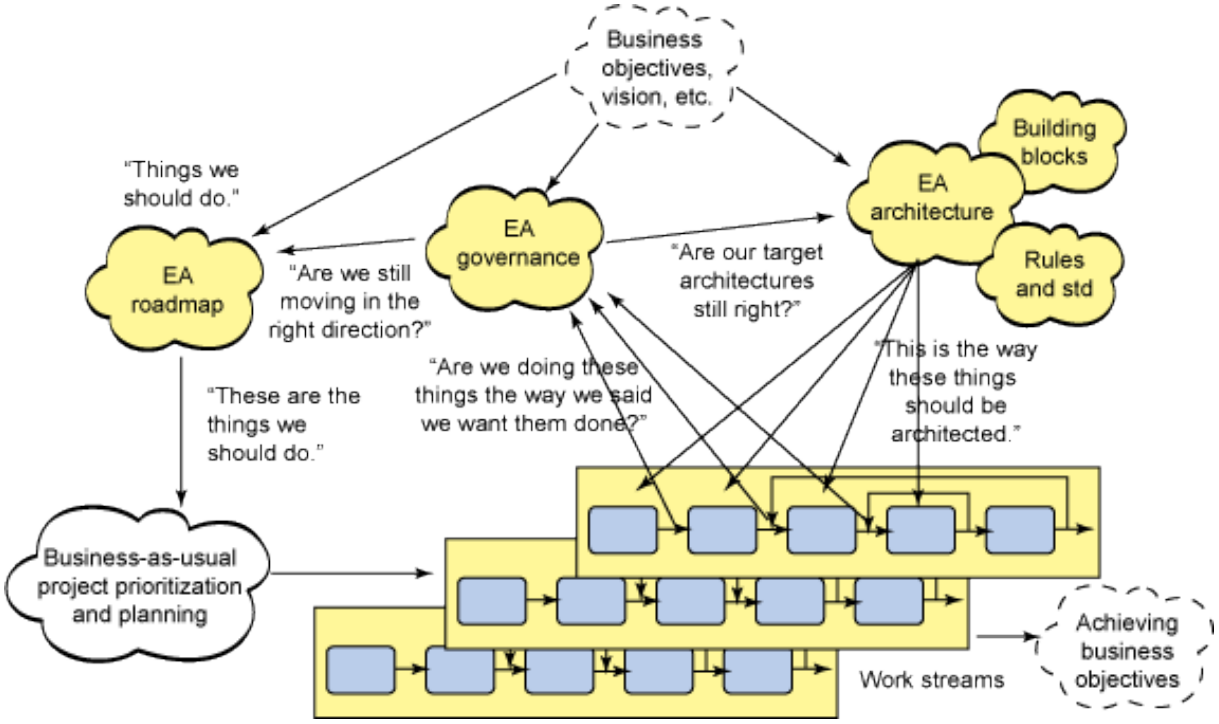


Figure 1 Enterprise Architecture

There is no shortage of EA frameworks in the IT industry, Zachman was the first to formalize the concept and publish a framework. Since then, many other EA frameworks have been published and are used by many organisations like:

- **FEAF** – US Federal Enterprise Architecture Framework
- **DoDAF/MoDAF –** US Department of Defence / Ministry of Defence Architecture Framework
- **TOGAF** – The Open Group Architecture Framework
- **IAF** – Capgemini Integrated Architecture Framework

The adoption of an architecture driven approach and an architecture practice was identified as one of the enablers needed to realise the University's IT Strategy [1].

1.2 Scope

This document presents an enterprise architecture framework for the University – the 'Birmingham Enterprise Architecture Framework' – based on TOGAF version 9. However the focus is not on frameworks but on delivering business value and on standards and artefacts that contribute directly to that goal.

1.3 Purpose

This document represents a starting point for the introduction of an Enterprise Architecture based approach. It is intended to show how the IT Strategy flows down into the enterprise architecture and how enterprise architecture will contribute to the realisation of the IT Strategy.

2 Framework Description

2.1 Architecture Process

The following diagram illustrates the architecture process, based on the TOGAF Architecture Development Method (ADM), the activities within it and the major inputs and outputs:

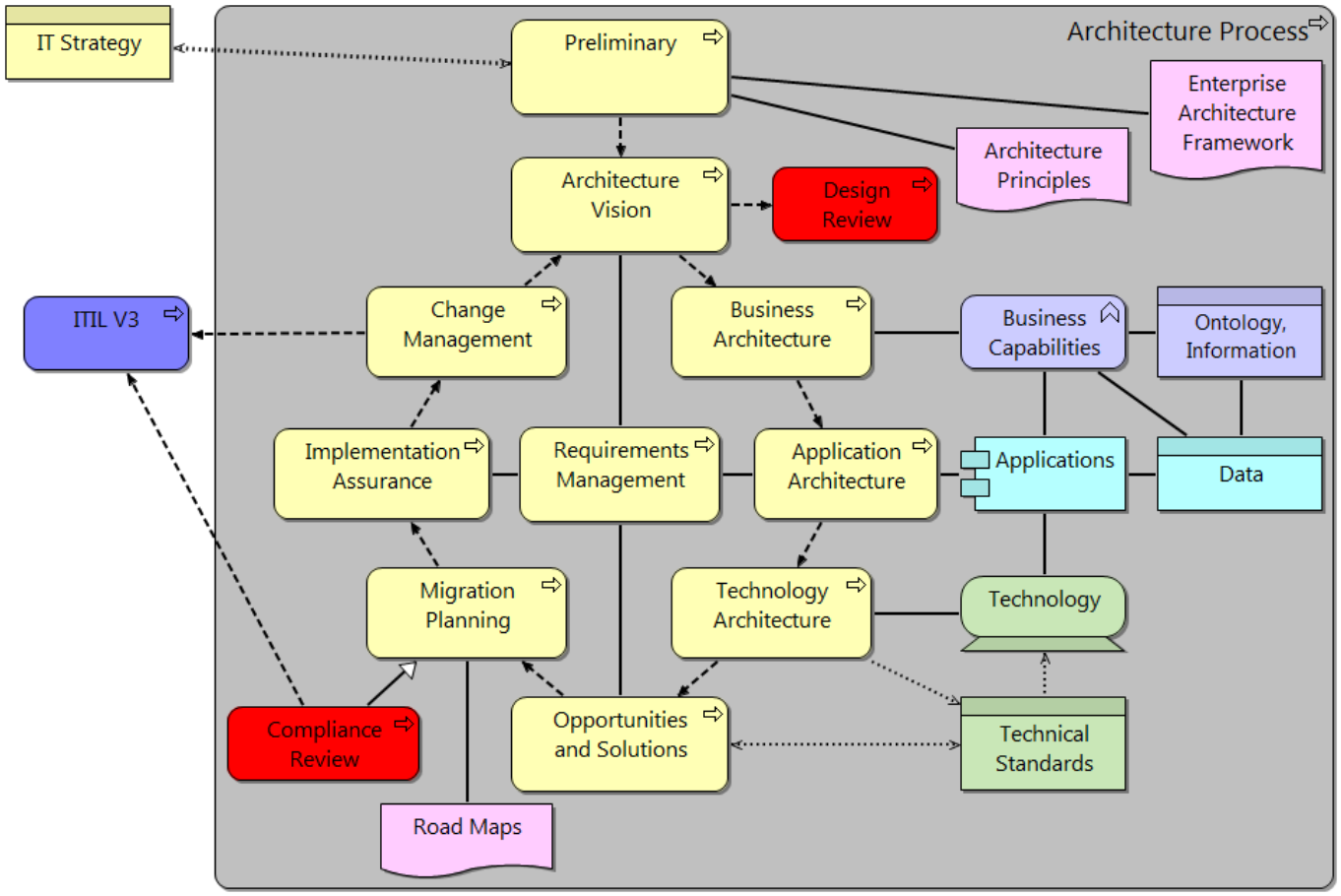


Figure 2 Architecture Process[1]

Application Architecture	Define application architecture including services, major functions, components and interfaces and show how these map to the Business Architecture. Develop logical data models and map to the information models in the Business Architecture.
Applications	Application systems and services.
Architecture Principles	Enterprise Architecture Principles based on the IT Strategy and industry best practice. The principles apply to all IT projects and architecture-related work.
Architecture Process	Generic architecture process based on TOGAF 9
Architecture Vision	Set the scope, constraints and expectations for a project or initiative. Create the architecture vision, based on the Architecture Principles, which realises the IT Strategy, aspirations and needs of the University. Initiated by a Request for architecture work or via completion of a previous iteration, this activity begins an iteration of the architecture development cycle. For projects, this usually begins in the project Start Up phase and continues into the project Initiation phase with the delivery of the Architecture Compliance Form (ACF) that summarises the proposed solution. Development of the vision usually involves a rapid iteration through high-level business, application and

[1] See Appendix B – Archimate Diagram Notation for key to diagram symbols.

	technology architecture activities and results in one or more architecture models to be added to the repository.
Business Architecture	Elaborate business architecture based on the identified business processes, stakeholders, services and capabilities. The principal technique will be Business capability Modelling (BCM) used in combination with business process models (using Triaster Process Navigator). Develop high-level information models that reflect the underlying enterprise-level informational structures and entities.
Business Capabilities	Main business functional areas that constitute capabilities of the enterprise (e.g. Teaching and Learning, Research and Knowledge Transfer, Information Management etc.).
Change Management	Changes to the architecture should be managed in the same way as any other system or infrastructure change – using the established IT Services change control mechanisms and subject to approval by the Change Board. Architecture Change Management is part of the ITIL Change Management process.
Compliance Review	A critical stage in Implementation Governance consists of a formal Architecture Compliance Review to be held toward the end of the Implementation Phase of a project. The principal input to the review will be the Architecture Compliance Form or Architecture Description.
Data	Data models.
Design Review	A architectural review that takes place early in the project life-cycle to verify strategic alignment and compliance.
Enterprise Architecture Framework	The overarching Enterprise Architecture document that describes the structure and scope of the Enterprise Architecture programme at the University.
Implementation Assurance	The Architects will provide on-going guidance and governance throughout the implementation phase of a project or programme. The basis for governance activities will be the Architectural Principles, Standards and Reference Models that constitute the architecture framework and the compliance of projects as documented in the project Architecture Compliance Form (ACF).
IT Strategy	University IT Strategy
ITIL V3	IT Infrastructure Library version 3 standard service life-cycle.
Migration Planning	Analyse cost, benefits and risk. Develop detailed implementation and migration plan. The architects will support the project team as necessary.
Ontology, Information	Conceptual knowledge and information models.
Opportunities and Solutions	Perform implementation planning and identify delivery vehicles for the building blocks derived from the preceding phases.
Preliminary	Prepare the organisation to undertake successful architecture projects through the introduction of an architecture framework and process based on the University's approved IT Strategy. This activity includes the creation of a set of Architecture Principles and the setting-up of a shared architecture repository.
Requirements Management	The process is based on requirements management. Requirements are identified, stored and input to all activities in the architecture process. This activity is of fundamental importance and needs a rigorous approach, preferably tool-based. Specific and testable non-functional requirements must be defined for every system. These constitute design objectives and effectively determine the type of system that will be delivered.
Road Maps	Architecture road maps showing Business, Application and Technology layers.
Technical	Standards Information Base (SIB) containing technical and related standards.

Standards	
Technology	Technology used to realize applications.
Technology Architecture	Define the infrastructure including computing platforms, storage, networks, operating system, middleware, database systems, other system software and deployable artefacts. Map them to the Application architecture to show how the components, data stores and so-on will be realised. This layer of architecture also encompasses the physical data models and XML schemas that are directly implemented though these will normally be created by the project team `

2.2 Architecture Framework

There is no formal 'architecture framework' in the traditional sense but the following matrix showing the architectural layers and verticals with example content.

		Security Architecture	Data Architecture
Business Layer	Business Capabilities Business Processes Ethnograpics	Threats, Vulnerabilities Requirements	Ontologies, Information Models
Application Layer	Application Models Portfolio Management	Application controls	Logical data models
Technology Layer	Infrastructure Technical Standards	Technical controls	Databases, Files, XML, Schemas

Figure 3 Architecture Model Matrix

2.3 Governance

There is no separate Architecture Board but rather Architecture governance is spread across three IT Services governance bodies – Information Security Steering Group (ISSG), Business Systems Steering Group (BSSG) and IT Infrastructure Group (ITIG) under the overall purview of the IT Strategy Planning Group as shown in Figure 4 Governance Chart.

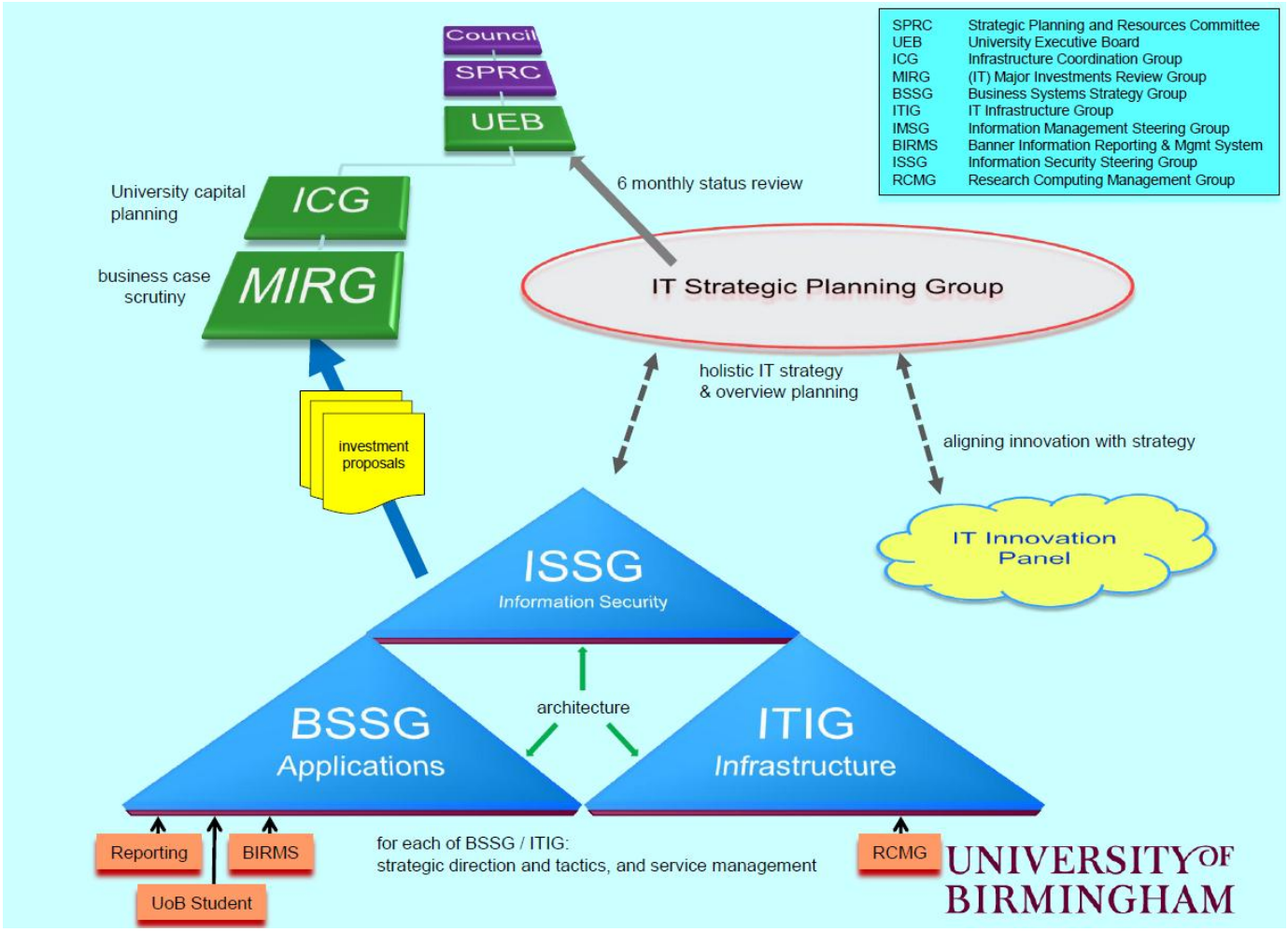


Figure 4 Governance Chart

2.4 Assurance

2.4.1 Project Implementation Assurance

The Architects will be responsible for architectural governance throughout the project life cycle and will organise design and compliance reviews. This is a two-stage process as follows:

1. **Design Review** – an overview of the system architecture that captures the essential information and forms the basis of agreement between the architects and the project team. Design Reviews should take place as soon as possible after approval of the Project Initiation Document (PID) when the overall shape of the solution is known. A series of review may be necessary to track changes or for a complex project. Multiple design reviews may be held throughout the life of a project to steer the realisation in a direction consistent with the IT Strategy and enterprise architecture vision.
2. **Architecture and Security Compliance Review** – a more formal review whose purpose is to verify that the solution fulfils the agreement made at the Design Review stage and that it conforms to the IT Strategy and Enterprise Architecture. Changes between the two steps must be made explicit and justified. This review is required for Architecture and Security sign-off.

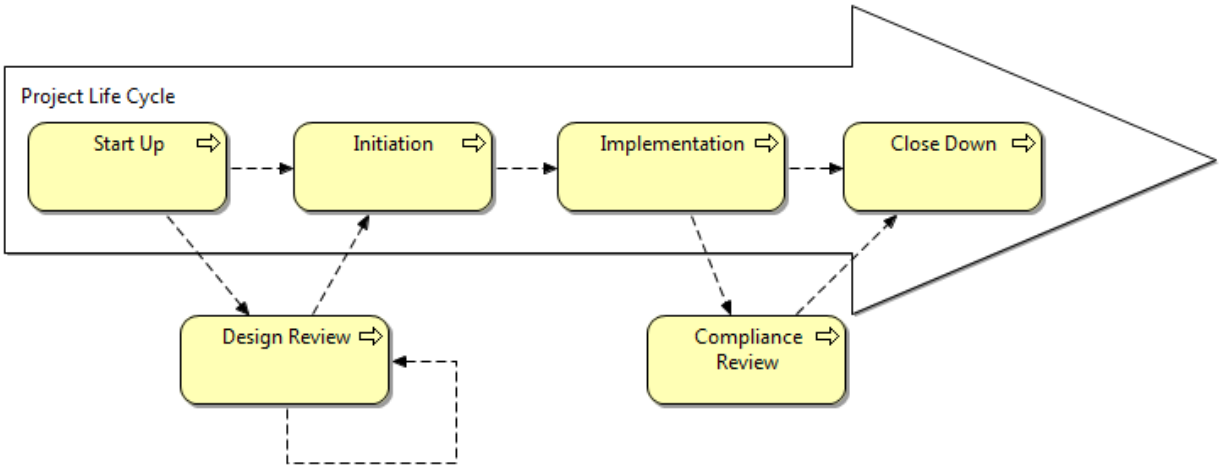


Figure 5 Architectural Governance for Projects

Compliance Reviews will be based on a standard agenda and standard terms of reference, which will be published in the Architecture Repository. The attendees should include:

1. **Chief Architect / Security Manager** – organises and chairs the meeting and is responsible for the minutes.
2. **Quality Manager** – or nominated representative.
3. **Technical Lead** – for the project (can be more than one person) and/or
4. **Project Manager** – if appropriate.
5. **Experts** – from within IT services (e.g. infrastructure or development specialist) as appropriate to the project. Preferably from outside the project team.

The Architecture Review Form summarizes the architecture and also constitutes a record of the meeting in place of minutes. Any major risks and issues that arise during the review will be added to the project registers by the project manager. If the result is a 'Fail', then the system should not go live until the issues are resolved.

2.4.2 Verification and Testing

Successful completion of all categories of testing, including operational testing, is a requirement for conducting an Architecture Compliance Review. If lacking then the Architects should update the project risk or issues log to the effect that the system may be fit for purpose, and this should also be reflected in the ACR minutes.

If possible, operational testing should take place directly in the live environment, or in a controlled environment that closely resembles it. If the testing environment is not full-sized, then it should be appropriately sized so that the results can be extrapolated by applying a simple multiplier (however threshold effects may invalidate this approach in some cases). Server virtualisation will make the process of testing in the live environment easier by providing the ability to dynamically relocate and duplicate (clone) virtual machines.

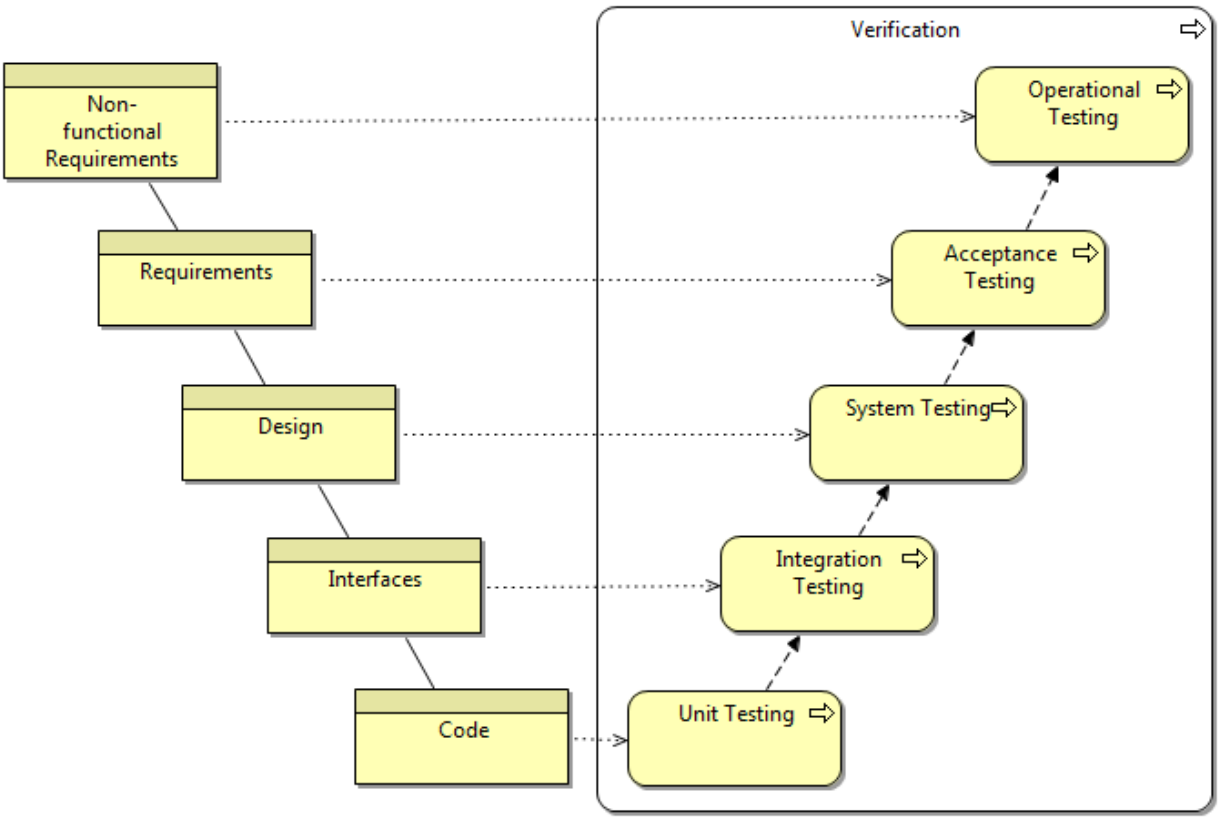


Figure 6 Verification Diagram[1]

Acceptance Testing	User acceptance testing with full security and user roles. Acceptance is performed by business users from prepared test cases. At the end of it, the system is signed-off by business representatives.
Code	Program code.
Design	Technical system design.
Integration Testing	Test components communicating via interfaces.
Interfaces	Interfaces between components.
Non-functional Requirements	The non-functional requirements including performance, scalability, availability, operability etc.
Operational Testing	Formal testing of the non-functional requirements in a live-like environment. This level of testing verifies that the system will perform correctly in its enviornment. Adequate operational testing normally requires the use of automated testing tools. Operational testing is usually signed-off by the architects, a technical design authority or equivalent.
Requirements	Functional requirements.
System Testing	Testing the system as a whole against the design.
Unit Testing	Low-level testing of code modules, classes and components. Must exercise the code through the full range of values in variables..
Verification	Verification that the system meets its functional and non-functional requirements.

2.5 Enterprise Architecture Principles

The principles constitute a basic reference point for every IT project and initiative and are drivers for architecture governance. Each new project will be expected to explain how they will conform to the principles and where not, why not. Conformity with the principles will be evaluated before a new application or product is launched and may result in new risks or issues being raised.

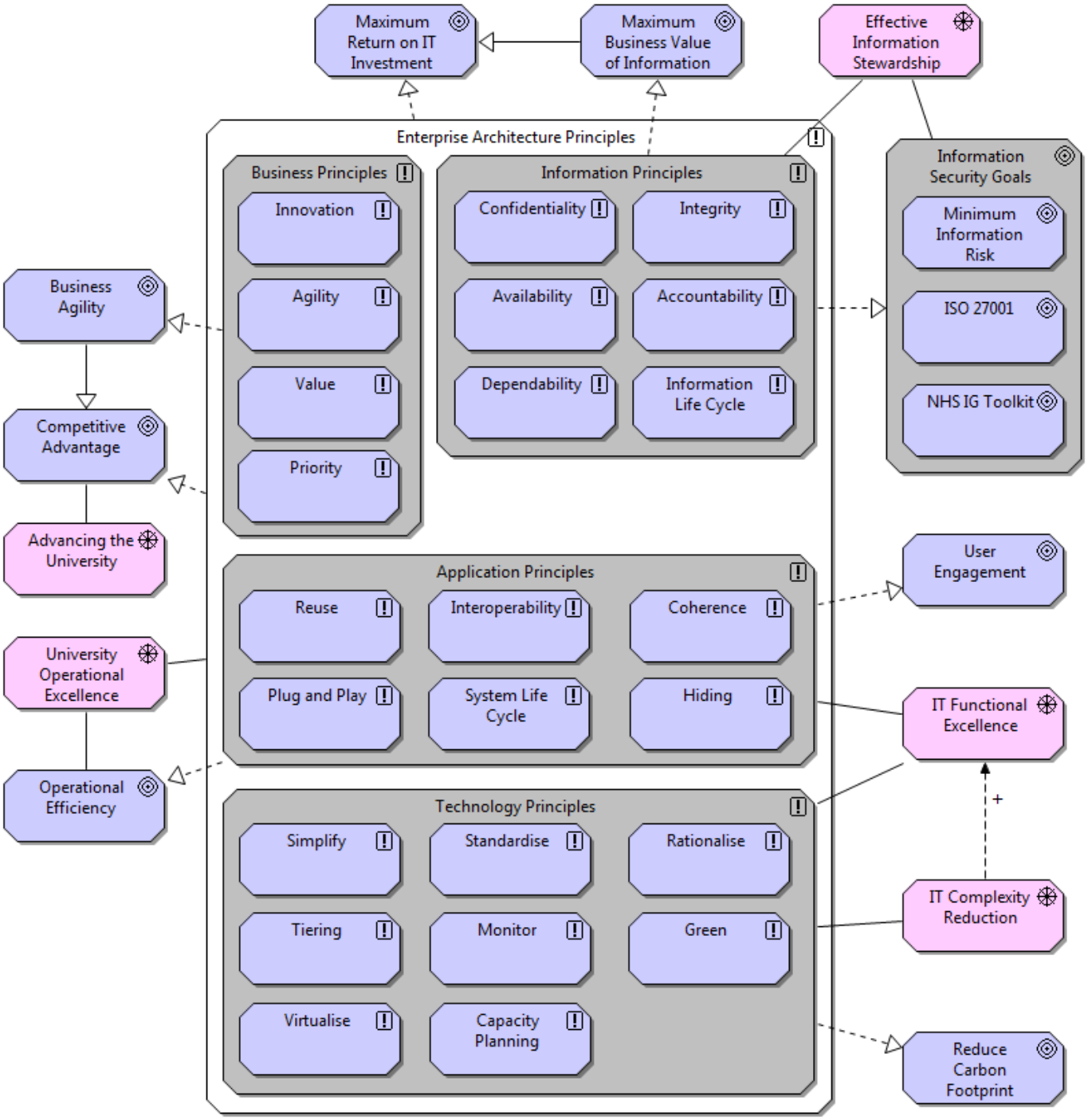


Figure 7 Enterprise Architecture Principles

2.5.1 Principles

Enterprise Architecture Principles			IT Strategy Themes				
	Principle	**Rationale**	**Advancing the University**	**Effective Information Stewardship**	**University Operational Excellence**	**IT Functional Excellence**	**IT Complexity Reduction**
		Business					
BUS1	**Innovation** Innovate for competitive advantage through differentiation and productivity	Helps realise competitive advantage and drives improvements in efficiency and productivity.	✓				
BUS2	**Priority** Prioritize satisfying business needs over all other considerations.	Architecture gives most benefit when closely aligned with business strategy and goals	✓		✓		
BUS3	**Agility** Promote business agility and adaptability.	Empowers the business to adapt and progress in a changing business environment.	✓		✓		
BUS4	**Value** Maximize the value of information assets and optimize their return on investment (ROI).	Organizing and managing the key information assets of the University drives the business processes needed to run the enterprise	✓		✓		
		Information					
INF1	**Accountability** Ensure that all information assets have an identified business owner who is accountable to the University and track and record all actions and events that lead to access or changes in information.	Those with the most knowledge of the data are best placed to make rational and coherent decisions. It is imperative to track all changes and access in order to enforce non-repudiation of actions.		✓	✓		
INF2	**Availability** Deliver information where and when needed, via multiple channels, to maximize its value as an asset, while ensuring that **Confidentiality** is enforced.	University business should not be limited or constrained by lack of available information wherever and whenever needed..		✓	✓		
INF3	**Confidentiality** Prevent unwanted access to information, limiting **Availability** to those with legitimate rights. Protect it in transit, at rest and in storage.	The University must respect the law, fulfil contractual obligations and protect the value of its information assets.		✓	✓		
INF4	**Dependability** Ensure consistency and predictability using appropriate constraints and controls.	Consistency and predictability reduce risks, lower costs and help increase the value of information assets.		✓	✓		

Enterprise Architecture Principles		IT Strategy Themes					
	Principle	**Rationale**	**Advancing the University**	**Effective Information Stewardship**	**University Operational Excellence**	**IT Functional Excellence**	**IT Complexity Reduction**
INF5	**Information Life Cycle** Take full account of the time dimension of information based on the standard Information Management Life Cycle.	Information must be actively managed throughout its life cycle and securely and efficiently disposed of at end of life.		✓	✓		
INF6	**Integrity** Prevent or detect and repair unwanted changes to information.	Data quality is a major factor in preserving and enhancing the business value of information assets.		✓	✓		
	Application						
APP1	**Coherence** Ensure services are coherent and comprehensible in their own right. Restrict the scope of a service to a distinct and well-defined problem area.	Easy to understand services are easy to combine, use and get value from.				✓	✓
APP2	**Hiding** Hide the internal details of services from consumers to avoid creating dependencies on internal structures and logic that may change. Handle errors and exceptions where they occur to prevent 'cascading errors syndrome'.	Keeping the internal structures and logic of services private from consumers of the services frees them to use and combined services in the way that best suits the business of the University.				✓	
APP3	**Interoperability** Maximize interoperability by using common standards and mechanisms for the exposure and use of services.	Enables systems and services to communicate and work together for greater synergy and efficiency.				✓	✓
APP4	**Plug and Play** Implement new services by assembling available services, components and resources in preference to writing new code.	Next generation application development is based on assembling building block components and services rather than bespoke software development. This increases speed of delivery, flexibility and reliability.				✓	✓
APP5	**System Life Cycle** Plan and manage application services throughout their entire life-cycle, including the 'end of life' phase.	Applications and services should be actively managed throughout their life cycle to extract maximum benefit for lowest cost.				✓	
APP6	**Reuse** Maximize reuse by designing services that are useful to the largest possible number of consumers.	Reusing existing services and systems reduces the work required to implement new ones.				✓	✓

Enterprise Architecture Principles		IT Strategy Themes	Advancing the University	Effective Information Stewardship	University Operational Excellence	IT Functional Excellence	IT Complexity Reduction
Principle		**Rationale**					
Technology							
TEC1	**Capacity Planning** Use capacity planning to optimize the sizing of infrastructure and ensure there is enough headroom for planned growth.	Oversized infrastructure wastes money and increases energy consumption.				✓	✓
TEC2	**Green** Reduce power consumption, heat and carbon footprint where possible. Get carbon accounts from suppliers and work to reduce.	Reduces the total cost of ownership and contributes to preserving the natural environment.				✓	
TEC3	**Monitor** Deploy automatic monitoring tools that cover application and data services as well as the underlying infrastructure.	Real-time monitoring allows immediate action to resolve failures and incidents with minimal cost and disruption to the business.				✓	
TEC4	**Rationalize** Minimize redundancy and reduce duplication.	Helps reduce complexity and promotes greater efficiency.				✓	✓
TEC5	**Simplify** Reduce complexity for greater flexibility and lower cost.	Lowers costs through economies of scale and reduces overhead of managing complexity.				✓	✓
TEC6	**Standardize** Adopt and enforce standards to improve operability and achieve economies of scale.	Standardization helps achieve economies of scale, reduces complexity and improves flexibility				✓	✓
TEC7	**Tiering** Adopt a tiered infrastructure for greater security, resilience and efficiency.	Separation of concerns between infrastructure tiers improves security and allows greater efficiency and flexibility.				✓	
TEC8	**Virtualize** Reduce dependency on hardware and promote flexibility, agility and sharing of resources through virtualization.	Virtualization promotes flexibility, allows more efficient use of hardware resources and reduces energy consumption				✓	✓

2.5.2 IT Strategy Drivers

These are the strategic themes from the IT Strategy, modelled as 'drivers' in Figure 7 Enterprise Architecture Principles.

Advancing the University	Deliver game-changing advances in technology support for academic research, learning and teaching, and providing a distinctive student experience.
Effective Information Stewardship	Focus on capturing, storing and providing effective and secure access to a wide range of information sets.
IT Complexity Reduction	Reduce complexity across the University including business, application and technology layers.
IT Functional Excellence	Strive for excellence in all IT capabilities including service management, staff skills base, development and networking, effective IT procurement, diverse funding sourcing, and selective introduction of internal charging.
University Operational Excellence	Improve how departments and functions operate across the University, including as facilitators to Sustainable Excellence improvements. This driver focuses on underlying step-change enhancements, carbon reduction initiatives and staff skills developments

2.5.3 Goals

A number of specific goals arise from the strategy drivers.

Business Agility	Maximise business agility including the ability to work from almost anywhere and have information and functionality delivered where and when needed.
Competitive Advantage	Achieve competitive advantage through optimal application services implemented using optimal technology investment.
Information Security Goals	Specific Goals for Information Security.
ISO 27001	Formal ISO certification for defined units, combined with general compliance for the University as a whole.
Maximum Business Value of Information	Seek to maximise the business value of the University's information.
Maximum Return on IT Investment	Achieve the highest possible ROI on investment in information assets subject to security and good information management constraints.
Minimum Information Risk	Minimum information risk consistent with achieving the University's other objectives.
NHS IG Toolkit	Compliance and certification under NHS Information Governance.
Operational Efficiency	High operational efficiency and productivity through optimal automation with services perfectly suited to business needs.
Reduce Carbon Footprint	Reduce the carbon account of the University and suppliers.
User Engagement	Engage the users through social networking, gmaification etc.

2.6 Non-Functional Requirements

Architecturally significant requirements mainly fall into the non-functional category but may also include functional requirements in some cases. Non-functional requirements for systems should be based on the following design objectives:

Property	Definition	Measurement
Performance	The speed at which the system performs a function that meets business requirements and user expectations.	L = latency – response time J = jitter - % variation in L H = headroom - % available spare capacity.
Scalability	The ability of the system to handle increasing or decreasing volumes of transactions, services and data.	SF = scalability factor in the range 0...1 – ratio of total load capacity and available hardware resources. SL = scalability limit – the maximum loading capacity of the system that is inherent in, or a consequence of, its design.
Availability	The readiness of the system to perform its functions when needed in spite of errors and exceptions.	% of target availability e.g. 99.98% of 24 x 7 and / or MTBF.
Operability	The ability of the system to fit smoothly into its environment and behave predictably.	High – Medium – Low
Usability	Users' perceptions of an application's usefulness, usability, and desirability based on the sum of all direct and indirect interactions.	High – Medium – Low
Security	Protecting information confidentiality, integrity, availability, dependability and accountability.	High – Medium – Low
Regulation	Degree of conformity with laws and regulations.	High – Medium – Low
Flexibility	Ease of change to meet changing business requirements.	High – Medium – Low
Feasibility	The ability of the organisation to deliver the system subject to constraints of available expertise, technology, time and resources.	High – Medium – Low

The system properties listed in the table are intended to be used to drive the development of detailed non-functional requirements (NFRs), in various contexts including:

- Project requirements specifications.
- Procurement PQQ and ITT questions.

2.7 Architecture Team

The Architects within IT Services are primarily responsible for the enterprise architecture of the University and for managing the Architecture Process (Figure 2 Architecture Process). There will eventually be a team of architects, including the roles shown in the diagram.

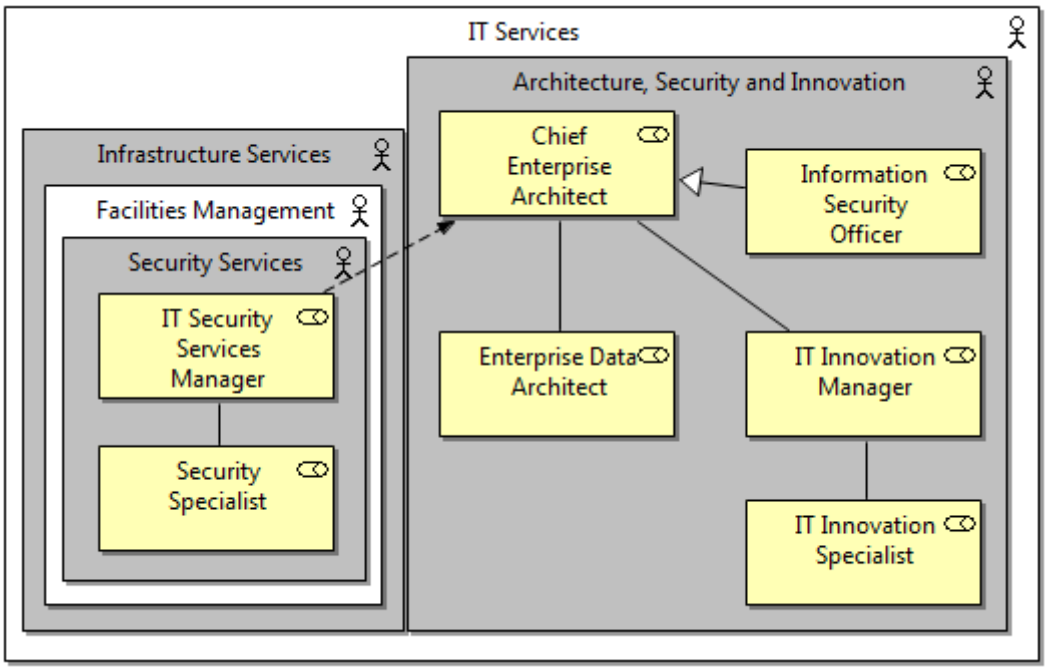


Figure 8 Architecture Team

Architecture, Security and Innovation	Architecture team (LNAB).
Chief Enterprise Architect	Leads on enterprise architecture and strategy, business, application and technology; architecture management; information security and innovation.
Enterprise Data Architect	Responsible for enterprise data architecture including Master Data Management, information management, data modelling and project management of related projects.
Information Security Officer	The Information Security Officer is a role normally assigned to the Chief Enterprise Architect.
IT Innovation Manager	Manages the IT Innovation Centre and team; acts as a focal point and coordinates innovation activities and initiatives. Project manages relevant IT projects.
IT Innovation Specialist	Assists the IT Innovation Manager, performs evaluations and experiments
IT Security Services Manager	Manages information security incidents and assists with the implementation of security controls.

3 Models

3.1 Business Layer

3.1.1 Business Capability Modelling

A 'Business Capability' is the ability of an enterprise to deliver products or services to customers or other parts of the same enterprise. Implementation of a capability involves mobilising resources and allocating them, partially or completely, to the business function that represents the new capability.

A capability can be represented by a 'business function' defined as a collection of business activities related by some convenient criteria such as required assets, competencies etc. Capability modelling is no more than a convenient framework for analysis of business processes, people and assets (mainly systems) and relating them together in a business context.

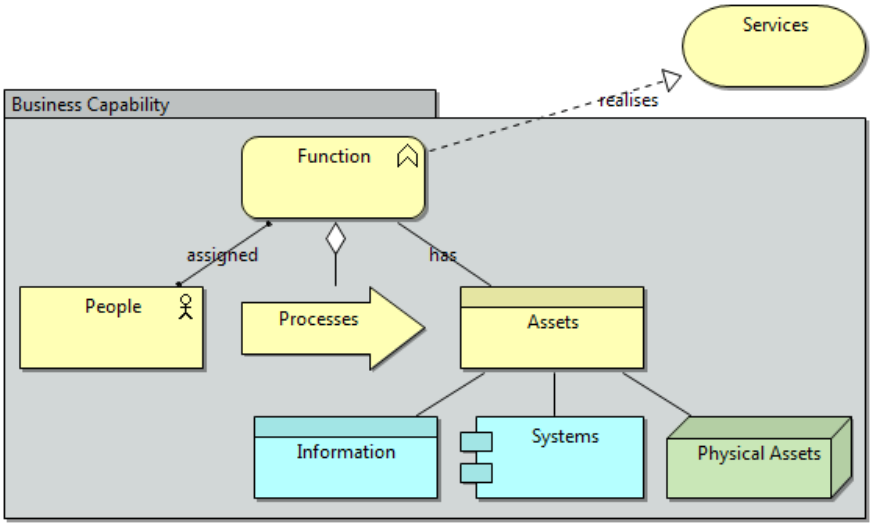


Figure 9 Business Capability Modelling

Assets	Anything that has value to the organisation or its customers, including physical assets, information, systems and people in their role as 'human assets'.
assigned	**People** assigned **Function**
Function	A convenient grouping of business activities that deliver the Services.
has	**Function** has **Assets**
Information	Information assets such as files, databases, documents, messages etc.
People	Organisational entity, or individual, capable of performing business behaviour.
Physical Assets	Physical assets such as buildings, vehicles, computers.
Processes	Business Processes that group behaviour based on an ordering of activities; intended to produce a defined set of products or business services. Processes can be considered behavioural components of the business function.
realises	**Function** realises **Services**
Services	Services, or products, delivered to other parts of the enterprise or external customers. Services represent the business value delivered and the justification for the capability.
Systems	A system is a combination of interacting elements organised to achieve a defined objective; includes hardware, software, processes, people, information, techniques and facilities. This term includes, but is not limited to, systems and applications.

The assets belonging to a given business capability may include anything that has value to the organisation, including participation by people in processes and systems. These are the same assets used for strategic planning, information security risk analysis and management as well as other related activities.

Business capabilities are documented using business capability maps as shown in the diagram:

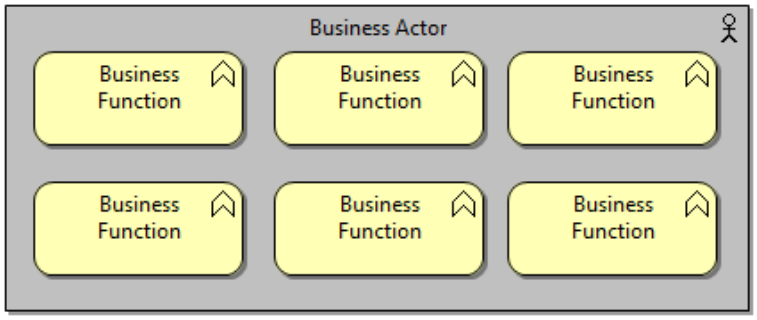


Figure 10 Business Capability Map

Business Actor	An organisational unit that is capable of performing behaviour.
Business Function	Business behaviour grouped according to a chosen set of criteria such as resources, competences or business culture.

3.1.2 Information Management Life Cycle

A standard Information Management Life Cycle applies to all information assets.

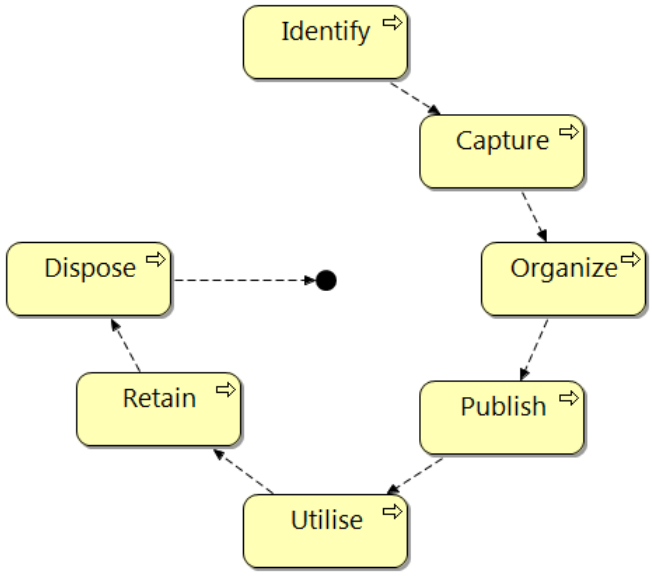


Figure 11 IMLC

Identify	Find or identify information
Capture	Acquire or create information; work on draft versions.
Organize	Organize the information and insert it into the appropriate place in enterprise information stores
Publish	Distribute information to its intended audience
Utilise	Use and manage the information
Retain	Keep the information for reference, even though no longer current
Dispose	Destroy or archive. The action to be taken at end of life may be defined in enterprise information retention and deposal policies.

Information Models

Information maps and models included within the business architecture layer include

3.1.3 Business Priority

The priority of the services delivered by a business capability depends on their alignment with the IT Strategy and Strategic Framework. In principle, investment in technology to support activities that have scope for delivering competitive advantage are prioritised over the need to keep basic services operating.

The business value increases up the hierarchy while risk decreases in the sense that lack of baseline services is high risk but lack of differentiation or innovation does not carry significant risk. The potential impact would be lost opportunities rather than harm to the University.

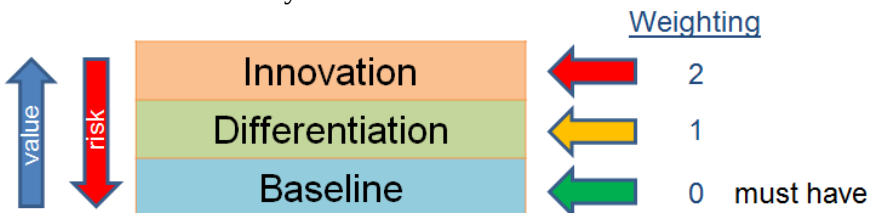


Figure 12 Business Priority

The Business Priority refers to the corresponding business function, or business capability, and not systems or information assets. It is intended to inform IT strategic planning and portfolio management processes by providing one factor to be taken into account when prioritizing projects.

3.2 Application Layer

3.2.1 Application Maps

Application maps are used to set context and drive further modelling efforts in the application layer. The diagram shows a snippet from an application map diagram.

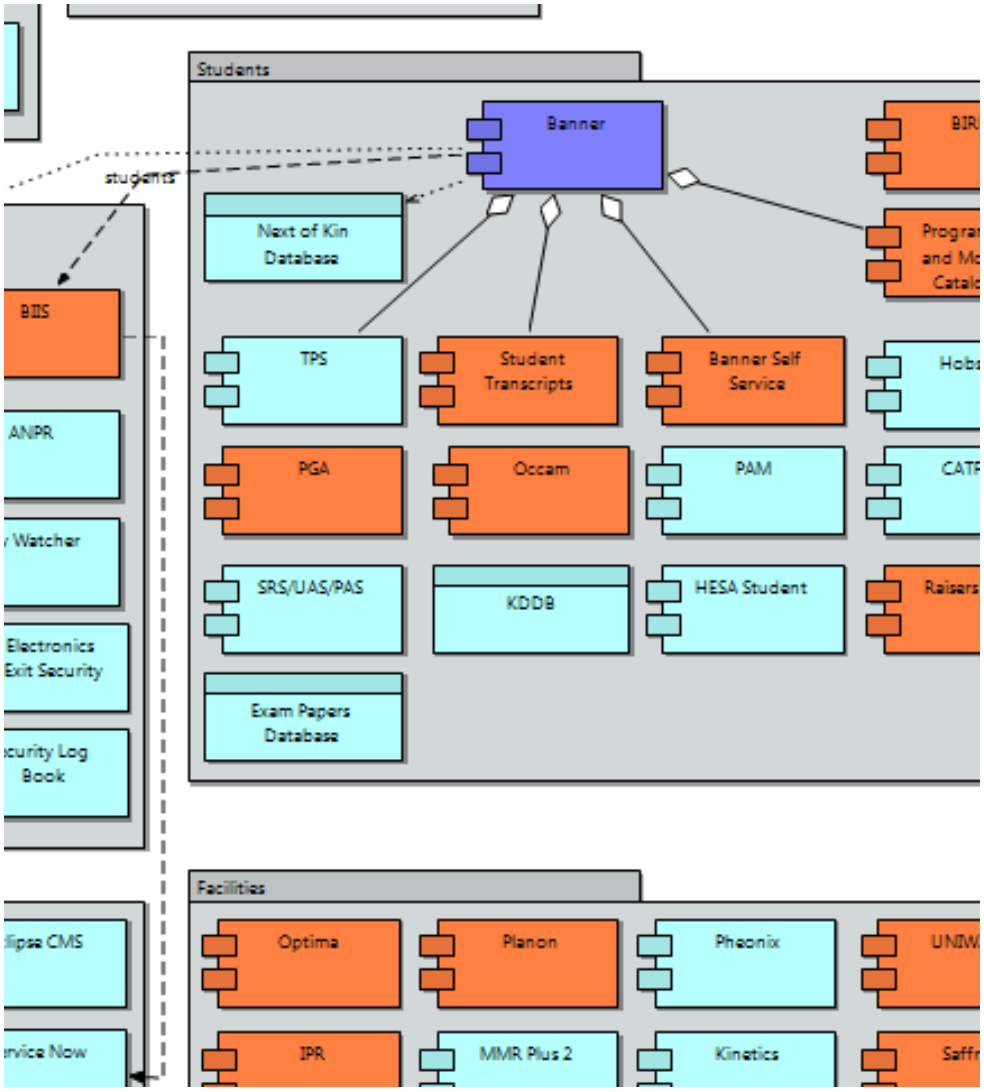


Figure 13 Example Application Map

3.2.2 Portfolio Management

Portfolio Management is a planning activity that focuses on how business capabilities are supported by existing information assets. This usually covers mainly applications and databases that are considered to be assets in their own right. The information assets are evaluated for business value delivered and technical quality using the evaluation matrix:

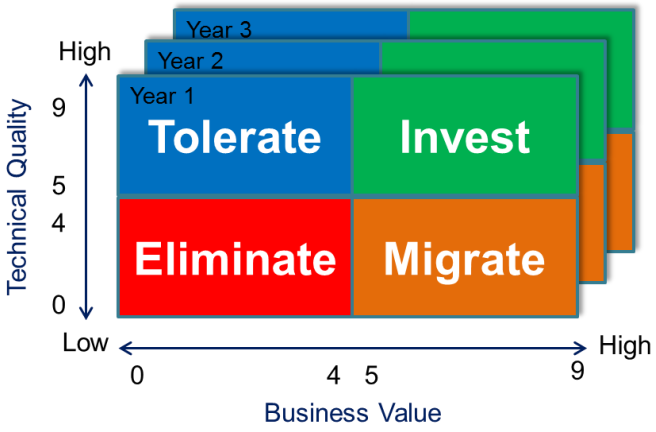


Figure 14 Evaluation Matrix

Business value is evaluated in the context of a given business capability. It is a largely subjective measure that relies on the experience and knowledge of the individuals involved. Their opinion may be coloured by their knowledge of other products on the market and the situation in other institutions.

The scores for business value and technical quality are combined using a simple grid to yield a result that drives decision-making concerning future investment in technology.

Verdict	Business Value	Technical Quality	Action
Eliminate	Low	Low	Remove and replace with a new system as soon as possible.
Tolerate	Low	High	Replace with something useful but no urgent technical reason to remove.
Migrate	High	Low	Fix the technology by upgrading or migrating to a new system.
Invest	High	High	Continue to invest, upgrade and build upon current system.

The value of conducting a series of evaluations over time is to track the declining technical quality and business value. A type of entropy applies to information assets, business value and technical quality tend to decline over time as the changing business and technical environments continue to evolve – opening up gaps and incompatibilities – unless the enterprise continues to invest in and develop its assets.

- **Business Value** – based on a value judgement by senior members of the business team working in the business capability being studied and scored on a scale of 0..9. A score of less than 5 means the system, or other asset, indicates that the asset is a poor investment with low returns, while 5 or over indicates a good investment.
- **Technical Quality** – assessed using the standard list of properties, or system quality attributes, shown in section 2.6Non-Functional Requirements. Each property is scored on a scale of 0..9.

3.3 Technology Layer

3.3.1 Technical Reference Model (TRM)

The purpose of the TRM is to be a classification scheme for standards, selected products and components The following diagram shows the default TRM from TOGAF but it is likely that this will expand and change to fit the needs of the University.

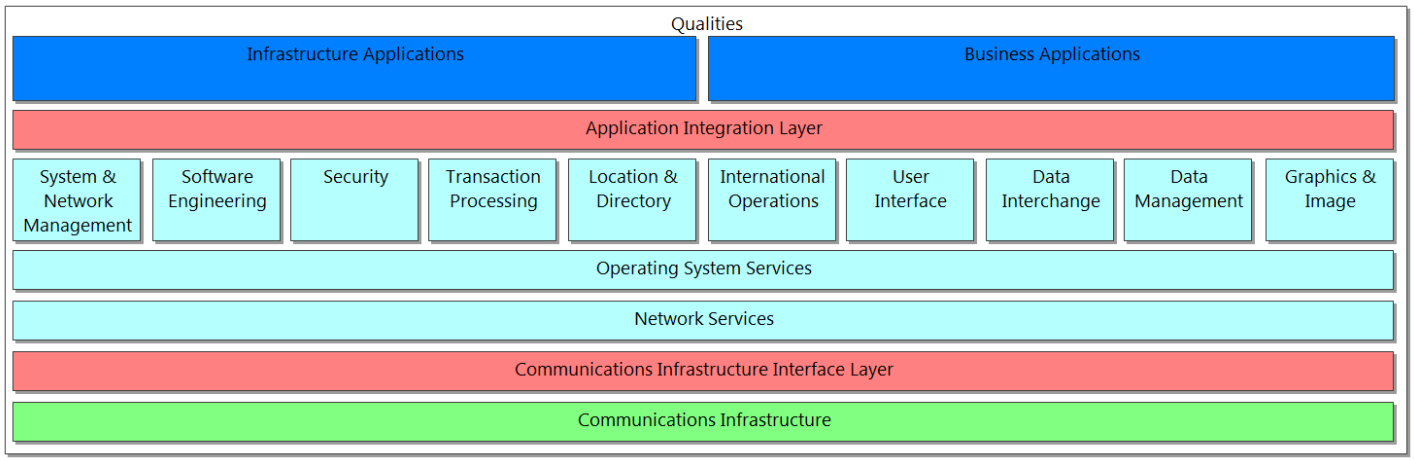


Figure 15 TOGAF Technical Reference Model

3.3.2 Standards Information Base (SIB)

The Standards Information Base (SIB) lists the industry standards, products and components that have been selected and approved for use by IT Services. There is a formal process for proposing, updating and removing standards.

The SIB will be organised into categories based on the Technical Reference Model (TRM), described in section 3.3.1. The following example shows example entries from a typical SIB implementation.

Security

Standard	Description	Version	Usage	References
AES Standard: 2011	**Advanced Encryption Standard (Rijndael)** U.S. Government standard widely used world-wide. Traced: DD	N/A	To be used where possible with 256-bit keys	http://www.esat.kuleuven.ac.be/~rijmen/rijndael
IPsec Standard: 2011	**Internet Security Protocol** A protocol suite for securing Internet Protocol (IP) communications by authenticating and encrypting each IP packet of a communication session. IPsec also includes protocols for establishing mutual authentication between agents at the beginning of the session and negotiation of cryptographic keys to be used during the session. Traced: IFF	N/A	Secure Communications	
ISO27001 Proposed: 2011	**Information Security Management Systems standard** Specifies a management system that is intended to bring information security under explicit management control. Being a formal specification means that it mandates specific requirements. Organizations that claim to have adopted ISO/IEC 27001 can therefore be formally audited and certified compliant with the standard. Traced: SPD	2005	Information Security Management	http://www.iso.org/iso/home.htm
ISO27002 Proposed: 2011	**Best Practices in Information Security Management** Best practice recommendations on information security management for use by those responsible for initiating, implementing or maintaining Information Security Management Systems (ISMS). Information security is defined within the standard in the context of the C-I-A triad: CONFIDENTIALITY - ensuring that information is accessible only to those authorised to have access, INTEGRITY - safeguarding the accuracy and completeness of information and processing methods, AVAILABILITY - ensuring that authorised users have access to information and associated assets when required. Traced: SPD	2005	Information Security Management	http://www.iso.org/iso/home.htm

3.4 Verticals

The approach to enterprise architecture is based on the Archimate graphical architecture description language (ADL), which is used for most of the models. Archimate focusses on mappings between the layers, for example in the Layered viewpoint.

3.4.1 Security Architecture

This pulls together those elements of the three architecture layers that are relevant to Information Security, focussing on the Information Principles and how they are realised.

3.4.2 Data Architecture

Information, or data, architecture consists of a hierarchy of models ranging from high-level information models and ontologies in the business layer to logical data models in the application layer and physical data models, schemas etc. in the technology layer.

3.5 Road Maps

One of the most important models is the Architecture Road Map, which typically shows the three layers – business, application and technology – and the mappings between them. Road maps are usually presented in Gantt Chart form or Archimate architectural models.

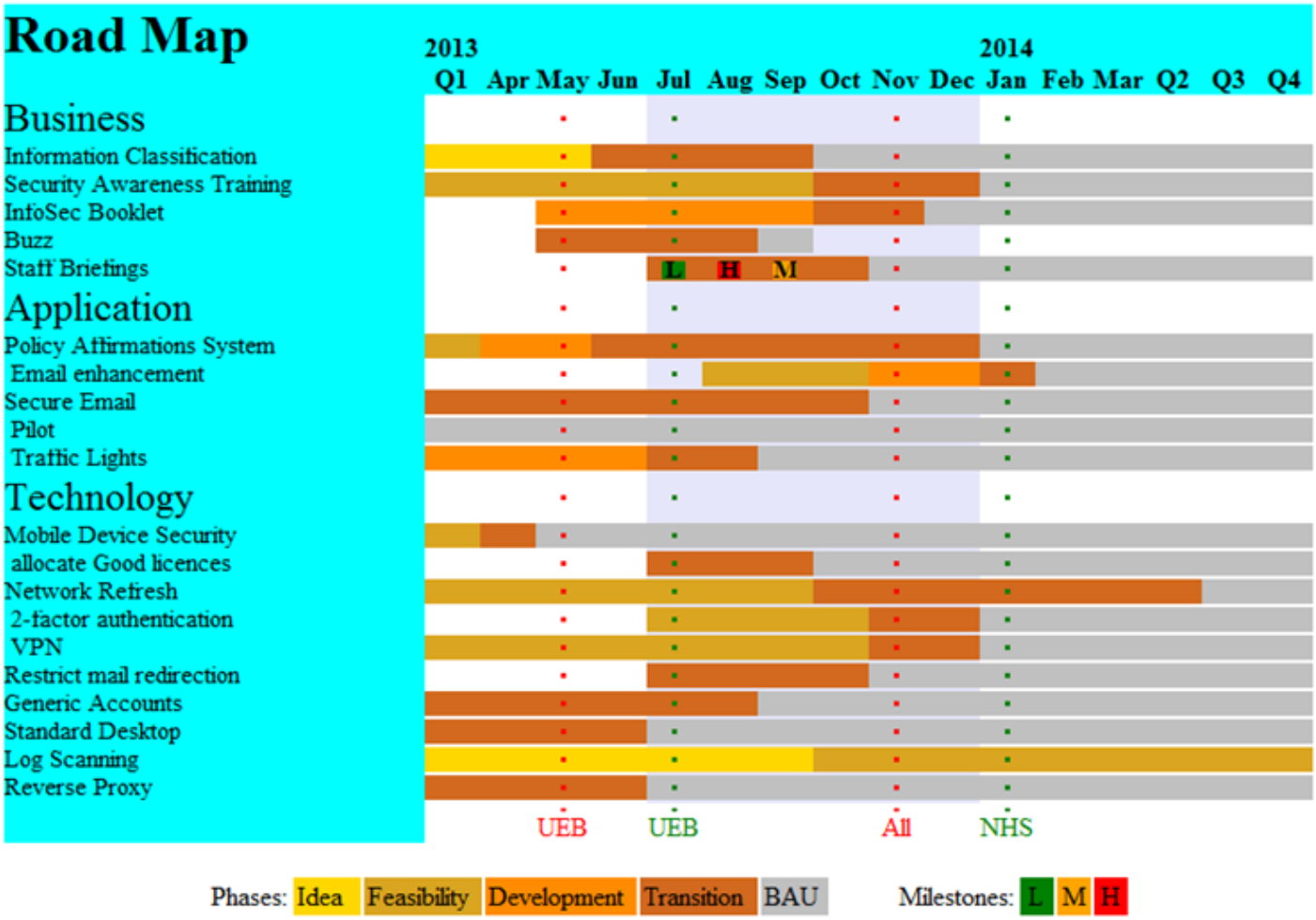


Figure 16 Example Road Map Gantt

The example refers to the standard system life cycle phases as shown in the following diagram:

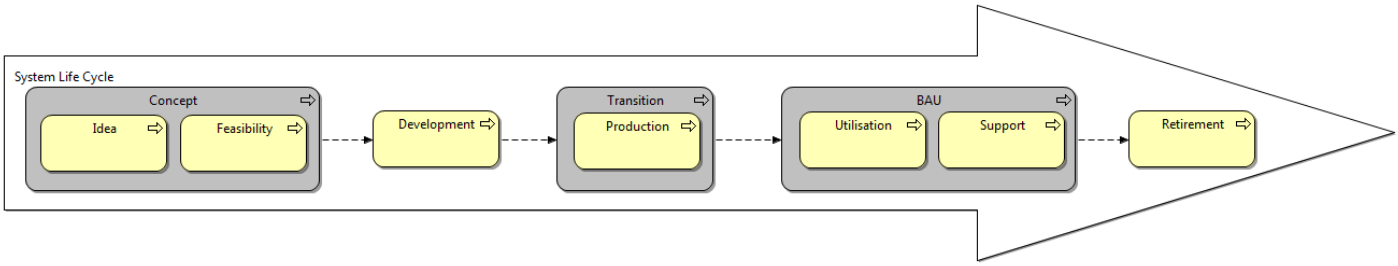


Figure 17 System Life Cycle

System Life Cycle	Standard system life cycle based on ISO/IEC 15288.
Concept	The Concept Stage is executed to assess new business opportunities and to develop preliminary system requirements and a feasible design solution
Idea	Creating or acquiring the initial idea, innovation or concept.
Feasibility	Evaluate the feasibility of the system.
Development	The Development Stage is executed to develop a system- that meets acquirer requirements and can be produced, tested [verified], evaluated, operated, supported, and retired
Transition	Transition to live including testing, release generation, installation and setup, training etc.
Production	Produce or manufacture the system, test / verify the system, and effect related supporting and enabling systems as needed.
BAU	Business as Usual - the system is actively being used and supported.
Utilisation	Operate the system, to deliver services within intended environments and to ensure continued operational effectiveness.
Support	Provide logistics, maintenance and support services that enable continued system operation and a sustainable service
Retirement	Provide for the removal of a system and related operational and support services, and to operate and support the retirement system itself

3.6 Patterns

An on-going activity of the Architects will be to document architectural patterns of various kinds and publish them in the Architecture Repository so that they can be reused in the future. Many patterns already exist and only need collecting together.

Patterns represent high-level reuse as opposed to low-level reuse in the form of directly reusable components.

Types of patterns:

1) **Business Services and Collaborations** – combining business processes, business services, collaborations and products.
2) **Information and Data** – common patterns in data models and in the management and organisation of data.
3) **Application** – common application design structures and relationships such as layering, web presentation, concurrency, distributed components.
4) **Technology** – common software stacks, hardware, standard builds, architectural tiering etc.
5) **Process** – reusable processes and activity definitions.

Glossary

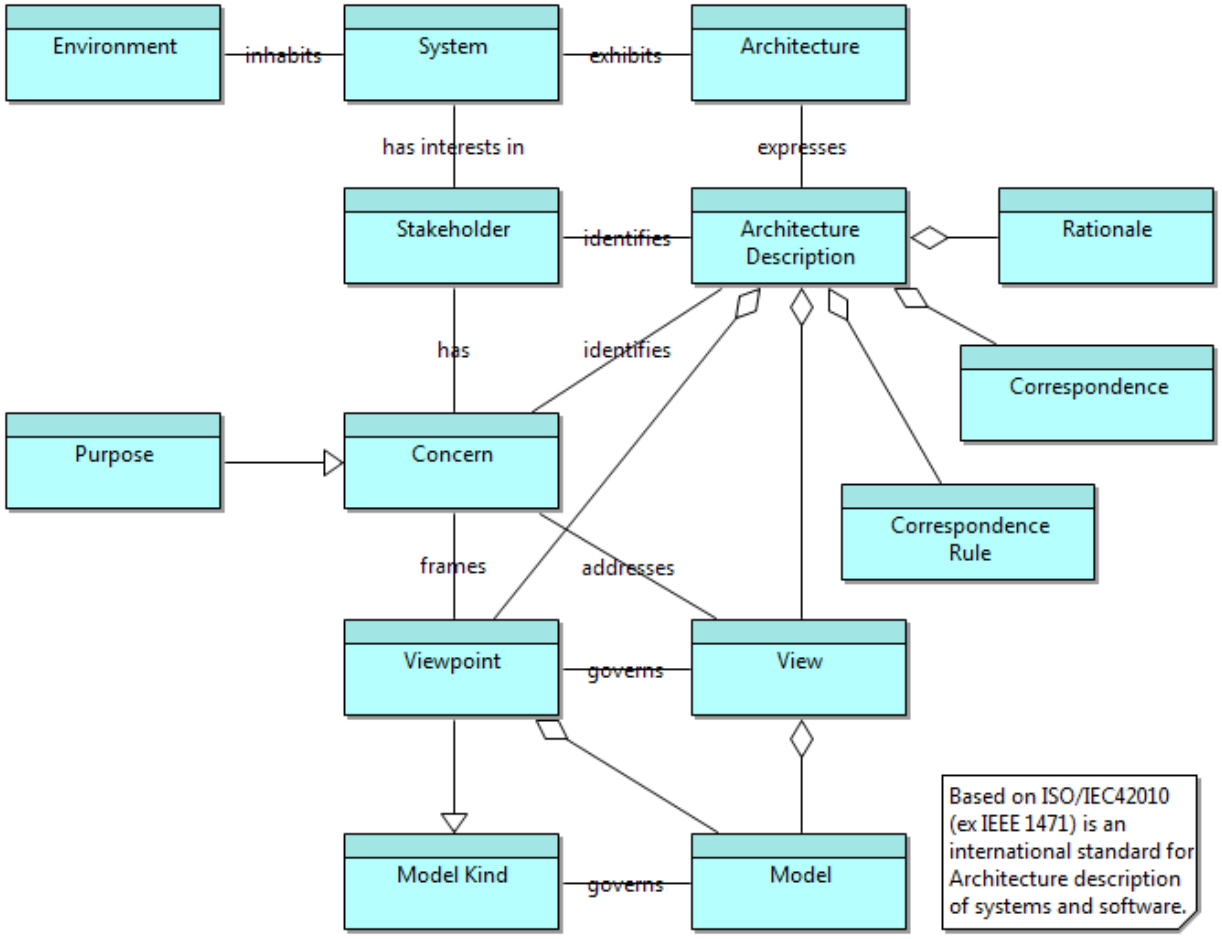
ACF	Architecture Compliance Form.
ADL	Architecture Description Language – used for describing architecture (e.g. Archimate).
ADM	Architecture Development Method – TOGAF.
EA	Enterprise Architecture.
EAF	Enterprise Architecture Framework
IEC	International Electrotechnical Commission, an international standards body..
IEEE	Institute of Electrical and Electronics Engineers, IEEE Standards Association
INCOSE	International Council on Systems Engineering.
ISO	International Standards Organisation.
ITS	IT Services department.
ITT	Invitation to Tender, the formal request for proposal sent to short-listed bidders in European OJEU and similar procurement processes.
MTBF	Mean Time Between Failures.
NFR	Non-functional requirement(s).
OJEU	European on-line journal that records public sector procurement exercises.
PID	Project Initiation Document.
PQQ	Pre-Qualifying Questionnaire, the initial questionnaire sent to prospective bidders for European OJEU and similar procurement processes..
SIB	Standards Information Base – TOGAF.
SOA	Service Oriented Architecture
TAM	Target Architecture Model.
TOGAF	The Open Group Architecture Framework.
TRM	Technical Reference Model – TOGAF.
XML	Extensible Mark-up Language.

References

[1]. IT Strategy	IT Strategy 2010-2015 v1.13 2011
[2]. INCOSE Systems Engineering Handbook	INCOSE Systems Engineering Handbook v3.2.1 2011
[3]. Architecture Principles	Enterprise Architecture Principles v0.1 2011
[4]. Archimate	Archimate 2.0 Specification – The Open Group 2012

APPENDIX A. Ontology

The ISO/IEC422010 standard constitutes a basic ontology for reasoning about systems of all kinds.



addresses	**View** addresses **Concern**
Architecture	The organisation of a System in terms of components, their relationships to each other and the environment.
Architecture Description	An Architecture Description is a work product used to express the Architecture of some System Of Interest. The Standard specifies requirements on ADs. An AD describes one possible Architecture for a System. An AD may take the form of a document, a set of models, a model repository, or some other form (AD format is not defined by the Standard).
Concern	A Concern is any interest in the system. The term derives from the phrase “separation of concerns” as originally coined by Edsgar Dijkstra. Examples of concerns: (system) purpose, functionality, structure, behavior, cost, supportability, safety, interoperability.
Correspondence	Correspondences express a relation between AD Elements. Correspondences are used to express architecture relations of interest within an Architecture Description or between Architecture Descriptions. Correspondences can be governed by Correspondence Rules.
Correspondence Rule	Correspondence Rules enforce relations within an Architecture Description or between Architecture Descriptions.
Environment	The environment, or context, in which the system exists including the social, business and technical aspects.
exhibits	**System** exhibits **Architecture**
expresses	**Architecture Description** expresses **Architecture** An Architecture Description expresses the architecture of the system.

frames	**Concern** frames **Viewpoint**
governs	**Model Kind** governs **Model**
governs	**Viewpoint** governs **View**
has	**Stakeholder** has **Concern**
has interests in	**Stakeholder** has interests in **System**
identifies	**Architecture Description** identifies **Stakeholder**
identifies	**Architecture Description** identifies **Concern**
inhabits	**Environment** inhabits **System**
Model	A view is comprised of Architecture Models. Each model is constructed in accordance with the conventions established by its Model Kind, typically defined as part of its governing viewpoint. Models provide a means for sharing details between views and for the use of multiple notations within a view.
Model Kind	A Model Kind defines the conventions for one type of Architecture Model.
Purpose	The purpose of a system is a concern of the relevant stakeholders.
Rationale	Architecture Rationale records the explanation, justification or reasoning about Architecture Decisions that have been made and architectural alternatives not chosen.
Stakeholder	Stakeholders are individuals, groups or organizations holding Concerns for the System of Interest. Examples of stakeholders: client, owner, user, consumer, supplier, designer, maintainer, auditor, CEO, certification authority, architect.
System	Any system of interest, including 'systems of systems'. The standard takes no position on the definition of the word 'system' but we define a system as a collection of parts that work together towards a commen end.
View	An Architecture View in an AD expresses the Architecture of the System of Interest from the perspective of one or more Stakeholders to address specific Concerns, using the conventions established by its viewpoint. An Architecture View consists of one or more Architecture Models.
Viewpoint	An Architecture Viewpoint is a set of conventions for constructing, interpreting, using and analyzing one type of Architecture View. A viewpoint includes Model Kinds, viewpoint languages and notations, modeling methods and analytic techniques to frame a specific set of Concerns. Examples of viewpoints: operational, systems, technical, logical, deployment, process, information.

APPENDIX B. Standard Agenda for Architecture Compliance Reviews

Introduction

General welcome and terms of reference for the meeting.

Project Summary

A description of the changes implemented by this project.

Architecture

Walk through the Architecture Compliance Form (ACF) or Architecture Description, including:

- Mission or purpose of the system.
- Architecture Principles – relevance and how realised.
- System Quality Attributes / Design Objectives.
- Data Utilisation – CRUD matrix.
- Interfaces.
- Security Architecture.
- Technology Stack.
- Environments
- Road Map.

Road Map

The time line for implementation and launch with any dependencies on other projects, infrastructure or business events.

Concerns

Architectural, security or other concerns that may spawn risks, issues and remedial work.

Exceptions

Documented exceptions to the Principles, Standards etc.

Questions

Discussion and Q & A.

Decisions

Recommendation to proceed or not with any agreements on remedial work or other actions to be taken before or after the launch. Risks and issues to be added to the project registers.

- Architecture sign-off.
- Security sign-off.

APPENDIX C. Strategic Reference

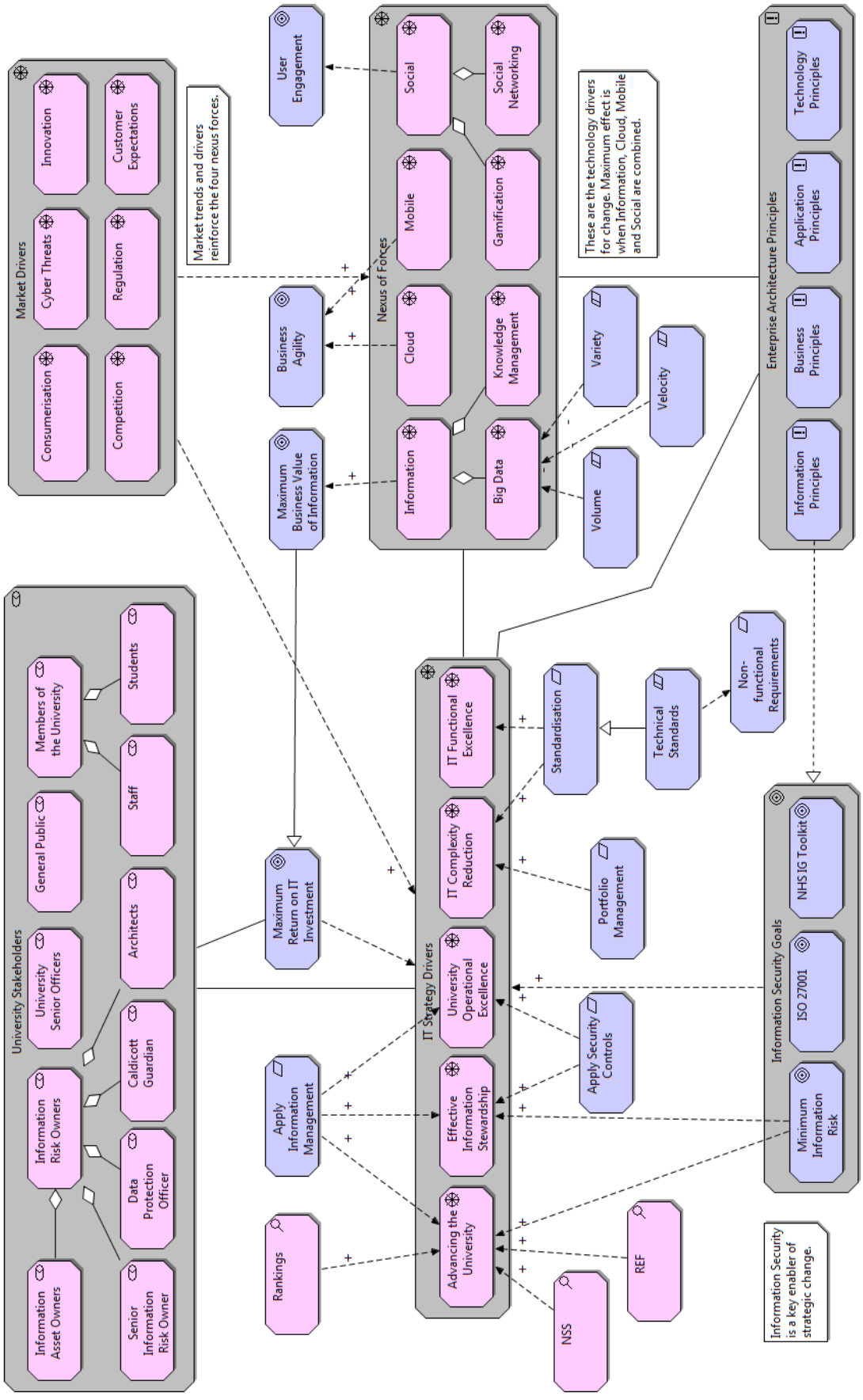


Figure 18 Motivational View

The motivational view diagram shows the strategic influences, drivers and guiding principles that influence both the IT Strategy and Enterprise Architecture.

Advancing the University	*Driver*	Deliver game-changing advances in technology support for academic research, learning and teaching, and providing a distinctive student experience.
Application Principles	*Principle*	Enterprise application architecture principles.
Apply Information Management	*Requirement*	Apply good information management and curation.
Apply Security Controls	*Requirement*	Apply controls to mitigate, track and repair harm caused by security attacks.
Architects	*Stakeholder*	Enterprise and security architects, security officers.
Big Data	*Driver*	Managing and extracting value from large volumes of data.
Business Agility	*Goal*	Maximise business agility including the ability to work from almost anywhere and have information and functionality delivered where and when needed.
Business Principles	*Principle*	Enterprise business architecture principles.
Caldicott Guardian	*Stakeholder*	Vice Chancellor Research and Knowledge Management.
Cloud	*Driver*	Cloud based services
Competition	*Driver*	Increasing competition from other institutions, public and private, in a global market.
Consumerisation	*Driver*	The increasing consumerisation of technology.
Customer Expectations	*Driver*	Increasingly stringent requirements from customers of all kinds including students, funding bodies, industrial partners.
Cyber Threats	*Driver*	Increasing cyber security threats.
Data Protection Officer	*Stakeholder*	Director of Legal Services.
Effective Information Stewardship	*Driver*	Focus on capturing, storing and providing effective and secure access to a wide range of information sets.
Enterprise Architecture Principles	*Principle*	Architecture principles from the Enterprise Architecture Framework (EAF).
Gamification	*Driver*	The use of game techniques to engage the users.
General Public	*Stakeholder*	The University is a public institution and the general public is a major stakeholder.
Information	*Driver*	Information as a business asset.
Information Asset Owners	*Stakeholder*	The business owners of information assets, usually senior managers who are accountable to the University for the assets.
Information Principles	*Principle*	Enterprise information architecture principles, including information security principles.
Information Risk Owners	*Stakeholder*	Nominated owners of information-related risks.
Information Security Goals	*Goal*	Specific Goals for Information Security.
Innovation	*Driver*	Technical and social innovation.
ISO 27001	*Goal*	Formal ISO certification for defined units, combined with general compliance for the University as a whole.

IT Complexity Reduction	*Driver*	Reduce complexity across the University including business, application and technology layers.
IT Functional Excellence	*Driver*	Strive for excellence in all IT capabilities including service management, staff skills base, development and networking, effective IT procurement, diverse funding sourcing, and selective introduction of internal charging.
IT Strategy Drivers	*Driver*	Drivers for Information Security.
Knowledge Management	*Driver*	Organising and managing knowledge, turning information into knowledge.
Market Drivers	*Driver*	Business and technology drivers in the market environment.
Maximum Business Value of Information	*Goal*	Seek to maximise the business value of the University's information.
Maximum Return on IT Investment	*Goal*	Achieve the highest possible ROI on investment in information assets subject to security and good information management constraints.
Members of the University	*Stakeholder*	Staff, students and others who are members of the institution as defined in the University statutes.
Minimum Information Risk	*Goal*	Minimum information risk consistent with achieving the University's other objectives.
Mobile	*Driver*	Mobile technology and mobility in general.
Nexus of Forces	*Driver*	Technology forces that drive disruptive change.
NHS IG Toolkit	*Goal*	Compliance and certification under NHS Information Governance.
Non-functional Requirements	*Requirement*	The non-functional requirements applied to IT projects.
NSS	*Assessment*	National student survey.
Portfolio Management	*Requirement*	Manage portfolio of information assets to optimise technology investment.
Rankings	*Assessment*	The position of the University in various rankings.
REF	*Assessment*	Assessment of research and researchers.
Regulation	*Driver*	Developing legal and regulatory framework.
Senior Information Risk Owner	*Stakeholder*	Senior Information Risk Owner - Director of IT Services.
Social	*Driver*	Social interaction, social networks, gamification.
Social Networking	*Driver*	Use of social networks including FaceBook, Twitter.
Staff	*Stakeholder*	University staff, including academics.
Standardisation	*Requirement*	Standardise hardware and software
Students	*Stakeholder*	Students, including undergraduates and postgraduates.
Technical Standards	*Constraint*	Approve, enforce and publish technical standards.
Technology Principles	*Principle*	Enterprise technology architecture principles.
University Operational Excellence	*Driver*	Improve how departments and functions operate across the University, including as facilitators to Sustainable Excellence improvements. This driver focuses on underlying step-change enhancements, carbon reduction initiatives and staff skills developments
University Senior Officers	*Stakeholder*	Members of UEB, RLG etc.

University Stakeholders	*Stakeholder*	Stakeholders in Information Security and the University in general.
User Engagement	*Goal*	Engage the users through social networking, gamification etc.
Variety	*Constraint*	The variation in values of data.
Velocity	*Constraint*	The speed at which data flows.
Volume	*Constraint*	High data volumes.

APPENDIX D. Process Comparison

The Architecture Process covers architecture work at the enterprise level as well as at the project or solution level. The following diagram maps it to the Prince II Project Management Process, the ISO/IEC 15288 standard for Systems Lifecycle Processes and ITIL Version 3.

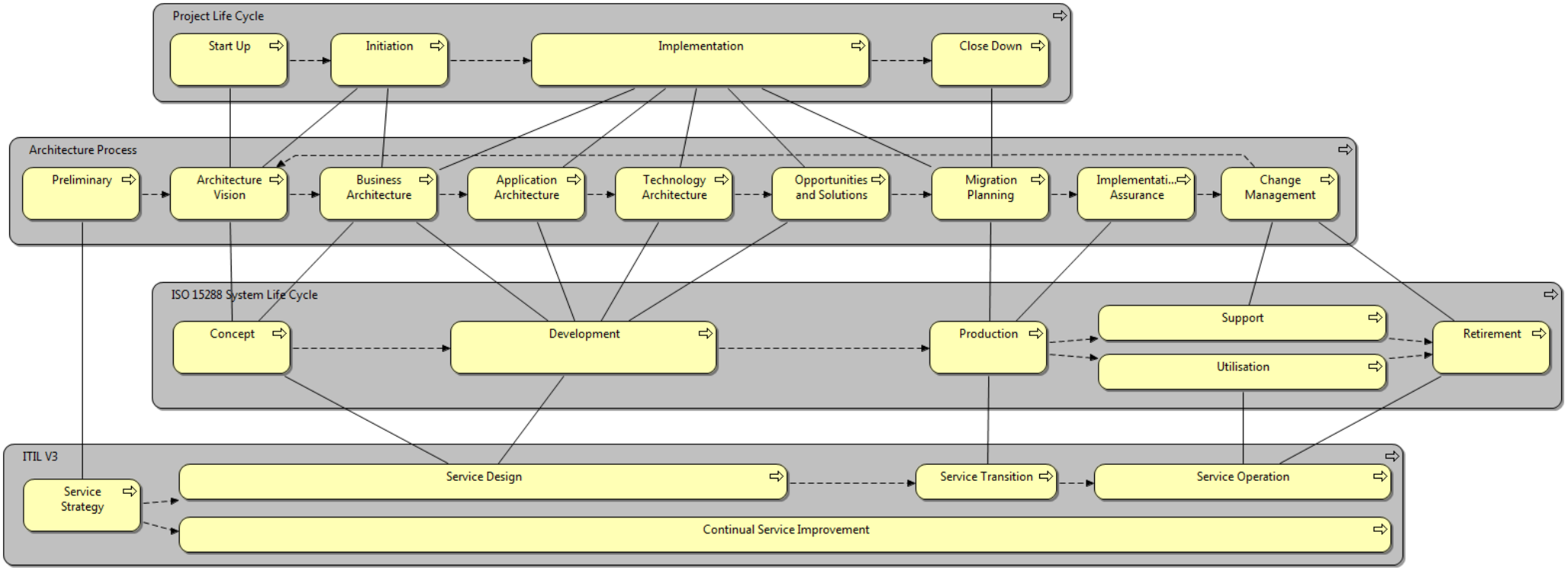


Figure 19 Process Comparison[1]

While the project life cycle, of course, ends with system go-live, the other processes shown in the diagram must continue for the entire life cycle of the system. ISO/TEC 15288 is a generic system life cycle model used in many industries and is not limited to IT. It provides explicitly for system Retirement which is covered by Architecture Change Management (TOGAF) and Service Operation (ITIL).

TOGAF and ITIL also cover the initial strategy phase while ISO 15288 is repeated for every system.

APPENDIX E. Archimate Diagram Notation Key

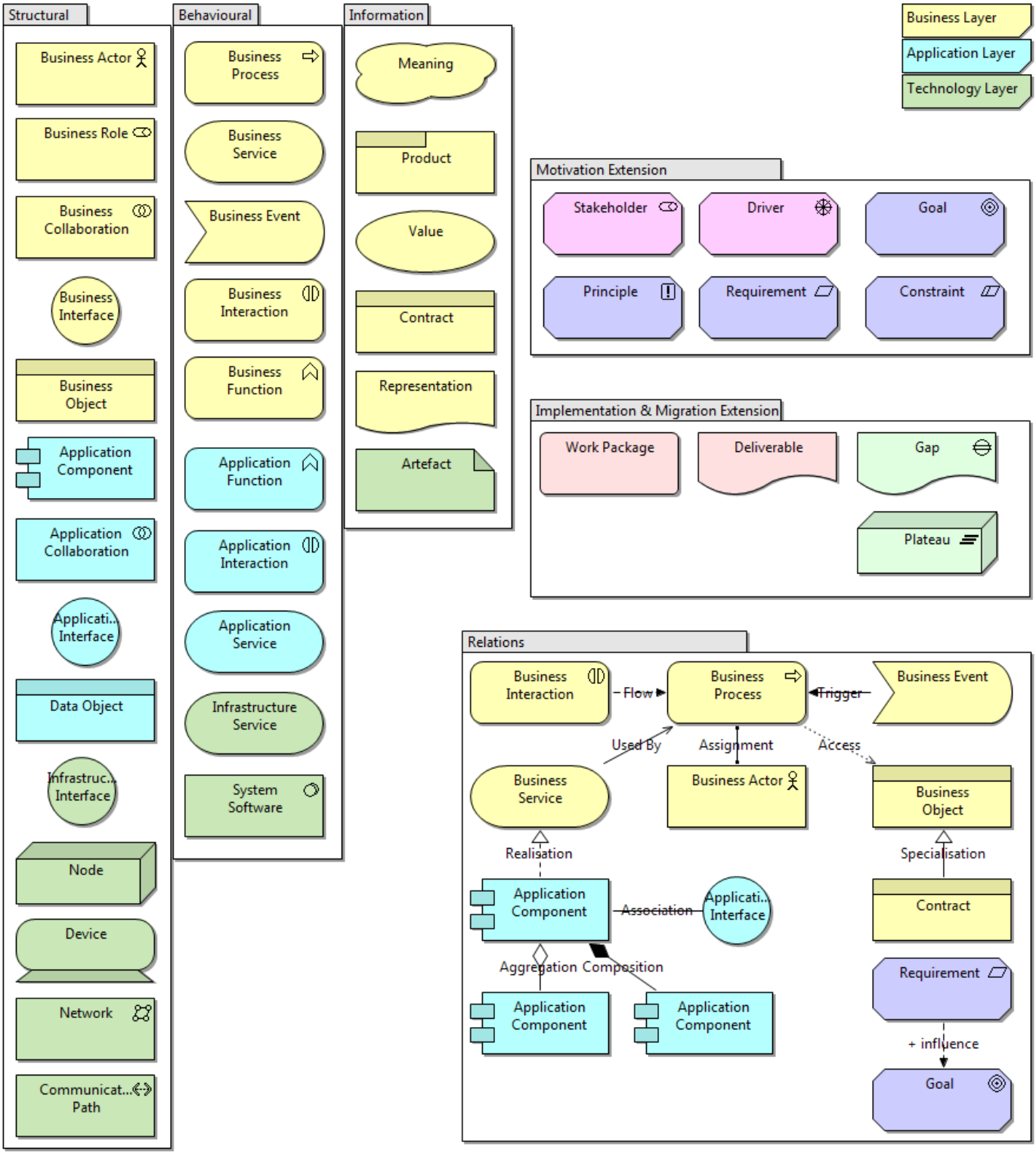


Figure 20 Key to Archimate Diagrammatic Notation