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EMEA 2012

Modélisation pour l'ingénierie d'entreprise

TRT-Fr/KTD-SYS/JLG,12-015

Architecture et Ingénierie de Systèmes sociotechniques avec une vision d'entreprise

Jean-Luc Garnier

24 au 26 octobre 2012, Arcachon

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Message

- La modélisation a déjà fait de grandes avancées dans les entreprises et les projets
- Des normes et standards existent pour couvrir des activités de niveau entreprise… même s'ils ne sont pas toujours bien connus, compris et utilisés
- Mais des sujets majeurs sont encore très peu explorés

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Agenda

- **Thales: An example of Engineering context**
- **Enterprise scope**
- **Architecting with an Enterprise Vision**
  - Methods and Formalisms
  - Status and evolution
- **Model-Based System Engineering**
  - Processes and methods
  - Status and evolution
- **Evolution and challenges (How research can help)**

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An example of engineering context

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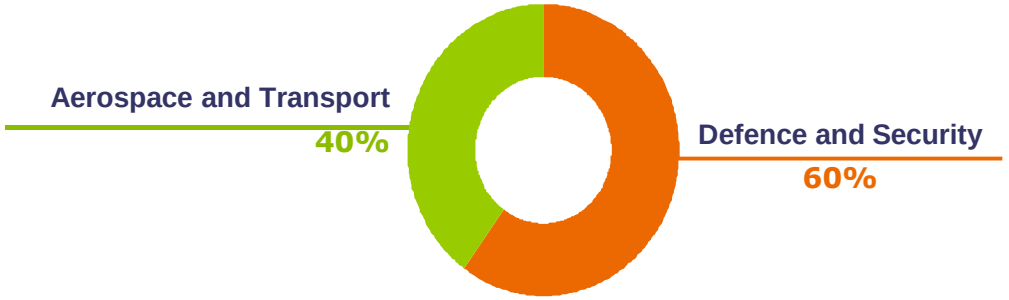
Key figures

2011 revenues	**13.03 billion euros**
Activities	
Employees	**67,000 in 50 countries**
Research and development	**2.5 billion euros** (approx. 20% of revenues) 22,000 people
Research and Technologies	**450 million euros** 3,000 people
System Engineers	**8,000 people**

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Some examples of Thales Products and Systems













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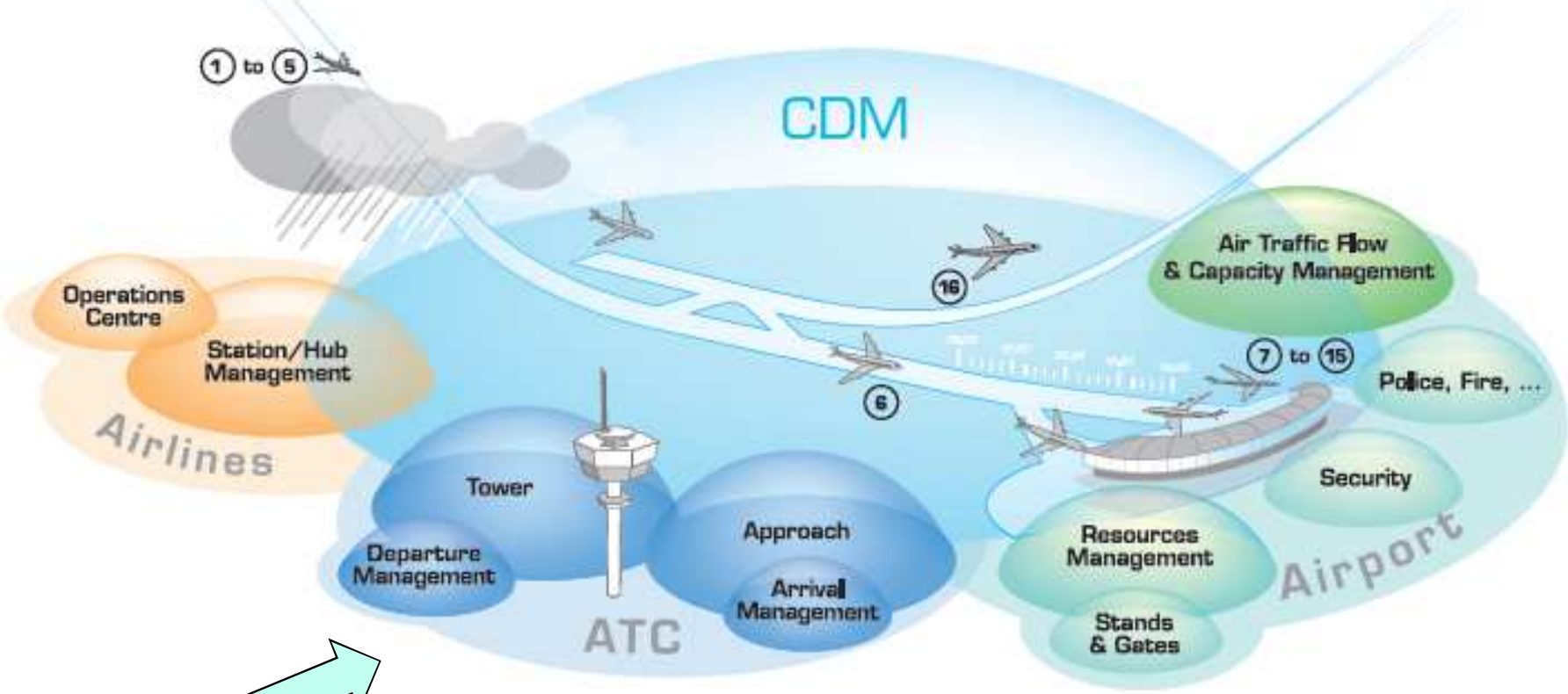
Difficulties: to find common processes, methods and tools…

…to engineer a large range of Products and systems



From pieces of equipment to Systems of Systems
Human-in-the-loop for most of the systems

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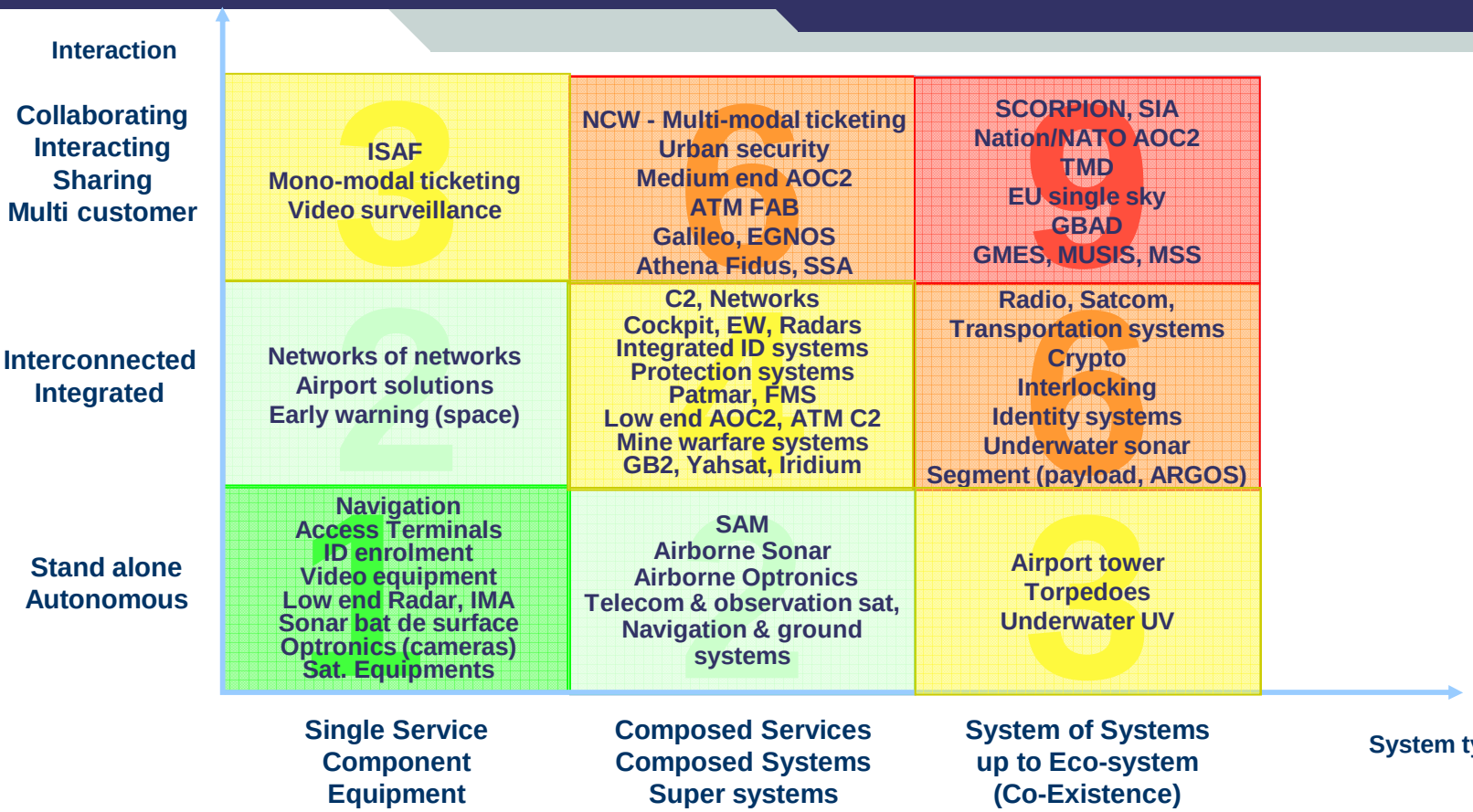
Characterisation of Thales Systems/Products



Technology driven system architecture
May embed electronic equipments where complexity mainly relies on technologies and algorithms
Methods and tools typically based on technical simulation tools and requirements analysis

Functional / non-functional driven architecture
May include complex hardware aspects where complexity mainly relies on high level of interaction between functions, non functional constraints, interfaces
Methods and tools typically based on Arcadia and Melody-Advance

Capability driven system architecture
Complexity comes from complex interactions between operational needs, capability and services, business processes and organisations
Methods and tools typically based on Architecture Frameworks and Business Process Modelling (BPM)

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Scope

ENTREPRISE

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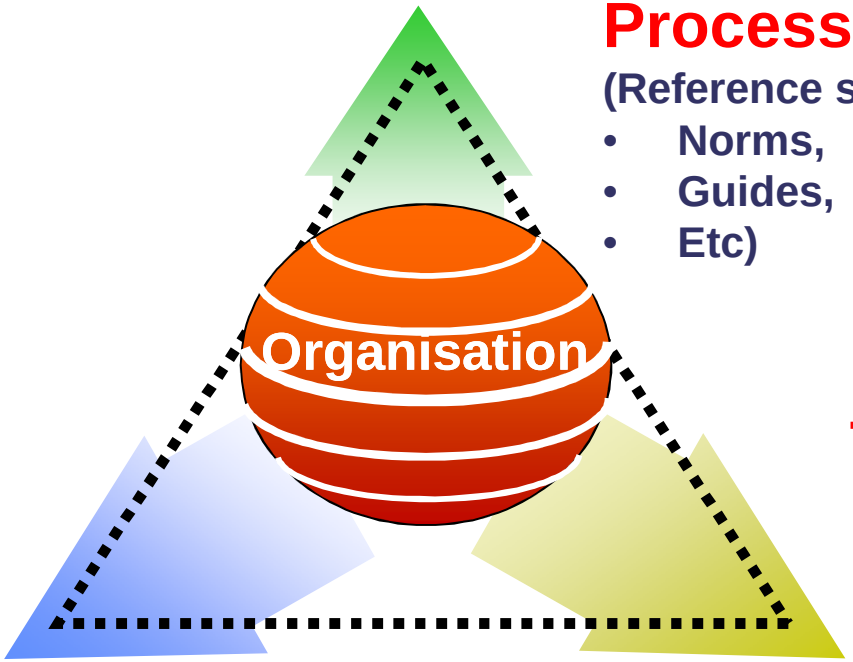
Enterprise

- **Enterprise [TOGAF V9.1]: any collection of organizations that has a common set of goals.**
  For example, an enterprise could be a government agency, a whole corporation, a division of a corporation, a single department, or a chain of geographically distant organizations linked together by common ownership.



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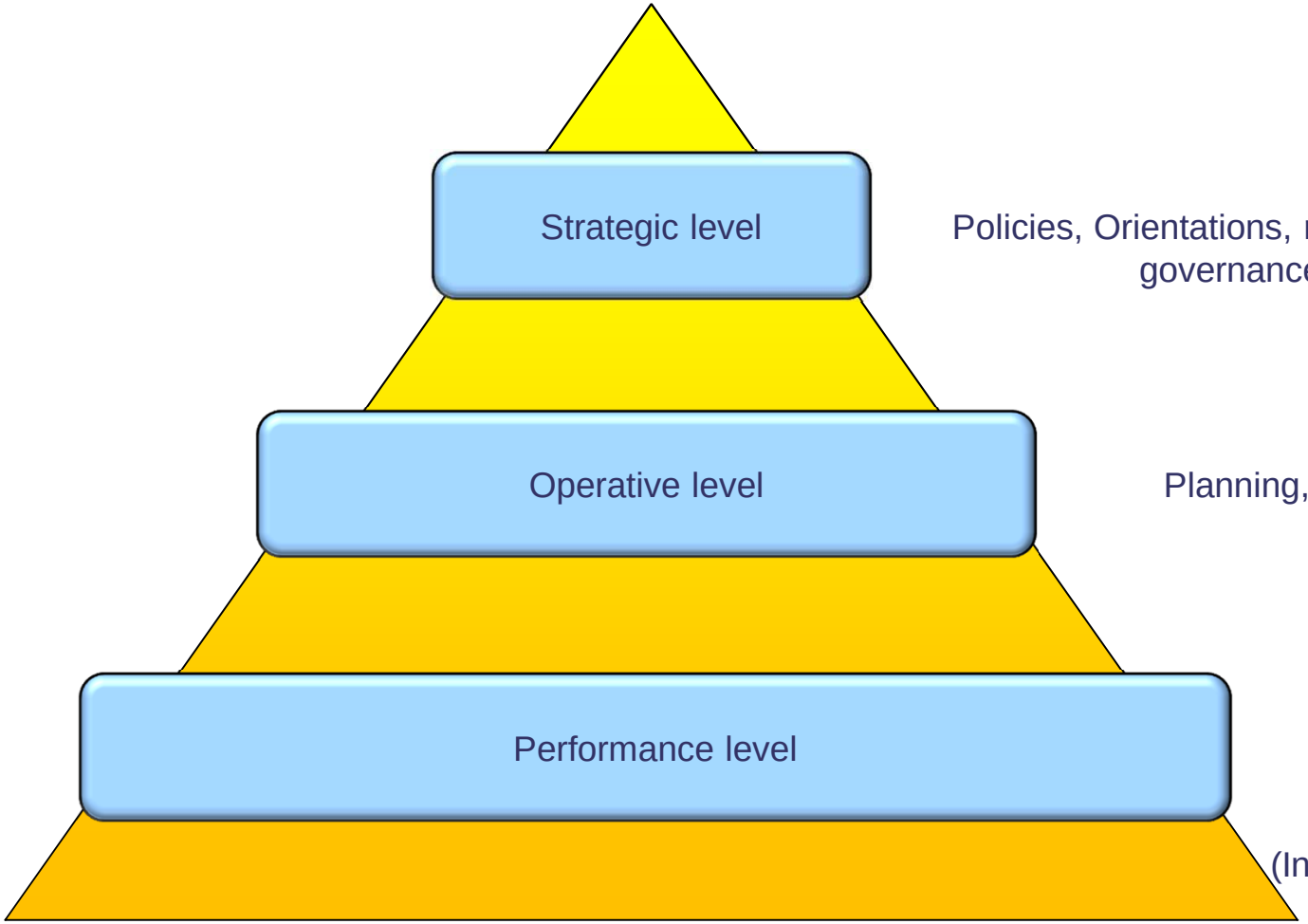
Entrerpise levels



Policies, Orientations, reorientation, governance.

Planning, Management

Sale,
Development,
Manufacturing,
Etc.
(Including support activities)

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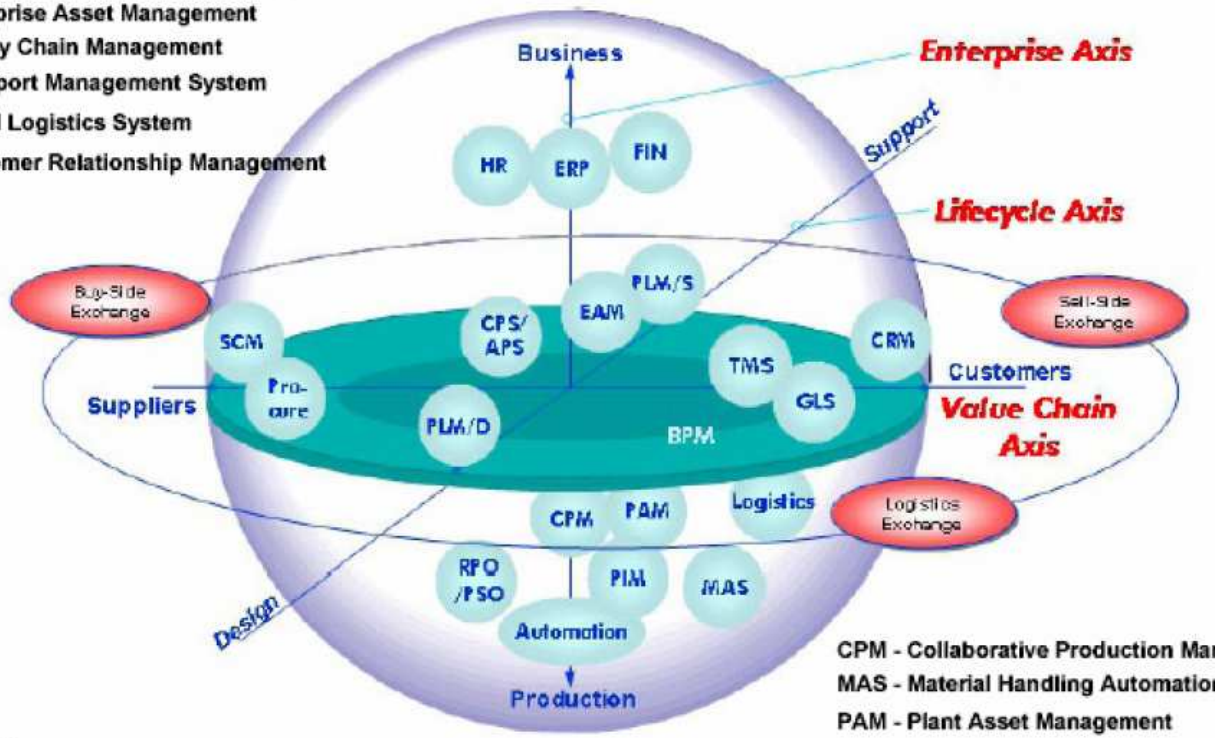
Enterprise concurrent processes

ISO/TC 184/SC 5
Architecture, Communications, Integration Frameworks

ARC Collaborative Manufacturing Management

APS - Advanced Planning & Scheduling
EAM - Enterprise Asset Management
SCM - Supply Chain Management
TMS - Transport Management System
GLS - Global Logistics System
CRM - Customer Relationship Management



CPM - Collaborative Production Management
MAS - Material Handling Automation System
PAM - Plant Asset Management
PLM/D - Product lifecycle Management / Design
PLM/S - Product lifecycle Management / Support
PSO - Process Simulation & Optimization

Source: ARC Advisory Group

E. delaHostria - 020528

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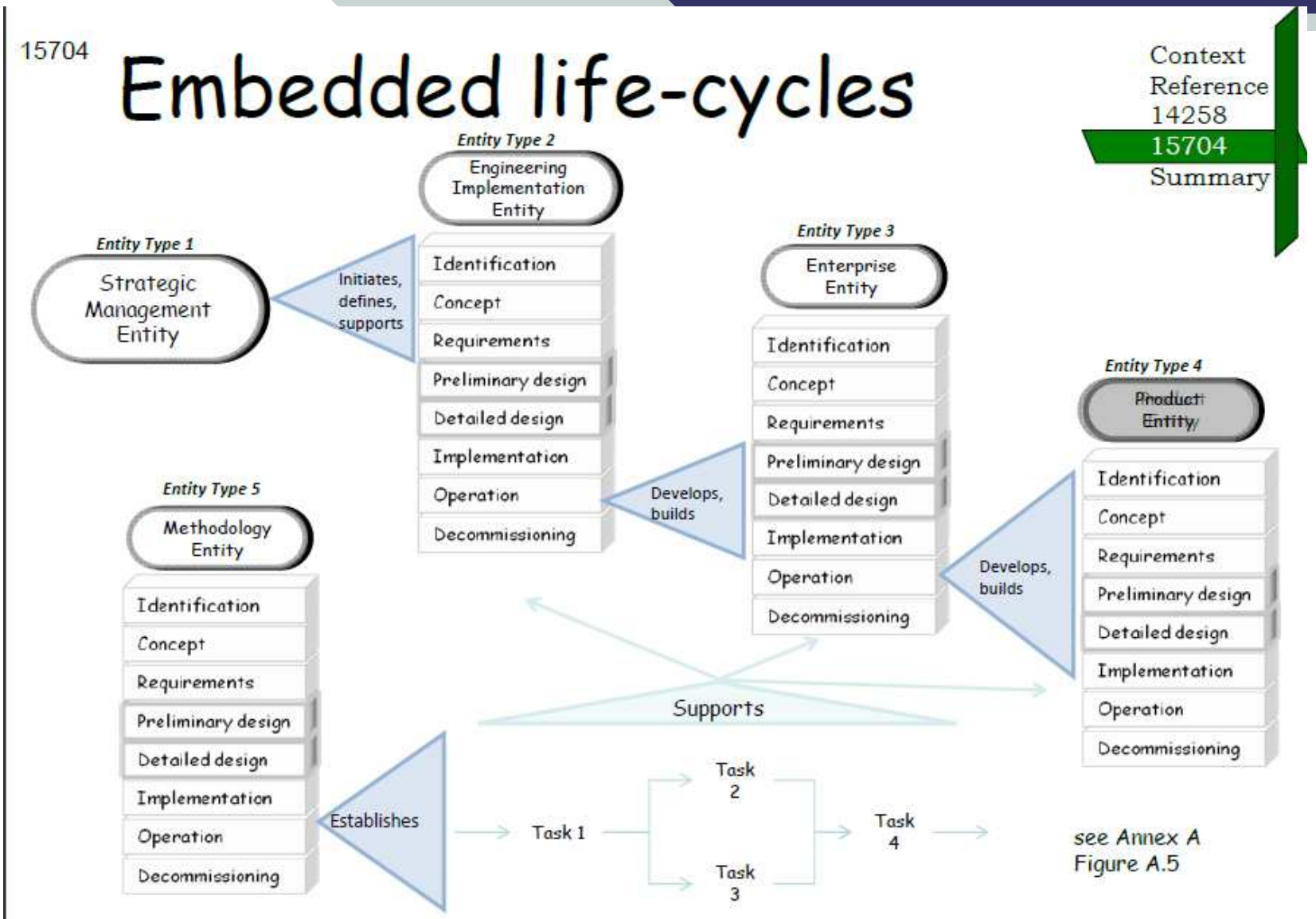
Enterprise interlaced life-cycles (ISO-15704)



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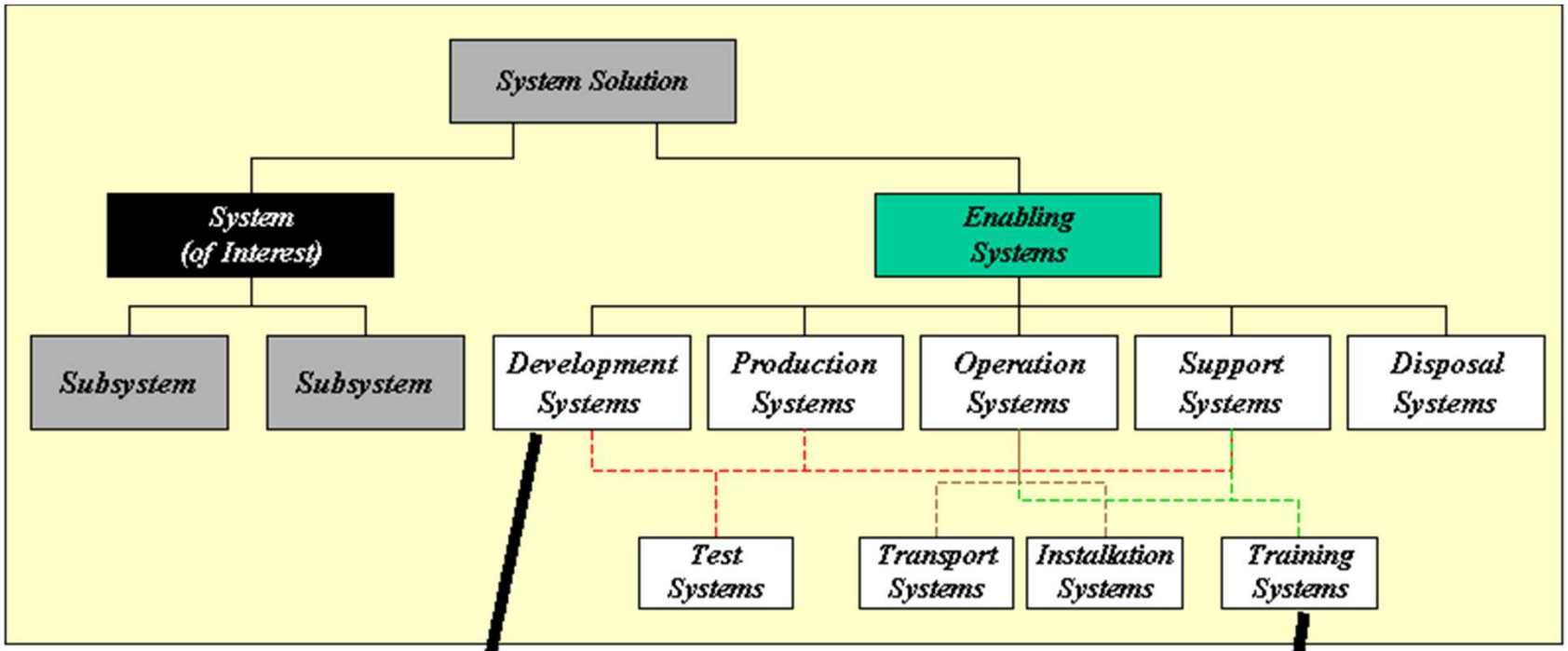
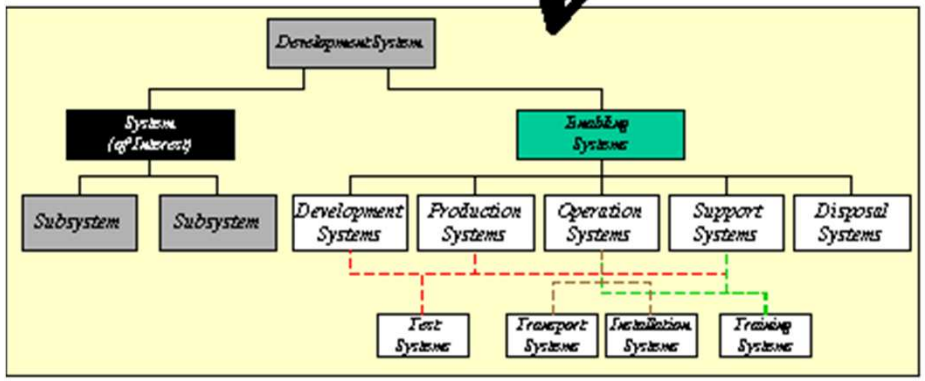
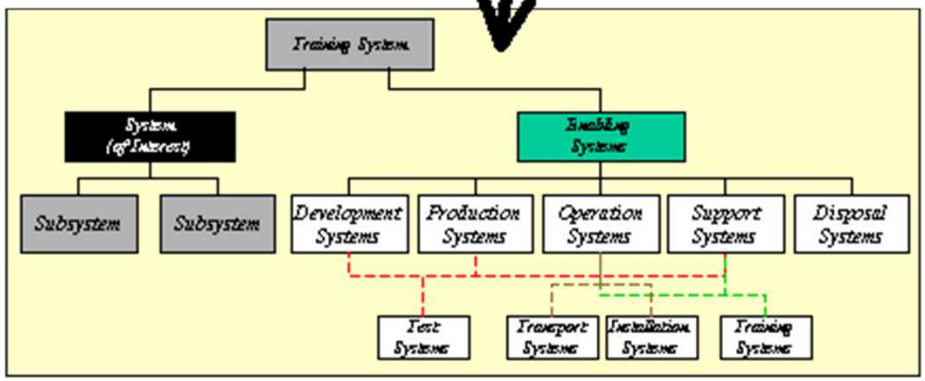
Solution decomposition (Adapted from EIA-632)







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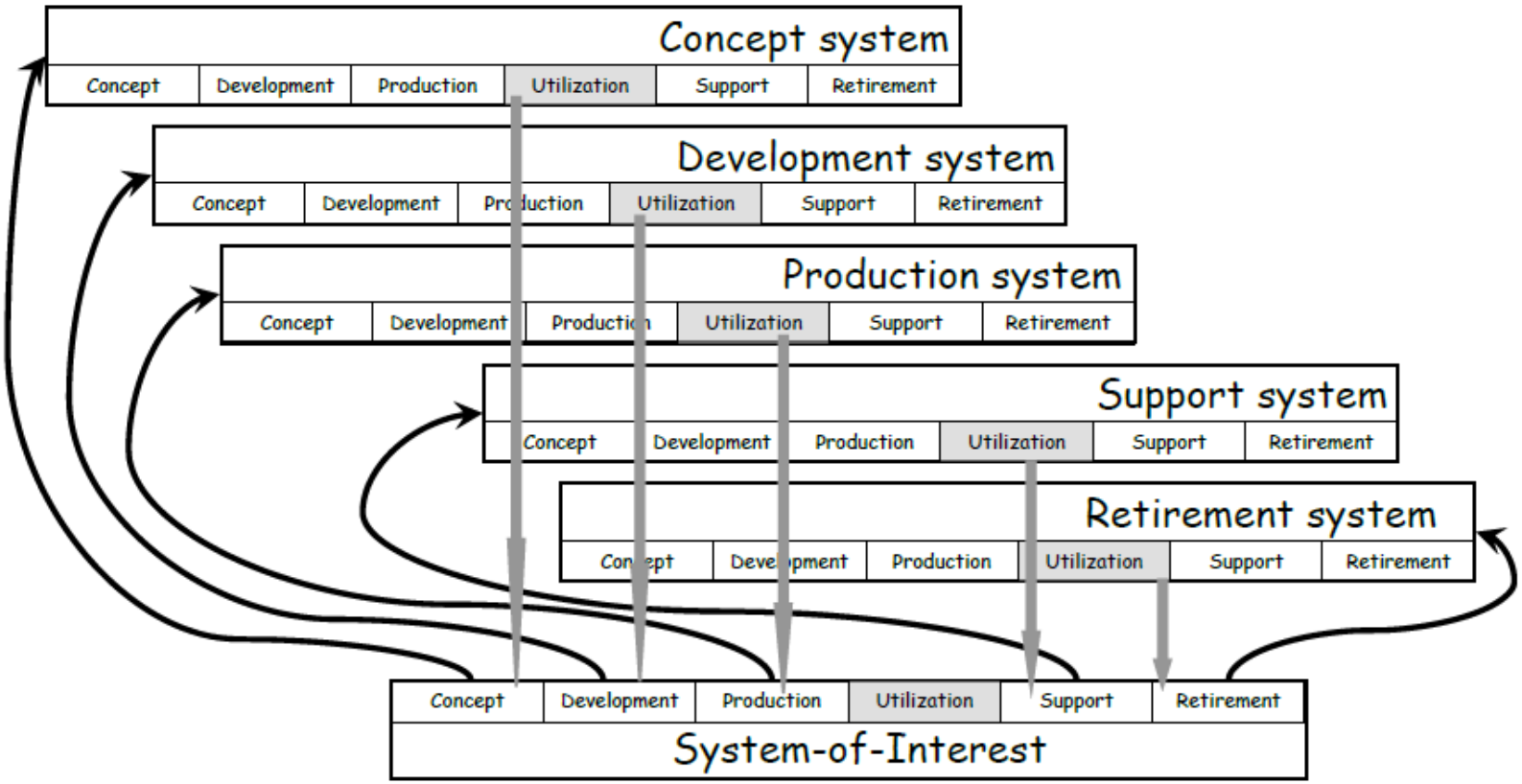
Solution interlaced process (ISO-15288)

Recursive refinement

cf. ISO 15288

Context
Reference
14258
15704
Summary



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Systems-Products dependencies: N-P complex problem

Process Waterfall

Enterprise need resources

Modelling

Engineering

Pilot plant

Build

Certify

Maintenance

Reconfiguration

Adaptation

Shutdown

Product Waterfall

Client need & resources

Conception & model building

Interface description

Engineering

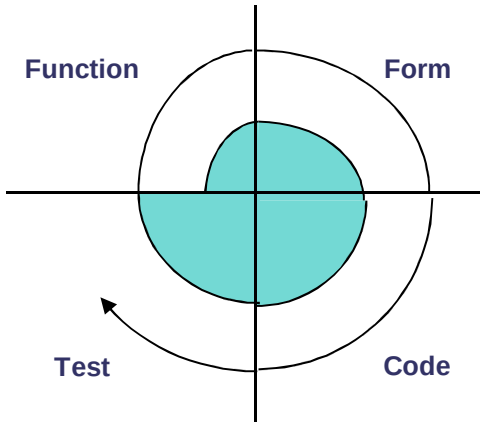
Production

Certification

Operation & diagnosis

Evaluation & Adaptation

Software spiral



Reference: The art of Architecting, M. Maier & E. Rechtin

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ARCHITECTING

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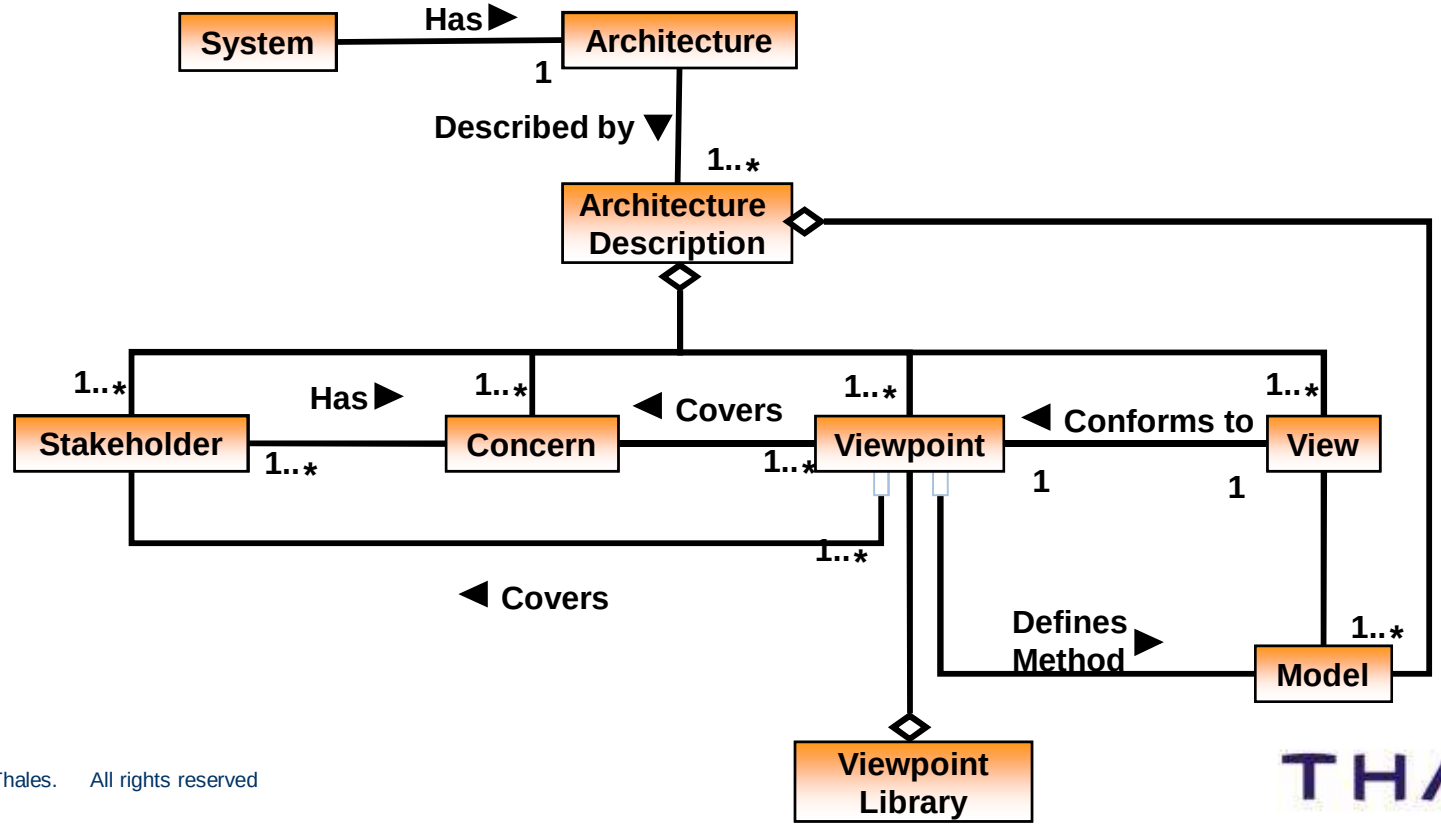
Architecture and Architecting

- (system) Architecture [ISO-42010]: fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution
- (System) Architecting [ISO-42010]: process of conceiving, defining, expressing, documenting, communicating, certifying proper implementation of, maintaining and improving an architecture throughout a system's life cycle



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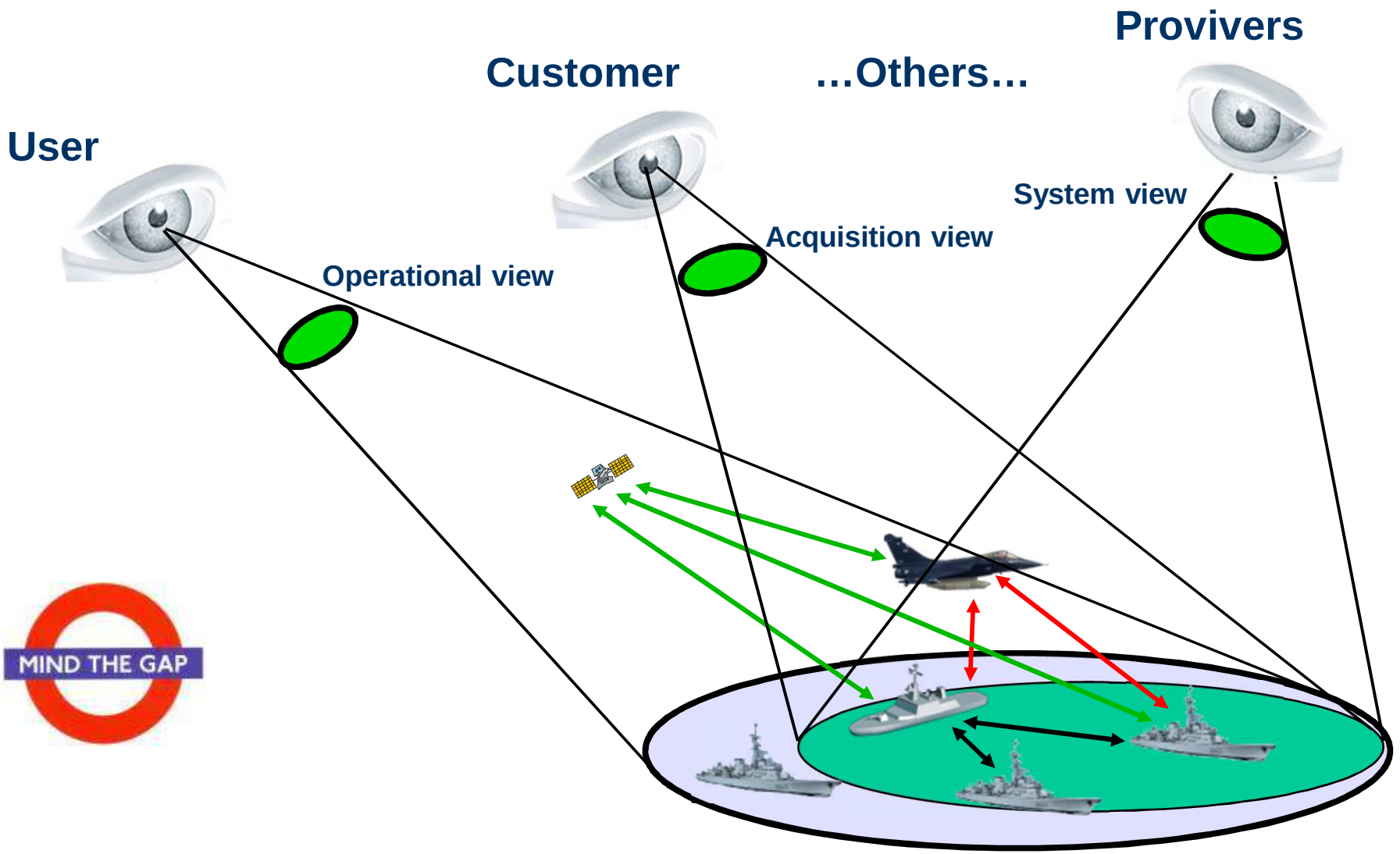
One view per stakeholder



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An Architecture has multiple views

- A view represents the whole system from a particular viewpoint.
- Reduces perceived complexity through separation of concerns
- Architecture views are an end result of doing “architecting”

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Architecture Frameworks

[TOGAF V9.1] An architecture framework is a tool which can be used for developing a broad range of different architectures.

- **It should describe a method for designing an information system in terms of a set of building blocks, and for showing how the building blocks fit together.**
- **It should contain a set of tools and provide a common vocabulary.**
- **It should also include a list of recommended standards and compliant products that can be used to implement the building blocks.**

In reality no A.F. addresses all these points completely

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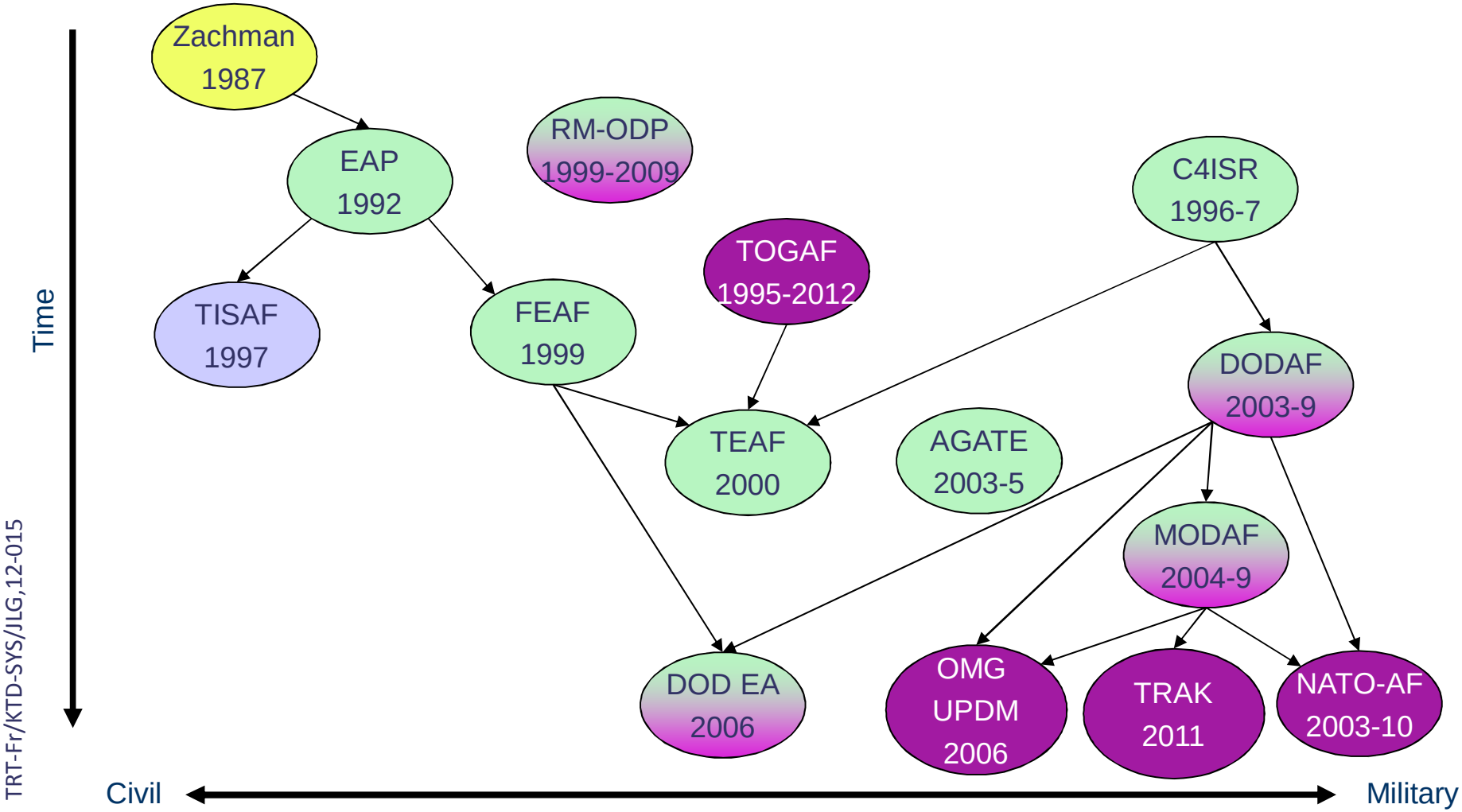
Architecture Frameworks Genealogy



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Architecture reference system: example → TOGAF

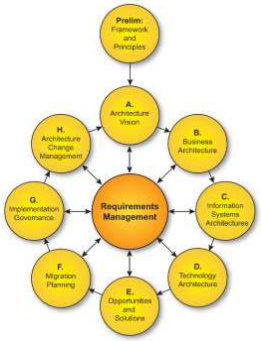
Adaptation from a Arismore's training course

TOGAF Cycle

- ✓ Architecture Definition
- ✓ Requirement management
- ✓ Implementation governance

ADM

- Architecture development method
- Recommendation and techniques

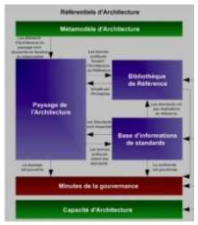


TOGAF Content

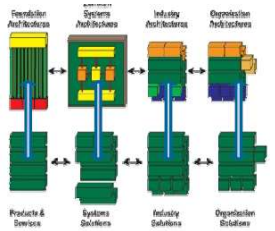
- ✓ Norms and rules
- ✓ System knowledge
- ✓ Normalised components

Content Framework

Architecture Repository

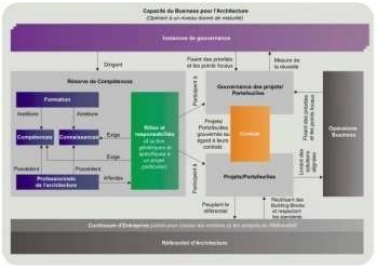


Enterprise continuum



TOGAF Capability

- ✓ Skills & competencies
- ✓ Governance
- ✓ Organisation



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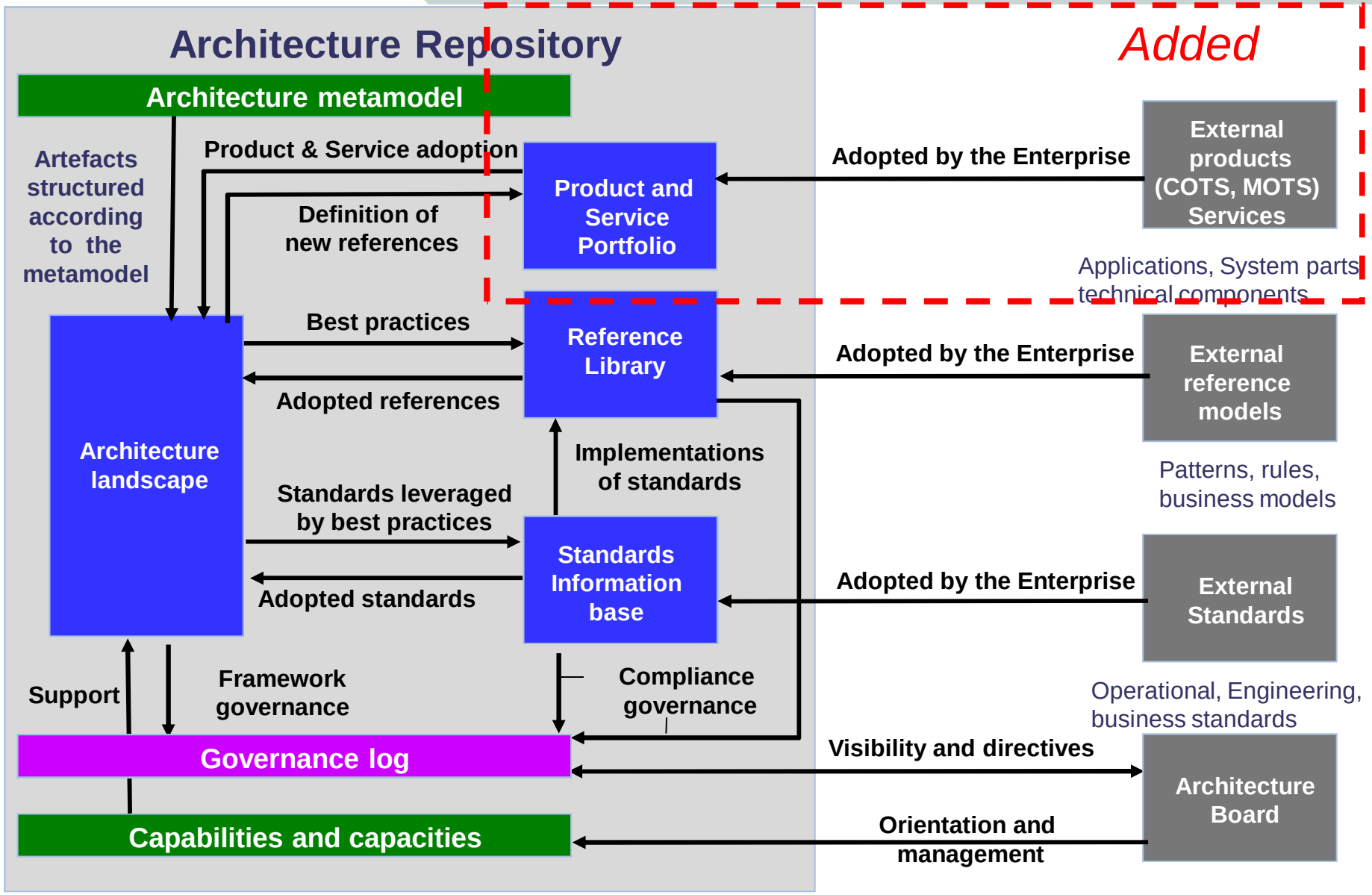
Architecting landscape: Adaptated from TOGAF



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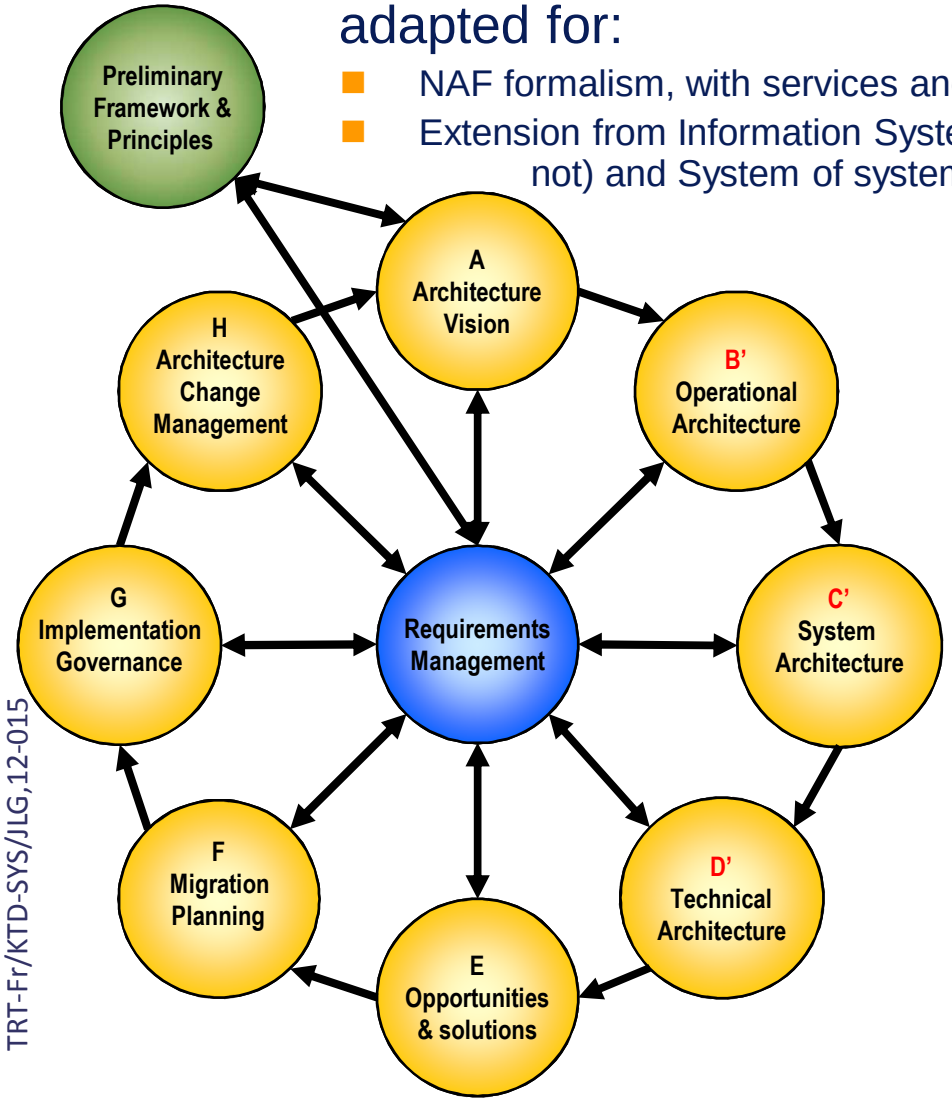
Architecting process based on TOGAF

Choice of the TOGAF Architecture Development Method adapted for:

- NAF formalism, with services and capabilities
- Extension from Information System to complete system (complex or not) and System of systems



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- Preliminary works: for the stakeholders and the enterprise
- A: strategy and business roadmap
- B': Operations and usage
- C': how system works?
- D': how it is made?
- E: Trade-offs
- F: Evolution roadmap
- G: Link with SE
- H: Evolution

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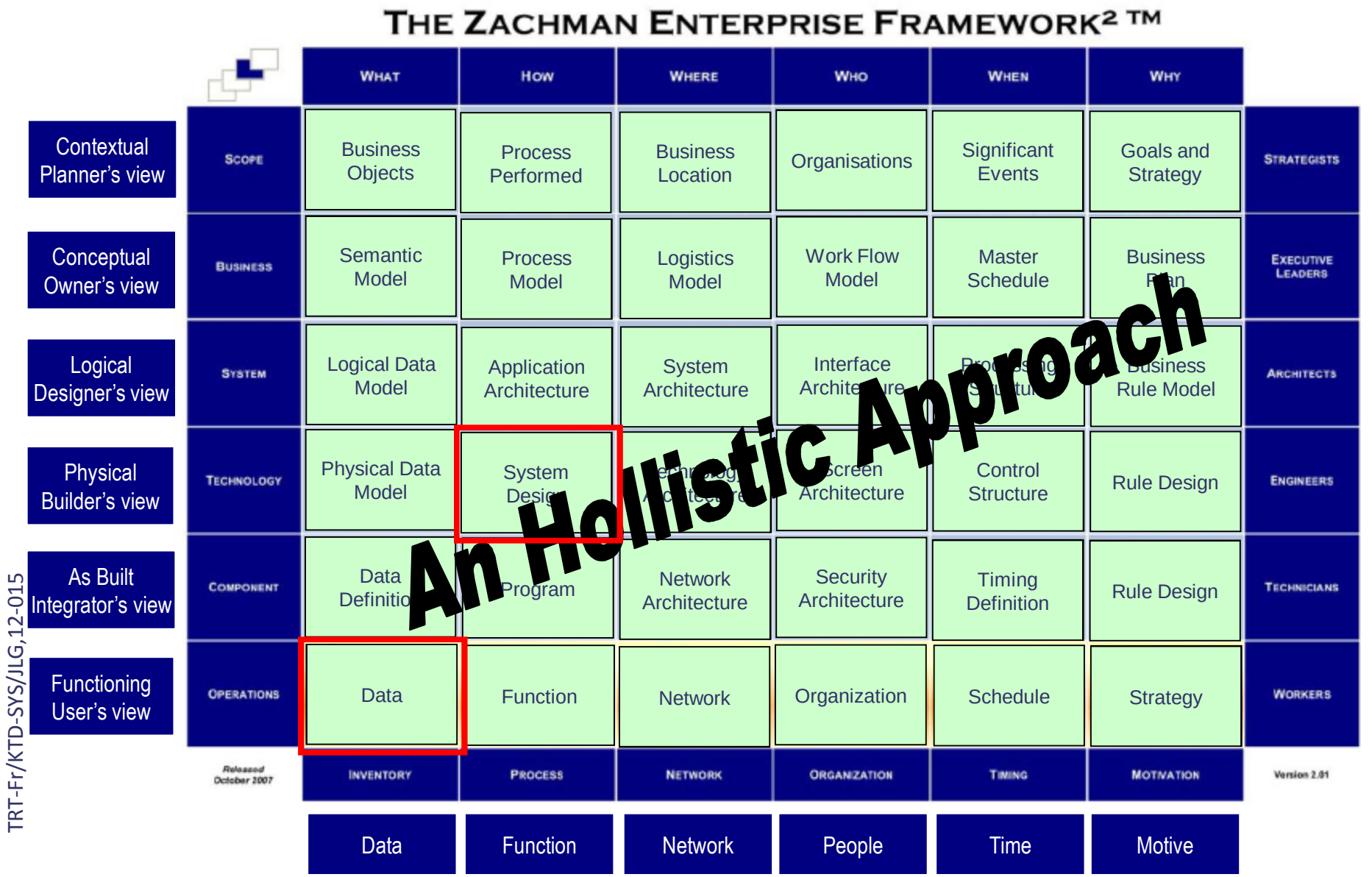
Architecting Formalism: Zachman



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Architecting Formalim: NATO Architecture Framework

Documents the strategic picture of how military capability is evolving in order to support capability management and equipment planning

NATO CAPABILITY VIEW

Provides summary information for the architecture that enables it to be indexed searched and queried

NATO ALL VIEW

Documents Human Concepts, Constraints, Functions, Roles, Human Networks, Training, and Metrics

HUMAN FACTORS

Documents the operational processes, relationships and context to support operational analyses and requirements development

NATO OPERATIONAL VIEW

Documents programme dependencies, timelines and status to inform programme management and procurement synchronization

NATO PROGRAM VIEW

NATO SYSTEM VIEW

NATO TECHNICAL VIEW

NATO SERVICES VIEW

Documents system functionality and interconnectivity to support system analysis and through life management

Documents policy, standards, guidance and constraints to specify and assure quality expectations

Documents Services functionality, constraints and interoperability

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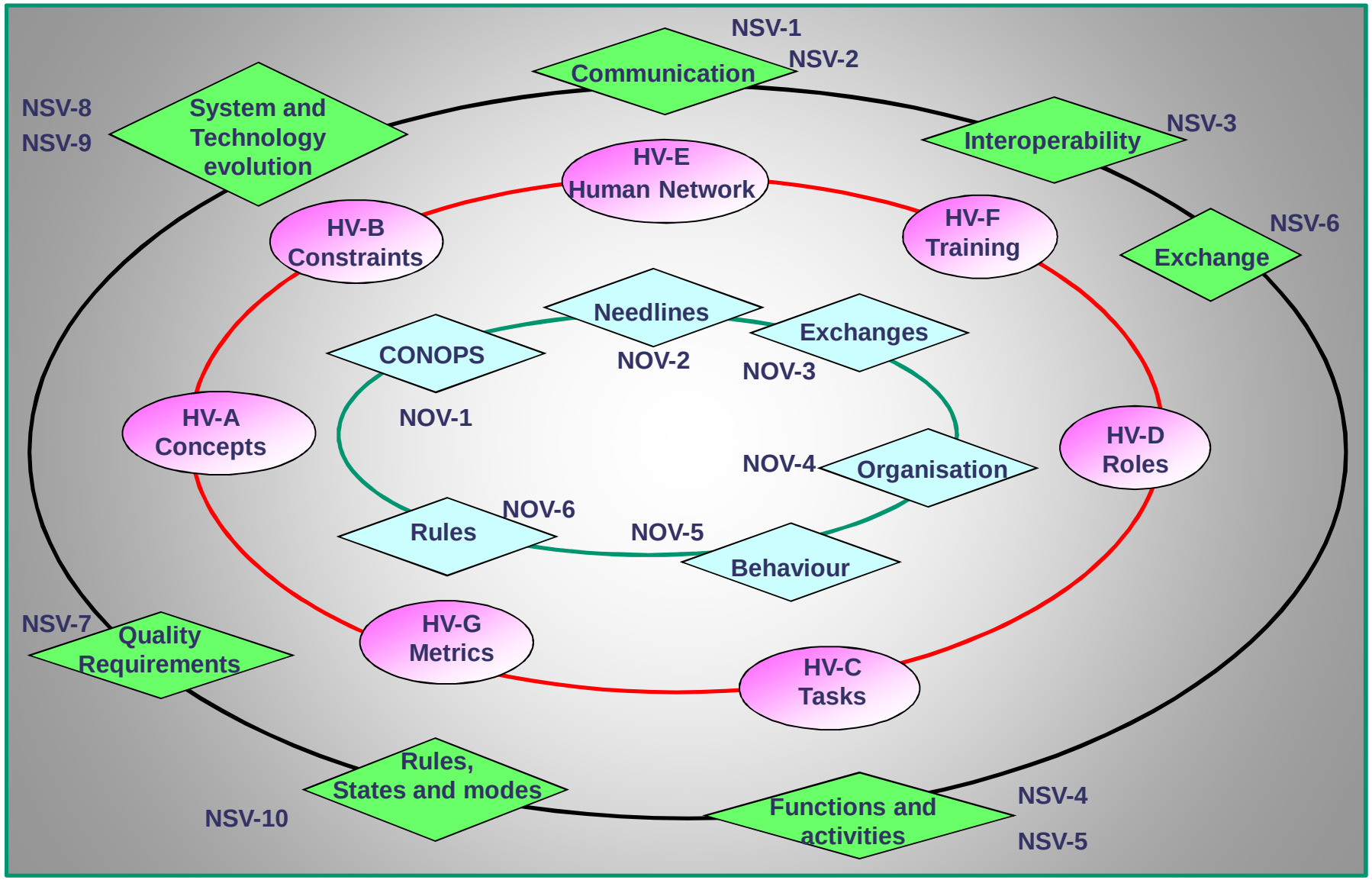
Human views: Adaptation from UK-MOD and NATO H.F. works



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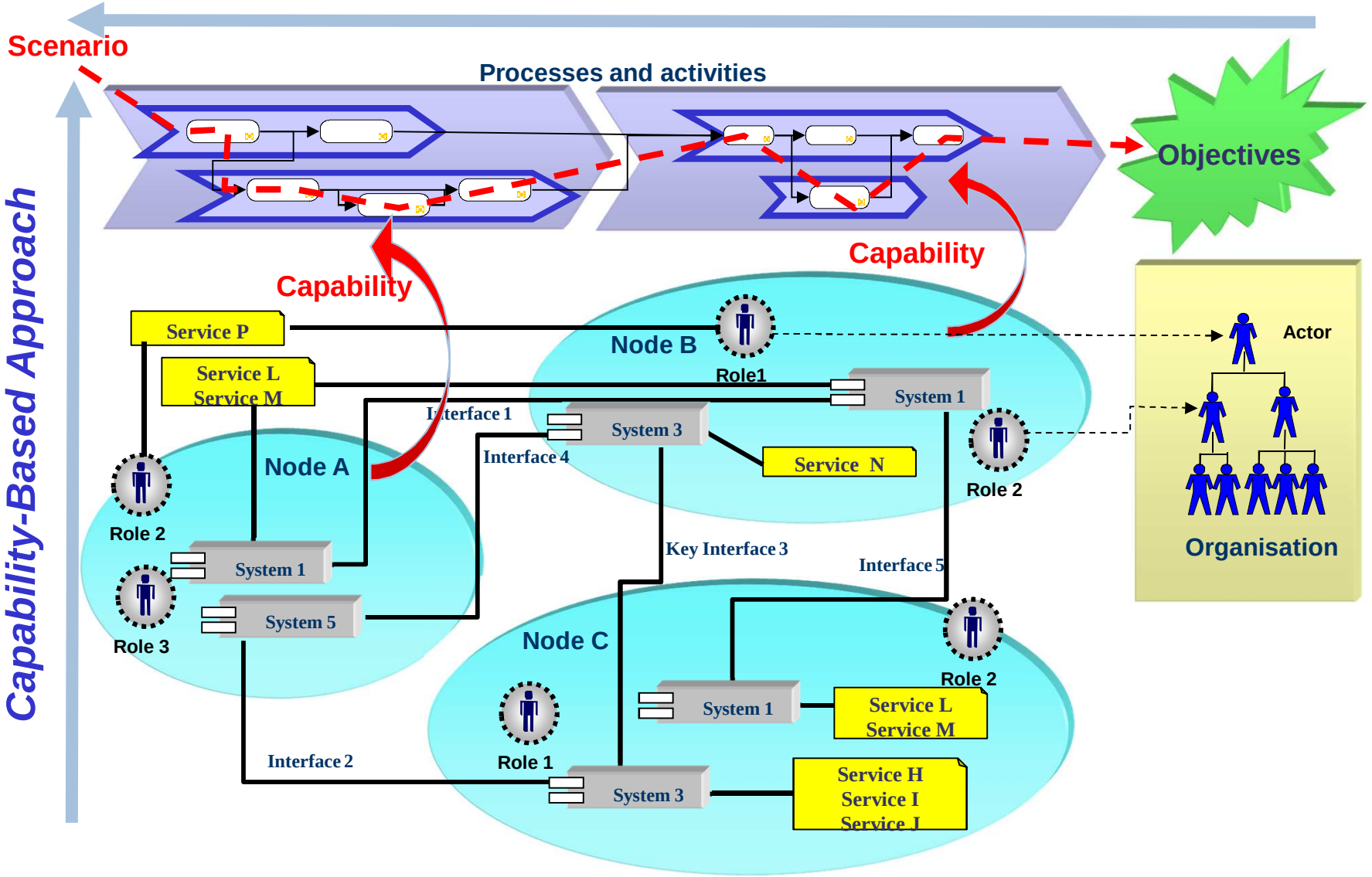
Overall Human-based Operational description

Objective/mission-driven Approach



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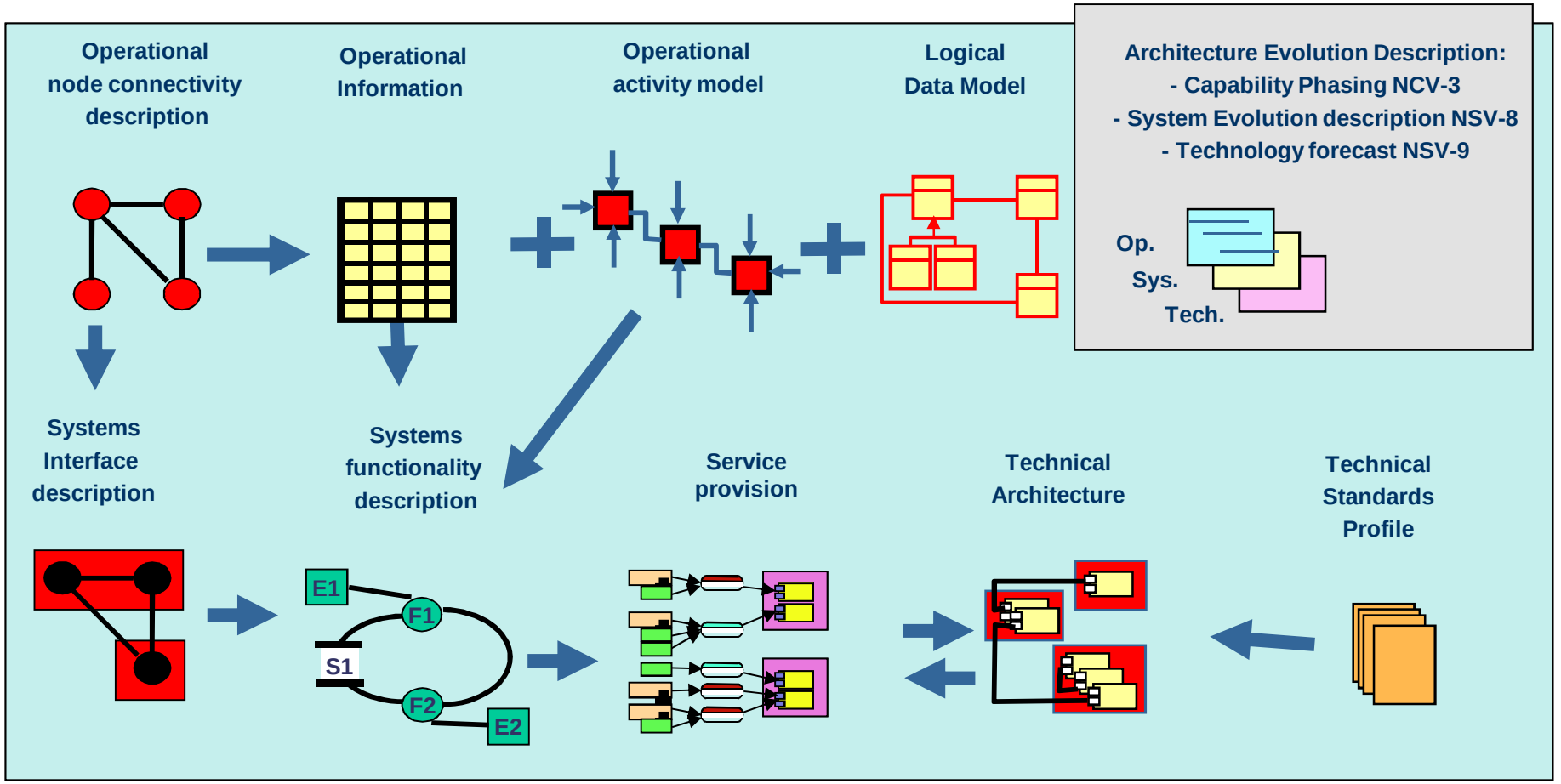
Example of view selection & architecting



Note: the selected NAF views can be translated into other AF views: DoDAF, MODAF, DNDAF, DAF, etc.

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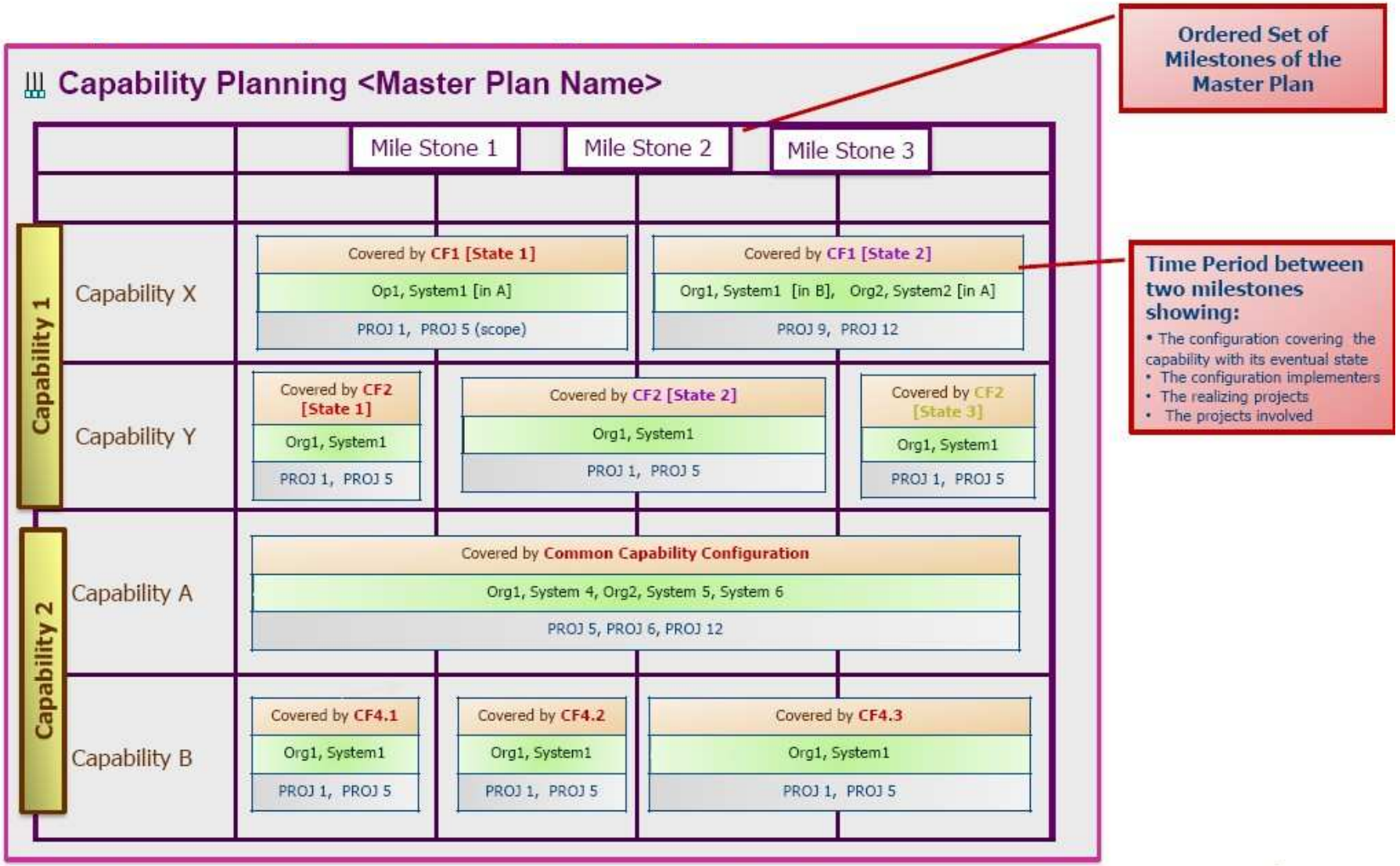
Projects and Capability phasing



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Architecture Framework status

- Currently the A.F. are mainly addressing the Acquirers concerns
- The focus is on the Information System. The AFs need to be extended to address all kind of Products, Systems and Enterprises
- Architecture Evaluation is not significantly addressed
- Terms and Concepts have to be improved
- Tools suffer many problems
  - Interoperability
  - Ergonomics
  - A.F. compliance
  - Standard Language compliance
  - Etc

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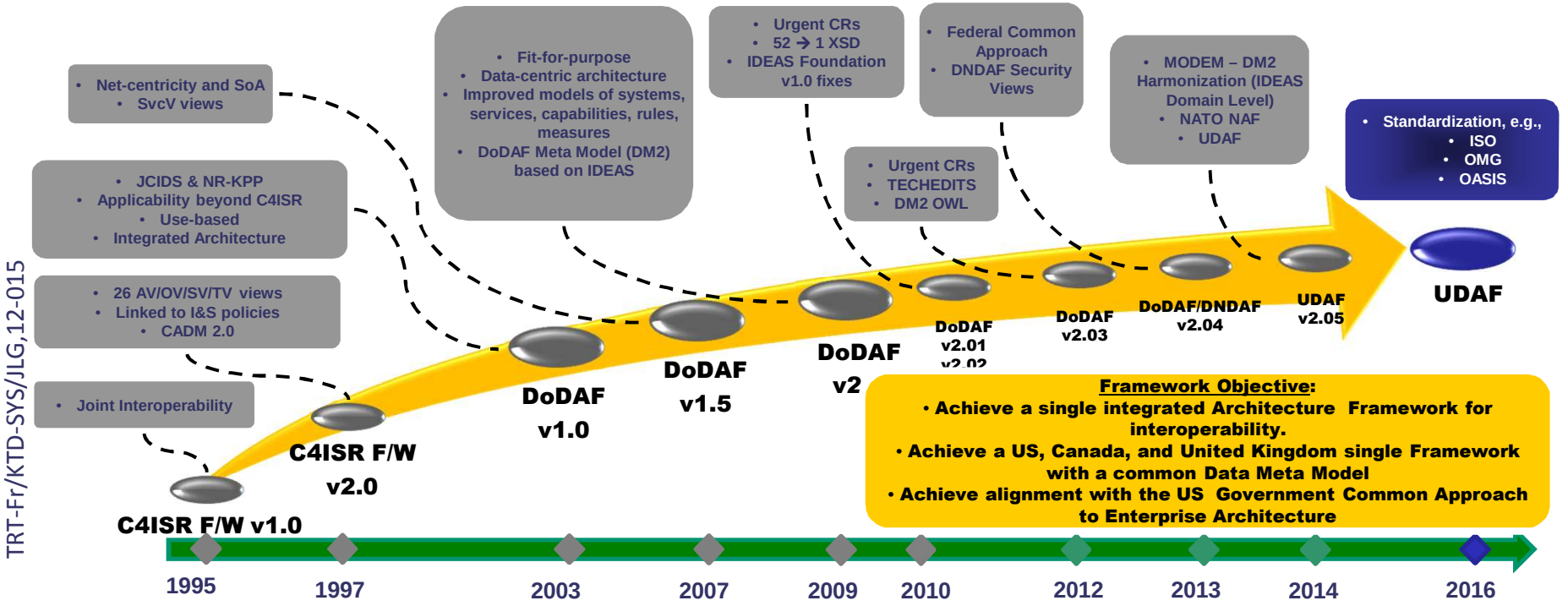
Architecture Framework Evolution

- **IDEAS initiative: New foundation for Interoperability**
- **MODEM: Ontology-based meta-modelling to sustain A.F.**
- **Sept'2012: During the "NATO Architecture CaT" conference, the main MOD announced a convergence of the A.F. towards a "Unified Architecture Framework" (UDAF).**



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Architecture refinement during Model-Based System Engineering

ARCHITECTURE REFINEMENT

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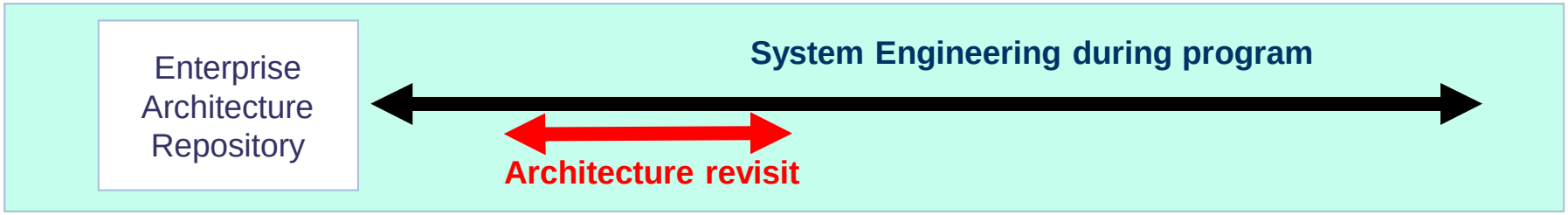
Architecting and Engineering

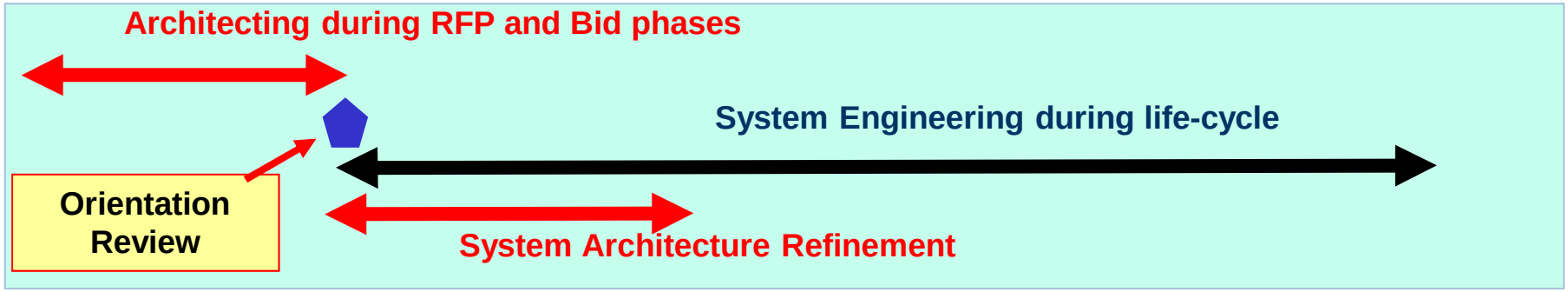
Programs can be “clones” of performed programs

- High reuse and stable architecture
- Architecture is sometimes limited



In other cases, real architecting is mandatory

- Establish the Public and Private architecting results to secure the feasibility and make the stakeholders decision to implement



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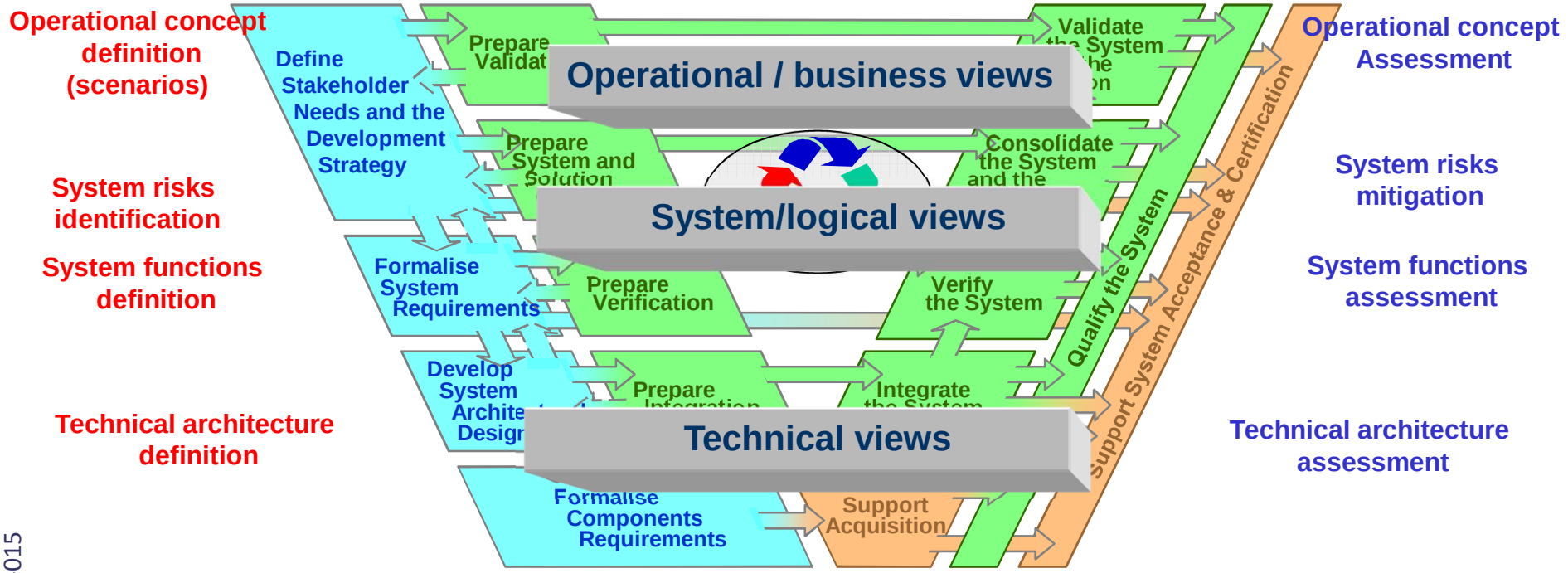
Architecting results are interleaved with S.E.



SYS-EM

Thales System-Engineering Method

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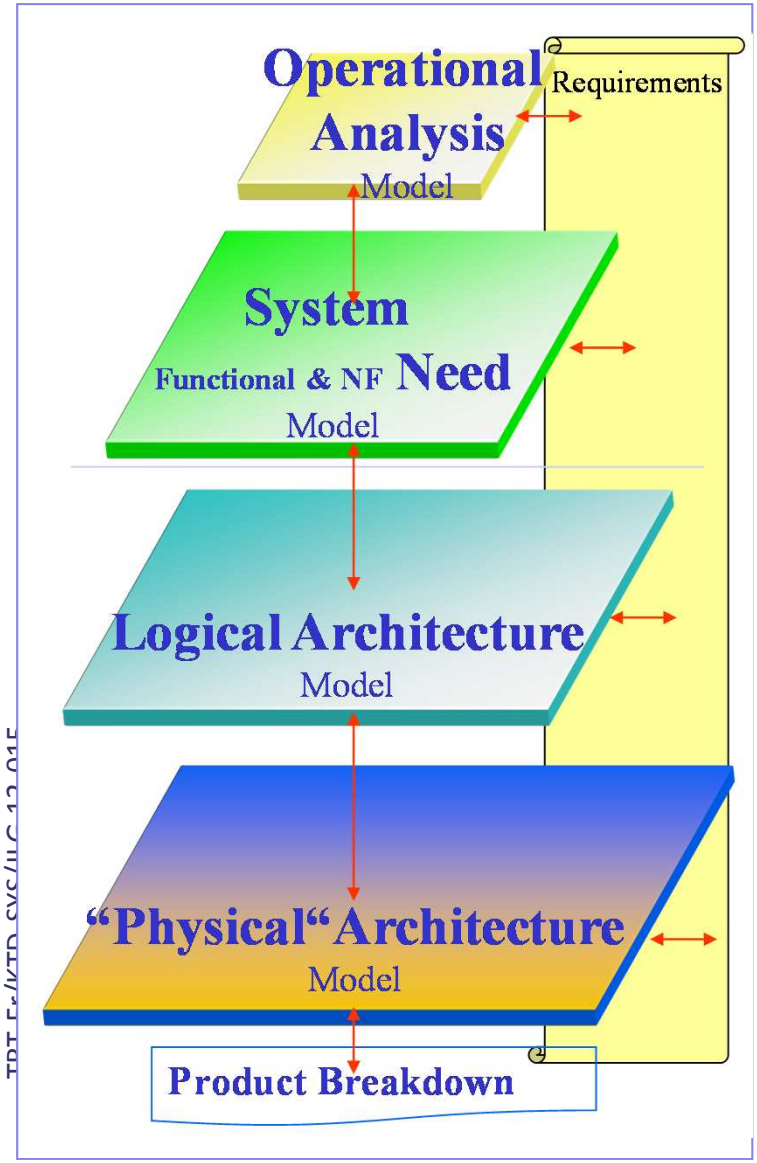
Thales MBSE Method : ARCADIA



User Need

What **the users** of the system need to accomplish

System Need

What the system has to accomplish for the Users

Engineering documents: SSS, IRS, OCD, …

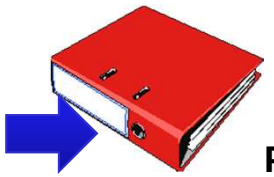
Notional Solution

How the system will work so as to fulfil expectations

Final Solution

How the system will be developed & built

Sub-contractors input



Engineering documents: SSDD, ICD, PIDS, SRS, …

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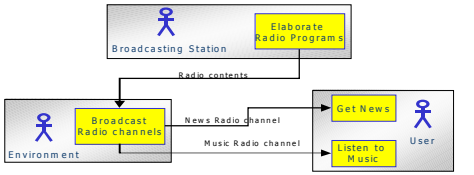
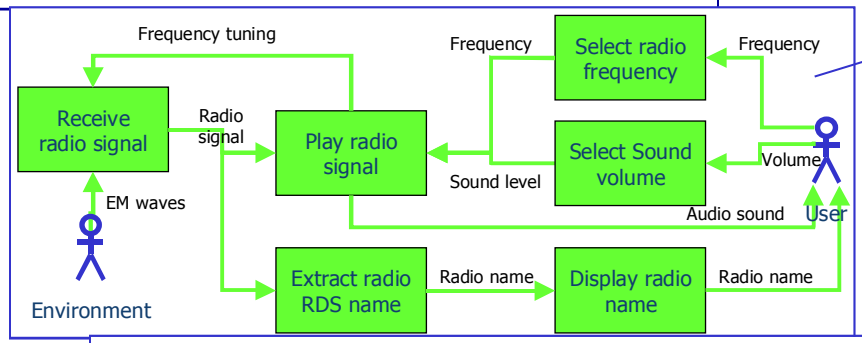
Radio set simplistic example

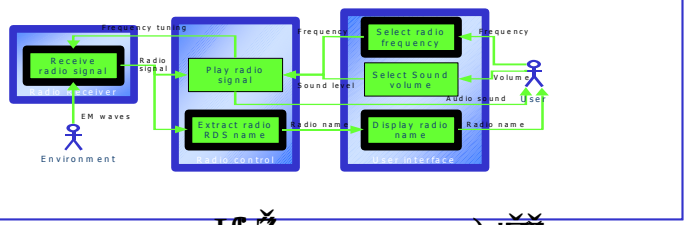
1° What **the users** of the system need to accomplish



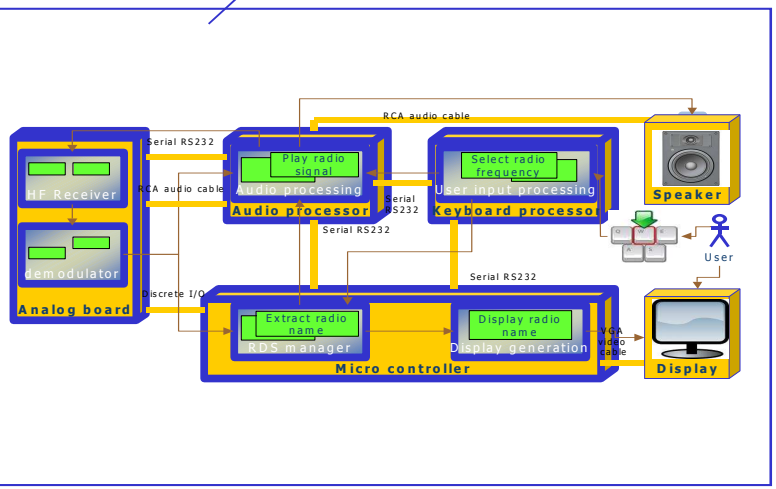
2° What the system has to accomplish for the Users



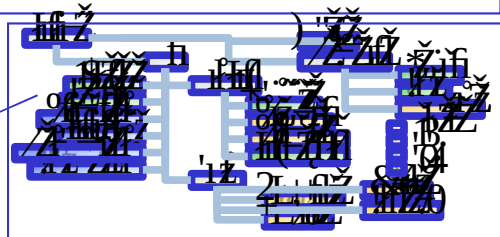
3° How the system will work so as to fulfil expectations



4° How the system will be developed & built



5° What is expected from each designer / sub-contractor



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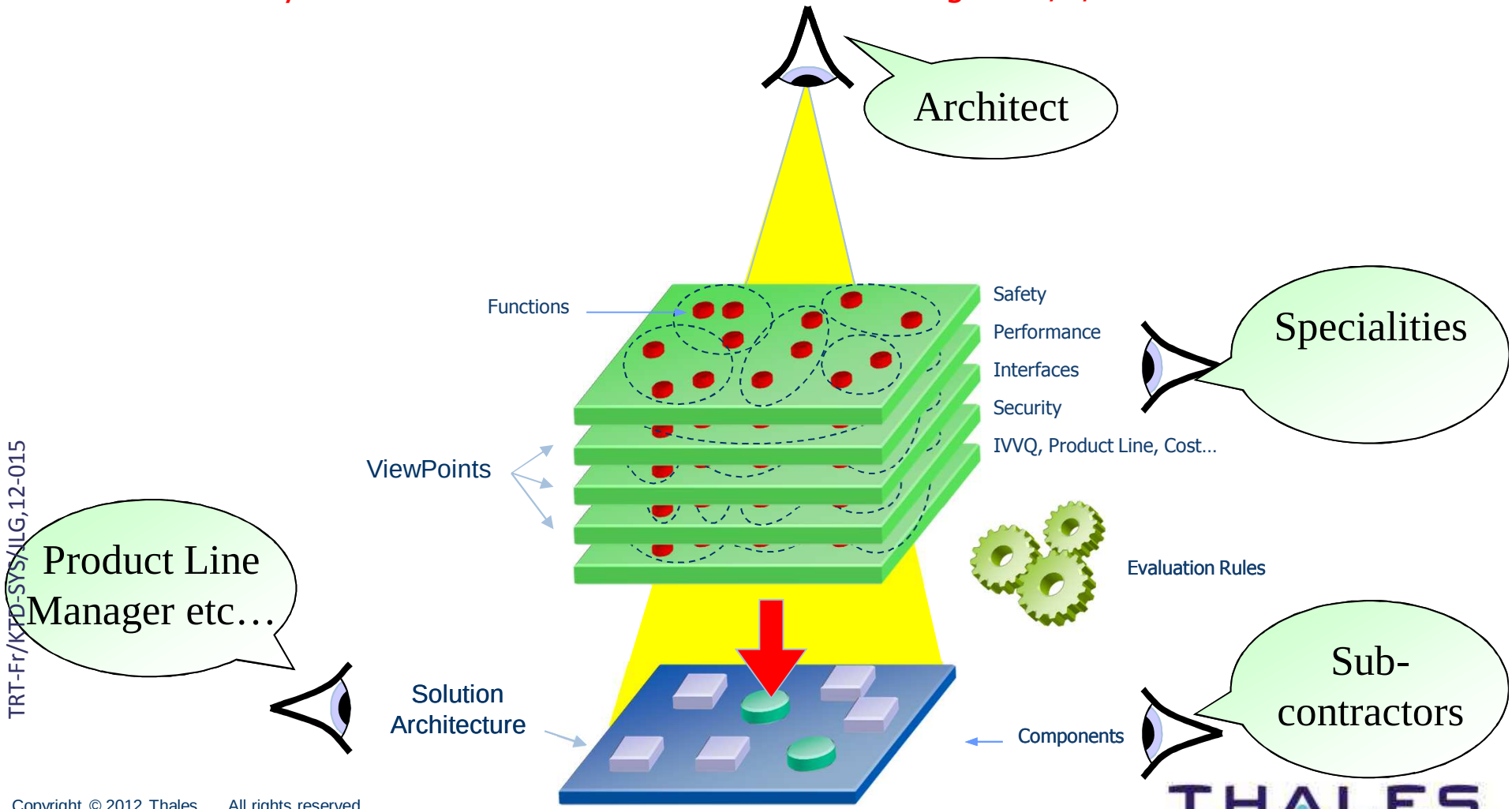
Early Validation: Specialities Know-how confronted to Architecture

Multi-viewpoint trade-off Analysis (see ISO 42010 standard)

- Safety, RAMT
- Security
- Performance
- Interfaces
- Product line
- Integration/V/V
- weight
- Cost…



TRT-Fr/KTD-SYS/ILG,12-015

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Status and Evolution of Model-Based System Engineering

- Model-Based System Engineering is not really addressed by norms and standards.
  Except OMG MDA/MDE partial approach for software part.
- Industry is currently using MBSE for functional/software intensive system.
- Non-Functional properties (Safety, Security, Human Factors, Performance) are not significantly addressed
- Physical representation is done separately
- Model evaluation is poorly addressed

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Evolution and Challenges: How Research can help

CONCLUSION

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Evolution and Challenges

Modelling techniques

- Multi-model Coherency addressing Multi-scale, multi-physic and multi-viewpoint representation
- Modelling of the non-functional properties (Safety, Security, Human Factors, Performance)
- Model evaluation addressing this multi-* scope and non-functional properties

Modelling with an Enterprise Scope

- [Model-Based] coherency of the life-cycles covering Enterprise Systems and Products via a multi-project organisation
- Maturity level for Model-Based System Engineering
- Knowledge management based on an Enterprise Model-Oriented approach with the multi-* scope

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jean-luc.garnier@thalesgroup.com

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Architecture Frameworks Overview

Links to A.F. documentations

- **Zachman: http://www.zifa.com/framework.html**
- **NAF: http://www.nhqc3s.nato.int/ARCHITECTURE**
- **DODAF: https://dars1.army.mil**
- **MODAF: http://www.modaf.com**
- **AGATE: http://www.ixarm.com/Referentiel-AGATE**
- **FEAF: http://www.feapmo.gov**
- **TOGAF: http://www.opengroup.org/architecture/togaf**
- **RM-ODP: http://www.rm-odp.net/**
- **UPDM: http://www.omg.org/spec/UPDM/1.0/PDF**

- **HFIDTC: http://www.hfidtc.com**
- **IDEAS/MODEM: http://www.borosolutions.co.uk/research/content/files/SwAF-MODEM-Behaviour%20Analysis%20Report%20-%20March%202011.pdf/at_download/file**

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