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Requirements-driven Project Management - dreams and realities

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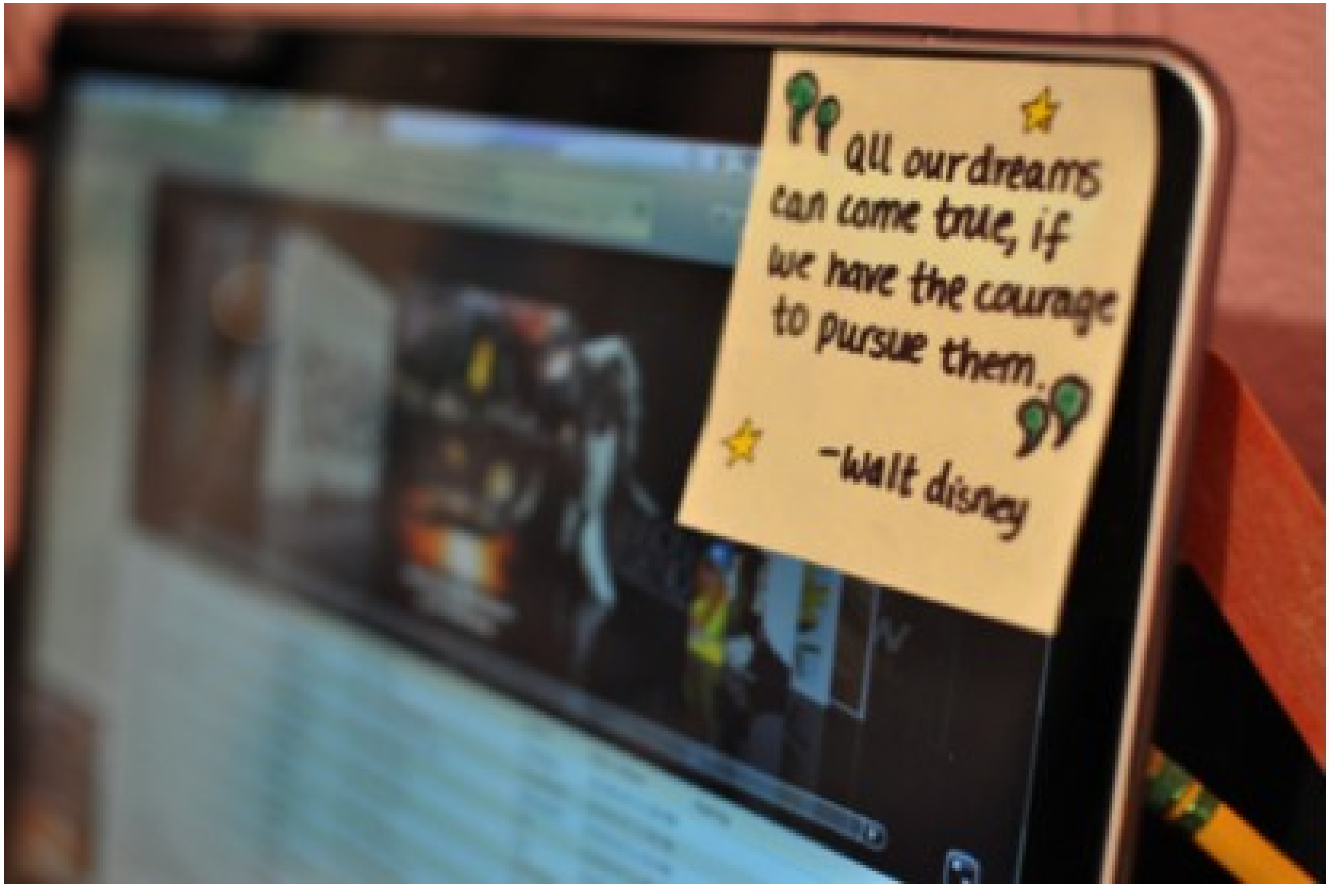
Dreams and Realities



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Topics to be Covered

- Common problems
- Requirements management
- Requirements-driven Design
- Project Support processes
- Benefits of Process Integration
- Managing Commercial and Legal Requirements
- Operation, Maintenance and System Disposal
- Benefits of Requirements-driven Design
- Example of graphical navigation
- Conformance to International Standards
- Multiple Life Cycles
- Profiling Requirements to Industry Sectors
  - Nuclear Safety Case Example
  - Pharmaceutical drug Development Example
- Multiple Contractors
- Information Requirements for Key Decision Makers
- Decision Process Integration and Information Flow
- Challenges

Common Problems

- Stakeholder & Programme/System Requirements inadequate
- Contractor(s) have previous experience and ‘know’ what is needed
- Even if more detailed requirements produced, not linked to Stakeholders’ Requirements
- Designs not linked formally to Stakeholders’ Requirements or System Requirements

Common Problems

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Legal advice => only award contracts against well specified sets of requirements

- Still no linkage between Stakeholders' Requirements and System requirements
- No auditable traceability from Stakeholders' Requirements to System Requirements & Design
- Can't prove design meets Stakeholders' & System Requirements
- When Client's specialists study completed designs, some aspects may fail to meet System and/or Stakeholder Reqs

Three Questions

Three Fundamental Questions must be Addressed for any Development:

- What do you want?
  - What => Requirement
- How will you do it?
  - How => Design
- Can you prove you have done what you said you would do
  - Proof => Verification

Strategy

The strategy must:

- address the three questions
- Provide a means of specifying and capturing the Requirements
- Allow for the specification of the Design(s), whilst accommodating various design approaches
- Provide verification mechanisms so that it can be shown you have done what you said you would do

Requirements Management - management aspects

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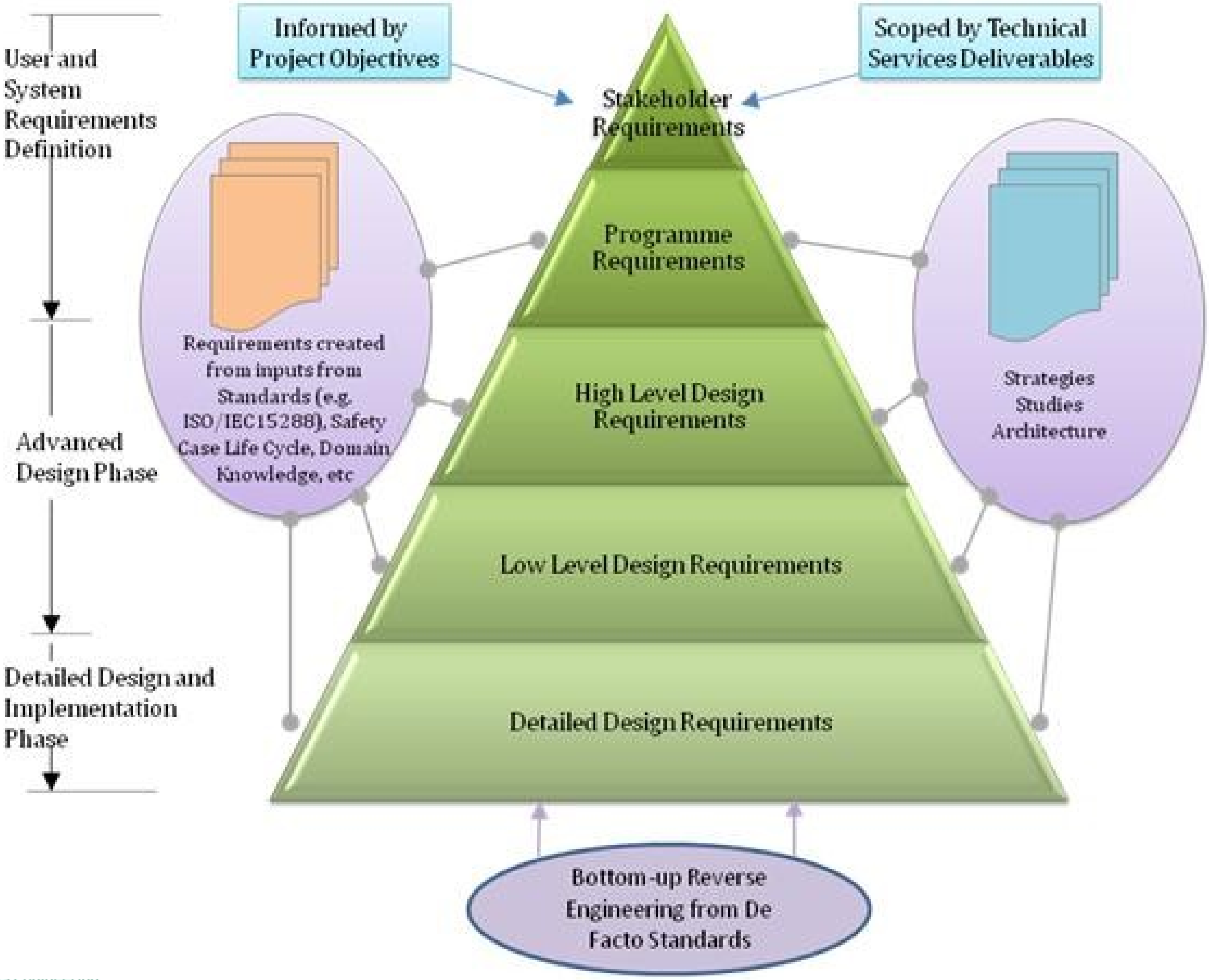
Requirements Management is necessary to avoid problems described

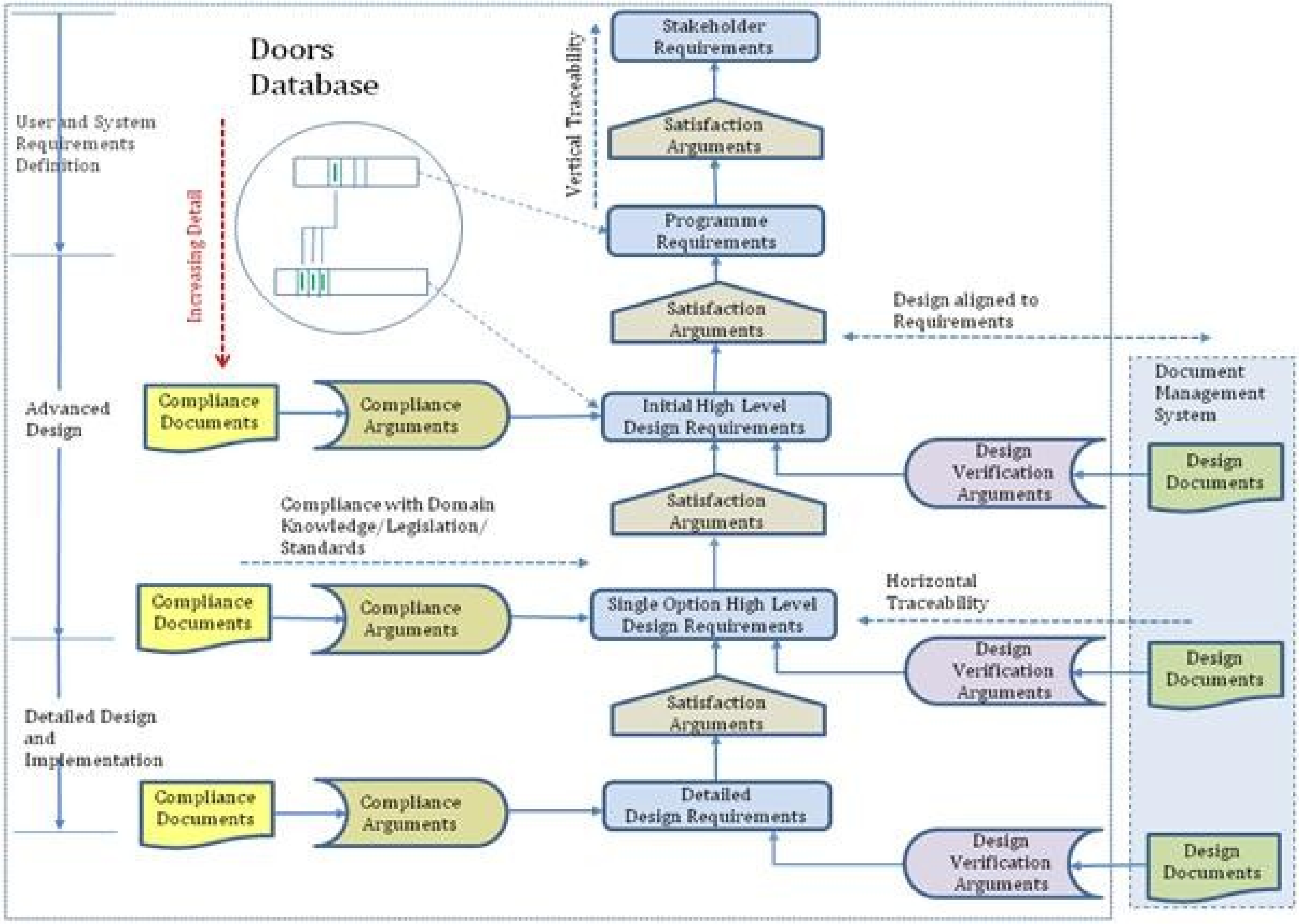
Needs:

- Senior Management buy-in
  - Backed up with budget
- A Requirements Manager
  - Requirements Management Plan
    - Strategy (which addresses the 3 questions)
    - Allocation of Resources (Team Requirements Representative)
    - Generic approach across the geography)
- Requirements management activities detailed in the project schedule
  - Elicitation
  - Analysis
  - Reviews

Requirements Hierarchy



Requirements-driven Design

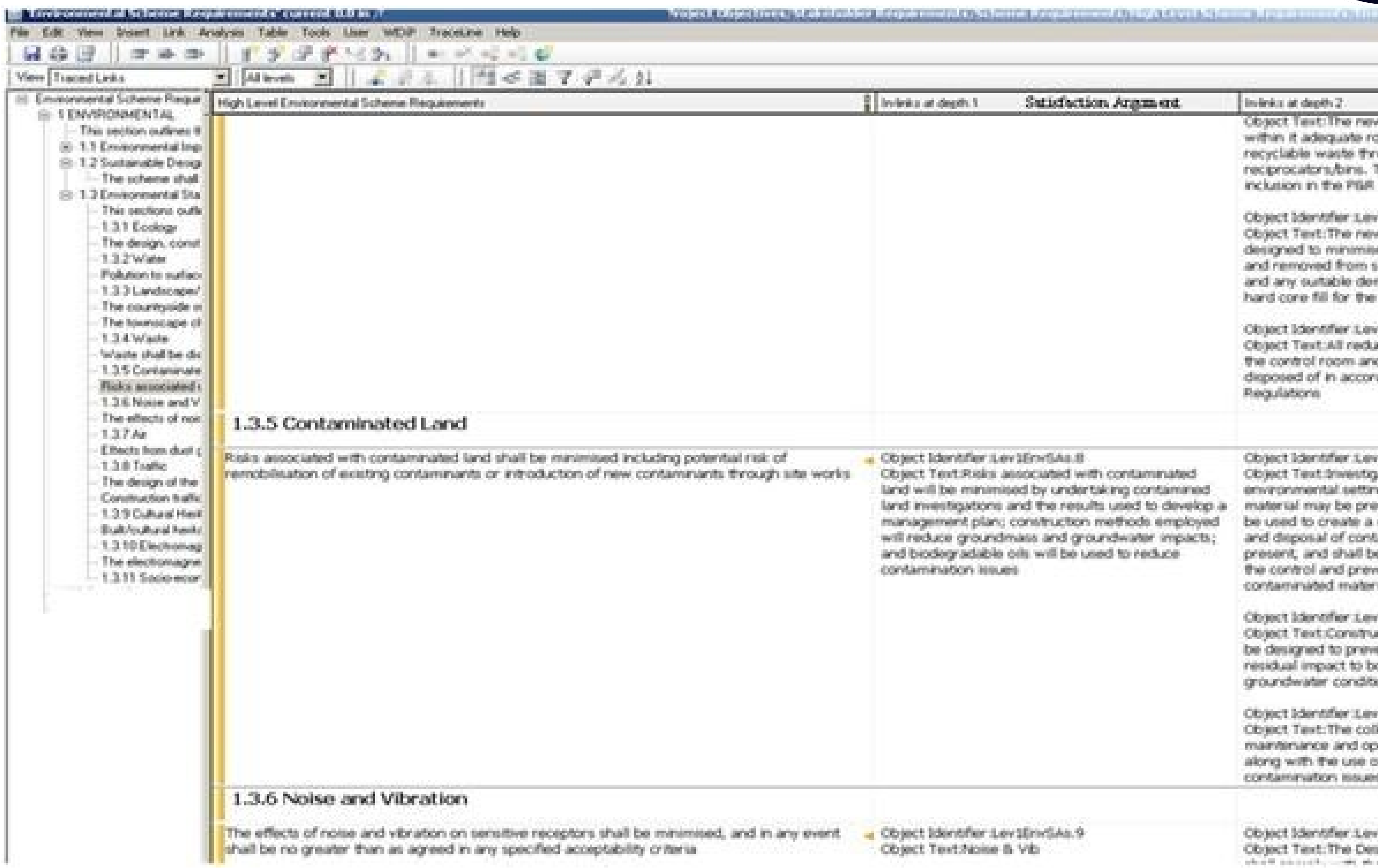


Requirements Driven Design

Requirements-driven Design

- Suitable for large development projects with known direction and desired outcomes
- Addresses the three questions:
  - Capture and evolve requirements hierarchy
    - only start design when a clear set of requirements agreed at corresponding level **What => Requirement**
  - Complete auditable traceability down through Requirements hierarchy and to designs **How => Design**
  - Verification evidence provided **Proof => Verification**
    - justifies all derived requirements
    - show how requirements are implemented by design

Requirements Modules in DOORS



Example of a Satisfaction Argument in the DOORS Database

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Requirements-driven Design Strategy

Overall Requirements Strategy

- Create Requirements Management Plan
  - Defines the overall strategy
- Requirements-driven Design Processes

  Implemented in 2 iterations per stage for each level of Requirements/Design

  1. Requirements Definition
     - Requirements Elicitation & Capture
     - Requirements Analysis
     - Requirements Review
     - Requirements Verification
     - Requirements baselining => **Delivers a set of Requirements**
  2. Design Specification
     - Create designs
     - Design and DVA Reviews => **delivering Design elements linked to corresponding Requirements**

Requirements Capture & Elicitation (Style & Formulation)

What makes a ‘robust’ requirement?

- Each requirement must:
  - Stand alone
  - Specify clearly and unambiguously what is wanted
  - Must be verifiable
  - Must be necessary
  - Must be achievable
  - Must be traceable
- **Must be at the right level**
- **Must be well-formed**
  - Each requirement must be written in a formal style

  e.g. The combined level of risk due to all the hazards under the direct control of the Infrastructure Controller shall not exceed 0.01 equivalent fatalities per year.

Requirements-driven Design - Processes

Requirements capture

'Flow-down' through levels of Requirements

Elicitation

depends on quality of source material (e.g. Performance and Risk Models) & experience and domain knowledge of Engineers

Web-based to access to DOORS (for remote site working)

Requirements analysis

Ensure 'Good Requirement' at right level

Requirements review

Gap analyses of Design against Requirements for alignment

Check Inter-disciplinary, Interface and Generic Requirements

Requirements verification

Vertical flow-down via SAs, supported by CAs (when necessary)

Requirements Baselining

Use the Baselining facilities of DOORS to create a 'frozen' Baseline of the Requirements

Design Verification

Conduct Design Reviews , plus reviews of the Design Verification Arguments

System Engineering Structures and processes

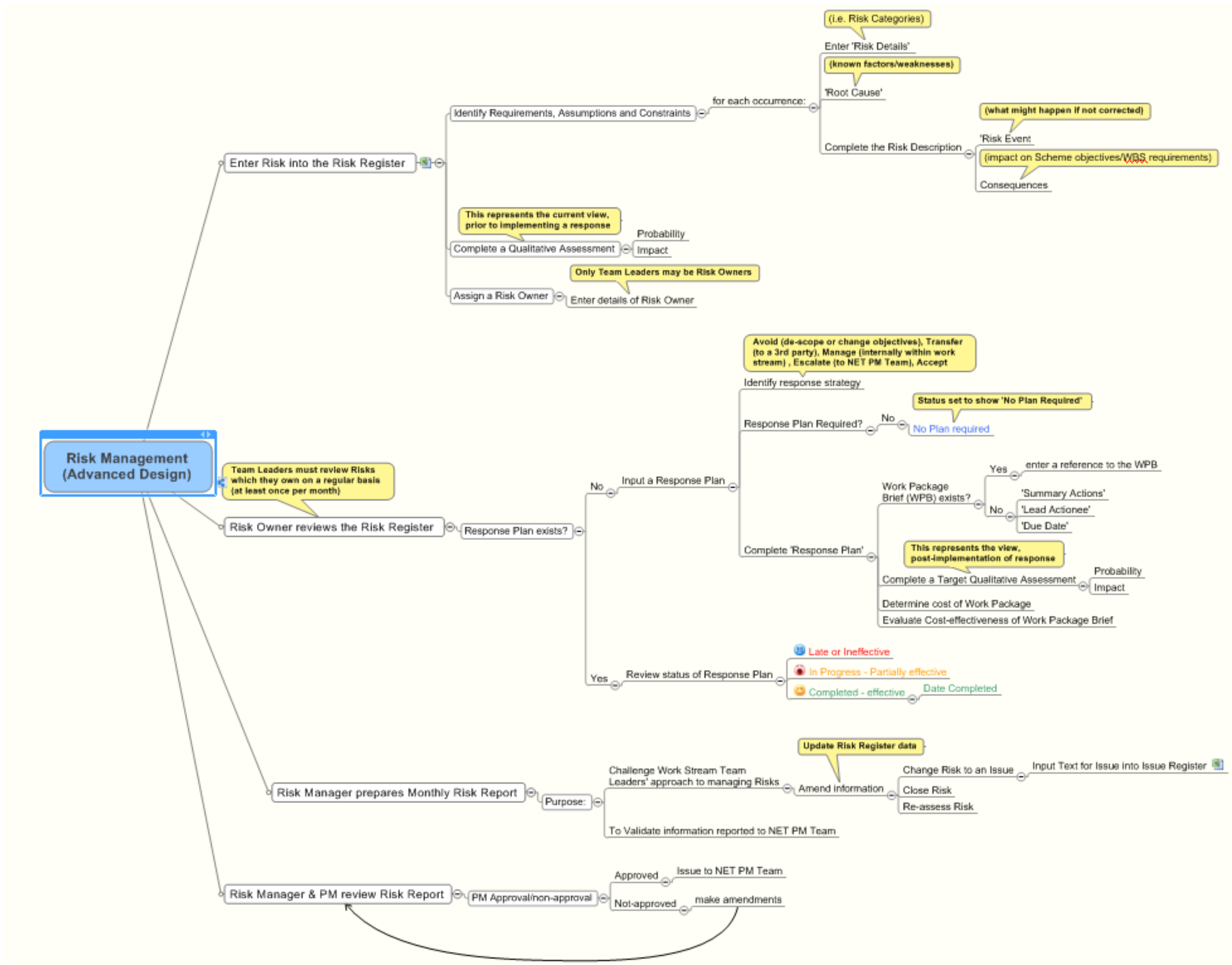
Important for Requirements Manager to work with other process managers to:

- Understand how other processes interact with Requirements Management process
  - Liaison with managers of key areas (Risk, Change Control)
  - Integration of processes
  - Determine data required to manage other processes
  - Establish specific data to be managed in DOORS
- Structures
  - Schema
    - Organisation of Requirements
    - Attributes of Requirements

Key Project Support Processes

- Requirements Management
- Assumptions Management
- Change Control
- Risk Management
- Issue Management
- Legal Process
- Environmental Management process

Supporting Project Processes - Risk Management



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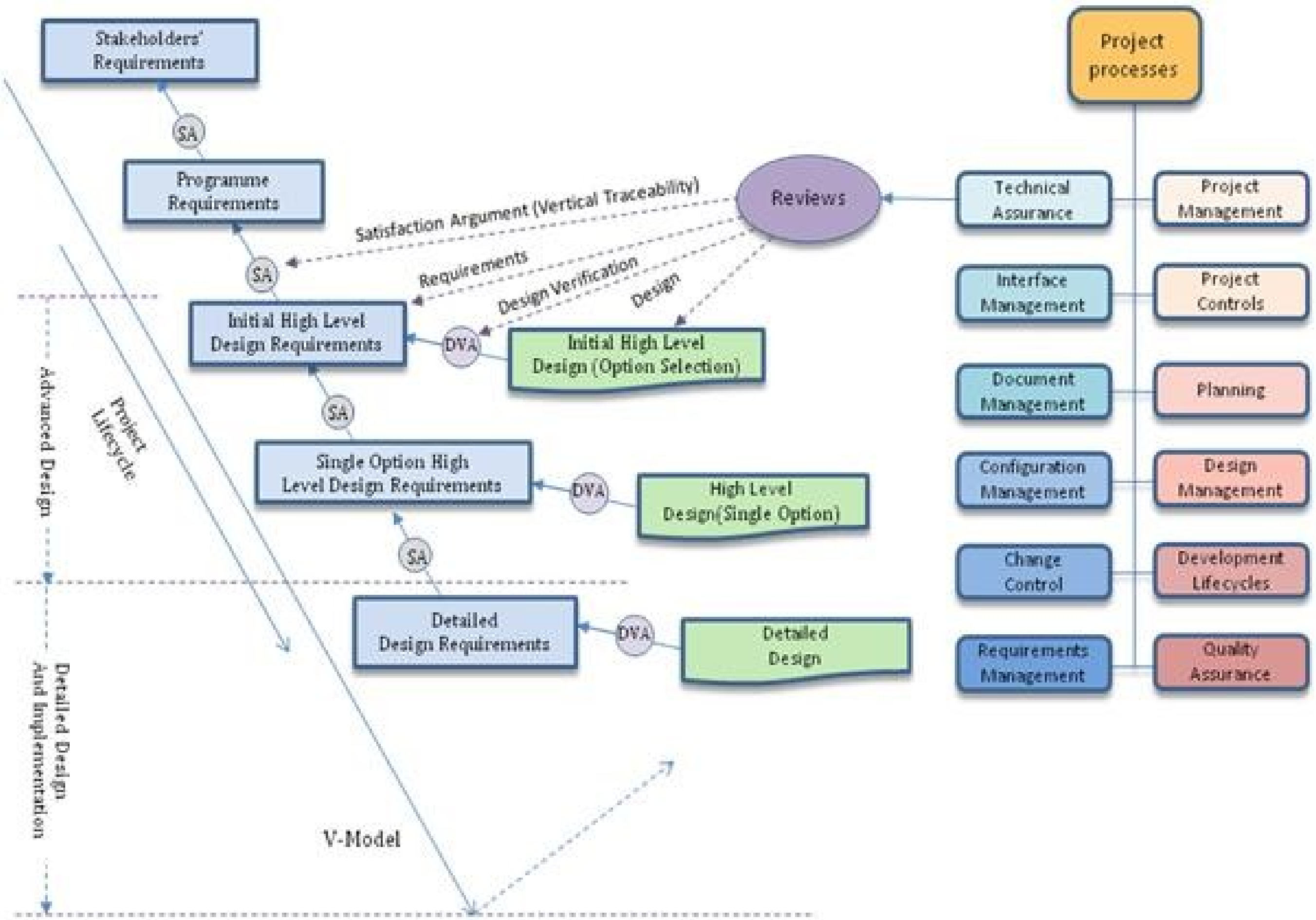
Project Support Environment



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Benefits of Processes Integration - Risk Management

A matrix can be constructed where the cells of the matrix reflect ranges of Risk Score

Probability	Very High	VHΛVL	VHΛL	VHΛM	VHΛH	VHΛVH
	High	HΛVL	HΛL	HΛM	HΛH	HΛVH
	Medium	MΛVL	MΛL	MΛM	MΛH	MΛVH
	Low	LΛVL	LΛL	LΛM	LΛH	LΛVH
	Very Low	VLΛVL	VLΛL	VLΛM	VLΛH	VLΛVH
		Very Low	Low	Medium	High	Very High
		Impact				

The highest Risk Score in the above example would be:
Probability(**Very High**) x Impact(**very High**)
Similarly, the lowest Risk Score would be:
Probability(**Very Low**) x Impact(**very Low**)
Individual risks can be given a Red/Amber/Green (RAG) status, corresponding to their Risk Score. In the above example scores of HΛH, or VHΛH, are shown in Red. Moderate and lower Risk Scores are indicated by the yellow and green areas in the matrix

Benefits of Processes Integration - Risk Management

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Enter new risk into the Risk Register

Requirements Manager check if any of the existing requirements (in DOORS) are impacted by the risk.

- If so, update ‘Risk ID’ attributes of the requirement(s)
- Link to the new risk’s Risk ID in the Risk Register

A risk can also be identified when a new requirement is created. Initially, some aspects of a new requirement may not be known completely:

- An Assumption is raised which is linked to a new (or existing) Risk
- The Risk ID attribute in DOORS is linked to the new (or existing) Risk in the Risk Register

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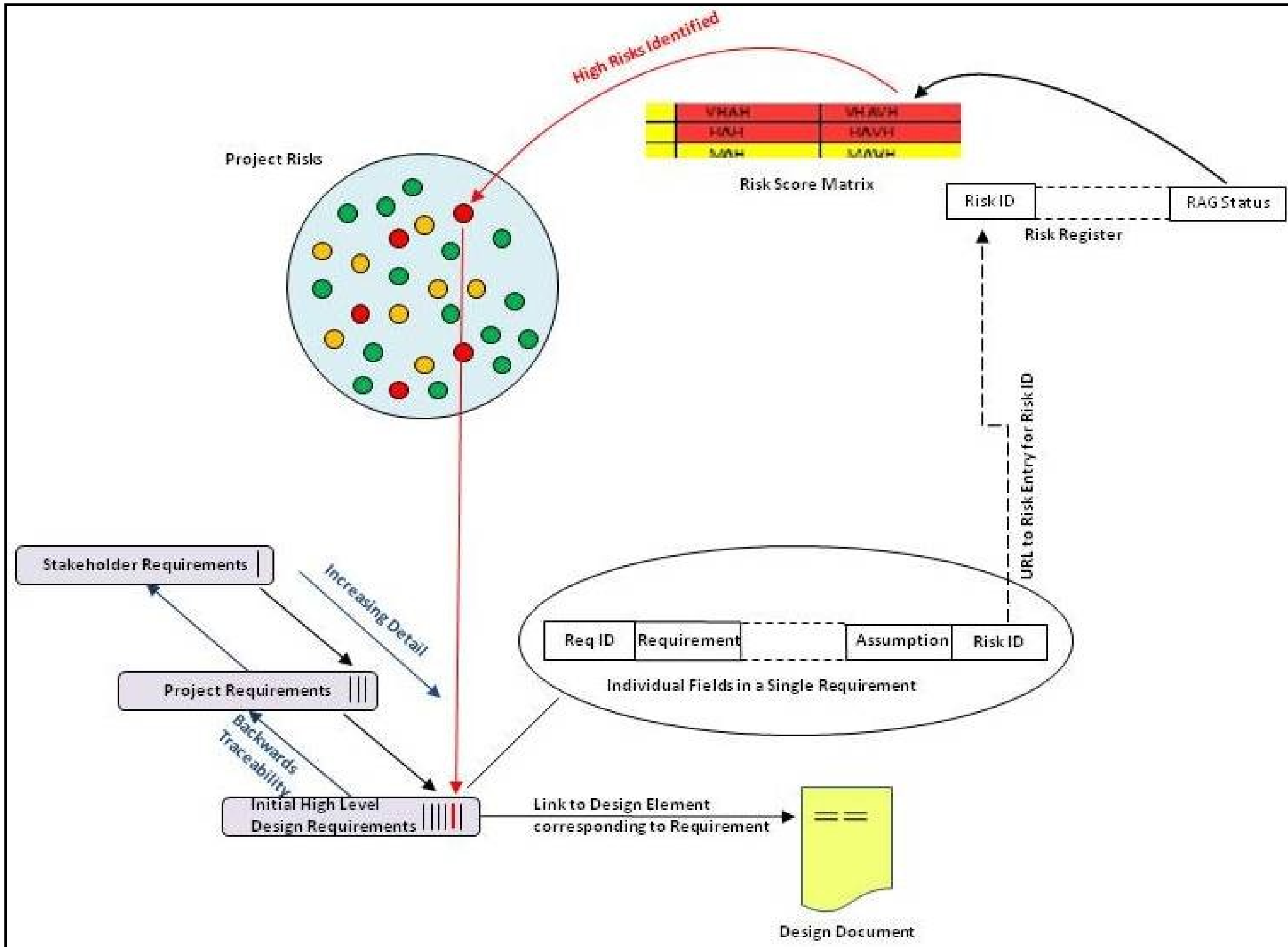
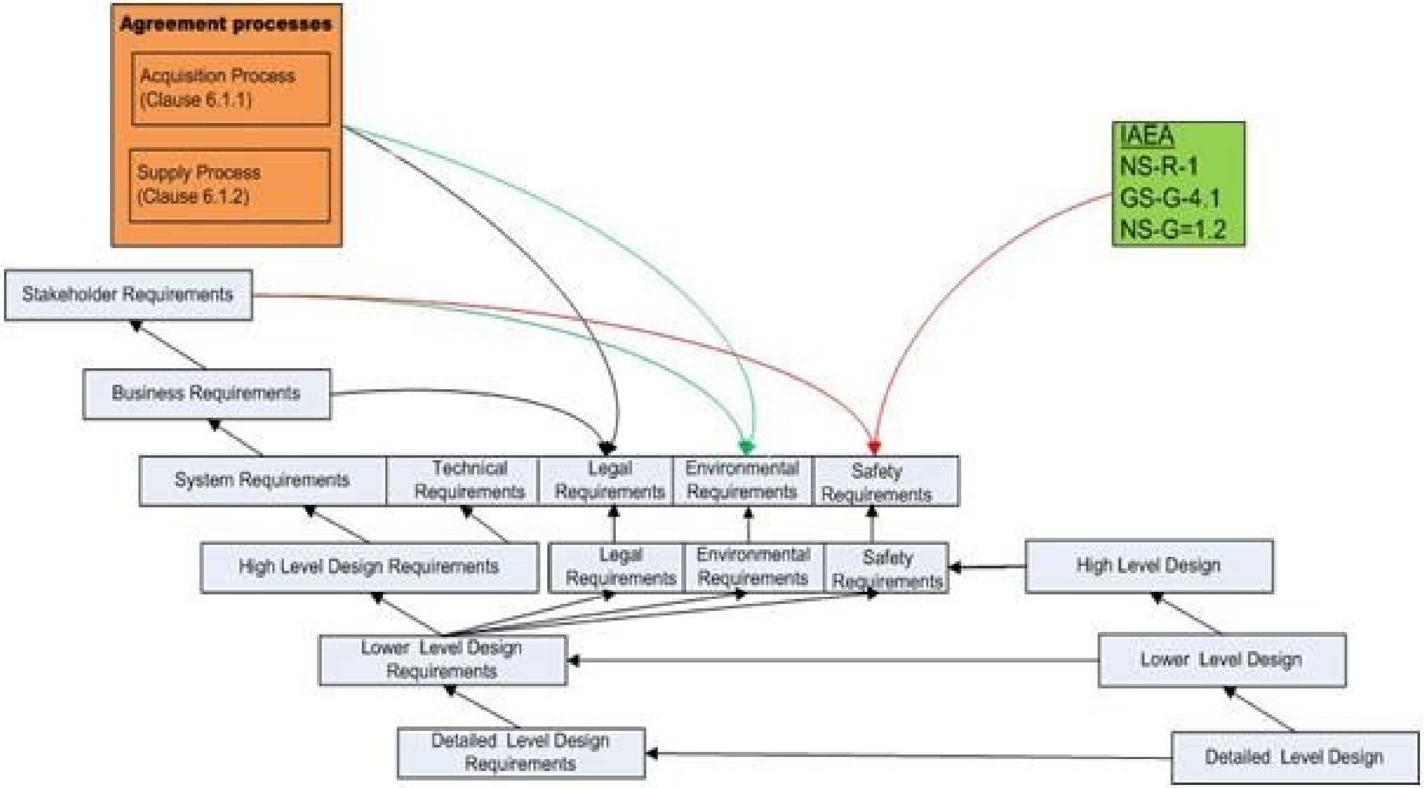
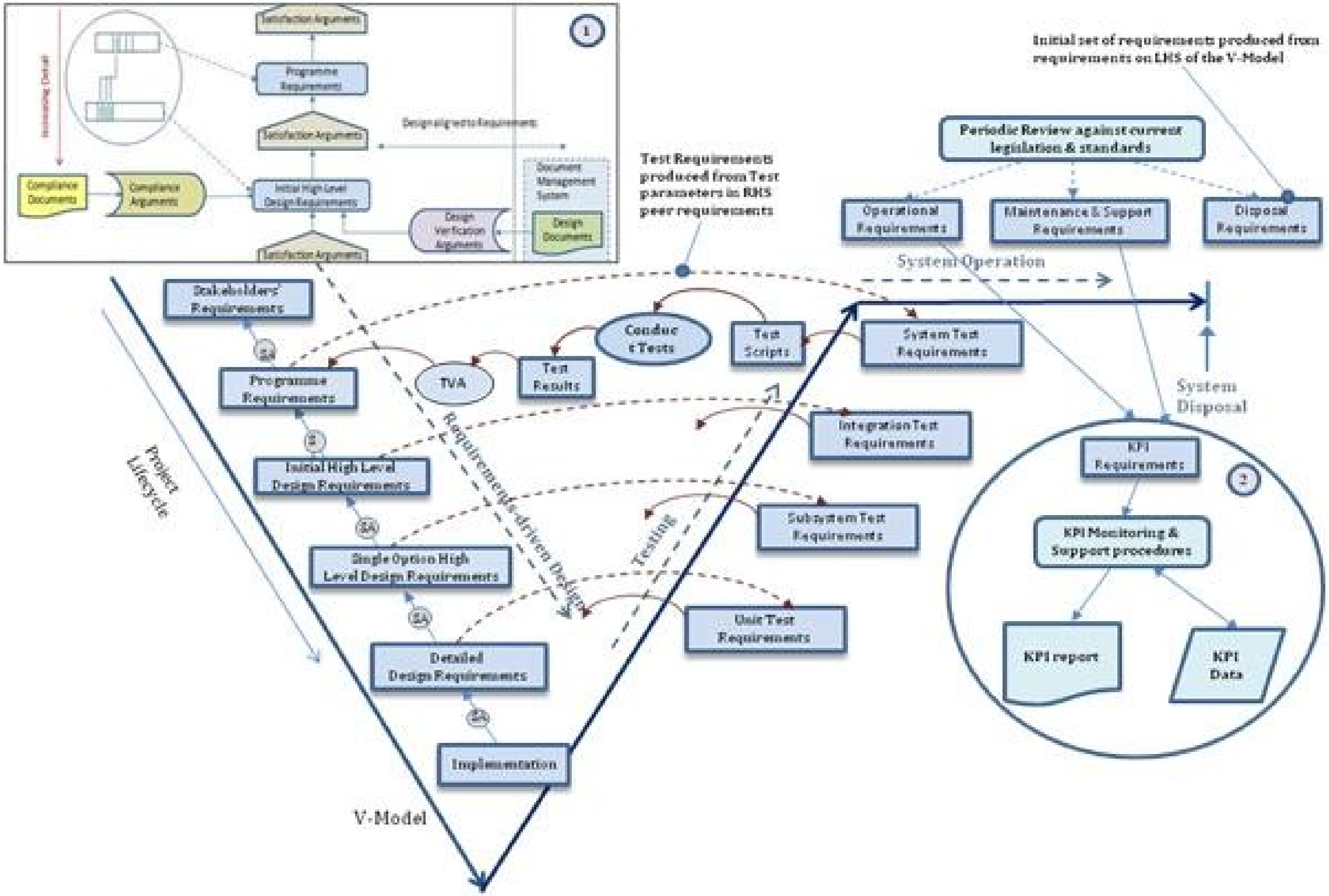
Benefits of Processes Integration - Risk Management



Managing Commercial and Legal Requirements



Whole Life Cycle Considerations



Benefits of Reqs-driven Design

Benefits of the Requirements Driven Approach:

- The Design evolves thoroughly from the Stakeholder Requirements
- The Design Brief will be clear, and the Design will require no iteration
- Large teams of Engineers will not be tied into the Design Phase for extended periods
- There is full, auditable traceability through the requirements hierarchy and to every element of each level of design
- Early Acquirer/Stakeholder visibility of the requirements enables changes to be made at that time, rather than later, after months of design reviews, when design changes would require much re-work with corresponding high cost
- Project-wide visibility, and use of natural language, promotes better understanding for engineers across all disciplines
- Verification evidence at each stage contributes incrementally to the Safety Case

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Example: Guide to Railway Investment Projects (GRIP)

One of key elements for success is good communication

- consider using graphical applications (e.g. MindManager) to document processes and process interactions
- include contextual help (including DOORS help)
- Link through to DOORS and carry out operations directly in DOORS

Example of processes integration:

- Guide to Railway Investment Projects (GRIP)
- Approach is based upon best practice within Network Rail and other industries that undertake major infrastructure projects
- Also best practice recommended by major professional bodies including:
  - the Office of Government Commerce (OGC)
  - the Association of Project Management
- Covers the investment lifecycle from inception through to the post-implementation realisation of benefits

Dynamic Map Examples

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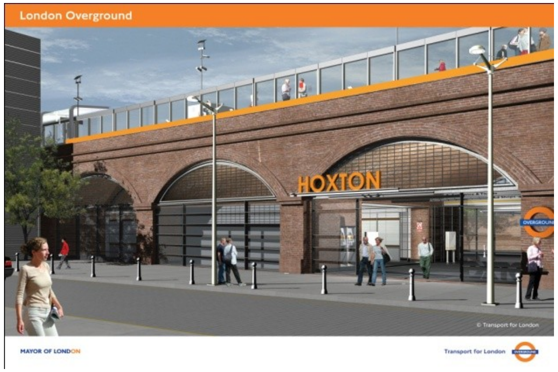
Some examples of large projects using DOORS

Heathrow Terminal 5

Cross London Rail Link (Crossrail)

East London Line



Multiple Life Cycles

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Multiple Life Cycles may operate concurrently:

- e.g. ISO/IEC 15288 and ISO/IEC 12207
- Safety Case (with involvement of the Regulator) and 61508 (nuclear) or 50128 (rail) for SIL software
- ‘Traditional’ Engineering V-Model

Conformance to International Standards

ISO/IEC 15288 Life Cycle Processes

Agreement processes

- Acquisition Process (Clause 6.1.1)
- Supply Process (Clause 6.1.2)

Organisational Project-Enabling Processes

- Life Cycle Model Management Process (Clause 6.2.1)
- Infrastructure Management Process (Clause 6.2.2)
- Project Portfolio Management Process (Clause 6.2.3)
- Human Resource Management Process (Clause 6.2.4)
- Quality Management Process (Clause 6.2.5)

Project Processes

- Project Planning Process (Clause 6.3.1)
- Project Assessment and Control Process (Clause 6.3.2)
- Decision Management Process (Clause 6.3.3)
- Risk Management Process (Clause 6.3.4)
- Configuration Management Process (Clause 6.3.5)
- Information Management Process (Clause 6.3.6)
- Measurement Process (Clause 6.3.7)

Technical processes

- Stakeholder Requirements Definition Process (Clause 6.4.1)
- Requirements Analysis Process (Clause 6.4.2)
- Architectural Design Process (Clause 6.4.3)
- Implementation Process (Clause 6.4.4)
- Integration Process (Clause 6.4.5)
- Verification Process (Clause 6.4.6)
- Transition Process (Clause 6.4.7)
- Validation Process (Clause 6.4.8)
- Operation Process (Clause 6.4.9)
- Maintenance Process (Clause 6.4.10)
- Disposal Process (Clause 6.4.11)

Additional ISO/IEC 12207 Life Cycle Processes

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Technical processes

- Stakeholder Requirements Definition Process (Clause 6.4.1)
- Requirements Analysis Process (Clause 6.4.2)
- Architectural Design Process (Clause 6.4.3)
- Implementation Process (Clause 6.4.4)
- Integration Process (Clause 6.4.5)
- Verification Process (Clause 6.4.6)
- Transition Process (Clause 6.4.7)
- Validation Process (Clause 6.4.8)
- Operation Process (Clause 6.4.9)
- Maintenance Process (Clause 6.4.10)
- Disposal Process (Clause 6.4.11)

Software Implementation

- Software Requirements Analysis Process
- Software Architectural Design Process
- Software Detailed Design Process
- Software Construction Process
- Software Integration Process
- Software Qualification Testing Process

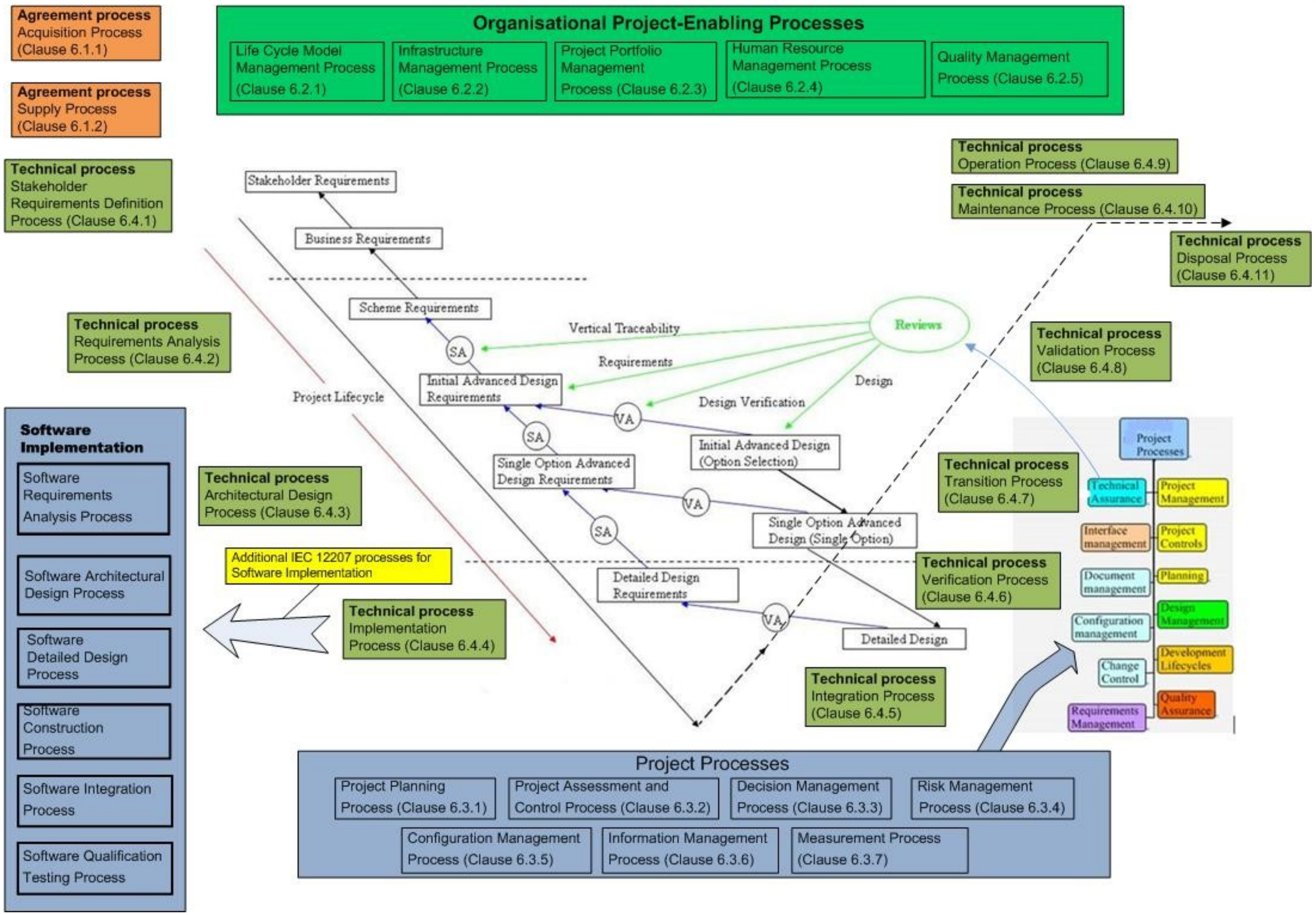
Software Re-use

- Domain Engineering Process
- Re-use Asset Management Process
- Re-use Program Management Process

Software Support

- Software Documentation Management Process
- Software Configuration Management Process
- Software Quality Assurance Process
- Software Verification Process
- Software Validation Process
- Software Review Process
- Software Audit Process
- Software Problem Resolution Process

Application of ISO/IEC 15288 & 12207 throughout the Lifecycle



ISO/IEC 15288 Systems Life Cycle

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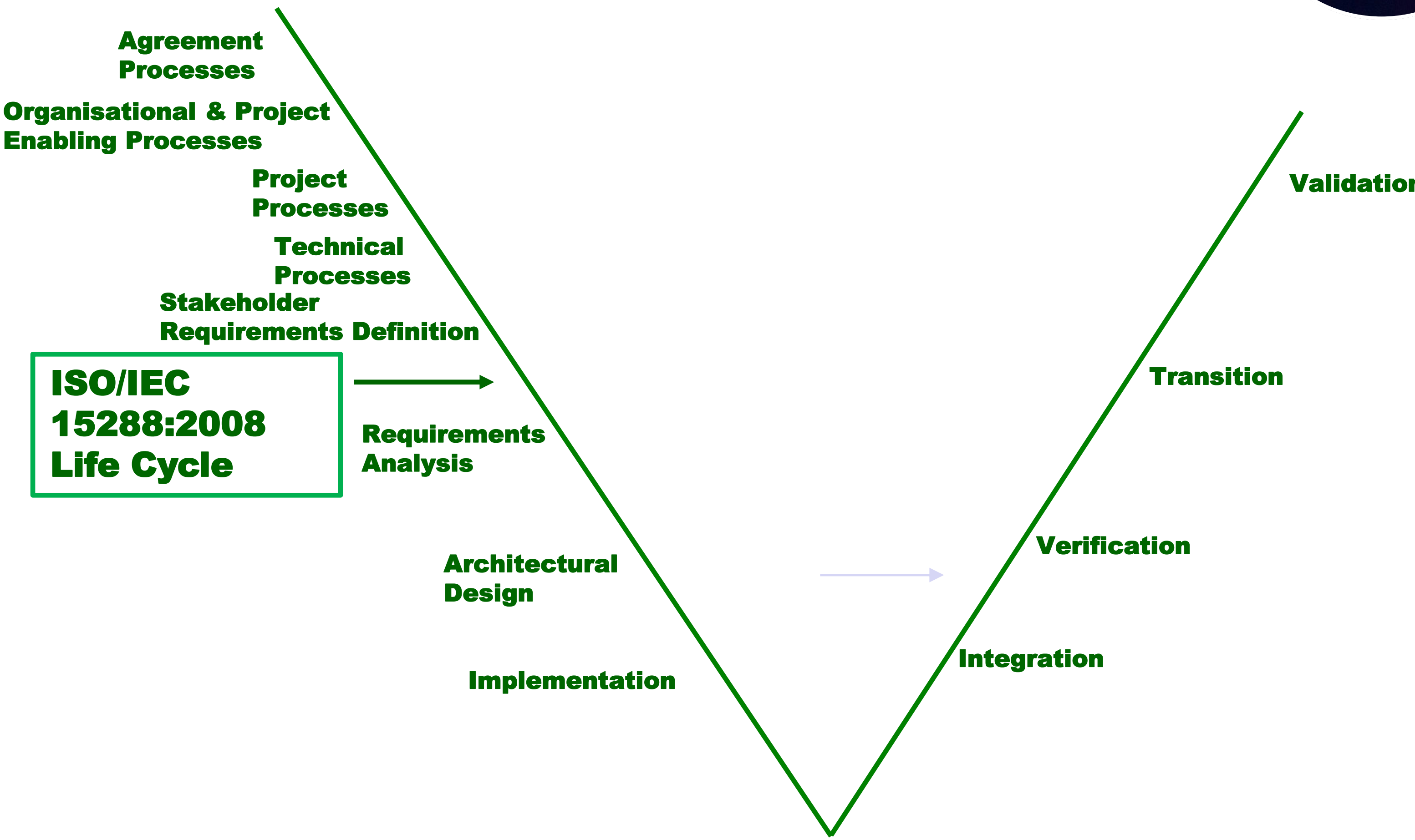
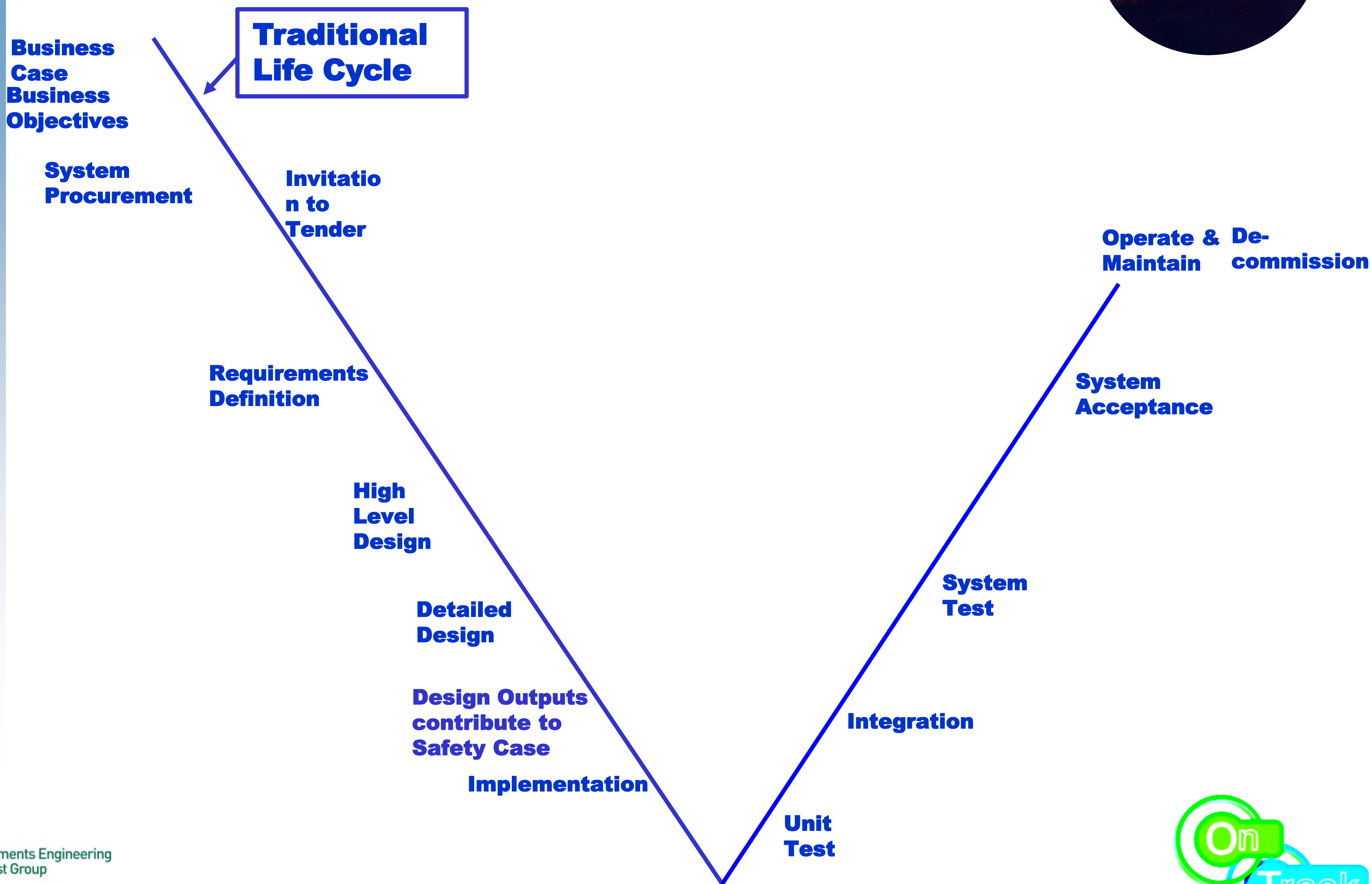


Safety Case Life Cycle

Traditional V-model Life Cycle



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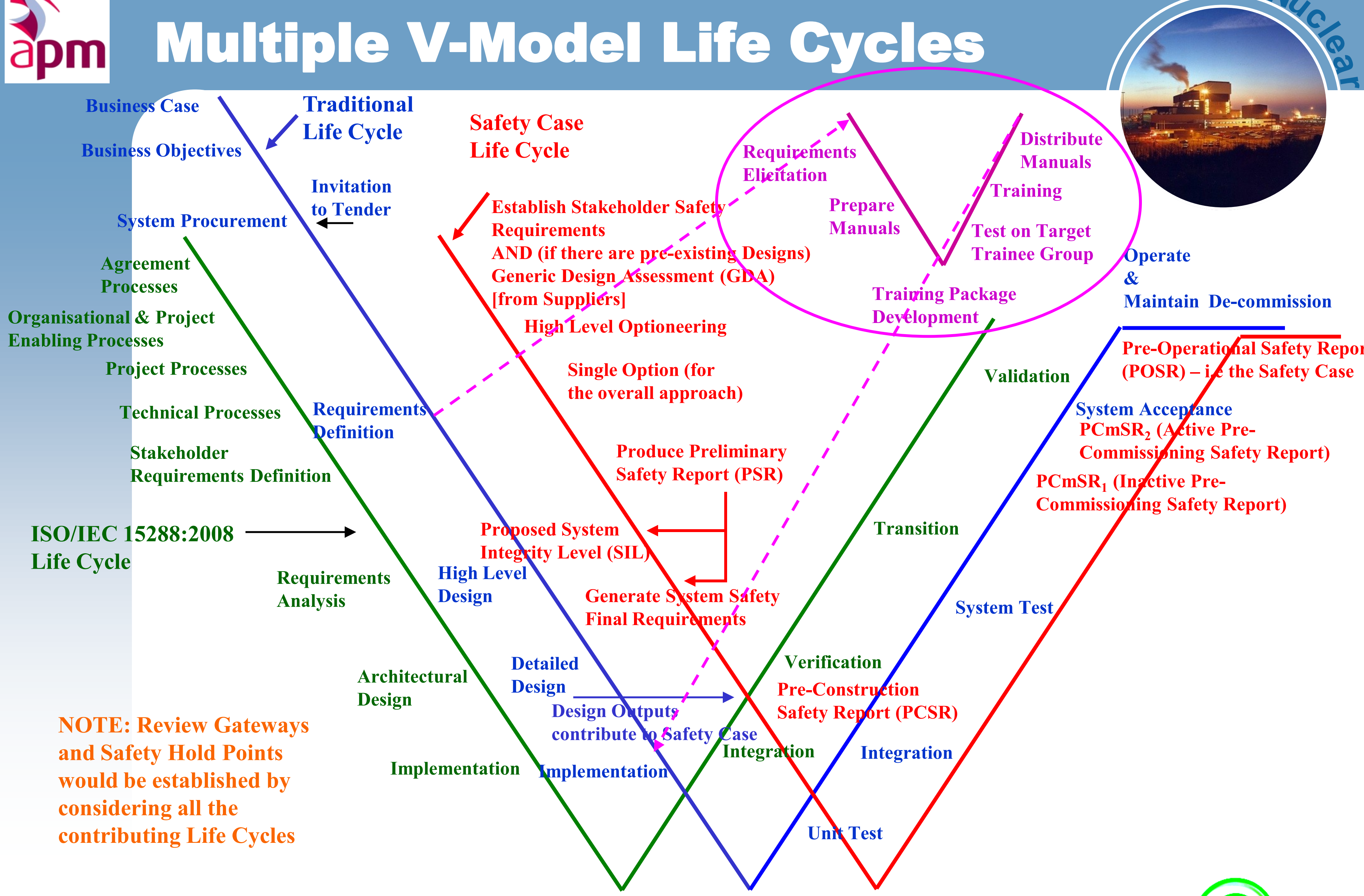
Multiple V-Model Life Cycles



NOTE: Review Gateways and Safety Hold Points would be established by considering all the contributing Life Cycles

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Mechanics of Conformance

Mechanics of Conformance

- Map major deliverables and Gateways onto traditional V-model
- Use CAs to merge in the requirements of a standard into the requirements sets at appropriate stages of the development life cycle
- Each CA links to clause in standard that has caused the need for a requirement
- CA argument states why requirement is necessary, and how it addresses the clause in the standard

Regulated Industries – Safety Case Considerations

In regulated industries:

- Essential to show compliance to the requirements of the regulatory body
- Usually achieved by building various forms of safety cases
  - compliance is shown by means of verification evidence, proofs, and testing/demonstration
- Only when the safety case has been accepted by the Regulator that the system will be allowed to go into operation
- Crucial to construct proofs of safety which are sufficiently thorough and robust that they can be understood and accepted by the regulatory body

Regulated Industries – Safety Case Considerations

In a major project:

- many large contractors involved who each contribute to the safety cases
- poor document organisation and structure => problems with completeness of the coverage
  - resulting in overlaps or gaps in information

Constructing safety cases requires diligent, detailed work to ensure a rigorous approach has been taken:

- Common for overall safety case to be composed of individual safety cases for subsystems, or of stage-related safety cases
- Each individual safety case will consist of numerous documents
  - even in a document management system, difficult to navigate
  - the safety cases (components of the overall safety case) difficult to review
  - difficult to see how individual documents fit within context of the overall system
- Often, where a major submission of documentation is scheduled (e.g. for a large safety case, a 'War Room' is set up

Regulated Industries – Safety Case Considerations

Significant business benefits would be obtained if the above scenario could be changed so that:

- Greater transparency is provided to both system developers and the regulators
- A co-operative development environment and culture could be established
  - developers **and** regulators could progressively review requirements and verification evidence throughout the development life cycle
- Complete traceability between regulatory requirements, system requirements, designs and verification evidence is provided
- Re-use of significant development/design information is made available for subsequent, similar system developments

Require a well-structured, easy-to-navigate, set of safety cases, so that individual documents containing safety related information can be examined in the context of the specific regulations that they address.

The requirements-driven design approach described below will provide the appropriate structures to allow ease of navigation, traceability, and accommodation of verification evidence so that the above business benefits could be achieved

Regulated Industries – Safety Case Considerations

Nuclear

Major Stages of a Nuclear Plant Life Cycle	Associated Safety Cases
Early Design	Preliminary Safety Case
Pre- Construction and Installation (including modifications)	Pre- Commencement (Construction) Safety Case
Pre- Commissioning	Pre- Inactive Commissioning Safety Case Pre- Active Commissioning Safety Case
Pre- Operation	Pre-Operational Safety Case
Operation	Plant or Station Safety Case or Site Wide Safety Case if relevant Updated as necessary Periodically reviewed
Post Operation	Post- Operational Safety Case
Pre- Decommissioning	Safety Strategy Overview (applies to complex decommissioning projects only)
Decommissioning	Decommissioning Strategy Safety Case(s) for Decommissioning Operations
Post- Decommissioning	Post-Decommissioning Clearance Safety Case

Regulated Industries – Safety Case Considerations

Pre- Inactive Commissioning Safety Case

- To demonstrate that the plant as-built meets relevant safety criteria and is capable of safe operation
- To enable the production of a programme of safety commissioning activities that will:-
  - demonstrate as far as practicable the safe functioning of all systems and equipment
  - prove as far as practicable all safety claims
  - confirm as far as practicable all safety assumptions confirm as far as practicable the effectiveness of all safety related procedures
- To list aspects of safety that cannot be demonstrated inactively

Regulated Industries – Safety Case Considerations

Key Points

- Requirements-driven Design provides a generic methodology that supports full vertical traceability through the requirements hierarchy, and links every design requirement to its corresponding design element, with verification evidence for all the linked information
- The Safety Cases need to access the verification evidence in specific, prescribed ways at each stage of the Safety Case Lifecycle and are, therefore, not generic

but

  – The verbs in the Safety Case Purpose statements are generic in the nature of what they require

Therefore

  - We can use generic sub-schemas corresponding to each type of verb alongside the generic structures of Requirements-driven Design

Regulated Industries – Safety Case Considerations

Req ID	Statement	Obj Type	Req Type
PSC.1	Statement of Intent	Header	
PSC.2	Textual Statement	Text	
PSC.n	Control and Management	Header	
PSC.n+1	Control and Management	Requirement	Demonstrate
PSC.n+2	Control and Management	Requirement	Demonstrate
PSC.m	Option Selection	Header	
PSC.n	Discussion and selection of options	Text	

Preliminary Safety Case Module

Regulated Industries – Safety Case Considerations

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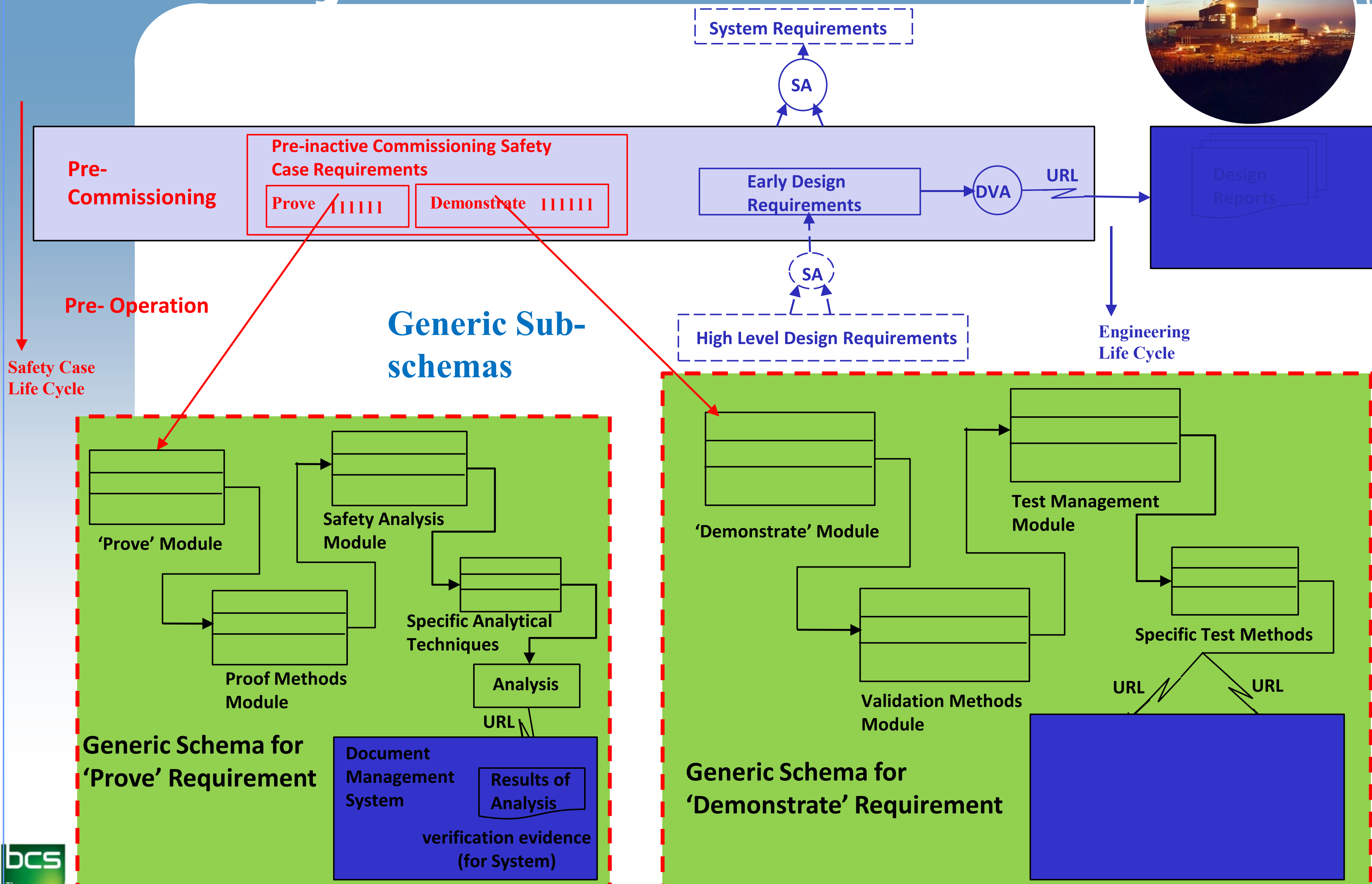
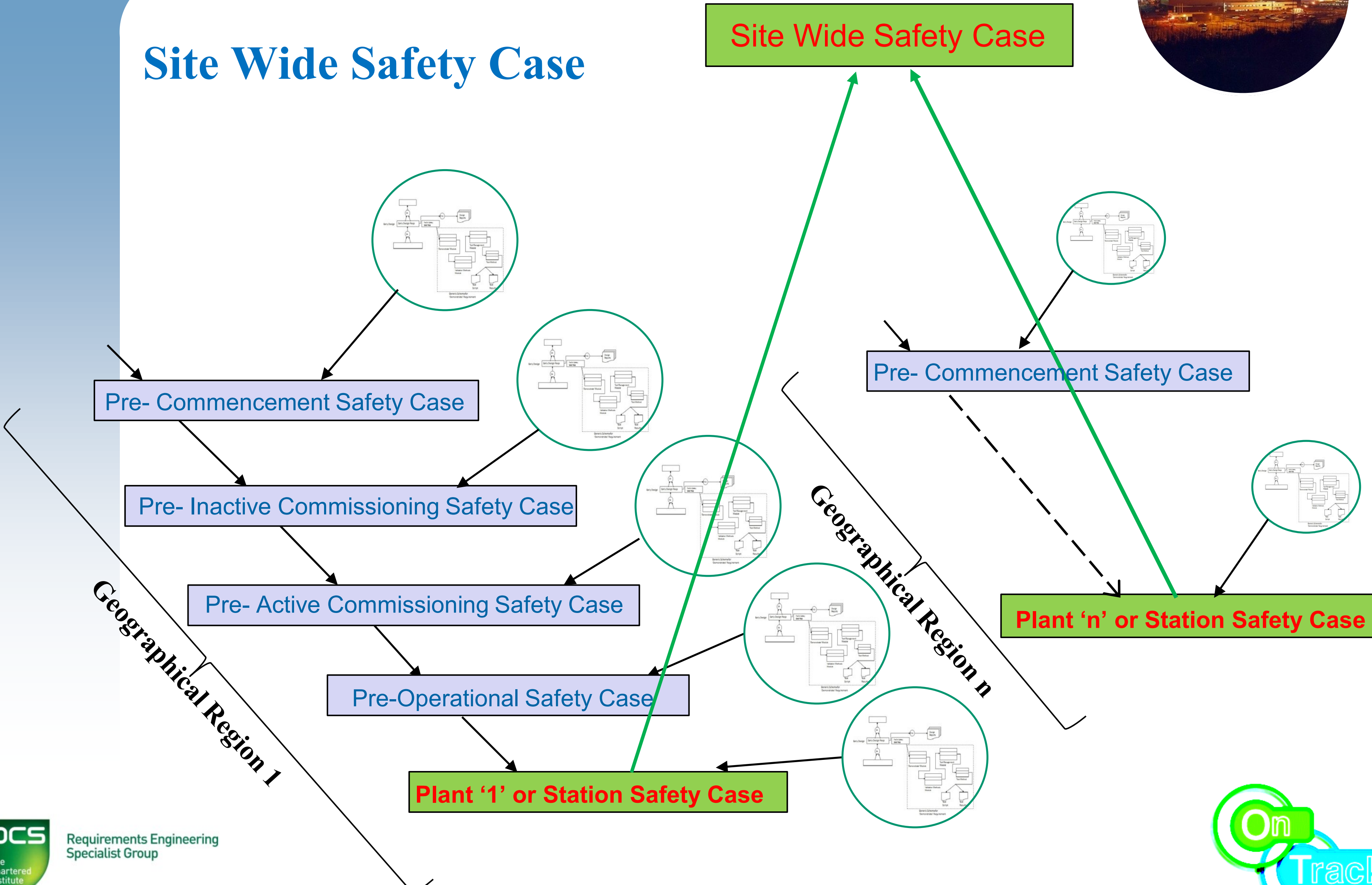


'Demonstrate' Schema diagram

Regulated Industries – Safety Case Considerations

Site Wide Safety Case



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Example: Pharma Development Life Cycle

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Life Cycle Management for the Life Science and Medical Devices Industries

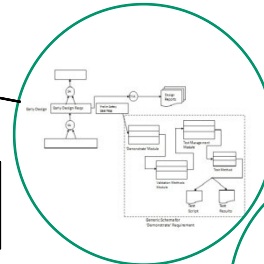
Compliance with the Quality System Inspections Technique used by US Food and Drugs Administration (FDA) field inspectors.

Inspector usually:

- examines the compliance of a single project.
- needs confirmation that design inputs were established.
- needs to verify that the design elements that are essential to the proper functioning of the device have been identified.
- needs to determine if risk analysis was performed.
- needs to ensure that changes to requirements were controlled

FDA's Drug Review Process

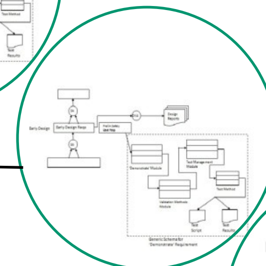
Pre-clinical (Animal) Testing



Investigational New Drug (IND) Application

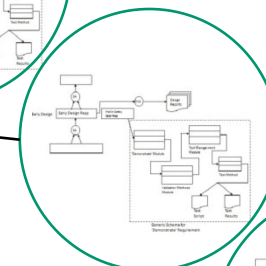
Show FDA results of preclinical testing and what is propose d for human testing

Phase 1 Studies



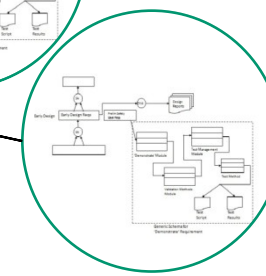
(typically 20 to 80 people)

Phase 2 Studies



(typically a few dozen to about 300 people)

Phase 3 Studies



(typically several hundred to about 3000 people)

Pre-NDA period (FDA and drug sponsors meet)

Submission of an NDA

Ask the FDA to consider a drug for marketing approval

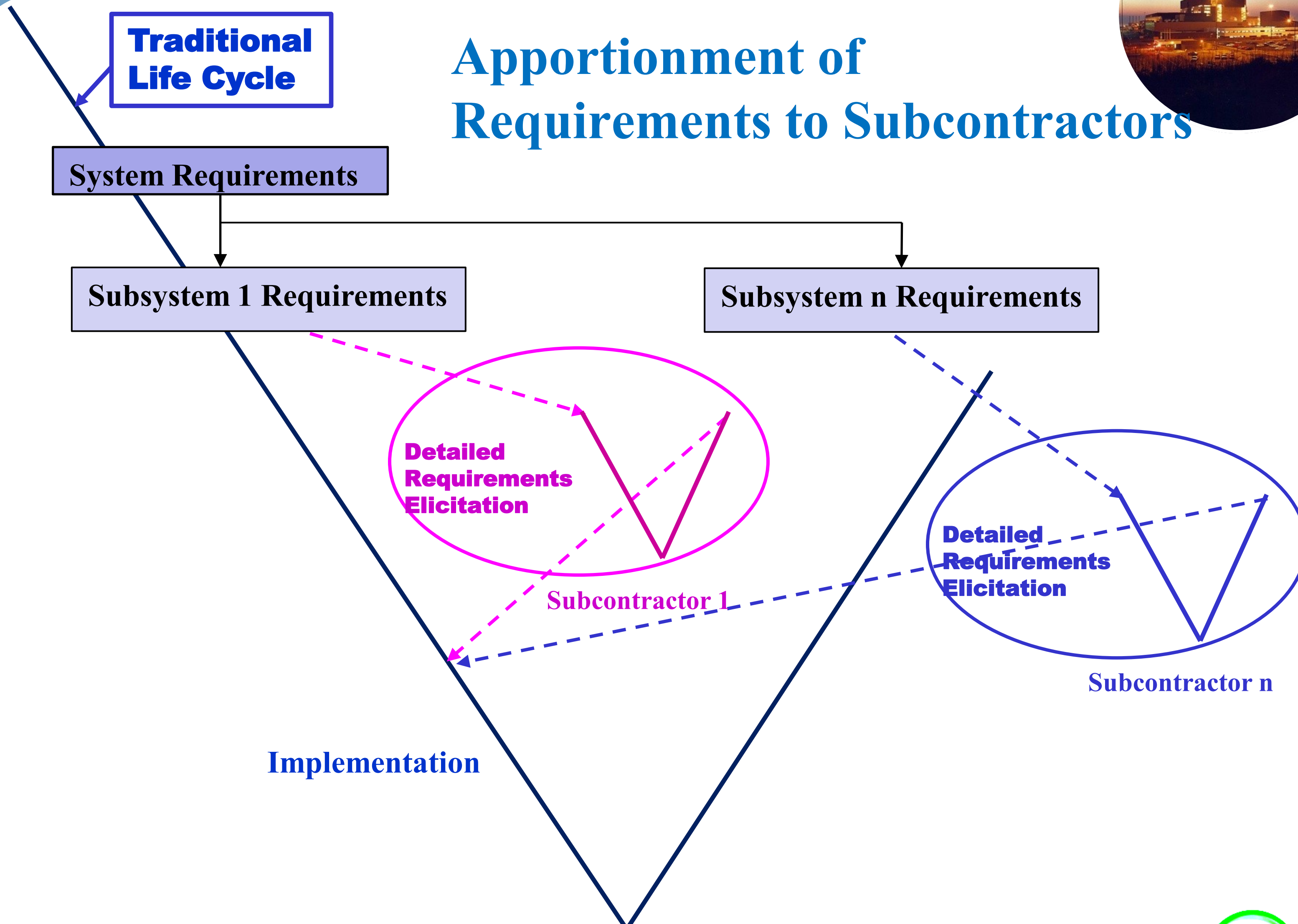
FDA decision whether to Review (60 day period)

FDA files NDA

FDA review team evaluates the sponsor's research on drug's safety and effectiveness

Managing Multiple Development Contracts

Apportionment of Requirements to Subcontractors



Main Project V-model Life Cycle

Managing Multiple Development Contracts

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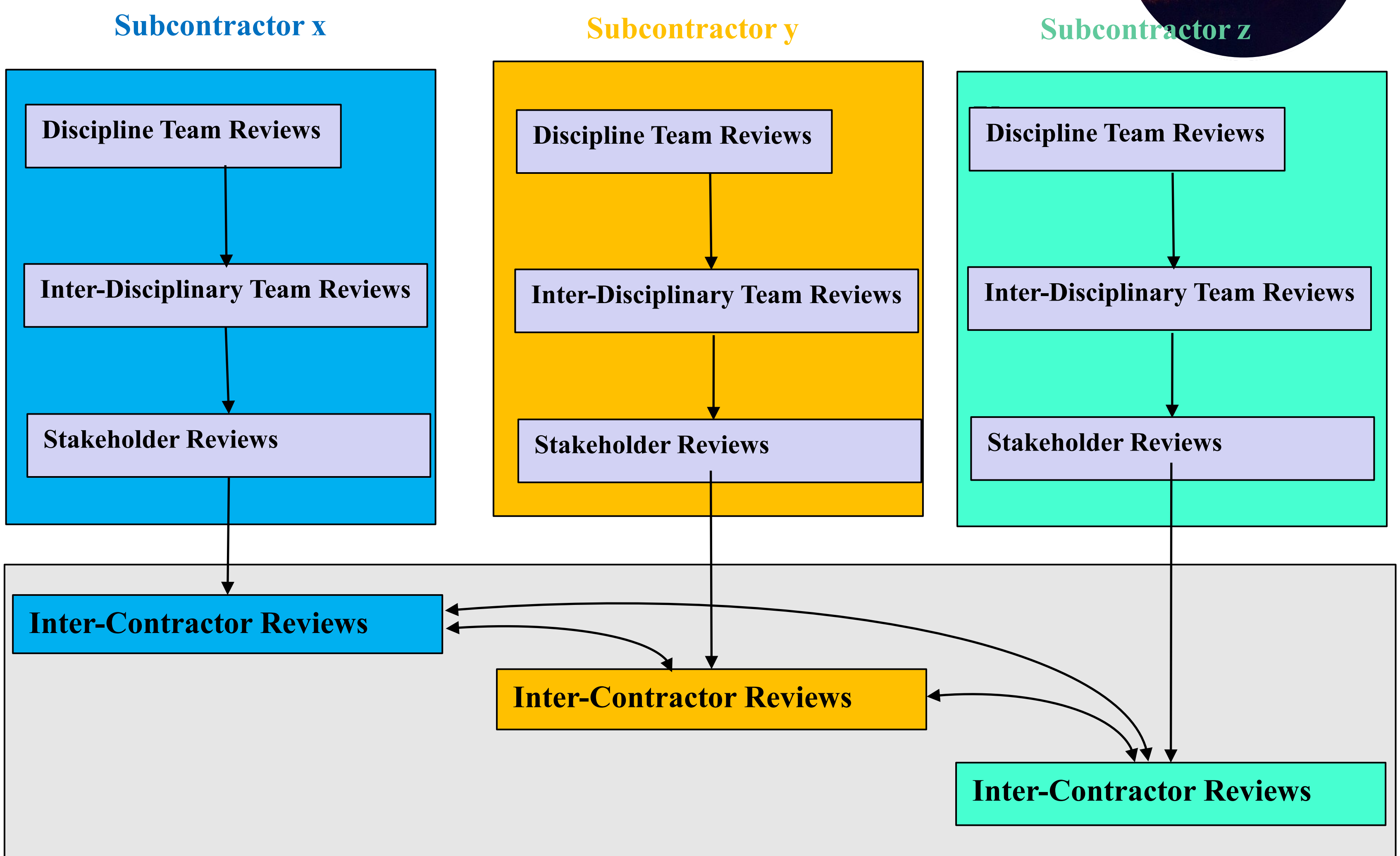
Access control & remote working capabilities of DOORS can support management of multiple contracts

- Sets of requirements can be allocated to, or produced by, various contractors
- Sets can be linked to Project Teams' requirements via SAs
- Contractors only given Read Access to Project Teams' requirements
- Subsystems developed & implemented, then tested by Contractors against contracted set of requirements, and test results reviewed by Client
- Completed subsystems can be integrated into overall system during the subsystem and system integration phases of life cycle

Inter-Contractor Requirements Reviews



Information Requirements for Key Decision-making

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Delivering the Desired Benefits

- Create the Business Plan
  - Establish the Desired Benefits
  - Set the Objectives for delivering the Desired Benefits
- Establish the Stakeholder Requirements
  - Consult with Key Stakeholders and produce the Stakeholder Requirements
  - Formulate the Benefits-related Business Requirements derived from the Objectives and merge them into the Stakeholders Requirements
- Use a Requirements-driven Design approach to produce the desired outcomes and benefits

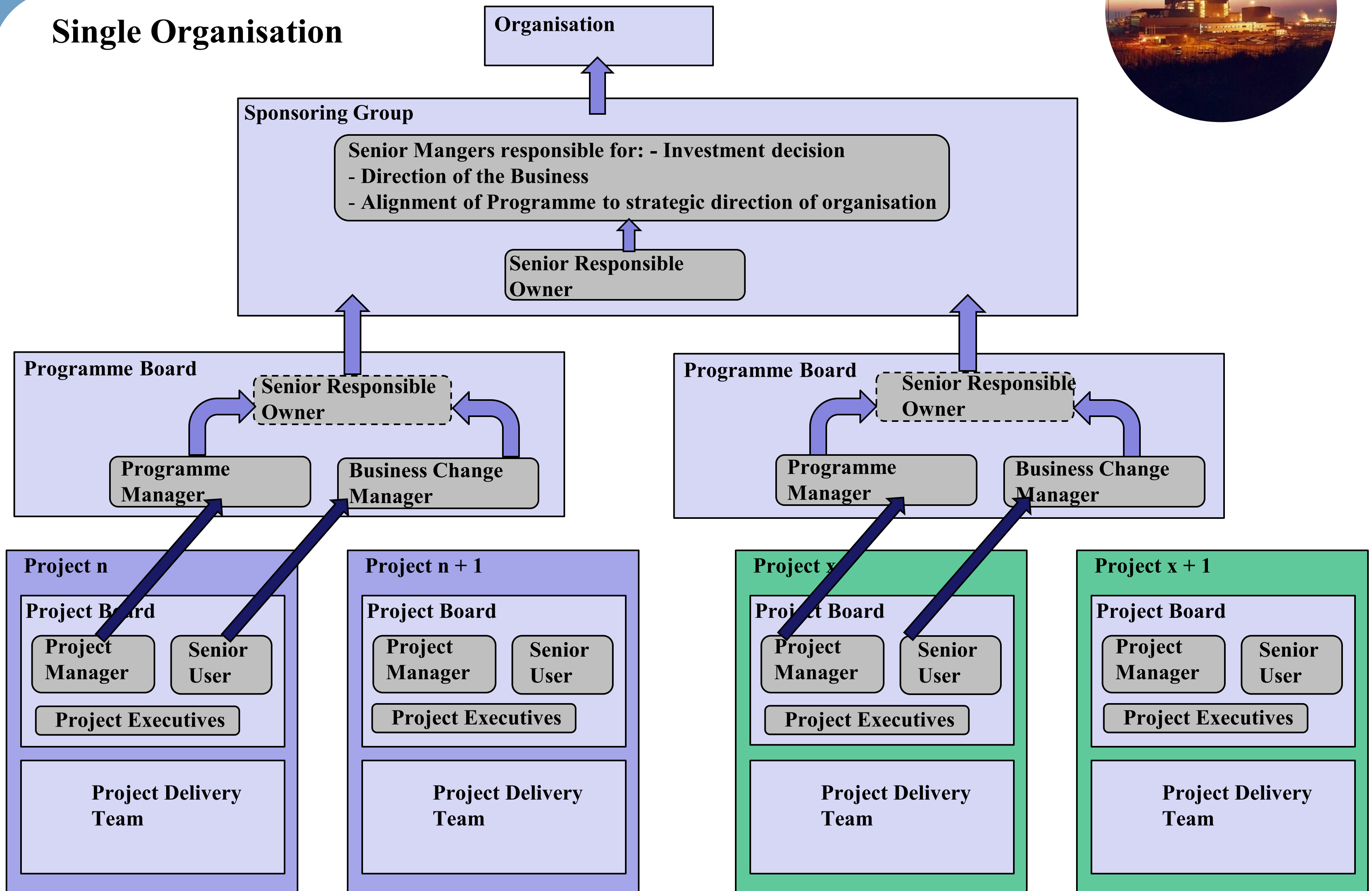
Information Requirements for Key Decision-making

Providing information for key decision making

- Use of Requirements-driven design alone is not sufficient
- Internal and external events impact projects and programmes
- Need to provide information to key decision-makers which will support the decision-making process
  - Requires integration of project and programme processes (e.g. Risk Management, Change Control)
  - Appropriate attendance of key people at reviews
  - Timely delivery of essential information to key people

Organisational Structures

Single Organisation



Roles and Responsibilities

Sponsoring Group

Responsible for:

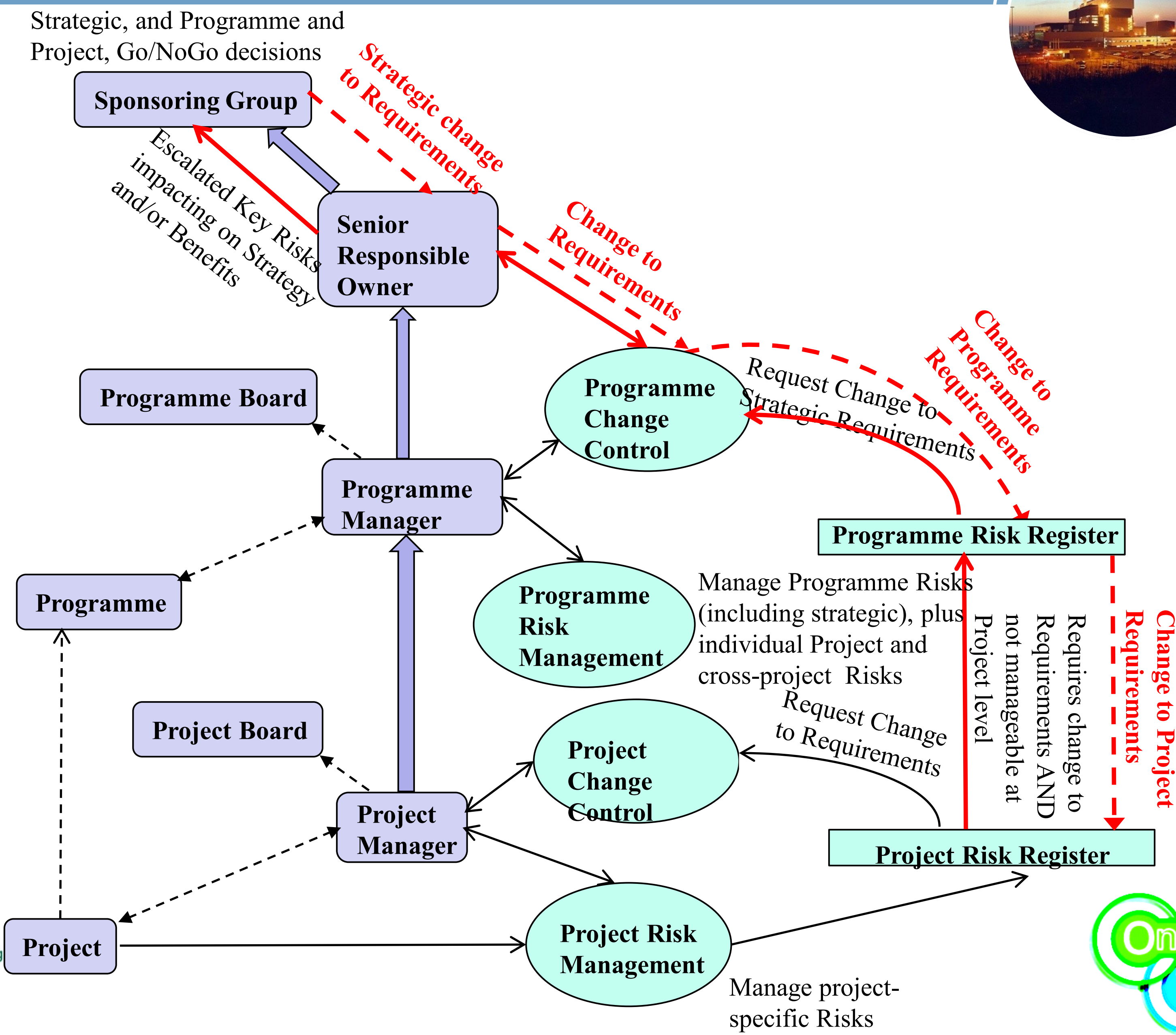
- Investment Decision
- Definition of Business Direction
- On-going alignment of programme to strategic direction of organisation

Senior Responsible Owner (SRO)

Responsible for:

- Securing investment for the programme
- Overall direction and leadership for programme
- Owns the Business Case
- Accountable for programme Governance
- Managing the interface with the Key Stakeholders
- Personal accountability for outcome of the programme

Process Integration and Information Flow

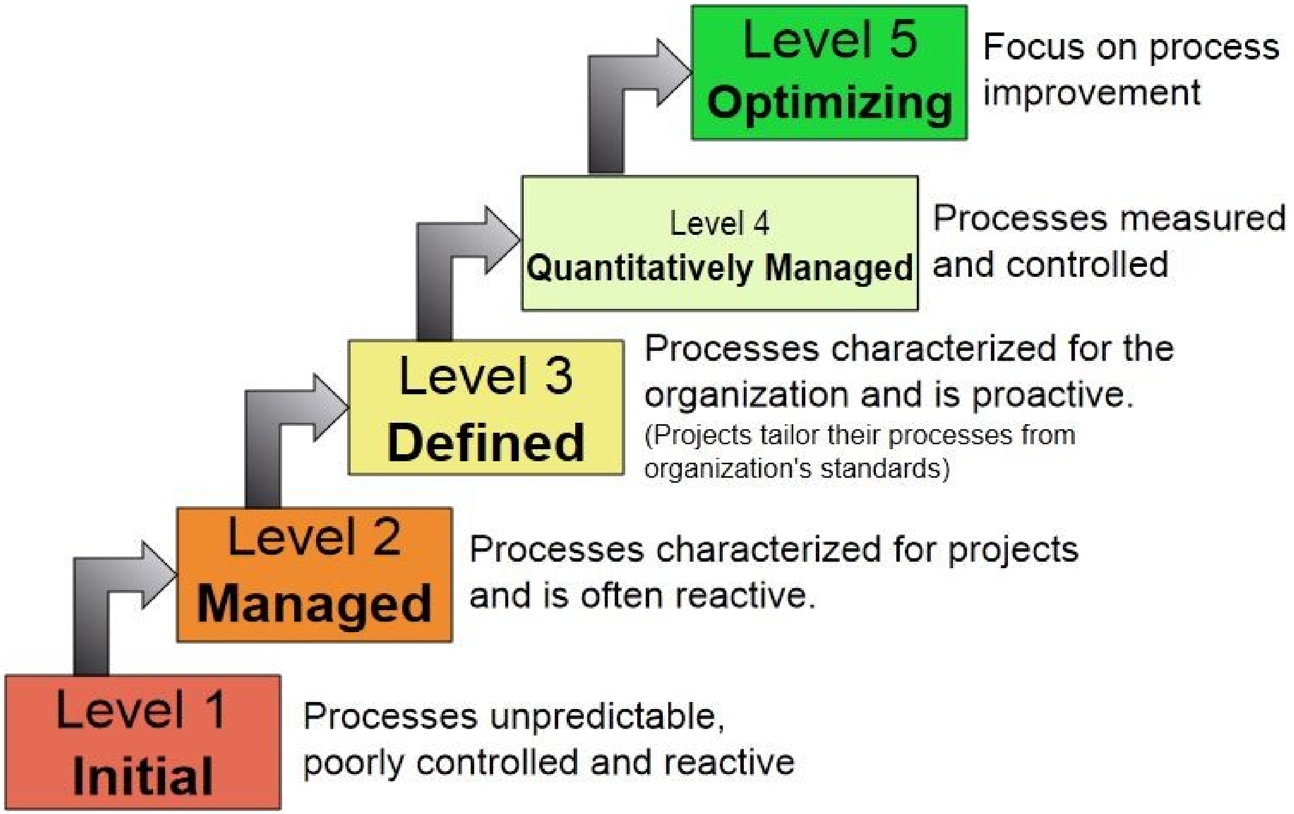


Challenges

For large complex programmes need to be CMMI Lev 3

Maturity Levels in Capability Maturity Model Integration (CMMI) for Development

Characteristics of the Maturity levels



Challenges

Maturity levels in Capability Maturity Model Integration (CMMI) for Development, core process areas for Maturity Level 3 - Defined

Abbreviation	Name	Core Process
DAR	Decision Analysis and Resolution	✓
IPM	Integrated Project Management	✓
OPD	Organisational Process Definition	✓
OPF	Organisational Process Focus	✓
OT	Organisational Training	✓
PI	Product Integration	
RD	Requirements Development	
RSKM	Risk Management	✓
TS	Technical Solution	
VAL	Validation	
VER	Verification	

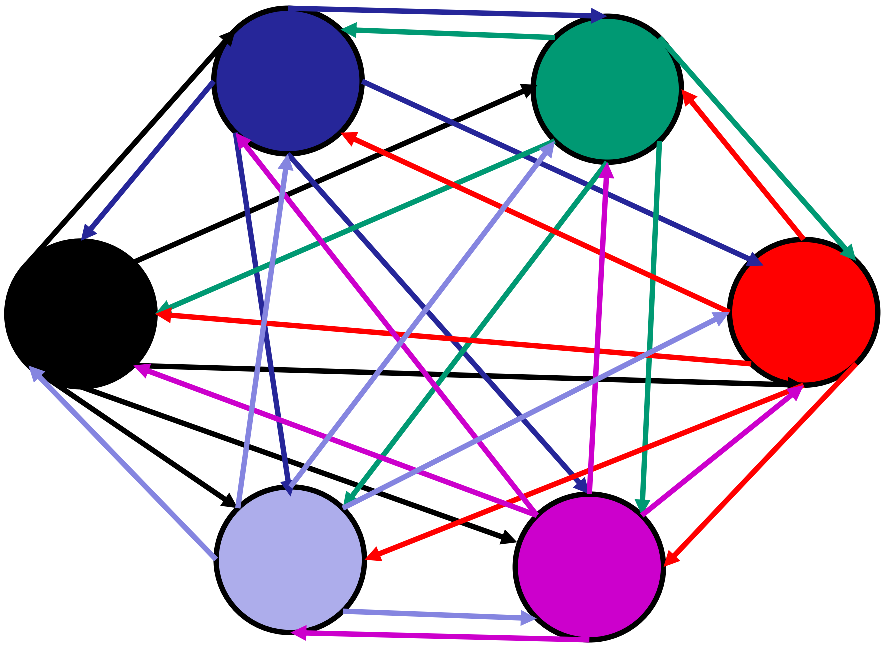
Challenges

At CMMI Level 3 need following Core Processes:

- Configuration Management (Level 2)
- Measurement and Analysis (Level 2)
- Project Monitoring and Control (Level 2)
- Project Planning (Level 2)
- Process and Product Quality Assurance (Level 2)
- Requirements Management (Level 2)
- Decision Analysis and Resolution (Level 3)
- Integrated Project Management (Level 3)
- Organisational Process Definition (Level 3)
- Organisational Process Focus (Level 3)
- Organisational Training (Level 3)
- Risk Management (Level 3)

Challenges

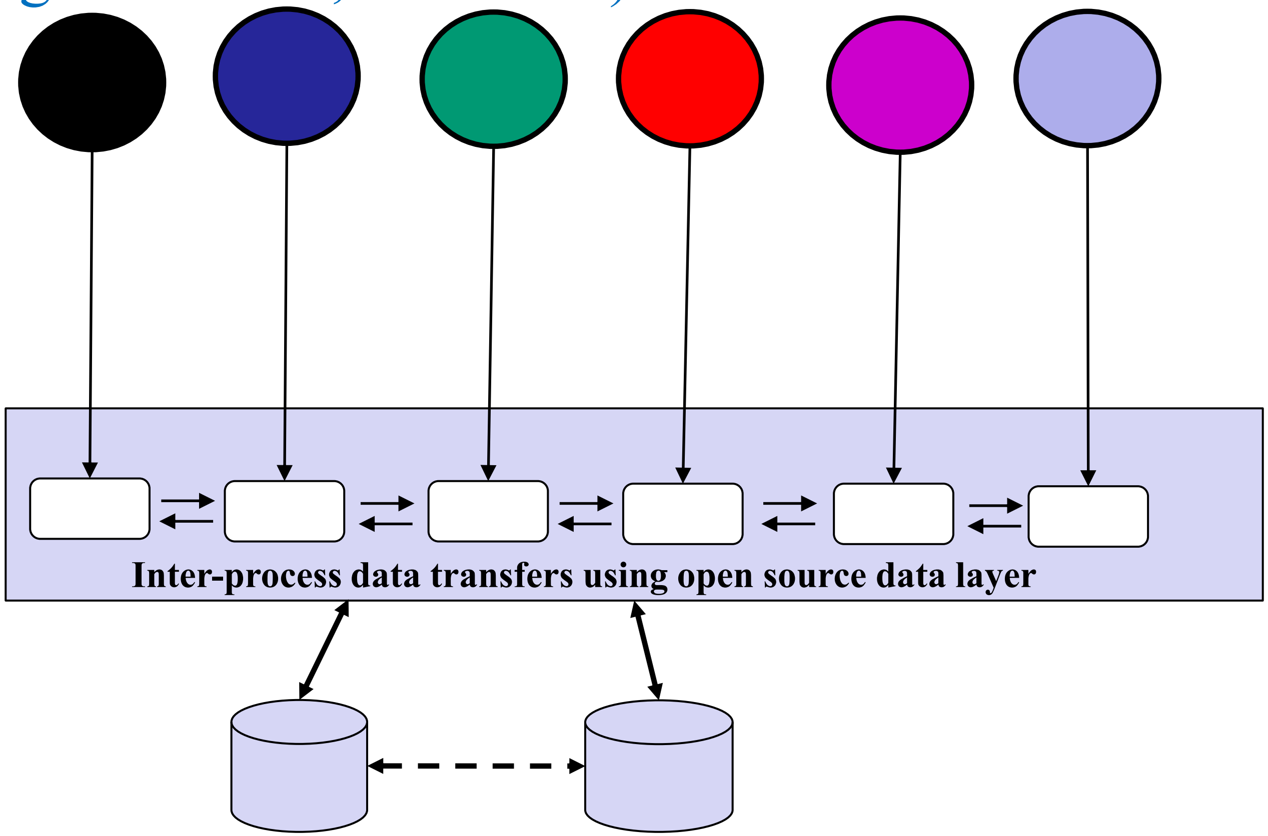
Need multiple, integrated tools & applications to manage complexities of large programmes and projects



- Integration of all applications/tools require N x (N-1) integrations at specific versions
- Each time an application/tool changes, may require (N-1) integrations with other application/tools

Challenges

- Consider an open source common data layer (e.g. IBM Jazz, or similar)



- Only necessary for 1 integration with the Data Layer for each application

Summary (i)

Summary

To manage the complexity

- A Requirements-driven approach has been described, which provides
  - A structured, top-down decomposition of the complexity into manageable sizes
  - Full traceability from the lowest elements of the Design/Implementation, back to the Requirements, and through to compliance documents (standards, etc.)
  - Verification mechanisms are an integral part of the mechanisms used in the approach
  - The Requirements-driven approach is supported by an integrated set of Project processes, which are also tightly coupled to bespoke modules and attributes in the DOORS Database

Summary (ii)

Three simple principles operate at the heart of this approach:

- Specify **what** you require of the system
- Show **how** you will implement it
- Provide the **evidence to prove** that you have produced the system that was required

These principles address the initial three questions, are valid for any development, and can be used across all business sectors

The Requirements-driven approach is one that attempts to ensure that

‘the right thing is built in the right way’

Summary (iii)

Requirements-driven Design alone is not sufficient to ensure the desired outcomes and delver the required benefits

Also need:

- A robust governance structure
- Core processes appropriate for organisations operating at a level ≥ CMMI Level 3
- Integration of Key Processes
- Sound delivery mechanisms to ensure that the necessary information reaches the Key Decision Makers in a timely fashion to support strategic decision making
- An adequate set of tools and applications to support the management of the complexity of large programmes and projects

Summary (iii)

The Requirements-driven approach is one that attempts to ensure that

'the right thing is built in the right way'

References:

'Managing Complexity in Large Development Programmes', series of three articles published in Project Manager Today (March – May 2010)

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Rivkin, S, (2010) Managing Complexity in Large Development Programmes, BCS Requirements Engineering Specialist Group Requirements Quarterly:

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About the Presenter

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Steve is a Project and Programme Manager specialising in systems integration, requirements management, and project/programme management. He has managed a number of high profile software development projects in various sectors. He has also defined and implemented Requirements Management strategies in the rail industry using the DOORS® Requirements Database. Steve is a Committee Member of the North West Branch of the Association for Project Management (APM). He has co-authored the Requirements Management section for the APM's Body of Knowledge 6th Edition, and given workshops and presentations in the nuclear sector describing a Requirements-driven Design approach to system development.

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