Managing complexity in large development programmes

Conformance to standards, multiple lifecycles, and whole lifecycle management

By **Steve Rivkin**

Last month Steve described a requirements-driven approach in which the DOORS Database was used to manage the requirements, providing full traceability and verification. This final article in the series considers some of the additional issues related to large, complex development programmes, such as: conformance to standards, multiple concurrent lifecycles, the management of legal and non-technical requirements, and whole lifecycle management.

In a European, or global market, it is essential to conform to accepted international standards. A generic, conformant design can be created which can be easily adapted with a degree of localisation for each specific country.

Illustration of a lifecycle for a Standard

There are many standards which are applicable to the whole lifecycle of a development project. Several key examples are described below.

ISO/IEC15288 is a standard that contains processes to support a complete V-Model lifecycle, and is used here as an illustration of how such a standard operates over a lifecycle.

The standard is concerned with those systems that are man-made and may be configured with one or more of the following: hardware, software, data, humans, processes (eg, processes for providing service to users), procedures (eg, operator instructions), facilities, materials and naturally occurring entities.

It establishes a common framework for describing the lifecycle of systems created by humans. It defines a set of processes and associated terminology. These processes can be applied at any level in the hierarchy of a system's structure. Selected sets of these processes can be applied throughout the lifecycle for managing and performing the stages of a system's lifecycle. This is accomplished through the involvement of all interested parties, with the ultimate goal of achieving customer satisfaction.

The standard also provides processes that support the definition, control and improvement of the lifecycle processes used within an organization or a project. Organizations and projects can use these lifecycle processes when acquiring and supplying systems.

When a system element is software, the software lifecycle processes documented in ISO/IEC 12207 may be used to implement that system element. ISO/IEC 15288:2008 and ISO/IEC 12207:2008 are harmonized for concurrent use on a single project or in a single organization.

Figure 1 shows a V-Model, and illustrates the requirements-driven design approach, with levels of requirements linked to corresponding levels of designs. The processes of Standards ISO/IEC 15288 and ISO/IEC 12207 are shown mapped onto the lifecycle according to how they would be used to support the lifecycle. The software processes are shown in blue, and the software lifecycle would normally start once the main subsystems have been identified and the appropriate level of functional definition and design has been reached in the main system lifecycle.

Mechanics of conformance

The mechanics of achieving conformance in the Requirements-driven approach is by the use of Compliance Arguments[1] (CAs) to merge in the requirements of a standard at the appropriate stages of the development lifecycle.

Requirements are created at the various stages of the development lifecycle, specifying what is required by the standard at each specific stage. Each CA references the clause in the standard that has necessitated the creation of the corresponding requirement at that stage in the lifecycle. The argument in the CA states why the requirement is necessary, and how it addresses the clause in the standard.

Multiple lifecycles

Where a standard operates throughout a lifecycle, it runs in parallel with the traditional development lifecycle. In development programmes that need to comply with safety regulations, a further Safety Case lifecycle also operates in parallel.

An example of this is shown in Figure 2 where the ISO/IEC 15288 lifecycle, a traditional V-Model development lifecycle,

1 CAs are described in the second article of this series, in the April 2010 issue of *Project Manager Today*

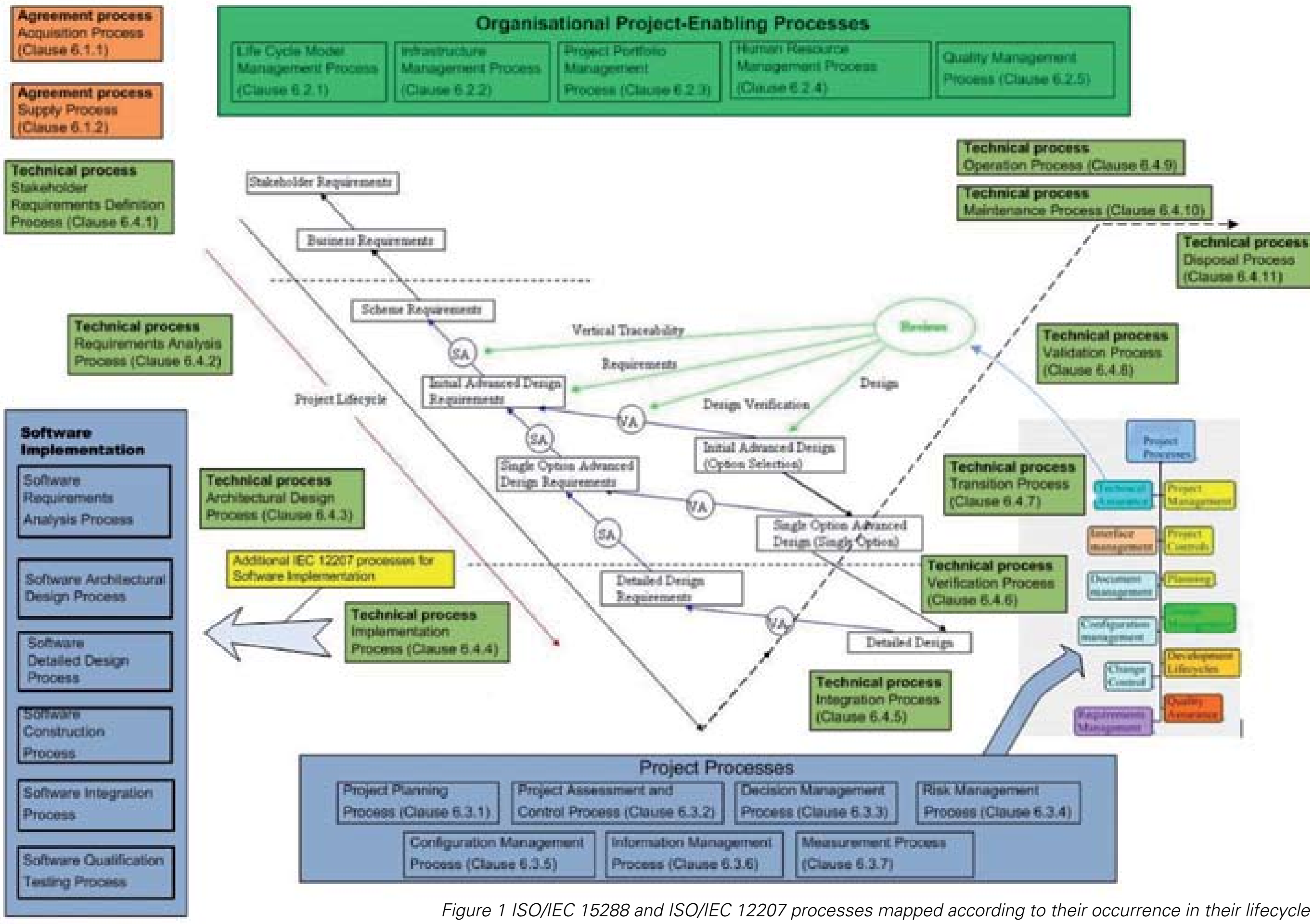


Figure 1 ISO/IEC 15288 and ISO/IEC 12207 processes mapped according to their occurrence in their lifecycle

and the UK Safety Case lifecycle for the nuclear industry, operate in parallel. Managing three, or more, separate lifecycles that operate in parallel would be extremely complex and error prone. The situation can be made more manageable by mapping all the lifecycles onto the traditional lifecycle, as this is the most widely understood.

The gateways for each lifecycle can be synchronised with those of the traditional lifecycle, and the contents/deliverables of the gateways for the additional lifecycles can be mapped onto the corresponding gateways of the traditional lifecycle.

Other additional lifecycles may occur during the main project lifecycle. A training package is shown in figure 2 as a 'mini V-Model'. This may perhaps be subcontracted out, and it starts during the 'Requirements definition' stage of the traditional lifecycle, and is delivered during the 'Implementation' stage. The training package may be developed using a V-Model, or some other lifecycle which is appropriate to the specific nature of the development.

A number of sectors in industry use specialist lifecycles that are specific to their sector. For example, in the rail industry in the UK, Network Rail uses the GRIP (Guide to railway investment projects) lifecycle, which is an eight-stage process designed to minimise and mitigate risks.

Where buildings are required, the RIBA (Royal Institute of British Architects) Outline Plan of Work may be used to help explain the different stages involved in the development of a building. It organises the process of managing, and designing building projects and administering building contracts into a number of key Work Stages.

In sectors that are concerned with production facilities ISO 15926 is used to facilitate the integration of data from various sources to support the lifecycle activities and processes of production. In development programmes that require specialist approaches to meet safety requirements, and where a high SIL (Safety Integrity Level)[2] is required, a number of standards can be incorporated into the main lifecycle, such as EN 50128 for the rail industry, IEC 61508/61513 for the nuclear industry, and IEC 61508/61511 for plant control in the refineries, petrochemical, chemical, pharmaceutical, pulp and paper, and power industries.

These specialist lifecycles can be merged into the traditional lifecycle programme and gateways, as described above for ISO/IEC 15288. Using Requirements-driven development provides full verification and traceability. As each stage of the lifecycle is

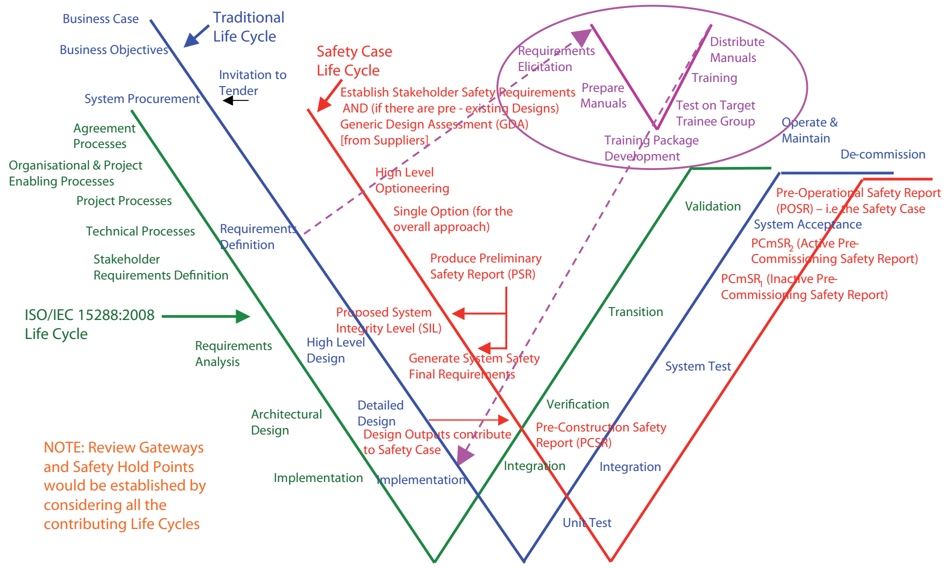


Figure 2 Multiple V-Models

2 There are four SIL categories, SIL 1 to SIL 4, where SIL 4, where SIL 4 has the most stringent requirements. If a system is designated SIL 0, there are no special safety measures required.

completed, the completed sets of requirements, and where appropriate, the designs, together with the corresponding verification evidence make an Incremental contribution to the Safety Case (Figure 3).

Managing commercial requirements

The Requirements-driven approach is capable of supporting both the technical and the non-technical requirements for a system. Continuing with the example of ISO/IEC 15228, figure 4 shows several sets of non-technical requirements (eg, legal and environmental) that are relatively high up in the requirements hierarchy.

The legal requirements are shown as having been generated from the Business Requirements and the Agreement Processes of ISO/IEC 15228, and are requirements that cover contractual arrangements and 3rd party agreements.

Similarly, the Environmental Requirements have been derived from the Stakeholder Requirements and the Agreement processes of ISO/IEC 15228, and the Safety Requirements have been derived from the Stakeholder Requirements and IAEA (International Atomic Energy Agency) documentation. These are requirements that may be binding contractually, and must move from being purely documented requirements to becoming part of the implemented system that meets these and all the other requirements that have been produced during the project lifecycle.

The project's legal advisors will be involved with formulating the various contracts and 3rd party agreements. Working with the Requirements Manager the legal team can provide the contractual and 3rd party agreement information that enables the legal requirements to be captured within the requirements hierarchy in the DOORS Database.

Without this capture, there is a risk that some of the legal obligations of the project may be overlooked during the design and implementation stages of the project, since there is normally little or no communication between the legal teams and the development teams. The contracts and 3rd party agreements solely constitute legal documents, but in system terms they require that some resulting activity must take place to satisfy the legal obligation.

Under normal circumstances, it is more efficient if generic designs are produced for the various elements of a system. Figure 4 shows how lower down in the requirements hierarchy, the legal, environmental and safety requirements merge into the technical requirements stream for implementation in the design. However some of these requirements, which may have been derived from non-technical sources, will require non-generic implementation. This ensures that all the legal obligations are satisfied by the project. As all elements of the designs, and all requirements, are traceable in DOORS, the sources of requirements, and the reasons why they are necessary, can be determined easily.

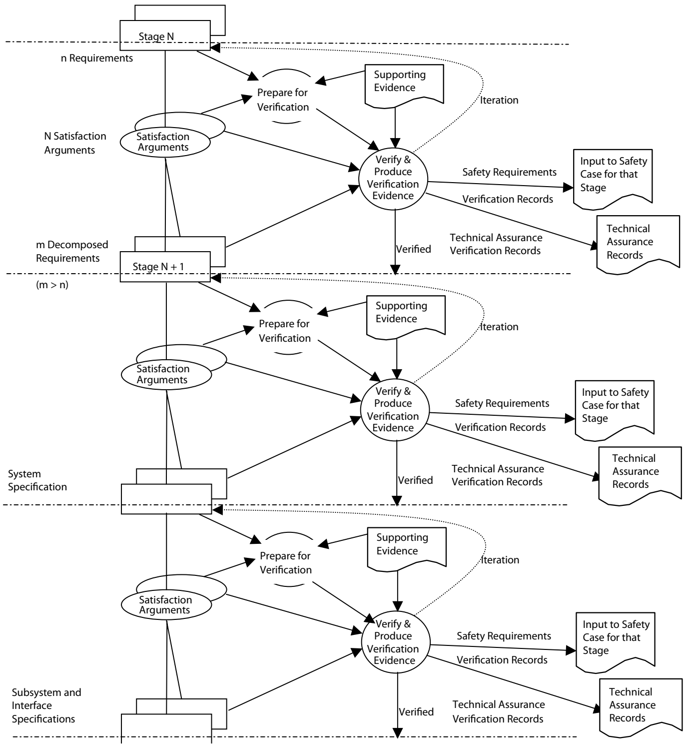


Figure 3 Incremental Contribution to the Safety Case

Managing multiple development contracts

In the second article of this series the importance was stressed of defining, early in the project lifecycle, the key project support processes that form part of the supporting project infrastructure. Typically such processes are documented as numerous sets of textual procedures, which are accessed as single documents only as and when they are required. In such a scenario it is difficult to see the context in which the procedure fits and its relationship to other procedures.

Currently, there are numerous graphical applications that allow process models to be captured as sets of connected graphical nodes. One of the key elements for success in any project is communication. Using graphical applications such as these, the behaviour and inter-relationships of the key project processes can be communicated graphically, and they can be easily assimilated by the project teams.

Where necessary, the text version of a procedure can be appended to the process diagram using hyperlinks. Also, it is possible to link through to the DOORS database from a node in some graphical applications (such as MindManager[3]), so that once the operation of a procedure is understood, subsequent actions can be performed directly in DOORS, allowing managers of the infrastructure processes to update data in DOORS relating to their process.

An example of this type of approach can be found by examining the APMG's graphical MindManager documentation for the PRINCE2 methodology. An example of a change control procedure produced using MindManager is shown in figure 5. Additional benefit can be gained in the future on similar projects by re-using some aspects of the infrastructure, subject to making a number of modifications to fit the new project context.

The creation of the key project processes that interact with DOORS helps achieve the integration of the project processes and infrastructure with DOORS. To assist further in the management of this integrated environment, PMConnex[4] is a product which can be used to create a project planning View of requirements in DOORS that are linked to activities in the programme, as shown in figure 6. Projects are stored in both the DOORS

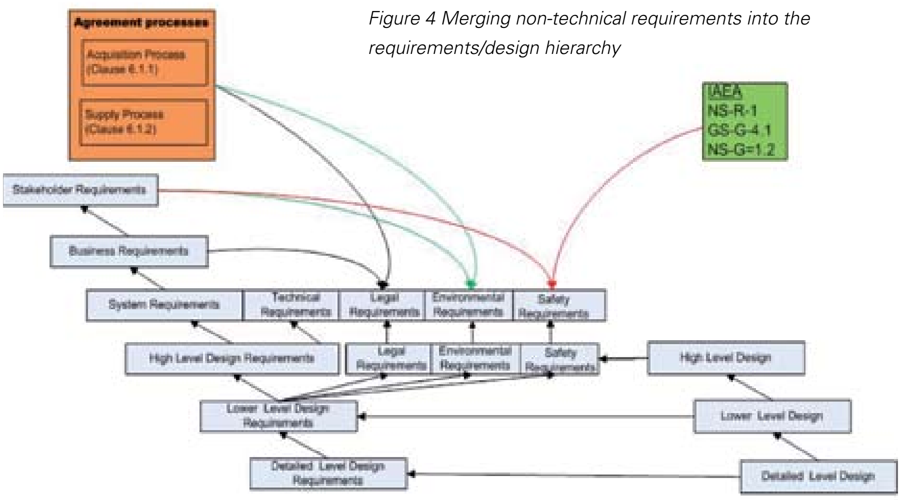
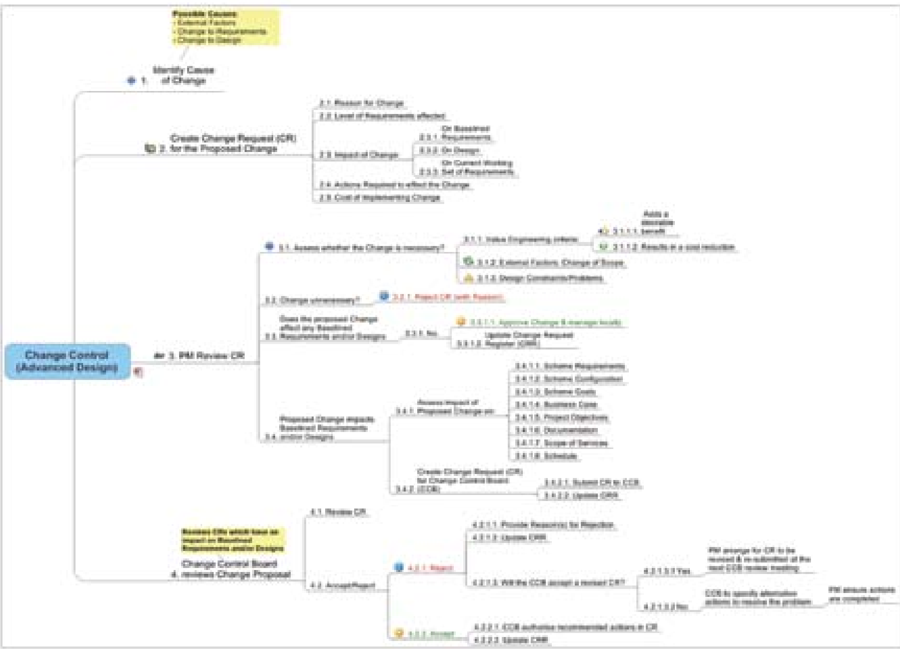


Figure 4 Merging non-technical requirements into the requirements/design hierarchy

3MindManager is a mind mapping application that is produced by Mindjet® (http://www.mindjet.com)

Figure 5 Graphical representation of project processes



Database and the PMConnex Database. Links can be established between the project's requirements and WBS elements and/or activities in the programme, and the projects in both databases can be synchronised to achieve alignment. PMConnex can produce project planning views between DOORS and Microsoft Project or Oracle Primavera.

The access control and remote working capabilities of DOORS are powerful features that can be used to support the management of multiple contracts. Sets of requirements can be allocated to, or produced by the various subcontractors, and the requirements in these sets can be connected to the requirements in the project team's development environment via Satisfaction Arguments (SA). (Note: SAs were discussed in the previous article, and a portion of the diagrammatic structure showing how SAs fit into the requirements hierarchy is shown in inset 1 of figure 7).

The subcontractors can evolve more detailed requirements and related designs within their own lifecycle and development environment, and be free to edit the requirements and operate their own change control. Using the access control facilities in DOORS, they cannot change requirements in the project team's environment, as they will only be granted read access to the layer of requirements in the project team's environment that they connect to with their SAs.

The subcontractors are able to access the project team environment using the remote access facilities of DOORS. The subsystems that are developed and implemented can be tested by the subcontractors against the initial set of requirements apportioned to them, and the subcontracted deliverables reviewed against contracted set of requirements. The completed subsystems can be subsequently integrated into the overall system during the subsystem and system integration testing phases of the project team's development lifecycle (see figure 7).

The right hand side (RHS) of the V-Model in figure 7 shows the progression through various levels of testing, from unit testing to system testing. When the requirements on the left hand side (LHS) of the V-Model are created, the method of testing also needs to be specified. This information is used to formulate the system test requirements, which are used to define what is needed in the Test Scripts. Peer-to-peer testing is conducted using the RHS Test Scripts to test the LHS requirements, producing a set of test results. A Test Verification Argument (TVA) is created linking each RHS test result to its LHS requirement, where the TVA shows how the test and test result verify that the LHS requirement has been met.

Operation, maintenance, and disposal of the system

On completion of testing and final acceptance, the system enters into its operational phase. The operational requirements need to be defined from the flow down from the Stakeholders' Requirements during the creation of the LHS requirements hierarchy. Similarly, the maintenance and support requirements are evolved during the creation of the LHS requirements hierarchy, and typically address a number of key areas:

- Performance of the maintenance contractors (eg, response time, problem reports, etc.)
- Condition monitoring of system assets
- Maintenance regime

The need to give early consideration to the Key Performance Indicators (KPIs) that are necessary to measure the performance of various aspects of the system was discussed briefly in the previous article. The resulting KPI requirements, produced as part of the LHS requirements hierarchy, enable the KPI monitoring and support procedures, plus any measuring mechanisms and systems, to be incorporated into the system design. The KPI monitoring and support procedures obtain metrics on the performance of the operational system, and also on the maintenance and support provided. This is stored as KPI Data (see figure 7, inset 2), which is used by the KPI monitoring and support procedures to produce regular performance reports against KPI targets.

Although the disposal of the system is not normally prominent in most peoples' minds during the design of a system, it is important that it is given adequate consideration during the design phase. Various factors such as build materials, construction, location, can impact on the options available for disposal when the system has reached the end of its operational lifetime. The disposal requirements need to be established as part of the LHS requirements hierarchy, as a set of requirements that are equally as important as any other system requirements.

The Operational, Maintenance and Support, and Disposal Requirements may exist for many years while the system is operational. It is important that they are subjected to periodic review to ensure that they remain valid in the light of legislation which is current at a future date.

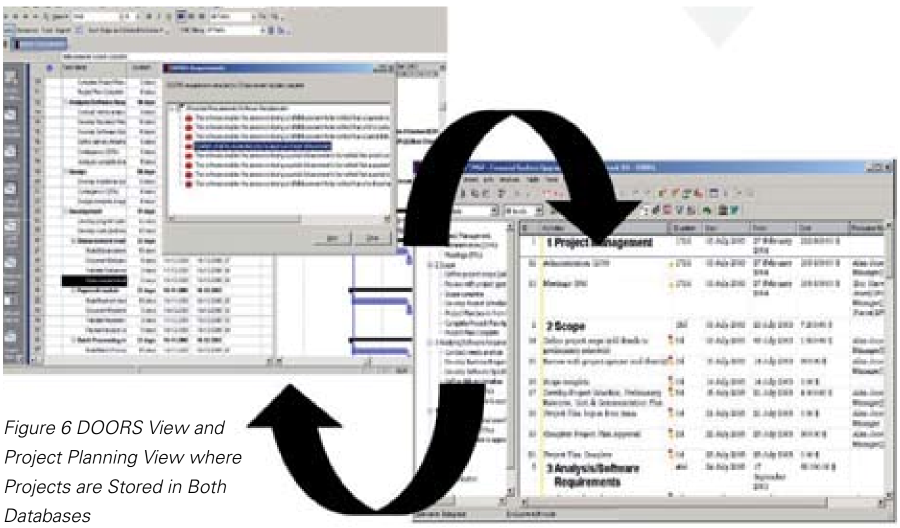


Figure 6 DOORS View and Project Planning View where Projects are Stored in Both Databases

4 PMConnex is produced by PMC (Project Management Centre Inc), 1 Antares Drive, Suite 550, Ottawa ON, K2E 8C4, Canada

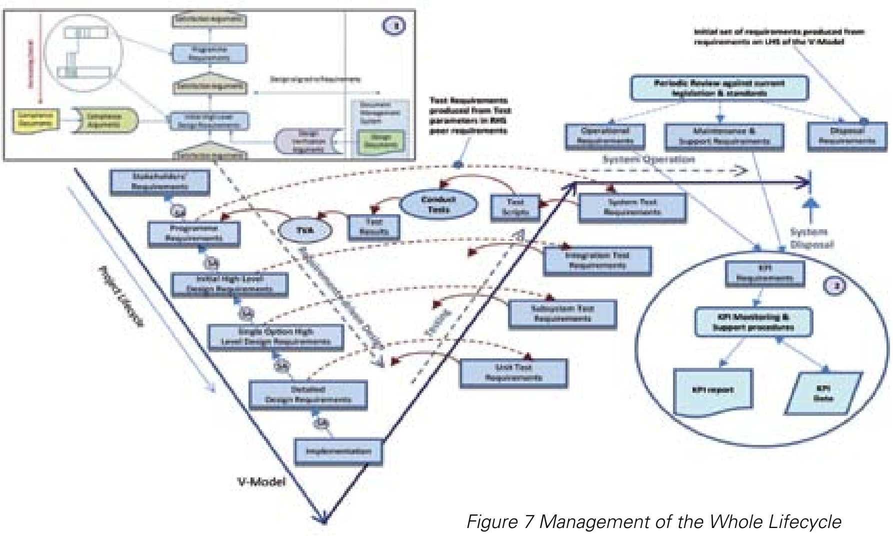


Figure 7 Management of the Whole Lifecycle

Summary

This series of three articles has highlighted a number of problems that can occur in large development programmes, and suggested ways in which they can be avoided. Particular emphasis has been given to a Requirements-driven Design approach. Although the structures may appear complex, there is a simple principle that operates at the heart of this approach: Specify what you require of the system, show how you will implement it, and provide the evidence to prove that you have produced the system that was required. This principle is valid for any development, so that the approach can be used across all business sectors.

The current world-wide recession makes it more important than ever to ensure development programmes are conducted efficiently and that they deliver products that meet the specified requirements. The Requirements-driven approach is one that attempts to ensure that 'the right thing is built in the right way'.

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After graduating in Applied Physics, Steve completed both his MSc and PhD in Computer Science at the University of Manchester. Subsequently, he gained considerable project management experience in high profile software development projects. As a commercial and operations manager for a leading software house, he supervised projects for the Industrial, Utilities, and Space Divisions. Consultancy assignments include project management and systems integration work in the transport sector, on both Highways Agency and major rail projects. Steve has had responsibility for defining and implementing Requirements Management strategies in the rail industry using the DOORS Requirements Database. He has also given workshops and presentations in the nuclear sector describing a Requirements-driven approach to system development. Steve is a freelance consultant, specialising in systems integration, requirements management, and project management. He is also available for presentations and workshops.

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