Chapter 4. Project Management

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4.1 Introduction

Nuclear projects need to apply a disciplined Project Management approach that includes suitable Quality Management arrangements. Nuclear Site Licensees and major nuclear contractors have a project management process as part of their quality management system. The Project Management process typically includes the following five stages:

The names and numbers of steps included in the process can vary from organisation to organisation and due to the use of different project management approaches. The Project Management process is normally based upon recognised good practice such as:

- BS 6079 Project management. Principles and guidance for the management of projects [1]
- BS ISO 21500 Guidance on project management [2]
- Association for Project Management (APM) Body of Knowledge [3]
- Project Management institute (PMI) A Guide to the Project Management Body of Knowledge (PMBOK® Guide) [4]
- International Project Management Association (IPMA) Standards [5]
- PRINCE2® [6]

The focus of this chapter is on major engineering projects that can be either new build or decommissioning projects. These types of projects are the most demanding in the nuclear industry. Nuclear new build projects, for example, face unique challenges because they are capital intensive, have very long project timescales, involve very technically demanding work and are subject to intense public and regulatory scrutiny. Project Management discipline is also applied to non-engineering projects such as significant IT developments and major management system improvements.

Particular challenges associated with large nuclear engineering projects are:

- Operating in a highly regulated environment
- Stakeholder management
- Effective allocation of risk
- Contractor selection to ensure they have the appropriate capability and capacity to deliver
- The establishment of a proactive nuclear safety culture with a strong focus on items important to safety (ITS) to prevent accidents, expensive rework and costly delays across the whole supply chain

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- Rigorous quality management through the project lifetime and across all areas to ensure that appropriate standards are specified and met
- Supply chain skill sets, to address key technical challenges such as the welding, fabrication, installation and commissioning of nuclear plant components

Very large programmes of work may require breaking down into a number of related sub-projects.

Given the nuclear safety implications and the complexity and cost of nuclear engineering projects, a strong nuclear safety culture and emphasis must prevail (see Chapter 3). All project organisation and supply chain members need to promote this culture, including adopting a disciplined and rigorous approach to Quality Management. For this reason, larger projects will typically have a dedicated Project Quality Engineer and team of engineers to support the project in achieving the high standards required.

4.2 Project Management Fundamentals

Project management focusses on planning and organising a project and its resources using various tools and techniques throughout the project lifecycle in order to deliver a defined scope within an agreed budget, to an agreed timeline or schedule and to the right level of quality. These fundamentals of Scope, Cost, Schedule and Quality when illustrated as a triangle show how changes to one aspect of the project fundamentals has a direct impact on the others.

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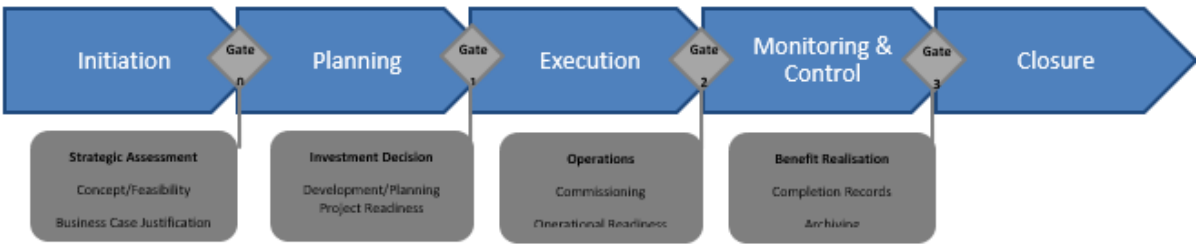
Compressing the project schedule, reducing costs or increasing the scope call all stress or even compromise the level of quality on the project if not properly managed. Equally, quality requirements must be commensurate with the project. Overly onerous quality requirements which are disproportionate to risk will add cost and consume the schedule, and too relaxed quality requirements may fail to meet the customer or regulatory requirements.

4.3 The Gated Process For The Project Lifecycle

A basic project stage gate process is shown in the diagram below and is typical for major projects although details and terminology may differ. Application of this type of process should significantly reduce non-value adding activities and yield the following benefits:

- Appropriate safety and technical development by each gate
- Good business governance
- Improved planning and alignment with business/technical requirements
- Earlier and more secure engagement of the supply chain
- Reduced project delays/abortive work
- Improved predictability of project performance

Stage gates are put in place as a key governance measure to control the project management process and independently review the projects readiness for advancement into the next stage of the project lifecycle and the allocation of the associated resources:



It is a challenge for organisations to establish a suitable gated process so that work that is minor and low risk does not get over-specified. This helps to manage the quality, cost, time triangle. A less onerous approach tailored to the risks involved, may be appropriate once a project nears the completion of its activities.

The project gated process enables effective governance. Gate reviews should be led at a seniority level such that they hold the project manager accountable for successful and compliant delivery of the project overall. The format and content of gate reviews should be tailored to a level which is appropriate given the complexity and cost of the project.

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Project stages may include sub-stages. The Initiation stage may include Concept, Feasibility and Definition phases resulting in the development of a project business case and functional specification, which will be reviewed and subject to business justification and strategic assessment at the stage gate prior to investing resources during the Planning stage.

The Planning stage may include Preliminary Design, Front End Engineering Design (FEED) and Detailed Design to develop the single option into a fit-for-purpose, cost effective design, able to deliver the performance requirements per the functional specification. Detailed Design should allow the design to be sufficiently developed to allow engineering procurement to be completed and to begin major procurement, manufacture, and construction activities, particularly in the case of long lead-time items (LLI). The investment decision gate should be a sanction and validation gate, as well as a Customer hold point. This will allow the final design to frozen after review both internally and by the Customer's engineering team if required.

All major project procurement, manufacture, construction and commissioning activities should be completed during the Execution stage. All project realisation information should be reviewed at the operational stage gate to ensure all commissioning is complete and the as-built condition is understood prior to operations in the Monitoring and Control stage.

The project close out review and post investment appraisal should occur once the project meets the functional specification requirements and the project has been formally transferred to operations. It is important that lessons learned are captured and are available for future projects to consider, this is known as Learning From Experience (LFE) and should be captured and recorded at the benefit realisation gate.

4.4 Project Arrangements and Documents

This section describes the arrangements and documents that would be typically expected of a major nuclear engineering project involving construction. It should be noted that detailed arrangements and terminology vary between countries and organisations.

The purpose of these arrangements is to:

- Ensure that nuclear safety requirements and implications are understood and appropriately managed, using the foundation that "Quality = Nuclear Safety"
- Establish and maintain consistent project management arrangements
- Ensure that all projects comply with the site licence
- Provide effective management arrangements built on risk, size and complexity
- Deliver projects to specified requirements
- Better define Licensee requirements to the supply chain
- Promote effective delivery in the supply chain
- Achieve maximum value from the supply chain

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- Improve project cost and schedule performance

Key project documentation and controls are discussed below. The extent that these are required depends on the complexity of the project in accordance with the graded approach (see Chapter 3) and many of these documents develop during the progress of the project. The expression “Delivery Organisation” refers to the organisation taking prime responsibility for delivery of the project; this may be the Licensee or the prime contractor.

Business Case

The key to success of a business is to understand where investment should be made in order to maximise the achievement of targets and objectives in the most efficient and effective manner possible.

It is essential that proposals for investment are presented in a clear and concise manner, while providing enough relevant information to enable sound decision making. The purpose of a business case is to provide justification for undertaking the proposed work. It evaluates the benefit, cost and risk of alternative options and provides a rationale for the preferred solution.

The Five Case Model [7] can be applied to minimise the chance of the project failing to meet its objectives due to inadequate scoping, planning and the consideration of associated risks. The model requires that the business case be considered from five interdependent perspectives:

1. Is the business case supported by a robust case for change that provides a rationale for intervention? (Strategic dimension)
2. Does the scope and schedule optimise net value to society? (Economic dimension)
3. Is the proposal commercially viable? (Commercial dimension)
4. Is the proposal sound from a cost and revenue perspective? (The Financial Case)
5. Are the delivery plans sound? (Management dimension)

Prior to the business case being submitted to the sanctioning body, it should be examined by an independent review panel in order to ensure that the content satisfies the above criteria. The business case is a management tool which develops, from first inception as an initial business case, through to the final business case. Various governance review points are required through the project’s lifecycle (Stage Gate Process), at which point funding can be requested for the next stage of the project.

Whilst striving to execute project delivery as efficiently and effectively as possible, history has shown that driving the completion of scope as quickly and cheaply as possible can lead to the project working to a schedule which is unachievable and results in cost overspend. Independent review should be carried out to ensure that the schedule is not overly

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optimistic, the risk profile is appropriate for the scope of work, and that value for money will be delivered.

Project Functional Specification

The Project Functional Specification is effectively the commitment made by the project on what will be delivered for the funding requested. It is key to managing project scope and to project governance. The specification bounds the scope of the project deliverables. It is also a key communication and vehicle for agreement between the project and its stakeholders.

The Project Functional Specification is the internal specification for the project at the strategic assessment stage gate and is not to be confused with a specification to be used for procurement via the supply chain. A functional specification or performance specification is defined within BS 7373-1 [8] as:

> *"A document that specifies requirements in terms of features, characteristics, process conditions, limits and exclusions defining the performance of the product'.*

The Project Functional Specification typically includes the following: Background; Scope; Requirements; Inputs/Feeds; Outputs/Products; Functional Performance; End State; Assumptions; Constraints; Dependencies; Exclusions; Annexes; References.

Project Execution Plan (PEP)

The PEP explains how the Delivery Organisation intends to deliver the specific scope within the agreed timescale, cost and to the appropriate specified requirements.

The PEP should accurately depict all the required management system arrangements that the Delivery Organisation intends to deploy in order to deliver the project.

Key focus should be the competence of the organisation and the methodology to be deployed in effectively managing the supply chain. The PEP should be periodically reviewed to ensure compliance to specified requirements.

Quality Strategy

The project Quality Strategy explains clearly how the Delivery Organisation will deploy their quality assurance (QA) and quality control (QC) processes to deliver the project to specified requirements. The strategy should be detailed in relation to the structure of the Delivery Organisation's quality arrangements, with special focus on supply chain management.

In addition, it is essential that the strategy defines the competence requirements for all Quality personnel and how the Licensee will disseminate the project Quality requirements into their supply chain.

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The Strategy needs to align with or include the QA/QC resource profile for the project.

Safety Case

The Safety Case is developed to demonstrate that the proposed activity fulfils all relevant legal requirements and minimises risk to as low as reasonably practicable (ALARP), whilst achieving:

- The strategic business drivers – the right job at the right time;
- The optimum method of implementation – in the right way;
- The use of relevant good practice.

The justification that the risk associated with a proposal is ALARP should be rational, equitable and defensible and requires that either:

- There is a net reduction in risk, from all types of harm, as a result of carrying out the proposal, and that the risk could not be reduced further except at a disproportionate cost; or
- Any net increase in risk is justified by the overall benefit, and that the risk could not be reduced except at a disproportionate cost.

The ALARP justification should recognise the overall risk impact across the facility and site and not just the risk associated with the proposal in isolation. The duration of the risks associated with the proposal should also be considered as part of the justification.

A new plant with no risk reduction role will need to demonstrate that risks are ALARP recognising that the benefits of the activity arise largely from the strategic commercial drivers.

In both cases, the safety case should show that the proposal is being done the right way, that is, that various options have been considered and no reasonably practicable way could be found to reduce risk further.

The most straightforward way to show that risk is ALARP is to use approaches which have already been accepted elsewhere, if relevant, that could include good practice from outside the nuclear industry. For new plants, relevant good practice usually means selecting appropriate design standards.

Knowledge Management Plans (also refer to Chapter 8)

A learning plan should be created in order to manage and apply knowledge effectively throughout the project lifecycle, before each stage of the project the Delivery Organisation is responsible for identifying and utilising appropriate learning. The outputs of the learning

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plan should be built into the PEP, estimates, programmes, plans, and risk management arrangements.

Supply Chain/Contract Requirements

The Delivery Organisation's supply chain or contract requirements are the general contract documents generated by the Delivery Organisation to its supply chain. It is essential that these documents adequately define technical and Quality requirements. As a minimum the following should be included:

- Required assurance and oversight
- Specifications, codes and standards
- Drawings
- Material Type
- Quantity
- Certification requirements
- Inspection requirements, at vendor and/or on delivery
- Functional testing requirements, at vendor and/or on delivery
- Cascade or flow-down of customer/client requirements as required
- Any special requirements such as packing, extra testing etc

Further information on Supply Chain Quality Requirements can be found in the UK Safety Directors' Forum (SDF) UK Nuclear Industry Good Practice Guide on Supply Chain Quality Requirements [9].

Focussed Audits, Reviews and Metrics

Key learning from nuclear projects is related to the importance of establishing appropriate assurance arrangements, including a focussed audit programme that covers all stages of the project, and all functions; this should also include nuclear safety culture implementation (refer to section 4.5).

Many nuclear projects fail to invest sufficient time and effort in planning assurance activities at the front end of the project. This can result in significant impacts on cost and schedule as organisations have made incorrect assumptions or have overlooked key activities.

It is highly recommended that delivery organisations engaged on nuclear projects establish an appropriate risk informed assurance plan so that adherence to the Safety Case and design intent is maintained.

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The examples in the figure above are not definitive lists and the actual audits, reviews, metrics selected will depend on the project and the requirements of the Delivery Organisation's management system. Audits, reviews, metrics and other assurance activities help to ensure that projects remain on track. It is very important to invest in assurance planning at the start of a project as opposed to relying on increased Quality control at later stages.

Contract Review Procedure

The Delivery Organisation's Contract Review process must clearly define how contract reviews are managed; the review must include all required Subject Matter Experts (SME), including Design, Project Management, Commercial, Health and Safety, Quality, Project Controls, Risk, Engineering, Construction and Commissioning personnel. All contract reviews should be recorded. A special focus for contract reviews is the currency of the contract specifications and standards, the Delivery Organisation's proposed tender questions related to contract selection and award and the quality of the proposed supply chain works information package. Additionally, the review should identify if there is any missing information within the supplied Delivery Organisation's works information pack.

It is essential that the Delivery Organisation tests the understanding of specified requirements within all tiers of the supply chain.

Specification Matrix

It is the responsibility of the Delivery Organisation to clearly define the relevant contract specifications and standards that are to be applied within the project/contract structure or project portfolio. The relevant specifications and standards should be identified on a matrix

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and as a minimum contain the title of the specification or standard, the current issue and any related or underpinning specifications or standards. The specification matrix should be managed as a live document and updated as required.

Works Information Package

The Delivery Organisation is responsible for compiling and issuing an accurate Works Information Package to each of their suppliers. The pack must contain all relevant Licensee supplied requirements such as specifications, standards, contract quality requirements, drawings and any specific forms or templates. The integrated project team must collate, review and approve the works information prior to issuing to the supply chain using the contract review process.

Approved Suppliers List

The Delivery Organisation is normally responsible for compiling and maintaining a Quality Approved Suppliers List. It is essential that the Delivery Organisation can provide documented evidence that all suppliers contained on the list have been subject to an appropriate assessment and selection process. This process typically involves considering supplier track record and other defined criteria.
Supply Chain Selection Procedure

The Delivery Organisation's Supply Chain selection process should be applied using a risk-based approach. The Delivery Organisation needs to demonstrate that a thorough review has been conducted against the supplied Works Information Pack issued to the potential suppliers. The process must consider all relevant aspects of the potential supplier's capability, such as Health & Safety (H&S) performance, Quality performance, financial stability, facilities and tooling, organisation and competence, and the supplier's specific supply chain management arrangements. It is important to select the supplier with the appropriate capability and capacity to complete the work to required standards.

Supply Chain Management Model

All Delivery Organisations working on major projects or project portfolios should generate a Supply Chain Model. The model should be risk-based and depict the totality of the supply chain and also identify the levels of audit, surveillance, inspection and test that will be carried out against each supplier.

Plant and Equipment Schedule

The Delivery Organisation's Plant and Equipment Schedule should include a full listing of the contract plant and equipment, the quality assurance and oversight arrangements that will be deployed against each plant item, the individual safety category or classification and the associated regulatory requirements (such as PUWER Provision and Use of Work Equipment Regulations assessment, pressure equipment directive, CE marking requirements etc). The schedule should identify specific resource requirements and inspection and test

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requirements allocated to individual items of plant and equipment, including factory acceptance test (FAT) and functional test requirements. It is essential that a delivery schedule is included which is well maintained, so that the Delivery Organisation can maintain an accurate resource plans and budgets.

Project Training Matrix

The Delivery Organisation is responsible for developing, implementing and maintaining a project specific Training Matrix. The matrix should identify all contract personnel and the level of training required for individuals against defined roles. A major project will require a standalone matrix, where a portfolio of projects may only require an overall matrix.

Suitably Qualified and Experienced Personnel (SQEP)

The Delivery Organisation is responsible for ensuring all personnel are SQEP. The organisation should develop, implement and maintain an agreed suite of SQEP records for each member of the team. Typical SQEP record pack contents are the incumbent's CV, training records, professional qualifications and associated role specification.

Quality Plans (also refer to Chapter 7 Quality Planning)

Quality Plans are typically produced for a specific deliverable such as a detailed design, manufacture of a key item, civil construction, inactive commissioning or active commissioning. The Quality Plan document is based on the sequential activities required to deliver the item or service. The activities are linked to; the relevant procedures, the person responsible and the documented evidence generated. Quality Plans also clearly identify hold points, witness points and required inspections. Paper versions of Quality Plans may also contain sign off boxes for the Delivery Organisation against each relevant activity. It is essential that all Quality Plans are approved prior to commencing work as this is a key control and supervision document.

Inspection and Test Plans (ITPs)

Inspection and Test Plans should be discipline specific and relate to the build and associated hold points to deliver the scope to the specified requirements. The Delivery Organisation should ensure that all suppliers generate Inspection and Test Plans. The benefit of this approach is to break the work down into manageable packages and to encourage concurrent Lifetime Record compilation. ITPs usually cover the phases of manufacture, construction and commissioning.

Risk Management Plan and Framework

The Delivery Organisation should develop and maintain a project Risk Register. The register should identify all relevant risks and grade them in order of significance. The register should be reviewed and updated on a regular basis in order to reflect current project risks. The Risk Management Plan should contain a set of allocated actions to manage identified risks to achieve predictable project delivery.

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Supply Chain Specification Dissemination Strategy

The Delivery Organisation has the responsibility to ensure that specified requirements are accurately disseminated, cascaded or flowed down throughout the supply chain. Therefore, it is a necessity that the Delivery Organisation has a clear Dissemination Strategy. This Strategy may be a section of the Quality Strategy or another project document.

The strategy should include appropriate nuclear safety and specification awareness briefings. A risk-based graded approach should be taken that takes account of the contractor's level of nuclear competence and awareness. It may be necessary to brief the contractor on each clause of the specification to ensure they have full understanding of the requirements.

In addition, the Delivery Organisation should have a schedule of regular meetings with key suppliers. Surveillances should be carried out to ensure that specified requirements have been successfully disseminated. In addition, all Licensee contractor induction courses should include appropriate safety, environmental and security awareness material.

Specification Awareness material that is included in the project and contractor inductions must be relevant to the scope of work being undertaken on the project.

Plant and Equipment/Product Release Procedure

The Delivery Organisation is responsible for authorising release of plant and equipment and product from a manufacturer's works. The Delivery Organisation may utilise their QC Inspection team to manage this process. The release process typically involves inspection of the plant, equipment or product and the associated records as specified in the relevant Inspection and Test Plan. Release of plant, equipment or products should only be carried out by SQEP personnel. Plant, equipment and products should not be released without verification that the required lifetime records are available; the issue of an appropriate release authorisation is required.

Goods Inward Inspection Procedure

The Goods Inward Inspection Procedure should be established on the Delivery Organisation's site or facility to receive plant, equipment, products and consumables. The process must ensure that all goods are received with a copy of the relevant documentation and are checked for quantities and transport damage. Any reservations against the delivered goods or documentation need to be recorded and inadvertent use of the goods prevented. Any goods that are found to be damaged or considered to be outside of specified requirements should be immediately quarantined. Goods and associated documentation, such as certificates, should be appropriately stored. Goods should be assigned an appropriate and unique identification number.

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Non-conformance Procedure

The Delivery Organisation is responsible for ensuring that a Non-conformance procedure is established. The procedure needs to apply both in the supply chain and on the Licensed site. The arrangements need to include:

- Non-conformance documentation, i.e. Defect Notes and Concessions;
- Quarantine arrangements; and
- Corrective Action, Rework, Re-grade or Scrapping arrangements.

Calibration Process

The Delivery Organisation is responsible for establishing and maintaining an appropriate Calibration process. All tools and equipment that require calibration should be uniquely marked and registered and be accompanied with the relevant calibration certification. Contractor calibration arrangements must be assessed and accepted by the Licensee.

Verification Process

The Delivery Organisation is responsible for ensuring that a Verification process is implemented and maintained in relation to Design outputs, releasing and installing Plant and Equipment, Lifetime Records and Commissioning. The process should define the levels of Site Licence holder and supply chain verification associated to specific work packages. The process should also identify the level of certification that will accompany the design outputs, plant and equipment, product or commissioning output. This is often managed by Validation and Verification plans.

Document Control and Records Management Procedures

The Delivery Organisation is responsible for ensuring that document control and records management procedures are implemented and maintained, both internally and within their supply chains. Documents that become records are included on the Project and Contract Records Schedule/Index. Records must be generated concurrent with design, manufacture, fabrication, construction and commissioning.

Lifetime Records

A sub-set of the records will require long-term retention for 30 years or more. Records in this category may be designated as “Permanent” or “Lifetime” records. It may be necessary to define a Lifetime Record Strategy.

LTRs must be generated and verified concurrent with project delivery activities. The Strategy must define the levels of LTR required for each contract discipline (Civil, Mechanical and Electrical) and identify how the LTRs are to be presented when complete. LTR compilation efficiency must be a key consideration, the use of LTR Indexes within the individual LTR is the most efficient method. This approach utilises specific indexes, which identify materials, consumables, Weld Procedures, NDT procedures, Test procedures, Welder Qualifications,

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NDT Qualifications and Calibration certificates. Whilst the original certification is held in Master Files, this practice can deliver major cost and schedule benefits.

Inspection Reports

The Delivery Organisation and supply chain are responsible for generating accurate inspection reports to capture all inspection results, including civil, electrical and instrumentation, mechanical build and fabrication. The gathered data can then be utilised to deliver Right First-Time metrics and associated trends.

Specified Storage Area

The Delivery Organisation is responsible for establishing a specified storage area on the Licensed site. The storage area should satisfy the relevant requirements of the associated Licensee's specifications and must be maintained to agreed standards. The specified storage area should contain a secure quarantine area.

Management Review

The Delivery Organisation is responsible for implementing a management review process.

The process must utilise the project assurance programme to plan the assurance and oversight activities for the financial year and use the findings to feed into the management review. This review forms part of the continual learning cycle promoted by ISO.

4.5 Nuclear Safety Focus In Projects

The primary objective of any Licensee has to be to establish a suite of robust nuclear safety arrangements within the organisation and their supply chain. The Licensee's Leadership must be fully committed to delivering this objective in each stage of their project (see Chapter 3). Supervisors must support and encourage conservative questioning and decision making. Human performance techniques are often utilised and play key to the success of many high-risk nuclear projects.

Within decommissioning nuclear projects there may be a need to deal with legacy nuclear waste/materials. All planning and arrangements need to safeguard the project, the workforce, the plant, the business, the community and the environment. Nuclear safety requires getting the design right and realising the design intent through the quality of workmanship. All plant and equipment need to be manufactured to the specified requirements.

A lot of new build projects are adjacent to active facilities. Each stage of a project must establish appropriate nuclear safety arrangements for both project activities and any ongoing nearby operations.

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Nuclear safety culture is about how everyone working on the project behaves. A vital aspect of this culture is the professionalism and example set by the project team. The responsibility and authority for nuclear safety must be well defined and clearly understood. The Project Lead Team must reinforce nuclear safety on a regular basis.

The culture should allow individuals to raise concerns without fear and demonstrate a questioning attitude by challenging assumptions, investigating anomalies and considering adverse consequences. The job does not proceed in the face of uncertainty.

The Challenge of balancing the demands of Quality, Cost and Schedule

The interaction and dependencies between Quality, Cost and Schedule must be clearly understood as described in section 4.2. This interaction will vary dependant on project complexity If there is a failure to recognise this interaction in design, the pressure will always come in the construction, manufacturing or installation stage. The focus will invariably shift to Cost and Schedule at the expense of Quality, with potentially significant nuclear safety consequences.

One key to avoiding problems is to define clear specification and acceptance criteria. It is important to avoid unclear general statements like “workmanlike finish” or “testing to be agreed with the contractor”. To mitigate the risks, designers need to produce a structured Plant and Equipment Schedule.

Key questions to be asked by Quality Professionals in all organisations in the supply chain are:

- Is the functional specification fully understood?
- Are the Design, Engineering Schedule and Technical Specifications absolutely clear?
- Are there clear dissemination and communication arrangements to ensure requirements are understood?
- Have adequate oversight arrangements been established?
- How many reviews and what involvement in reviews is required?
- What are the key items and issues to focus on in manufacturing and construction?

Intelligent Customer (IC) role

The concept of Intelligent Customer is based on the primary responsibility for the safety of a nuclear installation which rests with the licensee. The licensee must be able to demonstrate sufficient knowledge of the plant design and safety case for all plant and operations on the licensed site and must be in control of activities on its site, understand the hazards associated with its activities and how to control them, and have sufficient competent resource within the licensee organisation to be an ‘intelligent customer’ for any work it commissions externally [10].

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4.6 Independent Assurance

Independent Assurance is a function whose remit is to provide an independent professional opinion on the adequacy of plant and process to safely deliver the design intent in line with relevant nuclear industry standards and safety case methodologies.

Independent Assurance is normally undertaken on higher consequence safety case documentation prior to submission for acceptance at internal reviews at a Management Safety Committee or Nuclear Safety Committee. The expectation is that Independent Assurance comments will be adequately addressed by the project during the course of the Independent Assurance review. Nuclear Regulators take considered account of the demonstration of satisfactory Independent Assurance in undertaking their own assessments.

Independent Assurance will target key aspects aimed at confirming the adequacy of the design to be fault tolerant in relation to the intended process. The review should aim to identify any circumstances where there is a fault condition that could lead to a dangerous situation occurring. An example would be that the design has not recognised the potential for flammable gases in a vessel ullage with the potential for an explosion to occur.

It is important that an Independent Assurance assessor is suitably qualified and experienced (SQEP) and **independent**. Assessors must not be involved in the design or production of the safety case or have any ownership of the final output.

Independent Assurance focuses on issues that could undermine the successful achievement of the safety case, whether that be inadequate safety assessment or in the hardware itself (pipes, vessels, shielding etc). There is one consistent element, which is that potential for failures can lie in any aspect of design/manufacture/operation. Vigilance is needed at all stages and Independent Assurance provides one of the reassurances of adequate defence in depth.

4.7 Nuclear Safety Committees (NSC)

It is often a requirement of a Site Licence that nuclear sites have a Nuclear Safety Committee (NSC) which includes independent members. One of the key roles of the committee is to understand and challenge safety proposals to ensure that they are sound before they are referred for regulatory approval.

Safety cases and modification proposals are categorised as to their potential impact; only those with high impact are routinely considered by the Nuclear Safety Committee. Major project cases and modifications are often in this category, so the NSC provides independent advice to ensure the technical soundness of the project. Independent Assurance reviews are made available to the NSC.

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4.8 Key Learning From Nuclear Projects – Why They Fail

Nuclear projects can be complex, expensive and take several years from the original business case being made through to handover to operations or for decommissioning projects site clearance. Experience has shown that the more rigorous the up-front planning, the more likely that the project will succeed. The common pitfalls are:

- Unrealistic programmes/schedules
- Lack of front-end investment into assessing supplier's capabilities
- Out of date Licensee specifications
- Inaccuracy of Works Information
- Incomplete design/design amendments
- Contractors failing to understand the extent of and manage their own supply chain
- Failure to clearly disseminate specified requirements through multiple tiers of the supply chain
- Lack of contractor competent resources, work package managers, Project Management, Quality Control Inspectors and Subject Matter Experts in relation to welding and Non-Destructive Testing
- Focus on cost and schedule at the expense of Product Quality
- Main contractors failing to understand the complexity of the fabrication processes
- Unreasonable pressure placed on sub-contractors as a result of unrealistic programmes and lack of understanding in relation to complexity of build and specified requirements
- Supply chain failure to deliver Nuclear Grade materials, which are much more difficult to produce, test and certify
- Failure to hold the contractor to account for poor performance

More information on lessons learned can be found in the Further Reading section.

Further Reading

Nuclear Safety Culture

Guidance on the application of nuclear safety culture to nuclear new build is provided in the Royal Academy of Engineering's publication Nuclear Construction Lessons Learned Guidance on best practice: nuclear safety culture [11]

The World Association of Nuclear Operators (WANO) has published a principles pocketbook on the traits of a healthy nuclear safety culture [12]. The IAEA have released a harmonised safety culture model [13].

Additional Annex I of ISO/TR 4450:2020 Quality management systems — Guidance for the application of ISO 19443:2018 – sets out additional points of consideration for nuclear safety awareness training for personnel [14].

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Nuclear Safety in UK Construction and Manufacturing

Nuclear Safety in construction is all about realising the design intent and this requires that the Quality of Workmanship meets the specified requirements. ONR Technical Assessment Guide NS-TAST-GD-076 [15] "Construction Assurance" contains general guidance and advice on aspects of civil engineering construction assurance.

Relevant guidance is provided in the following ONR Technical Assessment Guides:
NS-TAST-GD-005 Guidance on the Demonstration of ALARP (As Low As Reasonably Practicable) [16];
NS-TAST-GD-050 Periodic Safety Reviews (PSR) [17]; and
NS-TAST-GD-080 Challenge Culture, Independent Challenge Capability (including an Internal Regulation function), and the provision of Nuclear Safety Advice [18].

Guidance on the Nuclear Safety Committee is provided in ONR Technical Inspection Guide NS-INSP-GD-013 [19].

Lessons Learned

The Royal Academy of Engineering publication Nuclear Lessons Learned [20], published in 2010, identifies lessons learned from a number of new build projects

IAEA publication NP-T-2.7 [21] provides guidelines and experience from nuclear power plant construction projects.

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Revisions

Revision date	Description	Contributors	Editors
January 2019	Hypertext links checked and updated. Minor textual changes made reflecting formation of ONR in April 2014, formerly NII / HSE. More general introduction added. Edit carried out to improve readability. Additional references to internationally recognised Project Management approaches added. Additional hypertext references added.	Richard Hibbert, Mike Underwood, Iain McNair, Stuart Allen, Tammi Smith, Victoria Derbyshire, Nathaniel Martin, Martin Davies	Andrew Mullinder, Iiliana Adamopoulou
January 2023	Content and format updated by NNG.	NNG Steering Group	NNG Steering Group

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