Improving Safety Culture During the Construction Phase of Nuclear New Build Projects

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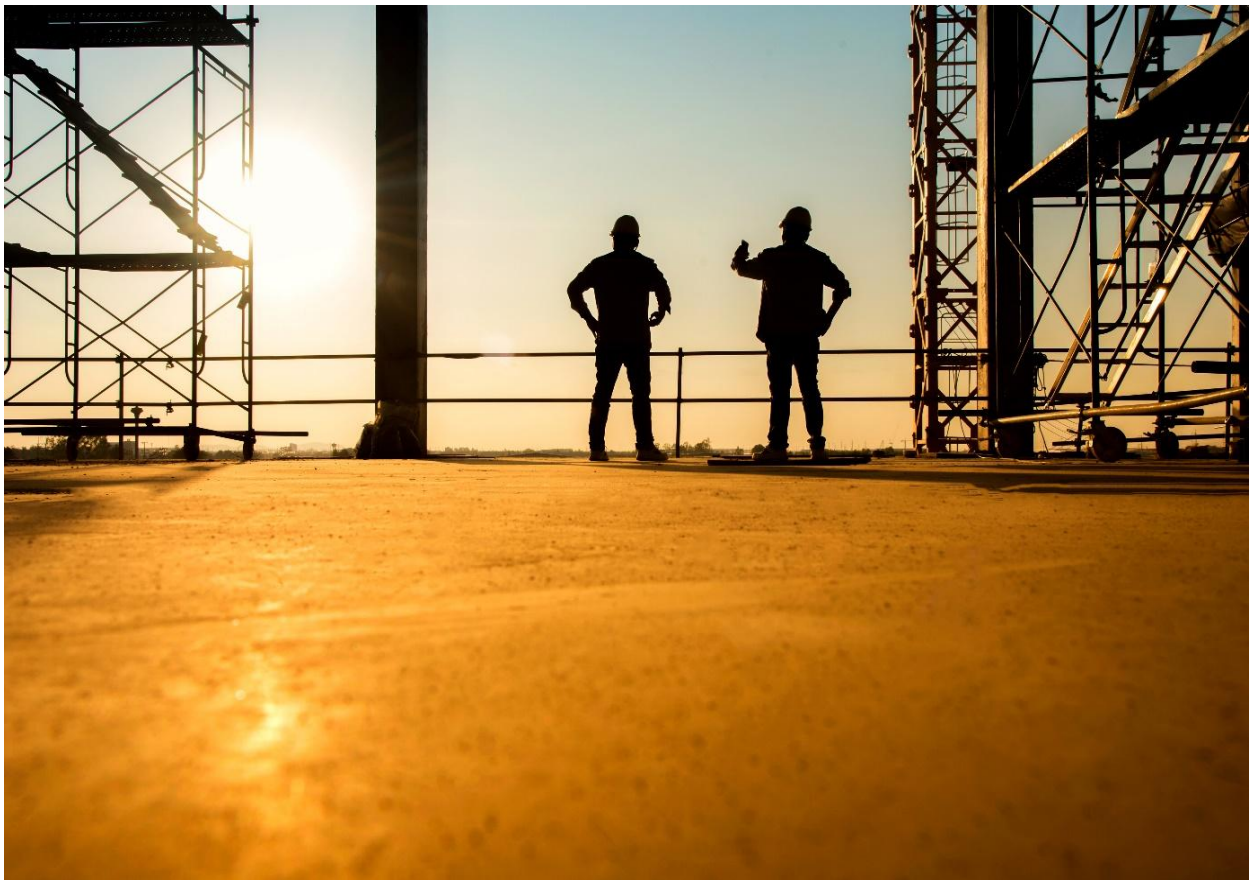

Abstract

The UK nuclear industry is in a period of growth and requires large workforces in relatively short timeframes. Traditional approaches to founding a safety culture, like those adopted throughout much of Great Britain's (GB) established nuclear industry, may not be appropriate or feasible for nuclear new build (NNB) sites. Therefore, this study explored current methods and challenges in developing a strong, homogeneous safety culture for NNBs in GB; and what actions could be recommended to enhance safety culture, safety performance and quality. A literature review was conducted to identify common factors within safety culture from NNBs and similar mega construction projects. Additionally, 16 semi-structured interviews were carried out as well as four focus groups with 38 participants based at an NNB construction site. Data collected from the interviews and focus groups were assessed using content analysis. Results were consistent with the literature, that leadership, organisational learning, training, collaboration, and engagement were key factors to developing and maintaining a strong safety culture. Findings suggest that understanding nuclear safety culture during the construction phase of an NNB remains unclear and requires further investigation and development. Observations, challenges and recommendations arising from the study's findings are discussed.

Keywords: Nuclear New Build, Construction, Nuclear Safety Culture, Mega Projects, Content Analysis

Acronyms

Acronym / Abbreviation	Definition
CDM	Construction (Design and Management) Regulations
EDF	Electricité de France
GB	Great Britain
HPC	Hinkley Point C
HSE	Health and Safety Executive
HS2	UK's new high-speed railway
IAEA	International Atomic Energy Agency
INPO	Institute of Nuclear Power Operators
INSAG	International Nuclear Safety Advisory Group
LTI	Lost Time Injury
NNB	Nuclear New Build
ODA	Olympic Delivery Authority
OL3	Olkiluoto 3
ONR	Office for Nuclear Regulation
SQEP	Suitably Qualified and Experienced Person
UK	United Kingdom
US	United States of America
WANO	World Association of Nuclear Operators

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1. Introduction

In 2023, approximately 9% of the world's energy was provided by nuclear power (International Energy Agency, 2023). This is estimated to increase to 2.5 times the current capacity by 2050 (International Atomic Energy Agency (IAEA), 2024). With the demand for nuclear power rising, the United Kingdom (UK) is intent on increasing its nuclear capacity (Burnett, N., Hinson, S., & Stewart, I. 2024; World Nuclear Association 2023) however, most reactors in the UK are due to be retired by the end of 2030. Hinkley Point C (HPC) in Somerset is the first of the new generation of nuclear power plants under construction, with further sites also projected. Such mega-projects, along with other nuclear sector commitments, generate the need for workforces at a significant scale and in relatively short timeframes to deliver projects at speed.

In the context of HPC alone, there have been approximately 18,000 people working directly on the project and with 12,000 workers based on site, it is the largest construction site in Europe (HPC Media Team, 2025). In addition to the scale of the workforce, high contractorisation means that a significant number of workers will be employed across different organisations, many of whom having travelled from various countries around the world. As a result, different organisational and national cultures are required to work together which could pose potential challenges due to the presence of different languages and communication styles.

With the above points in mind, it is accepted that people working for these organisations will hold a variety of beliefs and attitudes to safety which will be influenced by the values and cultures of their respective organisations. Whilst some of these organisations may have healthy safety cultures, others may have safety cultures which are less mature. Additional challenges commonly faced by the construction industry, such as high turnover rates, may also make it difficult for new nuclear projects to sustain changes to beliefs and attitudes towards safety. This poses three primary challenges:

- Some contractors may hold beliefs and attitudes towards safety which are not appropriate for construction activities carried out on a nuclear licensed site.
- A wide range of organisational and national sub-cultures could result in conflicting values, attitudes and beliefs as to how safety standards are applied.
- The time available to effect behaviour change may be more constrained than in other industries.

Traditional approaches to founding a safety culture, like those adopted throughout much of Great Britain's (GB) established nuclear industry, may not be appropriate or feasible for nuclear new build (NNB) sites for the reasons outlined above. However, the risks because of poor safety culture are high for onsite workers in terms of industrial accidents and for nuclear safety in terms of poor-quality standards.

As a result, the Office for Nuclear Regulation (ONR) has requested a scoping study to provide a greater understanding on how NNBs can promote, strengthen and maintain a positive safety culture in GB and will consider the following questions:

1. What has already been done and works effectively in relation to building a strong safety culture for NNBs, mega construction projects, or other comparable domains?
2. What are the gaps or challenges in developing a strong, homogeneous safety culture for NNBs in GB?
3. What actions could be recommended to enhance safety culture, safety performance and quality for NNBs in GB?

2. Methodology

This paper reviews existing literature and explores the perspectives and experiences of industry experts through interviews and focus groups. The reported findings within this document will take both the literature and research data into consideration, enabling a more comprehensive understanding of nuclear safety culture whilst also allowing for observations, challenges and recommendations to be identified.

2.1 Literature Review

A literature review was conducted to identify common factors in safety culture from NNBs and similar mega-projects from the construction industry. An initial broad search was conducted using PubMed, Scopus, Web of Science, Google Scholar and the Health and Safety Executive and Major Projects Association websites, to identify available literature and case studies. Abstracts were reviewed for relevance to the study and were excluded if they did not meet the inclusion criteria. Search terms used are summarised in table 1 below.

Table 1. Summary of Literature Review Search Terms

Search Terminology	
Nuclear New Build	Safety Culture
Nuclear Power Plant	Human Factors
Construction	Behavioural Safety
Construction Safety	Safety Performance
Mega / Large Construction Projects	Cross Cultural Communication

The literature search was limited to articles and reports published in English and were included in the review if they examined the relationship between any of the following: safety culture, safety performance, human factors, large scale construction projects, cross-cultural dynamics and nuclear power plants. Articles that focused on only one of these factors did not meet the inclusion criteria and were therefore excluded.

As this study focuses on GB culture, articles and case studies were also screened based on their geographical location. However, where information was limited and learning could be gained from other projects around the world, this was considered acceptable to obtain further learning around the current topic. For example, a case study published in an academic journal based on the building of the Øresund Bridge between Denmark and Sweden was included (Spangenbergen et al., 2003) since this covered both construction safety and, cross-cultural and national issues.

Relevant articles and case studies were also identified through the journal article reference lists and recommendations from subject matter experts. Grey literature was also included in the search and included organisational reports, newsletters, government documents and policy papers identified by using the key search terms in an internet search engine. Additionally, safety culture insights were drawn from UK mega construction project case studies. Included within this review are, the London 2012 Olympic Park, Thames Tideway Tunnel, and Thameslink Railway projects. Information about how these projects were managed and any safety culture insights drawn from them are discussed in section 3 of this report.

2.2 Interviews

Semi-structured interviews were carried out with a purposive sample of sixteen individuals working across a range of roles and organisations within the nuclear and construction industries. Roles included Nuclear and Safety Inspectors, Senior Construction Managers, Nuclear Safety Culture Specialists and a Human Factors Engineer. This is summarised in Table 2 below. Stakeholders were identified for their

key roles in NNB projects, or for their experience within previous mega-construction or nuclear projects, enabling for a wide variety of perspectives to be shared. Some participants were also recommended by other interviewees to take part in the study.

Table 2. Interview Participant Summary

Role	Num. of People Interviewed
Human Factors Engineer	1
Inspector	9
Nuclear Safety Culture Specialists	3
Senior Construction Mangers	3

Participants were contacted via email and once a participant had indicated their willingness to be interviewed, they were sent a consent form outlining the objective of the project, what the interview would cover and how their data would be treated. Interviews took place remotely via Microsoft Teams and lasted approximately one hour. Interviews were recorded with the permission of the interviewee for further analysis whilst another researcher simultaneously made written notes of the key themes from the conversation.

A semi-structured interview schedule was developed (see Appendix A) covering the knowledge and experience of participants regarding nuclear safety culture in mega-construction and NNB projects. Questions were adapted according to the participants' knowledge and experience to ensure questions remained relevant. Prompts were used to encourage participant engagement and gain a deeper understanding of the topics discussed. Following the interview, participants were sent a debrief form explaining how their data would be managed in the report; sample consent and debrief forms can be found in Appendices B and C. Data collection discontinued when saturation was reached, whereby the final interview had demonstrated significant comparative similarities and differences to those conducted previous (Glaser et al., 1999; Malterud et al., 2016).

2.3 Focus Groups

Four focus groups were carried out in-person with forty participants based at an NNB construction site. This included individuals across a variety of roles such as, but was not limited to, site supervisors, and workers within the mechanical and civil workstreams. A wide variation of roles and individuals were selected to ensure views and experiences were captured across different levels and specialisms of the project. Participants were identified and focus groups organised by a Point of Contact based at the site. Briefing information was given at the start of each focus group and consent obtained verbally; all participants were free to leave the focus group should they no longer wish to take part in the study.

Each focus group lasted approximately one hour and fifteen minutes. Written notes were taken to capture key quotes and a summary of experiences and views relevant to the studies aims. A semi-structured method (see Appendix D) was used to support flexibility in exploring emergent themes during the discussion (Easterby-Smith et al.,2015). At the end of each focus group, participants were given a debrief form (see Appendix C).

2.4 Data Analysis

Data collected from the interviews and focus groups were assessed using content analysis, a method which aims to identify trends and patterns of words, themes and concept. Based on the results of the literature review, words, and sets of words were chosen for coding, for example, leadership, high turnover, quality, safety, and training. During the interviews and focus groups, frequency of codes was recorded to identify patterns within the data, information deemed irrelevant to the purposes of this study was not quantified. Data was then assessed, and similar codes grouped together into a category that would determine the key themes of the study (Carley,1993). Frequency for each theme was totalled per

interview and focus group and given a weighting score of one to five (one being the theme with the lowest frequency score and five being the theme with the highest frequency score). The scoring results from the content analysis can be seen in Appendices E and F. The process of content analysis can be seen summarised in Figure 1 below.

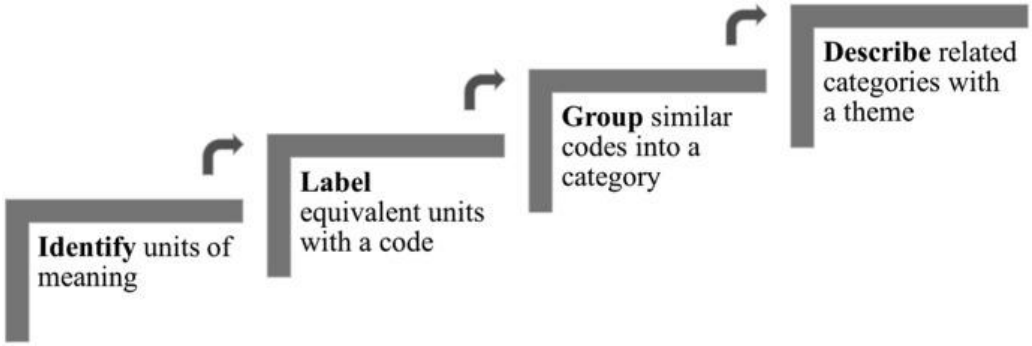

Figure 1. The Process of Qualitative Content Analysis (Kleinheksel et al., 2020)

3. Literature Review

This section presents the results from the literature review in which academic articles, grey literature and case studies were assessed (see section 2.1). The following subsections analyse and discuss findings from mega construction and nuclear projects as well as the wider nuclear industry, which may be applicable to the safety culture of NNBs during their construction phase. Evaluating available literature provides a summary of existing knowledge and builds a foundation in which to interpret the data collected from the interviews and focus groups. It is also advantageous in identifying underdeveloped areas of research which require further consideration.

3.1 Definition of Safety Culture

Research in the field of safety culture and safety climate has been ongoing since 1980, when Dov Zohar defined safety climate as *"employee perceptions about the relative importance of safe conduct in their occupational behaviour"* (Zohar, 1980). These perceptions are influenced by the attitudes and behaviours of people's management, supervisors and workmates. There have since been many other definitions of safety climate, but there appears to be no universally accepted definition.

The term 'nuclear safety culture' is reported as originating in the 1986 IAEA International Nuclear Safety Advisory Group (INSAG) 1 report after the Chernobyl disaster (INSAG, 1986), later superseded by INSAG 7 (1992). However, the concept was first properly defined in the INSAG 4 report (1991) as "*That assembly of characteristics and attitudes in organisations and individuals which established that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance"* (p. 1).

Since then, many general definitions have been published, including from the UK Health and Safety Commission (1993) which defines safety culture as *"The product of individual and group values, attitudes, perceptions, competencies and patterns of behaviour that determine the commitment to and the style and proficiency of an organisation's health and safety management. Organisations with a positive safety culture are characterised by communications founded on mutual trust, by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures"* (p. 23).

Simpler descriptions include James Reason's (1998) theoretical depiction of safety culture as consisting of five elements:

- An informed culture
- A reporting culture
- A learning culture
- A just culture
- A flexible culture

Reason considered the ideal safety culture to be the engine that drives the system towards maintaining maximum resistance to its operational hazards. It requires a constant high level of respect for anything that might defeat safety systems and defences, including commercial concerns. It means 'not forgetting to be afraid' and having a respectful wariness for the complex opaque defence-in-depth systems that characterise high hazard, high reliability industries. Such systems can hide latent conditions that can be realised as accidents and incidents when the relevant contributory factors coalesce. Due to their origins, the concept of safety culture is associated with the prevention of major organisational accidents, whereas safety climate is associated with the prevention of occupational accidents. The two concepts frequently overlap when discussing safety culture.

For the purposes of this report, safety culture is being examined in the context of preventing occupational injuries in construction workers but also in ensuring a respectful wariness about how poor building standards could lead to an organisational nuclear accident in the future. The research agenda will therefore take due cognisance of the defined characteristics of both safety climate and safety culture.

3.2 Safety Culture in the Nuclear and Construction Industries

The academic literature on the topic of safety culture is expanding in several high risk, high reliability industries, including the construction industry and the nuclear industry (Benoit, 2021; Morrow, Koves & Barnes, 2014; De Castro et al., 2013). The nuclear industry has also published numerous reports on safety culture via industry organisations such as the IAEA (1997; 1998; 2002; 2015; 2016) and Institute of Nuclear Power Operators (INPO; 2010; 2013; 2021) and World Association of Nuclear Operators (WANO; 2013). These reports and papers focus on safety culture in operational nuclear power plants; therefore, it is important to consider that they may not accurately reflect safety culture during the construction phase of an NNB.

The published academic research on the construction industry focuses on a wide range of issues, such as the development of safety management systems (Oswald et al. 2018; Choudhry, Fang and Ahmed, 2008), leadership in construction (Simmons, McCall & Clegorne, 2020) and safety and risk behaviour (Guo, Yui & Gonzalez 2015; Li et al., 2015; Guo, Yui & Gonzalez, 2016). Numerous studies focus on how to measure and manage safety culture in construction, see Berglund et al., (2023) and Tang (2025) for reviews. Other studies refer to the attitudes, values and perceptions of construction workers in terms of 'safety climate' (Melia et al., 2008; Schwatka, Hecker & Goldenhar, 2016; Xia et al., 2020). The key components influencing construction safety climate and safety performance have been identified as safety leadership (commitment to safety at senior management, middle management, supervisor and co-worker levels), safety management systems, training, social support and production pressure (Berglund et al., 2023; Tang, 2025, Xia et al., 2020).

In a study looking at the impact of formal safety training on hazard recognition and risk perception in construction superintendents and safety managers compared to university students Perlman et al., (2014), found that the safety managers identified more hazards than the superintendents and the superintendents identified more hazards than the students. The differences between superintendents and safety managers were attributed to the mindset of the managers for whom safety was the focus of their job.

Further, Xia et al. (2020) identified eighty-three factors from a literature review of employee safety behaviour in construction, which they then divided into five groups. None of the groupings were identified as 'safety climate' or 'safety culture'; instead, the five groups included:

1. Individual Characteristics
2. Interactions
3. Work and Workplace Design
4. Project Management and Organisation
5. Family, Industry, and Society

Finally, Tang (2025) studied positive leadership, job competence, safety participation, and safety compliance in two hundred and forty-nine respondents from two major construction companies in the Philippines. The results highlighted the importance of integrating leadership development with targeted safety training to address gaps in emergency preparedness and proactive safety engagement. Recommendations included fostering a safety culture through participative leadership, recognition programs, and using technology for training and hazard reporting.

In conclusion, the academic literature on safety climate, culture and performance across the international construction industry highlights its complexity, and the challenges of extracting the relative influence of various factors and determining the relationships between cause and effect. Since the focus of the current study is on NNBs within GB (albeit with a cross-cultural dimension), UK case studies in mega-construction projects provided a more applied source of information on how to develop and maintain safety culture in NNBs (see section 3.3 below for UK Case Studies).

3.3 UK Mega-Construction Project Case Studies

Documentation from three UK mega-construction projects covering the issue of safety culture were accessed and reviewed. The case studies demonstrated how safety culture could be created and maintained in UK mega-construction projects from an applied perspective. Summaries are provided below.

3.3.1 London 2012 Olympic Park

The Olympic Park was a mega-construction project for the 2012 London Olympics and is considered an example of success within the construction industry. It evidences that health and safety best practice is possible through engagement, worker involvement and organisational commitment, to develop a strong safety culture, so much so that accident frequency rates were reported to be less than half the construction industry average (Lattitude, 2013). A suite of research projects and independent evaluations were undertaken on health and safety in the construction programme, one of which specifically focused on safety culture (Healey & Sugden, 2012). The key safety culture factors which contributed to the excellent safety performance of the project were identified as follows:

- The strategic role of the Olympic Delivery Authority (ODA), setting safety as a priority and integrating standards and requirements into companies from the outset.
- Clarity throughout the supply chain of the organisational standards and requirements, including the desire for cultural alignment, i.e., consistent commitment to the same Health and Safety Executive (HSE) standard.
- Empowerment of Tier 1 contractors to develop their own processes and systems to deliver the ODA's objectives. The ODA focused on engaging with contractors and enabling them to develop their own best practice and drive their own performance, fostering a sense of ownership and encouraging worker engagement.
- Recognising the prestige associated with working on the Olympic Park and striving for excellence in all activities, including health and safety.
- The project scale and length of the construction phase meant there was enough time for initiatives to become embedded and tailored for their efficacy and success.
- Workers' belief in the genuine commitment to health and safety within all organisations due to the consistent, repeated message across the Olympic Park programme over time.

Olympic Park leadership actively engaged with staff, to ensure that the desired attitudes became embedded on site and were recognised as the only way of working. This was key to developing a positive safety culture across all construction companies involved in the project. Senior managers were aware of the risks of diverting attention from health and safety, consistently focusing on its importance and relevance to the workforce and putting effort into keeping safety messages 'fresh'. A series of Olympic Park case studies throughout the construction period identified factors such as Organisational Commitment, Engagement in Health and Safety, and Usability of Procedures and Incident Reporting as characteristics of the positive safety culture (Bolt et al., 2012; Sugden et al., 2015).

One article (Geoghegan, 2012) reports that the ODA took account for the health of employees, contractors and subcontractors after identifying over 40% of the workforce had reportable health concerns, such as high blood pressure. One causal analysis identified that many workers skipped breakfast and opted for high fat evening meals instead. Recognising that this created a risk to health and safety, the ODA offered an affordable breakfast option for those working on their sites. The ODAs approach to health and safety was thorough and provided occupational health services to all contractors and workers on site. The article reports that 78% of those working on site felt encouraged to make positive changes to how they worked and looked after their own health, and 73% of managers would behave differently in the future because of their learning on the project.

The success of the London 2012 Olympic Stadium demonstrates a positive safety culture is not only achievable but essential for mega-construction projects and highlights the importance of leadership, engagement and continuous improvement in achieving and maintaining high safety performance.

3.3.2 Thames Tideway Tunnel

The £4.2 billion Thames Tideway tunnel programme (Alder et al., 2022) is a large and complex civil engineering scheme designed to intercept and prevent untreated sewage from overflowing into the River Thames and is due for completion in 2025. At the outset, measures were taken to ensure that the delivery team collaborated to create a strong safety culture, including commitment of all organisations involved in the project to achieving 'transformational' health, safety and well-being, by:

- Adopting industry best practice in health, safety and well-being as minimum standards from the outset, i.e., getting the basics right. This was a foundation on which later arrangements were based.
- Establishing a culture and organisational arrangements to further develop, share and implement industry best practice.
- Seeking out and adopting innovation to further enhance health, safety and well-being.

To form and maintain the right culture throughout the build programme, the client designed and implemented an immersive induction experience via a combination of film and acting (Harvey at al., 2020). A construction site accident was simulated to highlight the actions, decisions and behaviour that led to that accident and to show the impact an accident can have on the victim's family, colleagues and friends.

The induction also included workshops to discuss how a positive safety culture is formed and to train people in the skills to constructively challenge unsafe conditions and unsafe behaviours. This was reinforced by an in-person message from one of the senior leadership team, making it clear that everyone has the right and obligation to intervene or stop their activity if they feel unsafe, and that they will be fully supported by the leadership team on their site. Although the safety culture was introduced on day one, it needs to be continually reinforced by actions across the whole team. Having everyone attend the induction created a strong starting position, with clear expectations and a common reference point for conversations throughout the project. As a cornerstone of safety culture, the 'Right Way' safety programme was designed with the clear and simple message that safety and well-being is a fundamental ethical responsibility, taking priority over schedule and cost. This message was also transferred to other important aspects of the work, e.g., building assets of quality that will function properly and be durable over time.

Additionally, on the Thames Tideway website (2019), the project reported that major construction projects are critical in 'improving workers understanding of health risks, and championing universally high safety standards across the industry'. This derived from research conducted by Loughborough University (Jones et al., 2019) which details the importance of large construction projects using their expertise to influence, train, and embed changes within their teams, contractors and supply chains. This contributes to a collective effort in making high safety standards the expected and accepted way of working.

3.3.3 Thameslink Programme

The Thameslink Programme is a major infrastructure upgrade to British Rail services designed to significantly increase capacity and improve train services in the Southeast of England. Safety culture was part of the Thameslink programme from its outset in 2008 (Fink, 2019). Programme leaders wanted to eliminate worker injury and committed to the Thameslink Programme being safer than the industry standard. National Rail and supply chain leaders also agreed that they needed to define and align on a clearly articulated message which represented a joint commitment. This joint commitment became the driver for the change in culture needed to deliver 'everyone gets home safe every day' (UK Government Web Archive, 2021).

The initial rollout of the safety culture change programme commenced with a two-day Safety Leadership Workshop in June 2008. An Executive level Safety Leadership Team was formed and launched in July 2008 and committed to meeting monthly and driving safety leadership for the Programme. The roll out programme consisted of:

- Interviews with a range of staff to understand how they viewed the safety leadership style of key managers and leaders. This helped leaders to reflect on the effectiveness of their safety commitment.
- Surveys to help understand what people working on the programmes thought about health and safety to inform the next steps.
- Reports on the findings of the interviews and surveys.
- Two-day leadership workshops held with Network Rail and Suppliers regarding their health and safety commitments and to address the outputs from the interviews and surveys.

The individual projects then held monthly safety leadership team meetings to drive health and safety, joining together with the Executive level Safety Leadership Team (later known as the Directors Health & Safety Steering Group). Over the ten years that the Thameslink Programme delivered its on-site works, the ability to grow and learn was central to its success in health and safety. Early processes evolved and the programme changed, educated and continually assessed and provided feedback to those involved. A compliant environment grew into one where people took responsibility and drove improvements. This was achieved through the partnership between Network Rail, suppliers and the workforce.

Finally, safety events were investigated fairly with positive rather than negative consequences (Health & Safety Conversations, 2018). This led to a growing awareness and confidence amongst the workforce, management, and leaders that their efforts were making a real difference. Engagement of teams through briefs and two-way interactions led to active participation in safety conversations, close calls, lost time reporting, fair culture, good practices and safety stand downs. Over the ten-year programme, safety performance was much better than predicted at the outset.

3.4 Safety Culture in Nuclear New Build (NNB)

One academic study and three reports on safety culture in NNBs were accessed via the literature search. These documents are reviewed below.

3.4.1 Safety Culture and Subcontractor Network Governance in a Complex Safety Critical Project

Only one published paper was identified to meet the criteria of the literature review (as described in section 2.1 of this document). Odewald & Gotcheva (2015) present a case study of the Finnish Olkiluoto 3 project (OL3), the first new nuclear power construction project in Western countries since the 1990s. They present their study from the perspective that an NNB project requires engineering resilience in a complex and dynamic network of subcontractors. An NNB project should steer a safety culture towards being able to anticipate, monitor, respond and learn to matters regarding the health, safety and well-being of its workforce.

Crucially, subcontractor networks are complex systems and do not regularly align with the traditional top-down hierarchical management model applied at OL3 and within the nuclear industry in general. The complex NNB subcontractor network organisation requires goal-oriented safety management alongside safety culture monitoring, assessment and development. The authors argue that one party should not be able to control the others; rather the network organisation learns to manage its own safety activities. This is challenging in practice because hierarchical management approaches are not able to govern the social and cultural experiences arising from the interactions between networks.

Complex adaptive systems require a balance between control and autonomy, and between local and centralised control. Subgroups should be responsible for each part of the new build and should have autonomy to make decisions, take responsibility and apply relevant knowledge. NNB subcontractors should be able to take the initiative to be competent and equal partners in the business network, and be responsible for familiarisation and training in, industry specific hazards, requirements, and practices, and norms. This should prevent the governance model and power relations drifting towards a top-down hierarchy. It is important to consider that the learnings taken from Odewald & Gotcheva (2015) are reflective of the strong egalitarian values representative across Finnish culture. Whilst flat organisational

structures are becoming increasingly common within GB, hierarchical organisational structure remain the most prevalent, particularly within large corporations.

3.4.2 Safety Culture in Pre-Operational Phases of Nuclear Power Plant Projects

As noted earlier, the IAEA has published a comprehensive suite of documents on nuclear safety culture focusing on nuclear power operations. IAEA Safety Report Series No. 74 (2012) focuses exclusively on safety culture in the design, construction and commissioning of nuclear power plants and provides guidance on how to address some of the challenges. These challenges include:

- Understanding nuclear safety and safety culture
- Multi-cultural and multinational elements
- Leadership
- Competencies and competition for experienced resources
- Management system process to support the safety culture
- Learning and feedback
- Cultural assessment and continuous improvement
- Communication and interfaces

The IAEA developed a three-element model for working with safety culture as shown below in Figure 2.

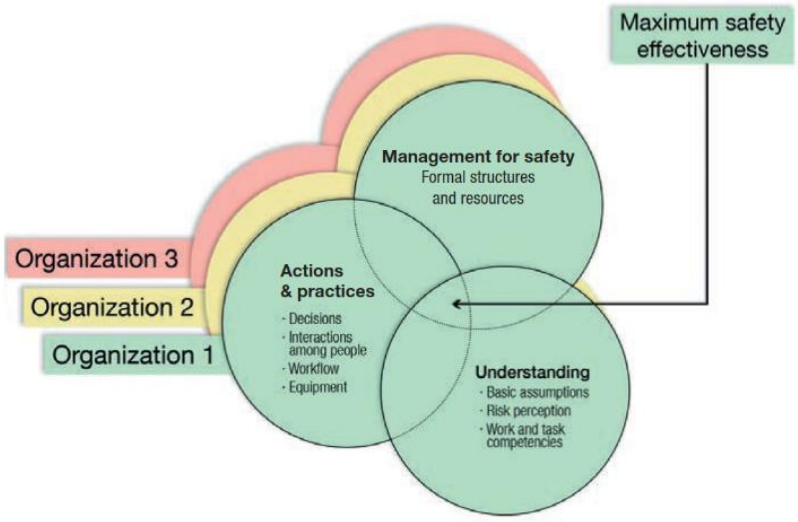

Figure 2. Three Element Model for NNB Safety Culture (IAEA No.74, 2012, p.16)

'Management for safety' includes the formal framework for achieving the desired practices and outcomes, e.g., processes, procedures, management systems, risk management, regulations, management programmes, and plans. 'Actions and practices' include the actual practices and actions, e.g., decisions taken, leader and worker behaviours, adherence to procedures, interactions between people and between organisations and other stakeholders. Finally, 'understanding' covers sense-making and understanding reality, e.g., basic assumptions, risk perceptions, comprehension of the work or task and perceptions of cause and effect. Most importantly it is the understanding that nuclear is different from other construction projects that contractors and subcontractors will have worked on previously and therefore requires a specific mindset about build quality. This is illustrated by the diagram in Figure 3 below.

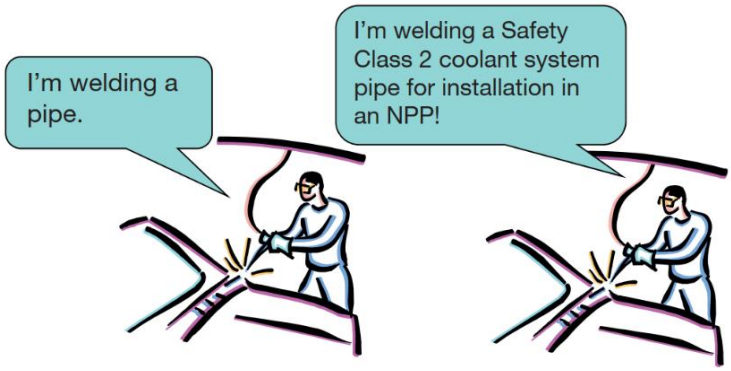

Figure 3. Example of Safety Culture Consciousness in Welders Working on a Nuclear Project, (IAEA No.74, 2012, p.32)

The overlapping area between the elements in Figure 2 represents the area where safety performance has the most impact. If one of the elements drifts away from the other and becomes unaligned, a risk is introduced. The model is expanded by considering the 'stack' of organisations involved in a new build project. An organisation that slips from the stack constrains the entire system. It is important to note that each organisation will have different systems and a different culture, but it needs to understand its role in contributing to the safety and effectiveness of the system, so it can interact appropriately with the other organisations. In conclusion, the comprehensive IAEA report endorses a focus on systems thinking and integration, with particular emphasis on the exchange of information between people, and knowledge transfer during the transition from one phase to another. It is also important to effectively integrate the fundamentals of management for safety, actions and practices, and understanding to safeguard nuclear safety.

3.4.3 INPO Report Principles for Excellence in Nuclear Project Construction (2010)

The INPO report, Principles for Excellence in Nuclear Project Construction, focuses on the design, construction and transition to operational phases in a nuclear build project. It discusses nine principles, and their associated attributes that create an excellent safety culture in an NNB. The principles and attributes address the goal of creating a plant that operates safely and reliably over its lifetime. While meeting cost and schedule requirements are important for a successful project, these requirements must be met through high levels of quality and safety. The nine principles from the report are listed below.

1. Leaders demonstrate alignment on a commitment to excellence
2. Strong first-line supervision is key to success
3. Personnel are qualified for their jobs
4. Schedules are realistic and understood
5. Construction of a nuclear plant has special requirements
6. Personnel safety is highly valued
7. The plant is built as designed
8. Deviations and concerns are identified, communicated, and resolved
9. The transition to plant operation is started early

The report provides guidance on implementing these 'principles for excellence'. It highlights the challenge leaders face of influencing the behaviour of workers from different organisations and cultures. It concludes that the success of the project will depend on how leaders of these organisations establish common expectations, achieve acceptance, and monitor and coach employees in the desired behaviours.

It is recommended that leaders should discuss the above principles as part of their communication of expectations, implementation of training programmes, and day-to-day policies and practices. All levels of management should continually reinforce their application, with verification through monitoring and

self-assessment. Consistent implementation of the principles across all organisations involved in the project will be beneficial for multi-plant construction sites, particularly when the construction workforce is required to move from one project to the next.

3.4.4 Nuclear Construction Lessons Learned – Guidance on Best Practice: Nuclear Safety Culture (2012)

The Nuclear Construction Lessons Learned report by the Royal Academy of Engineering examined six recent nuclear construction projects and supports the UK nuclear industry in learning from issues that led to delays, rework, and redesign. An industry stakeholder group was set up to focus on specific areas, one of which was nuclear safety culture, in which best practice guidance was developed. The guidance was based on the nine principles described in the INPO (2010) report (see section 3.4.3 of this document).

The eight recommendations for NNBs emerging from the discussion were as follows:

1. Establish a Leadership Charter, embodying the key principles, priorities and goals for stakeholders, setting out clear arrangements for communication and monitoring, and ensuring sign-on by all parties.
2. All companies involved in an NNB programme should work together to establish a leadership charter, based on the INPO and IAEA standards that support effective project delivery.
3. Role profiles should be established setting out the skills and knowledge required at different levels of supervision, with all supervisors taking formal competency assessments against these role profiles.
4. A systematic approach to training should be taken to provide confidence that all personnel are trained and competent.
5. An agreed industry-wide framework for industrial safety should be developed covering expectations, rules, rewards, and consequences to ensure consistent, predictable and first-class safety performance.
6. If design changes are deemed necessary, a formal system must be used to evaluate and sanction deviations from the original design, with appropriate oversight, record keeping and communications.
7. Companies should put processes in place to learn from and act on, operational experience gained from their own and other organisations.
8. A just and open reporting system should be put in place with its use publicised, reports investigated, feedback given, and the overall system monitored.

The report concludes that developing a robust safety culture requires highly focused leadership, development of a highly skilled and motivated workforce, and strong supportive processes at all levels of the delivery supply chain. The culture should encourage personnel to be open about any lack of competence and to be able to report their concerns if they feel subjected to excessive pressure to complete a task or make a decision.

3.5 Cross-Cultural and National Issues in Safety Performance and Culture in Construction

NNBs in the UK require a wide range of skills, knowledge and experience which is not necessarily available within one country and cultural context. For example, Electricité de France (EDF) reported that the HPC workforce is made up of 57 nationalities (EDF, 2024). With many different languages and understandings of safety this could pose a significant challenge to creating a strong safety culture. No academic studies on cross-cultural issues in NNB were identified, however, several articles on cross-cultural issues and safety performance in the construction industry were accessed (Ochieng et al., 2010; Ochieng, 2013; Zhou et al., 2018; Shepherd et al., 2021; Atasever et al., 2024). For example, Atasever et al. (2024) characterised several factors measuring safety culture in the construction industry across 10 countries, including practical aspects such as work experience, education level,

employment status, work pressure and work priority. In addition, they found the beliefs of fatalism and optimism contributed to safety culture.

Spangenbergen et al., (2003) provide insight into differences in safety performance between workers from two countries in a mega-construction project. The Øresund project was the building of a combined road and rail link between Denmark and Sweden, across the 16-km Øresund Strait. In the Øresund project, Danish and Swedish workers carried out the same types of tasks, using the same materials and the same reporting procedures for occupational injuries, making this study unique for safety comparisons. It was found that the Lost Time Injury (LTI) rate of the Danish workers was 4.7 times higher than the LTI for Swedish workers when both groups were working in the concrete element factory. When the comparison was extended to land works, the LTI-rate of the Danish workers was 3.6 times higher than for Swedish workers. Spangenbergen et al., (2003) analysed the reasons behind these statistically significant differences at the macro (national), meso (company) and micro (group and individual) level.

At the macro-level, differences in national educational programmes could have played a role in the differences in the LTI-rates observed. Danish construction workers had less formal education than their Swedish counterparts both in public schooling and professional training. In Denmark, construction work is classified as unskilled although it is often technically complicated and potentially hazardous. By contrast, Swedish workers had a long and structured educational background providing knowledge of construction methods and techniques, health and safety practices, as well as techniques for injury prevention.

At the meso-level, Swedish contractors' interests in health and safety were reflected in employment on a full-time salary basis for their workers, so they stayed with the company for several years. Danish workers were often employed on a temporary piecework basis and tended to move from employer to employer. The Swedish employment practices allowed more opportunity to enforce the company's health and safety policy, thus influencing their workers safety attitudes and behaviour. The Swedish contractors also used more time to plan and prepare for the work, including planning for health and safety issues. Danish contractors were inclined to rush into the project, with less emphasis on planning for health and safety.

At the micro-level, Swedish workers were initially trained through schooling and apprenticeships within specific industry sectors, e.g., concrete workers work with concrete and carpenters develop carpentry skills. The training of Danish construction workers was based on hands-on experience, often passed down from the work gang supervisor and more experienced colleagues, who were also self-taught. As a result, safety practices, norms and attitudes were inconsistent and not collectively agreed. The foreman's attitude to safety was noted to be of particular significance in the working environment at Danish construction sites. Finally, the Swedish employment conditions resulted in a stronger bond between the company and employees, leading to greater loyalty and willingness to perform well with due recognition of the hazards and risks of injury.

In conclusion, Spangenbergen et al. (2003) reported that the micro-level factors, such as differences in education and experience, along with training, learning and safety attitudes were the most important factors explaining the significant differences in LTI-rates between Danish and Swedish construction workers. However, these micro-level factors emerged because of the macro- and meso-level factors implemented by the national and company cultures respectively, making it difficult to disentangle the relative influences.

Nielsen et al. (2023) further investigated the factors responsible for the difference in construction injury rates between Denmark and Sweden. Denmark continues to consistently have twice the rate of reported injuries than Sweden and a 45% higher rate of fatal injuries. The authors conducted a questionnaire study completed by 346 construction workers from 48 Swedish construction sites and 465 construction workers from 37 Danish construction sites. Based on the results of previous research, the questionnaire measured the impact of cooperation, perceived organizational support, organizational citizenship behaviour, planning, safety motivation, and long-term orientation on safety climate and safety behaviour. The results show that all six predictors were positively related with safety climate and/or safety behaviour in both countries. As expected, safety motivation was associated with both safety climate and safety behaviour in both countries with no difference in the level of safety motivation

between the countries, but the relationship between safety motivation and safety behaviour was stronger in the Swedish sample.

The authors also found some support for their hypothesis that perceived organizational support, cooperation, and organizational citizenship behaviour would be higher in Sweden than in Denmark, and this was positively related to safety climate but not consistently related to safety behaviour. No statistical relationship was found between the predictors and compliant safety behaviour, although Swedish workers reported more participative safety behaviour. There was also support for a second hypothesis, that planning and long-term orientation would be higher in Sweden and positively related with perceived safety outcomes. Planning was the factor that differed most between the two countries. Finally, the results also showed that Swedish construction workers considered the long-term safety consequences of their behaviour to a greater extent than Danish workers, with long-term orientation being positively related to both compliance and participative safety behaviour, in both countries.

The national culture dimension of long-term orientation is generally higher in Sweden than Denmark (Hofstede, 1984). Hofstede (1984) defines long-term orientation, as the extent to which a society values and embraces long-term commitment and forward-thinking values, with an emphasis on perseverance and thrift to achieve future rewards. This may reflect a general difference between the two countries where a higher innate long-term orientation in Sweden would be expected to favour planning. Furthermore, workers' participation in planning processes may increase their understanding of the safety benefit of such planning and thus increases the priority of safe long-term outcomes. Thus, planning and long-term orientation may be mutually reinforcing. The authors concluded that the difference in long-term orientation between Danish and Swedish construction workers might be part of the explanation of the differences in occupational injury rates between the Danish and Swedish construction industry.

The complexities of understanding the relative influence of national values versus company values was investigated by Mearns and Yule (2009). The authors compared the impact of national culture and safety climate on safety performance, in a questionnaire study conducted in a multinational construction, maintenance and facilities management company. National values were measured using three of Hofstede's cultural value dimensions; Power Distance, Individualism and Collectivism, and Masculinity and Femininity (Hofstede, 1984), as these were the most relevant for the industry and national cultures under investigation. The study also measured safety climate (defined as perceived management commitment to safety) and self-reported risk-taking behaviour in 845 members of the front-line workforce in the UK (n = 87), United States of America (US; n = 216), US-Hispanic (n = 83), Malaysia (n = 73), Philippines (n = 303), and Australia (n = 83). Managers and supervisors were not included in the sample.

The results suggested that the more proximal influence of perceived management commitment to safety, exerted more impact on workers risk-taking behaviour than the fundamental national values measured by the Hofstede dimensions. These results suggest that if workers perceive that their managers are committed to safety, they are less likely to take risks at work, irrespective of their national cultural values. Management and leadership have emerged as significant determinants of safety performance in most industrial sectors. It is therefore likely that management's commitment to safety, reflected in quality training, planning and safety management, exert positive effects irrespective of cultural context.

4. Interview and Focus Group Results

Presented below are the content analysis results from the interviews and focus groups. Words, phrases, views and experiences from participants were coded into themes which are discussed below in turn. The following results also consider relevant findings from the literature review discussed in section 3 of this report. It is important to note that there is considerable overlap between the various themes identified. As a result, the information from the interviews and focus groups has been organised into a set of sub-themes, which may overlap with the primary themes identified. See table 3 below for a summary of the themes and sub-themes identified.

Table 3. Interview and Focus Group Theme Summary

Theme Sub-theme (if applicable)
Managing Organisational Pressures
Project Pressures
Capability and Competence
Logistics, Planning, and Management
Coordination via Communication and Collaboration
The Role of the Regulator
The Importance of the Design Phase
Community and Ethos
Pride
Collaboration and Engagement
Care and the Community
Coming Together from Different Backgrounds
Accountability
Learning Culture
Sharing Good Practice and Operational Experience (OpEx)
Transferring Lessons Learned to Future Projects
Reporting and Learning from Incidents
Communicating About Events
Training and Competency
Leadership
Leadership at Different Organisational Levels
Leaders Management of Risks
Appointing Leaders
Leadership Pressures
Understanding Nuclear Safety Culture During an NNBs Construction Phase

4.1 Managing Organisational Pressures

The challenges of managing and coordinating a mega-construction project, controlled by different organisations with different capabilities and competencies, while simultaneously coping with multiple project pressures were frequently discussed amongst participants. As a result, 'Managing Organisational Pressures' was the highest recorded theme across the interviews and focus groups.

It is a complex, interconnected theme comprising of various sub-themes as follows:

- Project Pressures
- Capability and Competence
- Logistics, Planning, and Management
- Coordination via Communication and Collaboration
- The Role of the Regulator
- The Importance of the Design Phase

The overall theme of 'Managing Organisational Pressures' was not a principal finding reported within academic literature, although some papers did discuss matters relevant to the identified subthemes e.g., planning management, capability, competence and production pressures (Berglund et al., 2023; Tang, 2025; Xia et al., 2020). For example, Spangenbergen et al., (2003) found that Swedish contractors spent more time planning the Øresund project than their Danish counterparts and this was one of the factors differentiating the two groups in their LTI-rate. A later comparison study between Danish and Swedish construction sites (Nielsen et al., 2023) found that planning positively influenced safety climate and safety behaviour with Swedish outperforming Danish workers on these measures (see section 3.6).

It was however reported significantly within the London 2012 Olympic Park (section 3.3.1) and Thames Tideway (section 3.3.2) case studies which discuss the importance of setting and agreeing, priorities, standards, and regulations from the outset. Reports discussing NNB best practice also identified similar subthemes, with five of the nine key principles listed within the INPO (2010) report correlating to the current theme. These five principles are listed below.

1. Personnel are qualified for their jobs
2. Schedules are realistic and understood
3. The plant is built as designed
4. Deviations and concerns are identified, communicated, and resolved
5. The transition to plant operation is started early

Additionally, the Nuclear Construction Lessons Learned report (2012) raises two recommendations relevant to the subthemes identified.

1. An agreed industry-wide framework for industrial safety should be developed covering expectations, rules, rewards, and consequences to ensure consistent, predictable and first-class safety performance.
2. If design changes are deemed necessary, a formal system must be used to evaluate and sanction deviations from the original design, with appropriate oversight, record keeping and communications.

It is important to note, that construction projects are also required to adhere to Construction (Design & Management) Regulations (CDM; 2015). CDM (2015) regulations are designed to manage potential risks relating to health, safety and welfare throughout construction projects. Duty holders are responsible for adhering to these regulations from the earliest project stage and are there to help projects:

- plan the work so the risks involved are managed from start to finish,
- have the right people for the right job at the right time,
- cooperate and coordinate work with others,
- have the right information about the risks and how they are being managed,

- communicate this information effectively to those who need to know,
- consult and engage with workers about the risks and how they are being managed (HSE Website, 2015).

The sub-themes identified within 'Managing Organisational Pressures' align significantly with the guidance set out by CDM regulations (2015). It is also recognised that guidance within CDM regulations can also be seen in Nuclear Industry Guidance documentation such as INPO (2010) as discussed above.

4.1.1 Project Pressures

Project pressures such as time constraints were acknowledged by most of the interviewees and participants at the focus groups and affected personnel at all levels.

> "*The higher you go up in the organisation, the same issues face, whether you're in nuclear or construction, or a mixture of both… And they have to deal with it in the same way as political pressures, financial pressures, and schedule pressures.*" (Interviewee C)
>
> *"We need to understand that the construction industry has traditionally been a very hard money, hard dollar survival industry. Survival of the fittest, don't share that information because you know you'll make your competitors stronger."* (Interviewee P)

A shortage of skills was also discussed as a significant challenge to NNBs in the UK. Resourcing a competent workforce is a key part of industry guidance and regulations (INPO, 2010; CDM, 2015) and therefore demonstrates a gap that will continue throughout the NNB construction industry should this issue not be addressed.

> *"Worry about the availability of workers to deliver them, and the potential implications of either bringing people who are not familiar with construction or retaining people and having an ageing workforce."* (Interviewee J)
>
> *"In the UK at the moment there simply is not the skill level required."* (Interviewee P)

The impact of these pressures influences attempts to coordinate different aspects of the work, and these pressures then have an effect on people's performance.

> "*Because of the schedule pressure and because people were so under pressure to deliver their own particular thing, there was a lack of interfacing between disciplines and people ignoring teams, messages and not getting back to you because they were so focused on their own work, and it isn't a criticism, it's the behaviours that were driven by that schedule pressure.*" (Interviewee D)
>
> *"We make quite large loud claims that safety, quality and environment come first. So, if the messaging that people see from their seniors is actually, it's the delivery of the project and pleasing our stakeholders and external expectations, that will have an absolute detrimental effect."* (Interviewee O)
>
> *"Slow and smooth moves faster but often conflicts with a fast paste schedule. Schedules need to be made alongside quality experts and additional buffer time needs to be considered."* (Focus Group 2)

The impact of organisational pressures was also highlighted within the Nuclear Construction Lessons Learned report (2012; see section 3.4.4.) and therefore a recommendation raised was that personnel should be able to report concerns when feeling subjected to excessive pressures.

4.1.2 Capability and Competence

The capability of the organisations involved in NNB and the competence of the people they hire to complete the work were seen as key to coping with organisational pressures and successfully organising and coordinating the many facets of the project. The Licensee and the Intelligent Customer role was considered central to ensuring that the NNB project ran smoothly and successfully.

> *"I would make sure that the organisation who is the responsible licensee does a proper assessment of what competence it needs, and a projection for the project in terms of how many people they need in-house, what functions those people will need to do, and what oversight they need to have, and make sure that the functions are properly staffed internally."* (Interviewee D)

> *"The organisational capability of duty holders to undertake their roles. They either appoint themselves to undertake as client, principal designer or principal contractor. Potentially not cooperating and coordinating effectively with all duty holders. You know, missing opportunities to do so. So, information is not fully passed on."* (Interviewee J)

During the focus groups, participants also discussed the pressures of incorrect staffing and resources for on-site workers.

> *"The skills gap is big, we have all had basic training and so should be sound, but it just isn't there. There is mass hiring, but we're not getting the right bum on seats."* (Focus Group 2)

Selection and development of the supply chain was also mentioned as important as illustrated by the following quote:

> *"I think there's something really vital and that is when you select your supply chain. That you have that leadership, and the behaviours, cultures, beliefs as part of that selection process."* (Interviewee P)

Role competence and capability was recognised as a key contributing factor to successful coordination and performance on a mega construction project. This observation can be seen echoed within academic literature as well as guidance and regulation documentation (Tang, 2025; CDM, 2015; IAEA Safety Report, 2012; INPO, 2010).

4.1.3 Logistics, Planning, and Management

Apart from having the Intelligent Customer capability and the right competencies in place, the key to coordinating projects successfully was reported to be effective logistics, careful planning and good management.

> "*In construction, new build is all about logistics. It's fun if you get logistics right, it's the flow of people and materials coming in, being assembled and people leaving the area. It's about competent people and the right time, and the right equipment, the right standard, the right quality specification coming in.*" (Interviewee E)

> *"A lot of that comes back to management issues. You know, planning, thinking about the controls, executing them properly."* (Interviewee F)

> *"There's a project risk and there's a safety risk, but also there's an individual people risk as well in terms of that lack of uncertainty and lack of understanding of what you should be doing, that wears on people."* (Interviewee L)

Project logistics, arrangement and planning were significant factors discussed throughout the focus groups and in particular the negative impact that it had on the team being able to perform their roles effectively.

> *"Everything is fixed by policy and process, and it creates delays. Process needs to allow for actions to actually happen on site."* (Focus Group 2)

One phrase that was used repeatedly throughout the study was the importance of 'getting the basics right' considering factors such as planning, staffing and setting expectations.

> *"Just get the basics right. These people are doing difficult work in difficult conditions. Just make their life as easy as it can be."* (Interviewee A)

> *"You've got to set your expectations early. You've got to know what you want to achieve, what your outcomes are and what you want them to be and how you're going to influence those. Don't leave it to making the assumption that you think it'll just happen."* (Interviewee B)

> *"Getting it right first time by making sure that we go through that extra planning and those extra cheques in the initial phases will give us the best chance of meeting programme demands as well."* (Interviewee L)

Strong planning arrangements, setting realistic timescales, and making safety a priority before the start of the project was recognised as a cornerstone to the success of the London Olympics and Thames Tideway case studies (see sections 3.3.1 and 3.3.2). Integrating standards and requirements into planning strategies was the foundation in which later arrangements were built on; with the projects, similarly, referring to the need to 'getting the basics right'. The Nielson et al., (2023) report on construction injury rates also identified that planning and long-term orientation was positively related to safety compliance and participative safety behaviour. It is also important to note that demonstrating effective project planning is also a legal requirement for construction projects (CDM, 2015). Alternatively, one interviewee shared that good planning, and logistics does not necessarily support in creating a positive safety culture.

> "You can have the poorest processes, but you have the right culture, you'll succeed. You have the best processes; you have a poor culture. You'll fail." (Interviewee K)

4.1.4 Coordination via Communication and Collaboration

Ensuring effective coordination was linked to timely and relevant communication. This was seen as particularly important given the multi-national, multi-cultural nature of the workforce on NNB projects. Nevertheless, interviewees did not dwell on the language and cultural differences of the workforce as being problematic, simply acknowledging that it had to be managed properly.

> "*That coordination and that understanding between the different groups is critical. This idea of silos keeps coming up."* (Interviewee B)

> "*A lot of the incidents tend to be around appropriate management, clarity, roles and responsibilities between the various groups. Coordination between the various sides."* (Interviewee G)

The importance of including contractors and ensuring they have access to relevant information was also reported; however, this was identified to often be overlooked.

> *"Sometimes contractors aren't necessarily as well embedded into those programmes as they could be. So, although you get some elements like the safety message and the pre job briefings and various things like that. You don't necessarily have sight of the overall kind of safety culture programme that's in place for the project."* (Interviewee D)

> "*So that's about coordination and proper communication between what would be the principal contractor and their contractors who come in on site. It is making sure that that is communicated properly to those contractors coming on site, once you've got those, if you have safety rules in place and you've got procedures in place, I think the culture should then follow from that."* (Interviewee N)

Subcontractor networks during the construction of NNB projects are large and complex systems. During the construction of a Finnish NNB, Odewald & Gotcheva (2015) believed that no party should be able to control the other and that each group should be able to manage their own safety activities, enabling autonomy and encourage initiative whilst all working together as equal partners. Similar experiences were shared following the London Olympics, where the ODA empowered contractors to develop their own processes and systems, to foster a sense of ownership and increase worker engagement.

4.1.5 The Role of the Regulator

One of the roles of the regulator is to ensure that organisations involved in NNB are aware of their legal responsibilities and the appropriate planning, controls and management are in place. This is alongside ensuring the competency and capability of the many roles in the project (CDM, 2015)).

> "*Lots of organisations have set out readiness for mega-projects and what you should and shouldn't do. Whether people hear that or not is another matter."* (Interviewee C)

> "*One of the areas that [project 1] focused on from a regulatory point of view is to seek assurance that the scalability of that is suitable and sufficient. And I think that's an area that [project 2] are trying to influence improvements in at this stage*." (Interviewee G)
>
> *"When we talk about culture, we talk about project culture, quality, culture, safety culture, organisational culture. We have a lot of terms for culture. And which could at the end of the day boil down to behaviours. And I think at the end of the day, that can be quite confusing and doesn't help with the clarity about what's needed. I also think, can you ever regulate culture?"* (Interviewee C)

4.1.6 The Importance of the Design Phase

The theme of 'getting it right' in the design phase was again raised when discussing work planning, risk management and controls.

> "*In terms of work planning, more consideration of health and safety in the design phase. So outside of the nuclear sector, but particularly within the nuclear sector, there's a responsibility for designers and the principal designer to look at the risks as they come across them during the design phase. And either eliminate them or control them in the design phase before they pass them on to the people that are actually going to do the work."* (Interviewee I)
>
> *"For any new build site, at the very start, you know that's where you would really be looking and concentrating on, the design, and I think if you can get things like that right, things like safety culture are going to follow."* (Interviewee N)
>
> *"Nuclear safety culture starts with design; it is the designers' responsibility to simplify the design for the construction stage and use common construction language." (*Focus Group 1)

It is important to note that guidance during the design phase of an NNB is also a key part of the IAEA Safety (2012) and INPO (2010) reports, in addition to their construction and operational related guidance.

4.2 Community and Ethos

A substantial theme identified across the interviews and focus groups was 'Community and Ethos' which encompassed numerous subthemes regarding the behaviours and beliefs of individuals and the organisation. The subthemes identified are:

- Pride
- Collaboration and Engagement
- Care and the Community
- Coming Together from Different Backgrounds
- Accountability

Recognising the importance of a shared approach as a component influencing safety climate and safety performance was identified within the academic literature. Such as the importance of social support (Berglund et al., 2023; Tang, 2025; Xia et al., 2020), individual characteristics, workgroup interactions; and family, industry and society (Xia et al., 2020). Further, Odewald & Gotcheva (2015) believed safety culture should be steered towards being able to anticipate, monitor, respond and learn to matters regarding the health, safety and well-being of its workforce.

This was also identified during the review of case studies (see section 3). The Thameslink railway safety culture programme identified engagement of teams through briefs and two-way interactions led to e.g., active participation in safety conversations, fair culture, and good practices, which had a positive impact on safety performance. The London 2012 Olympic Park project demonstrated care for individuals' overall health and well-being by offering an affordable and healthy breakfast on worksites. Finally, the Thames Tideway Tunnel project recognised the importance of the project's ethical responsibility, and that large projects should use their expertise to influence and embed positive change throughout the teams, contractors, and supply chain, to contribute towards a shared and collective way of working.

Despite the findings discussed above the importance of collaboration, engagement, community and autonomy are not captured within the recommendations from the Nuclear Safety Culture Guidance on Best Practice report (2012) or within the nine principles listen in the INPO (2010) report.

4.2.1 Pride

The importance of creating a connection between the project and individuals to evoke a sense of pride was a recurring point of discussion throughout the study and one also identified during the London 2012 Olympics Case Study. Participants often discussed pride in association with increased work ethic and motivation as well as better performance.

> *"There was a lot of pride in the country and the desire to deliver it, and the desire to deliver it safely. There was, nothing else that was of greater priority at that time."* (Interviewee A)

> *"The old NASA quote, which is when they asked the cleaner what do you do here? I help put a man on the moon, and every day [project] are building something that will be making a difference in the next century."* (Interviewee K)

> *"There is a lot of pride in working for Britain's first nuclear new build in 40 years!"* (Focus Group 4)

During the focus groups participants felt that pride of the onsite workforce could be increased through additional opportunities for self-development, such as obtaining formal qualifications.

4.2.2 Collaboration and Engagement

Working together, sharing knowledge and listening was consistently identified as a key factor in managing large and complex projects. The importance of having information that flowed through the business effectively to the right people and at the right time was key for productivity, efficiency, and integral to the success of a project. As discussed in section 3, organisational commitment and strong workforce engagement were attributes to the strong safety cultures present during both the Olympic Park and Thameslink projects.

> *"Having collaboration sites where you can have learning portals, where you can share OpEx, and broader learning from other industries and from that project etcetera."* (Interviewee D)

> *"All those tensions anticipated, and arrangements put in place so that it can all work in harmony, and so the right information's flowing to the right people."* (Interviewee F)

> *"The design information being up to date, being shared with all the relevant contractors so that they know what they're working on at what time, what their key risks are, what are all they're competing activities."* (Interviewee J)

One interviewee also identified the importance of having informal collaboration with the regulating bodies to increase shared learning and expectations.

> *"A good regulatory engagement plan, not just formal engagements, but I think a good practise that that I observed on project was our inspector was quite willing to have informal discussions. Getting that informal kind of interaction with the regulator early on to get that learning out, because they have a lot of experience."* (Interviewee D)

Overall, participants agreed on the importance of engagement throughout the project and with all groups of people being the foundation of building the right safety culture.

> *"Improve the engagement between designers and constructors. If you don't improve that engagement, then they will just carry on their work themselves… they will work in silos."* (Interviewee B)

> *"Really getting to know your colleagues, and to build trust, and build relationships I think is essential."* (Interviewee D)

> *"You've got to engage the workforce into that… What's the right way that we're going to do things around here?"* (Interviewee F)

4.2.3 Care and the Community

Throughout the conversations, participants discussed the need for people to feel genuine care and respect from their organisation, and to be recognised as being human both inside and outside of their role. The phrase 'treating them well' was said multiple times and was believed to be a fundamental starting point for encouraging the right behaviours and expectations early in the project. Matters cited across the interviews and focus groups were access to healthcare, transportation, and accommodation.

> *"[Project] regularly run health campaigns. They have nurses on site, they have GPs on site, it has been really insightful, but actually helpful to a lot of that community. So, in that area, they have been really height of the game in supporting people."* (Interviewee G)

> *"I'd say that transport is a sort of a very common gripe, which I suppose does affect you, doesn't it? It sets you up for the day."* (Interviewee N)

> *"You go beyond health and safety, you also are looking after the well-being of your workforce, it's the physical and the mental [well-being]."* (Interviewee P)

During the focus groups, participants discussed the impact of having a lack of available accommodation for the on-site workforce and was identified to be a significant source of stress. Focus group attendees also discussed the disparity in pay between roles and responsibilities which was said to negatively impact motivation. Alternatively, one interviewee highlighted that having the correct working environments for the individual teams also demonstrated care and helped set the team up for success.

> *"Some of the contractors didn't have space within their compounds so they were having to do their briefings outside, where it was raining. So, you've already sort of lost people, and you could just tell that the operatives just weren't very interested. So again, from a culture point of view, I would say you could really see the difference just in the environments that people are put into."* (Interviewee N)

An example of this is the London 2012 Olympic Park Case Study discussed in section 3.3.1, in which the ODA offered occupational health services to the entire workforce including its contractors. It demonstrated that championing the health and wellbeing of a workforce can effectively support and strengthen the safety culture on a mega-project such as an NNB.

Additionally, respect and humility were frequently quoted as cornerstones to building strong relationships, and ensuring individuals feel comfortable to share ideas, ask questions and stop work if they believe it is not safe to continue.

> *"People need to feel that their skills are recognised and appreciated."* (Focus Group 1)

> *"No matter where you work, if you want people to be respected and valued for who they are, the only way we're going to maximise the benefit, that knowledge and expertise and wisdom, is by ensuring that people are able to be themselves. You've got to have an environment of respect and humility so that people can be themselves and share."* (Interviewee P)

> *"It's about hearts and minds. It's about people feeling respected, knowing they can stop, ask questions, knowing they'll be listened to. Treated respectfully but also paid correctly. They'll be reimbursed correctly for what they're doing. They'll have somewhere to live. That's the whole combination of just treating people well. Being seen as a human is important, and all of those things do a massive amount for people to feel respected and welcome. And then there is more chance that they will also behave with the other things that you're wanting in terms of standards."* (Interviewee P)

Many participants extended these observations to go beyond the individual and look at the importance of creating a community for the workforce, recognising their family and friends as well as investing time around the local geographical community of the worksite. This observation can be seen supported by literature in which family, industry and society were identified as a contributing factor towards safety behaviour in the construction industry (Xia et al., 2020).

> *"Every month [organisation] used to donate to a local charity and allow them [the workforce] to choose the charity, it sort of engaged the local community. So, [project] involve the family, and*

> *[project] did quiz nights and stuff like that, and this is not new, but it works if you have got the right intention with it."* (Interviewee B)

> *"People are living away from home. Away from their partners, their children, their local footy clubs, so that whole belonging that they have, that they're away from, some people flourish with that. Others struggle with that, and so, you need to make sure that there's help there, should they choose to want it."* (Interviewee P)

> *"If we are away from home, we want to work the hours not sat alone at the weekend!"* (Focus Group 2)

4.2.4 Coming Together from Different Backgrounds

One of the objectives of this study was to understand the impact of a large multinational workforce on creating a strong safety culture. It was commonly reported that large multinational workforces were complex and that a learning period to understand the UKs safety process, standards and practices was required. Not only to work safely in their role but also in creating a harmonised safety culture.

> *"It's all fundamentally people, you know, whatever they've come from, whatever baggage they bring, you're trying to get them all into one consistent place."* (Interviewee C)

> *"Different political backgrounds, different perception of risk, and then you want them to work according to a standard. It's a massive challenge, isn't it."* (Interviewee P)

There was a common appreciation for the impact this could have on communication across the site and the need to adapt communication to ensure cohesivity in messaging.

> *"Cater for all the nationalities and languages that are spoken within the site and trying to mitigate that to provide a message that is understood. And is tailored to the culture of those joining."* (Interviewee J)

> *"Nationalities and individual cultures there as well. They will all have their own individual attitudes towards health and safety as well, and you've got a communication barrier potentially."* (Interviewee F)

During Focus Group 2, workers from outside of the UK were described as 'grafters' but that the different cultural safety standards sometimes resulted in an observed disinterest in accepting the safety culture standards onsite. Additionally, language barriers were believed by the participants to inhibit understanding of key terms and tasks, which resulted in damaged trust between workers and supervisors. Interestingly, one participant also discussed that these issues were not solely recognised amongst the multinational workforce, but they also appear across the different local cultures within the UK, between the different contracting organisations, and trades.

> *"The construction type workers, your concrete guys, your steel fixers, it's a dirty, wet, cold job that becomes known for them. So, they don't think nothing of walking through mud, but your electricians and your mechanical people, it's a cleaner and tidier environment, they expect a higher standard, then they'll be saying no, the toilets are not good enough, we're not walking in puddles to my site. It's different cultures and upbringings, for you think everyone would be the same, but they're not. So, whether it's a different culture from countries, or if you look more focused locally, there's different cultures and the different trades that people do, and it's getting a message for each one."* (Interviewee E)

Participants also referred to age and gender resulting in differences in approach to tasks onsite.

> *"It's quite often experienced electricians who have incidents and some of the younger electricians actually take the appropriate precautions. You get people who get complacent, and they've done it before, and they've got away with it and so they just carry on doing it like that."* (Interviewee N)

> *"There's a bit of a macho attitude in in the construction industry. There is a predominance of, 'let's just get on with it', 'let's get things done', 'let's solve problems quickly'."* (Interviewee I)

Further to the points discussed was the impact of turnover which exacerbates the challenges identified.

> *"You'll have different contractors coming in at different times, maybe different people working or moving on. That is a real challenge, how you maintain a culture consistently where there's constant churn all the time."* (Interviewee F)

> *"The biggest challenge has always been just the sheer size of [project]. [Project] is a mega-project; it is a huge construction site and the simple churn of personnel at a working level is enormous."* (Interviewee H)

It is evident from the data presented that achieving consistency in safety behaviours and beliefs within large multinational workforces can be difficult. Interestingly, participants also expressed difficulties with intracultural communications. During the literature review, education, job security, training, planning, employment conditions and societal values were identified as attributes which could impact an individuals' attitude to safety (Spangenbergen et al., 2003). Irrespective of nationality however, Mearns and Yule (2009) identified that if workers perceive a positive commitment to safety by managers, then workers were less likely to take risks. Further, Ochieng et al., (2010) identified that trust, communication, empathy and awareness in leadership can be effective in creating and developing a large multicultural team. However, Shepherd et al., (2021) describes the impact of large multicultural teams in construction as a 'topic that remains underexplored'. That said, their investigations with Spanish, Italian and British construction workers identified several recommendations such as, offering on-site training, digitalised materials suited to both native and migrant workers, use of role modelling as a communication tool, and soft skills training such as hazard awareness and cross-cultural communication (particularly for supervisors).

4.2.5 Accountability

The final subtheme identified was regarding the importance of ownership and accountability to ensure focus and direction within a project.

> *"You might have one area where you've got, say, six companies that come together to form an alliance, and that alliance is delivering the work from a safety culture point of view. What is really, important is the accountability element."* (Interviewee G)

> *"One of the things lost because of culture, is personal accountability, [project] are so worried about not blaming individuals that we've stopped looking at what human failures there are, and because we've stopped that, we don't implement things that help humans."* (Interviewee K)

Across three of the four focus groups there was a unanimous agreement that lack of accountability was a significant contributing factor to accidents and quality of work. Participants discussed how contractors on one project are 'paid to rectify mistakes' which one participant referred to as 'unlike any industry they had worked on before'. There was a general belief that this contractual set up with no accountability for errors resulted in poor work quality, no sense of pride in work, and the possibility for errors to go unnoticed. Particularly as participants believed that there was not enough pressure coming from within the organisation to enforce quality standards. This was discussed to significantly impact trust between the workforce. Participants also discussed occasions of work being knowingly handed over for inspection prior to being ready and identified milestone pressures as a contributing factor to this. Additionally, instances of intimidation and fear of challenging upwards were recognised as having a negative impact on morale, this was believed to be as a result of leadership receiving a monetary bonus for them achieving business milestones.

Participants discussed feeling that it was difficult to hold individuals accountable for their mistakes and that some people were 'milking the system', for instance individuals not attending mandatory training. Participants raised that a 'blame free' and 'safe space' culture resulted in determining no means of punishment for deliberate and intentional poor working behaviours. The Nuclear Construction Lessons Learned report by the Royal Academy of Engineering (2012) advises that both reward and consequence are required to drive first class safety performance. Factors participants felt contributed towards this, were the current UK national culture being 'too woke' and the strong unionisation of the workforce.

Participants referenced previous experience in the aircraft industry as having a good level of accountability balanced effectively with having a strong safety culture.

4.3 Learning Culture

The overall theme of 'Learning Culture' was a key point of discussion throughout the interviews and focus groups, and the associated sub-themes were regularly considered as significant components to a successful safety culture. The Learning Culture sub-themes are as follows:

- Sharing Good Practice and Operational Experience (OpEx)
- Transferring Lessons Learned to Future Projects
- Learning from Incidents
- Communicating About Events
- Training and Competency

'Learning Culture' is a fundamental component in James Reason's seminal safety culture work (Reason, 1997, 2007) and 'Continuous Learning' is one of the 10 nuclear safety culture traits recognised by INPO (2012) and WANO (2013).

The London 2012 Olympic Park project was notable in that it instigated learning throughout the build project and left what was termed a 'learning legacy', although the extent to which this legacy has been adopted and enacted in other mega-construction projects is not known. The Thameslink program also considered the ability to grow and learn to be central to its success in health and safety.

Learning and feedback were identified as one of the challenges for safety culture in pre-operational phases of nuclear power plant projects (IAEA Safety Report Series No. 74, 2012). In terms of addressing this challenge, one of the elements in the model for working with safety culture was 'Understanding', as encapsulated in sense-making, comprehension of work tasks and perceptions of cause and effect.

In the academic literature, Spangenbergen et al. (2003) found that differences in education, training and learning, were important factors explaining the significant difference in LTI-rates between Danish and Swedish construction workers. Further, Atasever et al. (2024) identified 'education' as one of several factors characterising safety culture across the construction industry in 10 countries. Finally, through an extensive literature review Littlejohn, Lukic and Margaryan (2014) found evidence for their hypothesis that there is a relationship between a good learning culture and safety culture in organisations.

4.3.1 Sharing Good Practice and Operational Experience (OpEx)

One interviewee noted that they have representatives from all companies on site to create a community of best practise, with the idea of exchanging lessons learned from other projects. One such best practise was reported to be promoting health as well as safety across the site, which was given as an example of learning from HS2 (the UK's new high-speed railway). However, it was noted that it is quite rare for companies to bring best practise from other industries.

> *"There are probably a lot of good practises in other sectors that nuclear doesn't really use, we can be quite insular."* (Interviewee D)

Regarding the sharing of OpEx, one interviewee also reported that there was a lack of access for contractors.

> *"Learning and access to things like OpEx, contractors aren't always able to access it that easily, and unless you're an embedded contractor you don't know about them."* (Interviewee D)

Throughout the interviews the constraints of contractual issues, intellectual property and politics were barriers to sharing good practise and OpEx.

> *"There can be intellectual property, export licence issues, contractual issues, there are contractual issues between the responsible designer for a reactor and the future licensee. So, things that are outside that contract won't be shared, support won't be given, which obviously can impact on competence learning."* (Interviewee D)

> *"Take the commercial and politics out of it. If there's lessons to be learnt that can help things be built more efficiently and safer, that's the best thing for the public. That's a big challenge and a big ask, but it's just the realities of the world we work in."* (Interviewee O)

4.3.2 Transferring Lessons Learned to Future Projects

Several participants reported that there were lessons learned at the design stage, which could be shared more widely for NNB, and that design teams should have access to these lessons learned. It was noted that there is complexity in the building space, including how different interfaces work, and if there are any insights and lessons to be learned, it was important to recognise what could transfer to other new build projects. In essence, it is important to make sure that future projects can learn from current projects and start developing their systems now.

> *"They put in place something that's scalable, so when it [project 1] gets to the [project 2] stage they have a system that will be suitable."* (Interviewee M)

It was noted that there was a high degree of reliance on individuals rather than corporate learning.

> *"The organisation believes they've captured a lot of that learning just by using the same people."* (Interviewee M)

Some interviewees reported that safety management systems were being established in some organisations to enable them to look more robustly at the learning from current projects however, there were concerns expressed that the systems were not as advanced as expected.

> *"No confidence that it is in place at the moment, though recognised as something that needs to be done."* (Interviewee M)

> *"The designers know about what is considered to be good practise. It's all there, but designers don't always use it."* (Interviewee B)

The importance of learning lessons from the design phase of NNB projects was stressed by more than one interviewee as demonstrated by the following quotes.

> *"I think any new build site starts from that inception of the design and making sure that safety is incorporated at that point and risks are designed out. If you can get things like that right, things like safety culture are going to follow."* (Interviewee N)

> *"You know, design issues, constructability, and then you take the learnings, which is massively important."* (Interviewee P)

The following quote from an interviewee encapsulates a key problem about the complexity of achieving a strong safety culture and a key lesson to be learned.

> *"One of the key lessons learned from [project] is trying to put out too many messages and too many behaviour expectations all at once… It was just too much because you're asking people to remember a list of 10 things, another list of 10 things, another 12 things, 10 things over here. So already with after one induction it's 40 things that you're supposed learn, which is a lot."* (Interviewee O)

4.3.3 Reporting and Learning from Incidents

Within the industry, efforts were being made to learn from incidents, both from NNB projects and more widely from other industries, however, arguments were presented about how challenging that was. It was perceived that with thousands of records and observations on the learning tools there is so much organisational learning that it is impossible to do.

> *"I think [project] try to do it so much to the nth degree that [project] miss some of the big issues and [project] have actions for everything and try and solve everything."* (Interviewee K)

> *"You always end up with a spreadsheet that's fed back to a board. There is 300 open investigations, and no one tracks the actions."* (Interviewee M)

> *"Thousands and thousands of records and observations on learning tools."* (Interviewee H)

Learning is not always captured, and it was noted that there was always a challenge in terms of having the right people to carry out investigations, in a timely manner, and following it through to close out actions.

> *"Experience shows it's not done very well. And so, [project] are keen to focus on making sure they've got the right arrangements in place. So, they've got SQEP[1] people carrying out the investigations to get this set up now and be effective now."* (Interviewee M)

It was recognised that a learning and improvement culture rather than a blame and punishment culture should be developed. This meant identifying the systemic causes of incidents rather than blaming individuals, whilst also understanding the context in which the incident occurred, when sharing the lessons learned. These lessons should be extended to other new build projects.

> *"[multiple projects] are trying to improve their performance in terms of responding to incidents, but prior to this there's been several repeat incidents which would suggest they weren't learning from them."* (Interviewee I)

> *"At [project 1] we see how they're building safety culture from the early stages, how they're learning from [project 2], some of the challenges that NNB face, and if they are transferable to [project 1]."* (Interviewee J)

One interviewee mentioned that one project intends to produce a strategy which set out how they would incorporate some of the learning from other NNB projects. This strategy was seen as key for establishing milestones and expectations. This document has not yet been produced, therefore the interviewee considered this to indicate how learning was not yet fully embedded by this interviewee.

On the other hand, fulfilling the requirements of CDM (2015) regulations and managing on site risks, was construction experience that the UKs first NNB in over thirty years did not have at the start of the project. Future NNB projects in the UK will have the advantage of being able to learn from this however, there was perceived to be a conflict between what the duty holder expects from an operator and what could be done from the perspective of the construction industry requirements.

> *"The importance of asking, the questioning attitude, being able to listen with humility in the industry about learning from events in terms of design."* (Interviewee P)

> *"Creating a safety culture that you want is about good organisational learning. And making sure that you involve all employees and use it to get the outcome that you want."* (Interviewee B)

The importance of reporting and learning from incidents was a key foundational strategy for The Thameslink Programme. Reporting safety events was highly encouraged; investigations were held fairly and feedback provided to the workforce. Additionally, monthly safety leadership meetings were used to learn from events and evolve the programme through continual assessment. Moreover, Case Studies following the construction of the London 2012 Olympic Park identified that Organisational Commitment, Engagement in Health and Safety, and Usability of Procedures and Incident Reporting were Characteristics of a positive safety culture (Bolt et al., 2012; Sugden et al., 2015). Finally, Odewald & Gotcheva (2015) believed that an NNB project needs to be able to anticipate, monitor, respond and learn to matters regarding the health, safety and well-being of its workforce.

4.3.4 Communicating About Events

When it came to effective communications about incidents and events, monthly webinars, weekly safety messages, alerts and quality briefings were mentioned. The monthly webinars involved a deep dive into a topic or event so that the project could learn from it and identify what could be done to mitigate the incident or event in the future. Again, it was recognised by interviewees that organisational learning is

[1] SQEP: Suitably Qualified and Experienced Personnel

difficult, but that leadership was integral, both in terms of relaying messages and being seen to take action.

> *"You've got to have that consistent message, and it's got to come from the top. And they've got to back that up by providing the information by learning from incidents and actually doing the monitoring of the health and safety work. This is what we say and we're going to back that up by checking the work that you do."* (Interviewee O)

> *"Leadership is key. Constructions change all the time, for example the fire escape route might be different from day-to-day. So, workers have got to be made aware of that, but also, are the principal contractor looking at this to make sure that the workers know this information."* (Interviewee I)

One interviewee noted that regarding conventional safety, operatives were not being told in a timely manner about what had happened in previous incidents. They were being told much later about what had occurred and the causes.

> *"People would have found it much more useful to find out a bit quicker, so you get that learning, but there seem to be a bit of a lack of communication around that."* (Interviewee N)

This is further evidenced by participants who believed that there is often a lack of transparency from organisations and that the workforce frequently work with outdated information.

> *"Delayed communication means the workforce is always working out of date, workers will push against new ways if it's not understood or the reason clearly explained."* (Focus Group 1)

> *"You get these kind of changing requirements, changing expectations without sufficient explanation, perhaps because they can't explain why for various sorts of project or contractual reasons."* (Interviewee D)

Comparing the participants viewpoints to the Thameslink Case Study discussed in section 3.3.3, demonstrates that feedback and communication post reporting activities is crucial to driving health and safety improvements and gaining strong workforce engagement.

4.3.5 Training and Competency

Training and competency are not usually included as part of the theoretical 'learning' component of safety culture; however, they have been identified in the literature as a constituent of construction safety climate/culture/performance in the academic (e.g., Guo et al., 2016; Perlman et al., 2014; Spangenbergen et al., 2003; Tang, 2025) and grey literature (IAEA, 2012; INPO, 2010; The Royal Academy of Engineering, 2012). It is important that the workforce has the appropriate skills, knowledge, and competencies to work safely and efficiently on an NNB site and therefore training and competency could be considered an aspect of effective learning, thus contributing to the safety culture. NNBs are also required to comply with CDM (2015) regulations ensuring that any 'designer or contractor appointed to the project have the necessary skills, knowledge, training, and experience to carry out the tasks allocated to that person in a manner that secures the health and safety of any person working on the construction site'. Moreover, the ONR also require licensees to comply with various licence conditions (ONR, 2017) regarding training and competence, highlighting its importance from a regulatory perspective. For this reason, training and competency has been included under Learning Culture as embodied by the following quotes:

> *"So, embedding that knowledge from [project] is part and parcel of that broader organisational learning piece."* (Interviewee O)

> *"We talk about nuclear safety; we go through some nuclear events that have happened around the world and then talk about error and the questioning attitude. So, it's quite a structured process that covers everything you need under a licence condition."* (Interviewee P)

Quite apart from ensuring that trained and duly authorised and suitably qualified persons are being employed on NNB projects, training programmes to support safety culture are being developed.

> *"What are the tangible things that you might observe that pertain to those values and then that will become a bit of a behaviour framework that will inform learning programmes and behavioural safety observation process. When you come into a project you then see it reflected in the language used in processes and procedures, and then when you go to enter an observation or a learning report again, you're seeing the same language. So, it all becomes very consistent and easy for people to understand quickly what the expectations are, and what happens if those expectations aren't met."* (Interviewee O)

One of the interviewees mentioned specific training they had developed on leadership and the importance of leaders, managers, and supervisors being visible in the field and engaging with the workforce.

> *"By doing some project specific training, making sure leadership was visible, so site supervision and making sure they were visible in the field. Having challenging conversations, speaking about safety, helping them to improve their skills, that drove their good behaviours. What I noticed was, I was seeing a difference in the field by the training that I was prepared to give them. It was like engaging with the workforce but actually caring about them."* (Interviewee B)

Additionally, participants from the focus groups raised that they felt not enough training was offered to on-site workers, this was emphasised by an individual who had been working on-site seven years prior to going on a relevant training course for their role. Further, another participant believed that the lack of testing performed during training courses had a negative impact on people's ability to learn.

> *"Guys on the ground receive no form of formal development, no progression, certification or support, the company need to instil pride, responsibility, and encourage upskilling."* (Focus Group 1)

> *"[Organisation] doesn't often train but has a lot of awareness courses."* (Focus Group 1)

> *"Need to divide training based on relevancy to roles."* (Focus Group 2)

Finally, inductions and daily briefs were seen as an integral means of reinforcing information and setting clear behavioural standards and expectations to the workforce.

> *"Your induction is a great starting point for setting the behaviours that you want."* (Interviewee B)

> *"[regarding an on-site briefing] You've got 15 minutes really, these are the main hazards we've got on site today and this is what we're going to be doing, and they started talking about a briefing about taking a laptop abroad, that's just waste, you really need to tailor briefings to the audience that you've got."* (Interviewee N)

> *"The morning meetings where you talk about who's doing what, who's doing what where, whether or not there's going to be any interactions, what you need to know about. So almost deconflicting from the start."* (Interviewee A)

Strong inductions with clear and simple messaging was also advocated by the Thames Tideway project as a means of creating a strong starting position and reference point for conversations throughout the project.

4.4 Leadership

'Leadership' was also a key theme identified by participants, although it was mentioned predominantly by those in managerial or leadership positions with experience working on NNB Projects. The themes, 'Managing Organisational Pressures,' 'Communication and Engagement,' and 'Learning Culture were discussed more frequently; however, it could be argued that these themes stem from effective Leadership. The 'Leadership' sub-themes are as follows:

- Leadership at Different Organisational Levels
- Leaders Management of Risks
- Appointing Leaders

- Leadership Pressures

The lack of reference to leadership within NNB from participants is somewhat surprising, given that the relationship between safety leadership and safety performance has been extensively explored in the academic literature across different sectors and industries (e.g., Clark, 2013; Flin and Yule, 2004; Griffin and Hu, 2013; Martinez-Corcoles et al., 2011; Mullen and Kelloway, 2009; Nielsen et al., 2013; Zohar, 2002). For example, perceptions of management's commitment to safety have been identified as one of the key dimensions to safety climate (Flin et al., 2000; Christian et al., 2009). Additionally, the importance of safety leadership is mentioned in research on safety culture in a range of industries, including the nuclear industry (Martinez-Corcoles et al., 2011).

In a review for the healthcare sector, Flin and Yule (2004) explored the importance of participative, transactional and transformational leadership styles for safety performance across all levels of management (supervisors, middle managers, and senior managers). Supervisors are considered first line managers whose primary responsibilities are to coordinate, facilitate and achieve daily work activities and are encouraged to talk about safety through, for example, the importance of wearing protective equipment. Comparatively middle managers are responsible for prioritising and reinforcing safety communications to supervisors as directed by senior management, and finally, senior managers are often distanced from operational activities and work at a higher strategic level; and thus have a greater potential to influence the organisations safety performance.

Flin and Yule (2004) found that transactional styles, i.e., monitoring and reinforcing worker safety behaviour, were most effective for supervisors, while middle managers, should focus on promoting open communication about safety and ensure safety system compliance. Transformational leadership is a style that inspires and motivates followers to go beyond their own perceived capabilities and achieve more on behalf of the organisation. These leaders are charismatic and are strong role models in representing the beliefs and values they want their followers to adopt. A transactional leadership style manages employees by establishing specific goals and offering rewards for achieving them. Finally, the authors concluded that senior management have the most influence on an organisation's safety culture and so they need to demonstrate this by a visible commitment to safety, which can be represented by the time they devote to safety. A transformational style was considered to be most effective for achieving positive safety outcomes, as demonstrated in other safety leadership studies (e.g., Clarke, 2013; Mullen & Kelloway, 2009). Nevertheless, a systematic review of safety leadership in high-risk industries has shown that all leadership styles (apart from passive leadership) have a positive impact on a range of safety performance indicators. The most effective style was dependent on context, and which performance indicator was being assessed, e.g. incidents, safety compliance, safety motivation (Ta, Kim & Gausdal, 2022).

Safety leadership was also a focus in the case studies reviewed for this report. For example, at the London Olympic Park it was reported that leadership actively engaged with staff to ensure the appropriate safety attitudes and behaviour were embedded on the site. The same leadership engagement approach was reported as being applied for the Thameslink Program and Thames Tideway projects.

4.4.1 Leaders at Different Organisational Levels

It is important to consider the role of various leadership positions within an organisation e.g., senior leadership, middle management, or supervisors. The review by Flin and Yule (2004) indicates that different styles of leadership may be appropriate at the different levels of management. One interviewee mentioned what successful 'leadership from the top' looks like, highlighting worker engagement as an important factor.

> *"Within the nuclear sector, it's licensees working in partnership with principal contractors and showing the workers that they're willing to take charge of things and incorporate the workers' ideas into areas."* (Interviewee I)

This interviewee also stressed the importance of leadership at all levels understanding and managing the risks.

> *"Also, if there is more awareness within leadership groups about risk profiling and where the actual risks lie and putting the resources into where they should be in terms of the risks."* (Interviewee I)

Despite the academic literature's focus on leadership styles for safety, one participant pointed out that it was important to modify leadership style depending on the context. This interviewee reflected that the construction sector does not upskill people to be good leaders, and they had to teach themselves the leadership skills required for the role, i.e., how to communicate with people, how to create a 'psychologically safe' environment to have good conversations, how to manage individuals, teams and tasks. 'Psychological safety' refers to the belief you can express ideas, ask questions and admit mistakes without fear of negative consequences (Edmondson, 1999), which in turn creates an atmosphere of openness. This interviewee also noted that a person may want to be a democratic, supportive type of leader most of the time, but a leader also needs to set high standards and expectations; therefore, if people are not complying with them, they need to have the ability to 'come down hard on them,' reverting to an authoritarian style.

4.4.2 Leaders Management of Risks

One of the interviewees who had worked in many different countries mentioned the 'risk appetite' of different nationalities working on the site, this observation has also been demonstrated in literature (Spangenbergen et al., 2003; Atasever et al., 2010). They discussed that it was important for leaders to recognise and acknowledge this, and work to ensure risks were understood and responded to appropriately. Ultimately, however, this could be best managed by the actions and strategies of leaders, reinforcing the appropriate standards and behaviours.

> *"But no matter where you're working, the standards and behaviours that are accepted are the standards that you* [as a leader] *set."* (Interviewee P)

> *"They [Leaders] should be empowering people to speak up if they don't believe what they are being asked to do is safe."* (Focus Group 4)

> *"I've seen so many times there's a mirror between the project director, and the culture on site, but you can also get a degree of risk blindness. One of the most risky things a lot of people do is drive a car. But once you pass your test and you're used to it, you don't really think about it much. And it can be the same, like working at height. You know the hazard is still inherent, but you may be used to it. You have to keep that risk alive."* (Interviewee E)

4.4.3 Appointing Leaders

A point was made by another interviewee about the selection process for senior leadership. There was a feeling that senior leader roles were, to some extent 'jobs for the boys', and that the individuals involved came from projects they had previously worked on together. However, it is important to make sure the right people are recruited, in terms of their knowledge, skills and experience, and their ability to drive the right safety behaviours and create a healthy safety culture. This echoes the findings from both the grey literature on leadership and safety culture in the construction industry, and the academic literature, which identifies the most effective leadership styles for safety (Clarke, 2013; Mullen and Kelloway, 2009; Nielsen et al., 2013). For instance, effective leadership traits are leaders who have high standards of integrity, take responsibility for their actions, who earn the trust of their followers, and are approachable. It is therefore important for leadership to set the appropriate standards and behaviours across the site and for this to be reinforced down the line.

> *"You need to have authentic leaders. They need to be trusted. They need to be good communicators. They need to be visible. You have got those basic line management fundamentals, learnt how to communicate with people, have got that sort of dynamic problem solving. That means that you've got things to draw on when issues emerge."* (Interviewee A)

> *"If you've got poor supervision, that will impact your safety culture massively. They [leaders] are literally worth their weight in gold."* (Interviewee B)

> *"The best leaders I observe are those that are clearly balancing their time between the technical office meeting-based work they have to do, and that time out in the field actually with the construction crews."* (Interviewee H)

Further, throughout the focus groups the effects of a poor leadership approach was discussed and the effect this had on individuals being able to fulfil their role safely, and effectively.

> *"They know [workers] they will get the sack or get moved teams, so people don't challenge."* (Focus Group 3)

> *"There is too much pressure on people. You have 20 people watching someone weld a valve, it's not fair."* (Focus Group 4)

> *"Leadership believe you can throw anyone into it, they will follow the process, and they will make no mistakes, which isn't the case."* (Focus Group 1)

4.4.4 Leadership Pressures

Timeframes, milestones, incentivisation of contracts and program pressures were aspects that all levels of management and leadership conveyed dealing with. It was reported that a senior leadership team were under an immense political pressure to meet milestones, and the question was raised as to how this motivates people to exhibit the right safety attitudes and behaviours, when these other pressures are being prioritised. It was stressed that senior leadership need to set expectations for supervisors, project managers and project directors, and that senior managers should be continually asking questions and constantly learning.

> *"A lot of it's about leadership and it comes down to how that is done on the ground, as well as in the boardroom, and that impacts on how people feel."* (Interviewee C)

> *"It's understandable that at their core it has to be very much delivery focused and driven by schedule and budget. And while we say safety, quality, cost and budget, in that order of what we should be prioritising, I don't think behaviour is always representing that. Fundamentally I think when push comes to shove, there's more emphasis placed on schedule and budget than on safety and quality. I think that what we need is for leadership to agree upon what the culture should look like, how to develop a strategy and embed that".* (Interviewee L)

The main discussion points from the interviews tended to be on senior leadership and how they influenced the safety culture from the top of the organisation. There was less discussion of what leadership should look like at middle management and supervisory levels. One interviewee mentioned that they liked to see supervisors, engineers and section managers walking around the project 'twice in the morning' and 'twice in the afternoon' so they know what is going on in the field. Supervisory staff also need to be equipped with the right skills, knowledge, and methods to be successful at safety engagement and safety management. The interviewee also stressed that it was important for site supervision to be given sufficient time to become familiar with what they are building, so that they know where the risks are, and are confident in dealing with situations. Furthermore, that the supervisor, is in the role of 'overseer', i.e. standing back and not getting involved in the job. Finally, one interviewee mentioned that supervisors should be taught how to have 'safety conversations', something that is not trained currently. This was further evidenced during the focus groups when participants reflected on the lack of training available for supervisors.

> *"We want more coaching on process, process is always changing and any support we get is too late."* (Focus Group 2)

The desire for leadership to become confident in the role was echoed during the interviews also.

> *"They move straight into supervision. That's the biggest problem that you'll get in terms of accidents because you need to give them space to get familiar with the project and that gives them the confidence that they know where the risks are."* (Interviewee B)

> *"We promote people because they were good at what they've done, but we don't upskill them to be a good leader."* (Interviewee E)

4.5 Understanding Nuclear Safety Culture During an NNB's Construction Phase

Across the interviews and focus groups, the theme 'Understanding Nuclear Safety Culture in NNBs' predominantly discussed understanding the meaning of nuclear safety culture during the construction phase of an NNB project; and for that reason, no sub-themes were identified. Although this theme was the smallest identified within this study, it potentially poses an important philosophical question for any future NNB project.

Literature and case studies examining nuclear safety culture during an NNB's construction phase is limited. The IAEA Safety Report Series (2012), however, informs that the challenge of understanding safety culture and nuclear safety must be addressed to build a strong safety culture. The report also observes that work on a nuclear project is fundamentally different from other high hazard industries, which also needs to be recognised (see figure 3 in section 3.4.2).

4.5.1 Understanding Nuclear Safety Culture in NNBs

It was evident from the interviews and focus groups that whilst overall the term 'nuclear safety culture' was understood, there were subtle differences in understanding amongst individuals. For example, some participants appreciated nuclear safety culture to be the need for higher attention to detail and thorough checking of work; to ensure the safe running and protection of operators and civilians in the future. Whilst for others conventional safety was often discussed as one and the same as nuclear safety. From the conversations it could be deduced that the reasoning behind this mindset lies with the word safety. The term 'safety', even when partnered with the term 'nuclear' appeared to suggest conventional safety issues on a construction site such as manual handling, falling from height and moving vehicles. This is not surprising given a universal understanding of safety to broadly mean 'protection from danger, risk, or injury'. This was particularly more evident in individuals from construction backgrounds.

The conversation regarding nuclear safety culture bought to light two points of discussion. Firstly, how relevant is nuclear safety during the construction phase of a nuclear new build and secondly, what is nuclear safety during the construction phase of an NNB. Interestingly, a significant number of participants reported they felt that nuclear was not relevant during the construction phase, due to the lack of nuclear material on-site.

> *"I often hear people talking about new build being different, not just culture related but in lots of activities. But I don't think it is different, and I think singling it out actually makes it harder. Operational sites still have construction workers and new builds still have highly technical people. All companies are trying to achieve an objective, and have risks associated with that, but getting a good culture still requires the same building blocks. Maybe by focussing on new build is a bit of a red herring?"* (Interviewee K)

> *"If they apply the nuclear standard during construction, they'll struggle. Although there's a couple of licences that apply, most of the licences [conditions] don't kick in till there's active material on site, so it's a construction project. So, you've got all these nuclear people who are managing the project who expect nuclear safety culture. Which is so different from construction culture."* (Interviewee E)

> "*It should be a safety culture and a safety baseline rather than a nuclear baseline. So, there's key roles that need to be fulfilled and you need to make sure you've got the organisational capability to fulfil them for the construction project."* (Interviewee M)

It was also mentioned during the focus groups that participants reported an NNB to be one of the safest sites they had worked on due to the lack of live systems.

> *"This site is safer than live plants, it's considered very safe, you see the risks of an NNB are significantly lower than a gas station, oil refinery, or a live nuclear power station."* (Focus Group 2)

One interviewee also discussed that high regulation within the nuclear industry stifles the innovation and creativity often seen in the construction industry.

Many participants reported that having separate nuclear and conventional safety cultures was confusing and reduced the importance of conventional safety hazards, which were perceived to be the biggest risk to on-site workers during the construction phase.

> *"The risk from asbestos is not maybe greater than radiological protection in this situation [construction phase], but it's probably equal. So why is there fifty [people] to one in this this area? I think it is a decent example of how the nuclear industry thinks."* (Interviewee I)

> *"Well, [conventional safety] were always seen as the 'poor relation', and this is the problem. It's constantly competing about where 'we're' better [nuclear safety]. This [nuclear safety] is more important."* (Interviewee K).

> *"We have a lot of terms for culture which at the end of the day boil down to behaviours and I think at the end of the day, that can be quite confusing and doesn't help with the clarity."* (Interviewee C)

This could be supported by evidence from the London 2012 Olympic Park, Thames Tideway and Thameslink railway case studies, all of which recognised the importance of clarity, cohesivity and simplicity of safety messaging as part of developing their safety culture. Across the interviews and focus groups confusion and lack of clarity in safety culture messaging was also discussed.

> *"There is confusion between health and safety, and nuclear safety. Is it health and safety on a nuclear site? The picture [safety culture] can be quite murky."* (Focus Group 3)

> *"[Project] overcomplicate it. You need to kind of really go back to basics. If you define where you want to go with the culture at the very start and be really positive that it's not just a nuclear safety culture, it's not a finance culture, it's not a health and safety or well-being culture. It's a culture of doing the right thing."* (Interviewee K)

> *"You've got these nuclear minded people who are trying to manage the project and can't understand why the construction guys are not understanding."* (Interviewee E)

Conversely, individuals from nuclear backgrounds believed that nuclear and conventional safety cultures needed to remain separate, and that more training on understanding nuclear safety culture was needed.

> *"Nuclear safety and conventional safety are not the same thing and can't be mixed. You need to tell people HOW to do things and WHY."* (Focus Group 4)

> *"Always take it back to the significance of what they're doing and the consequences of what they're actually working on, which obviously then ties it all back into nuclear."* (Interviewee H)

> *"So that's a big difference of people getting their mind through, I'm not just building a thing here and moving on, it's here to last and will be here for the duration."* (Interviewee O)

One factor that many participants agreed on was that during the construction phase of an NNB, nuclear safety culture primarily translated to a requirement for high quality construction standards. However, some participants reported that they felt this was not immediately obvious in the name, and during the focus groups alternative name suggestions were made such as 'Nuclear Quality Commitment' and 'Nuclear Quality Culture'.

> *"Nuclear safety culture is misleading. I always say to contractors, don't think about radiation, it's about warranties."* (Focus Group 1)

> *"They probably just need to appreciate, the quality side of things and the need to report."* (Interviewee A)

Several participants discussed the desire for safety culture standards to be incorporated into a policy by regulating bodies to aid with consistent and focused messaging and to reduce confusion.

> *"There is confusion in messaging and a lack of context for nuclear safety behaviours, and it negatively affects safety culture."* (Focus Group 4)

> *"There's a lot of concentration on the operational side of things. We focus on the risks during operations while it's in the design phase and we don't so much think about constructability enough or put resource into that particular area. So, how are you going to manage the health and safety during the construction phase?"* (Interviewee I)

Interestingly, conversations on nuclear safety culture highlighted that the meaning and or pertinence of nuclear safety culture appeared differently across the different stages of the project, which as a perception needs to be better understood. It was often translated within discussions of the NNB construction phase as immediate (conventional) and future (nuclear) risks to safety. The benefits and impacts of actions during the construction phase of the NNB will not be recognised until the plant goes live. This could be many years later, in which most contractors will have left the site. Interestingly, some participants discussed the reality of ever being able to achieve a uniformity in culture on such mega-projects and described it as "achieving the impossible". Projects such as the London Olympics consisted of several smaller projects and this approach was seen to have positive impacts on embedding safety culture.

Finally, participants also discussed the importance of clarifying what buildings and components do have nuclear significance and therefore are subject to higher levels of accuracy and inspection. It was discussed that declaring most buildings and equipment on-site as nuclear significant, increased workload considerably and resulted in quality fatigue and less rigorous testing.

> *"When everything is important, nothing is."* (Focus Group 4)

> *"Everything is important . . . so nothing is."* (Focus Group 1)

5. Discussion and Recommendations

This scoping review has identified several important factors for NNBs to consider during their construction phase. Findings suggest that the results from the interviews and focus groups support existing literature on safety culture, whilst also having identified potential challenges and areas requiring further consideration. The results from this study therefore aim to fulfil the following questions:

1. What has already been done and works effectively in relation to building a strong safety culture for NNBs, mega construction projects, or other comparable domains?
2. What are the gaps or challenges in developing a strong, homogeneous safety culture for NNBs in GB?
3. What actions could be recommended to enhance safety culture, safety performance and quality for NNBs in GB?

Both the literature review and qualitative research conducted within this study are discussed across the subsections below, with the aim of understanding how safety culture during the construction phase of NNB projects can be strengthened.

5.1 What has already been done and works effectively in relation to building a strong safety culture for NNBs, mega construction projects, or other comparable domains?

It is important to note, that many of the themes and sub themes identified through this study are already embedded into the comprehensive suite of documents on nuclear safety culture (IAEA, 2012; INPO, 2010; The Royal Academy of Engineering, 2012). For instance, the INPO Report Principles for Excellence in Nuclear Project Construction (2010) identified 9 principles of excellence, most of which were also identified in the qualitative research results. For example, the principle *'Strong first-line supervision is key to success'* was identified in the theme 'Leadership', in which participants described leaders as *"worth their weight in gold".* Additionally, that *'Personnel are qualified for their jobs'* was discussed as integral to the project's success within the results sub-theme 'Capability and Competence'. Recommendations on these findings are also seen included within the Nuclear Construction Lessons Learned report by the Royal Academy of Engineering (2012). This observation therefore highlights that there is a great deal of effective and valuable guidance documentation at the disposal of NNB projects already at present. The following bullet points highlight themes identified from the focus groups and interviews that are also corroborated in literature or demonstrated in the mega-construction case studies explored during this report.

a) **Realistic Timescales and Budgets:** Ensuring that timescales and budgets are realistic and achievable, whilst not undermining safety, was a consistent finding reported by most participants. Participants believed that accidents take place because of pressures such as schedule and cost, which have a negative effect on people's behaviour and performance. This is not a novel finding, *'ensuring schedules are realistic and understood'* is one of INPO's (2010) 9 principles for excellence. Additionally, this approach was also identified as a cornerstone for the safety cultures at the London 2012 Olympic Park and Thames Tideway Tunnel case studies. For instance, the 'Right Way' safety programme for the Thames Tideway project, was designed with a clear and simple message that safety and wellbeing is a fundamental ethical responsibility and therefore should take precedence over organisational pressures (e.g., schedule and cost). This finding therefore demonstrates that NNB projects must consider organisational goals (e.g. schedules and costs) alongside quality and safety experts, to ensure that safety remains the upmost priority of the project.

b) **Getting Things Right at the Start:** A prevalent quote used amongst participants was the phrase *'getting things right at the start'.* Similarly, representatives from all organisations involved in the Thames Tideway Tunnel project agreed that adopting excellence in '*getting the basics right*' was central to achieving their safety culture vision. These results indicate the importance of planning

activities in building a strong foundation for a successful safety culture. This can also be seen reflected in the recommendations and safety principles identified within the INPO (2010) and Nuclear Lessons Learned (2012) reports, as well as being embedded into CDM (2015) regulations. Moreover, participants also detailed the need for issues identified during the design phase to be proactively managed or eliminated before being passed on as an important factor to be considered as part of 'getting things right from the start'. As a result, this observation indicates that planning is a cornerstone to a strong safety culture in NNB projects in which for example, strategies can be put in place to control identified risks before progressing into subsequent project phases.

c) **Collaboration and Engagement:** Collaboration and engagement is well recognised in literature to positively affect an employee's intention to engage in safe behaviours and therefore result in an increased safety performance (Berglund et al., 2023; Tang, 2025, Xia et al., 2020). Strong workforce engagement was also employed during the Thameslink programme through briefs and two-way interactions which led to active participation in safety conversations, close calls, lost time reporting, fair culture, good practices and safety stand downs. Similarly, engagement was also attributed to the strong safety cultures present during the London 2012 Olympic Park and Thames Tideway projects. This is further evidenced from the results of the interviews and focus groups, in which participants believed that building trust and relationships with colleagues was essential. Moreover, that without engagement and collaboration, teams within the organisation or between organisations (i.e., contractors) will consequently work in silos. This was believed to negatively impact safety behaviours on site, for example, non-compliance and/or behavioural inconsistencies between teams. Further, that working in silos can result in workers losing sight of the 'bigger picture' that organisations are trying to achieve. NNB projects should therefore consider the collaboration and engagement of its workforce as crucial to achieving positive safety performance on an NNB site.

d) **Championing Health, Safety and Wellbeing:** An organisations commitment to championing an employee's health, safety, and wellbeing, beyond the minimum legal requirements, has been recognised to positively affect safety performance and attitudes (Xia et al., 2020; Geoghegan, 2012). The London 2012 Olympic Park project is a notable example in that the ODA took account for the health of its employees, contractors, and subcontractors, by offering occupational health services to all workers on site. Participants from the interviews and focus groups discussed that current NNB projects in the UK are employing these practices by providing workers with access to healthcare (access to on-site nurses and GPs); other relevant factors discussed were access to transport and accommodation. Ensuring that the workforce felt respected and valued was a key part of this discussion, as well as the importance of creating a sense of community for the workforce. Extending genuine care to an individuals' wellbeing and demonstrating respect for their communities can therefore be observed as a significant contributing factor to a strong safety culture of an NNB project; and should be considered in accordance with the project's safety and organisational objectives.

e) **Accountability:** Accountability was a subtheme identified from the interviews and focus groups within this report as it was considered part of the 'golden thread', ensuring ownership and responsibility throughout the project. It was identified that without clear lines of accountability, processes can become overly complex, ultimately resulting in a negative impact upon safety culture. When exploring individual accountability in particular, participants felt that it was difficult to address and stop poor working behaviours under 'no blame' safety cultures. The Nuclear Construction Lessons Learned report by the Royal Academy of Engineering (2012) examined six nuclear construction projects and identified similar findings which lead to the following recommendation to be raised; 'An agreed industry-wide framework for industrial safety should be developed covering expectations, rules, rewards, and consequences to ensure consistent, predictable and first-class safety performance.' Empowering employees to take ownership of their own work and safety was also considered critical within literature (Tang, 2025). These findings demonstrate that projects should encourage task ownership as well as

'blame free' reporting of genuine mistakes to ensure overall systemic improvement however, processes should also ensure that individuals are held accountable for reckless or poor working behaviours.

f) **Reporting and Learning from Safety Events:** A strong reporting and learning system is considered integral to the success of an NNB safety culture. The lessons learned report by the Royal Academy of Engineering (2012) made the following recommendation, 'A just and open reporting system should be put in place with its use publicised, reports investigated, feedback given, and the overall system monitored'. Nevertheless, the IAEA Safety Report Series (2012) acknowledged that embedding learning and feedback was a challenge to nuclear power plant projects. An example of a successful reporting and learning system was identified when exploring the Thameslink Programme case study. The project encouraged the reporting of safety events alongside fair and positive investigation, providing the workforce with timely feedback. Partnered with strong collaboration between the workforce and management, this resulted in a growing awareness and confidence that their efforts were making a real difference to the project. Similar findings were also identified on the London 2012 Olympic Park project, demonstrating that reporting and learning systems can be successful on mega-construction projects.

From the interviews and focus groups, participants understood and agreed the benefit of having such systems to understand the systemic causes of events rather than blaming individuals. However, participants reported that this is often not carried out effectively as a sizeable amount of safety events becomes difficult to manage, prioritise, action, and provide feedback on. Further identifying that this can lead to an inconsistency in top-down messaging. The Thameslink project identified feedback as a crucial communication tool that not only drives health and safety behaviours but also improves workforce engagement. Therefore, this observation indicates that the establishment of mechanisms to encourage and manage reporting can be successful in identifying risks and areas of improvement in mega construction projects such as NNBs. However, such processes must also be strongly promoted by leadership and include methods in which to exchange feedback.

g) **Safety Training:** Safety related training has been identified as a key component influencing construction safety climate and safety performance across literature (Perlman et al., 2014; Berglund et al., 2023; Tang, 2025, Xia et al., 2020). Additionally, it is also recognised as fundamental to the success of nuclear safety programmes within industry guidance (INPO, 2010; IAEA, 2012) and raised as a recommendation within the Nuclear Construction Lessons Learned report (2012); *'A systematic approach to training should be taken to provide confidence that all personnel are trained and competent.'* Participants within this study concurred that training was essential to promote the desired behaviours, values, and attitudes of the organisation to the workforce. Further, that supporting new leaders with training can have positive results on worker engagement. However, it was also identified that more training could be offered to the on-site workforce. Participants also discussed the benefit of strong inductions and daily briefs as key methods for reinforcing information and setting clear behavioural standards and expectations. Immersive inductions, alongside clear and simple messaging was advocated by the Thames Tideway project as a means of creating a strong starting position and reference point for safety conversations throughout the project. Safety training, including activities such as inductions and daily briefs, can therefore be observed as an effective means in which to positively influence and encourage safety behaviours and performance of workers on NNB projects.

h) **Management and Leadership:** Management and leadership consistently emerges as a significant determinant of safety performance in most industrial sectors, including both the construction and nuclear industries (Berglund et al., 2023; Tang, 2025, Xia et al., 2020; Simmons, McCall & Clegorne, 2020) and are seen stipulated within relevant guidance and legislation documentation (INPO; 2010; IAEA; 2012; CDM; 2015). Understanding the different

levels of leadership as well as leadership styles (e.g., participative, transactional and transformational) was also identified as key. For instance, Flin and Yule (2004) concluded that senior managers have the most influence on an organisation's safety culture compared to supervisors and middle managers and so need to demonstrate a visible commitment to safety. Similarly, a transformational style of leadership was considered the most effective to achieving positive safety outcomes (Clarke, 2013; Mullen & Kelloway, 2009). The Thameslink programme formed an executive safety leadership team and hosted interviews with a range of staff to understand how they viewed the safety leadership style of key managers and leaders on the project, to reflect on the effectiveness of their safety commitment.

Nevertheless, in a systematic review of safety leadership, all leadership styles (except passive) demonstrated having a positive impact on safety performance indicators, and that leaders should select the most appropriate leadership style dependant on the different organisational contexts (Ta, Kim & Gausdal, 2022). This view was echoed by participants within this study. It is therefore considered important for all levels of leadership to receive training on the different leadership styles, and how to use them effectively depending on the situational context. Participants from the interviews and focus groups discussed values such as trust, integrity, and respect as well as behaviours such as positive role-modelling and strong visibility as factors determining a good leader. A leaders' commitment to safety, and their engagement with the workforce, can positively influence the desired safety behaviours and attitudes seen on-site. Sentiments which are also echoed from the London 2012 Olympic Park and Thames Parkway projects. This observation demonstrates that leaders have a significant impact over the safety performance of the workforce on an NNB site and are therefore integral to the success of the project's safety culture. Further, that these effects can be strengthened by offering training to new leaders as well as wider training on the different leadership styles and ultimately setting high performance standards and expectations across all levels of leadership and management.

5.2 What are the gaps or challenges in developing a strong, homogeneous safety culture for NNBs in GB?

The points discussed below, highlight themes identified from this study that present a potentially significant challenge to NNB projects during their construction phase and therefore require further understanding.

a) **Competence and Resourcing:** The UK is currently constructing its first NNB in over thirty years in which finding a large quantity of highly skilled workers, with experience of working within the nuclear industry, was reported as a particular challenge by participants. Competence and resourcing is a known foundation to the success of any construction or nuclear project, as is seen reflected in relevant legislation e.g., CDM regulations (2015). The importance of competence and capability of the duty holder organisation, people hired to complete the work, as well as third parties supporting the project was a significant point of discussion throughout the interviews and focus groups. However, throughout the conversations three challenges became apparent that require additional consideration.
    1. Following a thirty-year break in the UK nuclear construction industry, how can the skill gap be closed to the magnitude required for future NNB mega-construction projects? It is important to consider that this issue may be mitigated as more NNB projects are constructed within the UK, as the level of skill and experience increases within the industry.
    2. As indicated by one participant *"Being selective at the start and then nurturing and developing that supply chain is vital."* However, when working with many contractors, partnered with high turnover rates, how can consistency of competency be managed and ensured effectively by third parties or by the duty holder organisation?
    3. Finally, during the construction phase of an NNB, what is the ideal allocation of capability and competence between construction and nuclear professionals?

Throughout the interviews and focus groups, a significant proportion of individuals believed that NNB construction projects were more heavily weighted towards nuclear competence, resulting in a shortage of construction specialist knowledge. Moreover, similar results were also identified during the design phase, in which participants believed that constructability was not sufficiently considered throughout the process.

Due to these challenges remaining unanswered, further investigation into ensuring the correct capability and competence on an NNB site would be beneficial, particularly as the UK is expected to construct more NNB projects over the coming years.

b) **Contractor Management and Engagement:** Participants within this study proposed that contractors need to be more embedded into projects, for instance, receiving the same training courses as well as access to the same systems and information as workers from the duty holder organisation. Further, that strong engagement, communication and collaboration with contractors was required to successfully create a positive safety culture. Conversely, results from the literature review discuss the importance of contractor autonomy, and that subcontractors should be able to take initiative e.g., be responsible for familiarisation and training as well as practices and norms (Odewald & Gotcheva; 2015). An example of this, is the London 2012 Olympic Park project where Tier 1 contractors were empowered to develop their own processes and systems and drive their own performance, which was identified to promote ownership and encourage worker engagement. Further to this, a participant from this study when discussing the uniformity of culture on NNB construction projects described it as "achieving the impossible". The challenge identified requiring further clarification, therefore, is how do duty holders appropriately engage, share and collaborate with subcontractors to build a strong safety culture whilst not diminishing their autonomy or ownership on the project.

c) **Engaging Multicultural Workforces:** Participants from this study discussed that it can be difficult to achieve consistency of safety behaviours and beliefs within large multinational workforces, because of different languages or cultural perceptions to safety. However, participants also discussed difficulties with intracultural communications for example, between different genders, age groups and specialisms on-site. During the literature review, there was evidence to suggest that societal values can impact an individual's attitude towards safety (Spangenbergen et al., 2003), yet, irrespective of nationality, workers were less likely to take risks if they perceived a positive commitment to safety from their managers (Mearns and Yule, 2009). Studies on multicultural teams in construction (Ochieng et al.; 2010; Ochieng, 2013; Shepherd et al.; 2021) identified that trust, communication, empathy, and awareness of leadership can be effective when developing large multicultural teams. Additionally, a study on Spanish, Italian and British construction workers (Shepherd et al.; 2021) recommended on-site training, digitalised materials, role modelling and training of soft skills (e.g., hazard awareness and cross-cultural communication) to support the collaboration and engagement of multicultural workers. Whilst fulfilling competency requirements is an essential and legislative obligation of the project (e.g., CDM regulations, 2015), there remains a lack of research understanding the impact of large multicultural teams in construction and NNB projects, with one article reporting it as a 'topic that remains underexplored' (Shepherd et al., 2021). More understanding is therefore required to identify opportunities for improvement, and to maximise the potential of large multicultural teams, particularly on an NNB construction site where safety is considered a fundamental priority.

d) **Learning from Other Industries:** Participants from this study discussed that it was rare for companies to incorporate learning from other industries. It is important to consider that for proprietary and competitive reasons, organisations across other industries may not always be open to sharing information. This is acknowledged in the IAEA safety series report (2012) that lessons learned from non-nuclear industries are not usually included in databases capturing

information on design, construction and commissioning. As a result of this, how can an NNB project:

1. Effectively collate information from other industries,
2. Manage a conceivably large number of data entries,
3. Interpret learnings from events which may not be reflective of the high standards of the nuclear industry,
4. Share feedback with the workforce that is meaningful whilst not overloading workers with information.

Therefore, whilst there is an observable opportunity for NNB projects to apply learning from other industries, the method in which this can be done effectively is yet to be understood.

e) **Conflicting Management Priorities:** Managers on mega construction and NNB projects are trained to understand that safety and quality are the top priority and a cornerstone to the project's safety culture. In practice however, the success of achieving this is often constrained by the pressure on managers to also achieve business objectives, for example, cost and scheduling goals. This was identified to result in inconsistent messaging throughout all levels of management, creating a sense of frustration and confusion for the workforce. Participants from the focus groups also reported that supervisors on one project were financially rewarded when they achieved organisational goals, which was believed to have a negative effect on the team's safety performance. Alternatively, when key performance indicators are driven by safety objectives for example, teams are given a targeted number of safety reports to complete, learning has become almost impossible to do due to the high number of recorded safety observations. Nevertheless, participants agreed that an individual's commitment to safety should be considered during the leadership selection process, and that new leaders should be trained on how to deal with conflicting safety and business objectives. However, whilst there is a common agreement that safety must be the ultimate priority, there is limited evidence on what has been successful previously (from literature or case studies) on effectively managing the negative impact of organisational pressures on the safety and wellbeing of the workforce. This is therefore an area that requires better understanding and further consideration, particularly when creating the processes and standards that will define an NNB projects safety culture.

f) **Defining Nuclear Safety During the Construction Phase of an NNB Project:** Throughout the interviews and focus groups, participants were divided on what nuclear safety looks like during the construction phase of an NNB, and two predominant points of discussion became apparent.

1. How relevant is nuclear safety during the construction phase of an NNB?
2. What is nuclear safety during the construction phase of an NNB?

Some participants believed that nuclear safety was integral across all phases of a nuclear power plant project, and that it is best defined by a high-quality work to ensure the safe running of the plant, and protection of operators and civilians in the future. As a result, participants suggested alternative terms such as 'Nuclear Quality Culture' or 'Nuclear Quality Commitment'. On the other hand, some participants believed that whilst the plant is not operational and there is no active nuclear material on-site, it is predominantly a construction project. Further to this, that the organisation needs the appropriate competence and capability to carry out the construction work, which was considered significantly different from nuclear competence. Overall, participants agreed that the *"picture can be quite murky"* due to the often-conflicting messaging between conventional and nuclear safety cultures, resulting in an overcomplicated and ambiguous safety culture, lacking a clear definition. One participant referred to the topic as a *"red herring"* and that fundamentally both cultures (conventional and nuclear) come down to the same behaviours and is better defined as a *"a culture of doing the right thing".*

This highlights a significant challenge to NNB projects in that, how can the organisation train and effectively communicate the importance of nuclear safety, or perhaps as suggested by participants, explicitly quality, if there is not a simple, established message. A message which needs to be embedded into the project from the start (i.e., prior to the beginning of the

construction phase) that also works in harmony with construction and conventional safety regulations, practices, and processes. More investigation is therefore required to understand the most appropriate and effective approach to defining, creating, and embedding a strong safety culture during the construction phase of an NNB.

5.3 What actions could be recommended to enhance safety culture, safety performance and quality for NNBs in GB?

The following recommendations are based on the findings from this study which identified opportunities in which safety culture and performance could be enhanced during the construction phase of NNBs.

1. **Reflecting on the Results from This Study:** Duty holders and regulating bodies may benefit from reflecting on the discussion points raised in sections 5.1 and 5.2 of this document alongside current processes, practices, documentation, and regulation, to identify potential areas for improvement, and opportunities to better promote existing methodologies and approaches.

2. **Pride:** Pride is an underexplored trait during the construction phase of an NNB and within the wider construction industry in general. Participants from the interviews and focus groups believed that invoking a sense of pride in workers on NNB projects was important for workers to appreciate the scale and significance of the project. Additionally, pride was believed to have a significant positive impact on the safety performance of workers on the London 2012 Olympic Park project. From this, there is evidence to suggest that pride is an important factor to consider regarding safety performance during NNB and mega-construction projects. Duty Holders should therefore consider exploring ways of promoting a greater sense of connection between the project and its workforce and how it could be incorporated into its safety culture strategy.

3. **Simple and Unambiguous Messaging:** Unclear and inconsistent messaging was highlighted to have a negative impact upon safety behaviour and safety performance throughout all themes identified within this study. As a result of unclear messaging, it was identified that teams often resulted to working in silos or failed to process messages due to being overloaded. The results from this study therefore suggest that safety culture values, expectations, and behaviours should be simplified to a small number of key capabilities, to reduce the risk of overloading the workforce with information and to improve knowledge retention. This is supported by evidence identified in the literature review from the Thames Tideway Tunnel project, which used a clear and simple message as the foundation for its 'Right Way' safety culture programme. Duty holders should therefore reflect on their safety culture strategy and consider how their safety messaging could be simplified and refined. Further, regulating and legislative bodies supporting NNB projects should reflect and explore if improvements could be made to current practices (e.g., guidance and legislation) to best support duty holders in achieving the simplification of safety culture messaging on NNB construction sites.

4. **Sharing NNB Construction Phase Learning for Future NNB Projects:** The UK is currently constructing its first NNB in over thirty years with further sites also projected. Whilst there is a legal obligation for duty holders to report certain types of accidents or risks to the health or safety across the site, it does not stipulate a specific reporting system for general learning during the pre-operational phases of a nuclear powerplant. As raised in section 5.1 above, the IAEA Safety Report Series (2012) recognised that embedding learning and feedback can be a challenge and often fails to capture experiences during the plant's preoperational phases. Additionally, that even when systems are put in place, they are often not accessible or interconnected with other processes or systems on-site. There is therefore an opportunity for relevant regulating and legislative bodies to reflect on current reporting requirements during the construction phase of an NNB project and identify areas in which learning from pre-operational phases can be better integrated into and across NNB projects.

6. Limitations and conclusions

6.1 Limitations

It is important to note that this study had some limitations. Firstly, it must be acknowledged that the interview sample used could be considered biased due to the higher number of Safety and Nuclear Safety Inspectors interviewed compared to other roles. Additionally, although a wide variety of workers were included within the focus groups, 'on the ground' workers were not accessed within this study. Therefore, this should be considered when reflecting on the results of the report and could be an area for future research, to use a superior sample that more accurately presents the entire function of an NNB. Secondly, the validity of data cannot be assumed due to the nature of qualitative research, particularly as participants were not selected at random, the data is therefore not able to be generalised to the workforce population of NNBs. A larger sample size and use of mixed methods (i.e., qualitative and quantitative measures) could assist with building reliability and validity of any future research.

6.2. Conclusion

In summary, many themes have been identified as key facets to safety culture within NNBs (i.e., leadership, training, organisational learning, planning and collaboration); however, many challenges to implement such approaches were also identified. Due to the size and complexity of NNB projects, such challenges require meaningful and purposeful action to be overcome. Nevertheless, it is vital that the approach to nuclear safety culture during the construction phase of an NNB is established collectively with conventional safety culture, to best support in creating a clear and homogenous safety culture objective.

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8. Appendices

A. Semi-Structured Interview Schedule

Semi-Structured Interview Schedule

Introduction

Thank you for agreeing to speak with us today; we are going to ask a series of questions about your experience, understanding and approach to safety culture regarding the nuclear and construction industries.

We expect the interview should take approximately one hour and we can pause for a break whenever needed. You can also stop and withdraw from the interview at any time during the conversation.

With your consent, we would like to record the interview so that we can review our discussion for relevant themes in our research. The recording will not be shared, handled or controlled by anyone outside of the researchers identified and will be deleted upon completion of the research project. Additionally, all data will be anonymised so that you cannot be identified.

- Have you received, completed and returned the participant consent form?
- Do you understand that you do not have to take part, that you can stop the interview at any time?
- Do you consent to your interview being recorded?
- Do you understand your involvement within this study?
    - your right to withdraw?
    - and how your data will be managed and used, in particular that we may use anonymised quotes from yourself to support and demonstrate our findings?
- Would you like any information repeating or clarifying?

There will be an opportunity at the end of the interview to ask more about the study.

- Do you have any questions before we begin?

Questions

(Text in italics represents prompts that can be used if necessary to help participants answer questions in full.)

1. Can you tell us about your role and experience in the nuclear industry?
    - *What is your role?*
    - *What are your responsibilities?*
    - *How long have you been in your role?*

2. As part of your role, or in previous roles, have you ever been involved at the construction stage of NNBs or mega-construction projects in the UK, and can you tell us a bit about your experience?
    - *What was the project and for how long did you support the project?*
    - *What capacity did you support, what was your role / responsibilities?*
    - *What was the size of the project?*
    - *What went well on the project?*
    - *Is there anything about the project that was difficult/ challenging?*

3. How would you describe the safety culture in NNBs, particularly during the time of their construction?
   - *Have you ever experienced contrasting attitudes and approaches to safety in the construction industry in general compared to the construction of NNBs / nuclear industry? Why do you think that is?*

4. From any awareness of incidents in construction are there any patterns/themes of factors that impact on safety culture and are there any lessons learned from incidents?

5. *From your experiences in NNB and/or other construction projects, what factors do you think*
   (a) impact detrimentally on safety culture/safety performance?
   (b) have enabled/supported a good safety culture/performance?

6. How do you believe that safety culture could be improved during the construction phase of an NNB?
   - *Can you expand on why you believe X could improve safety culture in NNBs?*
   - *Do you think this is unique to NNB construction compared to the wider construction industry?*
   - *Do you believe the approach to safety culture should be different from the wider construction industry?*

7. Is there anything else you think is important for us to know that we haven't discussed regarding safety culture during the construction of NNBs?

Interview Close Out

Thank you so much for taking the time out of your day to support us with our study. As a reminder we will delete the recording at the end of the research project and all data be anonymised.

Before we close the meeting, do you have any questions about the study that you would like to ask?

Thank you again, we will now send over a document confirming the details of the interview process as well as our contact information should you need to get in touch. If you are happy to do so we will now stop the recording which brings our interview to a close.

B. Participant Consent Form

Research Project Briefing Form: Safety Culture in Nuclear New Builds

Purpose of the research study
With the United Kingdom increasing its investment into nuclear power, understanding safety culture in nuclear new builds is paramount for creating a safe working environment, particularly during their construction. This study is explorative and aims to understand common factors that impact on the development and management of a successful safety culture in nuclear new builds.

What you will be asked to do
If you decide to participate, you will take part in a one-hour interview. Questions will be focused around understanding your experience and views on safety culture in both the nuclear and construction industries. With your permission, the interview will be recorded so that we are able to review the conversation for themes relevant to our research. If you would prefer the interview not to be recorded, only written notes will be taken.

Privacy and confidentiality
All recorded interviews will be stored in a secure folder only accessible by the research team and those who might collaborate as part of the research process. You will not be identified by name and all information discussed during the interview will be anonymised. No personal information will be shared with anyone outside of the research team unless required by law. The researchers may be required to share information should any information suggest that yourself or another person's health, security or well-being may be at risk.

Reporting of the results
Although the project outcomes will be determined by the research findings, a research paper will be produced for the Office of Nuclear Regulation which may be published on their organisation website. Any quotes will be anonymised and will not be attributed to a specific individual.

Withdrawing from the study
Your participation is completely voluntary, and you are under no obligation to participate. If you decide to participate but change your mind later, you are free to withdraw at any time. You can withdraw permission to use your interview as part of the research within one week following the interview. Following the one-week period, your data will already be anonymised, and we will not be able to remove your data.

Consent to Participate in Research

- I voluntarily agree to participate in the above-titled research study.
- I understand that even if I agree to participate, I can withdraw at any time or refuse to answer any question without consequences of any kind.
- I understand that I can withdraw permission to use data from my interview within one week after the interview, in which case the material will be deleted.
- I have had the purpose and nature of the study explained to me verbally (or in writing if requested) and I have had the opportunity to ask questions about the study.
- I understand that participation involves taking part in a one-hour interview where I will be asked questions about my experience of safety culture across both nuclear and construction industries.
- I understand that I will not benefit directly from participating in this research.

- I agree to my interview being recorded.
- I understand that all information I provide for this study will be treated confidentially.
- I understand that in any report on the results of this research my identity will remain anonymous. This will be done by changing my name and disguising any details of my interview which may reveal my identity or the identity of people I speak about.
- I understand that anonymised extracts from my interview may be quoted in the final report of this research.
- I understand that if I inform the researcher that myself or someone else is at risk of harm, they may have to report this to the relevant authorities - they will discuss this with me first but may be required to report with or without my permission.
- I understand that signed consent forms, transcripts, notes, and original recordings will be retained in a secure folder with restricted access for the research team only. Recordings and transcripts from my interview will be deleted upon completion of the project. Consent forms will not be deleted and will be kept within the same secure folder.
- I understand that I am free to contact the researchers to seek further clarification and information.

Questions and Contact Information

If you have any questions about the study or would like more information, please contact:

KM **LM**

Signature of Research Participant

| --- | --- | --- |
| Name of Participant | Signature of Participant | Date |

Signature of Researcher

I believe the participant is giving informed consent to participate in this study

| --- | --- | --- |
| Name of Researcher | Signature of Researcher | Date |

C. Participant Debrief Form

Research Project Debriefing Form: Safety Culture in Nuclear New Builds

Thank you for your time and for sharing your experiences as we explore safety culture in nuclear new builds, it was greatly appreciated!

Below is a reminder of the information outlined within the project briefing and consent form:

Purpose of the research study
With the United Kingdom increasing its investment into nuclear power, understanding safety culture in nuclear new builds is paramount for creating a safe working environment, particularly during their construction. This study is explorative and aims to understand common factors that impact on the development and management of a successful safety culture in nuclear new builds.

Your participation
You took part in a one-hour interview answering questions aiming to understanding your experience and views on safety culture in both the nuclear and construction industries. With your permission, the interview was recorded so that we can review the conversation for themes relevant to our research.

Privacy and confidentiality
All recorded interviews will be stored in a secure folder only accessible by the research team and those who might collaborate as part of the research process. You will not be identified by name and all information discussed during the interview will be anonymised. No personal information will be shared with anyone outside of the research team unless required by law. The researchers may be required to share information should any information suggest that yourself or another person's health, security or well-being may be at risk.

Reporting of the results
Although the project outcomes will be determined by the research findings, a research paper will be produced for the Office of Nuclear Regulation which may be published on their organisation website. Any quotes will be anonymised and will not be attributed to a specific individual.

Withdrawing from the study
You can withdraw permission to use your interview as part of the research within one week following the interview. Following the one-week period, your data will already be anonymised, and we will not be able to remove your data.

Questions and Contact Information

If you have any questions about the study or would like more information, please contact:

KM **LM**

Once again, thank you for your participation in this study!

D. Semi-Structured Focus Group Schedule

Focus Group Questions and Running

Intro

- Why are we here:
  - Scoping review to provide recommendations on how to improve safety culture within the construction stage of NNB
- What have we done to date:
  - Conducted interviews with inspectors, safety specialists, construction managers, design team
  - The purpose of the focus group today is to get your opinions / views and experiences of safety culture
- What we are doing, how we will use the information within this workshop:
  - Read aloud information on the consent form and get verbal consent to continue
- How will the session work?
  - 3 discussion points about 15-20 mins for each point
  - We are interested in hearing about your experience here at [NNB construction site] but also from previous projects, they don't have to be nuclear based, so please feel free to share any experiences from different projects and compare them. We will not be taking notes of company or individual names or details
  - Does anyone have any questions before we move on?
  - Quickly go around the room and introduce yourself and your role

Questions

1. What comes to mind when you hear the term Safety Culture?
   a. Have you found the safety culture at [NNB construction site] different from previous construction projects?
   b. How important do you think understanding the nuclear context is within your current role?

2. Next, we want to understand what things make a good safety culture for you?
   a. Do you have an example of when safety culture has been positive or negative and why you feel like it did / didn't work? (can be previous employment can be comparing two different places of employment)

3. If we could go around the room and tell us in less than one minute what you would do to improve the safety culture within your team today, what would you do / change or introduce?

Debrief

- Hand out focus group debrief forms – reminder of key points
- Any questions before we end the session?

E. Content Analysis Results

Table 4. Qualitative Content Analysis Results

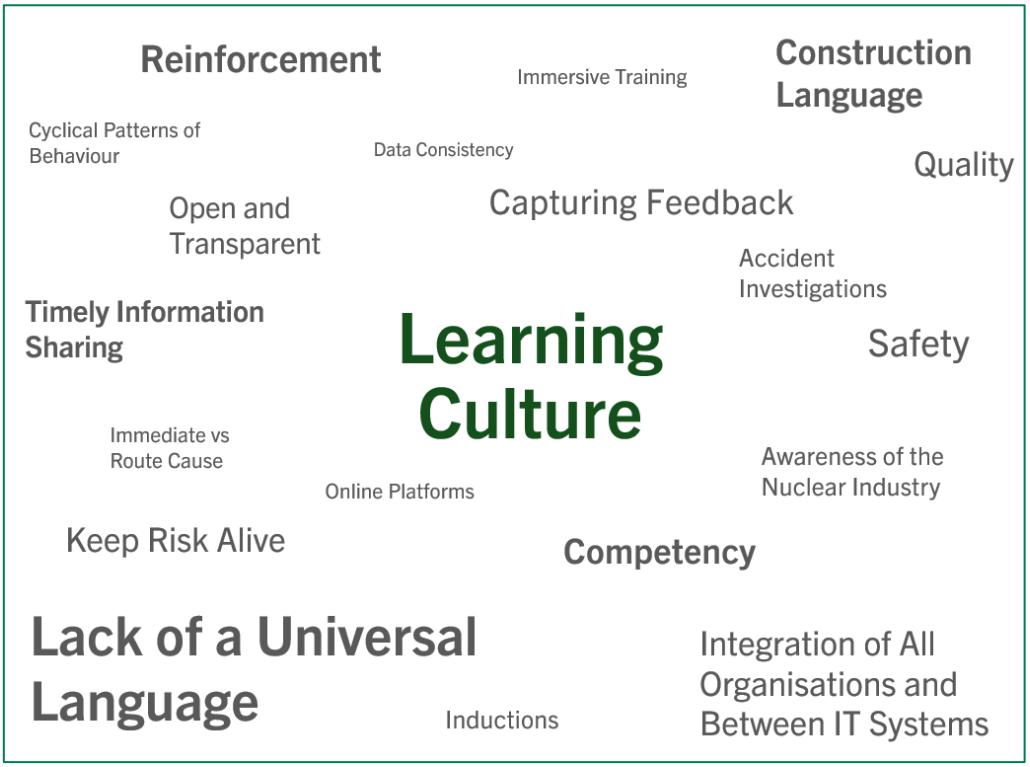
Theme	Interview Participant ID																Focus Group ID				Total
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	1	2	3	4	
Managing Organisational Pressures	5	1	5	5	5	5	5	2	5	5	1	5	5	5	3	4	4	5	5	2	**82**
Community and Ethos	5	5	3	3	4	4	4	5	2	3	5	4	3	4	4	5	5	4	2	3	**77**
Learning Culture	1	4	3	4	2	3	3	3	4	4	3	2	4	3	5	2	2	3	1	4	**60**
Leadership	3	3	3	1	3	1	1	1	3	1	3	3	2	2	1	2	2	2	3	1	**41**
Understanding Nuclear Safety Culture in NNB Projects	2	2	1	2	1	1	2	4	1	2	2	1	1	1	2	1	1	1	4	5	**37**

F. Qualitative Theme Word Results

F.1 Managing Organisational Pressures

F.2 Community and Ethos

F.3 Learning Culture



F.4 Leadership

F.5 Understanding Nuclear Safety Culture in NNB Projects