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Integrating Risk, Quality and Standards in Infrastructure Project Management: A Northeast Sunderland Case Study[1]

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Abstract

Northeast Sunderland is a geographically bounded multi-modal infrastructure environment encompassing railway, road and bridge projects delivered under multiple British and international standards, including BS EN Eurocodes, DMRB, NR/L2/CIV, ISO 9001:2015, ISO 31000:2018, ISO 45001:2018 and ISO 22163:2023. This paper reframes a focused thematic review of twelve peer-reviewed studies through a project-management lens, examining how standards, risk, quality and lifecycle requirements are integrated from project inception to handover. Three convergent themes are retained from the evidence base: Standards Framework Divergence, the Implementation Gap and ISO 31000 Under-Integration. The reviewed evidence indicates that structured project-management practices are positively associated with project success but are not consistently embedded from project inception, while non-safety risks and standards interfaces may be managed reactively. The paper therefore proposes a conceptual Integrated Project Management and Lifecycle Governance Framework for Northeast Sunderland. The framework positions scope and standards planning, ISO 31000 risk management, ISO 9001 quality management, procurement and contractor integration, digital information systems, and lifecycle value as coordinated project-governance components. The contribution is conceptual and inferential, and requires practitioner validation.

Keywords: Project management; Infrastructure projects; Risk management; Quality management; Project governance; ISO 31000; Standards integration; Multi-modal infrastructure

1. Introduction

Complex infrastructure projects in the UK are delivered within a multi-layered standards environment: railway projects are influenced by NR/L2/CIV and ISO 22163:2023; bridge projects by DMRB and BS EN 1991-2; and road projects by National Highways requirements together with ISO 9001:2015 and ISO 31000:2018. The project-management challenge is not compliance with each standard in isolation, but the coordinated integration of technical, risk, quality, information and lifecycle requirements from initiation through handover and asset use. Evidence in the reviewed literature indicates that structured project-management practices are not

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consistently embedded from project inception (Oyekunle, Abbey and Ibeh, 2024); the authors further infer, from the public asset-management documentation examined in Section 4.4, that standards implementation may be reactive in practice.

Northeast Sunderland contains railway projects on the Tyne, Wear and Coast Route, A19/A690 road corridors and bridge structures including Wearmouth Bridge (main span approximately 114 m). As a geographically bounded multi-modal setting governed by multiple standards and organisations, it provides a useful context for examining project-management interfaces without the complexity of a national-scale study.

This paper re-analyses the existing evidence base through a project-management lens. It examines how standards divergence, risk under-integration and inconsistent management practices can affect scope definition, design coordination, quality planning, procurement, contractor interfaces and lifecycle decision-making. It then proposes an Integrated Project Management and Lifecycle Governance Framework for Northeast Sunderland. Climate resilience is retained as a cross-cutting project risk that should be incorporated into project risk registers, design decisions and lifecycle value planning rather than treated as a separate operational issue.

1.1 Research Objectives

Five research objectives guide this study:

- To synthesise the twelve selected peer-reviewed studies to identify project-management implications arising from standards divergence and implementation gaps.
- To critically compare BS EN Eurocodes, DMRB and ISO Standards (9001, 22163, 31000, 45001) and identify interfaces requiring coordination within infrastructure project planning and delivery.
- To identify and categorise barriers affecting project scope, design coordination, quality, procurement and construction-phase implementation across railway, bridge and road projects.
- To evaluate proactive versus reactive integration of ISO 31000:2018 as a project risk-management mechanism from project inception through delivery and handover.
- To propose evidence-based recommendations and a conceptual Integrated Project Management and Lifecycle Governance Framework for Northeast Sunderland multi-modal infrastructure projects.

2. Literature Review

2.1 Theoretical Foundation — Project Management, Lifecycle Value and Standards Integration

BS 6079:2019 provides principles and guidance for the management of projects, while the reviewed infrastructure evidence shows that project decisions must also account for whole-life value, risk and asset information. ISO 55000:2014 defines asset management as coordinated activity to realise value from assets across the lifecycle (International Organisation for Standardisation, 2014). Revised 2024 editions have since been published; the 2014 editions are

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those consulted here. ISO 55000 is treated as a lifecycle-value input to project governance rather than as the primary organising framework. The project-management task is to connect scope, risk, quality, standards, information and handover decisions so that project outputs support subsequent lifecycle performance. Mahammedi, Hayes and Al-Mhdawi (2025) review the principal risks to UK bridge asset management, including ageing assets, funding limits, skills shortages and climate hazards, which underline the need for lifecycle-oriented planning.

2.1a International Lifecycle and Governance Practice — Comparative Framework

Table 1 compares infrastructure management practice across six jurisdictions on five dimensions: primary management framework, ISO 31000 integration, lifecycle cost maturity, smart infrastructure adoption and compliance orientation. For the present project-management framing, the comparison is used to identify governance practices that can be incorporated into project initiation, planning, risk, quality and handover processes.

Dimension	UK	Australia	Japan	Singapore	Germany	USA
Primary AM Framework	ISO 55000 + DMRB + NR/L2/CIV (sector-specific)	ISO 55001-aligned practice; IPWEA practice notes and IIMM	Ministry-led maintenance-cycle (PDCA) approach; ISO 55000 adoption indicated as growing (indicative)	Integrated AM approach aligned with ISO 55000 (indicative)	DIN ISO 55000 series adopted; federal infrastructure AM guidance (indicative)	ISO 55001 + FHWA TAMP (Transportation Asset Management Plan; federal requirement for the National Highway System)
ISO 31000 Risk Integration	Reactive pattern inferred by the authors for UK bridge assets from public documentation (cf. Mahammedi et al., 2025 on UK bridge risks); broader risk-informed approaches exist in railway track research (Sasidharan et al., 2022); extent of ISO 31000 integration in project delivery not established	Risk management expected within ISO 55001-aligned AM plans (IPWEA IIMM)	Not evidenced in the sources reviewed	Not evidenced in the sources reviewed	DIN EN IEC 31010 (risk assessment techniques) adopted; extent of project-level integration not evidenced	FHWA TAMP requirements include risk management analysis; AASHTO risk-based asset management guidelines
Lifecycle Cost Management	Inspection-triggered pattern inferred from public documentation; embedded whole-life approach not evidenced	Lifecycle cost analysis promoted in IPWEA practice notes (IIMM)	Long-term lifecycle planning orientation (indicative)	Life-cycle costing used in public infrastructure planning (indicative)	Federal transport investment appraisal (BVWP) uses cost–benefit analysis; extent of whole-life costing not evidenced	FHWA TAMP requires life-cycle planning; performance-based targets for NHS pavements and bridges

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Dimension	UK	Australia	Japan	Singapore	Germany	USA
Smart Infrastructure Adoption	BIM Level 2 mandated for centrally procured public projects (2016); Digital Railway programme; IoT pilots	BIM adoption growing; IoT sensor deployment in bridge and road networks	Structural Health Monitoring (SHM) reported on selected bridges and tunnels (indicative)	Smart Nation initiative promotes digital and sensor-based infrastructure monitoring (indicative)	BIM expected on new federal transport infrastructure projects (Stufenplan Digitales Bauen); other digital claims indicative	BIM adoption varies by agency (no single national mandate); AI-assisted inspection reported in research and pilots (indicative)
Compliance Orientation	Reactive — audit/inspection-triggered (authors' inference from public documentation)	Condition-based, lifecycle-oriented practice promoted in IIMM (indicative)	Preventive-maintenance orientation (indicative)	Performance-based governance orientation (indicative)	Standards-driven planning orientation (indicative)	TAMP and performance-management requirements for the National Highway System
Best Practice Benchmark for UK	— (baseline)	ISO 55001 LCA integration; community-of-practice model (IPWEA) for knowledge transfer	SHM deployment; long-term lifecycle planning horizon	Digital integration under Smart Nation; risk governance not evidenced	Standards-driven early planning; BIM-lifecycle integration	FHWA TAMP structure; risk-based asset management; performance-based targets

Table 1. International Infrastructure Asset Management Practice — Comparative Analysis Across Six Jurisdictions

Source: Authors' own comparative analysis based on Mahammedi, Hayes and Al-Mhdawi (2025); Wijnia and de Croon (2015); Frangopol and Soliman (2016); Alberti and Fiori (2019); ISO (2018) ISO 31000; FHWA (2019) Asset Management; IPWEA (2021) International Infrastructure Management Manual; Network Rail (2021) NR/L2/CIV. Note: The comparison is indicative and is used for contextual benchmarking rather than as a systematic evaluation of national performance. Entries marked 'indicative' for Japan, Singapore, Germany and other non-UK cases are not based on a document-level review and should be treated as hypotheses for future comparative work; 'not evidenced' means that no source reviewed supports a statement.

2.2 Digital Information Systems Supporting Multi-Modal Project Governance

Smart infrastructure technologies including IoT sensor networks, BIM, GIS, Digital Twin platforms and AI predictive analytics can support project planning, design coordination, risk identification, information handover and lifecycle decision-making (Sacks, Girolami and Brilakis, 2020). For Northeast Sunderland, their project-management value depends on integration into governance processes rather than isolated technology deployment. BIM and related digital systems can provide a common information environment linking project scope, standards requirements, risk controls, quality records and downstream asset information.

2.3 Theme 1 — Standards Framework Divergence: British and International Perspectives

Standards diverge measurably. Masrom and Goh (2018) quantify divergence through grillage analysis (BD37/01, EN 1991-2, UK National Annex; seven span lengths, 25–45 m): the UK National Annex αq modification produces a constant 5.5 kN/m² UDL and higher load-effect ratios than base EN in all conditions examined, while the EN load model governs maximum moment at spans of 30 m and above and BD37 governs below 30 m. Nhamage et al. (2025) report that, although IFC 4.3 (ISO 16739-1:2024) now includes bridge components, interoperability remains

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a key challenge for bridge digital twins. Gueorguiev (2023) notes that ISO/TS 22163:2017 expanded the ISO 9001:2015 core text from 29 to 69 pages and that ISO 22163:2023 introduces further changes; these added requirements may raise implementation effort for NR/L2/CIV projects, although the paper does not examine this directly. Lin et al. (2025), surveying 31 mainly European railway professionals, found about 48% rated the absence of comprehensive policies and standards Critical or High, although insufficient end-user experience was the most critical barrier.

2.4 Theme 2 — Project-Management Implementation Gap: Standards Compliance versus Best Practice

Oyekunle, Abbey and Ibeh (2024) surveyed 27 UK construction project managers: Spearman's rank correlations with project success were $\rho = 0.764$ for scope management, 0.692 for schedule management and 0.672 for cost management. Bidders' conferences, parametric estimating and team charters — practices that may support quality planning aligned with ISO 9001:2015 and BS 6079 — were among the least used techniques. Frangopol and Soliman (2016) review life-cycle engineering of structural systems, including life-cycle cost, monitoring and risk. Parlikad and Jafari (2016) summarise challenges identified by infrastructure owners and operators in UK and USA workshops, while Wijnia and de Croon (2015) set out a process reference model for infrastructure asset management. Figure 1 presents the integrated digital project governance framework.

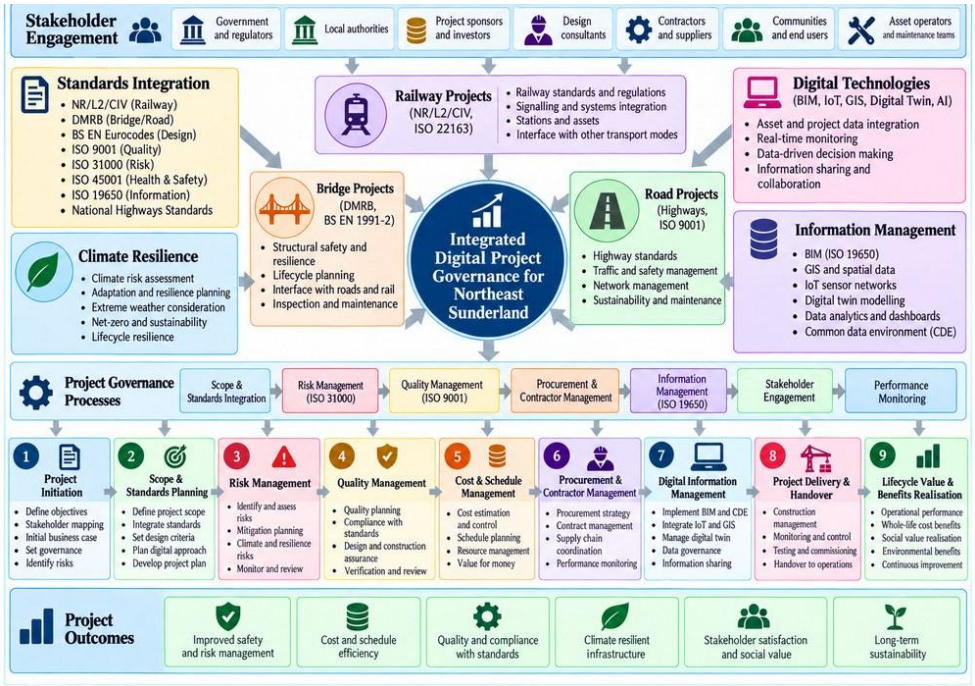


Figure 1. Integrated Digital Project Governance Framework for Northeast Sunderland

Source: Adapted from ISO 55000 series (2014–2024); ISO 31000:2018; Mahammedi et al. (2025); Oyekunle et al. (2024). In this paper the original lifecycle evidence is interpreted as supporting project governance, information integration and handover.

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2.5 Theme 3 — ISO 31000 Under-Integration in UK Infrastructure

Evidence for ISO 31000:2018 under-integration is limited and partly inferential. Mahammedi, Hayes and Al-Mhdawi (2025) review the main risks facing UK bridges, including ageing assets, funding limits, skills shortages and climate hazards, but do not characterise UK practice as reactive; any reactive pattern discussed here is the authors' inference from public documentation (Section 4.4). Sasidharan, Burrow, Ghataora and Marathu (2022) present a risk-informed life-cycle approach to UK railway track maintenance that compares maintenance, operating, travel-time, safety, social and environmental impacts, showing that risk-informed decision-making beyond safety is feasible. Their study does not, however, establish how widely such approaches are embedded in project delivery. From a project-management perspective, this indicates a need to extend risk governance beyond safety to include contractor, design-change, compliance, interface, climate and lifecycle risks from project inception. Dekker et al. (1997) provide a foundational comparator on the reactive-to-proactive transition, while Alberti and Fiori (2019) report, from a pavement case study, that risk-based management can be more effective than performance-based management alone, although their study does not address ISO 31000 specifically.

3. Methodology

This study employed a focused thematic review under a critical realist philosophy (Bhaskar, 1978; Sayer, 2000), consistent with Saunders, Lewis and Thornhill (2019). The evidence base and original search process are retained transparently. For this revised manuscript, the selected evidence is interpreted through a project-management lens to identify how standards, risk, quality and lifecycle requirements interact with project planning and delivery. No claim is made that a new project-management literature search was undertaken.

3.1 Search Strategy

Scopus, Web of Science and ICE Virtual Library were searched on 20 June 2026 using the original master string: ("asset management" OR "infrastructure management") AND ("railway" OR "bridge" OR "road") AND ("British Standards" OR "ISO 31000" OR "DMRB" OR "Eurocodes") AND ("United Kingdom" OR "UK"). Inclusion criteria were: peer-reviewed; primarily published 2014–2025, with one foundational maintenance-modelling review from 1997 retained as a theoretically relevant comparator (A7); English language; UK infrastructure or directly relevant international comparator; and standards-compliance or asset-management relevance. The search was not designed as a comprehensive project-management systematic review, so the twelve-study corpus is used without overstating the breadth of the evidence.

3.2 Screening and Selection Process

This study is reported as a structured literature review rather than a PRISMA-compliant systematic review. Article selection followed staged identification, screening, eligibility and inclusion steps, and the flow-diagram format of PRISMA 2020 (Page et al., 2021) is used only to present the counts. Twelve studies (journal and conference papers) were purposively selected, each addressing a distinct dimension of the research problem. The process proceeded through: Identification (n = 632); Screening (n = 342 after duplicates); Eligibility (n = 64 full-text reviewed;

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n = 52 excluded with reasons); and Inclusion (n = 12 final), as illustrated in Figure 2 and detailed in Table 2. During revision, three of these twelve studies (A8, A10 and A11) were removed after citation verification and replaced by three studies identified through targeted searches outside the original search string; the final corpus comprises nine original and three replacement studies (Figure 2, Table 2).

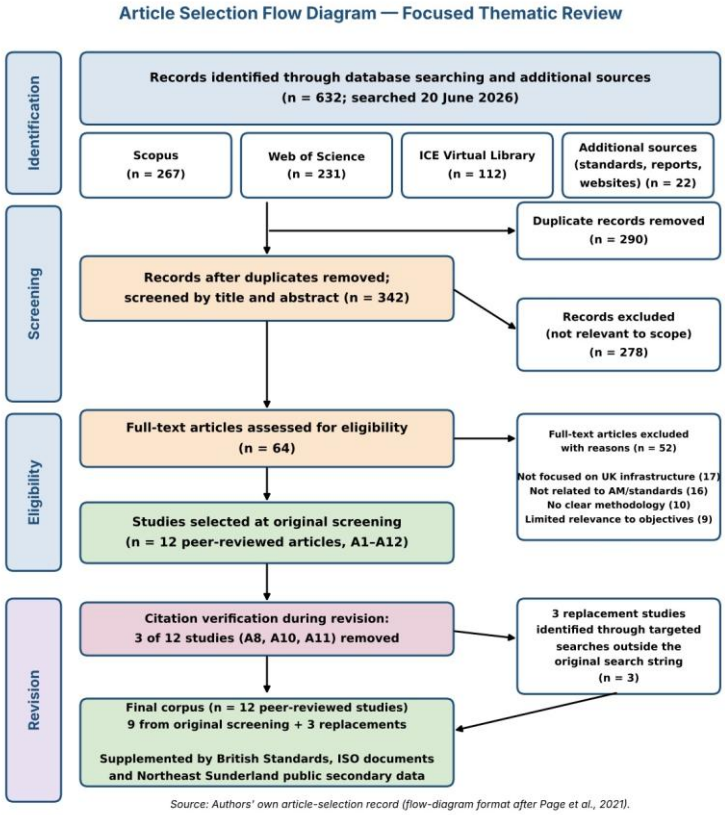


Figure 2. Article Selection Flow Diagram for the Focused Thematic Review, Including the Revision-Stage Replacement of Three Studies

Source: Authors' own article-selection record; flow-diagram format after Page et al. (2021).

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Selection Stage	Outcome / Count
Identification — initial database searches (Scopus, Web of Science, ICE Virtual Library; searched 20 June 2026)	Scopus: n = 267; Web of Science: n = 231; ICE Virtual Library: n = 112; Additional sources: n = 22. Total identified before duplicate removal: n = 632
Screening — title and abstract review against inclusion criteria	Records after duplicates removed: n = 342; Excluded (not relevant to scope): n = 278; Retained for full-text review: n = 64
Eligibility — full-text review and quality appraisal (peer review, methodology, UK relevance)	Full-text assessed: n = 64; Excluded with reasons (not UK infrastructure: 17; not AM/standards: 16; no clear methodology: 10; limited relevance to objectives: 9): n = 52
Inclusion — original selection meeting all four quality criteria	Twelve peer-reviewed studies selected at original screening (A1–A12).
Revision — citation verification and replacement	Three studies (A8, A10, A11) removed after citation verification; three replacement studies identified through targeted searches outside the original search string. Final corpus: n = 12 (nine from original screening plus three replacements), supplemented by standards documents (BSI, ISO, DMRB, NR) and NE Sunderland public data.

Source: Authors' own

Table 2. Article Selection Process — Focused Thematic Review Screening Stages and Outcomes

3.3 Quality Appraisal

Each article was assessed against four quality criteria: peer-review status; Scopus or Web of Science indexing; methodological transparency; and relevance to UK infrastructure standards compliance or asset management. Evidence was additionally mapped to project dimensions where supported: scope and standards coordination, risk, quality, procurement/contractor interfaces, information management and lifecycle handover. Standards documents were sourced from BSI Online, ISO.org and the National Highways DMRB portal. Northeast Sunderland contextual data were drawn from publicly available National Highways, Network Rail and Sunderland City Council documentation.

Formal CASP/JBI appraisal tools were not adopted — a recognised limitation — given the heterogeneous evidence base spanning structural analysis, framework development and survey research. The four-criterion appraisal framework was adapted from established structured-review principles appropriate to engineering literature.

3.4 Thematic Coding, Project-Management Mapping and Synthesis

The twelve selected articles were subjected to the original iterative three-stage thematic coding. Stage 1 assigned free codes to key findings; Stage 2 grouped codes into descriptive themes; and Stage 3 developed three analytical themes: Standards Framework Divergence, the Implementation Gap and ISO 31000 Under-Integration. These themes were then mapped to project-management implications only where supported by the evidence (the same dimensions listed above). The thematic framework is illustrated in Figure 3.

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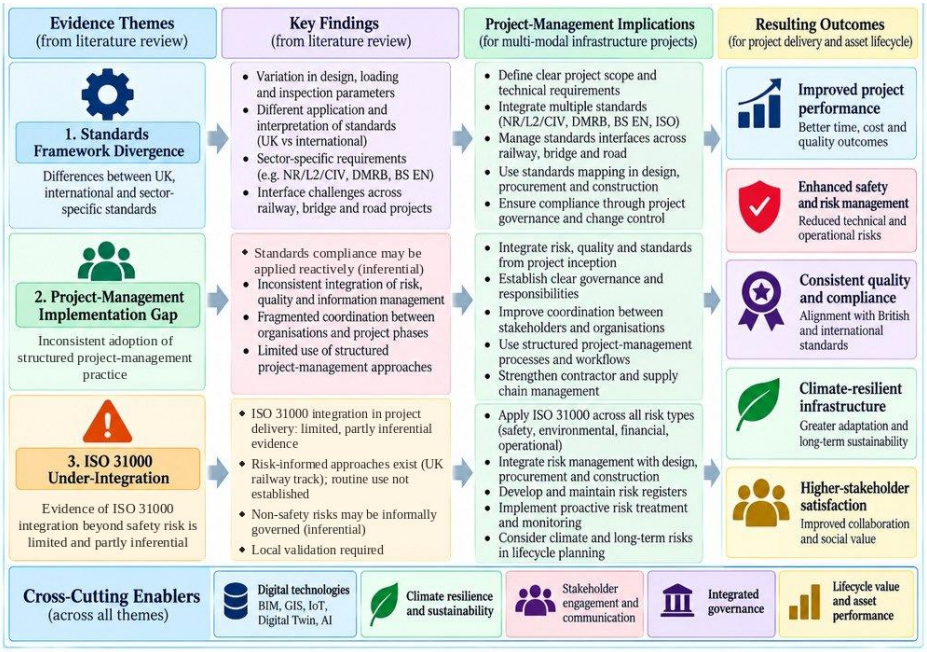


Figure 3. Thematic Framework — Three Evidence Themes Mapped to Project-Management Implications

Source: Adapted from ISO 55000 series (2014–2024); DMRB (National Highways, n.d.); Network Rail (NR/L2/CIV) (2021); Mahammedi et al. (2025); Sasidharan et al. (2022); Oyekunle et al. (2024).

No human participants were involved. AI tools were used to improve the readability and language of the manuscript. Figures 1–5 were generated using an AI image-generation tool, based on concepts, structures and content developed by the authors. All literature searching, critical analysis, interpretation and academic judgements were undertaken by the authors, and all AI-assisted outputs were reviewed and verified by the authors, in compliance with the University of Sunderland (2024) AI guidance.

#	Article (Harvard)	Methodology	Infrastructure Focus	Theme	Objective(s)
A1	Mahammedi et al. (2025). Urbanization, Sustainability and Society, 2(1), pp.364–406.	SLR (112 articles)	Bridge (UK risks / global comparison)	T2, T3	O2, O3, O4, O5
A2	Masrom and Goh (2018). AIP Conference Proceedings, 2020, 020037.	Quantitative grillage analysis (7 spans, STAAD.Pro)	Bridge traffic loading (BS vs EC)	T1	O2, O4
A3	Gueorguiev (2023). Proc. University of Ruse, 62(5.1), pp.164–169.	Qualitative review / comparative analysis	Railway QMS / ISO 22163	T1	O2, O3
A4	Sasidharan et al. (2022). J. Rail and Rapid Transit, 236(2), pp.183–197.	Risk-informed decision-support tool development (UK railway case data)	Railway track risk / life-cycle appraisal	T3	O2, O3, O4
A5	Oyekunle et al. (2024). Open J. Business and Management, 12, pp.2099–2117.	Quantitative survey (n=27)	UK construction PM practices	T2	O1, O3, O5
A6	Frangopol DM and Soliman M (2016). Life-cycle of structural systems: recent achievements and future directions. Structure and Infrastructure Engineering, 12(1): 1–20. https://doi.org/10.1080/15732479.2014.999794	Overview / review of life-cycle engineering for structural systems (life-cycle cost, monitoring, risk)	Bridge (lifecycle cost / whole-life AM)	T2	O3, O4, O5
A7	Dekker R, Wildeman RE and Van der Duyn Schouten FA (1997). A review of multi-component maintenance models with economic dependence. Mathematical Methods of Operations Research, 45(3): 411–435.	Review of multi-component maintenance, replacement and inspection models	Infrastructure (multi-modal / maintenance modelling)	T3	O3, O4

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#	Article (Harvard)	Methodology	Infrastructure Focus	Theme	Objective(s)
A8	Nhamage IA, Horas CS, Dang N-S, Campos e Matos JA et al. (2025). Strategies for maximising the value of digital twins for bridge management and structural monitoring: a systematic review. Archives of Computational Methods in Engineering, 32(7): 4555–4586. https://doi.org/10.1007/s11831-025-10280-1	Systematic review of digital-twin strategies for bridge management and structural monitoring	Bridge (digital twins / monitoring / interoperability)	T1	O2, O3
A9	Wijnia YC and de Croon JK (2015). The asset management process reference model for infrastructures. In: 9th WCEAM Research Papers. Lecture Notes in Mechanical Engineering. Cham: Springer, pp. 447–457.	Conceptual reference model for the asset management process in infrastructures	Multi-modal infrastructure (AM process framework / ISO 55000)	T2	O2, O5
A10	Lin Y-H, Khongsomchit L, Kaewunruen S and Plummer P (2025). Challenges and barriers in BIM adoption and implementation in railways. Frontiers in Built Environment, 11: 1714009. https://doi.org/10.3389/fbuil.2025.1714009	Survey of railway professionals (n = 31) on BIM adoption barriers	Railway (BIM adoption / policy and standards gaps)	T1, T2	O2, O3
A11	Alberti S and Fiori F (2019). Integrating risk assessment into pavement management systems. Journal of Infrastructure Systems, 25(1): 05019001. https://doi.org/10.1061/(ASCE)IS.1943-555X.0000472	Case study comparing risk-based and performance-based pavement management	Road (pavement management / risk assessment)	T3	O2, O4
A12	Parlikad AK and Jafari M (2016). Challenges in infrastructure asset management. IFAC-PapersOnLine, 49(28): 185–190. https://doi.org/10.1016/j.ifacol.2016.11.032	Synthesis of two industry workshops (UK and USA) identifying challenges for infrastructure owners and operators	Multi-modal infrastructure (industry challenges / whole-life cost)	T2	O3, O5

T1 = Standards Framework Divergence | T2 = Project-Management Implementation Gap | T3 = ISO 31000 Under-Integration

Table 3. Summary of Twelve Core Articles — Quality Appraisal and Thematic Relevance

4. Findings and Project-Management Analysis

4.1 Project Scope and Standards-Interface Management

Table 4 presents the standards comparison matrix. The critical project-management implication is that divergent technical requirements must be identified and reconciled during scope definition, design coordination and change control rather than discovered late in delivery. The αq factor modification in the UK National Annex to BS EN 1991-2 illustrates this interface: DMRB inspection requirements and BS EN Eurocode design parameters may need coordinating within one project lifecycle. Wearmouth Bridge (main span approximately 114 m; Structurae, n.d.) is hypothesised to experience this divergence to a greater degree than the shorter spans studied by Masrom and Goh (2018), requiring independent structural validation.

Standard	Infrastructure	Key Gap Identified	NE Sunderland Implication	Source
BS EN 1991-2 (UK NA)	Bridge	UK NA αq modification gives higher load-effect ratios than base EN; EN load model governs at spans ≥30 m, BD37 below 30 m	River Wear crossings (>30 m): DMRB and BS EN parameters may need reconciliation — extent requires independent structural validation	Masrom and Goh (2018)
DMRB (BD37/01)	Bridge / Road	Reactive maintenance; lifecycle compliance gap; inspection-triggered not LCA-driven	River Wear bridges and A19/A690 pavement may be managed reactively — inferred from ORR and council documentation; requires local validation	Authors' inference; cf. Mahammedi et al. (2025)

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Standard	Infrastructure	Key Gap Identified	NE Sunderland Implication	Source
NR/L2/CIV	Railway	Compliance and design risks may be handled informally (inferred; not directly evidenced)	Tyne, Wear and Coast route: contractor and compliance risks may remain outside fully integrated ISO 31000 governance; local validation required	Inferred (cf. Sasidharan et al., 2022)
ISO 9001:2015	All types	Structured project-management practices not consistently adopted from project inception (UK survey evidence); ISO 9001-aligned quality planning may not be embedded (inferential)	A19/A690 road projects: QMS compliance may be audit-triggered rather than proactive (inferential; not locally evidenced)	Oyekunle et al. (2024)
ISO 31000:2018	All types	Application beyond safety risk not consistently evidenced; contractor, compliance and design-change risks may be informal	All three NE Sunderland types: non-safety risks may be informally governed; local empirical validation required	Authors' inference; cf. Sasidharan et al. (2022)
ISO 22163:2023	Railway	Added requirements (ISO/TS 22163:2017 core text 29→69 pages; further changes in 2023) may raise implementation effort; QMS-to-delivery pathways inferred as limited	NR Tyne, Wear and Coast: ISO 22163 integration with NR/L2/CIV delivery is inferred to be limited; local validation required	Gueorguiev (2023)
ISO 45001:2018	All types	Addressed through CDM 2015 legal duties; implementation gap not assessed	CDM 2015 imposes legal duties across all three NE Sunderland types; whether this yields higher local compliance is not evidenced	HSE (2015)

Table 4. Standards Framework Comparison — British and International Standards Applied in Northeast Sunderland Infrastructure

Source: Authors' own, based on Masrom and Goh (2018); Sasidharan et al. (2022); Gueorguiev (2023); Oyekunle et al. (2024); Mahammedi et al. (2025); Nhamage et al. (2025); Lin et al. (2025); Alberti and Fiori (2019); Frangopol and Soliman (2016); Parlikad and Jafari (2016); Wijnia and de Croon (2015); and Dekker et al. (1997).

4.2 Project Implementation Barriers — Design and Construction Phases

Table 5 maps primary barriers to design and construction phases for each infrastructure type. From a project-management perspective, design-phase barriers are principally interface and scope-governance problems arising from standards divergence and absent integration pathways. Construction-phase barriers are principally workflow, quality, procurement and contractor-integration problems associated with reactive risk management and inconsistent embedding of controls.

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Infrastructure Type	Design Phase Barrier	Construction Phase Barrier	Source
Railway (Tyne, Wear & Coast Route)	Added ISO 22163:2023 requirements may raise implementation effort (inferential); NR/L2/CIV complexity; limited QMS-to-delivery integration pathways inferred	Contractor and compliance risks may be informally governed and risk treatment may be untimely (inferential)	Gueorguiev (2023); cf. Sasidharan et al. (2022)
Bridge (River Wear crossings, DMRB regime)	BS EN Eurocode vs DMRB (BD37) load-model divergence at spans ≥30 m; αq modification; possible extended design review cycles (inferential)	Possible reactive DMRB compliance; lifecycle planning not evidenced locally; maintenance may be triggered by principal inspection rather than condition-based planning (inferential)	Masrom and Goh (2018); authors' inference
Road (A19/A690 — National Highways & Sunderland City Council)	ISO 9001:2015-aligned quality planning may not be embedded at project planning stage; structured PM tools may not be applied from project inception (inferential)	Bidders' conferences, parametric estimating and team charters among least-used techniques; scope-management practice correlated with project success (Spearman's ρ = 0.764) in a small survey (n = 27)	Oyekunle et al. (2024)

Table 5. Primary Barriers to Standards Implementation in Northeast Sunderland — Design Phase and Construction Phase

Source: Authors' own, based on thematic synthesis of twelve core articles (A1–A12).

4.3 Project Risk Management — Proactive versus Reactive ISO 31000 Integration

The central diagnostic finding is an inferred reactive character of ISO 31000:2018 integration, drawn from public documentation (Section 4.4) rather than demonstrated by the reviewed studies, and strongest for bridge assets. Mahammedi et al. (2025) document UK bridge risks but do not describe practice as reactive, while Sasidharan et al. (2022) show that risk-informed life-cycle approaches exist for UK railway track but do not evidence their routine use in project delivery. Oyekunle, Abbey and Ibeh (2024) report a positive association between structured scope management and project success (Spearman's ρ = 0.764; n = 27). Together, these findings support the project-management case for establishing a broader risk register from project inception that includes design, standards-interface, contractor, compliance, climate and lifecycle risks in addition to safety.

By inference, the A19 and A690 corridors, River Wear bridge assets and the Tyne, Wear and Coast route may face similar inspection- or audit-triggered compliance rather than proactive ISO 31000 planning. This is inferential — derived from national UK studies — and requires empirical validation through primary research with local practitioners.

4.3a Integrated Project Management and Lifecycle Governance Framework — Justification and Proposed Validation

Figure 4 has not been empirically validated and should be treated as a conceptual framework. It is grounded in the twelve reviewed articles and informed by internationally used approaches. It repositions lifecycle evidence within project governance: initiation and scope definition establish standards and stakeholder requirements; planning integrates risk, quality, schedule/cost and procurement interfaces; delivery uses coordinated quality, information and contractor controls; and handover transfers verified information and residual risks into lifecycle management. A structured two-stage Delphi expert validation study (Hasson, Keeney and McKenna, 2000) remains the proposed future validation pathway. Stage 1 would engage 15 practitioners and 5 academic experts to assess structural completeness, standards accuracy, practical applicability and

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climate-resilience integration on a 1–9 Likert scale. Stage 2 would return anonymised responses, with consensus defined as ≥75% rating ≥7/9 on all criteria. Until completed, Figure 4 remains conceptual.

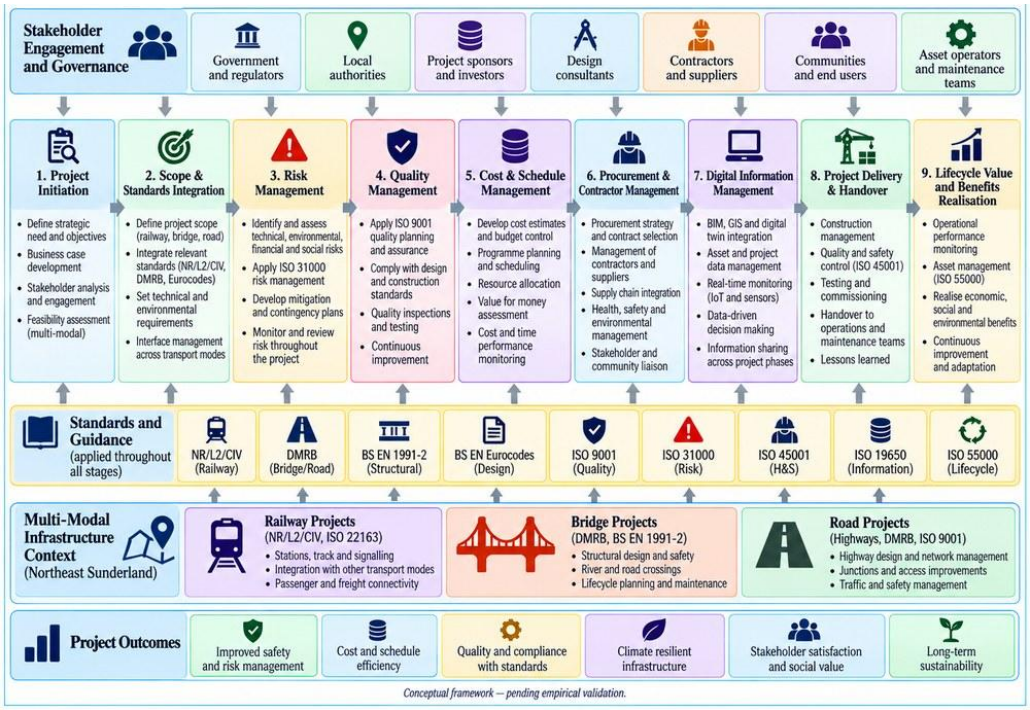


Figure 4. Conceptual Integrated Project Management and Lifecycle Governance Framework for Northeast Sunderland Multi-Modal Infrastructure (Pending Empirical Validation)

Source: Adapted from the ISO 55000 series; DMRB (National Highways, n.d.); Network Rail NR/L2/CIV (2021); BSI (2023); BS EN Eurocodes; UKRLG (2016); Mahammedi, Hayes and Al-Mhdawi (2025); and Masrom and Goh (2018).

Figure 4 reframes the evidence as a project-governance model. Its project layer comprises initiation and scope definition; integrated planning; coordinated delivery; information assurance; and handover into lifecycle management, supported by BIM, IoT, centralised information and data analytics. The standards foundation includes ISO 9001, ISO 31000, ISO 45001, ISO 19650, BS EN Eurocodes, DMRB and NR/L2/CIV, while ISO 55000 provides lifecycle-value and handover principles. Asset management is therefore not the paper's primary subject; lifecycle requirements are one input to project decisions.

4.4 Northeast Sunderland Infrastructure — Publicly Available Evidence Base

Publicly available documentary evidence across all three infrastructure types is triangulated here to contextualise the thematic findings within the Northeast Sunderland case study. This constitutes secondary public data — not primary practitioner data — and provides an inferential rather than empirical foundation, within the limitations stated in Section 4.4.4.

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4.4.1 Railway Infrastructure — Tyne, Wear and Coast Route (Network Rail)

The ORR Annual Assessment of Network Rail for 2022–23 reports a decline in national asset sustainability (Composite Sustainability Index −0.8%), worsening asset reliability in all regions except Scotland, and insufficient progress on structures examinations (ORR, 2023a). These national findings are consistent with a reactive asset-management pattern, although they do not themselves evidence ISO 31000 integration practice; route-level evidence for the Tyne, Wear and Coast Route is not separately published.

4.4.2 Bridge Infrastructure — River Wear Crossings (Sunderland City Council and National Highways)

Sunderland City Council's Highway Asset Management Policy and Strategy 2021–26 manages highway structures under the UK Roads Liaison Group Code of Practice, rates the structures asset group as Amber, and records significant gaps in the inventory of large structures, with a structures lifecycle plan not yet documented (Sunderland City Council, 2021). This is consistent with the inferred reactive pattern discussed in Section 4.3, which is the authors' inference rather than a finding of the reviewed studies.

4.4.3 Road Infrastructure — A19/A690 Corridors (National Highways and Sunderland City Council)

ORR's assessment of National Highways for 2022–23 found that the strategic road network, which includes the A19, met its pavement condition target only after a forecast shortfall attributed to extreme heat in July 2022, and that some renewals were under-delivered because asset needs were not adequately known at the planning stage (ORR, 2023b). Locally, Sunderland City Council (2021) reports that reactive defect repairs are funded from reduced revenue budgets supplemented by capital, an arrangement it does not regard as a long-term solution. Both findings are consistent with the Implementation Gap identified by Oyekunle, Abbey and Ibeh (2024).

4.4.4 Triangulation and Inferential Limitations

The triangulated evidence shows maintenance and planning problems rather than direct evidence of ISO 31000 practice. ORR and Sunderland City Council documents report declining asset sustainability, gaps in the structures inventory, renewals planned without adequate knowledge of asset needs and reliance on reactive defect repairs, and Environment Agency (2024) is flood-risk context only; none examines whether ISO 31000 was applied. The link to ISO 31000 under-integration is therefore the authors' inference: it is consistent with, but not demonstrated by, the documents reviewed. Three limitations apply: documentation reflects stated policy rather than operational practice; no project-level data quantifies the local implementation gap; and without practitioner interviews, local barriers remain unconfirmed.

4.4.5 Northeast Sunderland Infrastructure — Contextual Evidence Summary

Table 6 summarises verifiable public evidence relevant to Northeast Sunderland infrastructure across all three types. Most indicators are published at national or regional level rather than for Northeast Sunderland specifically; they are therefore used as contextual evidence rather than local measurements and are interpreted within the inferential limitations stated in Section 4.4.4.

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Infrastructure Type	Indicator	Published Evidence	Source	Project / Lifecycle Implication
Railway (national / regional)	Train punctuality (On Time measure)	National On Time fell from 73.1% (2021–22) to 67.8% (2022–23); regional figures ranged from 63.2% (North West & Central) to 70.6% (Eastern). No route-level figure is published for the Tyne, Wear and Coast Route.	ORR (2023a), pp. 4, 22–23	Performance pressure makes possession planning and asset-related delay risk project-level concerns
Railway	Asset sustainability and reliability	National Composite Sustainability Index −0.8% in 2022–23; asset reliability worsened in all regions except Scotland; progress on structures examinations judged not good enough.	ORR (2023a), pp. 7, 40	Supports proactive ISO 31000 risk registers and lifecycle-based renewal planning rather than reactive repair
Railway	Renewals delivery	91.3% of planned renewals delivered nationally; only 46% of planned metallic-structure renewals delivered (end of Year 3).	ORR (2023a), pp. 6, 46	Renewal under-delivery is a scope and schedule risk to be managed from project inception
Bridge (River Wear)	Wearmouth Bridge — main span	Steel three-hinged arch opened in 1929; main span approximately 114 m (the original 1796 cast-iron span was 71.9 m).	Structurae (n.d.); Tyne and Wear HER (n.d.)	Beyond the 25–45 m range analysed by Masrom and Goh (2018); load-model divergence at this span requires independent structural validation
Bridge (local network)	Structures asset information	Structures asset group rated Amber; significant gaps in the inventory of large structures; structures lifecycle plan not yet documented.	Sunderland City Council (2021)	Incomplete asset information is a design and handover risk; information requirements (ISO 19650) should be defined at project inception
Road (strategic network, incl. A19)	Pavement condition	Target of 96.2% of pavement requiring no further investigation met in 2022–23 after a forecast shortfall (96.1%) attributed to extreme heat in July 2022.	ORR (2023b), pp. 53–54	Heat-related deterioration should be recorded as a climate risk in project risk registers
Road (strategic network)	Renewals planning	Concrete safety barrier renewals under-delivered by 21% and bridge waterproofing by 9%; asset needs not adequately known at the planning stage.	ORR (2023b), pp. 58–59	Weak planning-stage asset knowledge creates scope and estimating risk; supports early asset-information and lifecycle planning
Road (local network)	Reactive maintenance funding	Pothole and defect repairs funded from reduced revenue budgets supplemented by capital; not regarded as a long-term solution.	Sunderland City Council (2021)	Reactive maintenance pattern; supports planned, risk-based maintenance programmes
All modes (England)	Infrastructure flood exposure	About 37% of railways (4,300 of 11,700 km) and 38% of roads are currently at risk of flooding, rising to 54% and 46% respectively by mid-century.	Environment Agency (2024)	UKCP18 climate scenarios should inform project risk assessment and design resilience (R6)

Table 6. Northeast Sunderland Infrastructure — Publicly Available Contextual Evidence Summary

Source: Authors' own synthesis from ORR (2023a, 2023b); Sunderland City Council (2021); Environment Agency (2024); Structurae (n.d.); Tyne and Wear HER (n.d.). Indicators are national or regional unless stated otherwise; no primary measurement was conducted.

5. Discussion — Implications for Project and Program Management

The three thematic streams converge on a project-management argument: the UK multi-modal infrastructure standards environment is technically comprehensive, but standards, risk, quality and lifecycle requirements are not consistently integrated into project governance from inception. This creates interface risks across scope definition, design coordination, procurement, construction

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workflows and handover. The following sections discuss the findings against the revised objectives and their implications for Northeast Sunderland.

5.1 Standards Divergence as a Scope and Interface-Management Issue

The divergence between BD37 and EN 1991-2 loading at spans of 30 m and above, together with the UK National Annex αq modification, has inferred project significance for Northeast Sunderland bridge work. River Wear crossings may require reconciliation of DMRB inspection requirements with BS EN Eurocode design specifications, subject to independent structural validation. Such divergence should be identified in requirements definition, design-interface registers and change control rather than managed as a late compliance issue. ISO 22163:2023 implementation demands represent a parallel standards-interface challenge for railway projects on the Tyne, Wear and Coast route.

5.2 Implementation Barriers as Project-Governance Problems

Table 5 reveals two distinct mechanisms. Design-phase barriers require clearer standards harmonisation, scope definition and integration pathways. Construction-phase barriers require stronger workflow integration, procurement and contractor coordination. Consistent with Oyekunle, Abbey and Ibeh (2024), the least-adopted PM tools are those that embed planning and compliance from project inception. This suggests that the implementation gap is organisational and governance-related rather than solely technical, although practitioner validation is required.

5.3 ISO 31000 as an Integrated Project Risk-Management Mechanism

The public documentation reviewed for bridge assets, read alongside the broader risk-informed approaches reported for railway track (Sasidharan, Burrow, Ghataora and Marathu, 2022), suggests that the gap lies less in the availability of risk-informed methods than in their integration into project governance; this remains an inference requiring local validation. Oyekunle, Abbey and Ibeh (2024) provide supporting evidence: Spearman's $\rho = 0.764$ indicates that structured scope management is positively associated with project success. Risk management therefore should be integrated with scope, quality, procurement and change control from project inception, while transferability to individual Northeast Sunderland projects requires local validation.

5.4 Northeast Sunderland — Multi-Project and Program-Level Implications

Northeast Sunderland's multi-modal character means the same governance issues can arise across railway, bridge and road projects. A railway civil project may face ISO 22163 implementation demands, informal contractor risk management outside ISO 31000 and underuse of ISO 9001-aligned project-management practices concurrently. At program level, a common standards-navigation approach, risk taxonomy and information-governance model could reduce repeated interface problems across multiple projects while still allowing asset-specific technical controls.

5.4a Health, Safety and CDM 2015 as Project-Governance Requirements

CDM 2015 imposes legal duties across all three infrastructure types. Where ISO 31000 risk management is not systematically integrated from project inception, pre-construction information, hazard identification and design-risk coordination may be weakened. Recommendation R1

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therefore aligns proactive project risk management with CDM 2015 requirements for River Wear bridge works, Tyne, Wear and Coast track projects and A19/A690 carriageway interventions.

5.5 Climate Resilience as a Project and Program Risk

For River Wear bridge projects, fluvial flooding, temperature cycling and freeze-thaw action should be treated as project risks affecting requirements, design decisions, cost, schedule contingencies and lifecycle value. For A19/A690 road projects, intensified rainfall, surface-water flooding and temperature cycling may accelerate pavement deterioration and should be incorporated into ISO 31000 project risk registers and lifecycle planning informed by UKCP18 scenarios. Local engineering validation remains necessary.

For railway projects on the Tyne, Wear and Coast route, Network Rail's Traction Decarbonisation Network Strategy (2020) creates transition requirements that can affect scope, interfaces and long-term value. Decarbonisation transition risk and carbon-reporting obligations under the Climate Change Act 2008 should therefore be treated as program- and project-level governance requirements rather than solely operational asset-management matters.



Figure 5. Climate Change Integration Framework for Project Risk and Lifecycle Governance in Northeast Sunderland

Source: Developed by the authors based on the Climate Change Act 2008; UK Government (2022) 2030 Nationally Determined Contribution; UK Government (2025) 2035 Nationally Determined Contribution; Met Office (2018) UKCP18; ISO 31000:2018; and ISO 55000:2014.

Figure 5 illustrates how UK climate commitments and UKCP18 projections can inform project and program risk governance. Flooding, temperature stress and storm disruption are linked to railway, bridge and highway exposure, evaluated through ISO 31000 and carried into project

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requirements, risk registers, design decisions, contingencies and lifecycle handover. BIM, GIS, IoT and Digital Twin applications can support this information flow, positioning coordinated adaptation planning over isolated engineering responses.

6. Conclusions

This study finds, through thematic synthesis of twelve peer-reviewed articles, that the principal management challenge in UK multi-modal infrastructure is not the absence of technical standards but their inconsistent integration into project governance. In the Northeast Sunderland context, standards interfaces, risk, quality, procurement, digital information and lifecycle requirements need to be coordinated from project inception through delivery and handover.

Three project-management findings emerge. First, standards divergence creates scope and interface-management risks that require early identification and controlled resolution. Second, the reviewed evidence suggests that risk management may not consistently extend beyond safety to contractor, compliance, design-change, climate and lifecycle risks, which may therefore remain informally governed; this is clearest for bridge assets and inferential elsewhere. Third, implementation barriers differ between design and construction phases and therefore require different project controls. The evidence supports a shift from reactive compliance to integrated project governance, while local empirical validation remains necessary.

6.1 Contribution to Project-Management Knowledge and Practice

This study makes five principal contributions to knowledge and practice:

- **Integrated Project Management and Lifecycle Governance Framework**: a conceptual model linking project initiation, scope and standards planning, risk, quality, procurement, digital information, delivery and lifecycle handover for Northeast Sunderland multi-modal infrastructure.
- **Cross-sector standards synthesis**: twelve peer-reviewed articles from engineering, infrastructure management, construction management and transportation are interpreted to identify project-management implications across railway, bridge and road projects.
- **Climate-integrated project risk governance**: flood risk, temperature-induced degradation and decarbonisation transition risk are positioned as ISO 31000 project/program risk categories with implications for scope, design, contingencies and lifecycle value.
- **Program-level coordination insight**: the six-jurisdiction comparison identifies transferable practices that may support common standards navigation, risk governance and lifecycle-value planning across a portfolio of Northeast Sunderland infrastructure projects.
- **Structured validation pathway**: the proposed two-stage Delphi protocol provides a replicable route for progressing Figure 4 from a conceptual project-governance framework to a practitioner-validated operational tool.

6.2 Practical Project-Management Recommendations

Six evidence-based recommendations are advanced. R1: establish an ISO 31000-aligned project risk register from project inception covering safety, design, contractor, compliance, climate and

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lifecycle risks (Sasidharan et al., 2022). R2: create a project standards/interface register reconciling BS EN Eurocodes, DMRB and NR/L2/CIV requirements and assign ownership for conflicts and changes (Masrom and Goh, 2018). R3: embed ISO 9001:2015 quality planning within project workflows from inception, supported where appropriate by bidders' conferences, parametric estimating and team charters (Oyekunle et al., 2024). R4: establish ISO 22163:2023 documentation-to-delivery pathways for railway projects, linking requirements, assurance records and handover information (Gueorguiev, 2023). R5: incorporate lifecycle performance requirements into project scope and handover criteria for River Wear bridge interventions rather than treating maintenance as a separate downstream concern (cf. Mahammedi et al., 2025, on the benefits of proactive asset management). R6: integrate climate scenarios into project risk, cost and lifecycle-value assessments, including flood, temperature-degradation and decarbonisation-transition risks.

6.3 Study Limitations and Future Research

The primary limitation is that the underlying search strategy was designed around infrastructure/asset-management and standards literature rather than as a comprehensive project-management systematic review. In addition, no primary data from Northeast Sunderland were collected: there were no practitioner surveys, interviews or direct observations. All regional applications are therefore inferential. Figure 4 should be interpreted as a conceptual, evidence-grounded and internationally benchmarked project-governance framework, not an empirically validated tool, until the proposed Delphi study is completed.

Future research priorities are: (1) a dedicated systematic review of project- and program-management literature for multi-modal infrastructure; (2) semi-structured practitioner interviews with Network Rail, National Highways and Sunderland City Council; (3) the two-stage Delphi expert validation study for Figure 4, engaging 15 practitioners and 5 academic experts; and (4) project-level case studies testing whether the proposed controls improve delivery and handover outcomes. Structural modelling of assets such as Wearmouth Bridge remains a separate engineering validation task.

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