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INFORMATION MANAGEMENT UNDER BS EN ISO 19650-2: A CROSS-CASE ANALYSIS OF IMPLEMENTATION CONDITIONS IN UK CONSTRUCTION PROJECTS

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SUMMARY*: Information management (IM) under BS EN ISO 19650-2 has become central to digital transformation in the UK construction industry. Despite its structured framework, implementation in practice remains inconsistent, with organisations interpreting and applying the standard in divergent ways. Existing research has focused on organisational and technological adoption, with limited attention to how IM is enacted within project delivery structures. In particular, the interaction between procurement routes, appointment arrangements, IM resources and Common Data Environment (CDE) practices remains underexplored. This study addresses this gap through a multiple embedded case study of four UK projects procured through Design–Bid–Build and Design and Build routes. Document analysis, interviews and clause-level assessment were used to examine how IM is configured and enacted across delivery and appointment structures, focusing on IM resources and CDE workflows at the lead appointed party level. Cross-case synthesis identified structural and operational conditions combined within four case-derived implementation configurations: fragmented early-stage, integrated delivery, centralised coordination and transitional governance. Variations in governance continuity and stability, coordination authority, appointment sequencing, IM resource formalisation and integration, IM structuring control, and CDE workflow structuring were associated with differences in how IM processes were organised, coordinated and controlled across the cases. The study provides a UK-based cross-case empirical analysis of BS EN ISO 19650-2, positioning implementation as a condition-dependent socio-technical process characterised by the interaction of structural and operational conditions rather than a uniform procedural model. The findings highlight the importance of alignment among procurement and appointment structures, IM resource integration and CDE workflows for consistent IM implementation.*

KEYWORDS*: BS EN ISO 19650-2, information management, BIM, construction procurement, common data environment.*

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1. INTRODUCTION

Information management (IM) has become a defining element of digital transformation in the United Kingdom (UK) construction industry, shaping how people, processes and technology interact across the project lifecycle. Within this context, the ISO 19650 series provides the overarching international framework for managing information in projects using building information modelling (BIM) (International Organization for Standardization, 2018). It supports long-standing goals for improved efficiency, transparency and technological integration in construction (Egan, 1998; HM Government, 2013; Latham, 1994). BS EN ISO 19650-2 specifies the IM processes for the project delivery phase in the UK. It formalises responsibilities between project parties, i.e., appointing party, lead appointed party (LAP) and appointed parties (AP), and employs project and appointment-level documents (IM resources). It also establishes the common data environment (CDE) as the central platform for governance, traceability and quality assurance (British Standards Institution, 2018). Despite its structured framework, implementation remains inconsistent in practice.

Existing research shows that organisations interpret and apply ISO 19650-2 in divergent ways, influenced by organisational capability, digital maturity and procedural cultures (Malla et al., 2024; Mondrup et al., 2012; Succar & Kassem, 2015; Succar et al., 2012). Empirical studies further highlight difficulties in operationalising the standard's requirements (Abanda et al., 2025; Kaya & Özener, 2024; Ramírez-Sáenz et al., 2018), particularly in balancing prescriptive workflows with project-specific flexibility (Bakar et al., 2020; Kaya & Özener, 2024). Complementary research examines regional adoption dynamics (Kaya & Özener, 2024; Robitaille et al., 2023; Sadrinooshabadi et al., 2020), technological enablers (Ajayi et al., 2023; Alhoz, 2021) and strategic organisational approaches (Malla et al., 2024).

While these contributions provide valuable insights into adoption conditions, they predominantly frame ISO 19650-2 as an organisational or technological challenge. Consequently, limited attention has been given to how IM processes are enacted within project delivery structures, where responsibilities are distributed across multiple actors and coordinated through formalised appointment structures. Research has also tended to examine IM resources, such as exchange information requirements (EIR), BIM execution plan (BEP) and master information delivery plan (MIDP), in isolation (Bakar et al., 2020; Ramírez-Sáenz et al., 2018; Zima & Mitera-Kiełbasa, 2021). However, there remains limited understanding of how the full suite of IM resources operates collectively across appointment structures and project stages, and how their application affects coordination and information governance in project environments.

This limitation becomes more pronounced when considering procurement. Although procurement routes define contractual relationships and influence responsibility allocation, existing ISO 19650 procurement studies focus on tendering practices and contractor selection rather than IM processes (Matos et al., 2024). Yet procurement structures influence appointment structures, affecting whether IM responsibilities are distributed across multiple parties or consolidated under a single lead organisation, with implications for coordination continuity and governance. In the UK, Design–Bid–Build (DBB) and Design and Build (DB) represent the dominant procurement routes (NBS, 2018) and differ in design responsibility, risk allocation and coordination authority (Masterman, 2003; Mosey, 2019). These differences influence how responsibilities are assigned, how IM resources are developed, and how information flows are controlled across project stages.

At the operational level, these dynamics extend to the configuration of the CDE. Research confirms the role of the CDE in ensuring consistent, accessible and accurate information sharing (Information Management Initiative, 2020; Patacas et al., 2020). However, compliance and workflow consistency vary in practice, particularly in projects using multiple CDE solutions (Jaskula et al., 2025). These findings show that technological environments interact with organisational and contractual structures rather than functioning independently as coordination platforms.

These limitations point to a lack of a project-level understanding of how procurement routes, appointment structures, IM resources and CDE practices interact in relation to BS EN ISO 19650-2 practice. As a result, variation in implementation outcomes across projects remains insufficiently explained despite the presence of a common standardised framework. In the UK context, this challenge is further influenced by policy initiatives (Cabinet Office, 2022; Infrastructure and Projects Authority, 2021) that have promoted the adoption of the Information Management Initiative (IMI) Framework across public sector projects. These initiatives introduce

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expectations for ISO 19650-aligned practices despite the absence of a formal mandate. This study addresses this gap through a multiple embedded case study of four UK projects procured through DBB and DB routes, focusing on variation in implementation rather than compliance. Accordingly, the study addresses the following overarching research question: How do procurement and appointment structures, IM resources and CDE practices interact to influence the implementation of BS EN ISO 19650-2 across project environments? The research question is addressed through three objectives (ROs):

RO_1. To compare how procurement routes (DBB and DB) influence appointment structures governing IM coordination under BS EN ISO 19650-2.

RO_2. To assess how appointment-level IM resources align with the clause requirements of BS EN ISO 19650-2 across the case studies.

RO_3. To examine how CDE configuration and workflow practices relate to the operationalisation of BS EN ISO 19650-2 IM processes.

The structure of this paper is as follows: Section 2 reviews the literature on IM under ISO 19650-2, procurement, IM resources and CDE. Section 3 outlines the methodology; Section 4 presents the case studies and Section 5 provides the empirical analysis of case study IM implementation under BS EN ISO 19650-2. Section 6 synthesises the cross-case findings, Section 7 discusses them and their implications, and Section 8 concludes the paper. The findings are framed within BS EN ISO 19650-2. However, given the global adoption of ISO 19650-2, the findings may be applicable to other regions adopting comparable ISO 19650 frameworks.

2. LITERATURE REVIEW

2.1 BS EN ISO 19650-2 framework

BS EN ISO 19650-2 provides the framework for IM in the project delivery phase in the UK (British Standards Institution, 2018). In line with ISO/IEC Directives, the standard is normative insofar as its clauses specify mandatory requirements through prescriptive language ('shall') against which conformity may be assessed, as distinct from informative guidance (International Organization for Standardization, 2026). The standard defines IM responsibilities among the appointing party, LAP and APs, supported by project-level and appointment-level IM resources and coordinated through a CDE. As a process-based standard, it specifies practices across the delivery phase, operationalised through these resources. The UK National Annex supplements this structure through requirements for information container identification, metadata, suitability codes and classification, aiming to standardise information exchange across project teams (British Standards Institution, 2018).

Despite its normative structure, BS EN ISO 19650-2 remains a voluntary standard, and its implementation is not formally mandated. In practice, however, adoption has been influenced by broader institutional and policy contexts. In particular, the Construction Playbook (Cabinet Office, 2022) established expectations for the adoption of the IMI Framework, while the subsequent Transforming Infrastructure Performance (Infrastructure and Projects Authority, 2021) further reinforced its application within infrastructure delivery. Although these initiatives stopped short of introducing a formal mandate, they strengthened the institutional positioning of BS EN ISO 19650-aligned practices, creating conditions in which adoption operates between voluntary uptake and expected compliance.

Empirical evidence on how clause-level requirements are enacted in live project environments remains limited. Existing research indicates that text-heavy standards are associated with misinterpretation of IM tasks (Di Martino et al., 2023), with practitioners often defaulting to best practices rather than formal compliance (Abanda et al., 2025; Ashworth et al., 2023; Sibenik et al., 2023). This perspective reflects a broader issue in standardisation, i.e., the divergence between formal structures and their enactment in practice (Brunsson & Jacobsson, 2000).

Standards establish common structures and expectations intended to support coordination and consistency across organisational settings (Brunsson & Jacobsson, 2000). Their implementation, however, involves translating formal requirements into situated organisational and project practices, which may require adaptation to specific contexts (Kaplan & Orlikowski, 2014). Such adaptation can create tensions with the consistency that standardisation seeks to establish (Weithmann & Luedtke, 2023). In the context of BS EN ISO 19650-2, the translation of prescriptive IM requirements into operational workflows is not straightforward, particularly where flexibility is required to accommodate project-specific conditions (Bakar et al., 2020; Kaya & Özener, 2024).

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A socio-technical systems (STS) perspective conceptualises organisational work systems through the interaction of social and technical elements. The social system includes people, relationships and organisational structures, including structures of authority, while the technical system encompasses tasks, processes and technology (Bostrom & Heinen, 1977). These elements are interdependent, with the functioning of organisational systems shaped by their interaction (Baxter & Sommerville, 2011; Bostrom & Heinen, 1977). This perspective is relevant to BS EN ISO 19650-2 implementation, where organisational arrangements governing roles, responsibilities and coordination interact with IM processes and the technological environments through which information is managed and exchanged.

2.2 Procurement and information management

BS EN ISO 19650-2 is intended to operate independently of procurement routes, providing a common IM framework applicable across different delivery arrangements, including traditional, DB and integrated approaches (British Standards Institution, 2018). However, procurement structures provide the framework for the tendering strategy, the selection process, the commercial model and the contractual arrangements through which projects are delivered. As a result, procurement influences how responsibilities are allocated, how information flows are organised, and how coordination is achieved in project environments.

In the UK, although alternative procurement models have been promoted in relation to BIM and IM (Cabinet Office, 2011), DBB and DB remain predominant (NBS, 2018; RIBA, 2022), each embedding distinct organisational and contractual logics that influence IM implementation. Previous BIM research has similarly indicated that project lifecycle structures need to accommodate differences between procurement routes (Amin & Abanda, 2019). Under DBB, the separation between design and construction introduces fragmented information flows, multiple approval interfaces and reduced opportunities for early coordination. Contractors often rely on information produced by parties outside their contractual control, increasing the risk of misalignment, rework and disputes (Eastman et al., 2011; Masterman, 2003; Mosey, 2019; Mosey et al., 2016). However, early contractor involvement (ECI) can be introduced during the pre-construction period through a pre-construction services agreement (PCSA), whereby the contractor participates in pre-construction activities before the construction-stage contract is agreed. Contractor involvement during this period can include buildability evaluation, service coordination and BIM input, while ambiguity may arise around the scope of pre-construction services and design obligations (Finnie et al., 2022). Empirical evidence also indicates that ECI can support more iterative interaction between contractors and design teams and enable construction-related information to inform design development (Laryea & Watermeyer, 2016; Ng et al., 2023). In contrast, DB consolidates design and construction responsibility, supporting more integrated communication and coordination (Masterman, 2003), but introduces discontinuity at novation when design responsibility transfers mid-process (Chappell, 2020).

These conditions further affect how IM responsibilities are interpreted, negotiated and operationalised within project teams. While procurement is not explicitly prescribed within BS EN ISO 19650-2, its influence is mediated through contractual and appointment structures that define organisational roles and information exchange processes. Despite this, empirical research examining how procurement routes affect the operationalisation of IM resources, particularly at the level of appointments and clause-level operationalisation, remains limited. This gap is critical, as procurement arrangements influence how IM processes are enacted in practice.

2.3 Information management resources

IM resources constitute the formal artefacts through which the requirements of BS EN ISO 19650-2 are enacted throughout the delivery phase. The standard distinguishes between project-level and appointment-level resources, with the role of each resource defined not only by its content but also by its procedural positioning, including authorship and stage of production. This dual dependency suggests that effective implementation relies on both the presence of resources and their correct positioning within project processes.

During tendering and appointment, project-level requirements are refined and formalised into delivery-specific mechanisms through LAP- and AP-authored resources, structuring how delivery teams produce and manage information (British Standards Institution, 2018; Information Management Initiative, 2022). In practice, IM resources may be issued as standalone documents or embedded within other artefacts, resulting in hybrid forms that perform distinct procedural functions within the BS EN ISO 19650-2 framework (Information Management

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Initiative, 2022). This variability indicates that practice is not uniform but reflects differences in how organisations configure and integrate these resources within their workflows.

Existing research examines only a subset of these resources, with a focus on EIR, BEP and MIDP. Studies show that EIR implementation is constrained by limited client capability, including digital literacy, terminology and procedural understanding (Godager et al., 2022; Gu & London, 2010; Piazzi et al., 2022). Research on BEP examines its structure, suitability and alignment with responsibility matrices, as well as emerging links with MIDP/TIDP automation (Ajayi et al., 2023; Bakar et al., 2020; Panagiotidou et al., 2023). However, the operationalisation of IM resources across LAPs remains insufficiently addressed, particularly in relation to how they are interpreted, coordinated and integrated across appointments. This gap limits understanding of how consistently IM resources function as mechanisms for coordination and control in delivery contexts.

2.4 Common data environment

The CDE is defined as an agreed source of information for a project or asset, used to collect, manage and disseminate information containers through a structured workflow (International Organization for Standardization, 2018). Within BS EN ISO 19650-2, the CDE is conceptualised both as a workflow and as a technical solution supporting IM. Information containers progress through defined states, including Work in Progress, Shared, Published and Archive, governed by review, authorisation and acceptance procedures.

While the standard defines the CDE in process terms, its execution is mediated through different technological configurations. Consistent with this, the IMI Framework distinguishes between a project CDE, managed by the appointing party or a delegated function, and distributed CDEs used by delivery teams for internal coordination. The project CDE remains the authoritative environment for formal information exchange (Information Management Initiative, 2020). This distributed configuration introduces variation in how workflows, responsibilities and control mechanisms are enacted across project teams.

Existing research highlights challenges in aligning CDE functionality with IM requirements. Empirical research on cloud/mobile BIM has also identified interoperability, data ownership, confidentiality, skills and trust as barriers to technology-enabled information exchange (Abanda et al., 2018). No single system fully supports all workflow needs (Jaskula et al., 2023), and integration between IM resources and CDE operations remains limited, particularly in relation to metadata, suitability and approval processes (Jaskula et al., 2025). This is also influenced by the fact that BS EN ISO 19650-2 defines IM processes but does not prescribe a single system environment, allowing for distributed configurations where multiple platforms support different workflow functions. However, the use of multiple systems introduces coordination boundaries between information production, review and exchange environments, increasing reliance on procedural controls to maintain consistency. In addition, issues of transparency and traceability have been identified as critical for enabling coordination and control within CDE environments (Kaya & Özener, 2024). These limitations suggest that, although the CDE is intended to standardise information exchange, its execution depends on platform capabilities, organisational practices and governance arrangements. Despite this, empirical evidence on how CDE workflows, permissions and information state transitions are operationalised in relation to BS EN ISO 19650-2 clause requirements remains limited. This gap limits understanding of how consistently CDE processes support information governance across project delivery.

BS EN ISO 19650-2 is positioned as a normative framework for standardising IM. However, research remains fragmented and largely examines individual components rather than their interaction in project environments. Empirical evidence on how clause-level requirements are operationalised across appointments remains limited, particularly in relation to procurement routes, appointment structures, the structuring of IM resources and CDE practices, leaving the conditions shaping implementation insufficiently understood. This study addresses this gap through a multiple embedded case study, examining how structural and operational conditions influence implementation at the LAP appointment-level.

3. RESEARCH METHODOLOGY

This study investigates IM under BS EN ISO 19650-2 as a contemporary organisational practice embedded in real project settings. A pragmatic research perspective is adopted, combining interpretivist insights to understand organisational processes with post-positivist elements to support structured document analysis (Creswell et al., 2003; Tashakkori & Teddlie, 2010). A multiple embedded case study design (Yin, 2017) was employed to enable

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in-depth examination of IM enactment under BS EN ISO 19650-2 across projects, supported by qualitative analysis and structured document assessment. The case study approach is suited to examining contemporary organisational phenomena embedded in real-world contexts, enabling investigation of the organisational and procedural conditions shaping IM practices (Säfsten & Gustavsson, 2020; Yin, 2017).

3.1 Case study selection

Case selection followed a purposive sampling strategy guided by replication logic (Yin, 2017). Criterion-based selection ensured that participating organisations and projects met predefined conditions, including active engagement with BS EN ISO 19650-2 application. Variation was introduced across procurement routes, appointment and governance structures to enable comparison across contrasting implementation conditions and support analytical generalisation.

At the organisational level, two UK-based firms were selected based on demonstrated BS EN ISO 19650-2 experience, sufficient digital maturity and willingness to provide access to project information and personnel. Organisation A (OR_A), a medium-sized consultancy, was recruited through the IMI Framework community. Organisation B (OR_B), a large interdisciplinary practice with formal certification aligned with BS EN ISO 19650-2, was identified through a targeted search aligned with the predefined criteria. Both organisations had seven years of experience with BS EN ISO 19650-2. The two organisations reflect variation in size, maturity and accreditation status. However, these characteristics are presented for contextual background and were not analysed as primary variables within the scope of the study. Organisation size was classified according to the UK Department for Business, Energy and Industrial Strategy (BEIS) definition, where large organisations exceed 250 employees and medium-sized organisations include between 50 and 250 employees. Table 1 summarises the organisational characteristics.

At the project level, procurement route served as the primary selection criterion, resulting in four ongoing projects, two DBB and two DB, across the participating organisations. Additional characteristics, including building type, scale and Royal Institute of British Architects (RIBA) stage at the time of access, were recorded to provide contextual background, but were not analysed as analytical variables in the study. Project scale was classified based on gross floor area, where large projects exceeded 50,000 m², medium projects ranged from above 10,000 m² up to 50,000 m², and small projects were below 10,000 m². All projects were ongoing at the time of data collection, reducing retrospective bias (Eisenhardt & Graebner, 2007).

Table 1: Case study selection criteria.

No.	Organisation	Building type	Scale	RIBA stage	Procurement	Status
CS_1	OR_A	Entertainment	Medium	5	Design–Bid–Build	Ongoing
CS_2	OR_A	Educational	Small	3	Integrated Design and Build	Ongoing
CS_3	OR_B	Healthcare	Large	Transition from 2 to 3	Design–Bid–Build with early contractor involvement under a PCSA	Ongoing
CS_4	OR_B	Healthcare	Medium	4	Novated Design and Build	Ongoing

Organisation representatives were selected using key informant sampling, focusing on individuals with specialised knowledge of IM and CDE practices (Marshall, 1996; Patton, 2015; Tremblay, 1957). In both organisations, IM and CDE responsibilities were centralised within single IM or BIM lead roles, providing cross-project visibility. The sample size was justified through information power, whereby high expertise and a focused case context reduce the need for larger samples (Malterud et al., 2016), consistent with digital construction studies that rely on one or two leads per organisation due to centralised IM responsibilities (Whyte et al., 2016). Potential informant bias was mitigated through triangulation with documentary evidence and cross-case comparison (Marshall, 1996; Yin, 2017).

3.2 Case study design

This study adopted a multiple embedded case study design, comprising four cases across two organisations. Each project constituted the primary unit of analysis with four embedded analytical subunits central to BS EN ISO

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19650-2 enactment, including (1) procurement routes; (2) appointment structures; (3) IM resources; (4) CDE practices (Yin, 2017). The analysis focused on LAP appointment-level IM activities and resources.

A case study protocol was developed to ensure consistency and maintain a clear chain of evidence across cases (Yin, 2017). The protocol defined data collection procedures, guiding questions and reporting structure, ensuring comparable processes across all four cases. The case study design supported embedded case analysis and cross-case comparison. The analytical strategy combined pattern matching and cross-case synthesis. Pattern matching compared observed IM practices with expected requirements derived from the standard, enabling systematic assessment of clause-level consistency. Cross-case synthesis treated each project as an independent analytical unit and compared findings to identify case-derived implementation configurations and the associated conditions under which they emerge across procurement routes and project delivery contexts. During cross-case interpretation, observed differences were considered in relation to the organisational context, project scale, building type and RIBA Stage reported in Table 1, so that differences between cases were not attributed to procurement route alone. These characteristics were treated as contextual features rather than independent analytical variables, and their individual effects could not be isolated within the four-case design. Following multiple case study logic, the case study design was organised in three stages (Figure 1). These comprised: (1) define and design, including case selection, development of the case study protocol and identification of embedded subunits; (2) plan, collect and analyse, incorporating scoping discussions, document collection, interviews and subunit-level analysis; (3) cross-case analysis and reporting, integrating findings across cases to address the research objectives.

Appointment structures are examined across RIBA Stages 0–6 to capture the full contractual sequencing of project appointments, while IM processes and resources are analysed at the LAP appointment-level, typically occurring during pre-construction stages up to RIBA Stage 4.

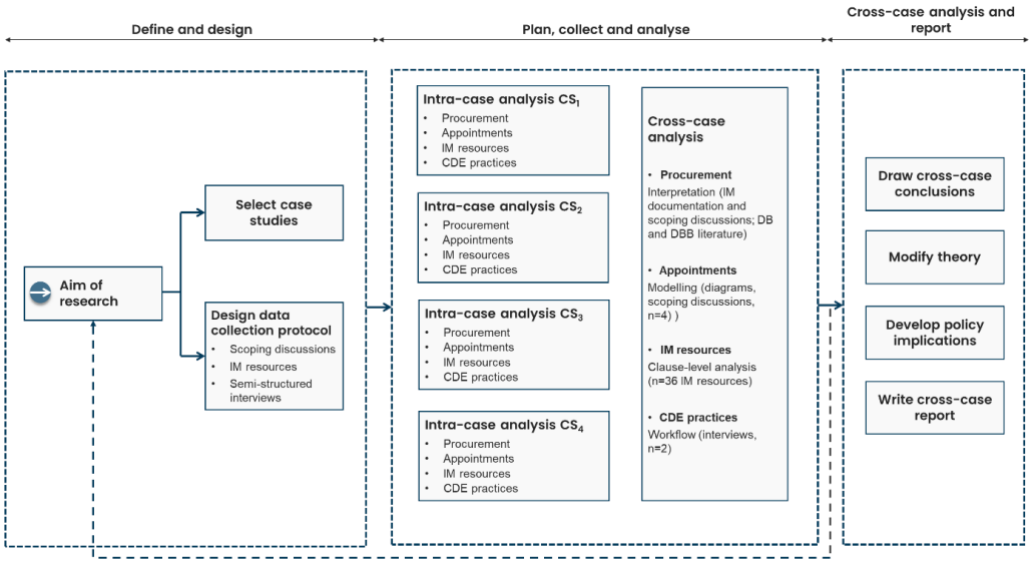


Figure 1: Multiple case study design, adapted from Yin (2017).

3.3 Content analysis of information management resources

This study adopts content analysis to examine how BS EN ISO 19650-2 requirements are translated into appointment-level IM practice through formal documentation. IM resources are treated as primary documentary evidence, assessed in relation to the specific LAP appointment they support. Appointment is defined as an agreed instruction for the provision of information, whether or not formalised contractually (British Standards Institution, 2018).

A documents-as-archive perspective was adopted, focusing on document content rather than circulation or use in practice (Prior, 2008). Given the clause-based and procedural nature of BS EN ISO 19650-2, an analytical approach capable of systematic, rule-based examination was required. Interpretive approaches such as document analysis (Bowen, 2009), framework analysis (Spencer et al., 2003) or thematic analysis (Braun & Clarke, 2006)

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prioritise thematic abstraction and offer limited procedural precision for evaluating alignment with technical standards. Content analysis was selected as it provides explicit rules for unitising text, applying deductive coding frames and generating reliable inferences grounded in clearly defined textual categories (Krippendorff, 2019).

Following Krippendorff (2019), the analysis was organised into six components: unitising, sampling, recording, reducing, inferring and narrating (Figure 2). Unitising defined each relevant ISO 19650-2 and National Annex clause as a discrete analytical unit. Sampling followed a full-population strategy within the defined analytical scope by including all IM resources from the LAP perspective, regardless of whether resources were standalone or embedded (e.g., PIR within EIR), consistent with the IMI Framework (Information Management Initiative, 2022). Recording involved transforming each resource into a clause-level dataset using predefined analytical categories. Reducing involved aggregating coded data to identify variations in existence, positional accuracy and clause-level consistency across resources and cases. Abductive inference connected observed variations to project-level conditions associated with IM implementation. Narrating synthesised the findings into cross-case comparisons.

This approach integrates qualitative categorisation with quantitative summarisation, recognising numerical outputs as legitimate analytical results (Krippendorff, 2019). To operationalise this analytical approach, a structured coding framework was developed and applied across cases, as described in Section 3.4.2

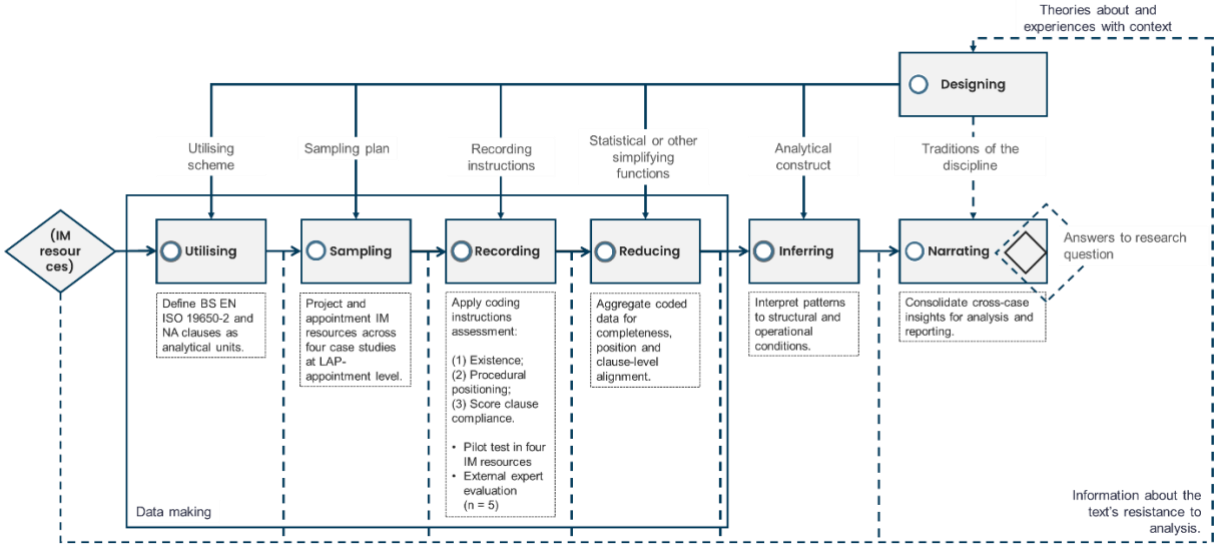


Figure 2: Components of IM resources content analysis, adapted from Krippendorff (2019).

3.4 Data collection and analysis

The study examined four embedded subunits within each project as the key project dimensions for the enactment of IM under BS EN ISO 19650-2: procurement arrangements, appointment structures, the structuring of IM resources and CDE practices. These dimensions operationalise the overarching research question through the three research objectives: procurement and appointment structures (RO_1), IM resources (RO_2) and CDE configuration and workflow practices (RO_3). The use of multiple data sources enabled triangulation across procurement, appointment, documentation and interview evidence. Data collection included four initial scoping discussions and 42 distinct project documents across the four cases (eight in CS_1, ten in CS_2, thirteen in CS_3 and eleven in CS_4). The documentary evidence was assessed against nine predefined IM resource types in each case. In addition, four semi-structured interviews were conducted, comprising two interviews per organisation. Data collection was conducted between July 2024 and September 2025, reflecting the stage each project had reached at the time of access.

The analysis adopted a normative evaluative approach, assessing how BS EN ISO 19650-2 IM requirements are operationalised in project environments. A cross-case synthesis strategy was applied to compare findings across cases and identify convergent and divergent patterns across contrasting procurement and appointment structures (Yin, 2011). Figure 3 presents the embedded analytical structure adopted for examining IM implementation under

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BS EN ISO 19650-2. Procurement routes and appointment structures are positioned as project-level structural conditions shaping the organisation of coordination, responsibility allocation and information governance. At the LAP appointment-level, the analysis examines operational conditions through two interconnected dimensions: formal IM governance, assessed through the existence, procedural positioning and clause-level compliance of IM resources; and operational data governance, examined through CDE governance and workflow practices. Cross-case synthesis integrates these analytical dimensions to identify case-derived implementation configurations and their associated structural and operational conditions.

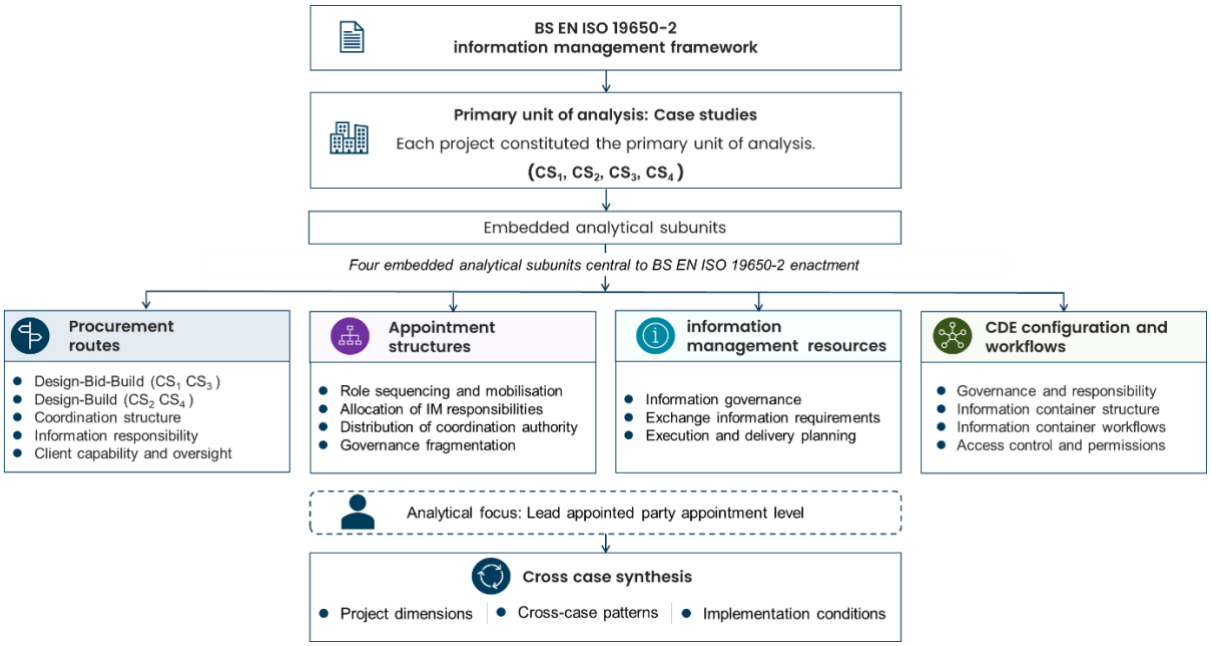


Figure 3: Embedded analytical design for examining information management implementation under BS EN ISO 19650-2.

3.4.1 Procurement and appointment

Procurement provides the overarching delivery context within which BS EN ISO 19650-2 processes are implemented, shaping the contractual and governance setting through which projects are organised. Although detailed tendering data were not collected, procurement routes were identified through project IM documentation and participant scoping discussions. Procurement was therefore treated as a project-level structural condition and analysed using procurement literature on DB and DBB and associated appointment arrangements to interpret how contractual arrangements relate to collaboration, information exchange and governance across cases (Yin, 2017).

In this study, procurement routes are considered in relation to their contractual realisation through appointment structures. The analysis focuses specifically on contract arrangements and appointment sequencing, as these define the allocation of responsibilities and coordination authority for IM activities. Appointment allocation defines how BS EN ISO 19650-2 responsibilities are distributed and enacted under different procurement routes. Data were obtained through four online scoping discussions with organisational IM leads. The scoping discussion questions are provided in Supplementary Appendix E (Table E2). The OR_A informant was an Information Manager providing evidence for CS_1 and CS_2, while the OR_B informant was a Senior BIM Manager providing evidence for CS_3 and CS_4. The same organisational informant therefore provided scoping evidence for both cases within their respective organisation. Both had seven years of BS EN ISO 19650-2 experience; the OR_B informant held individual certification aligned with the standard, while the OR_A informant did not. The discussions clarified the allocation of BS EN ISO 19650-2 responsibilities to organisational roles and confirmed the procurement arrangements and appointment structures represented for each project.

Based on these discussions and supporting documentation, appointment structure diagrams were developed to represent project relationships and were reviewed and confirmed by participants. These were complemented by diagrams illustrating appointment-level IM processes and resources across RIBA Stages 0–4. The diagrams were

constructed through systematic interpretation of interview data and project records and cross-checked for internal consistency across sources. These diagrams, together with appointment records, constituted evidence of project-level structure consistent with embedded case study research (Yin, 2017).

3.4.2 Assessment of information management resources

IM resources provided evidence of how BS EN ISO 19650-2 clause requirements were translated into formal documentation at the point of engagement. While the standard defines sixteen IM resources across project and appointment levels, this study focuses on those used or operationalised to support LAP-led coordination and delivery planning. Appendix A presents the analytical codebook and groups the assessed IM resources into information governance, exchange information requirements and delivery planning.

Nine predefined IM resource types were assessed in each of the four case studies. These comprised: (a) three project-level resources formalised at appointment that establish information governance, and (b) six LAP-level resources developed or consolidated by the LAP to operationalise project delivery, including appointment-specific EIRs for APs. Resources limited to procurement inputs, tender-stage planning or task-team production were excluded, as were project-level resources not directly associated with LAP responsibilities.

IM resources were assessed across three dimensions: (1) existence, referring to whether a resource was explicitly provided, embedded or inferred; (2) procedural positioning, referring to whether the resource was authored and issued by the appropriate party at the appropriate stage; and (3) clause compliance, referring to the extent to which BS EN ISO 19650-2 clause requirements were satisfied. These dimensions reflect the normative structure of the standard, capturing both the presence and procedural correctness of IM resources, as well as the degree of alignment with clause-level requirements.

Clause compliance was assessed using a 0–5 ordinal scale to differentiate between absent, partial, developing and more advanced applications. The scoring framework was pilot-tested using four EIRs and refined through two iterations to clarify decision rules, scoring anchors and evidence requirements. Coding stability was checked during development of the case-level and cross-case assessments by returning to the source documentation and verifying the assigned codes and clause-level scores against the relevant BS EN ISO 19650-2 requirements. Analytical consistency was supported through explicit coding rules, iterative refinement, and consistent application across cases (Krippendorff, 2019; Mayring, 2014). Coding and subsequent verification were undertaken by the same researcher; therefore, inter-coder reliability was not assessed. Expert review was conducted separately to assess the content validity of the coding framework and was not used as a measure of inter-coder reliability. Supplementary Appendix F presents the analytical audit trail documenting the relationship between case evidence, coding decisions and clause-level assessments.

Content validity was assessed through expert evaluation using the Content Validity Index (CVI) method. Experts were selected through criterion-based purposive sampling based on extensive professional experience in IM, including direct involvement in the development and management of IM resources under BS EN ISO 19650-2 (Patton, 2015), as summarised in Table 2. The majority of experts had seven or more years of experience, reflecting professional practice developed under BS EN ISO 19650-2. Experts evaluated the relevance of the three coding dimensions and the 0–5 scoring scale using a four-point ordinal scale (1 = not relevant – 4 = highly relevant), encouraging definitive judgement by excluding a neutral midpoint. Seven experts participated, exceeding the minimum of five recommended for content validity evaluation (Lynn, 1986).

Content validity was quantified at both the item level (I-CVI) and the instrument level (S-CVI/Ave), following established criteria and thresholds proposed by Lynn (1986). The I-CVI was calculated as the proportion of experts assigning ratings of 3 or 4 to each item, while the S-CVI/Ave was calculated as the average of I-CVI values across all items. An I-CVI threshold of 0.78 was used to assess item-level content validity, requiring at least six of the seven experts to rate an item as 3 or 4.

All items met or exceeded the required agreement threshold (I-CVI $\geq$ 0.78), with an overall S-CVI/Ave of 0.93, indicating high validity. The dimensions of existence and clause compliance achieved full agreement (I-CVI = 1.00), while procedural positioning and the scale achieved I-CVI values of 0.86. Qualitative feedback highlighted the importance of contextual factors in interpreting clause compliance, including contract type, procurement arrangements and project-specific conditions. Experts emphasised that certain clause requirements (e.g., “shall consider”) require context-dependent judgement rather than strict inclusion. These insights informed minor

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refinements to the interpretation of clause compliance without altering the coding framework. Detailed coding schemes, scoring criteria and validation results are provided in Appendix A, with detailed clause-level assessment results provided in supplementary Appendix D.

Table 2: Profile of expert participants involved in validation of the coding framework.

No.	Professional role	Experience in BS EN ISO 19650-2 (years)	Nature of involvement (direct/review/oversight/ limited/no)	Level of involvement (limited/moderate/high/ expert)	IM resources, CDE experience
P1	Information manager	5–6	Direct	High (responsible for implementation)	EIR, BEP, MIDP, IS, IPMP, RM, IP
P2	BIM Manager	7+	Direct	Moderate (supporting role)	EIR, BEP, MIDP, IS, IPMP, RM, IP
P3	BIM Manager	7+	Direct	Expert (leading, auditing, or training)	EIR, BEP, MIDP, TIDP, IS, IPMP, RM
P4	Information management consultant	7+	Direct	Expert (leading, auditing, or training)	EIR, BEP, MIDP, TIDP, IS, IPMP, RM, IP, CDE
P5	Digital construction specialist	5–6	Direct	High (responsible for implementation)	EIR, BEP, MIDP, TIDP, IS, IPMP, RM, IP, CDE
P6	Information management consultant	7+	Direct	Expert (leading, auditing, or training)	EIR, BEP, MIDP, IS, IPMP, RM, CDE
P7	Information management consultant	7+	Direct	Expert (leading, auditing, or training)	EIR, BEP, MIDP, TIDP, IS, IPMP, RM, IP, CDE

3.4.3 Analysis of common data environment practices

CDE practices, including configurations and workflows, were analysed to examine how BS EN ISO 19650-2 IM requirements were operationalised from the organisational perspective of the LAP. In this study, CDE configuration refers to the technological and system setup that enables IM processes, including platforms, metadata, permissions and system integration. CDE workflow refers to the procedural processes through which information is generated, reviewed, authorised and exchanged within that environment.

Given variation across cases in organisational procedures, client requirements and project contexts, the analysis focused on how CDE practices relate to the operationalisation of standardised IM, rather than on evaluating software performance. Relevant clauses relating to CDE establishment and operation were used as reference points to interpret how responsibilities, configuration decisions and workflow practices were enacted. Interview evidence relating to a specific project was assigned to the corresponding case, while statements describing practices across the organisation were retained as organisation-level evidence. Organisation-level statements were not attributed to an individual case unless supported by case-specific interview or documentary evidence.

CDE data were collected through semi-structured interviews with the IM or BIM lead within each organisation. Interviews followed a standard protocol, lasted approximately 45 minutes and were transcribed. The CDE interview questions are provided in Supplementary Appendix E (Table E1). Interview questions were structured around four predefined CDE categories, developed for the study (Figure 4). Interview transcripts were transformed into analysable data through a rule-based coding process. Each segment of interview data referring to CDE

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practices was treated as a recording unit and systematically assigned to predefined analytical categories derived from BS EN ISO 19650-2 clauses. This approach enabled coherent classification of empirical evidence according to governance arrangements, container structuring, workflow processes and access control mechanisms (Krippendorff, 2019).

The analytical framework was derived from relevant clauses of BS EN ISO 19650-2 and the UK National Annex and operationalised as observable CDE practices (Appendix B). These were consolidated into four analytical categories representing core operational dimensions of CDE operationalisation: (1) CDE governance and responsibility; (2) information container structure; (3) information container workflow; and (4) access control and permissions. Functional requirements were examined through container structuring and workflow processes, while non-functional requirements were examined through governance arrangements, access control and audit mechanisms. These categories form the basis of the CDE workflow model developed for this study (Figure 4). The model integrates the operational processes associated with the creation, structuring, transition, review and final disposition of information containers and informed the development of the interview guide across the four case studies.

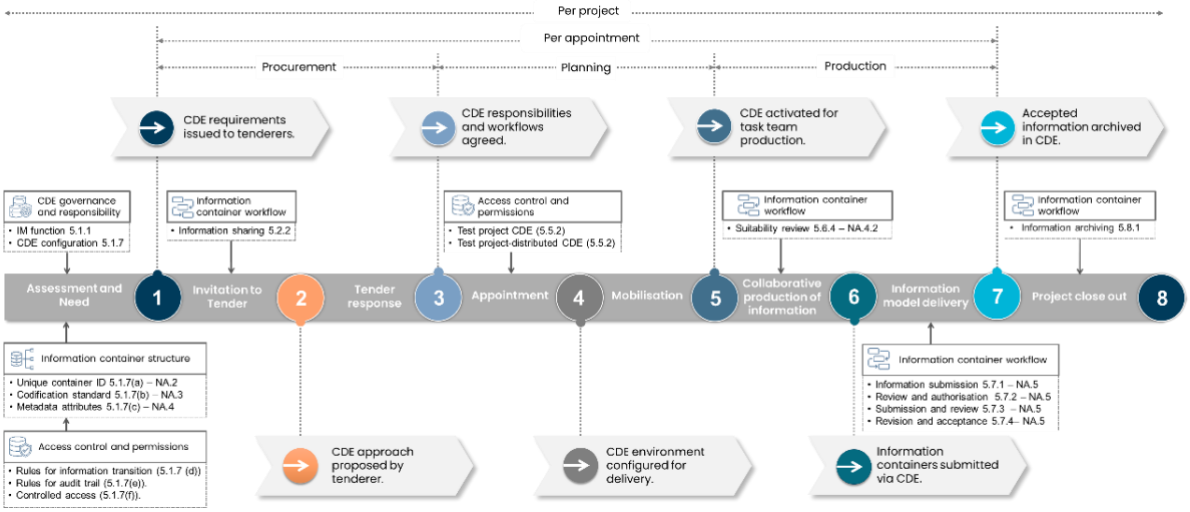


Figure 4: CDE workflow model under BS EN ISO 19650-2, developed by the authors.

Analytical consistency was supported through the use of a standardised interview protocol, predefined clause-based categories and rule-based coding procedures, ensuring uniform interpretation of interview data across cases (Krippendorff, 2019). This approach supported systematic linkage between empirical evidence and the normative framework.

4. CASE STUDIES OVERVIEW

4.1 Case study 1: Fragmented governance

Case study 1 (CS_1) represents a fragmented governance arrangement associated with a DBB procurement route, characterised by distributed appointments and staged IM responsibilities. The project, examined at RIBA Stage 5, was delivered without tendering. The client, acting as the appointing party, engaged multiple consultants to deliver architectural, interior design, structural and mechanical, electrical and plumbing (MEP) across the design stages. OR_A was first appointed by the client as LAP at RIBA Stage 2 to act as an information manager and to produce IM resources, assure quality and verify deliverables against requirements at RIBA Stages 3–6. A contractor was separately appointed as LAP to support coordination activities during later stages.

This structure reflects a staged and distributed allocation of IM responsibilities, with multiple LAP roles assigned across different functions and project stages. Although OR_A was present across stages, the separation between production, assurance and coordination responsibilities, combined with the involvement of a second LAP, limited continuity of governance across project phases. Although the client acted as the appointing party throughout, continuity of governance was not fully maintained, indicating that the existence of a single appointing authority

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does not in itself ensure reliable IM across project stages without clearly defined and sustained governance mechanisms.

4.2 Case study 2: Integrated delivery

Case study 2 (CS_2) represents an integrated delivery structure associated with a DB procurement route, characterised by continuity of governance and coordinated IM responsibilities across project stages. The project was examined at RIBA Stage 3. The invitation to tender for the design lead appointment (LAP2) was issued at RIBA Stage 1. OR_A was appointed by the client as LAP at RIBA Stage 1 to act as an information manager, supporting continuity of coordination and alignment of IM activities. OR_A was subsequently retained across RIBA Stages 2–4 to coordinate activities and verify deliverables against project requirements. A design lead was also appointed as LAP to deliver architectural, structural and MEP services within a coordinated structure. This arrangement reflects a continuous and internally coordinated governance structure, supporting integration of IM processes across the delivery team.

4.3 Case study 3: Contractor-led delivery

Case study 3 (CS_3) represents a contractor-led delivery arrangement under a DBB procurement route, characterised by ECI under a pre-construction services agreement (PCSA). The project was examined during the transition from RIBA Stage 2 to Stage 3, following tendering at RIBA Stage 1. During the period examined, the contractor was appointed by the client as LAP and assumed responsibility for IM and coordination activities. The contractor subsequently appointed OR_B as the architectural and interior design team, alongside structural and MEP appointed parties. A subsequent LAP appointment was anticipated for RIBA Stage 5 but had not been confirmed at the time of data collection. This structure was associated with an early concentration of IM and coordination responsibilities within the contractor organisation during the pre-construction period.

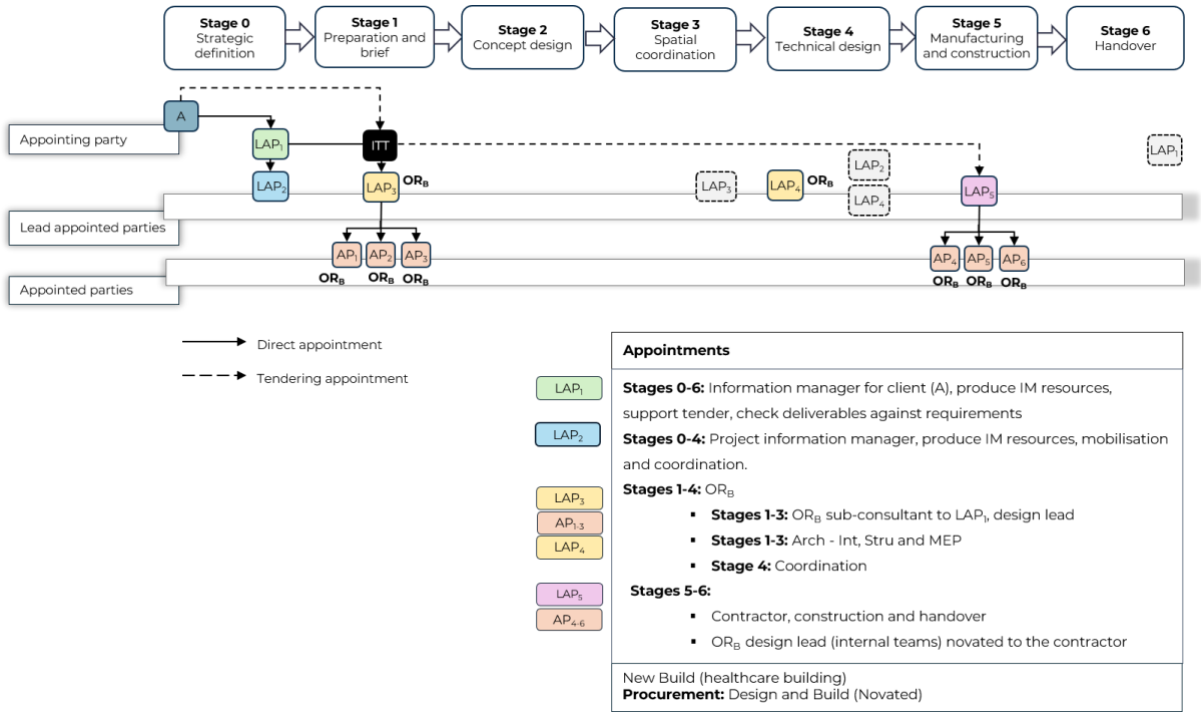


Figure 5: Appointment structure across RIBA Stages 0–6 for CS4 under a novated Design and Build procurement route.

4.4 Case study 4: Parallel governance

Case study 4 (CS_4) represents a transitional governance arrangement associated with a novated DB procurement route, characterised by a transition of IM authority from client-led to contractor-led control. The project, examined

at RIBA Stage 4, involved tendering at RIBA Stage 1. During early stages, the client established a distributed IM process through multiple LAP roles, associated with overlapping coordination responsibilities. This included the appointment of an information manager across RIBA Stages 0–6 and a project information manager at RIBA Stage 0. A design lead was also appointed as LAP at RIBA Stage 1 and later reappointed to support coordination activities.

Following tendering, governance shifted to the contractor, with the design team novated into the contractor's organisational structure. This transition introduced reconfiguration of IM responsibilities across project stages and reduced continuity of governance. The appointment structure, IM processes and IM resources across RIBA Stages for CS_4 are presented in Figure 5–7. Corresponding visualisations for CS_1–CS_3 are provided in supplementary Appendix C.

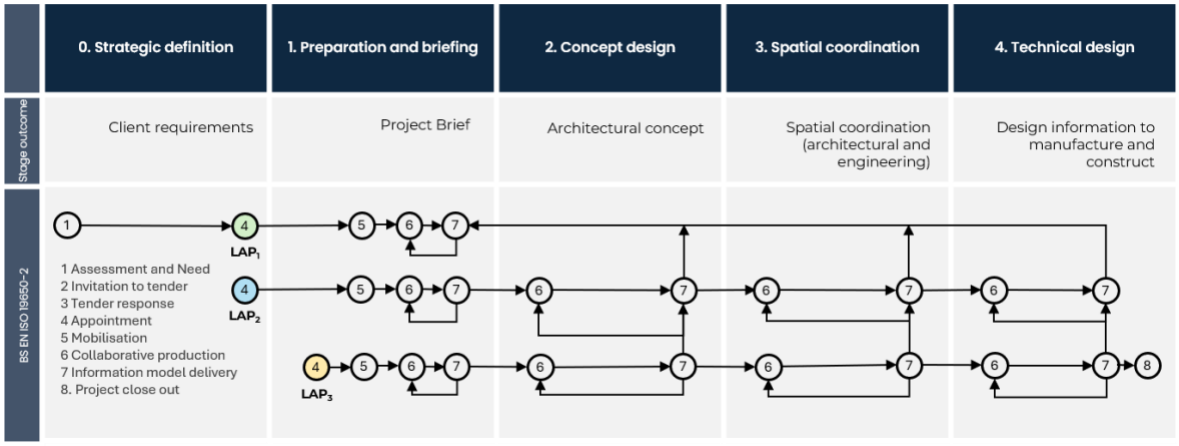


Figure 6: IM processes across RIBA Stages for CS4.

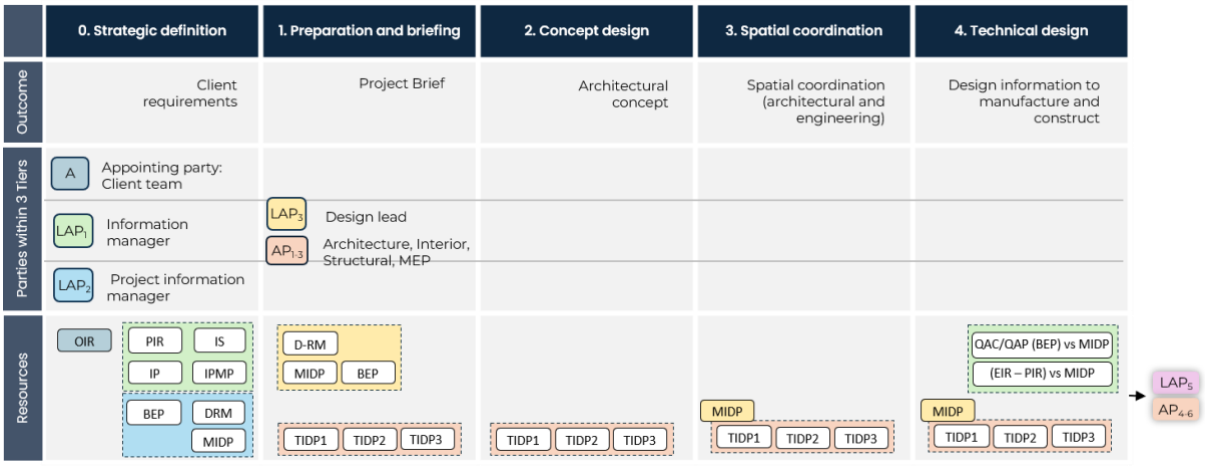


Figure 7: IM resources across RIBA Stages for CS4.

5. IMPLEMENTATION OF INFORMATION MANAGEMENT UNDER BS EN ISO 19650-2

This section presents the analysis of IM implementation under BS EN ISO 19650-2 across the four case studies. Consistent with the embedded multiple case design, each project and its embedded analytical subunits were examined to understand how the standard was enacted in practice (Yin, 2017). The analysis applies cross-case synthesis and pattern matching. The analysis is organised around key dimensions, including procurement routes, appointment structures, IM resources and CDE configuration and workflow. These dimensions represent the structural and operational conditions associated with IM processes. Cross-case synthesis identifies implementation configurations and conditions across the four cases.

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5.1 Procurement and delivery arrangements

Procurement routes are examined as part of the structural arrangement of each case, framing the contractual context within which collaboration, responsibility allocation and information governance operate. The analysis does not evaluate procurement performance but examines how each procurement route was realised through the contractual and appointment arrangements observed in the cases.

The four cases comprised two DBB and two DB arrangements, with differences in how these routes were implemented. CS_1 followed a conventional DBB sequence, with design appointments preceding contractor involvement. CS_3 was also identified as DBB but included ECI under a PCSA during the pre-construction period examined. CS_2 used an integrated DB arrangement, while CS_4 involved novated DB, with the design team novated into the contractor-led delivery structure. These arrangements provided different contractual and appointment contexts for the implementation of IM processes, examined further in Section 5.2. Table 3 summarises the procurement routes and observed appointment characteristics across the four cases.

Table 3: Procurement route and delivery characteristics relevant to BS EN ISO 19650-2 implementation.

Case study	Procurement route	Characteristics relevant to information management
CS_1	Design–Bid–Build	Design appointments preceded contractor involvement; IM responsibilities were distributed across sequential appointments
CS_2	Integrated Design and Build	Design and construction operated within a contractor-led appointment structure, with coordination and information control located within the delivery structure
CS_3	Design–Bid–Build with early contractor involvement under a PCSA	Contractor involvement commenced during pre-construction; IM responsibilities were delegated through a centralised LAP–AP structure during the period examined
CS_4	Novated Design and Build	Appointment relationships transitioned following novation, with overlapping coordination roles across the delivery structure

5.1.1 Coordination and collaboration

Project coordination refers to patterns of decision-making and communication among project actors (Malone & Smith, 1988). BS EN ISO 19650-2 emphasises collaborative coordination during the Collaborative production of information activity, requiring iterative coordination, shared validation cycles and early mobilisation of project parties (British Standards Institution, 2018).

The procurement arrangements identified across the cases were examined in relation to coordination and collaboration using the procurement literature. In CS_1, design appointments preceded contractor involvement. Such sequential DBB arrangements are associated in the literature with more limited integration across organisational boundaries, particularly where separation between design and construction restricts contractor involvement during earlier project stages (Ashcraft, 2008; Eastman et al., 2011; Masterman, 2003; McAdam, 2010; Mosey, 2019). CS_3 differed through ECI under a PCSA during pre-construction. Empirical studies associate earlier contractor participation with opportunities for iterative interaction and organisational integration between design and construction teams, although the extent of these benefits depends on the timing of contractor involvement (Laryea & Watermeyer, 2016; Ng et al., 2023; Wondimu et al., 2020).

CS_2 operated through an integrated contractor-led DB structure. DB arrangements are associated in the literature with greater integration between design and construction activities (Koppinen & Lahdenperä, 2004). CS_4 involved novation of the design team into contractor-led delivery. Previous research identifies such transitions as potential sources of divided responsibilities and reduced continuity during design transfer (Chappell, 2020; Griffith et al., 2003; Ng & Skitmore, 2002).

5.1.2 Information responsibility

BS EN ISO 19650-2 defines information responsibility as appointment-specific and requires a continuous chain of responsibilities across Assessment and need, Collaborative production of information and Information model delivery (British Standards Institution, 2018).

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The procurement arrangements identified across the cases were examined in relation to their implications for information responsibility using the procurement literature. CS_1 followed a conventional DBB arrangement involving separately appointed organisations. Such arrangements distribute responsibility for information production and approval across multiple contractual interfaces, with potential implications for continuity across project stages (Latham, 1994; Masterman, 2003). In CS_3, ECI under a PCSA introduced contractor participation during pre-construction without necessarily transferring design responsibility. PCSA-based contractor duties can include service coordination and BIM input, while contractor contributions to design can create uncertainty regarding the allocation of design obligations and liability, making explicit definition of responsibilities important (Finnie et al., 2022).

CS_2 and CS_4 operated through contractor-led DB arrangements. The literature associates DB with greater consolidation of responsibility within contractor-led structures and more centralised information control, with implications for transparency and accountability to the appointing party (Aibinu & Papadonikolaki, 2016). CS_4 differed through the novation of the design team into the contractor-led delivery structure, introducing a change in contractual relationships through which information responsibilities were allocated.

5.1.3 Client capability and information governance

Client capability is a critical factor influencing IM outcomes under BS EN ISO 19650-2, particularly in defining appointing party requirements and overseeing delivery teams (Kaya & Özener, 2024; Malla et al., 2024). The appointing party establishes information governance through the specification of requirements and monitoring of their implementation (British Standards Institution, 2018).

The procurement arrangements identified across the cases were examined in relation to client capability and information governance using the procurement literature. In DBB arrangements, the appointing party typically retains greater involvement during design stages, increasing reliance on client capability to maintain consistency of requirements and oversight across project stages (Turner, 1997). Where capability is limited, deficiencies in requirement definition may contribute to revisions and schedule impacts (Kaya & Özener, 2024), while experienced clients may mitigate these risks through detailed specification (Cheung et al., 2001; Masterman, 2003). Where ECI is introduced, client capability remains important because the owner must manage the earlier contractor interface and the associated procurement and governance arrangements. Relevant empirical studies identify client or project-owner competence as a condition for successful implementation (Laryea & Watermeyer, 2016; Wondimu et al., 2020).

In DB arrangements, such as those identified in CS_2 and CS_4, responsibilities may be more extensively delegated to the contractor, potentially reducing direct client control where requirements are not explicitly defined (Masterman, 2003; Mosey, 2019). In such contexts, the literature emphasises the clarity of appointing party requirements and the monitoring mechanisms established at appointment as important to information governance (Malla et al., 2024).

5.2 Appointment structures

In this study, procurement defines the overarching delivery strategy of the project, whereas appointment structures determine how IM roles, responsibilities and coordination authority are distributed within that context. Under BS EN ISO 19650-2, information management responsibilities are established through appointment relationships between the appointing party, LAPs and APs, making the sequencing and organisation of these relationships relevant to how the IM framework is structured during project delivery.

Across the four case studies, variations were observed in the sequencing of roles, allocation of IM roles and distribution of coordination authority. The appointment structures did not consistently correspond to a single sequential hierarchy of appointing party, LAP and AP relationships. Cross-case comparison identifies four variations in appointment structures shaping IM implementation (Table 4): misalignment between role sequencing and the IM framework (CS_1), role convergence between information production and assurance functions (CS_2), centralised delegation of IM responsibilities during the period examined (CS_3), and fragmented governance with overlapping coordination roles (CS_4). These variations indicate that IM coordination varies according to the alignment between role sequencing and the IM framework, clarity of hierarchical responsibility structures and the separation between information production and assurance functions.

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Table 4: Cross-case variations in appointment structures affecting IM implementation.

Case study	Appointment structure	Evidence from appointment analysis	Cross-case variation
CS_1	Consultants appointed before IM framework; absence of early IM obligations at initial appointment stages; consultant roles outside the AP structure	Consultants appointed before establishment of the later LAP–AP structure; early roles positioned outside the AP structure; supporting records indicate absence of early IM obligations	Misalignment between appointment sequencing and IM framework
CS_2	Overlapping IM roles within the same organisation performing both production and validation functions	Production and assurance functions allocated within the same organisational structure	Role convergence between information production and assurance functions
CS_3	Clear LAP–AP hierarchy during the period examined, enabling structured delegation of IM responsibilities	LAP_1 positioned above AP_1–AP_3 within a clear delegation structure during pre-construction	Centralised appointment structure and IM delegation
CS_4	Parallel IM coordination roles; fragmented appointment sequencing across LAPs; unclear contractual precedence of IM resources; weak coordination between planning and delivery roles	Sequential and overlapping LAP roles across the delivery stages, with multiple coordination relationships	Fragmented appointment structure and coordination authority

5.3 Information management resources structuring

This section examines how IM resources were structured and operationalised within the LAP appointment arrangements examined across the four case studies. The analysis evaluates three aspects: the existence and form of IM resources; their procedural positioning and their alignment with BS EN ISO 19650-2 requirements. The findings represent the status of the IM resources available and applicable to the LAP appointment arrangements at the time of data collection and do not imply that resources were not subsequently developed, revised or implemented. Table 5 summarises cross-case variations in IM resource structuring. The cross-case variations were derived from the resource-level and clause-level assessment, with detailed scoring provided in supplementary Appendix D.

5.3.1 Resource existence and alignment

Across the four cases, variations were observed in the existence and procedural positioning of IM resources at the LAP appointment stage (Table 6). Governance resources were inconsistently established. Information standard (IS) and Information production methods and procedures (IPMP) were either issued as standalone appointing party instruments or embedded within delivery documentation, such as the BEP. This variation was also reflected in the clause-level assessment. IS scores ranged from 2 in CS_2 and CS_3 to 3 in CS_1 and 4 in CS_4, while IPMP scores were 2 in CS_2 and CS_3, 4 in CS_1 and 5 in CS_4. CS_4 therefore showed the strongest alignment of the governance resources examined, with both resources established as standalone appointing party instruments and procedurally positioned in accordance with the relevant requirements. The Information Protocol (IP) was not identified in the documentation examined across all four cases and received a clause score of 0.

In Table 6, resource existence indicates whether the IM resource was formally established in any form at the LAP appointment stage. “Yes” denotes a standalone resource, “No” indicates absence, “Embedded” refers to resources incorporated within another IM resource, and “Inferred” denotes resources referenced or partially described within another IM document without formal establishment as a standalone resource. Procedural positioning assesses whether the resource was positioned in accordance with the relevant BS EN ISO 19650-2 clause, considering authorship and timing at the LAP appointment stage, where ✓ indicates alignment and ✗ indicates misalignment.

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Table 5: Cross-case variations in IM resource structuring.

Variation	Observed conditions	Case studies
Information governance		
Embedded governance instruments	IS and IPMP provisions incorporated within BEPs rather than established as appointing party governance instruments	CS_2
Production-oriented governance	Governance resources issued but focused on technical production control rather than lifecycle information governance	CS_1
Structured appointing party governance framework	Governance resources established as standalone appointing party instruments within the information requirements framework	CS_4
Absence of contractual governance	Information Protocol not incorporated into project appointments	CS_1, CS_2, CS_3, CS_4
Exchange information requirements		
Weakly-aligned project-level EIR	EIR issued at project-level but weakly aligned with appointing party decision points	CS_1, CS_3
Structured EIR framework	EIR embedded within appointing party information requirements framework with defined Level of Information Need processes and exchange milestones	CS2
Delivery-side definition of exchange requirements	Exchange requirements defined post-appointment by delivery team rather than by appointing party	CS_4
Absence of appointment-level requirement cascade	Appointment-specific exchange requirements not issued by the LAP	CS_1, CS_2, CS_3, CS_4
Execution and delivery planning		
Procedural BEP	BEP addressing clause requirements but lacking integrated delivery strategy and delivery planning logic	CS_1, CS_3
Integrated BEP and delivery planning	BEP linked to delivery planning and coordination strategy	CS_2
Limited or absent responsibility definition	Responsibility defined at high level or absent and described narratively, limiting clarity of allocation	CS_1, CS_2
Fragmented or implicit responsibility definition	Responsibility distributed across documents or implied through Level of Information Need framework rather than explicitly defined	CS_3, CS_4
Strong delivery planning organisation	MIDP/TIDP clearly structured and populated	CS_3
Limited operationalisation of delivery planning	Delivery planning templates present but not populated	CS_4
Legacy delivery planning practices	MPDT used instead of MIDP, reflecting continuation of PAS 1192 planning practices	CS_1, CS_2

EIRs also varied across the cases. Project-level EIRs were present and procedurally positioned in CS_1–CS_3, with clause scores of 3, 4 and 4, respectively, but differed in how requirements were structured and linked to appointing party decision points. CS_1 and CS_3 showed weaker links to these decision points, while CS_2 formed part of a structured information-requirements framework with defined Level of Information Need processes and exchange milestones. No appointing party EIR was identified in CS_4, which received a score of 0; exchange requirements were instead defined post-appointment by the delivery team. Appointment-specific exchange requirements issued by the LAP to appointed parties were absent across all four cases and received a score of 0.

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Delivery planning resources showed a different pattern. BEPs were present and procedurally positioned across all four cases, although their clause scores varied from 2 in CS_3 to 3 in CS_1 and CS_4 and 4 in CS_2. Greater variation was evident in responsibility definition and delivery planning. Detailed responsibility matrices were absent in CS_1, CS_2 and CS_4, with scores of 0, while CS_3 contained a detailed responsibility matrix that was not procedurally positioned in accordance with the relevant requirement and received a score of 2. The strongest contrast concerned MIDP/TIDP arrangements. CS_1 and CS_2 continued to use legacy Model production and delivery table (MPDT) practices and received scores of 0 and 1, respectively. CS_3 contained structured and populated MIDP/TIDP resources and received a score of 5, although their procedural positioning was not fully aligned. In CS_4, MIDP/TIDP templates were procedurally positioned but were not operationalised in practice, resulting in a score of 1. This contrast demonstrates that the existence and procedural positioning of a resource did not necessarily correspond to its degree of operationalisation or clause-level alignment.

Table 6: Existence and procedural positioning of IM resources at LAP appointment by resource category.

Resource category	IM resource	CS_1	CS_2	CS_3	CS_4
Governance	Information Standard	Yes/✗	Embedded (BEP)/✗	Embedded (BEP)/✗	Yes/✓
	Information Production Methods and Procedures	Yes/✓	Inferred (BEP)/✗	Inferred (BEP)/✗	Yes/✓
	Information Protocol	No	No	No	No
Exchange requirements	Exchange information requirements	Yes/✓	Yes/✓	Yes/✓	No
	Lead appointed party exchange information requirements	No	No	No	No
Delivery planning	BIM Execution plan	Yes/✓	Yes/✓	Yes/✓	Yes/✓
	High-level responsibility matrix	Embedded (BEP) /✓	No	Yes/✗	Embedded (AIR)/✗
	Detailed responsibility matrix	No	No	Yes/✗	No
	Master/Task information delivery plan	No (MPDT)	No (MPDT)	Yes/✗	Yes/✓

5.3.2 Information governance

In BS EN ISO 19650-2, the appointing party establishes key IM requirements and resources before appointment. In this study, governance is examined through three resources: the IS, defining information structuring and exchange; the IPMP, governing information production, review and delivery; and the IP, providing a contractual mechanism for incorporating IM obligations.

Across the four cases, governance structures varied in their form, procedural positioning and alignment (Table 6). In CS_2 and CS_3, governance provisions were embedded or inferred within delivery resources, primarily the BEP, rather than established as standalone appointing party governance instruments. In both cases, the IS and IPMP received clause scores of 2 and were not procedurally positioned in accordance with the relevant requirements. In CS_1, the IS and IPMP were issued as standalone resources and received scores of 3 and 4, respectively. However, the IS focused primarily on technical production control, while the IPMP was procedurally positioned in accordance with the relevant requirement. CS_4 showed the strongest governance-resource alignment, with the IS and IPMP established as standalone appointing party resources within the information requirements framework, procedurally aligned, and receiving scores of 4 and 5, respectively.

A common cross-case finding was the absence of the IP from project appointments. The IP was absent and received a score of 0 across all four cases, indicating that a dedicated contractual IM mechanism was not identified in any of the appointments examined.

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5.3.3 Exchange information requirements

BS EN ISO 19650-2 positions EIRs as appointing party resources established prior to appointment, defining required information, Level of Information Need, acceptance criteria and delivery aligned with project milestones and decision points. The LAP may also need to issue appointment-specific exchange requirements for its APs.

Case comparison showed variation in the definition and cascade of EIRs (Table 6). Project-level EIRs were identified and procedurally positioned in CS_1, CS_2 and CS_3, but differed in their content and relationship with appointing party decision points. CS_1 and CS_3 received clause scores of 3 and 4, respectively. In both cases, the EIRs defined project-level information requirements but showed weaker linkage to appointing party decision points. CS_2 also received a score of 4 but exhibited a more structured arrangement, with the EIR forming part of a broader information requirements framework incorporating Level of Information Need processes and defined exchange milestones.

In CS4, no appointing party EIR was identified, resulting in a score of 0. EIRs were instead defined post-appointment by the delivery team. A common cross-case finding concerned the cascade of requirements through subsequent appointments: appointment-specific exchange information requirements issued by the LAP to APs were absent across all four cases and received a score of 0.

5.3.4 Execution and delivery planning

Execution and delivery planning under BS EN ISO 19650-2 is structured through the BEP, high-level and detailed responsibility matrices (HLRM, DRM) and MIDP/TIDP resources, which coordinate information production responsibilities and delivery schedules.

BEPs were present and procedurally positioned across all four cases, but varied in their integration with wider delivery planning (Table 6). CS_1 and CS_3 received BEP clause scores of 3 and 2, respectively, with the BEPs addressing procedural requirements but lacking an integrated delivery strategy and delivery planning. CS_2 received a score of 4 and exhibited a more integrated arrangement linking the BEP to delivery planning and coordination strategy within the broader IM framework. CS_4 received a score of 3; although the BEP was present, wider delivery planning arrangements showed limited operationalisation.

Responsibility definition also varied across the cases. HLRM scores were 4, 3, 3 and 2 for CS_1–CS_4, respectively, but the form and procedural positioning of these resources differed. In CS_1, responsibility definition was embedded within the BEP and remained high-level; no standalone HLRM was identified in CS_2. CS_3 contained a standalone HLRM that was not procedurally positioned in accordance with the relevant requirement, while in CS_4 responsibility definition was embedded within the AIR and was similarly not procedurally positioned. Detailed responsibility definition was more limited: DRMs were absent in CS_1, CS_2 and CS_4, resulting in scores of 0, while CS_3 contained a DRM that was not procedurally positioned in accordance with the relevant requirement and received a score of 2.

The strongest cross-case variation concerned delivery planning. CS_1 and CS_2 continued to use MPDT practices originating from PAS 1192 instead of MIDP/TIDP arrangements, receiving scores of 0 and 1, respectively. CS_3 contained structured and populated MIDP/TIDP resources and received a score of 5, although their procedural positioning was not fully aligned. CS_4 contained MIDP/TIDP templates that were procedurally positioned but were not operationalised in practice, receiving a score of 1. The comparison therefore shows substantial variation between the existence, procedural positioning and operationalisation of delivery-planning resources across the four cases.

5.4 CDE configuration and workflow practices

This section analyses CDE practices by distinguishing between configuration (system setup) and workflow (process execution) to examine how BS EN ISO 19650-2 requirements are operationalised. The analysis is based on the CDE workflow model developed in the study (Figure 4) and draws on interview evidence concerning the configuration and operation of the CDE environment examined. The analysis focuses on four functional categories: governance and responsibility, information container structure, workflow and access control. Cross-case variations in CDE practices are summarised in Table 7. The variations are classified as either configuration or workflow conditions to distinguish between technological enablement and procedural implementation of CDE practices.

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Table 7: Cross-case variations in CDE configuration and workflow practices.

Variation	Type	Observed conditions	Case studies
Governance and responsibility			
Appointing party retains governance with IM advisory support	Workflow	Governance retained by appointing party with IM function supporting configuration and oversight, with coordination largely procedural	CS_1, CS_2
Delegated operational CDE management	Workflow	Governance formally retained by appointing party while operational management is delegated to delivery-side roles (e.g., LAP)	CS_3, CS_4
Information container structure			
Procedural container structuring	Configuration	Naming conventions and metadata applied through procedural verification	CS_1, CS_2
Platform-enforced metadata structuring	Configuration	Naming and metadata fields enforced through CDE configuration	CS_3
Naming-driven container identification	Configuration	Container information embedded primarily in file naming rather than metadata	CS_4
Metadata-supported classification	Configuration	Uniclass used to support classification and searchability	CS_1, CS_3
Folder-level classification	Configuration	Classification applied at folder level with limited integration into metadata or container identification	CS_2
Alternative classification system	Configuration	CI/SfB used instead of Uniclass due to usability considerations	CS_4
Information container workflow			
Single-environment workflow	Workflow	Information containers progress through workflow states within one CDE	CS_1, CS_3, CS_4
Distributed workflow architecture	Workflow	Delivery-side CDE used for production with submission to project CDE	CS_2
Access control and permissions			
Role-based permissions control	Configuration	Role-based permissions regulate user access and information transitions	CS_1, CS_3, CS_4
Access separated between delivery CDE and project CDE environments	Configuration	Permissions separated between delivery and client environments	CS_2

5.4.1 Governance and responsibility

BS EN ISO 19650-2 establishes CDE governance through the appointing party, who is responsible for the project CDE but may delegate operational management to other parties. The LAP is responsible for configuring and managing the delivery team CDE and its connection to the project environment.

Across the cases, governance responsibility formally remained with the appointing party, while operational management varied between advisory-supported and delegated arrangements (Table 8). In CS_1, the project and delivery team operated within the same CDE, while CS_2 used separate project and delivery team CDEs, with the latter managed by LAP_2. In these cases, governance was retained by the appointing party with IM functions providing advisory support and oversight, although the allocation of operational system management differed between the two cases. As one interviewee noted, "*my role was advisory…supporting alignment with ISO 19650 rather than directly managing the system*." In CS_3 and CS_4, operational management was delegated to delivery-

side roles, with LAPs managing the CDE on behalf of the appointing party during the periods examined. As the OR_B interviewee explained, "*the appointing party sets up the CDE, but the management is delegated*," illustrating the distinction between formal governance responsibility and day-to-day system management.

The cross-case comparison therefore identifies a distinction between formal governance responsibility and operational CDE management. While formal responsibility remained with the appointing party across the cases, its operational enactment varied according to the allocation of CDE management responsibilities within the delivery structure.

Table 8: Case study project and delivery team CDE setup and management.

Case study	Project (appointing party) CDE	Project CDE setup and management	Delivery team CDE	Delivery team system management
CS_1	Viewpoint for Projects	OR_A IM function (LAP_1), acting on behalf of appointing party	Project CDE	Appointing party
CS_2	Asite	OR_A IM function (LAP_1), acting on behalf of the appointing party	Autodesk Construction Cloud	Lead appointed party (LAP_2)
CS_3	Viewpoint for Projects	Delegated to contractor for coordination (LAP_1); appointing party retains formal responsibility	Viewpoint for Projects	Lead appointed party (LAP_1)
CS_4	Asite	Delegated to information manager (LAP_1), acting on behalf of the appointing party	Asite	Lead appointed party (LAP_1)

5.4.2 Information container structure

BS EN ISO 19650-2 requires the appointing party to define the structure of information containers within the CDE, operationalised in the UK through rules for naming, metadata and classification. In the cases analysed, container identification relied primarily on naming conventions, metadata and classification, supported by varying levels of system configuration and procedural verification (Table 7).

In CS_1 and CS_2, container structuring relied on procedural verification, with IM functions checking naming and metadata during exchange. As the OR_A interviewee noted, "*the naming convention had to be correct before anything could be shared, and then we would check the metadata afterwards*." In CS_3, structuring was more system-enforced, with naming and metadata applied at upload. In CS_4, structuring relied predominantly on file naming with limited use of metadata, indicating a greater reliance on naming conventions for container identification. The degree of codification varied across cases, ranging from structured, standard-aligned logic to simplified or project-specific conventions.

Classification practices also varied. Uniclass was applied in CS_1, CS_2 and CS_3. In CS_1 and CS_3, it supported identification and searchability. In CS_2, classification was applied at folder level. CS_4 used CI/SfB as a simplified classification approach. As the OR_B interviewee noted, "*Uniclass uses too long numbers, CI/Sf is much simpler*", highlighting a perceived trade-off between standardisation and usability. This suggests that classification choices may also reflect local usability considerations alongside requirements for standardised information structuring. Where metadata was not consistently applied or enforced, this may affect consistent traceability within the CDE. The evidence further suggests that usability considerations were framed primarily from the perspective of the lead organisation's delivery practices, indicating that local operational optimisation may occur at the expense of consistency and interoperability across the wider project environment.

Interview evidence further indicates that classification consistency was perceived to depend on user capability and training, as well as ongoing Uniclass updates, contributing to variability in information structuring across cases. The OR_A interviewee noted that "*...it requires greater education across both client and delivery teams"* and that "*frequent updates to the Uniclass system increase complexity, requiring ongoing maintenance and reclassification of previously issued information*". These accounts identify user capability, training and classification-system maintenance as operational considerations associated with the implementation of information-container structuring.

5.4.3 Information container workflow

BS EN ISO 19650-2 requires the controlled progression of information containers through defined workflow states to ensure traceability of revisions and approvals throughout delivery. Case comparison shows that workflow processes were implemented through CDE submission procedures combining metadata, naming conventions and suitability codes (Table 9). While platform configurations in some cases supported traceability through required fields and revision histories, workflow control varied in the extent to which it was system-enforced or procedurally managed. Where configured, platforms enforced required fields at upload, while revision histories and system logs supported traceability. As noted by the OR_A interviewee, "*when people were uploading information it enforced those fields, so they had to follow those conventions".* Review procedures were primarily governed through project protocols and IM or BIM management oversight.

Two workflow architectures were observed. In CS_1, CS_3 and CS_4, information containers progressed within a single CDE environment, avoiding the additional information-transfer interface associated with movement between separate CDE environments. In contrast, CS_2 adopted a distributed workflow, where information was produced in a delivery-side environment and submitted to the project CDE**.** As noted by the OR_A interviewee, "*manual downloading and re-uploading…can lead to loss of metadata*", identifying metadata loss as a potential risk associated with this transfer process. These findings indicate that workflow implementation varied with procedural requirements, CDE architecture and the allocation of document control responsibilities.

5.4.4 Access control and permissions

BS EN ISO 19650-2 requires the project CDE to establish controlled access, audit trails and rules governing the transition of information containers between workflow states. This includes mechanisms for recording user activity and ensuring that only authorised participants can create, modify or approve information.

Across the case studies, access control was implemented primarily through role-based permissions within the project CDE (Table 7). However, interview evidence indicated that where governance and system administration were separated, visibility of access control could be limited, as noted by the OR_A interviewee, "*access control is not always fully visible or consistently defined"*, identifying visibility and consistency of access control as potential governance concerns.

Two configurations were observed. In CS_1, CS_3 and CS_4, role-based permissions were managed within a single CDE environment, where administrators assigned user roles and maintained access rights. As the OR_B interviewee explained, "*control is implemented through role-based permissions ensuring only authorised users can upload, modify, or approve files."* In CS_2, access control reflected the distributed CDE architecture, with the delivery team operating in a separate production environment (ACC) and restricted access to the project CDE for submission and review (Asite). These findings show that access control was role-based across the cases, while its configuration varied between single and distributed CDE environments. Interview evidence further identifies governance visibility as a consideration where system administration and governance responsibilities were separated.

6. SYNTHESIS OF CROSS-CASE FINDINGS

The cross-case analysis identified case-derived implementation configurations in how BS EN ISO 19650-2 processes were enacted across the four case studies, together with the implementation conditions under which they emerged. Conditions refer to the structural and operational features associated with IM implementation, while configurations represent the combinations of these features observed within the cases. Figure 8 presents the cross-case synthesis of these dimensions, conditions and case-derived implementation configurations.

6.1 Contextual variation across the cases

The cases differed in organisational context, project scale, building type and RIBA stage, requiring these characteristics to be considered when interpreting cross-case variation. Differences in organisational context were observed alongside differences in the formalisation of IM arrangements. CS_1 and CS_2, undertaken by OR_A, were characterised by more procedural and project-based organisational IM arrangements, whereas CS_3 and CS_4, undertaken by ORB, operated within more formal and system-supported organisational arrangements. However, the different appointment, resource and CDE configurations observed within each organisation indicate that organisational context alone did not account for project-level implementation variation.

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Project scale and building type showed no consistent correspondence with the implementation configurations. The two medium-scale projects, CS_1 and CS_4, exhibited different configurations, as did the two healthcare projects (CS_3 and CS_4). With only one entertainment project (CS_1) and one educational project (CS_2), comparison across building types was limited.

RIBA stage provided an additional interpretive consideration because appointment sequencing and the establishment and use of IM resources vary across the project lifecycle. Nevertheless, no progressive relationship between project stage and implementation formalisation was evident. CS_3, examined during the transition from RIBA Stage 2 to Stage 3, exhibited structured delivery planning and system-enforced workflows, while later-stage cases exhibited less integrated arrangements in these areas. Stage was therefore used to contextualise these differences rather than as an independent explanation for them.

Overall, the contextual comparison indicates that no single case characteristic accounted for the observed implementation variation. The subsequent cross-case analysis therefore examines the configurations as combinations of structural and operational conditions within their respective project contexts.

6.2 Cross-case analysis of project dimensions

This section presents the cross-case comparison of project dimensions under BS EN ISO 19650-2 application (Table 9). The comparison highlights differences in procurement routes and appointment structures, as well as in the structuring of IM resources and CDE practices. These differences reflect variation in the distribution of governance responsibilities, structuring of information requirements and control of workflows across project environments, forming the basis for the identification of implementation conditions and configurations discussed in the following section.

Across the cases, these patterns reveal systematic differences in how IM is embedded within project contexts. Procurement and appointment are associated with distinct governance structures, but the cases indicate that procurement route alone did not account for the observed IM configurations. CS_1 exhibited fragmented appointment sequencing within its DBB arrangement, whereas CS_3 combined DBB with ECI under a PCSA and exhibited centralised coordination and stronger delivery planning organisation. The DB cases (CS_2, CS_4) also differed in governance continuity and coordination structures. Variations in IM resources and CDE practices further indicate differences in the level of formalisation and system support. CS_1 combined production-oriented governance resources and legacy delivery planning with predominantly procedural CDE controls; CS_2 combined embedded governance resources with a distributed CDE workflow; CS_3 combined embedded governance resources with structured delivery planning and greater platform enforcement; and CS_4 combined structured appointing party governance resources with limited operationalisation of delivery planning and predominantly procedural CDE practices. These differences reflect different enactments of the workflow structure illustrated in Figure 4. These observed differences suggest that project dimensions do not operate independently but form coherent combinations of conditions associated with how IM processes are established and coordinated across the cases.

6.3 Implementation conditions and configurations

This section synthesises the cross-case analysis (Table 9) by identifying the implementation conditions, examining their variation, and interpreting how they form implementation configurations. The analysis distinguishes between structural and operational conditions.

Structural conditions define the project environment within which IM is implemented, including governance continuity, integration of appointment sequencing with the IM framework, governance stability and the distribution of coordination authority. These conditions are associated with how responsibilities are maintained across project stages and how coordination is organised across actors. In the cases analysed, variation was associated with procurement and appointment structures. CS_1 exhibited greater discontinuity in governance and appointment sequencing, whereas CS_3 combined DBB with ECI under a PCSA and a centralised coordination structure during the period examined. The DB cases (CS_2, CS_4) also differed, particularly in governance stability and coordination authority.

Operational conditions relate to the organisation and enactment of IM processes, including the formalisation and integration of IM resources, control over IM organisation, delivery planning organisation and the configuration

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and enforcement of CDE workflows. These conditions relate to how information requirements are translated into delivery processes, how responsibilities and timelines are coordinated and how information is controlled within the CDE. The cases exhibited different combinations of these conditions: CS_1 relied more strongly on procedural controls and legacy delivery-planning practices; CS_2 combined greater integration of IM resources with a distributed CDE workflow; CS_3 combined structured delivery planning with greater platform enforcement; and CS_4 combined structured appointing party governance resources with limited operationalisation of delivery planning and predominantly procedural CDE practices.

Table 9: Cross-case project dimensions of BS EN ISO 19650-2 implementation.

Implementation dimension	**CS_1**	**CS_2**	**CS_3**	**CS_4**
Procurement route	Design–Bid–Build	Integrated Design and Build	Design–Bid–Build with early contractor involvement under a PCSA	Novated Design and Build
Appointment structures	Early consultant appointments	Dual IM roles	Centralised LAP–AP structure	Parallel IM governance
IM governance resources	Production-oriented standalone governance resources	Governance embedded in delivery artefacts	Governance embedded in delivery artefacts	Standalone governance instruments
Exchange information requirements	Generic EIR weakly aligned with decision points	Structured EIR framework	Project-level EIR weakly aligned with decision points	No appointing party EIR
Delivery planning resources	Procedural BEP and legacy MPDT planning	Integrated BEP but incomplete delivery planning structures	Structured MIDP-based planning	Limited operationalisation
CDE governance	Client retains governance; operational oversight advisory	Client governance with distributed delivery CDE	Contractor-led operational management	Governance delegated to information manager
CDE container structure	Naming conventions and procedural verification	Naming conventions and folder classification	Metadata enforced through platform configuration	File naming conventions dominate
CDE workflow control	Single CDE workflow with procedural oversight	Distributed workflow across delivery and project CDEs	Platform-enforced workflow information structuring	Procedural review via document controllers
CDE access control	Role-based permissions	Role-based permissions with client/delivery separation	Platform-managed permissions	Role-based permissions monitored by document controllers

Organisational context was further reflected in how these conditions were enacted, particularly in relation to the degree of formalisation, integration and system support of IM processes. Consultancy-based environments (OR_A) showed greater reliance on procedural coordination and embedded governance, while the larger, formally accredited organisations (OR_B) exhibited more formalised organisation of IM resources and system-enabled workflows. Organisational certification and accreditation therefore provide a contextual characteristic against which these differences can be interpreted, although their independent influence cannot be isolated from other organisational and project conditions in the cases examined. In the accredited organisation (OR_B), IM practices were generally more formally structured and consistent with BS EN ISO 19650-2 requirements, particularly in relation to governance definition, delivery planning and workflow configuration. However, certification was not associated with consistent alignment across all operational practices.

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Across cases, reliance on legacy approaches, such as the continued use of MPDT, indicates persistence of pre-BS EN ISO 19650-2 practices. The comparison therefore suggests an association between organisational formalisation and the structuring of IM practices, while also showing that project-level implementation remained variable within each organisational context. Established practices also remained evident in how IM processes were operationalised in project environments. These differences contribute to the formation of distinct implementation configurations identified across the cases, in which organisational context intersects with project-level structural and operational conditions.

Cross-case comparison revealed that these variations did not occur independently but combined differently within each case (Table 10). Four case-derived implementation configurations were identified: *fragmented early-stage* (CS_1), *integrated delivery* (CS_2), *centralised coordination* (CS_3) and *transitional governance* (CS_4) (Table 11). These configurations represent distinct combinations of structural and operational conditions within the four cases.

Table 10: Cross-case variations across implementation conditions.

Condition / variation	Description	Case studies
Structural		
Continuity of information governance	Extent to which IM responsibilities are maintained consistently across project stages	Fragmented: CS_1 | Continuous: CS_2, CS_3 | Transitional: CS_4
Appointment sequencing alignment	Degree to which appointment timing aligns with the establishment of the IM framework	Misaligned: CS_1 | Partially aligned: CS_2 | Aligned: CS_3, CS_4
Governance stability	Stability of governance arrangements across project stages	Transitional: CS_4 (novation) | Stable: CS_1, CS_2, CS_3
Coordination authority distribution	Distribution of coordination responsibilities across project actors	Centralised: CS_3 | Distributed: CS_1 (early stage), CS_4
Operational		
Formalisation and integration of IM resources	Degree to which IM resources are defined, structured and integrated as a coordinated system	Limited integration: CS_1 | Moderate integration: CS_2 | Structured planning: CS_3 | Structured governance: CS_4
Control over IM organisation	Locus of authority responsible for defining and managing IM processes, resources and workflows	Delivery-led: CS_2, CS_3 | Appointing party-led: CS_4 | Appointing party-led/advisory-supported: CS_1
Delivery planning structuring	Extent to which delivery planning is systematically defined and coordinated across the delivery team	Structured: CS_3 | Partially structured: CS_2 | Fragmented: CS_1, | Limited operationalisation: CS_4
CDE workflow structuring	Degree to which workflows are system-enabled and coordinated and whether they operate within single or distributed CDE environments	Greater platform enforcement: CS_3 | Procedural: CS_1, CS_2, CS_4 | Distributed workflow: CS_2 | Single-environment: CS_1, CS_3, CS_4
Organisational		
Organisational structuring of IM	Degree of formalisation and system support of IM processes within the organisation	Procedural/project-based: CS_1, CS_2 (OR_A) | Formal/system-supported: CS_3, CS_4 (OR_B)

The *fragmented early-stage* configuration is characterised by discontinuity in governance and misaligned appointment sequencing, associated with limited integration of IM resources and reliance on procedural coordination. The *integrated delivery* configuration combined continuous governance within a contractor-led

structure with greater integration of IM resources and convergence between production and validation functions. The *centralised coordination* configuration occurred within the DBB case involving early contractor participation under a PCSA and was characterised by centralised coordination authority, structured delivery planning and greater platform enforcement of CDE processes. The *transitional governance* configuration is characterised by shifting and overlapping coordination roles, alongside fragmented authority and inconsistent operationalisation of IM processes. Figure 8 synthesises the relationships between project dimensions, implementation conditions and implementation configurations.

Table 11: Case-derived implementation configurations and conditions.

Configuration	Key conditions	Case study
Fragmented early-stage	Fragmented governance; misaligned appointment sequencing; distributed coordination; limited IM integration; procedural workflows	CS_1
Integrated delivery	Continuous governance; delivery-led IM organisation; moderate IM integration; distributed workflow architecture; convergence of production and validation functions	CS_2
Centralised coordination	Continuous governance during the period examined; early contractor involvement under a PCSA; centralised coordination authority; delivery-led IM control; structured delivery planning; greater platform enforcement of CDE processes	CS_3
Transitional governance	Transitional governance (novation); parallel IM roles; fragmented coordination authority; limited operationalisation of delivery planning; hybrid or procedural workflows	CS_4

7. DISCUSSION

This study addressed three research objectives relating to the role of procurement and appointment structures (RO_1), the structuring and integration of IM resources (RO_2), and the operationalisation of IM processes through CDE practices (RO_3). The findings highlight that BS EN ISO 19650-2 operationalisation reflects the interaction of structural and operational conditions, rather than individual project dimensions in isolation. Building on the case-derived implementation configurations (Table 11), this section examines how these conditions (Table 10) relate to implementation across coordination, control and delivery outcomes, consistent with the embedded analytical design presented in Figure 3. Figure 8 further illustrates the interaction of structural and operational conditions within the four implementation configurations.

7.1 Structural conditions

Structural conditions define the organisational and contractual environment within which IM processes are established, including governance continuity, appointment sequencing, governance stability and the distribution of coordination authority (Table 10).

Governance continuity is a key condition in BS EN ISO 19650-2 implementation. While procurement routes and appointment structures are relevant to governance continuity, BS EN ISO 19650-2 positions the appointing party as a continuing source of information requirements and governance across project stages. This approach places emphasis on the ability of the appointing party to define and maintain information requirements and governance mechanisms throughout the project lifecycle. This becomes particularly important where contractual mechanisms for incorporating IM obligations are absent or not identified, as implementation may rely more heavily on procedural coordination.

In CS_1, the DBB arrangement was characterised by fragmented appointment sequencing, with responsibility distributed across sequential appointments, alongside limited consistency between information requirements and delivery processes. CS_3 differed despite being identified under the same procurement route. ECI under a PCSA introduced the contractor during pre-construction and was accompanied by centralised coordination authority within the lead organisation during the period examined. This is consistent with evidence that ECI can support iterative interaction and organisational integration between design and construction teams (Laryea & Watermeyer, 2016; Ng et al., 2023). The contrast between CS_1 and CS_3 indicates that governance continuity was associated with differences in the appointment arrangements through which the procurement route was realised. In CS_2, the DB arrangement coexisted with greater integration between requirements, planning and production, consistent with

literature associating DB with greater integration between design and construction activities (Holzer, 2015). CS_4 showed transitional governance following novation, involving shifts in responsibility and coordination authority.

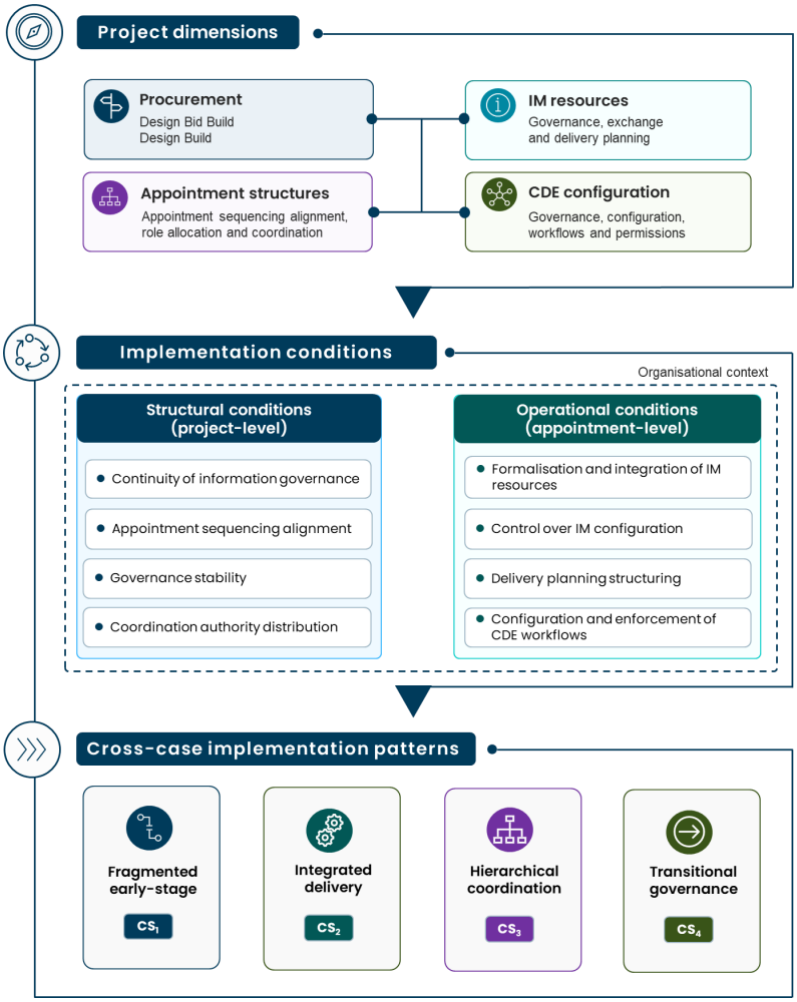


Figure 8: Cross-case synthesis of project dimensions, conditions and configurations in BS EN ISO 19650-2 implementation.

While procurement routes provide the broader governance context, continuity also depends on appointment arrangements and the distribution of coordination authority. Governance continuity therefore provides a basis for integration but does not itself demonstrate effective implementation, particularly without mechanisms that preserve transparency. These findings align with BIM procurement research emphasising transparency and standard-aligned governance across project stages (Ermolli & De Toro, 2017; Mahamadu et al., 2020; Popov et al., 2021; Wang et al., 2019).

The findings also highlight a distinction between the coordination model embedded in BS EN ISO 19650-2 and the practices observed across the case studies. The standard primarily structures coordination within delivery teams. Coordination across delivery teams is mediated through the appointing party's information requirements and exchange processes. This establishes a mediated coordination model, in which information flows upward to the appointing party and is then redistributed to other delivery teams. However, across the cases, coordination authority was also configured within delivery teams, particularly through LAPs. In these cases, coordination across delivery teams could operate more directly through delivery-side structures, with less dependence on the appointing party as an active intermediary. This finding indicates variation from the mediated coordination model anticipated by the standard, with coordination authority in some cases operating more directly through delivery-side structures.

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Appointment sequencing was associated with differences in whether IM processes were established before or after information production had commenced. In the misaligned structure observed in CS1, information production preceded elements of the IM framework, requiring subsequent integration into the developing IM arrangements. Where appointment sequencing was more closely aligned with the IM framework, information production could be structured within established IM arrangements, as observed particularly in CS_3. In CS_3, ECI also brought the contractor into the pre-construction period, indicating the importance of the timing of contractor participation in establishing coordination arrangements. The relevance of early participant integration to BIM-enabled delivery has also been identified in previous research (Amin & Abanda, 2019). The timing of contractor involvement represents an important condition in ECI implementation, influencing the extent to which contractor knowledge can contribute to project processes (Wondimu et al., 2020). Appointment sequencing therefore represents a condition associated with whether IM arrangements are established proactively or require subsequent integration during delivery.

Governance stability introduces additional complexity in transitional arrangements. In the novated structure observed in CS_4, shifts in responsibility were accompanied by overlapping coordination roles and changes in authority. The literature similarly identifies potential ambiguity in responsibility following novation (Ng & Skitmore, 2002). Similar challenges have been identified in BIM coordination, where unclear governance boundaries are associated with challenges in information control processes (Singh et al., 2011; Succar, 2009).

The distribution of coordination authority relates to implementation in terms of the balance between coordination efficiency and validation independence. In CS_3, operational control was concentrated within the lead organisation through centralised coordination authority, alongside structured delivery planning and greater platform enforcement of CDE processes. The PCSA arrangement introduced contractor participation during pre-construction without necessarily transferring design management responsibility. Under PCSA arrangements, contractor involvement can include service coordination and BIM input without necessarily constituting design management, although contractor contributions to design may introduce uncertainty around the allocation of design obligations and liability (Finnie et al., 2022). More distributed arrangements (CS_1, CS_4) involved coordination across organisational boundaries, requiring mechanisms to maintain role clarity and information control (Khoso et al., 2021; Mahamadu et al., 2020).

7.2 Operational conditions

Operational conditions are reflected in how IM processes are configured and enacted in practice, including the formalisation and integration of IM resources, control over IM organisation, delivery planning structuring and CDE configuration and workflow (Table 10).

Differences in the formalisation and integration of IM resources corresponded with variation in whether IM was structured as a coordinated system or as fragmented, document-driven practices. Across the cases, differences were observed in the alignment between requirements, responsibilities and delivery-planning resources. CS_1 combined production-oriented governance resources with procedural BEP and legacy MPDT planning, while CS_4 combined structured governance resources with limited operationalisation of delivery planning. CS_3 exhibited stronger delivery planning organisation, although governance, exchange and responsibility resources were not consistently integrated, while CS_2 showed moderate integration across IM resources. These observations extend research on EIRs, which emphasises alignment with organisational and asset requirements, while identifying limitations in client capability (Dwairi & Mahdjoubi, 2022; Zima & Mitera-Kiełbasa, 2021).

Control over IM organisation defines where authority for defining and enforcing IM processes is located. In delivery-led arrangements, CS_2 showed closer alignment between planning and production but greater convergence between production and validation functions, while CS_3 combined delivery-led IM control with centralised coordination and structured delivery planning. In appointing party-led arrangements (CS_4), formal control coexisted with limited integration across delivery-planning resources. In CS_1, distributed authority was accompanied by greater reliance on procedural coordination.

Delivery planning organisation relates to how requirements are translated into coordinated production processes. Structured delivery planning in CS_3 provided greater organisation of responsibilities, milestones and information production, although alignment across IM resources remained incomplete. CS_2 combined an integrated BEP with incomplete delivery-planning structures. CS_1 relied on legacy MPDT planning, while CS_4 contained MIDP/TIDP

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templates that showed limited operationalisation. Structured planning mechanisms such as MIDPs and TIDPs are intended to support coordination of information production and delivery (Kaya & Özener, 2024; Mahamadu et al., 2020) but are often used as technical artefacts rather than active coordination mechanisms. BEP-focused studies indicate that effectiveness depends on structuring coordination processes rather than documenting existing practices, despite tensions between standardisation and project-specific flexibility (Ayerra et al., 2021; Bakar et al., 2020; Çekin & Seyis, 2020; Panagiotidou et al., 2023). In practice, organisations may rely more strongly on experience-based practices than on structured planning, prioritising adaptation over formal compliance (Abanda et al., 2025; Ashworth et al., 2023; Sibenik et al., 2023).

CDE configuration and workflow structuring vary according to the extent to which workflows are system-enabled or procedurally managed. These workflow relationships correspond to the CDE workflow model illustrated in Figure 4. In CS_3, greater platform enforcement supported the consistent application of required fields and metadata at upload, while revision histories and system logs provided mechanisms for traceability. Procedural approaches (CS_1, CS_2, CS_4) relied more strongly on procedural verification and management oversight. Distributed CDE architectures (CS_2) introduced an additional information-transfer interface between production and exchange environments, while single-environment configurations avoided this additional interface. Interview evidence identified metadata loss as a potential risk associated with manual transfer between CDE environments.

These findings reflect limitations of current platforms in supporting ISO 19650 workflows (Kaya & Özener, 2024; Yousfi et al., 2025) and the importance of structured metadata and workflows for coordination and lifecycle continuity (Ajayi et al., 2023; Garbutt et al., 2023). The observed CDE arrangements further indicate that information exchange can operate through delivery-side structures alongside the appointing party-mediated coordination embedded in the structure of BS EN ISO 19650-2.

The contextual comparison further qualifies the interpretation of the structural and operational conditions. Organisational context corresponded with the degree of formalisation and system support surrounding IM practice, indicating that project-level configurations operate within broader organisational arrangements. However, variation between cases within the same organisational context, alongside the absence of consistent patterns according to project scale, building type or RIBA stage, indicates that these contextual characteristics showed no consistent correspondence with the implementation configurations across the cases.

7.3 Implications for BS EN ISO 19650-2 implementation

The findings show that BS EN ISO 19650-2 implementation operates as a condition-dependent system reflecting the interaction of structural and operational conditions. This interaction is consistent with a socio-technical perspective, in which organisational structures, relationships and authority interact with tasks, processes and technologies in shaping the functioning of organisational work systems (Baxter & Sommerville, 2011; Bostrom & Heinen, 1977). In the cases examined, procurement and appointment arrangements were associated with differences in roles, coordination authority and governance continuity, while differences in IM resources, delivery planning and CDE workflows shaped how information processes were operationalised. The findings therefore indicate that these elements cannot be considered independently when examining how BS EN ISO 19650-2 is enacted in project environments.

As a voluntary framework (International Organization for Standardization, 2026), BS EN ISO 19650-2 is implemented within organisational and project contexts in which requirements may be interpreted and operationalised differently (Ahrne et al., 2002). Implementation therefore depends on alignment across these conditions rather than on compliance with prescribed processes alone. Organisational certification may support this alignment by strengthening governance formalisation and workflow structuring but does not in itself ensure consistent operationalisation across project contexts. The cases further suggest an association between organisational formalisation and the structuring of IM practices, while showing that formal organisational arrangements did not ensure consistent operationalisation across project contexts.

These results position BS EN ISO 19650-2 as a context-dependent coordination mechanism operating within a policy environment that promotes and normalises its adoption despite its voluntary status. The findings further indicate that, while the standard assumes appointing party-mediated coordination across delivery teams, coordination across the cases was also configured through more direct, delivery-led mechanisms. While standardisation is typically associated with consistency and interoperability (Brunsson & Jacobsson, 2000), its

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implementation is shaped by organisational capabilities, standard characteristics, market conditions and institutional context (Hill, 1997; Schilling, 1999; Shapiro & Varian, 1999; van de Kaa, 2023). These findings reflect the broader divergence between formal standards and situated practices, where processes are adapted to organisational routines, contractual structures, and project constraints. Both insufficient alignment and overly rigid application may create limitations for implementation (Succar & Poirier, 2020).

The findings suggest that clause compliance cannot be interpreted as a purely procedural or checklist-based exercise. Its application depends on contextual factors, including procurement routes, associated appointment arrangements and organisational structures. Projects delivered under framework agreements may rely on organisation-level information requirements and supporting documentation, influencing how compliance is expressed at the project level. In addition, clause requirements formulated as "shall consider" introduce interpretive flexibility that depends on project and appointment conditions. Compliance should therefore be understood as a context-sensitive process rather than a uniform standardised output.

The findings also contribute to ongoing discussions on the status of BS EN ISO 19650-2 as a voluntary standard. While formally non-mandatory, its implementation occurs within broader institutional and policy environments that may shape expectations surrounding its adoption. In this sense, implementation can operate between voluntary uptake and expected compliance, reinforcing the view of BS EN ISO 19650-2 as a context-dependent coordination mechanism rather than a purely technical framework. While the study does not explicitly evaluate policy impact, the temporal overlap between the case studies and recent UK policy initiatives provides contextual grounds for considering this broader institutional environment, without establishing its influence on the implementation behaviours observed.

These findings have implications for both practice and research. For practice, improving implementation requires a shift from formal compliance towards alignment across procurement and appointment arrangements, IM resources and CDE practices. For research, the findings highlight the need to examine the standard's enactment as an emergent, context-dependent process rather than as a linear progression from adoption to compliance.

Adoption of ISO 19650 requires not only technical application but also the reconfiguration of workflows, integration of digital tools, development of competencies and adaptation of contractual and organisational processes (Ajayi et al., 2023; Godager et al., 2022; Malla et al., 2024; Yousfi et al., 2025). Differences in organisational structuring of IM were observed alongside differences in governance formalisation, delivery planning integration and workflow control.

BS EN ISO 19650-2 can be understood as an adaptive coordination framework whose implementation reflects the alignment between governance structures, organisational practices and digital infrastructures. As these elements evolve across project environments, implementation becomes a dynamic process of configuration and reconfiguration. Outcomes such as clause-level alignment, coordination effectiveness, information traceability and governance stability vary according to the interaction of structural and operational conditions within a policy environment that promotes its adoption despite its voluntary status.

8. CONCLUSIONS

This study employed a multiple case study approach across four UK projects to examine how procurement routes, appointment structures, IM resources and CDE practices relate to the implementation of IM processes under BS EN ISO 19650-2. Cross-case synthesis identified four case-derived implementation configurations associated with different combinations of conditions, showing that operationalisation varied across project environments rather than following a uniform procedural model.

In response to the overarching research question, the findings indicate that variation in BS EN ISO 19650-2 implementation reflects the interaction between procurement and appointment structures, IM resources and CDE practices. In relation to RO_1, procurement routes provide the broader delivery context for IM implementation, while associated appointment arrangements relate to variation in governance continuity, coordination authority and responsibility allocation. The contrast between the two DBB cases further indicates that procurement route alone does not account for differences in implementation, as ECI and appointment sequencing were associated with different coordination conditions within the same broad procurement route.

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For RO_2, the analysis shows that variation in the existence, positioning and integration of IM resources corresponded with differences in clause-level alignment, with variation observed in the formalisation of resources and the continued use of embedded and legacy practices. Regarding RO_3, the findings indicate that the operationalisation of IM processes differed according to CDE configuration and workflow practices, with variation in platform enforcement, procedural control, information-container structuring and information-transfer arrangements across the cases.

The analysis shows that BS EN ISO 19650-2 implementation varies according to the interaction between structural and operational conditions. Procurement and appointment structures were associated with variation in governance continuity, coordination authority, governance stability and appointment sequencing. Differences in the formalisation and integration of IM resources, control over IM organisation, delivery planning structuring and CDE workflow configuration and enforcement were associated with variation in their operationalisation within project environments. The results support analytical rather than statistical generalisation, offering an explanatory framework for understanding BS EN ISO 19650-2 variation across project contexts while recognising that outcomes remain contingent on specific organisational and project conditions.

The study makes three contributions to research on BS EN ISO 19650-2. First, it conceptualises IM under the standard through a socio-technical perspective in which implementation reflects interacting structural and operational conditions. Second, it provides clause-level empirical evidence of how IM resources, including governance instruments, EIRs and delivery planning mechanisms, are enacted and adapted in practice rather than implemented uniformly across project environments. Third, it shows how CDE configuration and workflow practices are associated with variation in workflow control, information-container structuring, access control and information exchange across the identified implementation configurations.

The findings should be interpreted in relation to the current evolution of the ISO 19650 framework. As of September 2026, ISO 19650-1:2018, ISO 19650-2:2018 and ISO 19650-3:2020 remain current, while revised editions are under development. The study remains grounded in the 2018 edition of BS EN ISO 19650-2 and its UK National Annex, which were used as the basis for the case analysis. The results highlight variation in governance continuity and responsibility allocation across appointment structures, the formalisation and integration of IM resources, and the configuration and enforcement of CDE workflows. These findings may inform future refinements of the ISO 19650 framework by identifying areas where additional clarification or guidance could support implementation across different project environments. Future research could examine how the revised editions address these areas and influence IM practices across different project delivery arrangements.

The analysis is based on four UK case studies and therefore reflects specific organisational and regulatory contexts. Organisational context, project scale, building type and RIBA stage were considered during cross-case interpretation, but the four-case design does not allow their individual effects to be isolated. While the cases represent two widely used procurement routes, the associated appointment and delivery arrangements varied across the cases, although the overall range of project delivery structures remains limited. A further limitation is that coding and verification were undertaken by the same researcher; therefore, inter-coder reliability was not assessed, although coding consistency was supported through the stability and verification procedures.

Future research could examine additional procurement models and delivery arrangements, as well as conduct comparative studies across different national contexts. Longitudinal research across project lifecycle stages could provide further insight into how information governance and delivery planning mechanisms evolve over time. Additional research may also explore emerging data-centric approaches, including machine-readable requirements, e-procurement, blockchain solutions and model-based specifications such as IDS. Future research could further examine how changes in UK government policies and strategic priorities relate to the continuity and effectiveness of BS EN ISO 19650-2 implementation across project environments.

BS EN ISO 19650-2 can be understood as an adaptive coordination framework through which IM is structured across complex project environments. Implementation should therefore be understood not as a uniform procedural process to be followed, but as a system to be configured, reflecting the interaction of governance structures, organisational practices and digital infrastructures rather than procedural compliance alone.

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DATA AVAILABILITY STATEMENT

The interview protocol, scoping questions, case study visualisations, analytical coding framework, detailed audit of project and appointment IM resources under BS EN ISO 19650-2, anonymised clause-level alignment results, worked scoring examples and analytical audit trail are provided as supplementary files with the manuscript submission. The data used in this study are confidential.

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APPENDIX A: ANALYTICAL CODEBOOK FOR IM RESOURCE ASSESSMENT

Table A1: IM resources analysed at the LAP appointment level under BS EN ISO 19650-2.

IM resource	Clause	Created by	Level / Status
Information governance			
Information standard	5.1.4	Appointing party	Project / agreed at appointment
Information production methods and procedures	5.1.5	Appointing party	Project / agreed at appointment
Project information protocol	5.1.8	Appointing party	Project / appointment
Exchange information requirements			
Exchange information requirements	5.2.1	Appointing party	Appointment / appointment
LAP exchange information requirements	5.4.3	LAP	Appointment / appointment
Execution and delivery planning			
High-level responsibility matrix	5.3.2	LAP	Appointment / for information
Delivery team's BIM execution plan	5.4.1	LAP	Appointment / appointment
Detailed responsibility matrix	5.4.2	LAP	Appointment / for information
Master/Task information delivery plan	5.4.5 / 5.4.4	LAP / AP (task team)	Appointment / appointment

Table A2: Coding scheme for IM resource assessment.

Dimension	Definition	Coding Options	What It Assesses	Relevance rating	Comment
1. Existence	Determines whether the required IM resources are evidenced as present (explicit, embedded or inferred).	Yes / No / Embedded / Inferred	Evidenced presence of project-level and appointment-level IM resources, regardless of document format.	1–4	Evidence location(s) and form of presence (explicit, embedded or inferred).
2. Procedural positioning	Assesses whether the IM resource is developed by the correct responsible party, at the correct stage and fulfils the procedural role defined in the relevant clauses.	✓=aligned; ✗=misaligned	Alignment with requirements on authorship, timing and process role.	1–4	Justification of positioning decision and reference to supporting evidence (e.g. stage tables, matrices).
3. Clause compliance	Evaluates the extent to which the IM resource satisfies both the wording and organisational intent of each clause.	0–5 scale	Technical specificity, correctness, process clarity and organisational alignment with the standard.	1–4	Rationale for score, including strengths, omissions or contradictions.

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Table A3: Decision rules for application of the IM resource coding scheme.

Coding decision	Decision rule
Yes	The required IM resource is formally evidenced as a standalone resource at the assessed appointment stage.
No	The required IM resource is not evidenced as established at the assessed appointment stage.
Embedded	The required IM resource is incorporated within another formally established IM resource rather than established as a standalone resource.
Inferred	The resource is referenced or partially described within another IM document without formal establishment as a standalone resource.
Aligned	The resource is developed by the responsible party at the relevant stage and fulfils the procedural role defined by the applicable BS EN ISO 19650-2 requirement.
Misaligned	The resource is evidenced, but its authorship, timing and/or procedural role is not aligned with the applicable BS EN ISO 19650-2 requirement.
Clause compliance 0–5	Available evidence is assessed against the relevant clause using the scoring anchors in Table A4. Clause compliance is assessed separately from resource existence and procedural positioning.

Note: The three coding dimensions were assessed separately. Resource existence did not imply correct procedural positioning or a particular level of clause compliance. Where relevant clause requirements were evidenced within another resource or document, clause compliance could therefore be assessed independently of whether the prescribed resource existed as a standalone artefact.

Table A4: Clause compliance scoring scale for IM resource assessment.

Score	Description	Interpretation
Score 0 – Missing	Clause not addressed.	Non-compliance.
Score 1 – Incorrect / vague	Clause addressed incorrectly, ambiguously or in contradiction to the intent of the applicable BS EN ISO 19650-2 requirement.	Very low compliance.
Score 2 – Partial	Clause acknowledged but weakly specified; generic or not operationalisable.	Partial compliance.
Score 3 – Generic compliance	Clause addressed in a functionally compliant manner, but largely generic or template-based with limited project contextualisation.	Basic compliance.
Score 4 – Project-specific	Strong alignment with clause intent; requirements clearly contextualised to the project, with defined responsibilities and process logic.	Strong compliance.
Score 5 – Advanced maturity	Strongly aligned with clause wording and organisational intent; technically specific, role-sensitive and coherently embedded within BS EN ISO 19650-2 process logic.	High maturity.

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Table A5: Content Validity Index (CVI) results for the IM resource coding scheme.

Item	Number of experts rating 3 or 4	Total	I-CVI
Existence	7	7	1.00
Procedural positioning	6	7	0.86
Clause compliance	7	7	1.00
Scoring scale (0–5)	6	7	0.86
S-CVI/Ave	–	–	0.93

Note: Ratings were based on a four-point relevance scale (1 = not relevant; 2 = somewhat relevant; 3 = quite relevant; 4 = highly relevant). The item-level Content Validity Index (I-CVI) was calculated as the proportion of experts assigning a rating of 3 or 4 to each item. The scale-level Content Validity Index (S-CVI/Ave) was calculated as the average of the I-CVI values across all items. For a panel of seven experts, the minimum acceptable threshold for item-level validity is I-CVI = 0.78 (Lynn, 1986).

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APPENDIX B: ANALYTICAL FRAMEWORK FOR CDE ASSESSMENT

Table B1: Clause-to-category mapping of CDE analytical framework under BS EN ISO 19650-2.

No.	Clause	Party	Description	Analytical topic	Category
Assessment and need (cl. 5.1)					
1	5.1.1	Appointing party	Nominate individuals or a third party to undertake IM functions.	IM function	CDE governance and responsibility
2	5.1.7	Appointing party	Establish, implement, configure and support the project CDE or appoint a third party or appointed party.	CDE configuration	CDE governance and responsibility
3	5.1.7(a) – NA.2	Appointing party	Establish unique container ID using agreed fields and hyphen-minus delimiter.	Unique container ID	Information container structure
4	5.1.7(b) – NA.3	Appointing party	Establish codification rules for each ID field.	Codification standard	Information container structure
5	5.1.7(c) – NA.4	Appointing party	Information container metadata attributes (status, revision, classification) for state transitions	Metadata attributes	Information container structure
6	5.1.7(d)	Appointing party	The ability for information containers to transition between states.	Rules for information transition	Access control and permissions
7	5.1.7(e)	Appointing party	Transitions to record user identity and date.	Rules for audit trail	Access control and permissions
8	5.1.7(f)	Appointing party	Controlled access at information container level.	Controlled access	Access control and permissions
Invitation to tender (cl. 5.2)					
9	5.2.2	Appointing party	Make available reference information and shared resources.	Information sharing	Information container workflow
Mobilisation (cl. 5.5)					
10	5.5.2	LAP	Configure and test during mobilisation.	Test project CDE	Access control and permissions
11	5.5.2	LAP	Configure and test connection during mobilisation.	Test project-distributed CDE	Access control and permissions
Collaborative production of information (cl. 5.6)					
12	5.6.4 – NA.4.2	Task team	Transition to shared only after task-team review and suitability assignment.	Suitability review	Information container workflow
Information model delivery (cl. 5.7)					
13	5.7.1 – NA.5	Task team, LAP	Information submitted by task team to LAP via the CDE.	Information submission	Information container workflow

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14	5.7.2 – NA.5	LAP	Review and authorisation of information according to IPMP.	Review and authorisation	Information container workflow
15	5.7.3 – NA.5	Task team/ Appointing party	Submission of task team information for appointing party review.	Submission and review	Information container workflow
16	5.7.4 – NA.5	Appointing party	Record of acceptance or rejection according to IPMP.	Revision and acceptance	Information container workflow
Project close out (cl. 5.8)					
17	5.8.1	Appointing party	Archival of information containers.	Information archiving	Information container workflow

Table B2: Example of coding of CDE interview data.

Code	Data excerpt	Category
Client-led CDE hosting	"The client was responsible for the CDE setup… hosted by the client using Viewpoint." (ORA, CS_1)	CDE governance and responsibility
Delegated CDE hosting	"The client appointed a BIM consultant to manage the CDE." (ORB, CS_4); "The contractor managed the CDE and defined the protocol." (ORB, CS_3)	CDE governance and responsibility
Delegated naming responsibility	"Naming conventions… defined collaboratively… with consultant input." (ORB, CS_3)	Information container structure
Formalised naming conventions	"Naming conventions were… documented… within BIM Execution Plans." (ORA, CS_1–CS_2)	Information container structure
Standardised classification system	"Uniclass is used… aligned with the UK National Annex." (ORA, CS_1–CS_2)	Information container structure
Classification approach	"We use CI/SfB codes… easier for design teams to use." (ORB, CS_4)	Information container structure
Manual compliance checking	"Data is exported from the CDE into Excel… to check compliance." (ORA, CS_1–CS_2)	Information container workflow
Stage-based compliance verification	"Audits are carried out… at key information exchange points." (ORA, CS_1–CS_2)	Information container workflow
Folder-based workflow logic	"Transitions are often managed through folder structures such as Work in Progress, Shared and Published." (ORA)	Information container workflow
Metadata inconsistency in exchange	"Manual downloading and re-uploading… can lead to loss of metadata." (ORA, CS_1–CS_2)	Information container workflow
CDE audit trail and traceability	"The CDE records the user, date, revision… all revisions are archived for traceability." (ORA, CS_1–CS_2)	Access control and permissions

APPENDIX C: CASE STUDY VISUALISATIONS

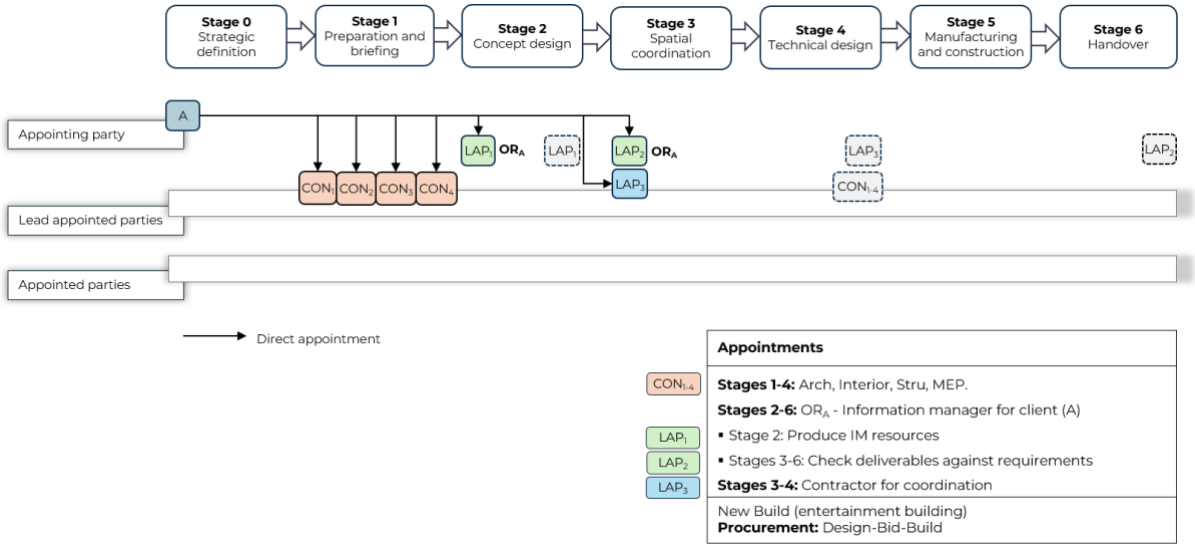


Figure C1: Appointment structure across RIBA Stages 0–6 for CS_1.

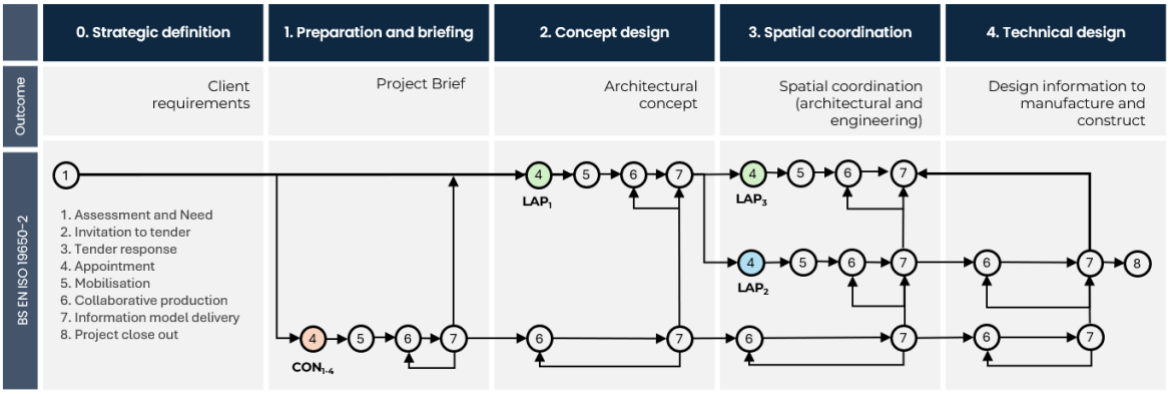


Figure C2: IM processes across RIBA stages 0-4 for CS_1.

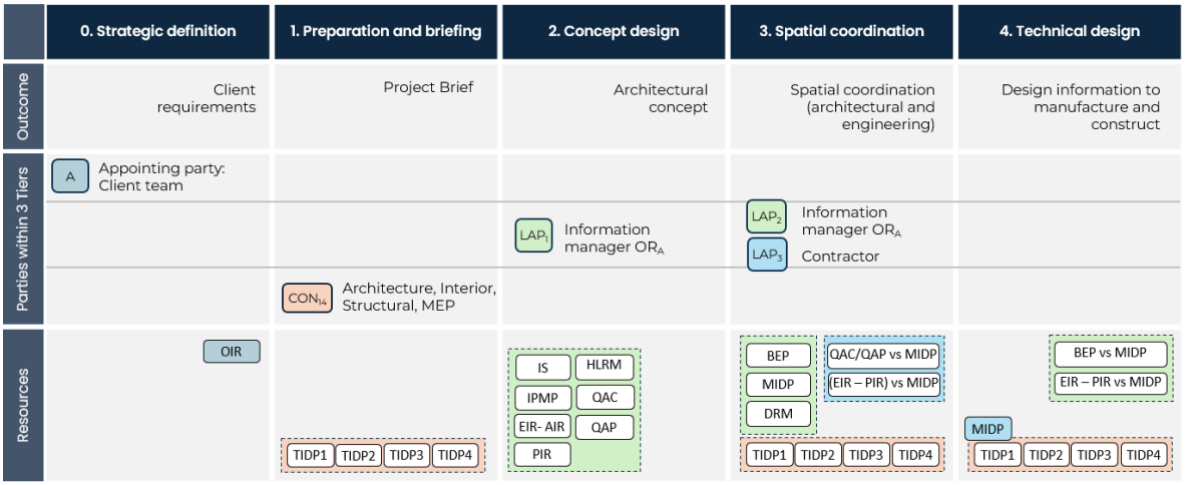


Figure C3: IM resources across RIBA stages 0-4 for CS_1.

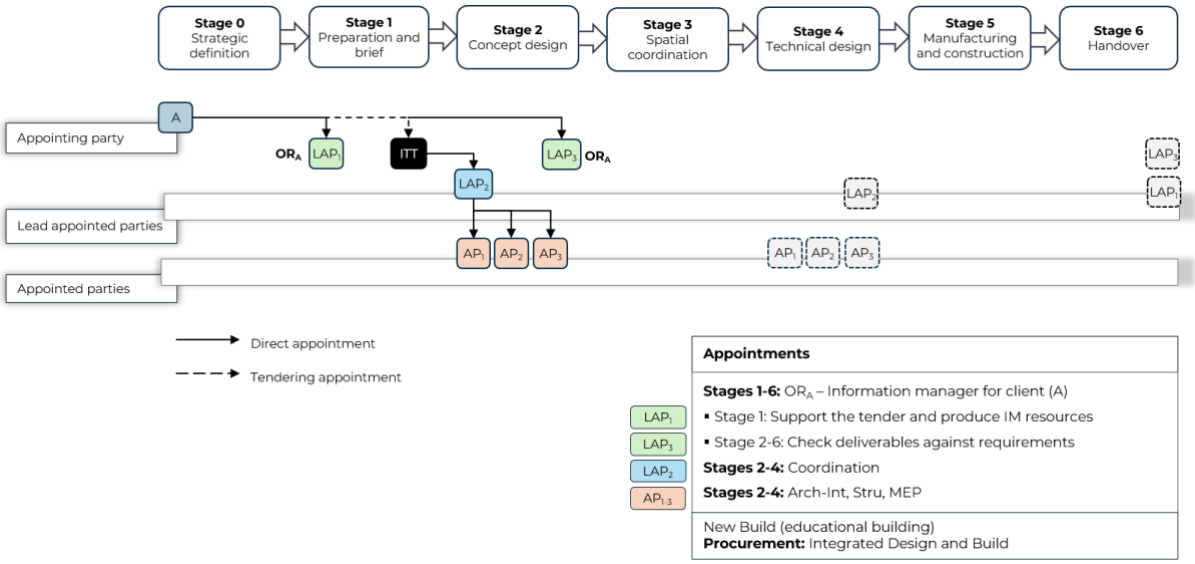


Figure C4: Appointment structure across RIBA Stages 0–6 for CS_2.

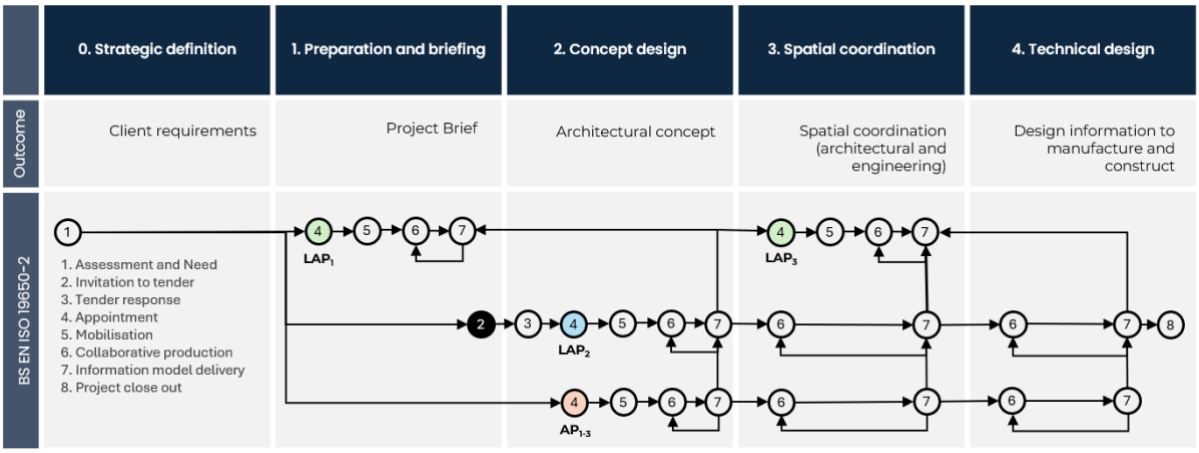


Figure C5: IM processes across RIBA stages 0-4 for CS_2.

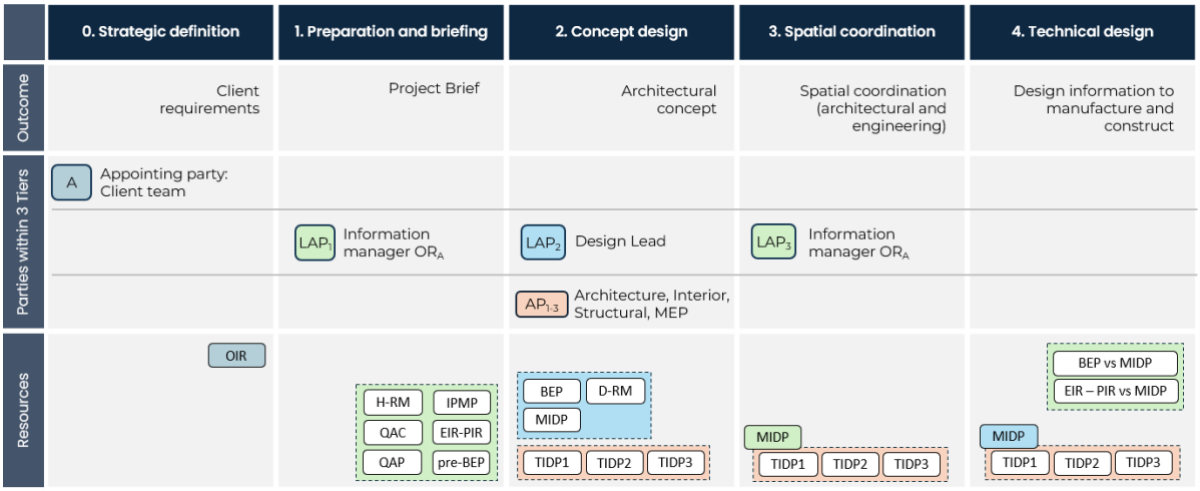


Figure C6: IM resources across RIBA stages 0-4 for CS_2.

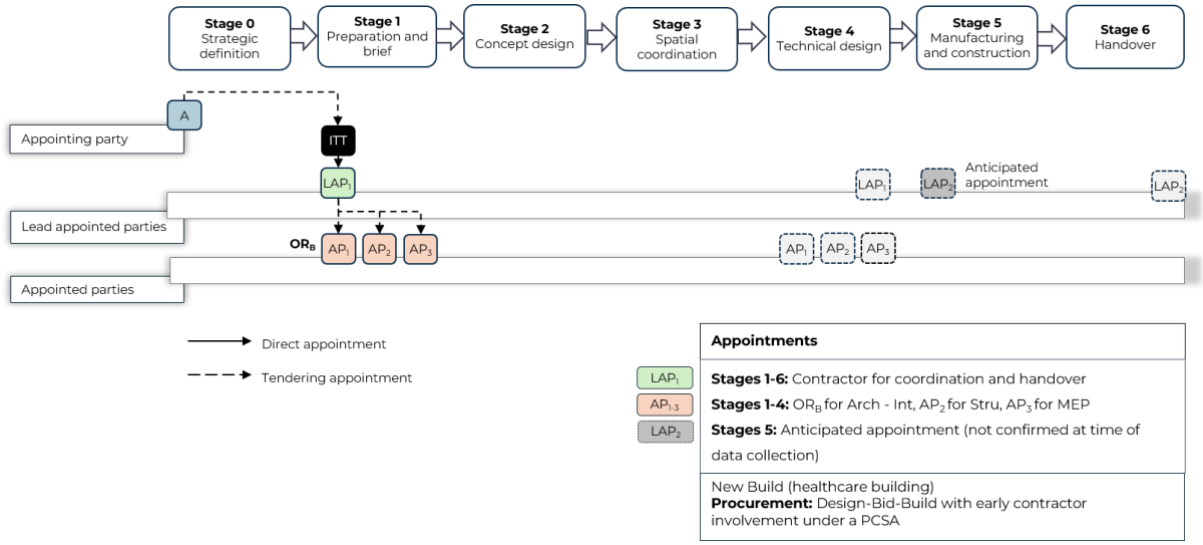


Figure C7: Appointment structure across RIBA Stages 0–6 for CS_3.

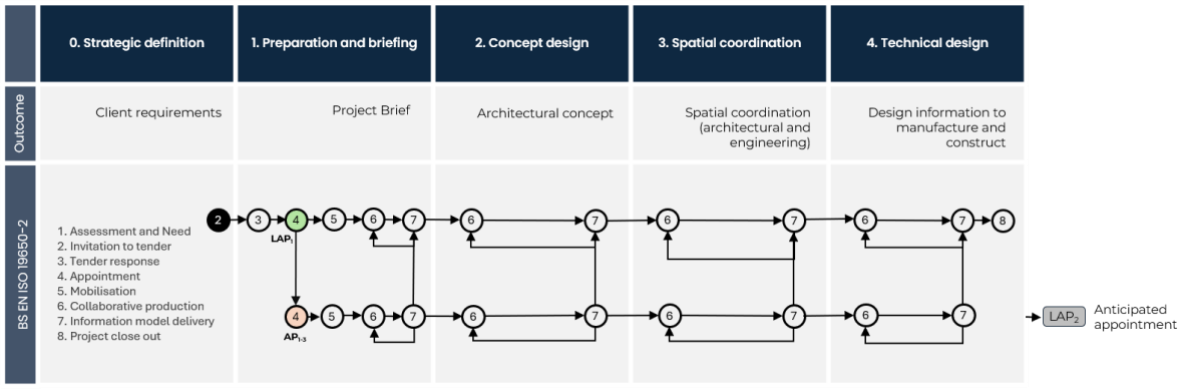


Figure C8: IM processes across RIBA stages 0-4 for CS_3.

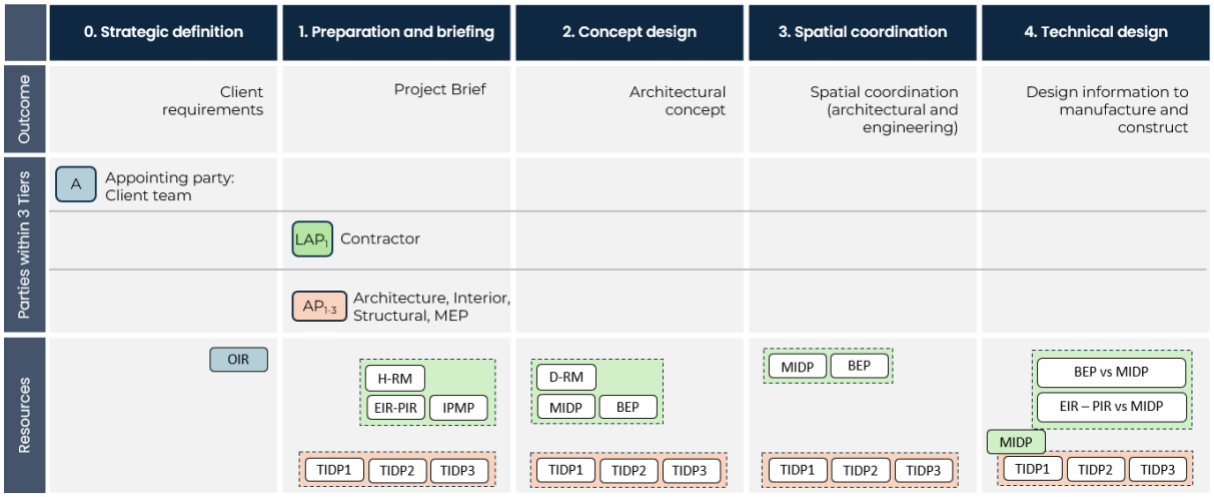


Figure C9: IM resources across RIBA stages 0-4 for CS3.

APPENDIX D: IM RESOURCE ASSESSMENT AND CLAUSE-LEVEL ALIGNMENT

Table D1: Project and appointment IM resources under BS EN ISO 19650-2 and IMI Framework.

No.	IM resource	Clause	Created by	Level / Status
Assessment and need				
1	IM assignment matrix	5.1.1	Appointing party	Project / for information
2	Project information requirements	5.1.2	Appointing party	Project / for information
3	Information standard	5.1.4	Appointing party	Project / agreed at appointment
4	Information production methods and procedures	5.1.5	Appointing party	Project / agreed at appointment
5	Project reference information and shared resources	5.1.6	Appointing party	Project / appointment
6	Project information protocol	5.1.8	Appointing party	Project / appointment
Invitation to tender				
7	Exchange information requirements	5.2.1	Appointing party	Appointment / appointment
8	Tender response requirements and evaluation criteria	5.2.3	Appointing party	Appointment / for information
Tender response				
9	Pre-appointment BEP	5.3.2	LAP	Appointment / for information
10	High-level responsibility matrix	5.3.2	LAP	Appointment / for information
11	Assessment of capability and capacity	5.3.3	AP (task team)	Task team / for information
Appointment				
12	Delivery team's BIM execution plan	5.4.1	LAP	Appointment / appointment
13	Detailed responsibility matrix	5.4.2	LAP	Appointment / for information
14	Master information delivery plan	5.4.5	LAP	Appointment / appointment
15	LAP Exchange information requirements	5.4.3	LAP	Appointment / appointment
16	Task information delivery plan	5.4.4	AP (task team)	Task team / appointment

Note: The IM resources, responsibilities, levels, statuses and corresponding BS EN ISO 19650-2 clause references were derived from the IMI Framework Guidance Part A resource table. The nine resources included in the case-study assessment are identified in Appendix A (Information Management Initiative, 2022).

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Table D2: Clause-level alignment of IM resources at LAP appointment across case studies.

Resource category	IM resource	Level/Status	Clause	CS_1	CS_2	CS_3	CS_4
Governance	Information standard	Project / agreed at appointment	5.1.4	3	2	2	4
	Information production methods and Procedures	Project / agreed at appointment	5.1.5	4	2	2	5
	Project information protocol	Project / appointment	5.1.8	0	0	0	0
Exchange requirements	Exchange information requirements	Appointment / appointment	5.2.1	3	4	4	0
	LAP Exchange information requirements	Appointment / appointment	5.4.3	0	0	0	0
Delivery planning resources	Delivery team BEP	Appointment / appointment	5.4.1	3	4	2	3
	High-level responsibility matrix	Appointment / for information	5.3.2(d)	4	3	3	2
	Detailed responsibility matrix	Appointment / for information	5.4.2	0	0	2	0
	Master/Task information delivery plan	Appointment / appointment	5.4.4 - 5.4.5 (content)	0	1	5	1

Note: Where a clause comprises multiple subclauses (e.g. a–e), the reported score represents the unweighted mean of the subclause scores, rounded to the nearest whole number for comparative purposes. Scores range from 0 to 5, as defined in Appendix A, Table A4.

Table D3: Examples of clause compliance scoring for BS EN ISO 19650-2 and UK National Annex requirements.

Clause	Score	Meaning	Example
5.2.1 (EIR)	0 - Missing	Clause not addressed	No Exchange information requirements issued; no definition of exchange requirements at the assessed appointment stage.
	1 - Incorrect / vague / misinterpreted	Clause addressed incorrectly	Requirement present at the assessed appointment stage but incorrectly defined or assigned
	2 - Partial	Limited / incomplete	Defines modelling scope and responsibilities but not linked to decision points or milestones
	3 - Generic compliance	Correct but template-level	Lists information requirements and Level of Information Need in generic terms without project-specific exchange logic
	4 - Project-specific	Clear and tailored	Defines exchange milestones, Level of Information Need processes and responsibilities aligned with project stages
	5 - Advanced maturity	Enhanced IM capability	Includes decision-point logic, acceptance criteria, traceability, and integration with delivery planning
NA.3. Metadata requirements	0 - Missing	No metadata requirements	No metadata fields defined; reliance only on file naming
	1 - Incorrect / vague / misinterpreted	Unclear or inconsistent	Metadata will be added where necessary, without defined fields or rules
	2 - Partial	Some fields missing	Limited metadata fields used (e.g. suitability, revision), with no full NA.3 alignment
	3 - Generic compliance	Procedural compliance	Required metadata fields defined but applied through manual verification
	4 - Project-specific	Structured implementation	Metadata and classification (e.g. UniClass) defined with project-specific rules
	5 - Advanced maturity	System-enforced and integrated	Metadata fields enforced at upload through CDE configuration with validation and workflow integration

Note: Examples illustrate the application of the clause compliance scoring scale defined in Appendix A, Table A4. They are provided to demonstrate the analytical scoring procedure and do not represent a formal conformity assessment against BS EN ISO 19650-2.

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APPENDIX E: INTERVIEW PROTOCOL AND CASE STUDY SCOPING QUESTIONS

Table E1: Interview questions for the four case studies.

No.	Question	Focus	Relevant clauses
Governance and responsibility			
1	Can you describe your role and activities in managing information within the CDE?	IM function	5.1.1
2	Who is responsible for setting up and managing the CDE?	CDE configuration, establishment, support	5.1.7
Information container structure			
3	What approach do you use to assign a unique ID and metadata to information containers in the CDE?	Unique container ID; metadata attributes	5.1.7(a) – NA.2; 5.1.7(c) – NA.4
4	How was the agreed and documented naming convention established and implemented?	Naming convention procedure	5.1.7(a) – NA.2
5	Which codification standards and classification systems do you use?	Codification standard; classification	5.1.7(b); NA.3
6	How are status codes, revisions and classification applied and managed in the CDE?	Metadata attributes (status, revision, classification)	5.1.7(c); NA.4
7	How do you ensure that all project participants apply these standards consistently?	Consistency of naming, metadata and coding	5.1.7(a–c); NA.2–4
8	What challenges have you encountered in maintaining consistency in these attributes?	Consistency challenges in metadata	5.1.7(c); NA.4
Information container workflow			
9	What processes does the CDE facilitate to manage transitions between information states?	State transitions; workflow behaviours	5.6; 5.7
10	Are there any challenges during sharing and exchanging information containers in the CDE?	Sharing and suitability processes	5.6.4; NA.4.2
11	How does the system record the username and date when an information container transitions between states?	Audit trail	5.1.7(e)
12	Can you describe how you track and audit these transitions against the defined information management requirements?	Audit trail; review	5.1.7(e); 5.7.1–5.7.4; 5.8.1
Access control and permissions			
13	What mechanisms provide controlled access at information container level?	Controlled access; access rights	5.1.7(f)
14	How do you ensure that access levels are clearly defined and consistently enforced?	Access permissions; enforcement	5.5.2; 5.1.7(f)
15	What significant challenges have you encountered in implementing or using the CDE solution across projects?	Platform usability; implementation issues	5.1.7; 5.6

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Table E2: Case study scoping discussion questions.

No.	Single-case study scoping questions	Focus
1	What was the procurement route and how were appointments distributed for this project?	Procurement route and appointments
2	Could you outline how BS EN ISO 19650-2 IM responsibilities are allocated within your organisation for this project?	Organisational structure and role allocation
3	Could you outline how BS EN ISO 19650-2 IM resources are developed for this project?	IM resource development

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APPENDIX F: ANALYTICAL AUDIT TRAIL

Table F1: Analytical audit trail.

Case study	IM resource	Relevant clause	Evidence / form and analytical rationale	Existence / procedural position	Clause score*
CS_1	Information Standard	5.1.4	Standalone governance resource, but focused on technical production control rather than broader lifecycle information governance.	Yes / ✗	3
CS_2	Information Standard	5.1.4	Governance provisions incorporated within the BEP rather than established as a standalone appointing-party governance instrument.	Embedded (BEP) / ✗	2
CS_3	Information Standard	5.1.4	Governance provisions incorporated within the BEP rather than established as a standalone appointing-party governance instrument.	Embedded (BEP) / ✗	2
CS_4	Information Standard	5.1.4	Standalone appointing-party governance resource established within the information requirements framework.	Yes / ✓	4
CS_1	Information Production Methods and Procedures	5.1.5	Standalone resource; governance remained primarily production-oriented.	Yes / ✓	4
CS_2	Information Production Methods and Procedures	5.1.5	Provisions inferred from the BEP rather than formally established as a standalone appointing-party resource.	Inferred (BEP) / ✗	2
CS_3	Information Production Methods and Procedures	5.1.5	Provisions inferred from the BEP rather than formally established as a standalone appointing-party resource.	Inferred (BEP) / ✗	2
CS_4	Information Production Methods and Procedures	5.1.5	Standalone appointing-party governance resource established within the information requirements framework.	Yes / ✓	5
CS_1–CS_4	Information Protocol	5.1.8	No dedicated Information Protocol was incorporated into the project appointments.	No	0
CS_1	Exchange Information Requirements	5.2.1	Project-level EIR issued, but weakly linked to appointing-party decision points.	Yes / ✓	3
CS_2	Exchange Information Requirements	5.2.1	EIR formed part of a structured information-requirements framework with defined Level of Information Need processes and exchange milestones.	Yes / ✓	4

CS_3	Exchange Information Requirements	5.2.1	Project-level EIR issued, but weakly linked to appointing-party decision points.	Yes / ✓	4
CS_4	Exchange Information Requirements	5.2.1	No appointing-party EIR was issued; exchange requirements were defined post-appointment by the delivery team.	No	0
CS_1–CS_4	LAP Exchange Information Requirements	5.4.3	Appointment-specific exchange requirements were not issued by the LAP to appointed parties.	No	0
CS_1	BIM Execution Plan	5.4.1	BEP addressed procedural requirements but lacked an integrated delivery strategy and delivery-planning logic.	Yes / ✓	3
CS_2	BIM Execution Plan	5.4.1	BEP was linked to delivery planning and the coordination strategy within a broader IM framework.	Yes / ✓	4
CS_3	BIM Execution Plan	5.4.1	BEP addressed procedural requirements but lacked an integrated delivery strategy and delivery-planning logic.	Yes / ✓	2
CS_4	BIM Execution Plan	5.4.1	BEP was present, while wider delivery-planning arrangements showed limited operationalisation.	Yes / ✓	3
CS_1	High-level responsibility matrix	5.4.1	Responsibility definition was embedded within the BEP and remained high-level.	Embedded (BEP) / ✓	4
CS_2	High-level responsibility matrix	5.4.1	No standalone HLRM was identified; responsibility was defined at high level or narratively.	No	3
CS_3	High-level responsibility matrix	5.4.1	Standalone HLRM was present but was not procedurally positioned in accordance with the relevant requirement.	Yes / ✗	3
CS_4	High-level responsibility matrix	5.4.1	Responsibility definition was embedded within the AIR and was not procedurally positioned as the required appointment resource.	Embedded (AIR) / ✗	2
CS_1	Detailed responsibility matrix	5.4.2	No detailed responsibility matrix was identified.	No	0
CS_2	Detailed responsibility matrix	5.4.2	No detailed responsibility matrix was identified.	No	0
CS_3	Detailed responsibility matrix	5.4.2	A detailed responsibility matrix was present but not procedurally positioned in accordance with the relevant requirement.	Yes / ✗	2
CS_4	Detailed responsibility matrix	5.4.2	No detailed responsibility matrix was identified.	No	0

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CS_1	MIDP/TIDP	5.4.4–5.4.5	MIDP/TIDP were not established; delivery planning relied on legacy MPDT practice.	No (MPDT)	0
CS_2	MIDP/TIDP	5.4.4–5.4.5	MIDP/TIDP were not established; delivery planning relied on legacy MPDT practice.	No (MPDT)	1
CS_3	MIDP/TIDP	5.4.4–5.4.5	Delivery planning was structured and populated, although procedural positioning was not fully aligned.	Yes / ✗	5
CS_4	MIDP/TIDP	5.4.4–5.4.5	Planning templates were present but were not operationalised in practice.	Yes / ✓	1

Note: * Clause scores reproduce the anonymised resource-level scores reported in Supplementary Appendix D (Table D2). Scores are unweighted means of the relevant clause sub-scores, rounded to the nearest whole number.