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A CONCEPTUAL HYBRID FRAMEWORK FOR CDE CONFIGURATION: BALANCING ISO 19650 RIGIDITY WITH AGILE FLEXIBILITY

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ABSTRACT

While Building Information Modelling (BIM) workflows rely heavily on the Common Data Environment (CDE) for centralized information management, integrating rigid governance standards into turbulent construction phases creates significant operational friction. Specifically, the ISO 19650 standard mandates a highly structured BIM Execution Plan (BEP) and predefined data protocols. However, empirical realities within the Architecture, Engineering, and Construction (AEC) sector frequently expose ad-hoc, unmanaged workarounds as practitioners attempt to bypass static systems to maintain workflow speed. To resolve this paradox, this study proposes a novel Conceptual Hybrid Framework that balances rigid compliance with operational flexibility. Prioritizing theoretical contribution, this paper introduces two primary mechanisms to eliminate system friction: a "Two-Tier BEP" structure and the elevation of the Information Manager to an "ISO 19650 Gatekeeper." The Two-Tier BEP divides CDE configuration into a static "Core BEP" (The Rigid Backbone) for legal immutability and an iterative "Dynamic Appendix" (The Flexible Muscle) managed via Agile Project Management (APM) sprints. Derived via deductive document analysis and reinforced by technical desktop verification, this dual-layered approach ensures agile adaptability without compromising federated model integrity. Ultimately, this framework offers a structured pathway to substitute unmanaged chaos with Managed Agility. Future empirical studies will evaluate the practical validity of this framework through industry expert interviews.

Keywords: *Agile Project Management, Building Information Modelling, Common Data Environment, Hybrid Framework.*

1. INTRODUCTION

Building Information Modelling (BIM) serves as a digital catalyst for optimizing collaboration and asset data integration within the Architecture, Engineering, and Construction (AEC) sector (Biswas, Sim and Lau, 2024). In contemporary project delivery, BIM has transitioned from an optional technical enhancement to an

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indispensable operational standard across construction workflows (Datta et al., 2023; Daoud et al., 2025). The realization of these sociotechnical benefits is highly contingent upon the deployment of a centralized Common Data Environment (CDE). As an integrated digital platform, the CDE dissolves traditional data silos by providing an immutable, synchronized node where multi-disciplinary project teams can access data concurrently, directly mitigating the fragmentation that historically penalizes industry productivity (Dolla, Venkatachalam and Kumar, 2024).

To institutionalize data governance and streamline BIM adoption across global supply chains, international regulatory frameworks have been established, most notably the ISO 19650 standard series (Gonzalez et al., 2024). The ISO 19650-1 and ISO 19650-2 guidelines advocate for a highly structured information management process, mandating that comprehensive information requirements, data protocols, and a definitive BIM Execution Plan (BEP) be front-loaded and frozen at the earliest stages of the project lifecycle.

However, empirical realities frequently diverge from these linear, perfectly fine-tuned expectations. The inherently turbulent, unpredictable nature of physical construction projects forces project participants to operate within highly fluid, localized information streams (Dolla et al., 2024). When confronted with the friction of rigid CDE access protocols, asymmetric team BIM maturities, and compressed design schedules, practitioners frequently bypass the authorized CDE to maintain operational speed, inadvertently creating unmanaged, ad-hoc information workarounds that dismantle the platform's status as the 'Single Source of Truth' (Malla et al., 2024; Radl and Kaiser, 2019).

While Agile Project Management (APM) principles have emerged as a viable alternative for navigating volatility through iterative adaptation, its direct application to CDE governance introduces a contractual paradox: unbridled flexibility threatens the legal accountability and standard compliance demanded by ISO 19650.

Current AEC literature extensively details the systemic friction of implementing ISO 19650 standards (Radl and Kaiser, 2019; Mesároš et al., 2022); however, a critical research gap remains: the lack of a concrete operational mechanism that balances contractual data rigidity with localized workflow agility. Existing frameworks treat the CDE as a monolithic repository with static architecture, failing to delineate which technical parameters must remain structurally immutable and which can be adapted dynamically without inducing system failure.

To address this gap, the primary aim of this study is to develop a conceptual Hybrid Framework for technical CDE configuration. This framework systematically splits platform variables into a fixed compliance layer governed by ISO 19650 guidelines and an iterative adaptive layer managed via Agile principles, thereby replacing unmanaged ad-hoc chaos with disciplined, managed flexibility.

2. LITERATURE REVIEW: INFORMATION MANAGEMENT FRICTION

This section presents the information friction in real-world practices when working in CDE. Thereby, it clearly demonstrates the triggering point where BIM team demands the most, as a result of construction workflow dynamics.

2.1 THE STATIC CDE ASSUMPTION

Much of the current literature and standard guidelines approach BIM implementation with the assumption of a smooth, linear transition of information. According to Jaskula et al. (2025) and Lestari, Purwanto and Saputra (2022) CDE is often treated as a static digital platform that is perfectly established and configured at the very beginning of the project. However, the fragile and turbulent project environment creates significant friction when applying these rigid, pre-defined workflows to real-world construction phases.

2.2 REAL-WORLD FRICTION POINTS

In practice, managing the CDE reveals an ad hoc nature that is highly controversial and contradicts the perfectly fine-tuned scenarios suggested by linear frameworks (Kaya and Özener, 2025). Several key friction points drive this chaos. First, construction schedules rarely follow perfect sequences, causing parallel executions where the CDE must manage multiple simultaneous workflow "mini-lifecycles." Second, standard workflows assume a smooth, one-way transition, yet real-world clash detections create rapid feedback and rejection loops; without system flexibility, practitioners bypass the CDE entirely (e.g., sending files via email), destroying the "Single Source of Truth" (Radl and Kaiser, 2019). Furthermore, real projects rely on progressive assurance rather than massive handovers, requiring continuous reconfiguration of suitability codes to indicate partial data maturity. Finally, projects frequently suffer a maturity reality gap, where rigid protocols break down across mixed-maturity teams, forcing manual interventions to uplift non-compliant data (Mesároš et al., 2022). These friction points highlight the necessity for adaptive gateways to execute workflows, rather than rigidly adhering to an initial plan.

2.3 THE AGILE ALTERNATIVE

Because of the above-mentioned friction points, there is a growing interest in the applicability of a flexible project management approach. APM represents a pragmatic shift from the traditional Waterfall approach. Originally introduced by the software industry due to its drawbacks in reacting to rapid technological evolutions, APM utilises structured agility and iterative development.

Instead of treating these practical friction points and iterative loops as project failures, APM recognises them as normal, expected changing requirements (Hohl et al., 2018; Owen and Koskela, 2006). Therefore, this paper will borrow APM principles to systematically manage the CDE, transforming chaotic ad-hoc practices into a structured, flexible workflow.

2.4 HYBRID PROJECT MANAGEMENT APPROACHES

To overcome the rigidity of traditional architectures while preventing the chaotic drift of unmanaged flexibility, modern organizational theory has shifted toward Hybrid Project Management (HPM) as a deliberate middle path (Reiff & Schlegel, 2022; Adaba, 2026; Krupa & Hájek, 2024). HPM represents a spectrum of design choices that systematically integrate plan-driven governance with adaptive execution mechanics (Silvius-Zuchi & Silvius, 2026).

2.4.1 Structural Archetypes and Customization Logic

While the project management literature identifies several distinct archetypal hybrid configurations such as Water-Scrum-Fall or the Hybrid V-Model (Reiff & Schlegel, 2022) this study aligns structurally with the Agile-Stage-Gate archetype. This model embeds short, time-boxed agile sprints inside structural stage-gate review milestones to achieve speed and tactical adaptivity within fixed administrative loops (Cooper & Sommer, 2018; Reiff & Schlegel, 2022). Operationally, applying this to a CDE requires a deliberate customization logic. Rather than segregating different methodologies into distinct, linear lifecycle stages (“Hybrid-by-Phases”), this framework necessitates a “Hybrid-by-Methods” approach (Mirzaei et al., 2025). This involves simultaneously blending contrasting agile and plan-driven practices within the exact same lifecycle phase to achieve continuous value optimization across complex socio-technical boundaries (Mirzaei et al., 2025).

2.4.2 Socio-Technical Hybridization Mechanisms

At the micro-operational layer, hybridization is an active process of socio-technical negotiation rather than a static design choice (Adaba, 2026). Grounded theory conceptualizations by Adaba (2026) establish that HPM stability is sustained through specific operational mechanisms including:

- Structural Anchoring: Utilizing formal governance frameworks to provide stability, auditability, and legal legitimacy inside compliance-heavy enterprise environments.
- Boundary Work and Role Hybridization: Deploying dedicated cross-functional translator roles who internalize dual accountability, seamlessly bridging the divide between control-oriented governance mandates and delivery-focused adaptive loops.

2.4.3 Enterprise Scaling vs. Project-Level Hybridity

While the broader software engineering discipline relies on comprehensive models like the Scaled Agile Framework (SAFe) for enterprise-level scaling and portfolio governance (Krupa & Hájek, 2024), direct application to CDE technical configuration presents a scope misalignment. The friction experienced in BIM implementation under ISO 19650 is rarely a failure of enterprise portfolio alignment; rather, it is a project-level, micro-operational conflict between static compliance gateways and dynamic task execution (Adaba, 2026). Therefore, the framework proposed in this study deliberately deviates from enterprise-scaled models, focusing instead on project-level socio-technical hybridity that governs the immediate interface between the Information Manager and the task teams.

3. METHODOLOGY

To systematically resolve the operational friction between standard compliance and site-level agility, this study adopts a qualitative deductive approach focused on conceptual theory-building, reinforced by an initial technical desktop verification. The research design is executed in three sequential stages: (1) exploratory identification of real-world CDE friction points via literature; (2) deductive document analysis of ISO 19650-1 and ISO 19650-2 to establish a Traceability Matrix; and (3) a desktop verification against active enterprise platforms to confirm baseline viability.

3.1 METHODOLOGICAL APPROACH: DEDUCTIVE DOCUMENT ANALYSIS

To address the chaos in developing CDEs and to conceptualise a flexible workflow, this study adopted a Deductive Document Analysis approach to derive the technical variables and construct the theoretical Hybrid Framework. This current paper focuses on establishing the necessary theoretical foundation for hybrid CDE configuration as a comprehensive, standalone conceptual theory-building study.

Initially, an exploratory literature search was conducted to identify and compile practical barriers and friction points that hinder the effective use of CDEs in real-world construction environments. The primary data source for this desk study was the ISO 19650 standard series (specifically Part 1 and Part 2), as it represents the globally recognised baseline for BIM implementation. Rather than arbitrarily selecting CDE features, the standard was analysed to extract mandatory information management mechanisms and cross-referenced with the friction points identified in the literature.

3.2 DERIVING THE VARIABLES (THE TRACEABILITY MATRIX)

To scientifically identify the functional requirements of the CDE product, a "Traceability Matrix" was developed. This matrix establishes a logical chain of evidence between a real-world project problem and the technical software setting required to manage it. The derivation process was executed through document-based manual coding, facilitated by Microsoft Word macros, to systematically map the identified friction points against specific normative clauses in ISO 19650. The derivation followed a three-step logic:

I. The Theoretical Need (The Problem): Identifying a functional information friction point from current AEC literature (e.g., teams using incorrect file versions).

II. The Operational Mechanism (The Standard): Identifying the specific clause or mechanism within ISO 19650 designed to govern that problem.

III. The Configuration Item (The Product Feature): Translating the ISO mechanism into a specific, configurable setting within the CDE platform (e.g., configuring automated status code validators).

By applying this traceability method, the study successfully translated broad BIM implementation challenges into a concrete "Provisional Product Backlog" of CDE settings. As illustrated in Table 1, this functional decomposition demonstrates how identified friction points were systematically mapped to ISO 19650 mechanisms and their corresponding CDE configuration items.

Ultimately, by extracting these concrete variables from the turbulent project environment, this derived list of configuration items serves as the essential foundation for categorising the CDE features into the proposed Hybrid Framework.

3.3 DEDUCTIVE CATEGORISATION (DEFINING THE HYBRID BOUNDARY)

Once the Provisional Product Backlog of CDE configuration items was derived, a deductive categorisation process was applied to allocate each item into the proposed Hybrid Framework layers. The boundary was defined by evaluating the "System Shock" risk of altering a variable mid-project. This deductive categorisation relied on the authors' expert judgement to evaluate the operational and contractual consequence of altering each variable.

Table 1: Example of the traceability matrix for CDE variables

1. Scientific Concept (Friction Point)	2. Operational Mechanism (ISO 19650)	3. Derived "Configuration Item" (CDE Feature)
Data Integrity and Trust: Continuous data updates create errors and force reliance on outdated models. (Radl and Kaiser, 2019)	Status Codes: Information containers must have a status code to indicate permitted use (ISO 19650-1).	Status Code Validation Rules: System settings that restrict file movement based on approved codes.
Interoperability: Fragmented disciplines struggle to align digital outputs. (Mesároš et al., 2022)	Unique Identification: Every container shall have a unique ID based on an agreed convention (ISO 19650-2).	Naming Convention Enforcers: Automated gateway rules that reject non-compliant file names.
Intellectual Property (IP): Firms are reluctant to share information due to liability risks. (Smith, 2014)	CDE States: Distinct separation between Work in Progress (WIP) and Shared states (ISO 19650-1).	Folder Permission Gates: Granular user access controls defining who can view or edit specific states.

Variables whose alteration would compromise the legal integrity, federated model links, or ISO 19650-2 compliance were classified as the Rigid Backbone (Bucket A). Conversely, variables related to user experience (UX), workflow speed, and task-level access, which require adaptation to the turbulent project environment, were classified as the Flexible Muscle (Bucket B).

3.4 Scope and Intentional Boundaries of Technical Verification

Conceding that the proposed framework is conceptual, a targeted technical desktop verification was conducted within this study to evaluate real-world alignment. This verification is explicitly non-comprehensive; it does not aim to verify all different software configurations or map every edge-case possibility across commercial platform APIs. Instead, its discrete objective is to perform a baseline reality check: observing whether the database-level limitations, schema mutations, and workflow controls of dominant commercial CDE architectures naturally segregate along the framework's hypothesized "Rigid Backbone" (Bucket A) and "Flexible Muscle" (Bucket B) boundaries.

The primary data source for the structural baseline was the ISO 19650 series. To cross-examine these findings against commercial realities, developer documentation, system incident logs, and technical user environments from five leading international CDE ecosystems were synthesized. To maintain source traceability, these documentation nodes are indexed within a compact URL Reference Matrix (Table 2).

4. PROPOSED CONCEPTUAL FRAMEWORK: THE HYBRID MODEL

Based on the literature survey to scrutinise the CDE configuration items and derive viable flexibility for each item, the following hybrid framework is explored.

4.1 OVERVIEW OF THE HYBRID FRAMEWORK AND AGILE PARADIGM SHIFT

To successfully apply APM to BIM implementation, a fundamental paradigm shift is required. This framework redefines the "Project" strictly as the technical configuration, development, and ongoing management of the CDE platform, treating it as an evolving digital service rather than a static repository established at project inception. Managing the CDE as an Agile product allows shifting requirements to be captured as new items in a "Product Backlog" for iterative refinement, rather than triggering system shocks under a rigid Waterfall approach.

Table 2: Technical CDE verification URL reference matrix

Reference Tag	Source Platform / Ecosystem	Documented Technical Attribute / URL Link
URL1	Autodesk Forums	ACC ISO 19650 Naming Standard Schema Migration
URL2	IMAGINiT Technical Logs	ACC Naming Standards Field Enforcement Limits
URL3	Bentley Communities	ProjectWise Database SQL Document Code Constraints
URL4	Bentley Learn Server	ProjectWise Document Code Definition Wizard Workflows
URL5	Procore Support Central	Editing Active In-Flight Workflow Templates
URL6	Autodesk Technical Support	ACC Dynamic Candidate Modifications Mid-Review Engine
URL7	ABC Training Documentation	Autodesk Docs Advanced Custom Attribute Management
URL8	Autodesk University Systems	ACC API Metadata Extensions & Model Properties Indexing

Consequently, standard Agile roles map directly to the ISO 19650-2 capability matrix (Hohl et al., 2018). The Appointing Party acts as the Product Owner, dictating workflow requirements based on the construction schedule. The Task Teams act as the Users, whose feedback drives iterative updates. Crucially, the Information Manager acts as the Developer and "ISO 19650 Gatekeeper." They filter all workflow requirements through a strict compliance check, rejecting operational updates that threaten the system's legal integrity to protect against ad-hoc chaos.

The findings from the functional decomposition suggest that the CDE cannot be treated as a single, homogenous entity. Instead, this Conceptual Hybrid Framework dictates that technical CDE configuration must be divided into two distinct management layers: a "Rigid Backbone" governed by strict Waterfall compliance (ISO 19650), and a "Flexible Muscle" managed via Agile iterations (Sprints).

To operationalise this visual model, the technical variables previously derived from the Traceability Matrix (Table 1) must be formally categorised. Table 3 presents the Hybrid CDE Configuration Matrix. This matrix serves as the functional blueprint for the Information Manager, explicitly delineating which CDE settings are locked within the legal contract (Bucket A) and which are managed iteratively as an evolving product (Bucket B) to prevent workflow friction.

To conceptualise the proposed solution, Figure 1 illustrates the Conceptual Hybrid Framework for CDE Development. This model visually articulates the paradigm shift from a monolithic, static CDE to a dynamic, dual-layered system. The framework begins by acknowledging the "Real-World Friction" generated within a turbulent project environment. Rather than allowing these friction points to trigger unrecorded workarounds, they are systematically captured as actionable requests within a "Product Backlog."

Table 3: The hybrid CDE configuration matrix

Category	Configuration Item	Framework Allocation	Justification / Agile Function
Identity	Naming Convention (ISO 19650-2)	Bucket A (Rigid Backbone)	Changing field lengths or codes mid-project invalidates existing federated links. Causes severe "System Shock."
Governance and Security	State Gateways (WIP > Shared > Published)	Bucket A (Rigid Backbone)	These transitions define the fundamental rules for legal liability and contractual handovers. Cannot be bypassed.
Compliance	Immutable Audit Trail & Retention	Bucket A (Rigid Backbone)	System-level logs must be locked to ensure a permanent, legally binding "Single Source of Truth."
Workflow	Approval Routing & Timings	Bucket B (Flexible Muscle)	Automated review cycles (e.g., cutting a 14-day review to 3 days) must adapt iteratively to fast-tracked schedules.
Access	Granular Folder/File Permissions	Bucket B (Flexible Muscle)	Requires Agile sprints to rapidly grant access to newly onboarded specialist sub-consultants without core disruption.
User Experience (UX)	Container-Level Metadata & Tags	Bucket B (Flexible Muscle)	Iteratively adding project-specific attributes (e.g., "Fire Safety" tags) prevents user fatigue and improves searchability.

Importantly, the model introduces a structural "Gatekeeper" mechanism. Before any CDE configuration is altered, the Information Manager subjects each backlog item to a rigorous "Bucket A Compliance Check." This decision node determines the trajectory of the requested change:

- Strategic Changes (High Risk): If a requirement threatens the legal integrity of the system (e.g., altering ISO 19650 naming conventions), it is routed to the central core, Bucket A: The Rigid Backbone. Here, changes are strictly governed by the Core BEP and require formal, Waterfall-style contract variations.
- Operational Updates (Safe): If the change is deemed legally safe (e.g., adjusting granular permissions or approval workflow timings), it is routed to the outer ring, Bucket B: The Flexible Muscle. Within this layer, the CDE is continuously refined through Agile Sprint Cycles, updating the Dynamic Appendix without disrupting the fixed core.

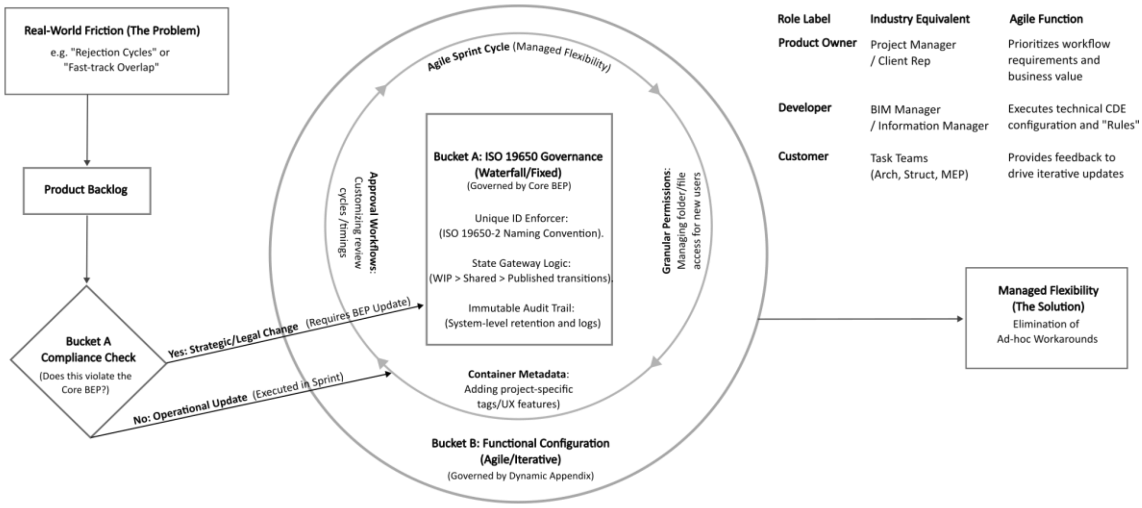

Figure 1: The hybrid CDE framework showing the rigid backbone and agile muscle layers

Ultimately, this structured workflow acts as a theoretical engine that processes chaotic project friction and outputs "Managed Flexibility. When mapped against established structural archetypes (Reiff and Schlegel, 2022), this framework functions as a direct project-level operationalization of the Agile-Stage-Gate model (Cooper & Sommer, 2018). It establishes an immutable macro-governance perimeter (Bucket A) to protect data integrity, while embedding short, time-boxed adaptive execution mechanics (Bucket B) to navigate localized workspace friction points. At the micro-operational layer, this dual-allocation represents a structural enactment of Mirzaei et al.'s (2025) "Hybrid-by-Methods" customization logic, simultaneously blending plan-driven standardization and sprint-driven flexibility within the exact same information management phase.

4.2 BUCKET A: THE RIGID BACKBONE (ISO 19650 COMPLIANCE)

Bucket A contains the configuration items that establish the project's legal and structural foundation. These are the settings that must be defined at the project's commencement. Altering these parameters mid-project causes a "System Shock" and introduces high risk to data integrity.

- Identity and Naming Conventions: ISO 19650-2 mandates a unique identifier for every information container. The CDE must be configured with file naming rules and mechanisms to rigorously enforce unique file naming. Changing these field lengths or codes mid-project invalidates existing links and federated files, making this a strictly rigid configuration.
- Security, Governance, and State Gateways: The transition of information across CDE states (Work in Progress > Shared > Published) acts as the fundamental rule for legal liability. Consequently, the system must rigidly track meta-data for the CDE state at the information level and utilise a strict version control system. These compliance metadata fields (e.g., S0, S1-S4) cannot be altered on a whim.
- Audit and Retention: To ensure a reliable and legally binding history of the project, system-level configurations for information archival and audit trail capture (recording both state transitions and WIP versions) must be locked. Preventing user modification of these logs ensures a permanent single source of truth.

4.3 BUCKET B: THE FLEXIBLE MUSCLE (AGILE / THE "PRODUCT")

Bucket B represents the adaptable components of the CDE product. These are the items that frequently drift into "ad-hoc" territory under traditional frameworks yet should be formally managed and updated via Agile Sprints to serve the evolving needs of the project team.

- Approval Workflows and Automation: While the ultimate legal states are rigid, the journey to get there is dynamic. The CDE's workflow engine, which handles the automation of repetitive workflows, as well as the specific approval and verification routing, must be iteratively adjusted. For instance, an initially configured "14-day review" window might prove too slow for a fast-tracked design phase and requires Agile adjustment.
- Granular Permissions and Access: High-level legal roles are fixed, yet customisable permission controls restricting read and write access at the job, folder, and file level require continuous Agile adaptation. This allows the BIM Manager to quickly grant remote accessibility or external access to a newly onboarded specialist sub-consultant without disrupting the broader system.
- Container-Level Meta-data and UX: As project priorities shift, the project team may request the addition of new meta-data at the information container level (e.g., adding a new "Fire Safety" attribute mid-project). Furthermore, user experience (UX) features such as notifications and alerts, advanced search functionality, and advanced reporting and analytics must be tweaked iteratively in Sprints to prevent user fatigue and improve workflow efficiency.

4.4 THE TWO-TIER BEP: RECONCILING AGILE WITH CONTRACTS

A common criticism when applying Agile approaches to BIM implementation is the assumption that continuous iterative changes violate the approved BEP. As discussed earlier, standard guidelines suggest a rigid BEP must be defined at the early stage of the project. However, because updating a formal BEP mid-project requires Appointing Party sign-offs and legal reviews, BIM team members often avoid formal updates. This reluctance forces the team to bypass the system, directly leading to the controversial ad-hoc nature of CDE management.

Hence, to successfully implement the Hybrid Framework without breaching legal boundaries, this study proposes a "Two-Tier BEP" structure. This paradigm shift divides the traditional monolithic document into two distinct components: the Core BEP and the Dynamic Appendix.

4.4.1 The Core BEP (The Legal Contract)

The Core BEP acts as the primary legal agreement established at project inception. This tier exclusively governs the "Rigid Backbone" (Bucket A) configurations. It defines the strict ISO 19650-2 naming conventions, high-level security protocols, and the legal parameters of the "Published" state. Altering these parameters causes system shocks to the federated models. Thus, the Core BEP remains strictly under a Waterfall approach and requires a formal contract variation to change.

4.4.2 The Dynamic Appendix (The Agile Playbook)

Conversely, the Dynamic Appendix functions as an evolving technical playbook. This tier manages the "Flexible Muscle" (Bucket B) configurations, including iterative folder structures, granular permission matrices, and specific approval workflow timings. Rather than treating this as a static document, it is explicitly defined as a living appendix. Accordingly, the Information Manager (acting as the Developer) can systematically update the Dynamic Appendix at the end of every Agile Sprint to reflect the newly configured CDE settings. Thus, by categorising the BEP in this manner, the project team can substitute ad-hoc chaos with managed flexibility. Operational updates are executed rapidly within the Agile Sprint Cycle, ensuring the CDE adapts to the fragile and turbulent project environment while protecting the ISO 19650 legal baseline of the Core BEP.

4.5 TECHNICAL DESKTOP VERIFICATION: EMPIRICAL PLATFORM ALIGNMENT

To demonstrate the real-world operational validity of the proposed framework, its deductive boundaries were cross-examined against the documented technical architectures, database constraints, and runtime behaviours of market-leading Common Data Environments (CDEs). While commercial CDE platforms are built on traditional standard protocols, their administrative environments have evolved to satisfy site-level user demands, effectively institutionalizing a practical division between rigid data integrity and adaptive workspace flexibility. (Refer to Table 2 for URLs given below)

4.5.1 Bucket A (Rigid Backbone) Software Validation

Desktop evaluation confirms that modifications to core information schemas mid-project induce severe relational conflicts, schema mutations, or catastrophic data loss across active file systems.

- Schema Mutation Constraints: In Autodesk Construction Cloud (ACC), the file naming standard operates as a binary, mandatory schema validator. Altering an active root naming standard mid-project is structurally blocked if directories contain documents. It necessitates a complex, manual workaround where all existing models must be completely moved to an external workspace, the standard modified, and files migrated back, disrupting desktop sync continuity and model links (URL1, URL2).
- Database Transaction Blockers: In Bentley ProjectWise, document codes are locked via explicit SQL server integrity rules. Altering structural fields mid-lifecycle causes the integration server to audit existing records. If legacy rows contain blank values for a newly mandatory code field, the database aborts the commit and rejects the change with the explicit hard error: “Failed to update document code structure. New code definitions cannot be saved because some required fields are empty” (URL3, URL4).
- In-Flight Process Freezes: Regarding workflow states, Procore protects legal audit trails via rigid process encapsulation. Master workflow template changes cannot propagate dynamically to documents currently in transit. Forcing an update requires a destructive workflow template restart, which immediately erases all submitted reviewer responses, clears active review queues, and resets progress back to inception (URL5).

4.5.2 Bucket B (Flexible Muscle) Software Validation

In contrast to immutable core schemas, software vendors explicitly design localized operational parameters to absorb live project sprint dynamics via dynamic runtime engines and background processes.

Dynamic Review Infrastructure: To prevent process stagnation during design phases, ACC utilizes a runtime compiler pattern for its approval engine. Unlike rigid workflow architectures, ACC's "Current step candidates" user interface allows authorized administrators to add, remove, or substitute active reviewers on the fly without breaking the workflow thread or erasing active progress, keeping the legal audit trail perfectly intact (URL6).

Asynchronous Metadata Extensions: Appending custom descriptive fields (e.g., discipline codes or asset tags) to adapt to changing information requirements is natively handled as a non-disruptive layer across ACC and Aconex. When a new custom attribute is injected mid-lifecycle, the CDE database triggers an asynchronous background indexing routine (URL7, URL8). This schema extension propagates across thousands of documents silently with zero platform downtime, ensuring continuous coordination and searchability without altering the core ISO 19650 baseline.

5. CONCLUSIONS, LIMITATIONS, AND FUTURE WORK

The development and management of Common Data Environment (CDE) pose a unique paradox in real-world practice. This research demonstrated the need and potential applicability of an iterative approach in using BIM projects rather than a rigid, waterfall-like approach in ISO 19650. Static and dictated by pre-planned project requirements creates system frictions, especially in project environments like in construction, which are characterised by many uncertainties. Owing to the inherited turbulent and dynamic nature, project team members are inevitably resorting to ad hoc workarounds.

To resolve this, this study utilised deductive document analysis and technical desktop verification to derive a Conceptual Hybrid Framework. The proposed conceptual hybrid model paves the way for a balance between a rigid backbone, namely the legal and structural foundation, and a flexible muscle that incorporates flexibility. Thereby, it addresses the system friction that exists in the standards.

The proposed hybrid model consists of both Bucket A-Rigid backbone and Bucket B-Flexible Muscle. By maintaining a Rigid Backbone for naming conventions, legal status codes, and security protocols (Bucket A) locked within a static "Core BEP," the project's contractual integrity remains intact. Simultaneously, by applying Agility to user-facing configurations such as folder structures, metadata tagging, and review workflows (Bucket B), the BIM Manager can act as a "Developer," responding to the "Product Owner's" shifting requirements to ensure a smooth workflow with minimal disruptions. This shift from "Unmanaged Flexibility" to "Managed Agility" ensures that the CDE remains a high-performance tool rather than a bureaucratic hurdle.

5.1 LIMITATIONS

While the proposed Conceptual Hybrid Framework provides a structured approach to CDE configuration, this study acknowledges explicit limitations. Primarily, the framework relies on a technical desktop verification of system schemas and developer documentation rather than primary empirical data gathered from human subjects. Furthermore, the technical desktop verification, while confirming baseline structural viability across major platforms, is limited to the API behaviours and database-level rules of dominant international environments and does not account for the extensive platform variability present in the wider AEC software market. Finally, the framework has not yet been tested against project scale constraints; the operational friction and "System Shock" risks may vary significantly between small-scale localized builds and mega-infrastructure projects.

5.2 FUTURE WORK

To address these limitations, subsequent empirical research is recommended to test the practical utility of the framework via scenario-based semi-structured interviews with experts in the industry. While the current paper successfully validates the technical and structural feasibility of the dual-layered configuration through desktop simulation, future work will focus on evaluating human-centric factors, such as practitioner willingness to adopt the ISO 19650 Gatekeeper role and the contractual acceptability of the Two-Tier BEP across different procurement routes. This phase will be critical to evaluate platform-specific variabilities and scalability, validating the framework's practical efficacy in eliminating the "ad-hoc" drift in practice.

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