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A BIM–DIGITAL TWIN ARCHITECTURE FOR CONSTRUCTION AND INDUSTRIAL TRANSPORT LOGISTICS: TRANSFERABILITY FROM SPAIN TO KAZAKHSTAN

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Abstract. Construction and industrial transport logistics depend on information held in separate systems: models, schedules, transport management, supplier and sensor systems. The study aims to design an architecture linking these sources at model-element level, to test whether open models carry the information logistics needs, and to assess which elements of Spain's public BIM framework can transfer to Kazakhstan. A design science research methodology was followed. Requirements were derived from ISO 19650, ISO 16739-1:2024 (IFC 4.3), ISO 7817-1 and published studies of BIM-based logistics; the artefact is a reference architecture with a common data environment, an event-driven integration service and an enrichment service. The evaluation material comprised ten IFC 4.3 reference models published by buildingSMART International (348 physical elements), Spain's BIM Plan for public procurement (Orden PCM/818/2023) and Kazakhstan's Construction Code of 2026. Every element carried a persistent identifier and a spatial containment or aggregation relation, and 94 % had a material, but, pooled over all models, only 9 % had quantity sets and 16 % a classification reference; none had a weight or a link to a schedule task, and none of the materials carried a density. Volumes could be computed from geometry for all elements with a representation and matched stored values where present, so volume enrichment can be automated; weights need an external material catalogue. Neither regulatory framework addresses logistics data. In the author's assessment, Spain's explicit IFC requirement and its staging by contract value and date are the primary candidates for transfer, followed by the common data environment definition, maturity levels and model submission to geoinformation bases; Kazakhstan could introduce them through the normative documents to which its Construction Code delegates information requirements. The contribution is an architecture traced to explicit requirements and a measured gap between model content and logistics needs. Field validation remains to be done.

Keywords: building information modelling, digital twin, construction logistics, common data environment, IFC 4.3, design science, Kazakhstan

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ҚҰРЫЛЫС ЖӘНЕ ӨНЕРКӘСІПТІК КӨЛІК ЛОГИСТИКАСЫНА АРНАЛҒАН BIM МЕН ЦИФРЛЫҚ ЕГІЗ АРХИТЕКТУРАСЫ: ИСПАНИЯ ТӘЖІРИБЕСІН ҚАЗАҚСТАНҒА КӨШІРУ

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Аннотация. Құрылыс және өнеркәсіптік көлік логистикасы әртүрлі жүйелерде сақталған деректерге сүйенеді: ақпараттық модельдер, күнтізбелік кестелер, тасымалды басқару жүйелері, жеткізушілер жүйелері және құрылыс алаңындағы датчиктер. Зерттеудің мақсаты – осы көздерді модельдің жекелеген элементтері деңгейінде байланыстыратын ақпараттық архитектураны жобалау, ашық модельдерде логистикаға қажет деректердің бар-жоғын тексеру және Испанияның мемлекеттік сатып алудағы BIM жүйесінің қандай элементтерін Қазақстанға көшіруге болатынын бағалау. Жобалау ғылымы (design science research) әдіснамасы қолданылды. Талаптар ISO 19650, ISO 16739-1:2024 (IFC 4.3), ISO 7817-1 стандарттарынан және BIM-логистика бойынша жарияланған зерттеулерден алынды; артефакт – ортақ деректер ортасы, оқиғаларға негізделген интеграция қызметі және деректерді байыту қызметі бар эталондық архитектура. Бағалау материалы – buildingSMART International жариялаған IFC 4.3 он эталондық моделі (348 физикалық элемент), Испанияның мемлекеттік сатып алудағы BIM жоспары (Orden PCM/818/2023) және Қазақстан Республикасының 2026 жылғы Құрылыс кодексі. Барлық элементтің тұрақты идентификаторы мен кеңістіктік байланысы болды, 94 % элементте материал көрсетілген, бірақ барлық модель бойынша жиынтығында тек 9 % элементте сандық көрсеткіштер жиыны (Quantity Sets), 16 % элементте жіктеуішке сілтеме болды; массасы немесе күнтізбелік кесте тапсырмасымен байланысы бар элемент, тығыздығы көрсетілген материал болмады. Геометриялық көрінісі бар барлық элементтің көлемін геометрия бойынша есептеуге болды және ол модельде сақталған көлеммен (бар жерінде) сәйкес келді; бұл көлемді автоматты түрде толықтыруға болатынын көрсетеді, ал массаны сыртқы материалдар каталогынсыз анықтау мүмкін емес. Екі нормативтік жүйенің ешқайсысы логистикалық деректерді реттемейді. Автордың бағалауы бойынша көшірудің негізгі үміткерлері – IFC-ке қойылатын нақты талап пен BIM-ді келісімшарт құны мен мерзімдер бойынша кезең-кезеңімен енгізу, одан кейін – ортақ деректер ортасының анықтамасы, жетілу деңгейлері және модельдерді геоақпараттық базаларға беру; Қазақстанда оларды Құрылыс кодексі ақпаратқа қойылатын талаптарды жүктейтін мемлекеттік нормативтік құжаттар арқылы енгізуге болады. Жұмыстың үлесі – нақты талаптармен байланысы көрсетілген архитектура және модельдер мазмұны мен логистика қажеттілігі арасындағы өлшенген алшақтық. Зерттеу жобалық және құжаттық сипатта; нақты жобада сынақтан өткізілген жоқ.

Түйін сөздер: ақпараттық модельдеу, цифрлық егіз, құрылыс логистикасы, ортақ деректер ортасы, IFC 4.3, жобалау ғылымы, Қазақстан

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АРХИТЕКТУРА BIM И ЦИФРОВОГО ДВОЙНИКА ДЛЯ СТРОИТЕЛЬНОЙ И ПРОМЫШЛЕННО-ТРАНСПОРТНОЙ ЛОГИСТИКИ: ПЕРЕНОС ОПЫТА ИСПАНИИ В КАЗАХСТАН

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Аннотация. Строительная и промышленно-транспортная логистика опирается на данные из разных систем: информационных моделей, графиков, систем управления перевозками, систем поставщиков и датчиков на строительной площадке. Цель исследования – спроектировать информационную архитектуру, связывающую эти источники на уровне отдельных элементов модели, проверить, содержат ли открытые модели данные, нужные логистике, и оценить, какие элементы испанской системы BIM в госзакупках переносимы в Казахстан. Использована методология проектной науки (design science research). Требования выведены из ISO 19650, ISO 16739-1:2024 (IFC 4.3), ISO 7817-1 и опубликованных исследований BIM-логистики; артефакт – эталонная архитектура со средой общих данных, событийно-ориентированным сервисом интеграции и сервисом обогащения данных. Материалы для оценки – десять эталонных моделей IFC 4.3 buildingSMART International (348 физических элементов), испанский План BIM для госзакупок (Orden PCM/818/2023) и Строительный кодекс Республики Казахстан 2026 г. Все элементы имели постоянный идентификатор и пространственную привязку, 94% – материал, но в совокупности по всем моделям лишь 9 % – наборы количественных характеристик (Quantity Sets) и 16 % – ссылку на классификатор; ни один элемент не имел массы или связи с задачей графика, ни один материал – плотности. Объём удалось вычислить по геометрии для всех элементов с геометрическим представлением, и он совпал с хранимыми в моделях объёмами там, где они были, что указывает на возможность автоматического обогащения объёмами; массу без внешнего каталога материалов получить нельзя. Ни одна из нормативных систем не регулирует логистические данные. По оценке автора, основные кандидаты на перенос – явное требование IFC и поэтапное введение BIM по стоимости контракта и датам, далее – определение среды общих данных, уровни зрелости и передача моделей в базы геоинформации; в Казахстане их можно ввести через государственные нормативные документы, к которым Строительный кодекс отсылает требования к информации. Вклад работы – архитектура с прослеживаемостью к явно сформулированным требованиям и измеренный разрыв между содержанием моделей и потребностями логистики. Исследование носит проектный и документальный характер; апробация на реальном объекте не проводилась.

Ключевые слова: информационное моделирование, цифровой двойник, строительная логистика, среда общих данных, IFC 4.3, проектная наука, Казахстан

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Introduction.

Construction sites and the transport systems that serve them – industrial sidings, haul roads, loading fronts and the vehicles that use them – are coordinated through information. The building information model describes what is to be built, the schedule says when, transport and fleet systems say where vehicles and materials are, and site sensors record what has actually arrived. In practice these sources sit in separate systems owned by different parties, so a late delivery is often discovered on site and propagated to the schedule by telephone or spreadsheet.

Public clients are pushing building information modelling (BIM) into procurement. Spain has adopted a staged plan that makes BIM mandatory in central government contracts above set value thresholds from April 2024 (Orden PCM/818/2023, 2023), and Kazakhstan's Construction Code, in force from 1 July 2026 (art. 148), makes information modelling mandatory for the types of construction objects listed by the authorised body (art. 62) (Construction Code of the Republic of Kazakhstan, 2026). Both frameworks concern the information about the built asset. Whether that information can also serve logistics – the movement of materials and vehicles that the asset depends on – is a separate question.

Two developments make the question timely. First, the open exchange schema has been extended beyond buildings: IFC 4.3, published as ISO 16739-1:2024, adds entities for rail, road, ports and bridges (ISO 16739-1, 2024), so the infrastructure that industrial transport runs on can now be described in the same open format as the buildings it serves. Second, information management under ISO 19650 organises the exchange of this information between parties through a common data environment (ISO 19650-1, 2018; ISO 19650-2, 2018). Neither development is aimed at logistics, yet both determine what information a logistics system could obtain from the model and in what form. For industrial transport, where sidings, haul roads and loading fronts are themselves infrastructure assets, this means that the same model could in principle describe both the asset and the place where materials and vehicles move.

Studies of construction logistics show why this matters. 4D BIM can expose logistics conflicts, but its use is limited by the late involvement of trades and the continued reliance on two-dimensional plans (Whitlock et al., 2021: 325–348), and logistics digital twins that fuse the model with schedules and quantities still leave supplier and vehicle data for future work (Gehring, Rüppel, 2023). For an owner who introduces BIM through procurement rules, the practical question is therefore not whether a digital twin is possible, but which information has to be required in contracts so that the delivered models can serve logistics.

The object of this study is the information flow of construction and industrial transport logistics: models, schedules, transport, supply and sensor data. The subject is a reference architecture that integrates these flows and the conditions under which it could be adopted in Kazakhstan. The study has three aims: to derive explicit requirements and design an architecture that meets them; to test whether openly available reference models contain the information that logistics requires; and to compare the Spanish and Kazakh frameworks to identify transferable elements.

Three research questions follow from this framing and from the gaps identified in the literature review below: which requirements an integration architecture must meet to support

construction and industrial transport logistics, and how it can meet them (RQ1); to what extent openly available IFC 4.3 models satisfy the element-level information requirements of logistics (RQ2); and which elements of Spain's public BIM framework are transferable to Kazakhstan, and under what conditions (RQ3). The questions are answered with a design science approach, in which the proposed artefact is kept separate from the observed evidence – the content of public models and the text of the regulations – so that each claim can be traced to its source.

The study contributes a reference architecture traced to explicit requirements, a reproducible audit of what openly available IFC 4.3 models contain at element level, and a structured comparison of two public BIM frameworks with an assessment of what could be transferred. The remainder of the paper is organised as follows: the literature review identifies the gaps and states the research questions; the materials and methods section describes the design science process, the requirements, the model audit and the documentary comparison; the results section answers the research questions; the discussion and conclusion interpret the findings, state the limitations and outline further work.

Digital twin research in construction has moved from concept to taxonomy. Boje and colleagues argued that a construction digital twin requires semantic integration of BIM with sensor data and set directions for research (Boje et al., 2020). Sacks and colleagues framed construction with digital twin information systems as a closed control loop over planning and execution (Sacks et al., 2020). Reviews describe a progression of maturity in which most reported twins remain at early levels (Deng et al., 2021: 58–83) and map applications across the life cycle (Opoku et al., 2021).

Studies that address logistics directly link parts of the problem. Whitlock and colleagues showed that 4D BIM exposes logistics conflicts but is limited by late involvement of trades and continued reliance on two-dimensional plans (Whitlock et al., 2021: 325–348). Greif and colleagues examined digital twins for construction site logistics (Greif et al., 2020). Karmakar and colleagues automated route planning on site from BIM, explicitly limited to internal movements (Karmakar et al., 2022: 827–844). Gehring and Rüppel fused the model, the 4D schedule and bills of quantities into a logistics twin and left supplier and vehicle telemetry for future work (Gehring, Rüppel, 2023). Internet of things platforms linked to BIM track components and materials within single projects (Zhou et al., 2021; Yang et al., 2024), and a review of supply chain twins maps challenges to solutions largely borrowed from other industries (Bakhshi et al., 2024).

Research on the common data environment (CDE) treats it as an information management tool. Seyis and Özkan analysed the added value of CDEs for project performance (Seyis, Özkan, 2024: 247–263), and Jaskula and colleagues showed that running several CDEs at once undermines accountability and reliability of data (Jaskula et al., 2025: 1522–1541). Neither line of work connects the CDE to logistics data flows. Spanish published cases of BIM-based twins concern operation rather than logistics: a railway station on the Bilbao–Orduña line (Pavón et al., 2025: 747–762), port asset management (González-Cancelas et al., 2025) and BIM–GIS integration for an urban ring road (Cepa et al., 2024).

Three gaps follow from the reviewed literature. No study found links an ISO 19650 CDE, open IFC models, a transport management system and sensor data in one architecture evaluated against explicit requirements. No study measures whether the models that clients will receive contain the element-level information logistics needs. No study compares the Spanish and Kazakh BIM frameworks with a view to transfer. The research questions are therefore: RQ1 – which requirements must an integration architecture meet to support construction and industrial transport logistics, and how can it meet them? RQ2 – to what extent do openly available IFC 4.3 models satisfy the element-level information requirements of logistics? RQ3 – which elements of Spain's public BIM framework are transferable to Kazakhstan, and under what conditions?

Materials and Methods.

The study follows design science research, which builds and evaluates artefacts against stated problems (Hevner et al., 2004: 75–106), using the process of problem identification, objectives, design, demonstration, evaluation and communication (Peffer et al., 2007: 45–77). The observed evidence (model content, regulatory text) is kept separate from the proposed artefact throughout. The working hypothesis for RQ2 is that reference models satisfy identity and location requirements but not quantity, weight and schedule requirements; it is tested on public models rather than assumed. Each result is labelled by type: the model audit and the geometry test are computed from open data; the framework comparison is documentary; the architecture and the scenario walk-through are design artefacts. Results are reported in the order RQ2, RQ3, RQ1, because the assessment of requirement coverage (RQ1) draws on the audit and the comparison.

Requirements. Eight architecture requirements were derived (Table 1). Sources are the information management principles of ISO 19650-1 and -2 (ISO 19650-1, 2018; ISO 19650-2, 2018), the IFC data schema including the IFC 4.3 extensions for rail, road, ports and bridges (ISO 16739-1, 2024), the level of information need concept (ISO 7817-1, 2024) and the logistics gaps identified in the review. Each requirement is traced to architecture components and to the evaluation used.

Table 1 – Architecture requirements and their traceability

ID	Requirement	Source	Component	Evaluation
AR1	One governed source of asset information with status control	ISO 19650-1, -2	CDE	Analytical
AR2	Vendor-neutral exchange of models and issues	ISO 16739-1; Spanish Plan	CDE (IFC, BCF)	Documentary
AR3	Element-level link between logistics objects and model elements	Gehring, Rüppel, 2023	Integration service	IFC audit (L1, L7)
AR4	Event-driven propagation of transport and sensor events to schedule and model	Karmakar et al., 2022; Sacks et al., 2020	Integration service, adapters	Scenario walk-through
AR5	Supply of quantities and weights missing from models	ISO 7817-1	Enrichment service	IFC audit (L3–L5), geometry test
AR6	Georeferencing for GIS and route data	Spanish Plan, section 4.8	CDE, GIS adapter	IFC audit (project level)
AR7	Roles, access control and audit trail across parties	ISO 19650-1; Jaskula et al., 2025	Governance service	Analytical
AR8	Information delivered at the level needed by each logistics use	ISO 7817-1	Governance, enrichment	Analytical

Source: compiled by the author. CDE – common data environment; BCF – BIM Collaboration Format; L1–L10 – element-level information requirements (see Materials and methods and Table 2).

The architecture (Figure 1) has three layers. Existing systems remain the sources: authoring tools, the 4D schedule, the transport or fleet management system (TMS), sensors, supplier systems and geoinformation. The integration layer adds three components: a CDE following ISO 19650 with IFC 4.3 and BCF as exchange formats; an integration service with an event bus and adapters that maintains canonical logistics objects (delivery, trip, slot) linked to IFC GlobalIds and schedule tasks; and an enrichment service that derives missing quantities from geometry and weights from a material catalogue. Services on top provide a logistics twin view, decision support, governance and reporting to the client.

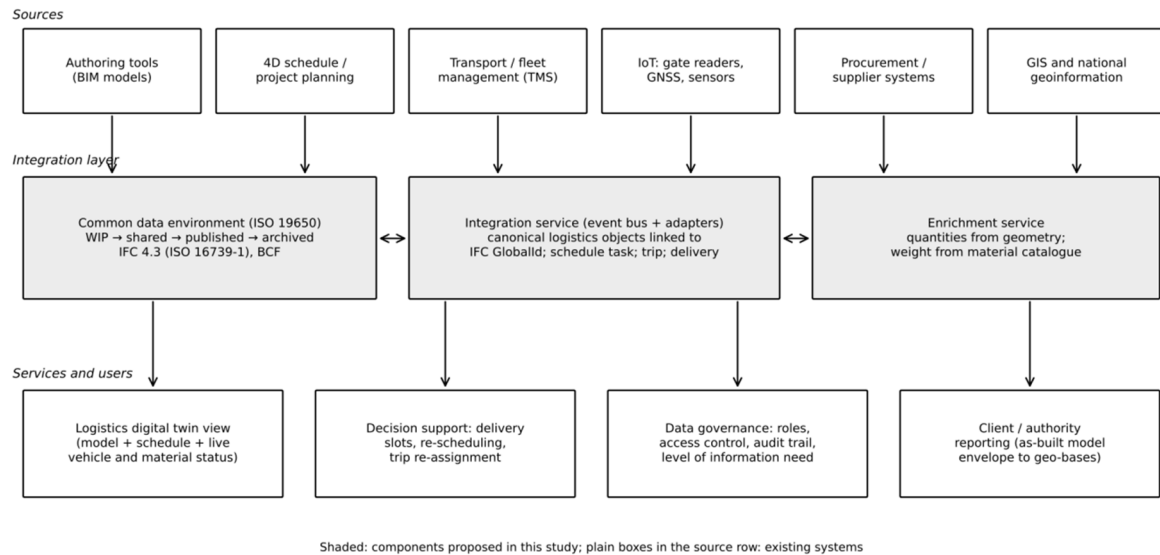


Fig. 1. Reference architecture for BIM-enabled logistics integration

Source: designed by the author. TMS – transport management system; GNSS – global navigation satellite system; WIP – work in progress.

The architecture was walked through for one scenario: a supplier reports a later arrival for a delivery of structural elements (Figure 2). The integration service resolves the delivery to model elements by GlobalId, retrieves location and quantities, identifies the affected schedule tasks, presents the site logistics manager with options, returns the decision to the TMS and records the status on the elements. The scenario was used to check that every message has a defined source, identifier and receiver.

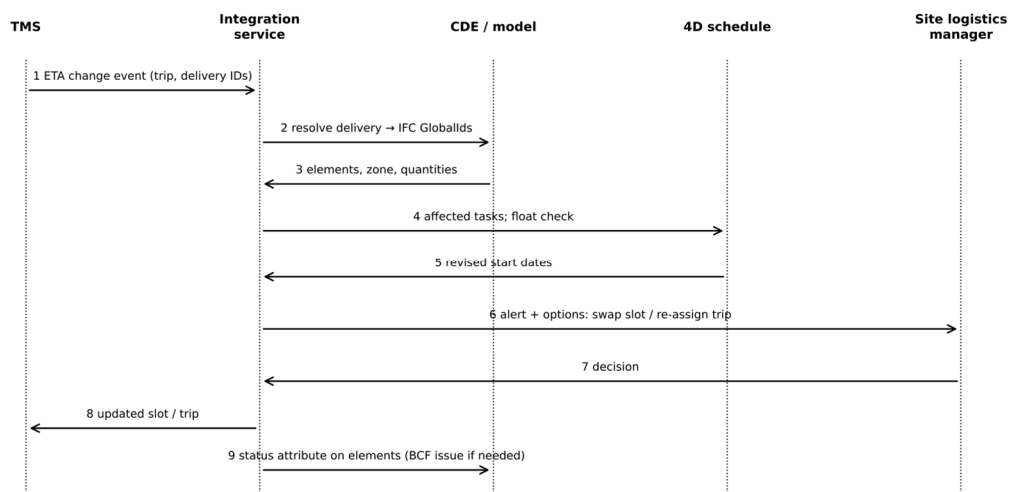


Fig. 2. Information exchange sequence for a delayed delivery

Source: designed by the author. ETA – estimated time of arrival.

Model audit (RQ2). Ten IFC 4.3 ADD2 models from the buildingSMART International certification datasets were analysed: Building-Architecture, -Hvac, -Landscaping and -Structural, and Infra-Bridge, -Electrical, -Landscaping, -Plumbing, -Rail and -Road (buildingSMART International, 2026). The files are published under the CC BY 4.0 licence; the repository state used is commit 80d976a of 4 September 2026. All instances of IfcElement except feature elements

(openings) were counted as physical elements. The count includes 80 geographic elements (terrain and vegetation), 18 element assemblies, whose parts are also counted, and 18 proxy elements; a sensitivity count without geographic elements and assemblies is reported. For each element ten information requirements were tested: L1 persistent identifier; L2 classification reference on the element or its type; L3 element quantity set; L4 weight quantity; L5 weight derivable, that is, a volume quantity together with a material density; L6 material association on the element or its type; L7 spatial containment or aggregation; L8 type object; L9 property set; L10 assignment to a process (task). In addition, every material defined in the models was checked for a density property. Georeferencing (IfcMapConversion) was tested per model. As a check on enrichment, element volumes were computed from the triangulated geometry; each mesh was tested for closure (every edge shared by exactly two triangles), and computed volumes were compared with stored volume quantities where both existed. The audit was implemented in Python 3.13 with IfcOpenShell 0.9.0; scripts and outputs are retained.

Documentary comparison (RQ3). The Spanish BIM Plan for public procurement (Orden PCM/818/2023, 2023), the Spanish public procurement law (Ley 9/2017, 2017: additional provision 15, para. 6), Royal Decree 1515/2018 establishing the interministerial BIM commission (Real Decreto 1515/2018, 2018) and the Kazakh Construction Code (Construction Code of the Republic of Kazakhstan, 2026) were compared on seven criteria fixed in advance: legal basis, trigger, maturity levels, standards, data environment, geoinformation and governance body. Full texts were read on the official portals; statements are limited to what the texts contain.

Results.

RQ2 – model content (computed from open data). The ten models contain 348 physical elements (Table 2). All of them have a GlobalId (L1) and a spatial containment or aggregation relation (L7), and all ten models are georeferenced through IfcMapConversion. Materials (L6) are assigned to 94 % of elements and type objects (L8) to 93 %. The information that logistics needs most is largely absent: pooled over all models, quantity sets are present for 9 % of elements, classification references for 16% and property sets for 14 %; no element carries a weight or an assignment to a schedule task. None of the 62 materials defined in the models carries a density property, so weight cannot be derived from the models alone (L5). The pooled shares are dominated by Infra-Landscaping (111 of 348 elements), which holds 55 of the 56 classified elements and 48 of the 49 elements with property sets; the unweighted means across models are 6.6 % for classification, 14.3 % for quantity sets and 5.1 % for property sets. Without geographic elements and assemblies (250 elements), the shares are 0 % for classification, 13 % for quantity sets, 0 % for property sets, 99 % for materials and 90 % for type objects. The working hypothesis for RQ2 is therefore supported for these models.

Table 2 – Share of physical elements meeting logistics information requirements in IFC 4.3 reference models

Model	Elements	L2 class.	L3 qty set	L4 weight	L5 weight deriv.	L6 mat.	L8 type	L9 Pset	L10 task
Building-Architecture	13	0%	54%	0%	0%	92%	92%	8%	0%
Building-Hvac	6	0%	0%	0%	0%	100%	100%	0%	0%
Building-Landscaping	6	17%	0%	0%	0%	100%	100%	0%	0%
Building-Structural	17	0%	59%	0%	0%	94%	100%	0%	0%
Infra-Bridge	50	0%	30%	0%	0%	96%	92%	0%	0%
Infra-Electrical	6	0%	0%	0%	0%	100%	100%	0%	0%
Infra-Landscaping	111	50%	0%	0%	0%	91%	96%	43%	0%
Infra-Plumbing	29	0%	0%	0%	0%	93%	100%	0%	0%
Infra-Rail	75	0%	0%	0%	0%	97%	100%	0%	0%
Infra-Road	35	0%	0%	0%	0%	94%	54%	0%	0%
All models	348	16%	9%	0%	0%	94%	93%	14%	0%

Source: author's analysis of buildingSMART International IFC 4.3 ADD2 certification models (CC BY 4.0). L1 (identifier) and L7 (spatial containment or aggregation) were met by 100% of elements in all models and are omitted. Shares are pooled over elements. class. – classification; qty – quantity; deriv. – derivable from volume and density; mat. – material; Pset – property set.

Of the 348 elements, 324 have a geometric representation, and a positive volume could be computed from the triangulated geometry for all 324 of them; 294 of these meshes are closed. For the 32 elements that also carry a stored volume quantity, the computed and stored volumes agree to within 0.0001%. Volumes, though not other quantity types, can therefore be derived by the enrichment service; the volumes of the 30 open meshes, mostly terrain and landscape surfaces, should not be used without inspection. Weight cannot be derived, because no material in the models carries a density. This splits AR5 into a part that can be automated from the model and a part that requires an external material catalogue.

RQ3 – documentary comparison. Table 3 summarises the comparison. Spain combines a general legal permission in procurement law, under which contracting authorities may require BIM tools for works and related contracts (Ley 9/2017, 2017: additional provision 15, para. 6), with a plan that makes BIM mandatory by contract value and date (Plan, section 4.3): for contracts of €5,382,000 or more, from 1 April 2024 at the initial level, 1 October 2025 at the medium level, 1 October 2027 at the advanced level and 1 April 2030 at the integrated level; for contracts from €2,000,000 to below €5,382,000, the initial level is recommended from 1 April 2024 and the initial, medium and advanced levels become mandatory on the three later dates. The Plan defines five BIM levels – pre-BIM, initial, medium, advanced and integrated – across four categories (strategy, processes, technology support, people) and defines the CDE (section 4.9), lists the applicable standards, including IFC under the UNE-EN ISO 16739 series (section 4.6), and provides for the submission of models to national digital geoinformation bases (section 4.8). Kazakhstan's Code makes information modelling technology mandatory for the types of construction objects listed by the authorised body (art. 62, para. 1), delegates requirements for information management, including the composition of digital models at life-cycle stages, to state normative documents (art. 62, para. 2), and declares the data of the state urban planning cadastre a state digital resource (art. 63, para. 3). Neither text contains provisions on logistics data: the Spanish Plan does not mention logistics, and the term does not occur in the Russian-language text of the Kazakh Code.

Table 3 – Comparison of Spanish and Kazakh BIM frameworks and assessed transferability

Criterion	Spain	Kazakhstan	Transferability
Legal basis	Ley 9/2017 (add. provision 15.6) permits requiring BIM; Orden PCM/818/2023 approves the BIM Plan	Construction Code 2026, art. 62	Equivalent basis exists
Trigger	Contract value thresholds with dates, 2024–2030 (section 4.3)	List of object types approved by the authorised body (art. 62.1)	Primary: value-and-date staging as a complement
Maturity levels	Five levels across four categories (section 4.9)	Not established in the Code	Secondary: through a normative document
Standards	IFC (UNE-EN ISO 16739) and other standards listed (section 4.6)	Delegated to state normative documents (art. 62.2)	Primary: explicit IFC requirement
Data environment	CDE defined in the Plan (section 4.9)	Not defined in the Code	Secondary: through normative documents
Geoinformation	Submission of models to national digital geoinformation bases (section 4.8)	Urban planning cadastre data as a state digital resource (art. 63.3)	Secondary: via the cadastre
Governance body	Interministerial BIM Commission (RD 1515/2018)	Authorised body for architecture, urban planning and construction	Equivalent body exists
Logistics data	Not addressed	Not addressed	Gap in both; contractual requirements needed

Source: compiled by the author from Orden PCM/818/2023 (BOE-A-2023-16784), Royal Decree 1515/2018 and the Construction Code of the Republic of Kazakhstan of 9 January 2026 No. 253-VIII. The transferability column is the author's assessment, not a legal opinion.

RQ1 – requirement coverage (design artefact). In a single-scenario walk-through every message had a defined source, identifier and receiver, so AR3 and AR4 are addressed by the design on the condition that GlobalIds are kept stable between model versions. AR1, AR2 and AR7 are addressed by the CDE and governance components by design; this rests on analytical and documentary assessment only and has not been tested. AR6 is met at project level by all audited models. AR5 is met only partly: volumes can be derived, weights cannot without an external catalogue. AR8 depends on the client stating the level of information need for logistics uses, which neither framework requires. Compared with point-to-point links among the six source systems, which would need up to fifteen interfaces, the hub design needs six adapters; this is an arithmetic property of the design, not a measured saving.

Discussion.

The audit shows where the information gap lies. Identity, location and georeferencing – the elements that allow a delivery to be linked to the right place in the model – are present. Quantities, weights, classifications and links to the schedule – the elements that allow a delivery to be planned and loaded – are not. This is consistent with the finding by Whitlock and colleagues that logistics planning still relies on information outside the model (Whitlock et al., 2021: 325–348) and with the scope limits reported by Gehring and Rüppel, whose logistics twin left supplier and vehicle data for future work (Gehring, Rüppel, 2023). The practical implication is that clients who want logistics to use the model must state logistics information requirements in their exchange requirements, and that an enrichment step is needed regardless.

The reference models are certification datasets, built to test software rather than to represent delivered projects. Their results indicate what the schema permits and what a minimal model contains; production models may carry more quantities and classifications. The audit is reproducible and can be repeated on any client model, which makes it useful as an acceptance check rather than as a statement about the industry.

On transfer, the Spanish framework offers two primary elements that Kazakhstan's Code leaves to secondary documents: an explicit requirement for open IFC exchange and a staged schedule tied to contract value and date. Since article 62 delegates information management requirements and the composition of digital models to state normative documents, both appear transferable without changing the Code; this is the author's reading of the text, not a legal opinion. Kazakhstan's object-type list and Spain's value thresholds are different triggers but not incompatible. The CDE definition, the maturity levels and the submission of models to geoinformation bases are secondary candidates that could follow through the same documents. Logistics data are a gap in both frameworks, so transfer from Spain does not close it; it must be addressed in contract-level information requirements, which the architecture is designed to receive.

The study has limitations. The architecture has been demonstrated by walk-through, not implemented and measured on a project. The audit covers ten small reference models. The documentary comparison is limited to the texts read; secondary normative documents in Kazakhstan, including the list of object types, were not analysed. No Spanish project data were used, and no claim is made about Spanish practice beyond the published regulatory text.

Conclusion.

The study designed a reference architecture for BIM-enabled construction and industrial transport logistics, traced to eight explicit requirements; tested ten IFC 4.3 reference models against ten element-level information requirements; and compared the Spanish and Kazakh public BIM frameworks on seven criteria fixed in advance. The results are of three types: a design artefact (the architecture and the scenario walk-through), computations on open data (the model audit and the geometry test) and a documentary analysis (the framework comparison).

The model audit answered RQ2. The models met identity, location and georeferencing requirements fully: every element had a persistent identifier and a spatial containment or aggregation relation, and every model was georeferenced. The information that logistics needs most was largely absent: pooled over all elements, quantity sets were present for 9 % and classification references for 16 %, and no element carried a weight or a link to a schedule task; none of the 62 materials defined in the models carried a density. Volumes could be computed from geometry for all elements with a representation and agreed with the stored volume quantities where these existed, which suggests that an automated enrichment step for volumes is feasible, whereas weights require an external material catalogue. Because the pooled shares are dominated by one model, the unweighted model means (6.6 % for classification, 14.3 % for quantity sets, 5.1 % for property sets) and a sensitivity count without geographic elements and assemblies (13 % with quantity sets, 0 % with classification) were also reported; they do not change the conclusion.

The documentary comparison answered RQ3. Spain combines a general permission in procurement law with a plan that makes BIM mandatory by contract value and date – for contracts of €5,382,000 or more from 1 April 2024 at the initial level up to the integrated level from 1 April 2030 – while Kazakhstan makes information modelling mandatory for the types of construction objects listed by the authorised body. Neither framework regulates logistics data. In the author's assessment, Spain's explicit IFC requirement and its staging by contract value and date are the primary candidates for transfer to Kazakhstan, followed by the CDE definition, the maturity levels and the submission of models to geoinformation bases. Since article 62 of the Kazakh Construction Code delegates requirements for information management and the composition of digital models to state normative documents, these elements could be introduced through such documents; this is a reading of the published texts, not a legal opinion.

For RQ1, the scenario walk-through showed that every message in a delayed-delivery scenario had a defined source, identifier and receiver, provided that GlobalIds remain stable between model versions; the requirements on the common data environment, exchange formats and governance are addressed by design but were assessed only analytically. The requirement to supply missing quantities and weights is met only in part.

The novelty of the work lies in combining three elements that the reviewed studies treat separately: an integration architecture evaluated against explicit, traceable requirements; a measured, reproducible gap between the content of openly available models and the information that logistics needs; and a comparison of two public BIM frameworks aimed at transfer. The audit procedure and the requirement set L1–L10 are not tied to the reference models and can be applied to any model a client receives.

For practice, the findings suggest that clients who want models to serve logistics should state logistics information requirements – quantities, weights or material densities, classification and links to schedule tasks – in their exchange requirements, and should plan an enrichment step regardless. The audit scripts can be used as an acceptance check on delivered models.

The study has limitations: the architecture was demonstrated by a walk-through rather than implemented, the audit covers ten small certification models rather than production models, and the secondary normative documents in Kazakhstan were not analysed. Further work should implement the integration and enrichment services on a live project, measure information latency and manual handovers against current practice, extend the audit to production models from Kazakh projects, and analyse the secondary normative documents in Kazakhstan once published.

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