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"free the data"

Global context - Hypothesis

The full impact of digital technology has not yet been achieved in the architecture, engineering, construction and operation sector (AECO) due to the lack of data mobility:

- Better information resolution and higher information mobility improves productivity and outcomes by 1-2% per year while reducing risk.[1]
- Dramatic reductions in the unit cost of information management and storage (cost per kb; cost per kb/s; cost per Mflop) have not yet resulted in an equivalent increase in data availability and data mobility and the ensuing benefits.

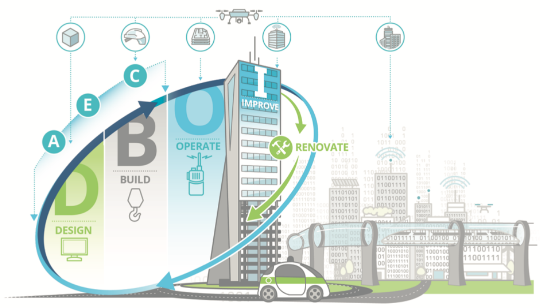
Desired state – An Agile AECO Digital Ecosystem

An Ecosystem – to enable the new vision for our industry:

The right product, designed better, built more efficiently, and operated more effectively – to achieve a better outcome for society, the economy and the environment. (Dr Martin Fischer, Stamford University CIFE)

Attributes:

- high resolution, high clock-speed AECO data mobility – a collaborative ecosystem enabling rich information to be seamlessly consumed and exchanged, creating opportunities for better outcomes through process efficiency gains, and new value chains (business model change).[2]
- low unit cost (processing, connection, transmission), high resilience (availability, quality and security), high scalability and agility (deployable, adaptable and futureproof)



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An ecosystem is presented as one of the "Five Keys to Unlocking Digital Transformation in Engineering & Construction"[3]

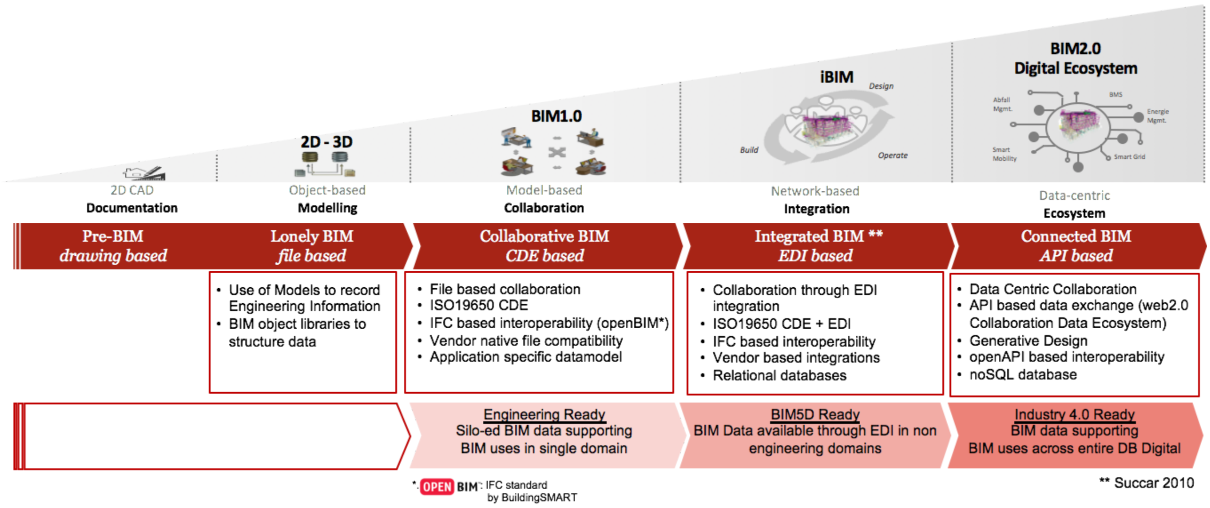
[1] 2004 cost analysis prepared by RTI International (Health, Social, and Economic Research) and the Logistic Management Institute for NIST (The National Institute of
Standards and Technology) estimates the cost of inadequate interoperability in the U.S. government facilities industry being in the reign of $15.8 billion per year, representing between one and two percent of the industry revenue.

[2] For example, UK Project 13.

[3] Five Keys to Unlocking Digital Transformation in Engineering & Construction - Global Industry Council Report 2018)

The transition from the current 'Common Data Environment' to the new ecosystem

Currently, most building information modelling (BIM) implementations are file-based (performance level 1, formerly UK BIM Level 2), supporting "*BIM uses*" emerging from the engineering domain. As BIM implementation progresses, the digital maturity of the team increases, and they turn to "*BIM uses"* that require connections to other information systems, such as scheduling (time - so-called 4D), Enterprise Resource Planning (ERP; cost - so-called 5D), Enterprise Asset Management (EAMS - sometimes 6D, though definitions vary). However, connecting systems requires costly 'point integrations', for example RIB iTWO integration with BIM to provide project control, or integration to SAP to support FM . File-based integrations rely on BIM object libraries, native or open file formats (IFC), and relational databases.



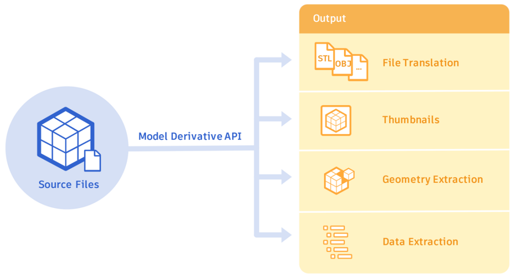
To overcome the high complexity of the integrations, a new cloud-based approach is emerging, offering more agile integration, at the data level. This approach uses technologies developed for the internet age, and at the core of Industry 4.0: APIs (Application Programming Interface), graph databases (no-SQL) which support extensible data schema.

First implementations include AutoDesk Forge™ and Bentley iModelHub™. They both work on their internal (proprietary) data model (Alexandria and iModel 2 respectively) and two tier APIs (the exposed Open API and the internal API).

In this scenario, the role of the IFC file format for information transfer is by-passed, or possibly eliminated. IFC files become static, future proof, "images" of the data set at a given time. Through an "API call", a new IFC model file "derivative" of any given state can be generated – assuming that the provider offers that "API Call", and holds the required source data in a data model that it can translate to IFC (using a Data Dictionary).

The key components of interoperability in the Industry 4.0 era are therefore:

- API definitions that are open
- Data dictionaries that are interoperable
- Data taxonomy standards



An Open API[4] approach will:

- Improve the availability of data from systems
- Maximise interoperability by exposing application functionality
- Reduce vendor lock-in to closed systems
- Promote and accelerate innovation through stackable functionality

[4] See Annex A below for "Open API" definitions (not to be confused with Open Source API)

Current State: Collaborative BIM

File-based information exchange enables benefits including better design of built assets, and better construction, through better information – mostly in the Engineering domain - during the capital delivery phase:

- Information resolution and quality is increased through the use of BIM models. Those models are assembled in relational database technologies.
- Adoption is driven by individual stakeholder benefits (internal process efficiencies) and procurement action (data specs in contract EIR).
- Information mobility is improved through the use of file exchange through defined common data platforms following defined protocols.
- Information is embedded in "BIM objects" which are inserted in models, specified as data containers, and curated in libraries. The information transfer and data definitions are at the level of a "BIM object".
- "Native files" are authored by proprietary applications; and remain the sole full resolution source of editable data sets. BIM models in "IFC format" ("IFC BIMs") can be created as derivatives of the "native BIMs" with a loss in fidelity and/or functionality. IFC BIMs are future proof in terms of data access.

Challenges in current state

The challenges relating to the BIM 1.0 arise from the nature of an approach which is:

1. File-based
2. Transmits data through complete BIM Objects
3. Proposes open interoperability through a single, fixed data model (IFC)

We see challenges in implementing the more advanced BIM uses which require greater data interoperability:

A. Challenges in reaching full benefits of information exchange in internal processes:

- High cost of integration between domains: for example design and engineering analysis, or design to ERP integration – which in turn drives up adoption cost and/or limits adoption leading to lower benefits
- High complexity to manage the BIM objects, to specify data sets, and to validate data quality
- Rapid technology obsolescence : BIMs are only fully editable, manageable in their "native" file format; requiring yearly updates of the native BIM files and upgrades of the authoring packages – to overcome the loss of access to the source data.
- IFC is not available for all asset classes, especially infrastructure. This forces data archival to be done at lower fidelity: COBIE data set, and .dwg or 3D pdf

B. Commercial Challenges arising from the use of BIM 1.0 :

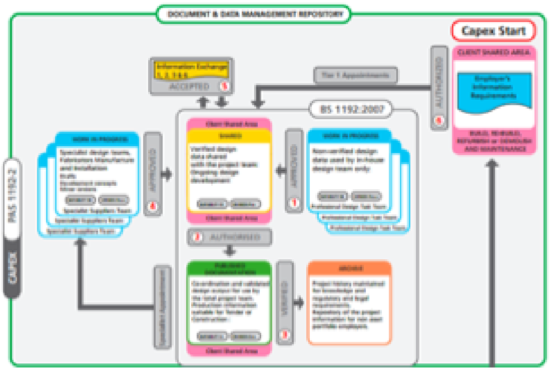
- Exposure to lock-in by tech vendor into a single tech stack; Information exchange between apps being file-based, creates a lock-in into tech platform through native file format (until IFC works with low/no loss in fidelity)

- Reduction of supplier base to those that have adopted the tech stack specified in procurement
- Proprietary BIM objects

C. Challenges in reaching full benefits of information exchange in external processes:

- External stakeholders face the same internal challenges for themselves (see A above)
- Collaboration with external stakeholders or parties remains file-based (no EDI) – enabled through a closed information exchange platform (the Common Data Environment – as per ISO19650-2) mobilised for each project / each stakeholder group
- Information exchange being file-based and based on a closed platform is therefore:
    - low clock speed
    - only available on a "Push Basis" (I upload my deliverable)
    - only available as part of a big data set, with a file as the container
    - Inflexible to respond to a changing and overlapping stakeholder map

System Definition Approach



Theoretical Information Map of Construction Project

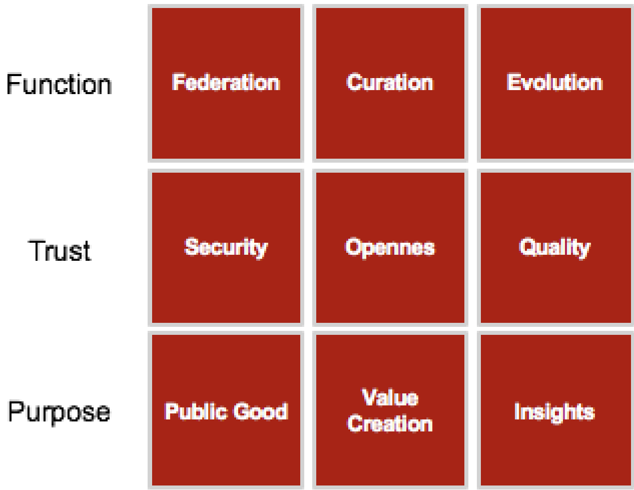
EcoSystem Definition Approach

Information Map of typical Construction Project

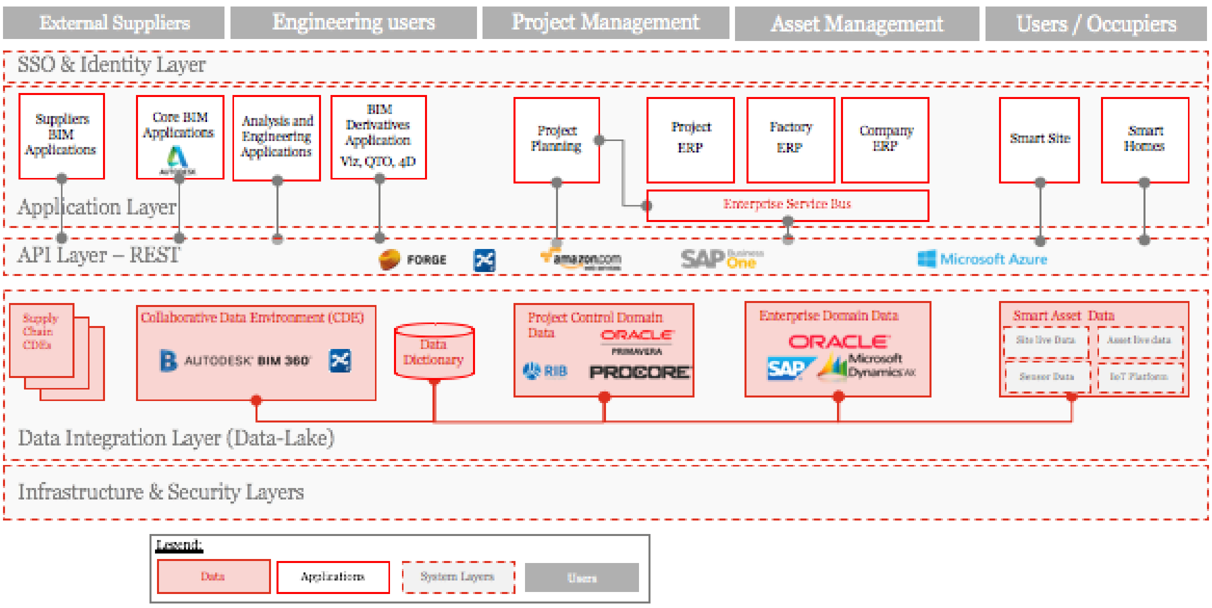
Future State BIM 2.0: platform based Digital ecosystem for the Built Asset

Data-centric information exchange. API-based; enabled by Data Dictionaries.

The ecosystem will support the creation of dynamic, connected Digital Twins, with the attributes identified by the UK Centre for Digital Built Britain, as the necessary attributes for successful deployment:



A layered solution architecture - multi-vendor



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Annex A: Open API definition

The term Application Programming Interface, or API, refers to any mechanisms which allow a system or service to access data or functionality provided by another system or service. Consequently, APIs enable true software interoperability.

Open APIs are those APIs that have been exposed to enable other systems to interact with that system, and those APIs have been sufficiently documented that the available functionality is discoverable, fit for purpose and re-usable. Open also means potential users of the API can access the API documentation free of charge and also access the API free of charge. Also that access to Open APIs or related documentation would not be subject to any Non-Disclosure Agreement (NDA).

"Open API" is not to be confused with the term "Open Source APIs" as this refers to the availability and licensing terms of the source code for any interested party to freely change, fix or modify the code.

Level	Policy	Objectives
A	1. all functionality provided by the system should be available via an "***Open API***" 2. where a vendor provides both a service and solution, the solutions must be "replicable" though the Open API of the service, with no loss of performance 3. all data held on the host system must be made available as instructed by the user	Full Interoperability
B	4. the existence of each Open API must be published on publicly available resources. 5. each exposed API must have freely accessible documentation that has sufficient information that would enable a competent developer has to make use of the API without further information. 6. each exposed API should be accessible free of charge to enable testing. Where access to the API is chargeable and/or access is identified, developers must have non chargeable access to test APIs.	Technical Level-Playing field

C	7. All commercial agreements relating to the development and use of Open APIs must be fair and transparent. 8. Licences for usage of Open APIs by a consuming system with anonymous access must be royalty free, perpetual, non-exclusive and transferable. 9. Licences for Open APIs accessing data by a consuming system should be non-exclusive.	Commercial Level-Playing field
D	10. Access to confidential data, through any API must meet the same requirements for information governance, authentication and authorisation, and auditing as the host system the API exposes.	Data Security