buildingSMART
International

What do Facility Managers need from BIM?

Case: openBIM for Space Management at Universities

A perspective from the Building Room

CONTENTS

1. Goal of the Paper

The goal of this paper is to provide a Building Information Management (BIM) protocol for the ISO 41000-series on Facilities Management for data automation and geometry revision in a Common Data Environment (CDE) workflow for space management during the facilities lifecycle operations phase. The definition of Facility Management (FM) according to ISO 41001:2018 is:

"[An] organizational function which integrates people, place and process within the built environment, with the purpose of improving the quality of life of people and the productivity of the core business."

The proposed protocol should define an information exchange requirement and information model to facilitate the space management process. However, the protocol will not specify a particular technology solution to execute the proposed information exchange that it defines.

The purpose of the protocol itself is to improve the efficiency and effectiveness of space management operations at universities by improving the accessibility, use and maintenance of asset information for those involved in the space management process.

Ultimately, the proposed protocol should be leveraged to ensure that information delivered into the CDE of the appointing party's organization (a university) can subsequently be aggregated into their facilities management system to meet the demands of their respective space management workflows.

2. Methodology

Development of the proposed protocol is framed by the information management process described in the ISO 19650 standard. ISO 19650 is the international standard for managing information over the whole life cycle of a built asset using BIM. This framework provides the guidance needed to establish common data environment (CDE) workflows necessary for the digitalization and automation of space management activities at universities.

CDEs are essential for digital transformation, automation and effective collaboration between the various actors and teams involved in the university space management process. The challenges describing a protocol for improving the efficiency and effectiveness of space management operations for universities become manageable using the BIM process described in the ISO 19650 standard.

Members of the expert panel for this paper provided examples for space management at universities based on their own or their client's experiences. A consultative approach was leveraged to evaluate these experiences to formulate a recommendation for the proposed protocol. With this approach, the panel used this information to outline the composite shape of a common space management process at universities and the personas (actors) involved in that process.

The panel was then able to define the organization information requirements (OIR) driving the space management process and the activities of the actors involved in it. These OIR were used to define the space information requirements (SIR) demanded by it. Next, the panel was able to describe the properties for the space information model (SIM) resulting from the SIR.

Completing these steps, the panel was then able to describe the essential exchange information requirements (EIR) needed to deliver information models of the space management process into the organization's CDE. To the extent that these recommendations borrow from previous thinking represented in ISO 19650, they adapt the framework provided to the particulars of Space Management. For example, instead of Asset Information Requirements, we write about Space Information Requirements, instead of an Asset Information Model we write about a Space Information Model, and so on.

ISO 19650 "distinguishes between a CDE workflow (the process) and the solution (the technology). A CDE uses solutions to support processes which ensure that information is managed and readily available for those who need it when they need it." The CDE workflow is comprised of information containers with connections between them to support the information management needs of the business process it supports. The information management needs are those defined through the BIM process, as expressed through the defined SIR and EIR, and as manifested by the physical data contained within it, including the asset information model and the various information models aggregated into it.

AIM   asset information model
PIM   project information model
A   start of delivery phase – transfer of relevant information from AIM to PIM
B   start of operational phase – transfer of relevant information from PIM to AIM
C   post-occupancy/implementation evaluation or performance review
D   trigger events during the operational phase
NOTE   Information can be transferred between PIM and AIM during the delivery phase as well as at points A and B

Figure 1: Information management during the life-cycle of an asset [SOURCE: ISO 19650-3 Figure 1]
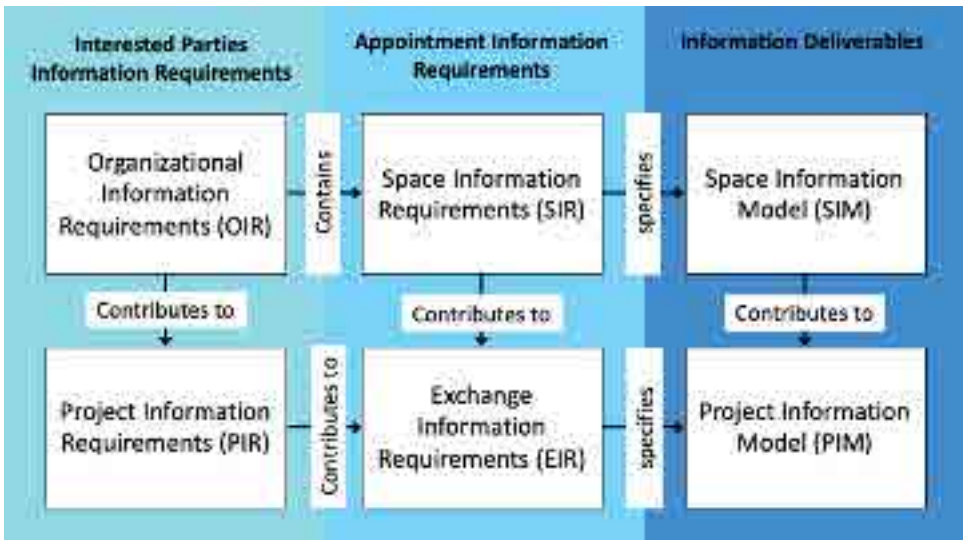
Figure 2: Hierarchy of information requirements, ISO 19650-1 as adapted for Space Management

3. Discussion

Information requirements such as the protocol described in this paper must serve a purpose to be useful. When employed correctly they prevent inundating those engaged in the space management process with too much information or denying them the information they need to carry out their respective jobs. These needs underpin the golden thread of information which conveniently mirror the methodology the panel employed to develop this protocol, as well as the spirit and intent of the protocol itself.

Without clear information requirements there can be no information management, thus no facilities management system or BIM – BIM devoid of information requirements is not BIM. Information requirements are not inductively constituted from what exists by default in an IFC STEP file, but rather deduced from the needs of the demand organization as expressed in the form of specific OIR, SIR, and EIR addressing requirements for specific workflows like space management at a university.

Further, appointments should be scheduled for the production and delivery of required information products based on foreseeable trigger events. Trigger events "represent those events during the operational phase when new or updated information concerning an asset will be generated or required." To mitigate negative impacts from unexpected information requests by information requestors or unexpected delivery by information providers, identification of trigger events is critical in developing an organization's SIR. In the context of the golden thread this occurs in the 'Define' and 'Appoint' phases of the information requirements cycle, as illustrated in the diagram below.

Figure 3: The Golden Thread: the information requirements cycle

The golden thread defines the information management cycle which is reflected in the philosophy for the ISO 41000 and ISO 19650 series, which have clear origins in the 'Plan' > 'Do' > 'Check' > 'Act' procedure specified by ISO 9000. As adapted by the ISO 41000, this paradigm is reframed as 'Plan & Support' > 'Operate' > 'Evaluate' > 'Improve'. Given the scope and intent of ISO 41000 and ISO 19650 there are clear opportunities to support FM information management activities for:

1) understanding and communicating the context of the organization;

2) communicating the FM policy, responsibility and authorities for relevant roles;

3) developing Organizational, Asset and Exchange Information Requirements essential for supporting the planning function for FM systems;

4) providing documented information and communications capabilities for FM systems support;

5) coordinating between interested parties (appointing/appointed) and integration of FM functions; and

6) evaluating the performance of FM systems with information retained by the technology solutions deployed in support of established CDE workflows.

Recommended Information Requirements

Based on the information collected and processed by the expert panel a composite picture for the prototypical space management process at a university has been developed. First, we will describe this process in the context of the ISO 41000 approach of Plan & Support, Operate, Evaluate and Improve. In each section, we describe the necessary end-user tasks. Then we will follow this description by discussing the information requirements in the context of the ISO 19650.

Plan & Support

Any organization using the recommendations provided in this paper needs to first develop a strategic space management plan (SSMP). The SSMP should guide the establishment or space management objectives and describe how the space management system meets these objectives. This includes the organizational structure, roles and responsibilities needed for the system to operate effectively. Stakeholder support, risk management and continuous improvement are important issues to be addressed in the establishment and operation of the space management system.

The SSMP can have a timeframe that extends beyond the organization's own business planning timeframe, requiring the space management system to address the complete lifetimes of the assets and spaces involved.

The organization should also use its SSMP to guide its space management system in the development of its space management plans (i.e. in establishing what to do).

The space management plans themselves should define the activities to be undertaken on facilities, their spaces, and should have specific and measurable objectives (e.g. timeframes and the resources to be used). These objectives can provide the opportunity for alignment of operating plans with the organizational plan and any unit-level business plans.

Aligning the space management objectives with the organizational objectives, as well as linking asset reports to financial reports, can improve the organization's effectiveness and efficiency, The linking of asset reports to financial reports can also improve and clarify the assessment of the financial status and long-term funding requirements of the organization.

Not only does the organization need to create an SSMP, but it also needs to support it with the resources needed to realize it, which includes establishing and maintaining necessary space information and data requirements.

Key Tasks

- **Space & Facilities Managers, Space Planners/Analysts, Architects**
  - (Re)evaluate organizational objectives
  - Define, confirm, update SSMP objectives
  - Define, confirm, update actors and responsibilities to operate the space management system
  - Define, confirm, required activities for facilities and their spaces
  - Define, confirm, update performance measures for space and facilities
  - Define, confirm, update performance measures for actors
  - Define, confirm, update Organizational Information Requirements (OIR)
  - Define, confirm, update Space Information Requirements (SIR)
  - Define, confirm, update Exchange Information Requirements (EIR)
  - Define, confirm, update foreseeable trigger events

Operate

The organization's space management system can enable the directing, implementation and control of its space management activities, including those that have been outsourced. Functional policies, technical standards, plans and processes for the implementation of the space management plans should be fed back into the design and operation of the space management system.

Operation of the space management system can sometimes require planned changes to space management processes or procedures, which can introduce new risks, and risk assessment and control in the context of managing change is an important consideration in operating a space management system.

When an organization outsources some of its asset management activities, this should not remove those outsourced activities from the control of the organization's space management system.

For example, working with BIM models and derivative data to support various aspects of the BIM process outlined in ISO 19650 requires expertise and discipline. The management of BIM models and their derivatives during the operational phase presents many important challenges, such as:

- The obsolescence of resource BIM files due to regular software updates

- Standards for BIM models can differ greatly, so determined adherence to uniform guidelines is required

- Documenting changes for building renovations and extensions is difficult if only data derived from BIM data is available

- In practice, rooms can be merged, split up or changed. This can have a major impact on the building and BIM model. A simple merging of spaces can lead to an enormous impact on BIM models and drawings, for example by making adjustments to fire compartments, sprinkler installation, fire-resistant partitions, construction, architectural and/or other disciplines.

In situations where interacting activities are outsourced to different service providers, the responsibilities and complexity of control will be increased.

Key Tasks

- **Executives**
  - o Oversees the university's building and space inventory
  - o Assigns space

- **Space & Facilities Manager**
  - o Approves and provides reports on the university's space inventory and usage to the campus community and governmental and other external entities.
    - > federal indirect cost reimbursement.
    - > for use in allocating space-related costs for the upcoming budget cycle by university financial budget & finance division
  - o Presents space assignment recommendations to university executives

- **Space Planners/Analysts, Architects**
  - o Identifies individual room types, occupants, and the overall utilization of university space.
  - o Establish the space inventory
  - o Update the space inventory (inserts/adds/deletes)
  - o Reviews and ensures accuracy of floor plans for all university-owned, leased and occupied buildings.
  - o Evaluate space requests
  - o Makes space assignment recommendations
  - o Creates reports on the university's space usage for use by the campus community, governmental and other external entities.
  - o Confirm donor requirements for space inventory and allocation
  - o Conducts an annual space utilization survey
  - o Collect and update data on space utilization

Evaluate

The organization should evaluate the performance of its space and facility assets, its space management, and its space management system. Performance measures can be direct or indirect, financial, or non-financial.

Space and facility performance evaluation is often indirect and complex. Effective space data management and the transformation of data to information is a key to measuring space and facility asset performance. Monitoring, analysis and evaluation of this information should be a continuous process. Space and facility asset performance evaluations should be conducted on directly managed spaces and outsourced spaces.

Space management performance should be evaluated against whether the space management objectives have been achieved, and if not, why not. Where applicable, any opportunities that arose from having exceeded the space management objectives should also be examined, as well as any failure to realize them. The adequacy of the decision-making processes should be examined carefully.

The performance of the space management system should be evaluated against any objectives set specifically for the system itself (either when it was established or following previous evaluations). The primary purpose of evaluating the system should be to determine whether it is effective and efficient in supporting the organization's asset management.

Periodic audits should be used to evaluate the performance of the asset management system; these may be complemented by self-assessments.

The results of performance evaluations should be used as inputs into management reviews.

Key Tasks

- **Executives**
  - o Evaluates the objectives of the system itself

- **Space & Facilities Manager**
  - o Determine what needs to be monitored and measured

- **Space Planner/Analysts, Architects**
  - o Develop data to establish performance baseline (internally benchmarked and/or externally standards-based)
  - o Determine triggers/appointments for the monitoring and measuring
  - o Determine when the results of the monitoring and measuring will be evaluated
  - o Evaluate accuracy for facility and space inventory
  - o Evaluate if synergistic or like activities are functionally adjacent
  - o Evaluate space assignments to determine how well current usage serves the needs and priorities of the university
  - o Evaluate space utilization – is the space over or underutilized?
  - o Evaluate space functionality – does the designed use meet the current use?
  - o Evaluate space and facility condition – what is the material condition and is it adequate?
  - o Evaluate tenant satisfaction with the assigned space
  - o Evaluate tenant satisfaction with space management services
  - o Evaluate which space allocations serve long-range plans
  - o Evaluate which space assignments save money, enhance revenues, or encourage interdisciplinary interaction
  - o Evaluate how well the space inventory and allocation meet donor requirements
  - o Evaluate the length of tenancy
  - o Evaluate which space uses require specialized building systems
  - o Evaluate ability to process space requests and assign space
  - o Evaluate ability to provide space management documentation and reports to internal and external stakeholders

Improve

An organization's space management system is likely to be complex and continually evolving to match its context, organizational objectives, and its changing asset portfolio. Continual improvement is a concept that applies to the space and facility assets, the space management activities and the space management system, including those activities or processes which are outsourced.

Opportunities for improvement can be determined directly through monitoring the performance of the space management system, and through monitoring space performance.

Nonconformities or potential nonconformities of the space management system can also be identified through management reviews and internal or external audits. The nonconformities require corrective action and the potential nonconformities require preventive action.

Of particular importance are space and facility-related incidents or emergencies, for which emergency response planning and business continuity planning for identified risks should be addressed by the space management system. All such incidents, including unanticipated events, should be investigated and reviewed to see if any improvements are needed to the space management system, to prevent their recurrence and to mitigate their effects.

Improvements should be risk assessed prior to being implemented.

Key Tasks

- **Space Managers**
  - o Determine threshold parameters of success/failure according to the key performance indicators (KPIs) leveraged to evaluate:
    - > space and facility assets, and
    - > the space management system
  - o Determine the time it takes to improve so performance is within defined thresholds
  - o Evaluate corrective actions and make changes to the space management system as needed

- **Space Analysts/Planners & Architects**
  - o Define procedures for reviewing and correcting non-conformities
  - o Implement corrective action
  - o Report non-conformities and corrective actions to organizational stakeholders

4. Organization Information Requirements (OIR)

OIR defines the data needed to answer questions regarding an organization's strategic objectives and can concern many domains, like policy, capital planning, strategic business operations, etc. The following requirements regarding space management at universities were assembled based on the panel's experience and interactions with practitioners.

- To start, universities own the space, not the schools within it.

- The planning department for the university resides within its operations division and works with the provost/chancellor to allocate space the various schools and their departments.

- The provost reviews and confirms the allocation of space on an annual basis as part of reporting requirements to the state, national government and other entities providing funding for research to the university and its schools.

- The ability to accurately account for the space it maintains, what it is used for, who is using it and what funding and financial markers are associated with those spaces is one of the most important activities undertaken by university leadership. It is critical in the continued justification of existing research and educational programming, as well as for requests for additional funding of the same.

- Other peer departments are Capital Programs, Facilities and Engineering Services, Dining, Auxiliary Services, Public Safety, Real Estate, and related services.

- Planning department staff is typically comprised of mix of senior and junior architects, as well as space planners.

- Junior architects handle most of the equipment and furniture changes, while senior architects handle everything from current design to master planning

- There are working groups (residential life, athletics, learnings spaces, etc.) that work with the planning department to convey their space needs, e.g. total amounts, by type and adjacency requirements.

- The space planner oversees keeping the floorplans updated and has a goal of inspecting a quarter of the total space inventory on an annual basis to confirm use, occupancy, size, etc.

- The space planner also manages an annual survey that goes to every school to confirm essential data regarding the spaces that each school and their departments use.

- The survey includes relevant floorplans for the departments it is sent to, and includes a spreadsheet used by faculty and aides to update/confirm space and building properties.

5. Space Information Requirements (SIR)

Space Information Requirements logically follow from the OIR. They establish the management and technical aspects of space information and should reference applicable standards. The SIR define detailed information requirements to answer space related OIR. The 'Key Tasks' previously enumerated represent typical trigger events for space management at a university and SIR should be prepared for each event during operations. They should manifest so they are easily absorbed into space management appointments (activities) supporting the university's mission, which are for the most part defined by procedure as an appropriate response to trigger events.

For example, if we consider the first task listed in the discussion on 'Operations', "Space Analyst identifies individual room types, occupants and the overall utilization of university space," there are a number of requirements needed to complete this task. For those involved in the business of space management there is no lack of data provided for or issuing from the work they are engaged. In many respects they are swimming in a sea of data and the challenge is to prevent them from 'going under' and then to facilitate their arrival to their desired destination. What they require is the organization of these data to share (exchange) among those involved in the current task for the purpose of decision making and subsequent action taking (to complete the task).

From the end user's perspective, what is described here is a demand for Information Products. What are Information Products? Well, it is simply a container for data that is determinate and with purpose. It is the compilation of authoritative knowledge from of facts, data, or interpretations in any medium (e.g., print, digital, Web), including textual, numerical, graphical, spatial, cartographic, or audiovisual, that is delivered to a defined end-user, expert or non-expert, internal or external, for a specific purpose. The result provides end-users the ability to do many things, like ask questions about has happened, what is happening, and what needs to happen or is likely to happen based on the former two. But, most importantly they provide capabilities for decision making and action taking based on the answers provided. Clearly, there is a connection being made here to the location and importance of the SIR in the context of a CDE for space management. In many respects, the SIR is the logical design of the CDE, and the physical design of the CDE is such that the technologies used for it provide the frame for the data delivered to it, which manifest as actual information products for real end-users.
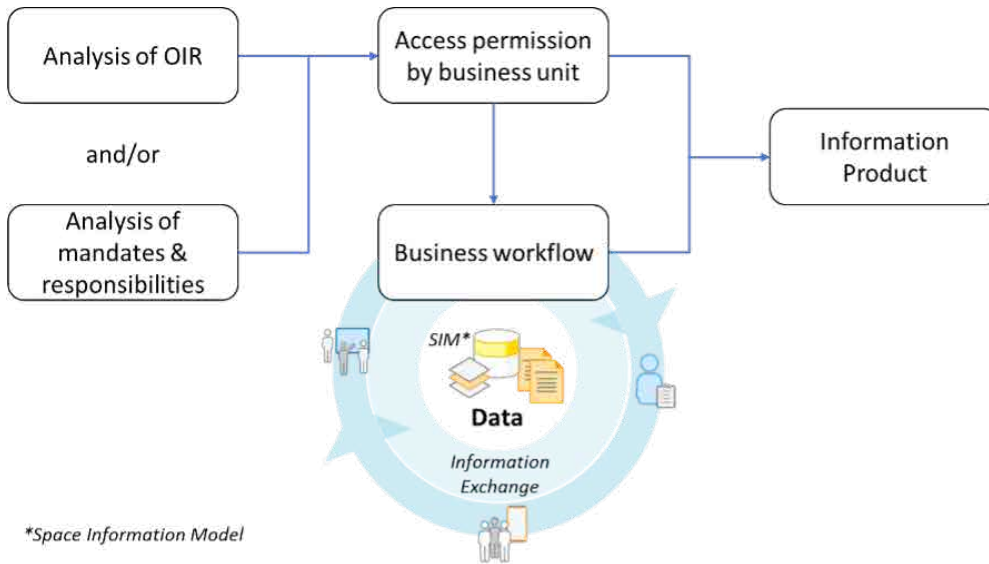
Figure 4: Information Product Logical Diagram

If this task is decomposed we can see there are five other information products needed to create the information product required for this task. One is a complete space inventory with use types designated for each. The SIR should also point to applicable information standards as appropriate. In this example, the FICM standard used in the United States could be leveraged as it represents core concepts in classifying space by use. Since larger physical spaces can be used for multiple purposes, there exists a 1:M relationship between space type and the singular physical space itself. The result is a new requirement for a related information product for a 'room type' inventory. There is a similar need for a 1:M space:occupant inventory, a 1:M floor:space inventory, at 1:M building:floor inventory, and a 1:M site:building inventory. Each of these inferred information products will also need to be defined and trigger events for each should also be defined.
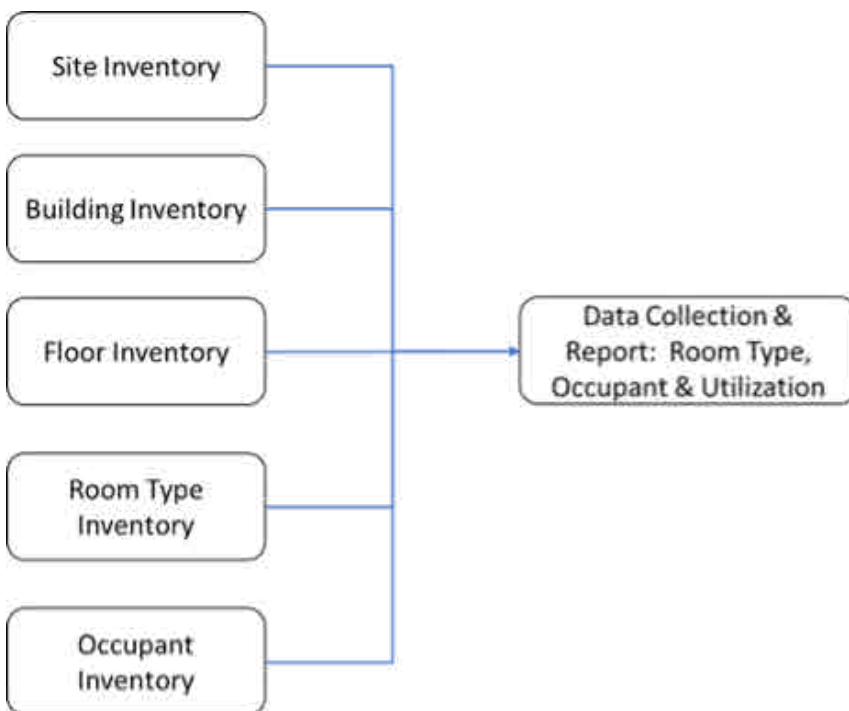

Figure 5: Information Products Inferred by the 'Room Type, Occupant, Utilization Information'

Additionally, it is logical that precise geometric data will be needed to calculate the area of the space. Ideally, there is also a spatial representation of the space (para-line drawing, CAD, BIM, GIS, reality capture) that can be used as a reference for this and to support other facets of implementing the SIR. It is key that space management business units at universities clearly define what space is and how it will be measured, otherwise management of it will be difficult.

To this end, there are numerous space measurement standards, both national and global that should be considered. Coventry University in the UK provides a good example of this that is depicted in the following space definitions and floorplans.

- Gross External Area (GEA) is the area of a building measured externally on each floor. For Coventry, the GEA is captured in their plans – but not recorded in Planon, their CAD and Facilities management system.

- Gross Internal Area (GIA) is the area of a building measured to the internal face of the perimeter walls at each floor level and this content (the geometry and properties) are stored in their space management system.

- The GIA that the University uses for management and planning (excluding a number of areas) includes: derelict Space, accommodations neither maintained nor paid for, any structure attached to the outside of the external wall of a building (e.g. external open-sided balconies, covered ways, fire escapes and canopies). The excluded areas are what the UK Higher Education Statistics Agency (HESA) defines as 'balance areas'. HESA space definitions are similar to the FICM standards maintained by the National Center for Education (NCES) in the United States.

- Coventry University also documents net internal area (NIA) which is the useable space within a building. These measurements are taken up to the internal face of the perimeter walls on each floor level. The NIA figure is also stored in their space management system.

Further development of the 'Room Type, Occupant and Utilization' SIR requires knowing where, when and by who the information product will be used during space management operations. Experience shows that this type of information product for a Space Planner and Architect is three-fold. One part regards the collection of the data, another analyzes what is collected and already available, and a third is the presentation of these data and analysis to the Space Manager and Executives at the university. Each has its own form-factor.

The data collection information product should work on both mobile devices and in a desktop browser, the information product facilitating the assembly of the analysis will most likely happen on a desktop client and browser, and the information product that the Space Analyst assembles for the executive and space manager will need to be available from a desktop or mobile browser. Consequently, this one task is part of a workflow that requires data from five other information products and results in three additional information products. Each of these three will need access to different groupings of data and have its own exchange information requirements.
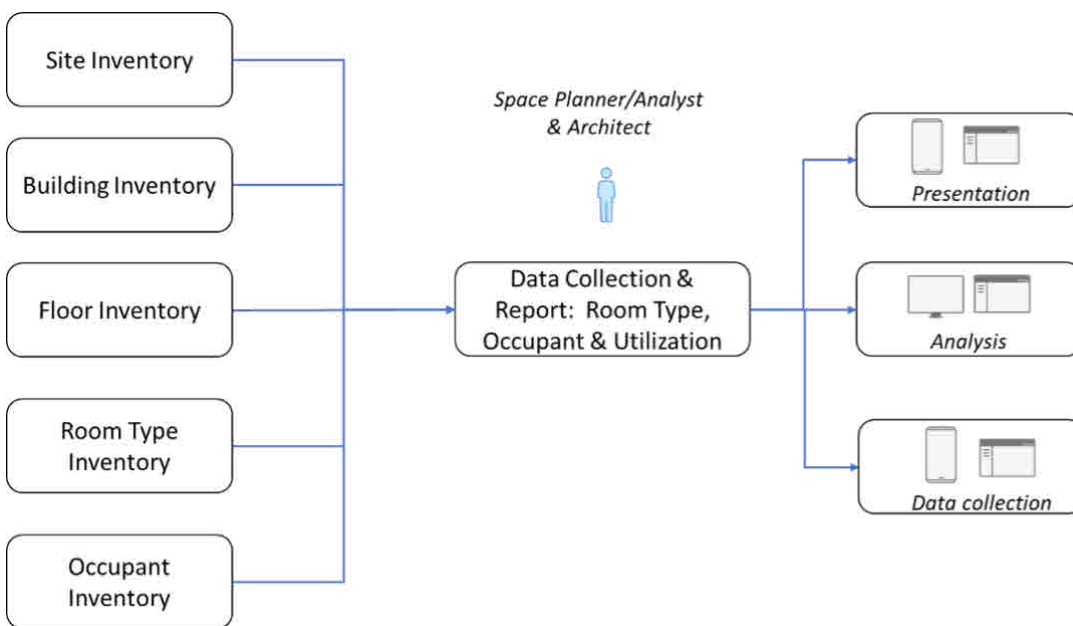

Figure 6: information products for Data Collection and Reporting

13

The following section continues this discussion and provides an explanation of how the space information requirements (SIR) are developed into a space information model (SIM).

6. Space Information Model (SIM)

The SIM supports the day-to-day space management operations for a university and includes data for various topics such as inventories/registers, operating costs, dimensions, geometry, occupants, use and more.

Returning to our example case of an SIR, there must be a data property to capture room 'type', the number of occupants, probably the business unit for the occupants, and how much of the space they occupy and for what proportion time during the business day. There are also a number of properties implied, e.g. the space name, space ID, floor number, floor ID, building name, and building ID, …. Properties like these will allow the university to link the characteristics of this one space to the whole so that understanding of the performance for this one space with respect to the whole can be provided. Other characteristics like space size the unit of measure for that size are required to fully understand the occupancy KPIs.

As discussed, there is a requirement for a spatial representation by most universities for space, floor, building and site inventories. This need necessitates the aggregation of project deliverables of CAD and BIM data, into a single Space Information Model for use in space management for those universities whose CDE leverage those technologies. For example, in the case of Tufts University in the United States, they use CAD for the generation of initial space and floor inventories. These drawings are then used to update the BIM for the buildings they are related to. Then all the BIM data is aggregated spatially into a GIS (Esri ArcGIS Indoors) that is used to capture transactional business data associated with those spaces, floors, buildings, etc. In a parallel manner, Coventry University in the UK uses a space management system (Planon) to deliver the same information products.

Example properties for this one SIR might look like this:

FIELD NAME	ALIAS	FIELD TYPE
[SPACEID]	Space ID	Text
[SPACENAME]	Space Name	Text
[FLOORID]	Floor ID	Text
[FLOORNUMBER]	Floor Number	Short
[BUILDINGID]	Building ID	Text
[BUILDINGNAME]	Building Name	Text
[SPACEAREA]	Space Area	Double
[SPACEUOM]	Space Unit of Measure	Text
[SPACETYPE]	Space Type	Text
[OCCUPANTS]	Number of Occupants	Short
[OCCUPIED]	Occupied	Boolean
[OCCUPANCY]	Occupancy %	Double
[HOURSAVAILABLE]	Hours Available	Double
[HOURSOCCUPIED]	Hours Occupied	Double
[GEOMETRY]	Geometry	Geometry

With this logical progression towards the establishment of a SIM, the space management business unit at a university can begin specifying its Exchange Information Requirements (EIR) needed to deliver the data to the right end-user in the right interface at the right time in their workflow.

7. Exchange Information Requirements (EIR)

The Exchange Information Requirements (EIR) are defined as the managerial and technical aspects of producing and delivering information. They should specify detailed pieces of information required to carry out appointments generated by known or foreseeable trigger events.

The example requirement in the previous section can now be translated into a variety of EIR, as a JSON specification made actual in a REST service endpoint or web API, as an Excel spreadsheet, as a STEP File, and so on. The critical point is that the specification matches the technological reality of the organization implementing the standard.

One example illustrating the principles provided above is at Coventry University in the UK. The university requires that all active asset information is maintained in a file share accessible by all involved in the execution of the defined task. In their case, they use the Planon facilities and space management system and in Planon which maintains fields like these that can be configured on implementation of that system. In another example, Brigham Young University in the United States uses Esri's ArcGIS Indoors Space Planner system where some of the fields above are in the default data model and if implemented in that system would just be extensions to that data model and made available to the Space Planner or Analyst accessing the data through a REST service endpoint.

Information management can be represented as a sequence of maturity stages, shown as Stages 1, 2 and 3 in the Figure below. This Figure shows that the development of standards, advances in technology and more sophisticated forms of information management all combine to deliver increased business benefits. In this sense, the EIR must reflect the technological reality of the university implementing them and the CDE they have established.
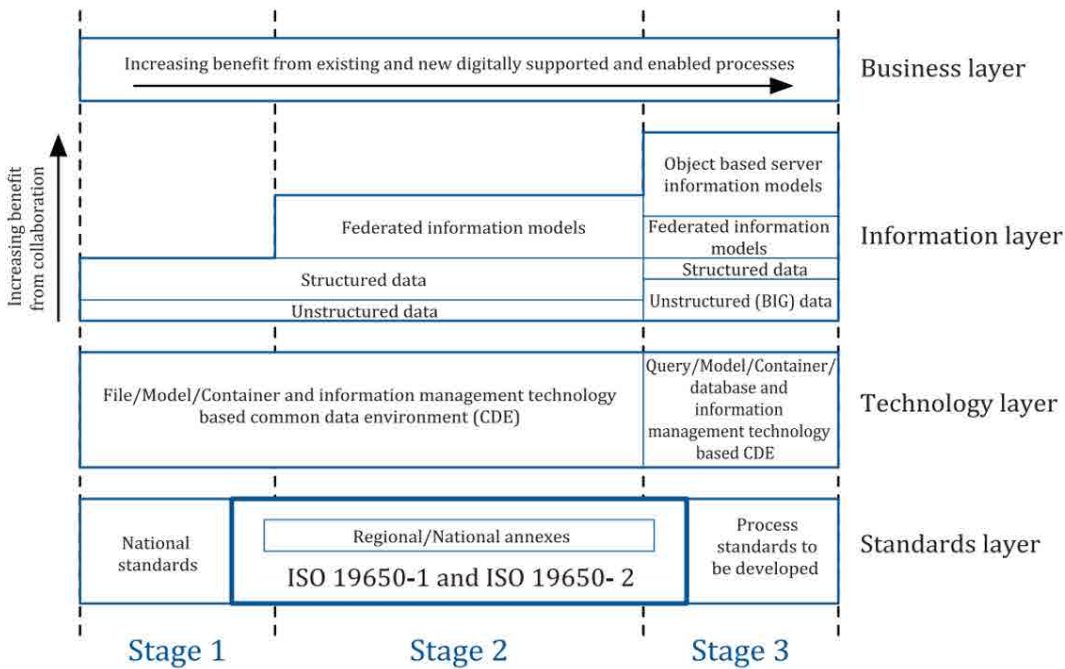

Figure 7: ISO 19650 Digital Maturity & Federated Architecture

Below is a diagram of service areas at Coventry University Estates as an example of affected areas by a space change that requires notifying and support.
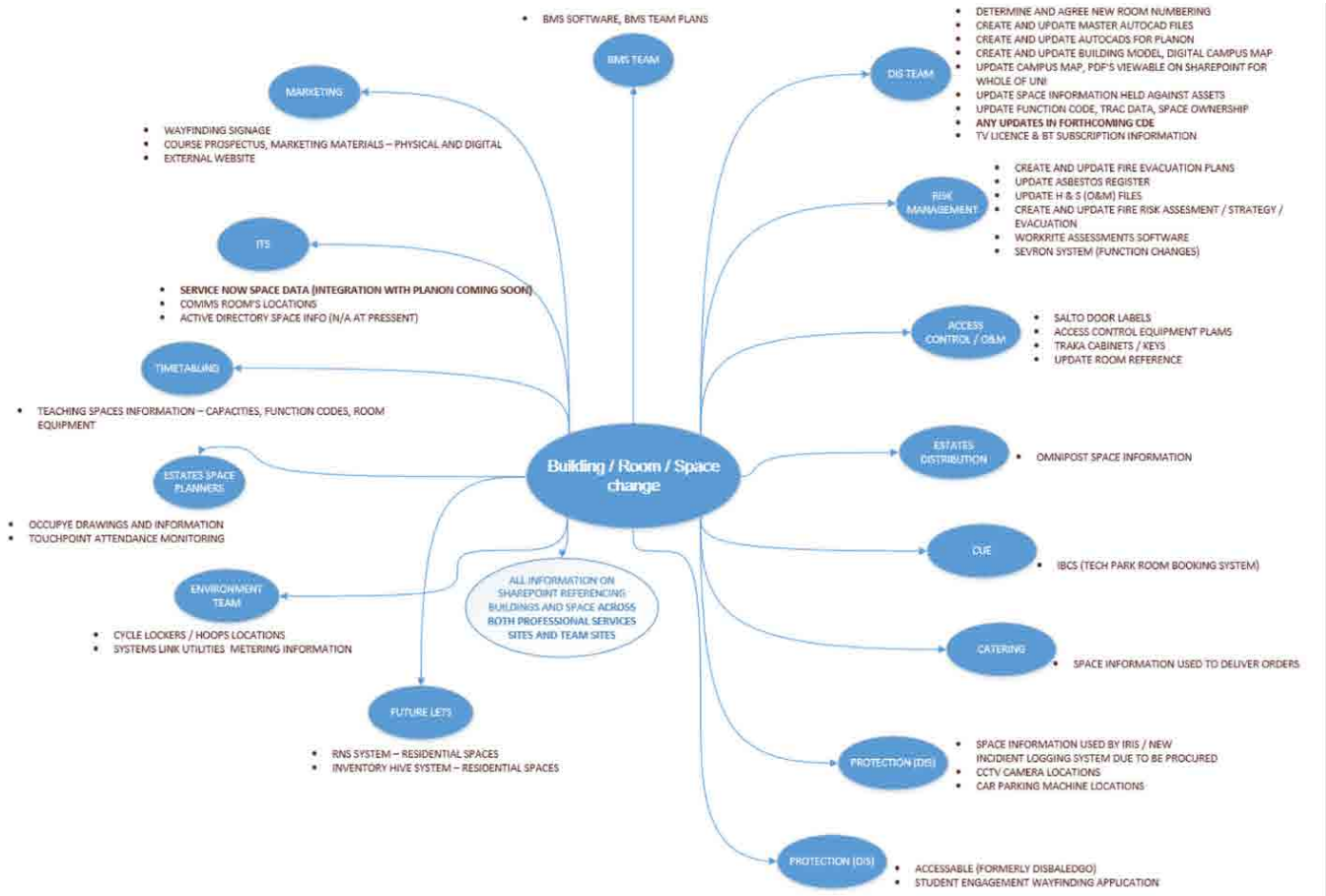

Figure 8: Coventry University Estates – example of areas affected by a space change

The following represent 'appointments' that follow from the 'Trigger Event' of a space change for Coventry University. The types of changes and the chain of data sources affected by a space change are summarized in the following categories:

• Space Numbering

• Building drawings that will require an update

• Physical Change to a space

• Documentation that will need to be updated

• Systems Data that will need to be updated

• Asset information update

• Student services affected by space change

• Subscription services

8. Next Steps

To support this future use of BIM, clients and industry need to agree on standardized digital building lifecycle process definitions, optimized open data & information exchanges, and standardize critical information content with clear identification, classification, naming conventions, and consistent levels of granularity.

The enhancement of existing openBIM standards and IFC terminology to deliver these requirements is an obvious consideration. Known and well-proven openBIM benefits, design and construction stages are also extendable to the handover and operational stages.

An openBIM for FM approach would ensure:

• Interoperability is centre and key to the digital transformation

• Open and neutral standards are used and developed to facilitate interoperability

• Reliable data exchanges would depend on independent quality benchmarks

• Collaboration workflows are enhanced by open and agile data formats

• Flexibility of choice of technology creates more value to all stakeholders

• Sustainability is safeguarded by long-term interoperable data standards

The development of a FM information requirements protocol would help define how interoperability can be consistently achieved between the space information model and facility management in accordance with traditional layers of interoperability. The next phase of this project will include the development of the FM information requirements protocol.

9. Acknowledgements

Authors

Patrick Wallis, ESRI

Hadeel Safaa Saadoon, Coventry University

Hans Hendriks, BIM Specialist

Jan-Fokke Post, Planon Software

Rogier Roelvink, Oracle