

ES121493

Creating Intelligent Digital Built Enviroments

Daniel Kazado



Ahmet Çıtıpıtıoğlu, Ph.D., P.E.



Learning Objectives

- Understand the process of BIM and facility management integration
- Learn about challenges for a successful BIM-FM Integration
- Learn how to use BIM as a platform to integrate existing digital infrastructure
- Gain a virtual model-based browser for your built environment

Description

With Building Information Modeling (BIM), data now has the means to coalesce, become information, and be analyzed as never before. Data granularity and its volume achieved around BIM open the doors for the creation of a Google-like virtual model-based browser for the built environment. We utilize the combined design, construction, and operation know-how of TAV Construction and TAV Airports, based on innovative tools and technologies created for the built environment industry. Based on the success of the BIM-FM integration at the Medina Airport, we are expanding the use of BIM as a means to improve the operations of their investments. This effort has become a case study for us and for the industry in which several challenges have been addressed, opening the way for future possibilities. Using BIM as a platform to integrate existing digital infrastructure—such as computerized maintenance management system (CMMS) and BMS/BAS software—enables better analytics, performance for operations, energy management, sustainability, business, and more.

Speakers

Daniel Kazado is a Mechanical Engineer with experience on more than 18 large airport projects including the New Doha Airport, Pulkovo International Airport, Cairo International Airport, Ankara Airport, İzmir Airport, Tashkent International Airport. He worked at several capacities from BIM Manager to Project Manager, exposing him to many levels of perspectives. He is currently at ProCS Engineering as Managing Partner & BIM Consultant. In the last 10 years, he gained extensive know-how with BIM and its use on large scale projects from design, construction, to operations. His success with large scale projects lies in implementing the MEP Services using BIM system with the highest beneficial use to increase the productivity in the project.

daniel.kazado@procs.com.tr

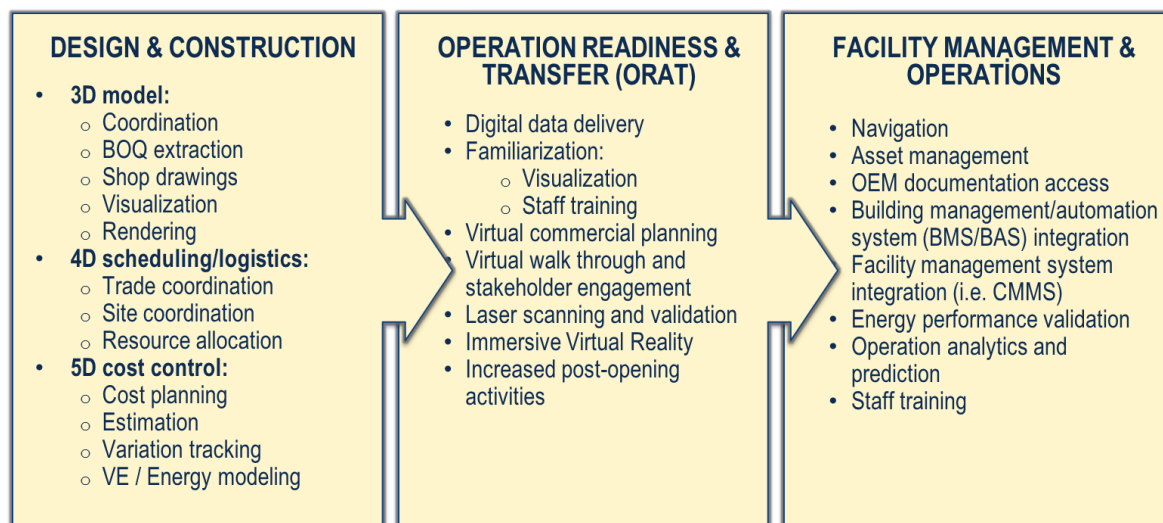
Ahmet Çıtırtıoğlu, Ph.D., P.E. has been involved in the design, construction and technical operations of several high-performance facility structures, from nuclear power plants, airport terminals, and high-rise buildings around the world. Working on several large airport projects at TAV, he is also leading the implementation of advanced design and construction coordination tools used at all phase of the built environment facilities - design through facilities management. His experience with all phases of large projects gives him a unique perspective from the early phases of a project with knowledge of the needs of operation. He is a Registered Professional Engineer in the State of California with more than 20 years of industry and consulting experience.

ahmetc@tav.aero

Introduction

Building Information Modeling (BIM) has gained enormous traction in the design and construction of a project. With Building Information Modeling (BIM), data now has the means to coalesce, become information, and be utilized as never before. Facility owners and operators are increasingly recognizing the value of utilizing BIM models for post-construction use throughout the lifecycle of their facilities and assets. Thus, there are higher expectations, resulting in greater BIM requirements. Models are to reflect the as-built conditions accurately and contain or link to information that is useful to Operations and Facilities Management.

Under the Public Private Partnership (PPP) framework TAV Airports execute Built-Operate-Transfer (BOT) projects where typically TAV will design and construct airport facilities in return for the concession to operate the airport for 25 to 30 years. Such a long horizon makes maintenance of its investments ever more important to ensure efficient operations and reduced risks to the long-term investment. Combining its design, construction, and operation know-how of TAV Airports and TAV Construction - TAV Integrated Solutions has been implementing innovative tools and technologies like BIM at its airports for the past several years.



SCOPE OF THE DIGITAL TOOLS AND TECHNOLOGIES USED ON PROJECTS

BIM for Facilities Management (FM)

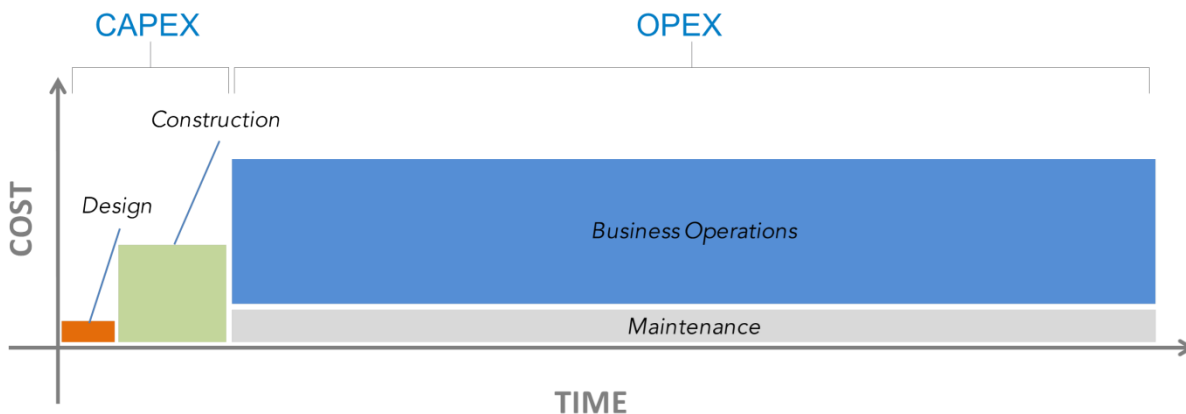
There are several considerations to take in to account in developing BIM and GIS data models on projects with the objective to improve operations and facilities management. Lack of a proper approach and planning most likely will result in models with insufficient structure and content to be useful for their objectives, risking extensive and expensive rework.

Using BIM as a platform to integrate and supplement existing digital infrastructure such as an asset management system, computerized maintenance management system (CMMS) or BMS/BAS enables better performance for operations, energy management, sustainability, and overall better business.

There are several motivations for such an endeavor:

- Contractual requirements
- Information mobility
- Digitize and future proof data
- Capture & coalesce information
- Information granularity
- Know what is managed
- Utilize extensive integration opportunities

The impact of the accumulated information with BIM transcends the design and construction phases. When comparing cost and duration - operations and associated maintenance cost (OPEX) clearly dominates the cost of the capital investment (CAPEX). The OPEX can benefit from the improvements by utilizing BIM. Comparing the CAPEX and OPEX of a mid-size airport shown in the figure below it is clear that there is greater value to be gained from BIM on the operations side when compared to the design and construction phase.



RELATIVE COST & TIME OF CAPEX AND OPEX FOR A MID-SIZED AIRPORT BOT PROJECT

Beyond the use of BIM during design and construction there is much to gain in the long run throughout the facilities lifecycle and this is reflected in the recent surge of BIM delivery requirements aimed at FM use within project specifications on a wide range of projects from airports, high rises, datacenters, multipurpose development to datacenter.

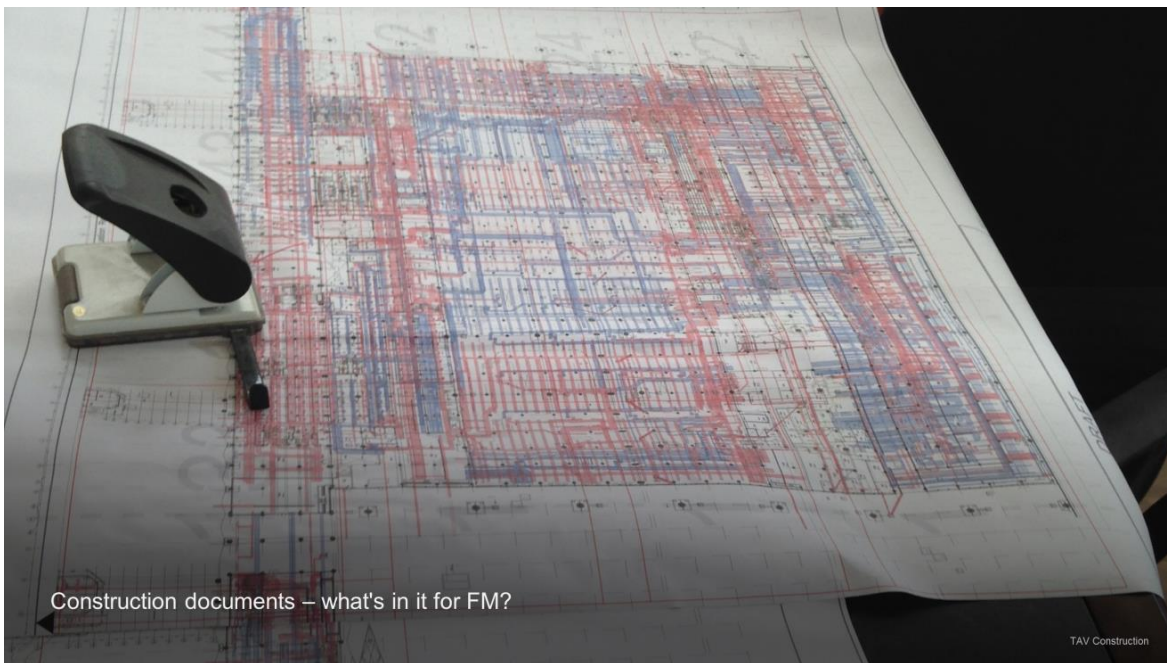
Though the objectives of BIM model use following construction are typically not well elaborated. This makes it challenging to ensure models are authored so to be useful for the intended purpose of the

facilities operator. The step and roadmap towards using BIM models for creating intelligent digital built environments will be elaborated in the following sections.

Understanding the Process for BIM-FM Integration

Buildings are Data

What will happen to the information delivered on drawings? For operations will they be accurate or even accessible many years later? This is the essence of our motivation to capture and deliver construction data digitally for future use during the lifecycle of the facility. We are now building both digitally and physically...



How will information on drawings from construction be useful for FM?

Let's look at what it takes to take data and turn it into useful information. The steps to take data and turn it into useful information is common to several functions during construction and after, i.e. design, modeling, site inspections for QA/QC or HSE, for FM for work orders etc.

- the data is authored or registered by some means, i.e. pen and paper, sketches, drawings, BIM models, mobile tablet etc.
- they are stored via some medium, i.e. binder, database, model, excel etc.
- shared through some means – a Common Data Environment (CDE), email, transmittal letter etc.
- finally, data can be processed, reported to have a higher understanding of the data presented – meaning information

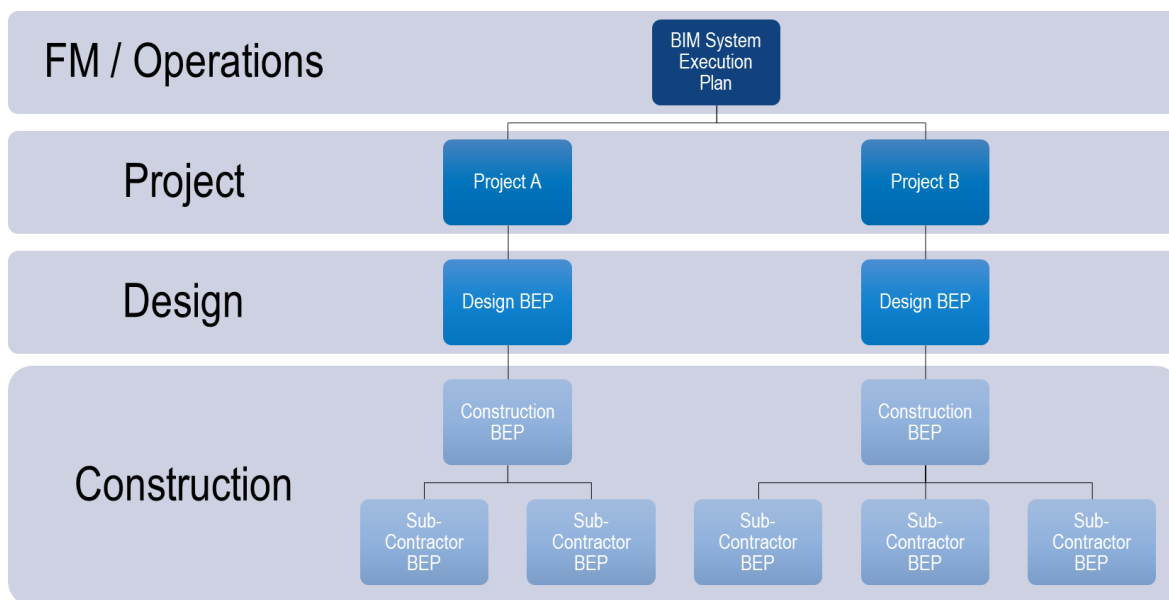
There are three main cornerstones in making this happen:

- Technology > fairly matured
- Process > need to be developed to ensure delivery of objectives
- People > need to be trained to competencies to use the technology and following the processes

Allocating the funds to hire the right people or train staff to develop and execute the processes is a good start. It is essential for the client/operator to establish all guidelines within a BIM Execution Plan (BEP) where all the objectives and requirements are defined and documented in detail, at a minimum covering the following:

- BIM content and attribute definitions
- BIM asset element requirements
- Existing facility BIM model requirements
- New and future facility BIM model requirements
- BIM content update methodology
- Data management
- BIM hardware and software updates
- BIM Management workflows

The BEP developed by the client/operator is a document that covers all aspects of BIM use throughout the lifecycle of the facility. It is the parent document that dictates all future projects which will have their own separate BEP. This is to ensure all future development and additions to the facility BIM database are consistent and compliant with systems in use. Each phase of each project will require its own BIM Execution Plan developed by the responsible consultant or contractor.



HIERARCHY OF BIM EXECUTION PLANS FOR FACILITY

What is “a” LOD500 BIM Model?

It is common for project specifications to require as-built LOD 500 BIM model delivery at the end of the project, though there really isn’t such a thing as “a” LOD 500 model. A model will contain elements at various levels of development. Therefore, we use LOD Matrixes for each element type and describe all associated visual and attribute information to ensure a mutual understanding between all parties. MEP system information is also essential for operations and this information needs to be identified through the BIM model as well.

Delivery methods such as COBie which describes the means to compile/aggregate data from sub-contractors, alone is not descriptive – specifically about the naming and content of information. Nomenclature between design and operations may also vary - FM staff may not identify the Supply Air System the same way as specified during design or construction. All this need to be defined prior to any modeling.

001 FIRE SPRINKLER WET		SYSTEM DEFINITION
Item Category - Fire Protection		Description: Wet Sprinkler System and Hose Cabinet Piping Sytem.
SYSTEM FAMILY TYPE	Routing Preferences	Information
FIRE SPRINKLER WET	Pipe Segment	Black Steel Pipe
	Elbow DN25-DN50	Threaded
	Elbow DN65-DN300	Grooved
	Preferred Junction Type	TEE
	TEE DN25-DN50	Threaded
	TEE DN65-DN300	Grooved
	Cross	None
	Transition DN25-DN50	Threaded
	Transition DN65-DN300	Grooved
	Union DN25-DN50	Threaded
	Union DN65-DN300	Grooved
	Flange	None (Create as Family for Valves)
	Cap DN25-DN50	Threaded
	Cap DN65-DN300	Grooved
FIRE SPRINKLER WET-MECH TEE	Preferred Junction Type	TEE
	TEE DN25-DN300	MECHANICAL TEE
ADDITIONAL INFORMATION:		
1. Do not use Reducing TEE , all three connection of the TEE shall be same size. If needed use transition after TEE.		
2. For transition from DN65 to DN50 or smaller use Grooved-Threaded transition.		
3. Direct sprinkler connection for pipes over DN50 shall be made with Mechanical TEE . This is the only case to use FIRE SPRINKLER WET-MECH TEE System.		
4. Bell Type Reducer shall be used for each sprinkler connection from 25mm to sprinkler size. Except then this fitting, there shall not be any other fitting under DN25 size.		
5. Connect all valves with flanges. Create flange as a family and do not use Routing Preference.		

SYSTEM DEFINITION TABLE FOR FIRE SPRINKLER SYSTEM MODELLING

Anyone who Google’s BIM will find several versions of charts showing each phase a building lifecycle from conception to demolition surrounding a central BIM model. Talking about such a cycle around “a” Central Model from start to end stands is an over simplification of what really happens. Rather than having “a” BIM model - typically there are several models for each discipline split per floors or zones as necessary which are constantly updated throughout design and construction.

Models are updated and combined together (federated), elaborated, updated and this continues on where by the end of a project several versions of several models have been generated and used as reference for coordination and data drops. This is part of the challenge to assemble all the information for FM use at the end of the project.

Our broad understanding of LOD is more of a phasing issue where the amount of known information increases from LOD 300 to 500. The graphical detail of the elements typically does not differ throughout the modeling cycles. This is in part due to available element libraries and increased computer power. Simplification of elements if it is readily available is not really necessary. Thus, the main difference is the content and attributes within the model.

A general misconception is that you will end up with LOD 500 model by default as you have been continuously updating during construction. This is hardly the case – if the objective is not clear at the beginning or modeling critical information and features may be excluded and this would mean additional man-hours and costs at the end of the project to rectify the models.

Construction – Shop DrawingsHandover - As-Built Drawings

$$\sum_{k=1}^n (\text{LOD400})_k \neq \text{LOD500}$$

CONSTRUCTION MODEL UPDATES DO NOT TRANSLATE TO AS-BUILT MODELS AT THE END OF THE PROJECT

Organization and Processes

On projects with BIM requirements need to be organized where the engineering team on-site is staffed with BIM Coordinators embedded with the discipline managers involved in coordination with additional staff on hand for modeling. The BIM effort should not be set as a separate entity. With the volume of information generated through BIM and delivery expectations it may be necessary to include a dedicated Information Manager.

The typical workflow for modeling and coordination during construction involves a continuous cycle of model updates based on new information or changes due to coordination and design variations. Each change may require updating the pre-engineering documents within the BEP, including the LOD matrix, element attribute tables, system tables etc.

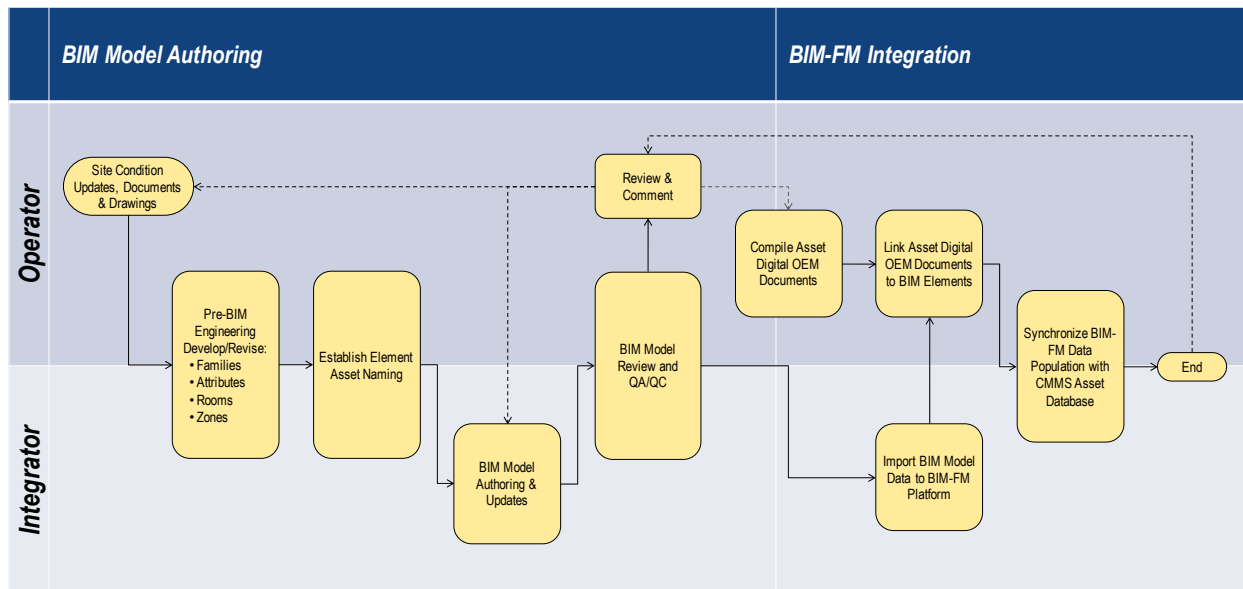
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        IFC --> RFI1{RFI}
        CDE --> RFI1
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System tables]
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•Coordination  
•Review  
•Approvals  
•Instruction for Shop Drawings]
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        Clash2 --> Revise2[Revise BIM Model]
        Revise2 --> Clash2
        Revise2 -.-> Submit[Submit Coordinated BIM Model]
        Submit -.-> Clash2
        Clash2 --> Shop[Shop Drawing Production]
        Shop --> Approve{Approve}
        Approve -- No --> RFI8{RFI}
        Approve -- Yes --> End([End])
        RFI8 -- Yes --> IFC
        RFI8 -- No --> Revise2
    end
  
```

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Modeling does not end with at the completion of a project. Operated facilities continuously evolve. BIM models need to be maintained to reflect current conditions. Changed equipment, room assignments and so forth need to be updated in the models. This information can flow from site to the CMMS or Asset Management database at certain intervals depending on the criticality of the facility or system. The following figure shows the exchange of information and workflow between the operator and integrator to maintain the content of the BIM models and integration with FM digital infrastructure.



IDEALIZED MODELING AND INTEGRATION WORKFLOW DURING OPERATION

Model Content

Element Organization

BIM models are inherently structured – in Revit we start out with the predefined categories of families and further define the types of family elements. This organization in model may not be consistent with the intended way you would organize your asset registry (management database). To align the data with a COBie like structure, we also identify additional important **family** type parameters used to identify elements:

- Type Name
- Type Description
- Manufacturer
- Model
- Omniclass Number
- Omniclass Title

With the family structure and types defined a model would have several hundred instances of an element – this is where all the modeling effort goes. Placing all the elements in the right location. Each instance of element will have unique properties that need to be defined for the asset registry. Here additional important **instance** parameters used to identify elements instances:

- Instance Name
- Instance Description
- Manufacturer
- Room Number
- Room Name
- System Code
- Subsystem Code
- Barcode
- Serial Number

As mentioned the organization within the BIM models may not be consistent with the organization of the asset registry. Facility and Asset Management may approach data different than what is set-up from the BIM models during the Design and Construction phases. For example, an AHU (Air Handling Unit) unit will be defined as different type within the BIM model - whether the unit is horizontal or vertical or even if it is single or double story. But from a Facilities or Asset Management point of view –the equipment has a fan and filter, depending whether it is large or small it will be identified as an AHU or FCU (Fan Coil Unit). It is very important to have the BIM model authored for FM use to be setup accordingly. Otherwise another layer of mapping of different types between the BIM models and FM platform will be required.

Element Tagging

Element tagging is one of the main unique mechanism that we can use to link elements between the BIM models and FM infrastructure. Multiple tags exist for multiple purposes. There are several types of unique identifiers that can be used together to may be necessary to define or capture as attribute information within BIM models:

- Barcode tag numbers
- Equipment serial numbers
- As-built / shop drawing schedule mark
- Object ID compiled of several levels of coding
- GUID tags
- Classification Number: Omniclass [Masterformat, Unifomat] (US), Uniclass (UK), NL-SfB (NL), CoClass (SWE), etc.

While there are many ways to tag elements, it is critical to identify the basis for integrating the BIM and FM infrastructure. The client/operator needs to define this within their BEP and establish QA/QC procedures to ensure the accuracy of tagging in the model.

Several levels of information can be used to assemble element tags. Though long tags with too much information is not convenient. Human decipherable concise tags with the minimum number of layers that ensure each tag will be unique for each element is ideal.

Dispersed facilities like airports with several different buildings across a wide should take inconsideration not only maintainable assets, but also areas, zones, and roads which also need to be maintained and thus need their own unique identifying tag. This is useful to assign non-asset work orders, so everything including a roadside curb is an asset.



Object ID Naming Levels	Description
Level 1: System Code	<u>AA</u> : Two-digit System code as defined by Tibah e.g. 04 for HVAC System
Level 2: Sub-System Code	<u>BB</u> : Two digit Sub-System code as defined by Tibah e.g. 01 for Air Condition Units under HVAC system
Level 3: Room Number	<u>CCCC</u> : Terminal room number as defined by Tibah e.g. M281
Level 4: Unique ID	<u>DDD</u> : Counter restarting at each room. e.g. 1,2,3, etc.

SAMPLE ELEMENT TAGGING WITH THE MINIMUM NUMBER OF LAYERS

Tagging schemes need to take into account the need to track location independent assets or assets that may be relocated, decommissioned and later recommissioned. Tracking the lifecycle of an asset without the proper tagging element management, deleting any element from the model will cause deleting all its history.

Space Definition

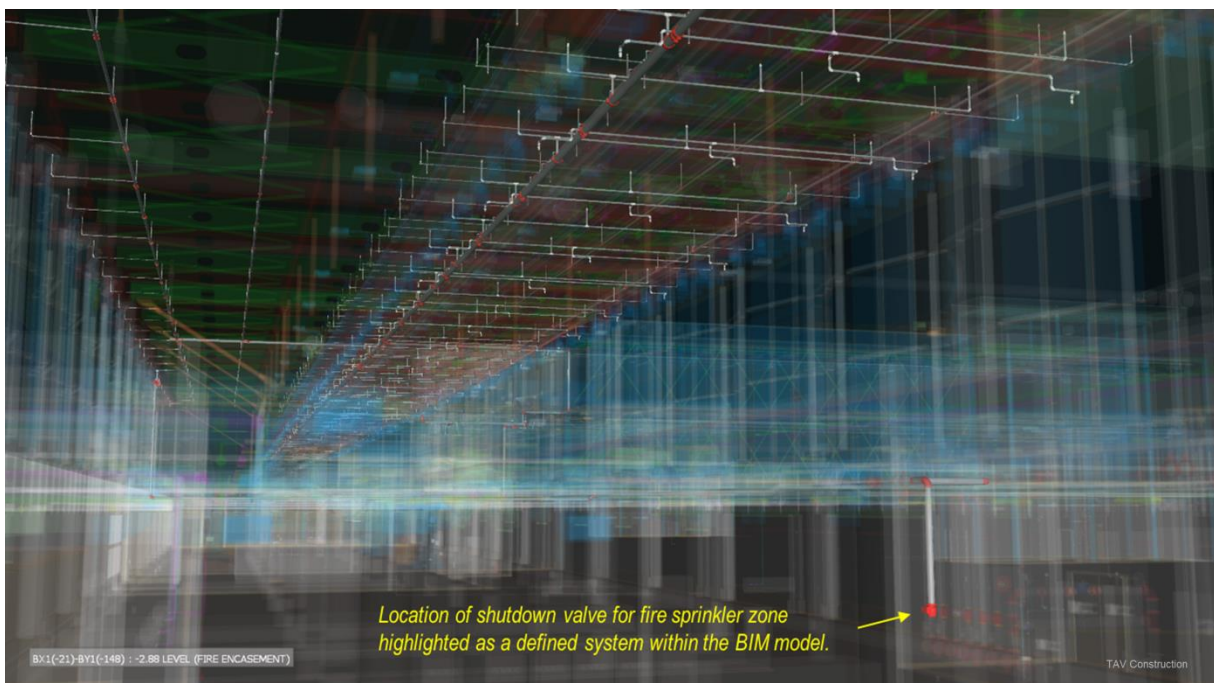
Room, space and zone definitions are important for operations and asset management. We would like to know where assets are located. Typically, rooms are defined by the volume enclosing the room layout from the structural slab level to the upper structural slab soffit. This is to ensure all elements in the room including the mechanical equipment above suspended ceilings are captured. Large mezzanines may need to be separated vertically to emphasize equipment at high locations requiring special access.

Room and space identification in facilities are ever changing: during construction and at the beginning of operations all areas may be renumbered based on necessity. Room schedules need to be managed specifically before extracting data for FM. Similar to element tagging, space assignment must be rigorously checked through a QA/QC process defined in the BEP to prevent any faulty information.

System Definition

Along with assets defining the several systems is extremely useful for operators, for instance to track the all ductwork routing from a selected grill to the AHU. Tagging systems across the multiple BIM models require tagging to manage systems. Naming of the systems shall also be done by consulting with the operating FM staff.

Definition of systems having enormous number of members is a challenge in complex facilities. Additionally, one equipment in system will generally be a part of more than one system. All these systems should be defined in reference to a characteristic base equipment such as the main pump or AHU.



MODEL SHOWING SPRINKLER SYSTEM OF A GIVEN ZONE

It is practical to have the visual 3D models with the systems defined such as the HVAC systems, or the Fire Fighting system where FM staff can be easily visualize the nearest shut off valve of a particular zone from the model. This may not be a critical for mid-size project, but for a terminal building nearly a million square meters with more than 200 wet alarm valves, it is critical information during emergencies.

Challenges of Successful BIM-FM Integration

Expectations vs Specifications

As previously mentioned one of the main challenges to successful BIM delivery for FM are projects with:

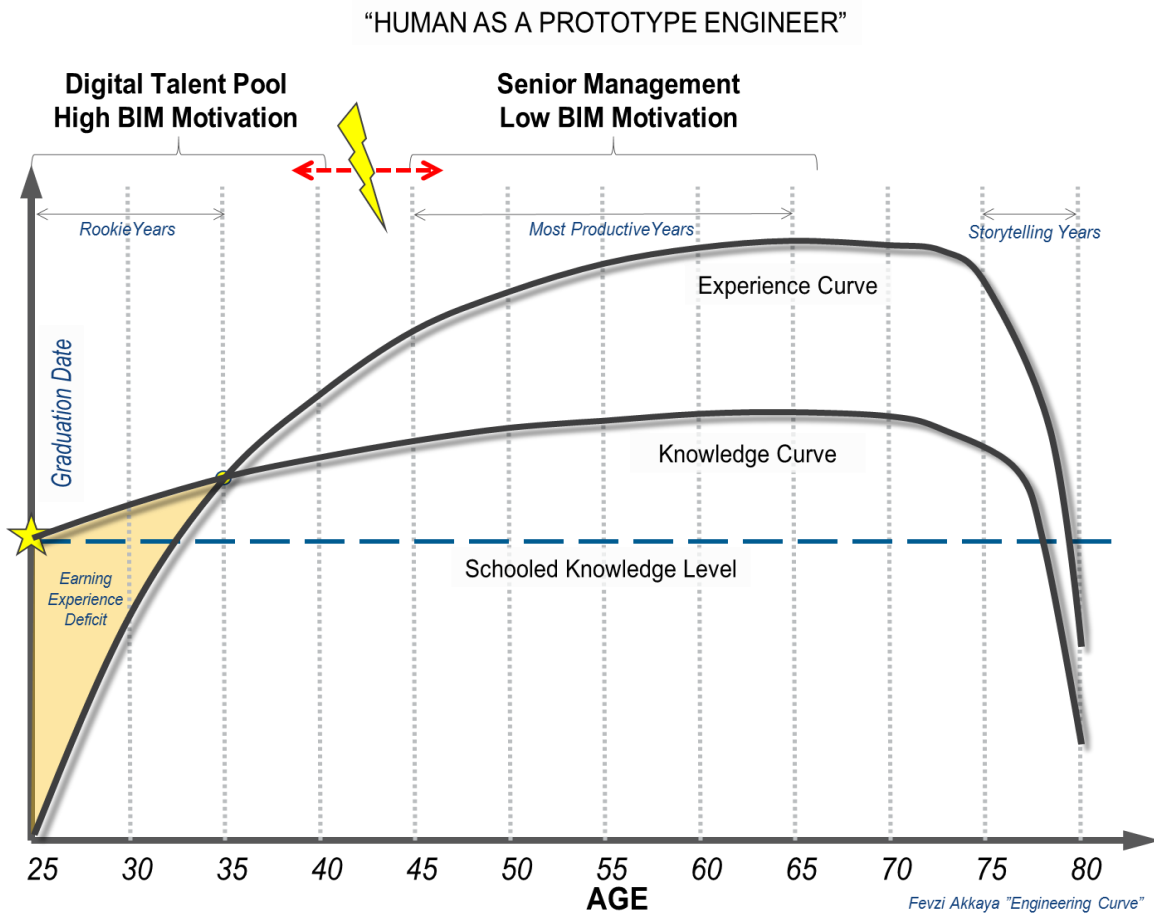
- Insufficient BIM requirements and/or specifications
- Broad requirements leading to scope gaps
- Extensive requirements lacking clear objectives and asset specific nomenclature

Whether the project defines single line BIM requirements or includes hundreds of pages of extensive requirements and a BEP – it does not help if the objectives and end uses are not clearly communicated. Project Specifications are currently the main driver for BIM implementation on projects. Insufficiently defined BIM scope makes budgeting for BIM on projects difficult. Delivery BIM for FM requires clarity on the intent and the knowledge that it requires continuous care throughout the project. Unfortunately, the market is still pricing BIM as a model delivery. BIM models are not something to be purchased. BIM is not a product – it is a process.

Digital Talent

Currently setting up the organization to staff the authoring of BIM models from the early design phase through construction is challenging due to the limited sourcing of digital talent. The ability to draft or at least work with CAD drawings is a given and widely taught in engineering and architecture schools. Whereas BIM is relatively new and not prevalent. Companies faced with BIM requirements on their projects can use in-house talent is available, training staff, or out-source the scope.

Projects are now requiring positions with job titles that did not exist a few years ago. The digital talent pool with high BIM motivation and the more senior staff with lower BIM motivation creates experience gaps which need to be well managed. We are assigning responsibility to junior staff on projects that can operate the digital tools may yet lack the experience to produce the output needed for projects.



CURRENT BIM GAP WITH RESPECT TO EXPERIENCE AND KNOWLEDGE THROUGH ENGINEERS CAREER

While BIM is utilized as a tool to help reduce risks on projects, it also raises new risks with the additional workflows it introduces to projects. The generation and experience gap between will eventually close eliminating these risk, yet it something that currently needs to be dealt with.

BIM Resourcing

Companies ideally would have in-house resources to execute projects with BIM, those that lack or are short on BIM resources either close the gap through training their own workforce or out-source the scope altogether. The desirable scenario is having work executed with BIM as part of regular workflows – just as now with everybody comfortable producing 2D CAD drawings.

On large projects where the market is short on companies with sufficient BIM resources, qualified external BIM providers that clearly understand project BIM requirements should be nominated. Overall this approach in not desirable where timely delivery of coherent BIM models is at risk. With BIM resourcing outsourced, there is a gap between coordination and the model updates. There becomes additional overhead between the decision makers and modelers.

The ideal scenario during construction is having all the BIM effort on- site or at least represented and integrated with the design/engineering team. The subcontractors should also be set-up the same way where all the modeling-coordination-and decisions are done one site with staff fully involved and aware of the day-to-day activities and issues.

BIM Lifecycle Management

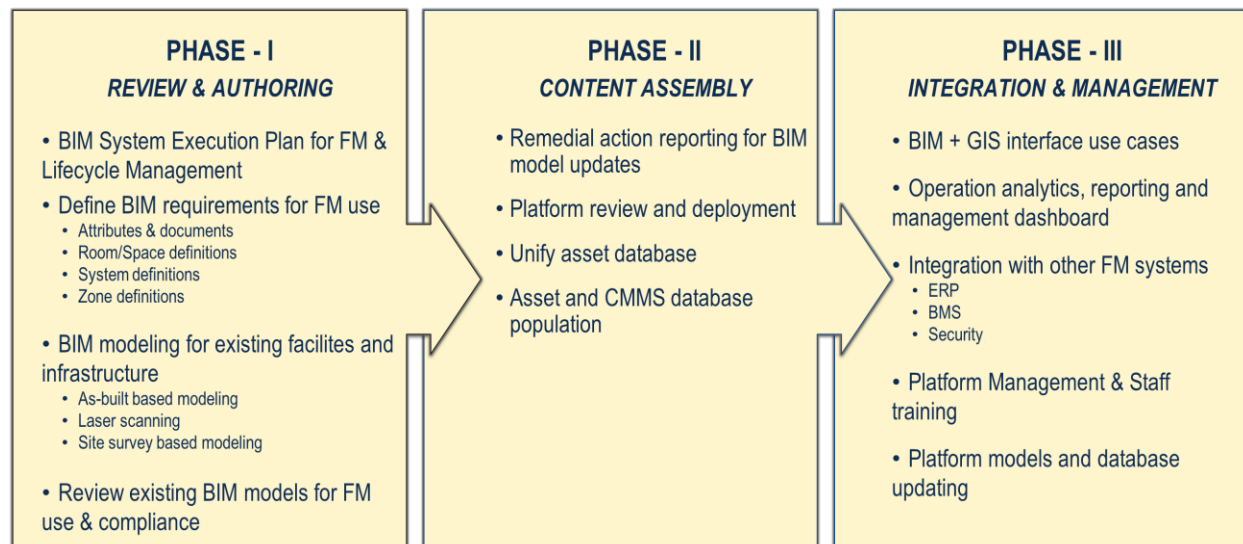
Another challenge is validating the content and then keeping models up to date reflecting the actual site conditions. There are several opportunities near the end of a project for BIM content validation with as-built conditions that are mutually beneficial: snagging, testing & commissioning and handover.

There will be several parties on site that can make use of the model for their own purposes while providing feedback for the models during their work on-site. Each room information is already in the model so that saves a lot of time filling datasheets for site review. This is also the case for operations where work orders and regular inspections should be integrated with model updates. There are several mobile device apps that can incorporate BIM models to checklists.

BIM as a Means to Integrate Digital Infrastructure

Roadmap: BIM/GIS FM Implementation for Integration and Management

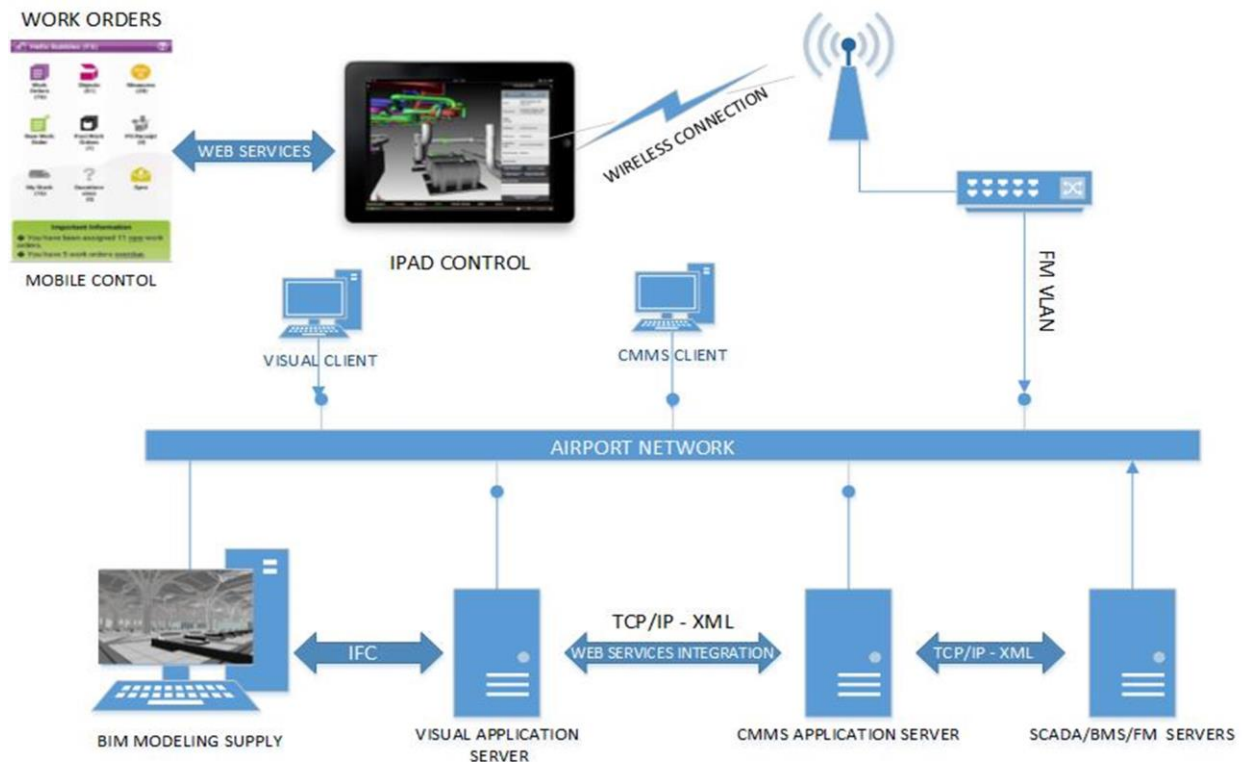
The following figure outlines the major steps to achieve an integrated digital infrastructure for FM and operations with BIM and GIS (Geographic Information System). These steps are essential to ensure a sustainable system for a cohesive interface for relevant data transactions.



ROADMAP FOR BIM AND GIS USE FOR FM DIGITAL INFRASTRUCTURE INTEGRATION AND MANAGEMENT

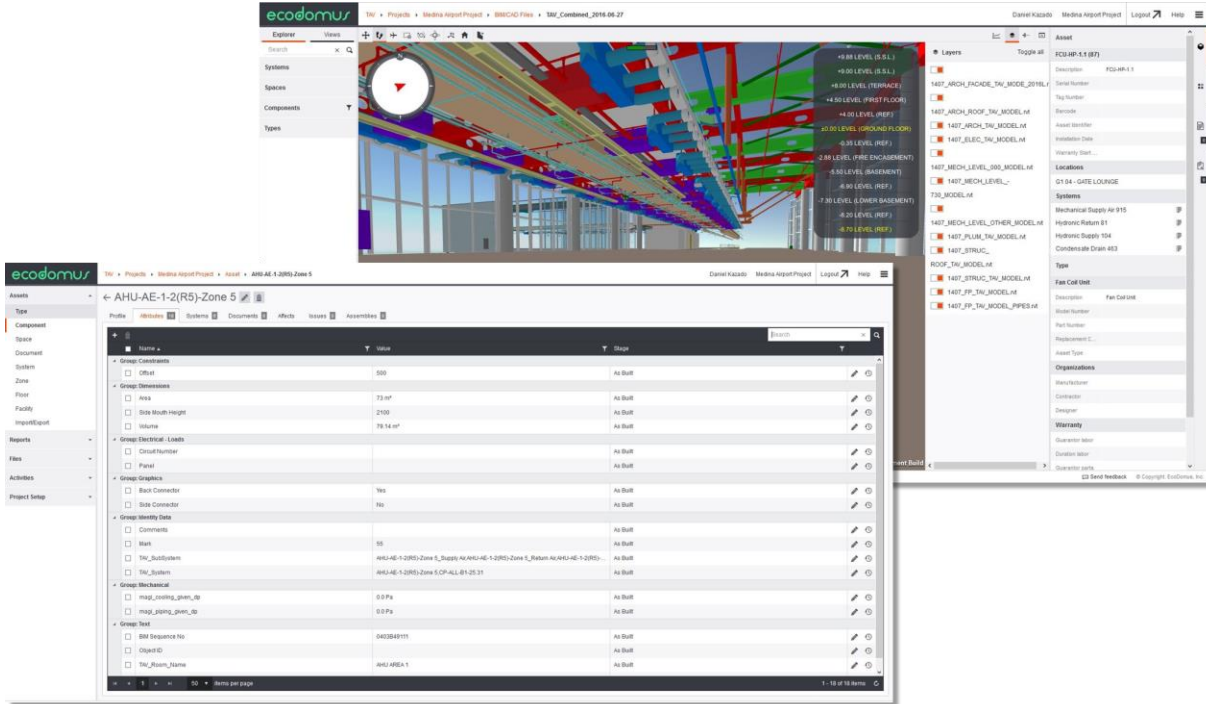
Interoperability is Key

Pre-engineering content prior to modeling is important if we want BIM content to be utilized with other systems. How the data is authored, shared and stored is a strategic decision: Do you keep all the data within a single source and sync? Or do you continuously sync data between the multiple systems? Or do you delineate the various functions to various systems and map data from one system to another?



BIM-GIS-SYSTEM INTEGRATION STRATEGY

BIM-FM Integration software provides access to asset and operational data through the BIM model. It enables quality control of the content. On the site using mobile devices and work orders are opened/closed or interrogated along with other relevant information such as drawings, documents etc.



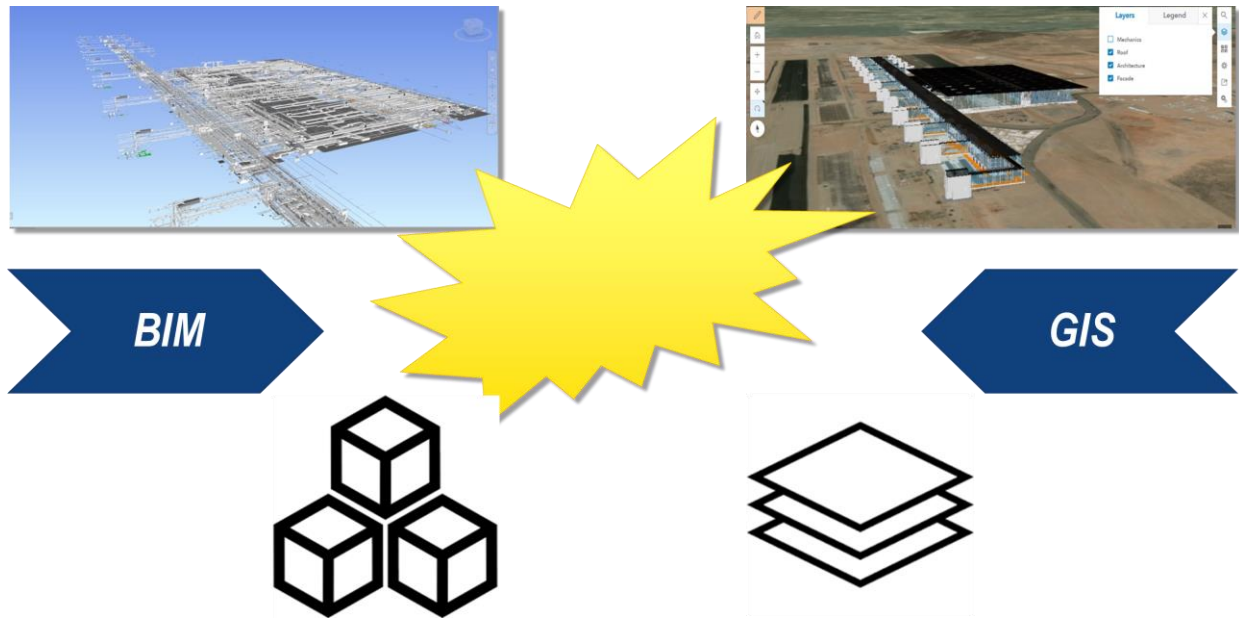
ACCESSING AND AUTHORIZING OPERATION AND ASSET CONTENT THROUGH BIM INTERFACE

Contextualize BIM Content with GIS

BIM is an excellent tool to author detailed models and content of the built environment. Representation of all systems and disciplines of a particular building is a composite of several models. Facilities are digitally represented with the composite of several buildings and infrastructure.

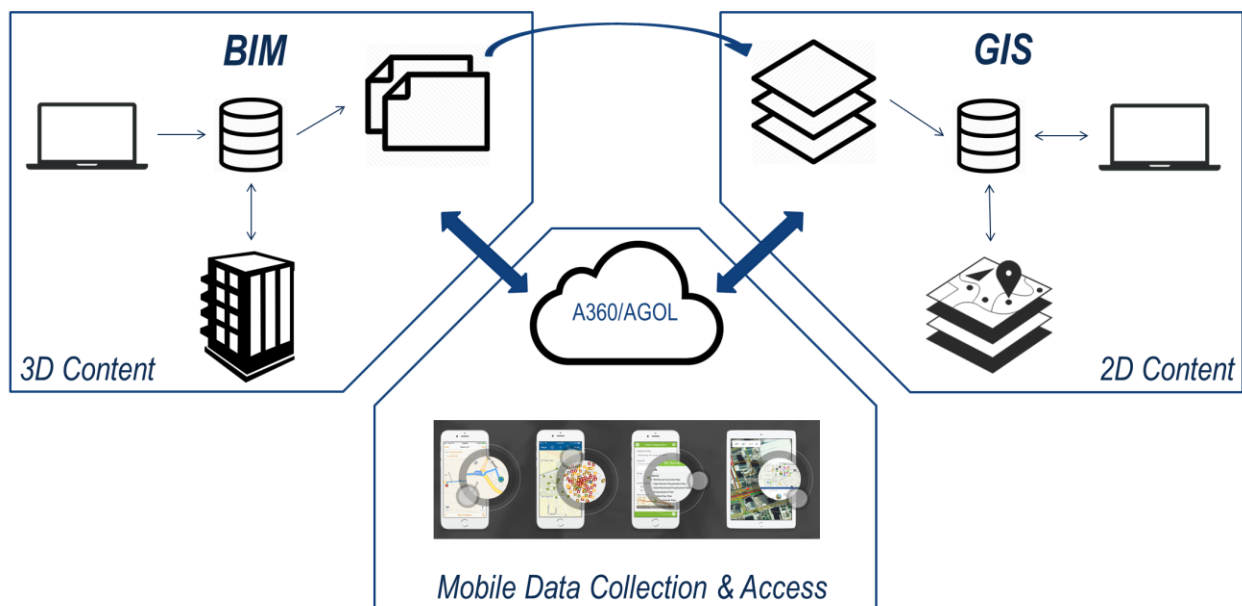
With large models there are practical challenges end users faces when trying to consume building content through the BIM interface. One is the lack of contextual relationship of the building model with the overall facility setting. Using large 3D models on mobile device is not always smooth and moving around a digital environment on site on a tablet when you have work to do is not always practical. End users trying these systems have issues finding rooms in 3D models or navigating and filtering out the viewpoint one needed.

Combining BIM models within the GIS environment with creative hybrid modeling techniques. With GIS all the models of the whole facility are combined in a full digital representation with proper geographical relationship. Models can be imported 3D or flattened to 2D layers. In the 2D format GIS allows a more familiar interface for site staff to interact with greater ease. The amount of data pushed on the mobile device can be reduced by one or two order of magnitudes which relieves connectivity issues with the models.



CONTEXTUALIZING BIM CONTENT WITH GIS

However, translating BIM to GIS is not trivial. Practical and efficient workflows for data reduction and model translations are a must to have the two systems maintain their sync with the continuous updates. BIM models remain to be the primary authoring source of both the geometry and content. Geometry and content are pushed from BIM models to GIS and flattened. Content data is maintained for consistency.



INTEGRATING BIM AND GIS DATA

Digitizing Workflows

At the end of the day we are striving to digitize workflows for technical FM. The purpose of developing the digital infrastructure using BIM models is to make existing work cycles more effective and reporting accurate as well as automated as much as possible.

The typical flow of information between various parties regarding issues and their rectification follows:

- An issue or defect is submitted – at an airport this would be the Technical Operations Center (TOC)
- The TOC creates a work order and dispatch the relevant staff or sub-contractor
- The issue is rectified
- Dispatcher confirms and closes the work order
- The work order process is monitored and reported periodically

Several functions during construction and operations work the same basic workflow described here. Whether it is QA/QC, HSA etc.

A use case can be demonstrated for energy management. Energy simulations executed based on BIM models coupled with design information is used to form a benchmark for the actual performance measured by the thermostat information relayed via the BMS. Such monitoring can be used to monitor the health of the HVAC system and point to any faults in the system while metering use.

In a world where big data is brought up everywhere – in construction data is still not easily collected digitally in a manner that can be holistically merged and analyzed. Well defined data procurement around BIM and other digital means provides fantastic promises seen in other industries. The tools are available and it is a matter of well thought out organizational implementation. The aim is to utilize these tools in every possible way to enhance the bottom line of the business of construction and operations.

Conclusion

This effort has become a case study for us and for the industry in which several challenges have been addressed, opening the way for future possibilities. Using BIM as a platform to integrate existing digital infrastructure—such as Computerized Maintenance Management System (CMMS) and Building Management/Automation System (BMS/BAS)—enables better analytics, performance for operations, energy management, sustainability, business, and more.