



EFFECTIVE FACILITY MANAGEMENT AND OPERATIONS VIA A BIM-BASED INTEGRATED INFORMATION SYSTEM

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ROYAL INSTITUTE
OF TECHNOLOGY



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Problem - Interoperability in FM&O

Interoperability: the ability that data generated by any one party can be properly interpreted by all other parties (Shen et al. 2010).

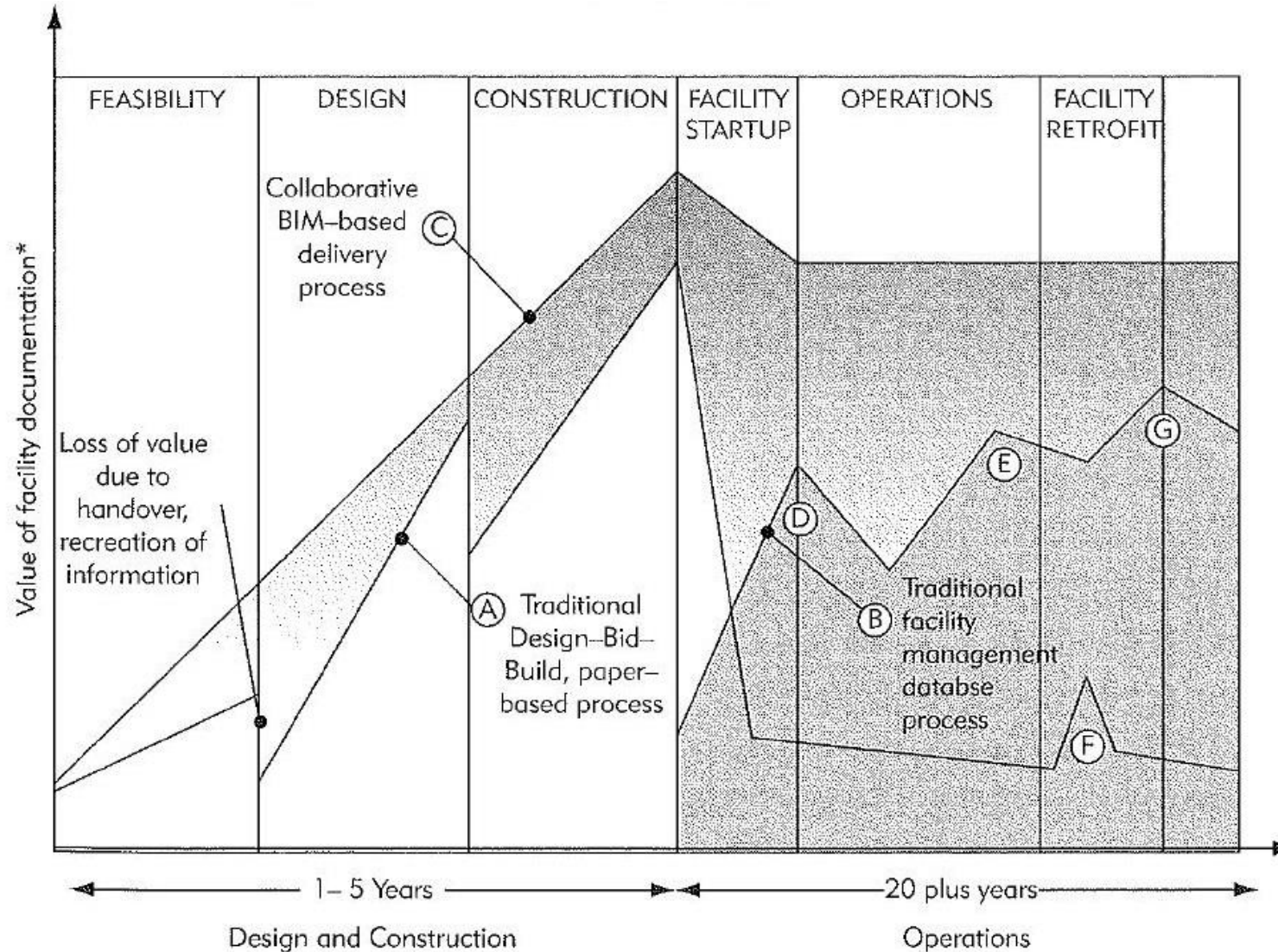
- Facilities account for 10 to 40 of total assets of the companies.
(Zeckhauser & Silverman, 1983; Rodriguez & Sirmans, 1996; Bon et al., 2002)
- In the building industry, 85 percent of life-cycle costs of a facility occur post construction.
(Jordani, 2010)
- Availability of required information is central to efficient facility management and operation (FM&O) (Teicholz 2013).
- Two-thirds of the loss originating from issues with interoperability in building industry is associated with the FM&O phase (NIST, 2004).
- This amount constitutes 12.4 percent of the mean total annual FM&O costs (Eastman et al., 2011).

Building Information Modeling / Management (BIM)



- A modeling technology and associated set of processes to produce, communicate, and analyze building models (Eastman et al., 2011).
- BIM is a data rich digital representation cataloging the physical and functional characteristics of design and construction. Its purpose is to make the design information explicit, so that the design intent and program can be immediately understood and automatically evaluated (GSA, 2007).
- A set of interacting policies, processes and technologies producing a methodology to manage the essential building design and project data in digital format throughout the building's life-cycle (Succar, 2009).

BIM / Interoperability in FM&O



(Eastman et al., 2011)

BIM for FM - Obstacles



Information Technology

(East et al., 2013; Parsanezhad & Tarandi, 2013)



Workflows

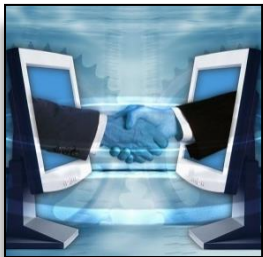


Contracts

- Industry Foundation Classes: technologies, processes, and people (Owen, 2009)
- BIM framework fields of activity: technology, process, and policy (Succar, 2009)

Purpose

- ❑ To summarize the status quo of the building information management technologies applied in the facility management and operations (FM&O) sector and identifying prevailing issues
- ❑ To devise technical solutions for those issues based on an exemplar case

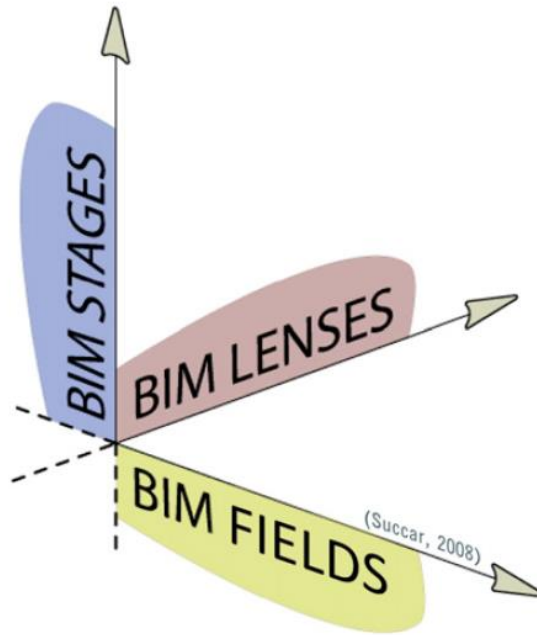


Information Technology Workflows Contracts

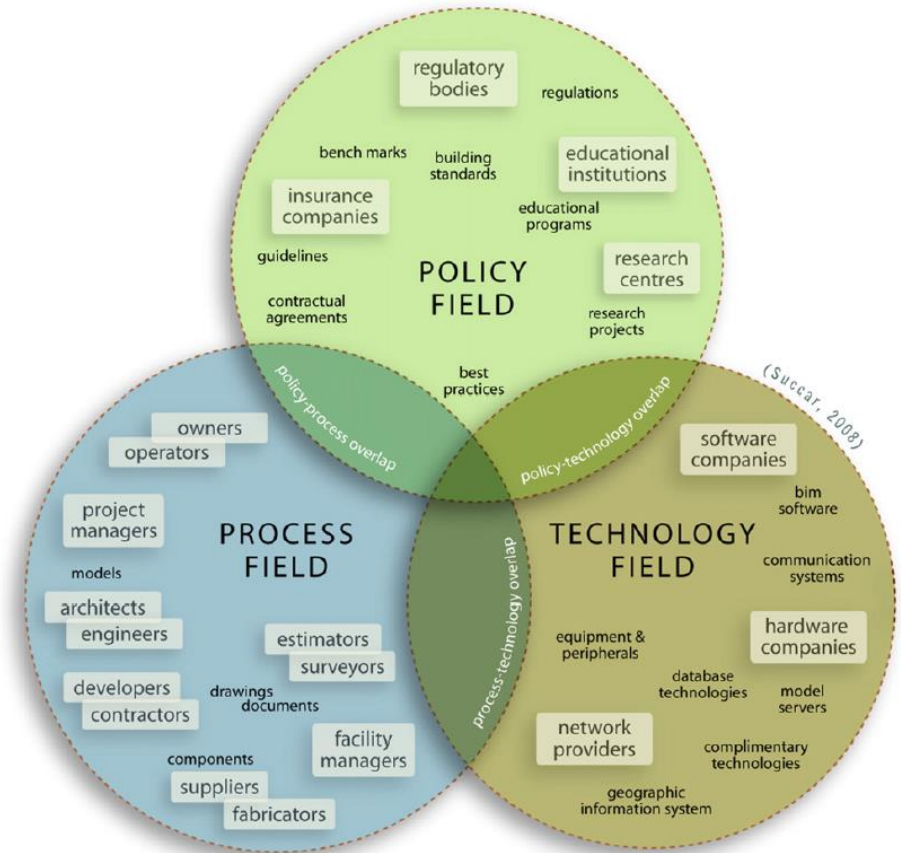
Approach - Theory

- BIM Framework: a research and delivery foundation that maps domain dynamics and allows AECO stakeholders to understand underlying knowledge structures and negotiate BIM implementation requirements (Succar, 2009).
- New frameworks may be invented for new conditions or substantial changes and applied by the researcher for representing stereotyped situations (Minsky, 1974).

BIM Framework



Succar's tri-axial knowledge model



- BIM lenses: layers of analysis that “allow the domain researcher to selectively focus on any aspect of the AECO industry and generate knowledge views that either (a) highlight observables which meet the research criteria or (b) filter out those that do not”
- Mesoscopic Lens implies medium coverage, focus and detail

Approach - Methodology

- Qualitative study
- Grounded theory research rather than theory-driven and linear models (Flick, 2009) (Glaser & Strauss, 1967).
- Literature on ad-hoc solutions
- Information management configurations in eleven projects > issues
- Narrative and illustrative representation and reconstruction of a case project: less subjectivity and less distortion (Flick, 2009) (Bakis, Kagioglou, & Aouad, 2006) (Morse, 1998)
 - Primary selection
 - Good informant (Morse, 1998) (Flick, 2009; Patton, 2002)
 - Participant observation (Denzin, 1970)
- Analysis of data: three major categories of technological issues

State-of-the-art: FM&O digital tools and databases

- Paper documents
- Spreadsheets
- Computer-Aided Facility Management (CAFM) tools
 - **Examples:** FM:Interact (by FM:Systems), Archibus, AiM Space and Facilities Management (by AssetWorks)
- Computerized Maintenance Management Systems (CMMS's)
 - **Examples:** FAMIS by Accruent, IBM Maximo, Corrigio, WebTMA (by TMA Systems), and AiM Maintenance Management (by AssetWorks)
- Document Management Systems (DMS's)
- Building Management Systems (BMS's)
- Building Automation Systems (BAS's)



State-of-the-art: Applied technical solutions

Table 1: Today's technical solutions for optimizing information transfer from BIM to FM software

Solution	Technical approach(es) for linking information
Using spreadsheets as simple document indexing tools	Hyperlinking
Using spreadsheets according to COBie guidelines	Hyperlinking, exchanging and synchronizing data
Using the IFC format for exchanging building information among BIM and FM&O systems	Exchanging and synchronizing data (embedding and integrating data to the recipient system)
Coupling CMMS's with BIMs via Application Programming Interfaces (API)	"Portal solution"
Using proprietary middleware such as EcoDomus, Onuma Systems, FM:Interact	"Portal solution"

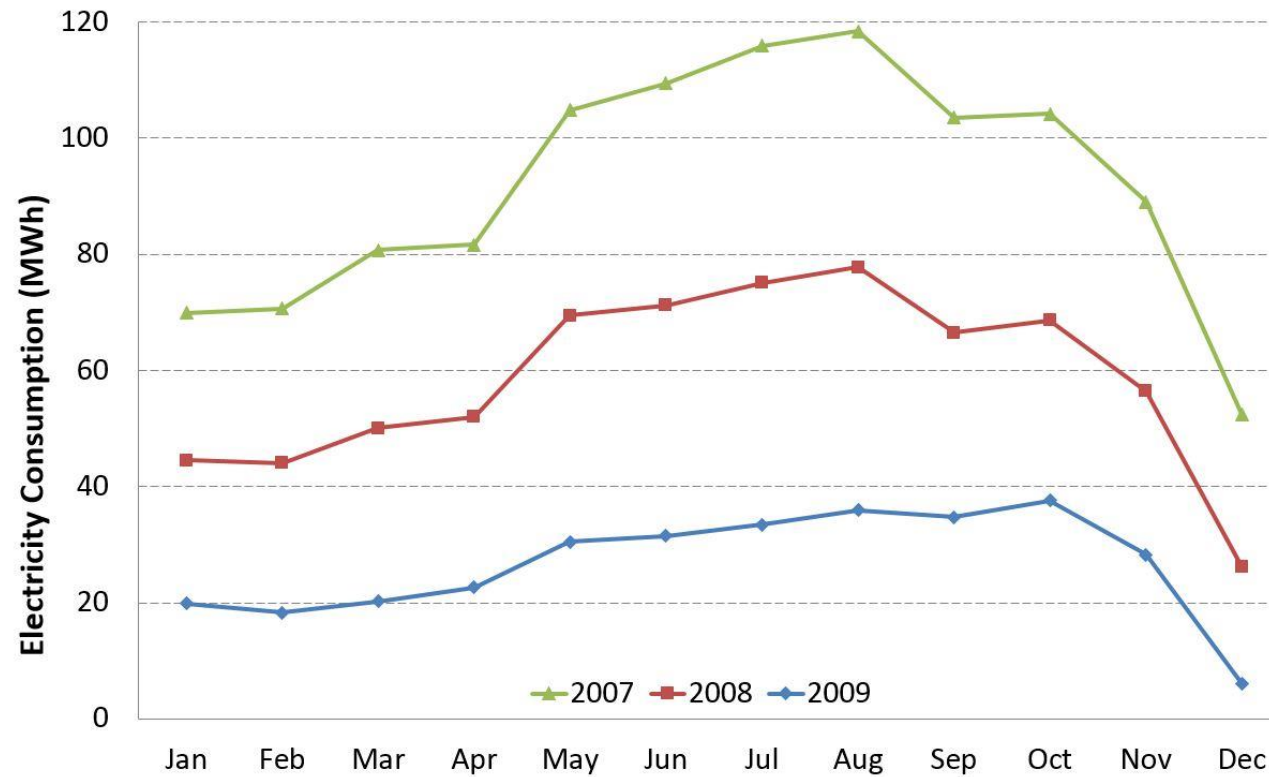
State-of-the-art: Recent Projects Progresses and Problems

- **Sydney Opera House:** central data repository (Ding et al., 2009; Sabol, 2008; Schevers et al., 2007)
- **Ryan Companies:** USC FM, a searchable Navisworks model (Jordani, 2010)
- **General Services Administration's (GSA) project** (Teicholz, 2013)
- **A federal project in New Jersey:** Onuma Systems was for validating COBie deliverables (Teicholz, 2013)
- **A federal project in Minneapolis** (Teicholz, 2013)
- **A courthouse project:** integrating disparate BIM, CMMS, and BAS systems of : OmniClass Table 13 and Unifomat, inventory spreadsheets (Teicholz, 2013)
- **Mathworks project:** FM:Interact-Revit integration, COBie (Aldaham et al., 2013)
- **An existing health science center:** TOKMO (EcoDomus) via COBie, OmniClas (Beatty et al., 2013)
- **A construction project at the University of South California:** links to BAS, CMMS, and DMS; *Master attributes*, OmniClass for equipment names, and National CAD standards (Aspurez and Lewis, 2013)
- **Construction project of Xavier University in Cincinnati, Ohio:** FM:Interact Space Management, Revit CMMS (WebTMA) (Afedizie et al., 2013)
- **A residential hall at University of Wisconsin:** Revit exported to IFC format, imported to the CMMS (TMA Systems) + and a SQL database (Lewis, 2013a)
- **A renovation project in the University of Chicago:** CMMS (Maximo) (Lewis, 2013b)

Facility Management and Operations at UNITEC Institute Of Technology

- Three campuses in Auckland, New Zealand
- Around 23,000 students and about 800 staff members
- Assets with a total value of approximately US\$300 million (current replacement value, CRV)
- FM department is managed under the directorate of “Strategic Property Development”
- Divisions of the FM department:
Planning, Projects, FM, Administration Services, Compliance and Cleaning contracts, Security, Transportation, Signage, and Inwards Goods





Significant energy saving after FM BIM implementation

Case Study: Background

The BIM project started in 2008 for assisting day to day operations

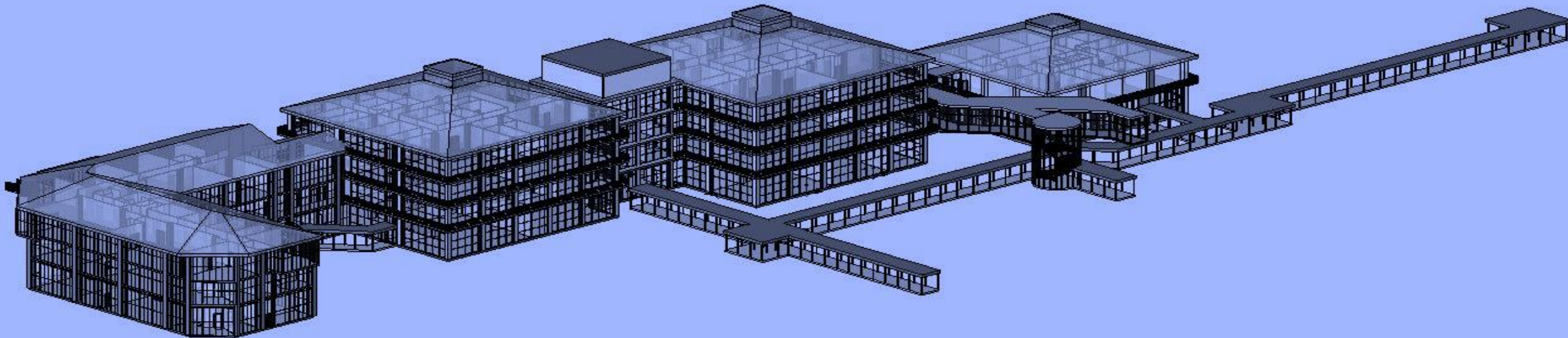
- “FM Desktop” by Autodesk was discontinued
- Archibus only dealt with 2D plans and was not BIM compatible
- Commercial software applications all used proprietary database systems and did not allow for customization

Two mainstream activities:

- a. Constructing object-based models of the campus**
- b. Developing a BIM FM integration system**

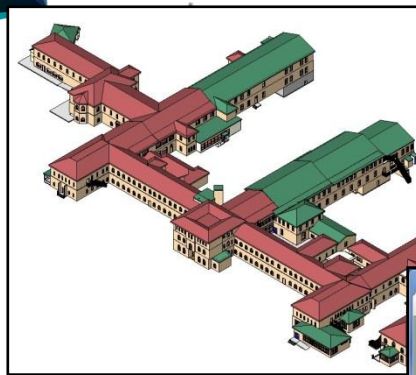
Case Study: a. Modeling

- A site survey to obtain the finished floor levels.
- An as-built survey for capturing wall construction type, wall linings, floor linings, special features, major fixtures and fittings, type of doors and windows, etc.
- Photos were taken as part of the survey as visual aid.
- Aerial photographs were used as visual data
- Using CAD "base drawings", a total of 191 buildings were modeled in Revit over 4 years and in three different stages.



Case Study: b. BIM FM system

- A software tool was developed for use within Revit to automatically update or synchronize data from the Revit model with a centralized database in a SQL Server DBMS
- A number of downstream applications were created to access the centralized database



FM BIM

FM BMS

Syllabus

BMS

FM Maintenance

Complementary
data

Maintenance

FM GROUNDS

Select a location grid containing trees: [1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15] [16] [17] [18] [19] [20] [21] [22] [23] [24] [25] [26] [27] [28] [29] [30] [31] [32] [33] [34] [35] [36] [37] [38] [39] [40] [41] [42] [43] [44] [45] [46] [47] [48] [49] [50] [51] [52] [53] [54] [55] [56] [57] [58] [59] [60] [61] [62] [63] [64] [65] [66] [67] [68] [69] [70] [71] [72] [73] [74] [75] [76] [77] [78] [79] [80] [81] [82] [83] [84] [85] [86] [87] [88] [89] [90] [91] [92] [93] [94] [95] [96] [97] [98] [99] [100]

ID	Location	Family Name	Age	Tree Type	Last updated by
10001	Location 1	Family 1	Age 1	Tree Type 1	Updated by 1
10002	Location 2	Family 2	Age 2	Tree Type 2	Updated by 2
10003	Location 3	Family 3	Age 3	Tree Type 3	Updated by 3
10004	Location 4	Family 4	Age 4	Tree Type 4	Updated by 4
10005	Location 5	Family 5	Age 5	Tree Type 5	Updated by 5
10006	Location 6	Family 6	Age 6	Tree Type 6	Updated by 6
10007	Location 7	Family 7	Age 7	Tree Type 7	Updated by 7
10008	Location 8	Family 8	Age 8	Tree Type 8	Updated by 8
10009	Location 9	Family 9	Age 9	Tree Type 9	Updated by 9
10010	Location 10	Family 10	Age 10	Tree Type 10	Updated by 10
10011	Location 11	Family 11	Age 11	Tree Type 11	Updated by 11
10012	Location 12	Family 12	Age 12	Tree Type 12	Updated by 12
10013	Location 13	Family 13	Age 13	Tree Type 13	Updated by 13
10014	Location 14	Family 14	Age 14	Tree Type 14	Updated by 14
10015	Location 15	Family 15	Age 15	Tree Type 15	Updated by 15
10016	Location 16	Family 16	Age 16	Tree Type 16	Updated by 16
10017	Location 17	Family 17	Age 17	Tree Type 17	Updated by 17
10018	Location 18	Family 18	Age 18	Tree Type 18	Updated by 18
10019	Location 19	Family 19	Age 19	Tree Type 19	Updated by 19
10020	Location 20	Family 20	Age 20	Tree Type 20	Updated by 20
10021	Location 21	Family 21	Age 21	Tree Type 21	Updated by 21
10022	Location 22	Family 22	Age 22	Tree Type 22	Updated by 22
10023	Location 23	Family 23	Age 23	Tree Type 23	Updated by 23
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10026	Location 26	Family 26	Age 26	Tree Type 26	Updated by 26
10027	Location 27	Family 27	Age 27	Tree Type 27	Updated by 27
10028	Location 28	Family 28	Age 28	Tree Type 28	Updated by 28
10029	Location 29	Family 29	Age 29	Tree Type 29	Updated by 29
10030	Location 30	Family 30	Age 30	Tree Type 30	Updated by 30
10031	Location 31	Family 31	Age 31	Tree Type 31	Updated by 31
10032	Location 32	Family 32	Age 32	Tree Type 32	Updated by 32
10033	Location 33	Family 33	Age 33	Tree Type 33	Updated by 33
10034	Location 34	Family 34	Age 34	Tree Type 34	Updated by 34
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10062	Location 62	Family 62	Age 62	Tree Type 62	Updated by 62
10063	Location 63	Family 63	Age 63	Tree Type 63	Updated by 63
10064	Location 64	Family 64	Age 64	Tree Type 64	Updated by 64
10065	Location 65	Family 65	Age 65	Tree Type 65	Updated by 65
10066	Location 66	Family 66	Age 66	Tree Type 66	Updated by 66
10067	Location 67	Family 67	Age 67	Tree Type 67	Updated by 67
10068	Location 68	Family 68	Age 68	Tree Type 68	Updated by 68
10069	Location 69	Family 69	Age 69	Tree Type 69	Updated by 69
10070	Location 70	Family 70	Age 70	Tree Type 70	Updated by 70
10071	Location 71	Family 71	Age 71	Tree Type 71	Updated by 71
10072	Location 72	Family 72	Age 72	Tree Type 72	Updated by 72
10073	Location 73	Family 73	Age 73	Tree Type 73	Updated by 73
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10075	Location 75	Family 75	Age 75	Tree Type 75	Updated by 75
10076	Location 76	Family 76	Age 76	Tree Type 76	Updated by 76
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10081	Location 81	Family 81	Age 81	Tree Type 81	Updated by 81
10082	Location 82	Family 82	Age 82	Tree Type 82	Updated by 82
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10085	Location 85	Family 85	Age 85	Tree Type 85	Updated by 85
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10091	Location 91	Family 91	Age 91	Tree Type 91	Updated by 91
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10098	Location 98	Family 98	Age 98	Tree Type 98	Updated by 98
10099	Location 99	Family 99	Age 99	Tree Type 99	Updated by 99
10100	Location 100	Family 100	Age 100	Tree Type 100	Updated by 100

FMActions

Manage Jobs View Jobs Payment/Notes AC Reports Historical Exp Help Order Admin Logout

First Name: [John] Last Name: [Doe] School/Department: [School] Date: [27 Aug 2013] Priority: [Low]

FM Help ID: FM1075939 Category: [Punting] Notes: [No Action] Status: [Open]

Description: [Ref 4879 1510-27 The shower door is broken]

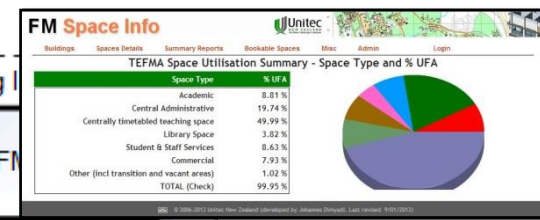
AC Name: [] Choose File [No file chosen] Replicate: [] Replicate: []

AC No: [] Vendor: [] New Job Requests: []

Create/Update - Email: [] Assigned by: [] Job Assigned Externally: []

Order # [] Order # [] Standing Order: [] Job # (Status): []

Lookup: [] Standing Order: []



FM SpaceView

Building Level: [1] Plan View: [1] Campus Plan: [1] (All Rooms)							
Room No	Room Name	Area	Volume	Height	Year Built	Room Type	Room Status
101	Room 101	100	1000	10	2010	Classroom	Occupied
102	Room 102	100	1000	10	2010	Classroom	Occupied
103	Room 103	100	1000	10	2010	Classroom	Occupied
104	Room 104	100	1000	10	2010	Classroom	Occupied
105	Room 105	100	1000	10	2010	Classroom	Occupied
106	Room 106	100	1000	10	2010	Classroom	Occupied
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197	Room 197	100	1000	10	2010	Classroom	Occupied
198	Room 198	100	1000	10	2010	Classroom	Occupied
199	Room 199	100	1000	10	2010	Classroom	Occupied
200	Room 200	100	1000	10	2010	Classroom	Occupied

Legend (Rooms)

101 1000000

101 at this place: 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200

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116	Room 116	100	1000	10	2010	Classroom	Occupied
117	Room 117	100	1000	10	2010	Classroom	Occupied
118	Room 118	100	1000	10	2010	Classroom	Occupied
119	Room 119	100	1000	10	2010	Classroom	Occupied
120	Room 120	100	1000	10	2010	Classroom	Occupied
121	Room 121	100	1000	10	2010	Classroom	Occupied
122	Room 122	100	1000	10	2010	Classroom	Occupied
123	Room 123	100	1000	10	2010	Classroom	Occupied
124	Room 124	100	1000	10	2010	Classroom	Occupied
125	Room 125	100	1000	10	2010	Classroom	Occupied
126	Room 126	100	1000	10	2010	Classroom	Occupied
127	Room 127	100	1000	10	2010	Classroom	Occupied
128	Room 128	100	1000	10	2010	Classroom	Occupied
129	Room 129	100	1000	10	2010	Classroom	Occupied
130	Room 130	100	1000	10	2010	Classroom	Occupied
131	Room 131	100	1000	10	2010	Classroom	Occupied
132	Room 132	100	1000	10	2010	Classroom	Occupied
133	Room 133	100	1000	10	2010	Classroom	Occupied
134	Room 134	100	1000	10	2010	Classroom	Occupied
135	Room 135	100	1000	10	2010	Classroom	Occupied
136	Room 136	100	1000	10	2010	Classroom	Occupied
137	Room 137	100	1000	10	2010	Classroom	Occupied
138	Room 138	100	1000	10	2010	Classroom	Occupied
139	Room 139	100	1000	10	2010	Classroom	Occupied
140	Room 140	100	1000	10	2010	Classroom	Occupied
141	Room 141	100	1000	10	2010	Classroom	Occupied
142	Room 142	100	1000	10	2010	Classroom	Occupied
143	Room 143	100	1000	10	2010	Classroom	Occupied
144	Room 144	100	1000	10	2010	Classroom	Occupied
145	Room 145	100	1000	10	2010	Classroom	Occupied
146	Room 146	100	1000	10	2010	Classroom	Occupied
147	Room 147	100	1000	10	2010	Classroom	Occupied
148	Room 148	100	1000	10	2010	Classroom	Occupied
149	Room 149	100	1000	10	2010	Classroom	Occupied
150	Room 150	100	1000	10	2010	Classroom	Occupied
151	Room 151	100	1000	10	2010	Classroom	Occupied
152	Room 152	100	1000	10	2010	Classroom	Occupied
153	Room 153	100	1000	10	2010	Classroom	Occupied
154	Room 154	100	1000	10	2010	Classroom	Occupied
155	Room 155	100	100				

Results

Issues with current FM&O information systems

Provisions in Unitec's FM System

Issues with as-designed and as-built information

<ul style="list-style-type: none"> Issues with identifying which data are important for FM&O 	<p>The solution has been developed by the FM department of Unitec and thus directly addresses the requirements of their FM team on information types and LODs.</p>
<ul style="list-style-type: none"> Issues with specifying LODs required for the FM model 	<p>See above.</p>
<ul style="list-style-type: none"> Varying information requirements according to the organizational role of the FM&O actors 	<p>See above.</p>
<ul style="list-style-type: none"> Non-useful information coming from design- and construction-intent models 	<p>BIM models were constructed and populated in conformity with the needs of the FM&O staff.</p>
<ul style="list-style-type: none"> The variety of industry-wide standards, local naming conventions, and data classification structures, and established colloquial names deployed in various FM&O information sources of the facility 	<p>An in-house developed BIM Standard and Conventions handbook is used, which is based loosely on commonly used industry standards.</p>

Results

Issues with current FM&O information systems

Provisions in Unitec's FM System

Issues with FM&O systems

<ul style="list-style-type: none"> Proprietary database systems not allowing for customization 	<p>An industry standard, DBMS (SQL Server-ISO/IEC 9075), has been utilized to maximize data interoperability and to facilitate system maintenance. Further efforts for using IFC more centrally in the system are in progress.</p>
<ul style="list-style-type: none"> Lack of knowledge for specifying a CMMS early in the design phase. 	<p>Not applicable to this project since the system was developed for existing facilities.</p>
<ul style="list-style-type: none"> Information fields in the CMMS's not matching those in the BIM authoring tool 	<p>The same SQL DBMS that is derived from the BIM model also feeds information to the FM&O applications.</p>
<ul style="list-style-type: none"> Lack of direct integration or linking among the CMMS data with the BIM model 	<p>Unitec's FM applications suite has bidirectional links with the BIM models.</p>
<ul style="list-style-type: none"> Lack of interoperability among the CAFM system and the CMMS 	<p>Functionalities of both CMMS's and CAFM systems are incorporated into the web-based FM solution.</p>

Results

Issues with current FM&O information systems

Inefficient workflow processes

- Manual and time-taking querying and updating routines in CAMF systems such as overlaying polygons on 2D drawings
- The BIM systems and models not fully integrating with the FM&O workflow
- Issues with updating as-built models after construction

Provisions in Unitec's FM System

FM Space and FM Space View provide access to a set of BIM-generated floor plans in various scales.

FM Help controls soliciting the information required for streamlining workflows from the BIM information resided in the SQL database, and channeling the query results to respective workflow applications, e.g. FM Actions, FM Security, FM Cleaning, and FM Vehicles. More specific applications such as FM Maintenance Costs and FM PropLease extract accurate and current information from BIM models for each FM&O task.

A custom-made software synchronizes the Revit model with the SQL DBMS after each construction project. FM Projects performs the synchronization procedure.