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

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Problem - Interoperability in FM&O

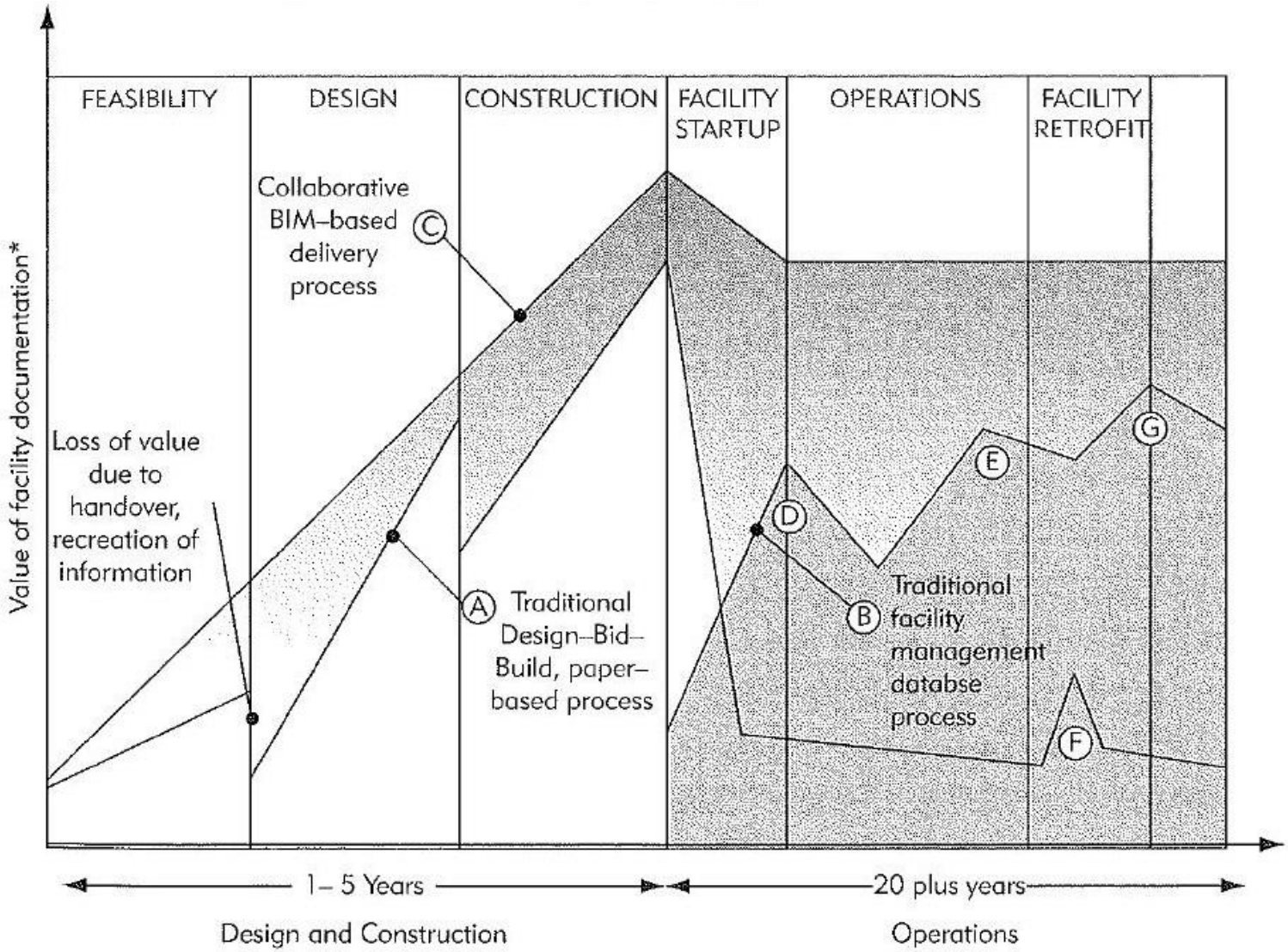
Interoperability: the ability that data generated by any one party can be properly interpreted by all other parties (Shen et al. 2010).

- 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

Workflows

Contracts

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

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

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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

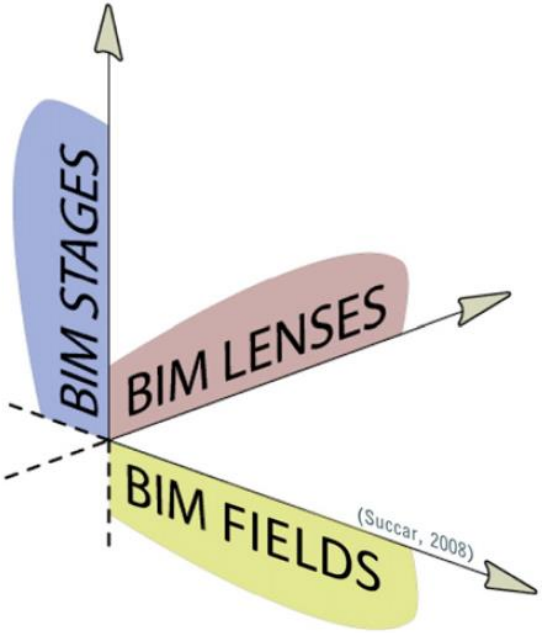
Information Technology Workflows Contracts

Approach - Theory

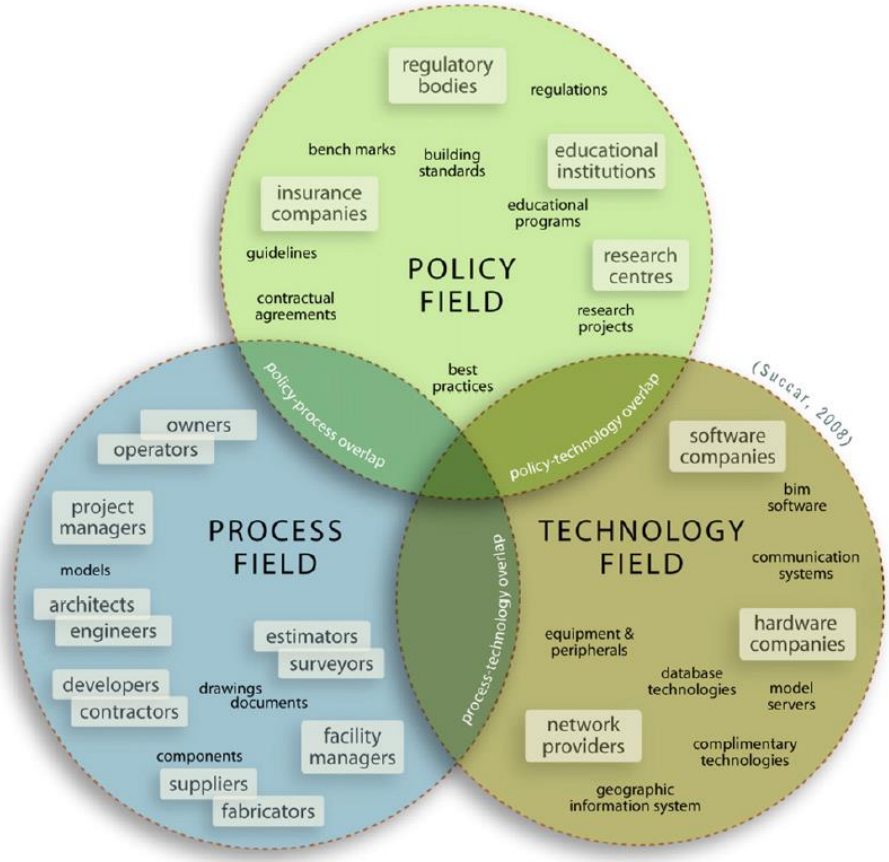
- BIM Framework: a research and delivery foundation that maps domain dynamics and allows AECO stakeholders to understand underlying knowledge structures and negotiate BIM implementation requirements (Succar, 2009).

- 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, Corrigo, 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"

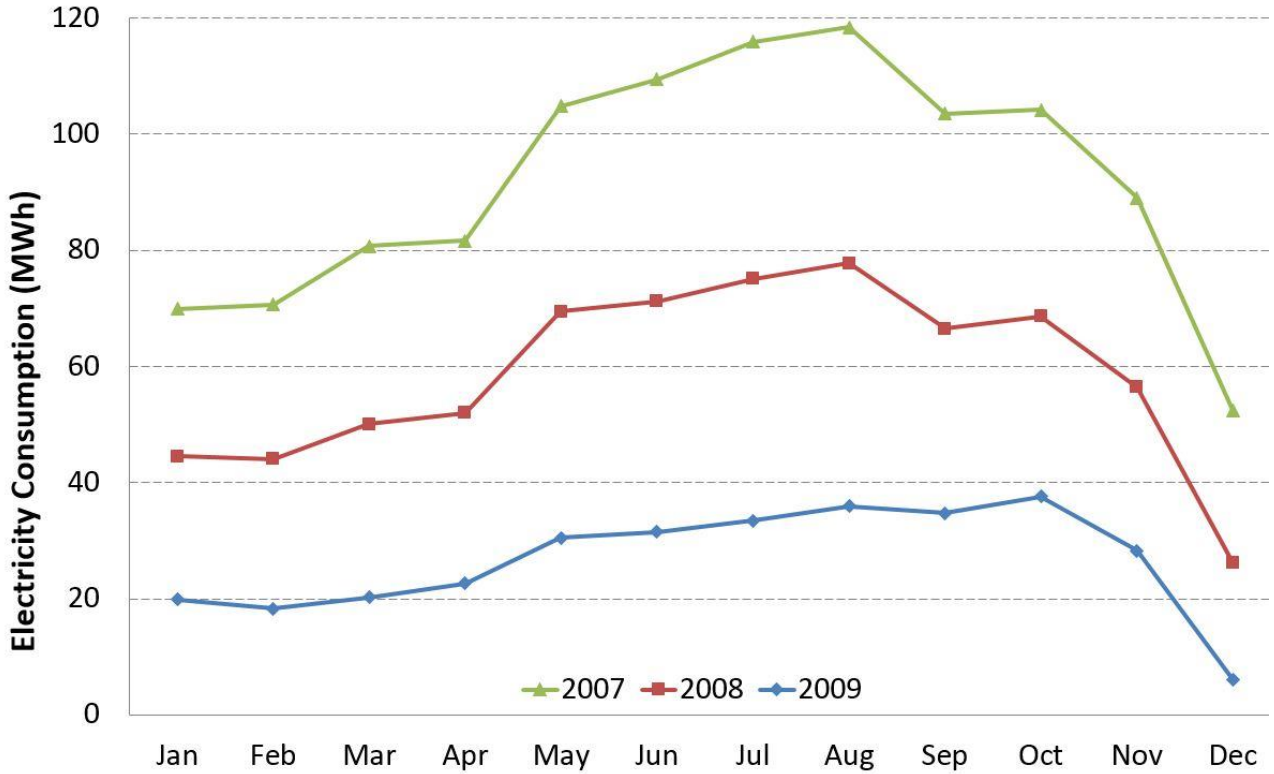
State-of-the-art: Recent Projects Progresses and Problems

- **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 Jersy:** 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 Uniformat, 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 Californi**a: 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 (TMASystems) + and a SQL database (Lewis, 2013a)
- **A renovation project in the University of Chicago**,:CMMS (Maximo)(Lewis, 2013b)

Case Study

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

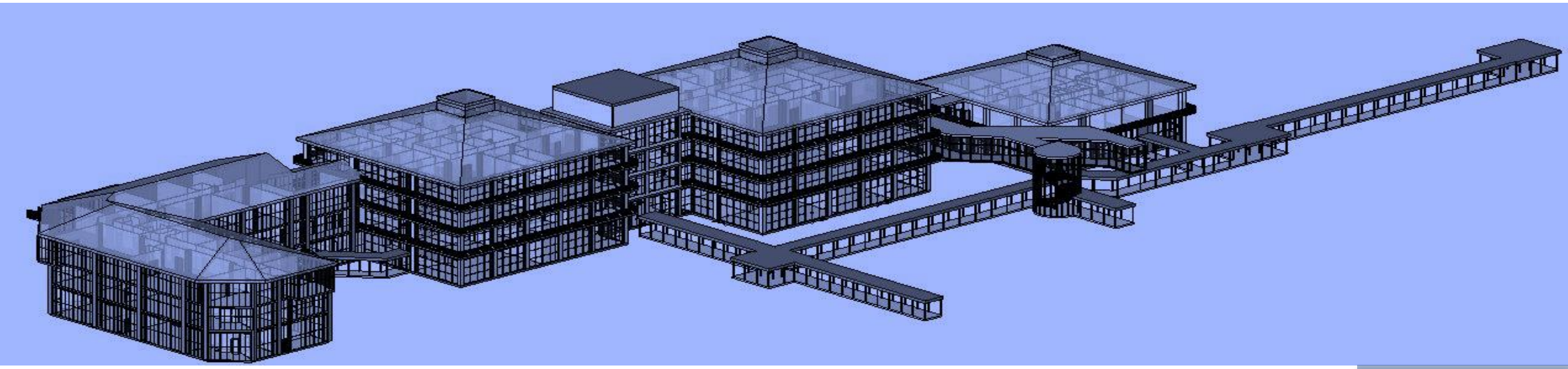
- “FM Desktop” by Autodesk was discontinued
- Archibus only dealt with 2D plans and was not BIM compatible
- Commercial software applications all used proprietary database systems and did not allow for customization

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

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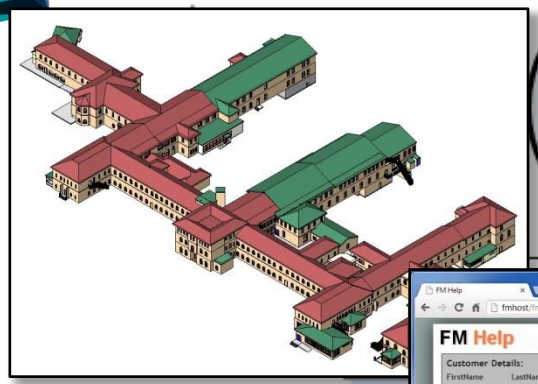

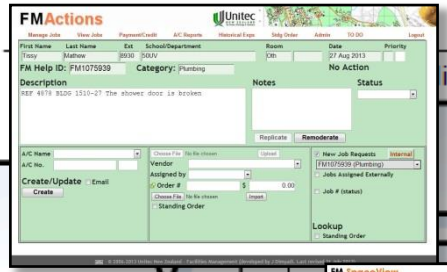

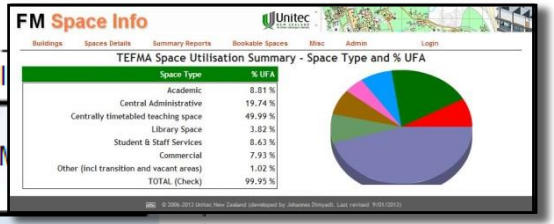

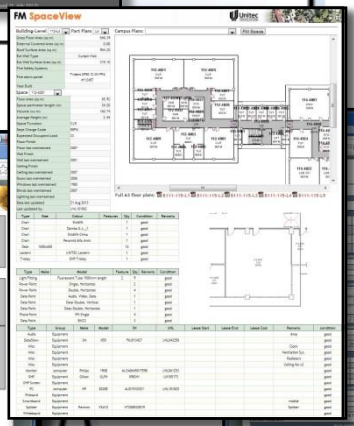

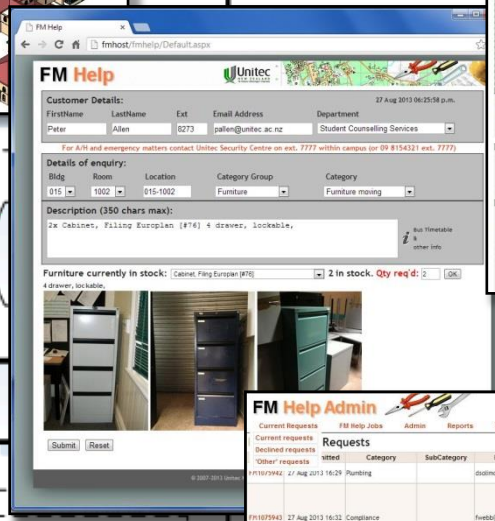

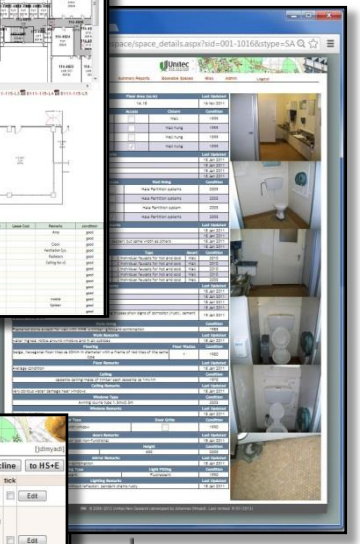

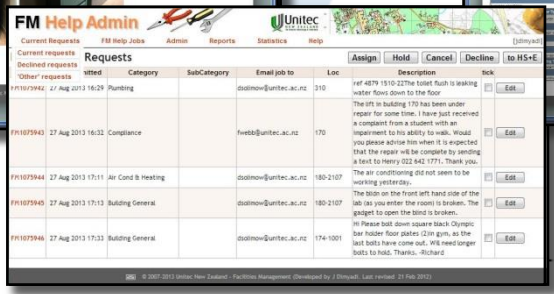

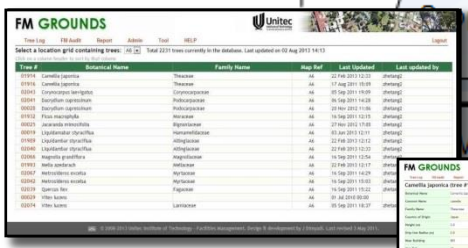

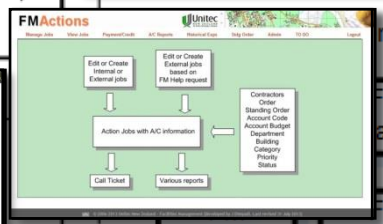

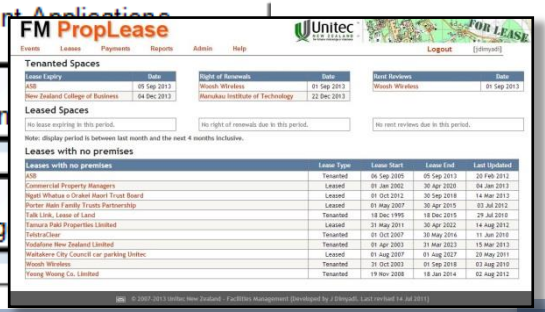

FM BIM

FM BMS

Syllabus+

BMS

FM Maintenance

plementary data

Maintenance

Security

Signag

Results

Issues with current FM&O information systems	Provisions in Unitec's FM System
Issues with as-designed and as-built information	
▪ Issues with identifying which data are important for FM&O	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.
▪ Issues with specifying LODs required for the FM model	See above.
▪ Varying information requirements according to the organizational role of the FM&O actors	See above.
▪ Non-useful information coming from design- and construction-intent models	BIM models were constructed and populated in conformity with the needs of the FM&O staff.
▪ 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	An in-house developed BIM Standard and Conventions handbook is used, which is based loosely on commonly used industry standards.

Results

Issues with current FM&O information systems	Provisions in Unitec's FM System
Issues with FM&O systems	
▪ Proprietary database systems not allowing for customization	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.
▪ Lack of knowledge for specifying a CMMS early in the design phase.	Not applicable to this project since the system was developed for existing facilities.
▪ Information fields in the CMMS's not matching those in the BIM authoring tool	The same SQL DBMS that is derived from the BIM model also feeds information to the FM&O applications.
▪ Lack of direct integration or linking among the CMMS data with the BIM model	Unitec's FM applications suite has bidirectional links with the BIM models.
▪ Lack of interoperability among the CAFM system and the CMMS	Functionalities of both CMMS's and CAFM systems are incorporated into the web-based FM solution.

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Results

Issues with current FM&O information systems	Provisions in Unitec's FM System
Inefficient workflow processes	
▪ Manual and time-taking querying and updating routines in CAMF systems such as overlaying polygons on 2D drawings	FM Space and FM Space View provide access to a set of BIM-generated floor plans in various scales.
▪ The BIM systems and models not fully integrating with the FM&O workflow	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.
▪ Issues with updating as-built models after construction	A custom-made software synchronizes the Revit model with the SQL DBMS after each construction project. FM Projects performs the synchronization procedure.