THE DEVELOPMENT OF INDUSTRY FOUNDATION CLASSES FOR FACILITIES MANAGEMENT

Industry foundation classes

J. WIX
AEC3/Jeffrey Wix Consulting, 30 Northfield Road, Thatcham, Berkshire, RG18 3ES, United Kingdom
K. YU
Timberline Software Corporation, 15195 NW Greenbrier Parkway, Beaverton, Oregon 97006 USA
P. S. OTTOSEN
Aarhus University, Building Department Ministry of Education, Aarhus, Denmark

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Abstract

The Industry Foundation Classes (IFCs) are integrated object models of building projects developed by the International Alliance for Interoperability (IAI). The IFCs support data sharing and exchange between industry processes across multiple domains such as architecture, structural engineering, building services, construction and facilities management (FM).

Maintenance management is one of the major functions in FM. It requires object information about building systems and components that are generated from different domain processes throughout different stages of the project development life cycle. Supported by the IFCs, this information can remain available until the building operation phase for maintenance processes to use. However, this information requirement must be defined based on detailed analysis of maintenance processes, and must be modeled using a formal modeling methodology, that is, the IFCs.

This paper describes the current and proposed developments in facilities management in the IAI, particularly for maintenance. It also discusses a planning ‘roadmap’ that identifies discrete packages of information that support FM processes.

The paper demonstrates a general maintenance process model developed to define the object requirements and interfaces for sharing maintenance information. Based on the process information analysis, the paper develops and presents a set of IFC object models that support the maintenance processes. Additionally, this paper discusses the necessities and capabilities of the IFC maintenance objects to access and utilize external information provided by various library resources.

Keywords: data modeling, facilities management, International Alliance for Interoperability, Industry Foundation Classes, maintenance management

1 Introduction

Facilities Management (FM) is at least as important as design and construction within the overall scope of the building construction industry. This is particularly so in developed countries where growing interests in the conservation of the building stock, management of energy use, social and environmental factors play a large part in determining development policy. Refurbish and maintenance business can account for nearly 50% of the annual revenues in building construction in some countries and it is probable that this figure will increase.

Most of the effort that has gone into the development of models for information exchange and sharing in building construction to date has been focused on design with a limited (but increasing) effort in the construction process. Little effort has yet gone into facilities management. In this respect, building construction is in the same state as other industry sectors such as process engineering and shipbuilding.

Within the International Alliance for Interoperability, there has been recognition of the increasingly important role of the Client and Building Owner as an actor in the overall building construction process [CB1 1998]. The Client/Building Owner (called the Client in this paper) is the actor for whom a building must fulfil its intended function and who pays the bills for ensuring that it does so. Client members of the IAI show a keen interest in the development of Facilities Management models and have driven this to become one of the key development areas for Industry Foundation Classes (IFCs) [IAI 1998a].

In this paper, the role of facilities management within the IAI [IAI 1998a] will be discussed and the development of the IFCs to meet facilities management needs explained. In particular, the development of a model for engineering maintenance will be presented and the objectives for the future development of this and other FM models considered.

2 Positioning the FM process

Whilst this paper emphasises on FM, it recognises the roles that are played in the information lifecycle by the requirements, design and construction processes (See Figure 1). Each of these has the role of information provider to the downstream process and, ultimately to the FM process. The state of the model following each process is of interest to the FM process in which the facilities manager ‘operates and manages’ the facility. For many highly technical buildings, the process of demolition and the maintenance of information to enable demolition is increasingly important and should be included as a high level process.

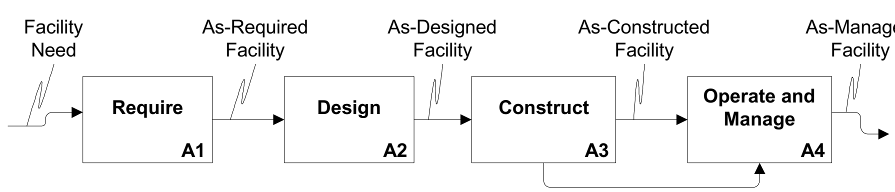

Fig. 1: Positioning the FM process

Facilities management is also important as a provider of information to other processes whether within the same facility or as a historical basis for other facilities. The importance of this is being recognised in the work on design feedback [BSRIA 1998]. Feedback is also important in the refurbishment of existing facilities. Where information on facilities operation and management is maintained, the need to 'discover' the existing situation by survey is reduced with a consequent benefit in design cost and a reduction in risk cost. Risk, as will be seen later, is a key factor in the business benefit of a FM model.

3 Lifecycle considerations

Buildings and engineering installations have a long life cycle. However, many of the components that go into them require maintenance and periodic replacement. Computer Aided Facilities Management (CAFM) systems have the capability to store maintenance histories. There are potential benefits to being able to share this information so that better evidence for investment decisions is available.

Within the United Kingdom, there is growth in the number of 'Design-Build-Operate' projects in which the responsibility for the entire facility rests with a single source, the revenue coming from payments made periodically by the building owner. Unlike projects that do not have an 'operate' component, life cycle costs can acquire significance in the profitability of the overall contract. It may be relevant to invest more in the relatively short 'Design-Build' component to use higher quality components and achieve a higher quality facility and to reduce the operating and maintenance costs as a result.

In the case of such projects, investment decisions may be made on a 20-30 year revenue expectation and not on the short-term capital costs of construction. Availability of life cycle information is crucial both to initial and ongoing investment decisions [Wix 1998].

4 Features and benefits

Traditionally the benefits of data exchange have been identified as a reduction in the amount of time that has to be spent re-keying data and minimisation of the risk of error that is inherent in such re-keying. Recent work within the FM group of IAI UK did identify this as a benefit but saw it as secondary to the reduction in risk that availability of information made possible. Table 1 lists the features of an interoperable FM model and the business benefits that can result from its use.

Continued work on the benefits of information exchange increasingly understands the reduction of risk. Frequently, this is equated with inherent quality built into 'intelligent and appropriate' information exchange. In a recent interview, a structural consultant identified a cost reduction of approximately 30% on a steelwork project directly attributable to increased quality and reduced risk. This 'hard' evidence, isolated though it still is, suggests that the expectations of Facilities Managers expressed above may be conservative.

Table 1: Features and benefits of data exchange

Features	*Benefits*
1. Operating and Maintenance information can be captured during project design and construction stages.	Reduces cost of asset list creation.
	Reduces the requirement for inspection visits and information gathering by the owner/operator after project hand over or by a maintenance contractor prior to taking on or taking over a maintenance contract.
2. Greater certainty that operating and maintenance information has been fully captured as it will not be missed or hidden during inspection visits.	Reduces risk in delivering the maintenance service. Risk value may be as high as 10% on a new project and, for comprehensive maintenance on an existing project it may be from 15% to 40% depending on age, condition and other factors. It is estimated that with higher quality and more complete information, the risk value can be at least halved without affecting profitability for the maintenance contractor.
3. Details of items requiring maintenance are complete at project hand over including item specification and supplier.	Reduces cost of order/invoice development for the client on shared risk contracts.
	Reduces recurring annual cost of 5% - 10% p.a. that normally applies due to not having all required data.
4. Complete and certain information with reduced cost of risk enables a maintenance contractor to provide an improved service at lower cost with equal or better profitability.	Increases the competitiveness of the maintenance contractor.
5. Access to operating and maintenance that can be directly incorporated into or referred to by maintenance management systems.	Accuracy of information will lead to better maintenance and improved maintenance scheduling.
6. Access to industry standard information that can be directly used for creating work orders.	Use of best practice information agreed on an industry wide basis will lead to improvements in the quality of maintenance work done.
	Best practice information will include for assessments on spares, tools, consumables and labour use that can lead to improved maintenance scheduling.
7. More complete and better information available during operation and maintenance.	More extensive queries and reports can be made that can lead to better analysis of the lifecycle and reliability of items being maintained.

5 FM scope and road map

There are many aspects of building operation that a facilities manager takes responsibility for. Some of these benefit greatly from the use of an interoperable FM, others less so. Within the IAI North America FM domain committee, typical FM functions have been identified including maintenance operation, property management and services (See Figure 2), acknowledging that all these identifiable FM functions have the fundamental characteristics of general project management functions such as scope, cost, time, work and risk management [Yu, Froese, and Grobler 1998]. A similar research by the IAI UK FM committee has come up with a similar FM function list.

6 Key maintenance processes

The IAI Engineering Maintenance project [IAI 1998d] identified a number of key processes: Identify Asset, Plan Maintenance, Do Maintenance, Record Maintenance, Use Maintenance Libraries, Purchase Equipment for Maintenance, and Account for Maintenance Costs (See Figure 3). A high level IAI project planning diagram was also developed that enables a series of maintenance processes to be identified for initial work whilst others will be subject to further development once the basic requirements are met (See Figure 4).

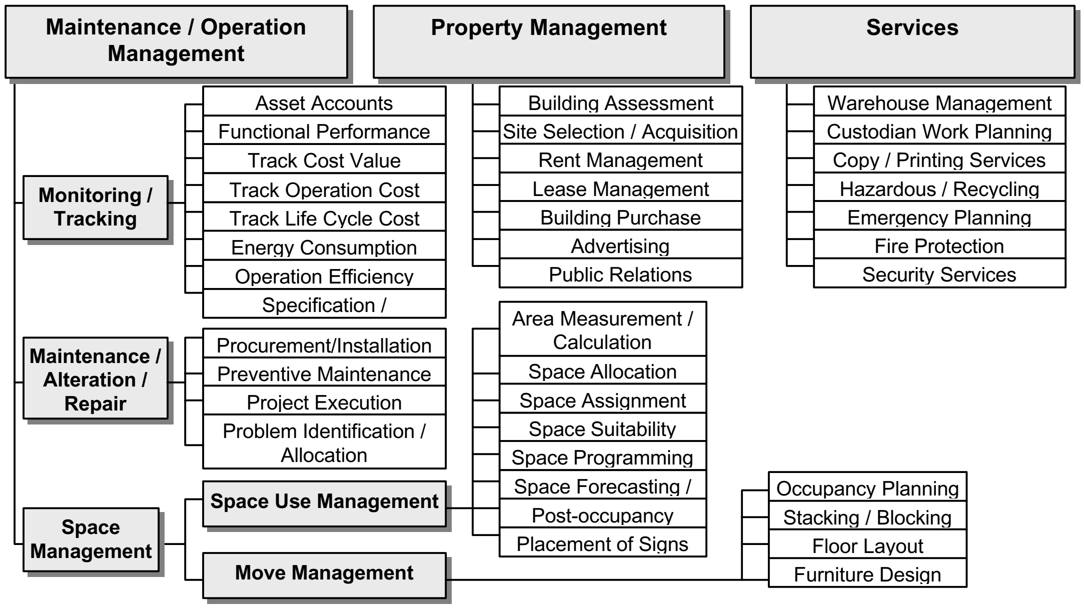

Fig. 2: Identifiable FM functions

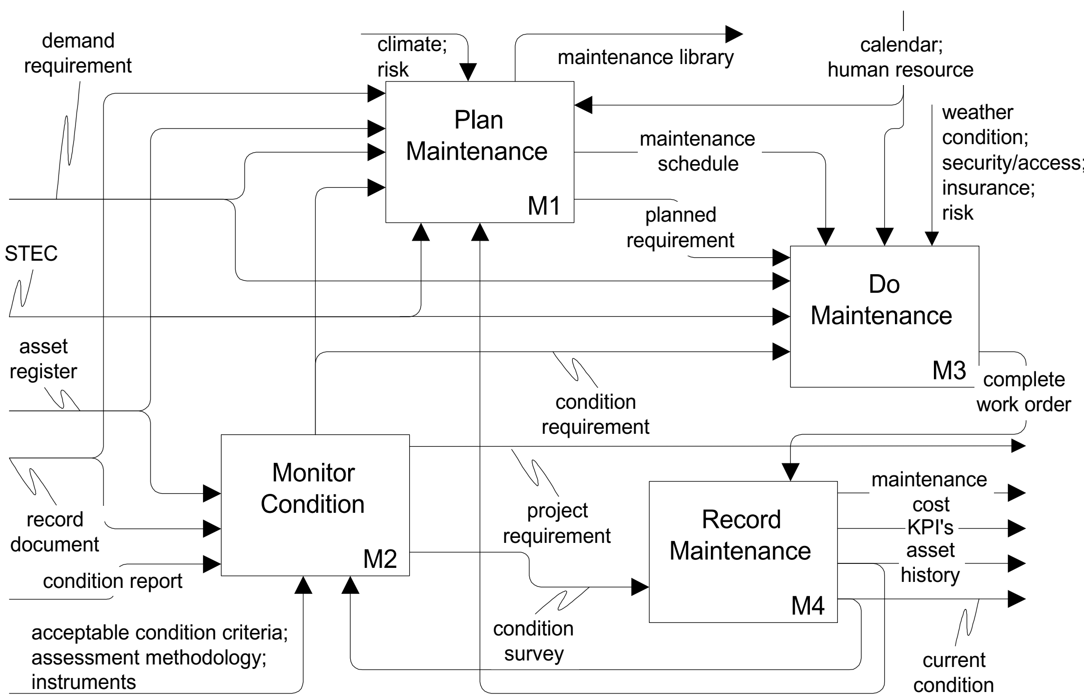

Fig. 3: Maintenance process model

7 Key maintenance concepts

Two key concepts are identified in defining engineering maintenance processes:

- The asset: i.e. a valued object on which maintenance work is to be performed.
- The work order: i.e. a contract, agreement, or request for the execution of the work.

An asset may be either a singular object or a group (or aggregation) acting as though they were singular (See Figure 5). In this case, 'singular' means for the purpose of maintenance work. From the point of view of an object model, an asset is similar in nature to any other grouping that combines to form an aggregated class. For instance, cost elements contain the idea of groups of things that have a single cost whilst a process may comprise a number of work tasks that have a single duration for completion of work. Similarly, an asset may be composed of individual component parts that require specific maintenance tasks. This idea of assembly is supported by the provision of a template class for the nesting of components within an assembly supported in the IFC Object Model [IAI 1998b].

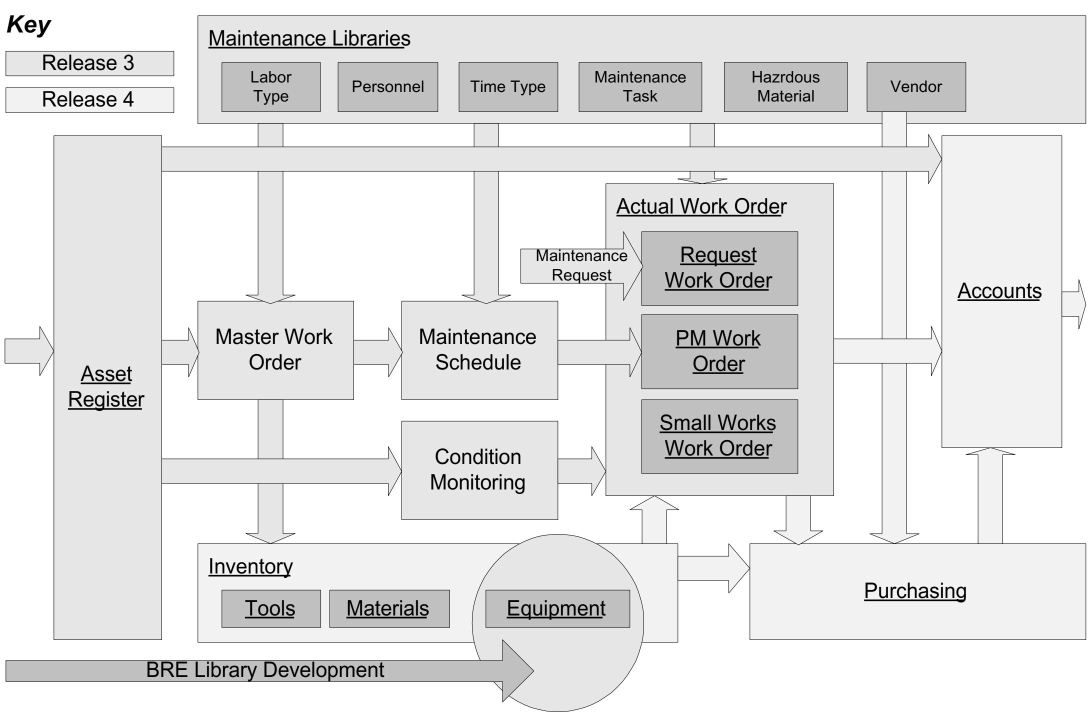

Fig. 4: IAI project planning road map for engineering maintenance

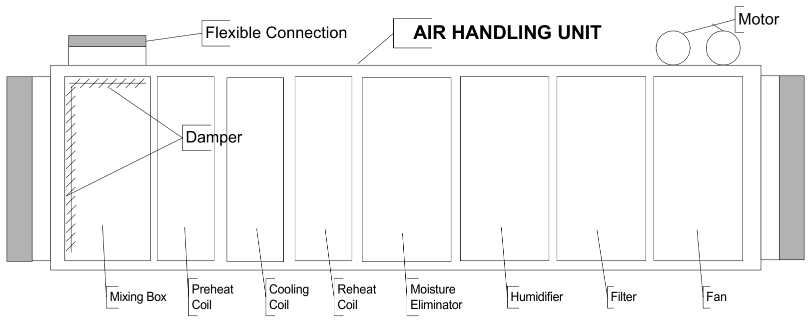

Fig. 5: An asset with grouped components-an air handling unit

The work order is explained above as expressing a contract between the issuer of the work order and the performers that carry out the process of maintenance. Although it may not be considered as a contract in the conventional sense of the term, it does in fact exhibit all the appropriate characteristics as follows:

- It has an author and a performer.
- It specifies work to be done.
- It specifies a deliver period.
- It identifies the skills and leadership necessary from the performers.
- It is uniquely identifiable.

Although the work started out on the basis of engineering maintenance, it has become clear that the identified ideas and processes apply to any work that can be construed as 'maintaining' that incorporates the ideas of an asset as something of value and that includes the issuing of an order to do work.

8 Maintenance planning

Initially, the sole objective of the project was to support the development of master work orders for planned preventive maintenance. A master work order acts as a template from which individual work orders can be created as needed. In looking at this topic, the possibility that standard data for work orders could be provided become apparent. Using the data requires either that an IFC work order class is structured so that it can accept the data or that an IFC property set is declared such that it can be bound to the model at runtime. Figure 6 shows an IFC model proposal for master work orders using simplified EXPRESS-G diagram.

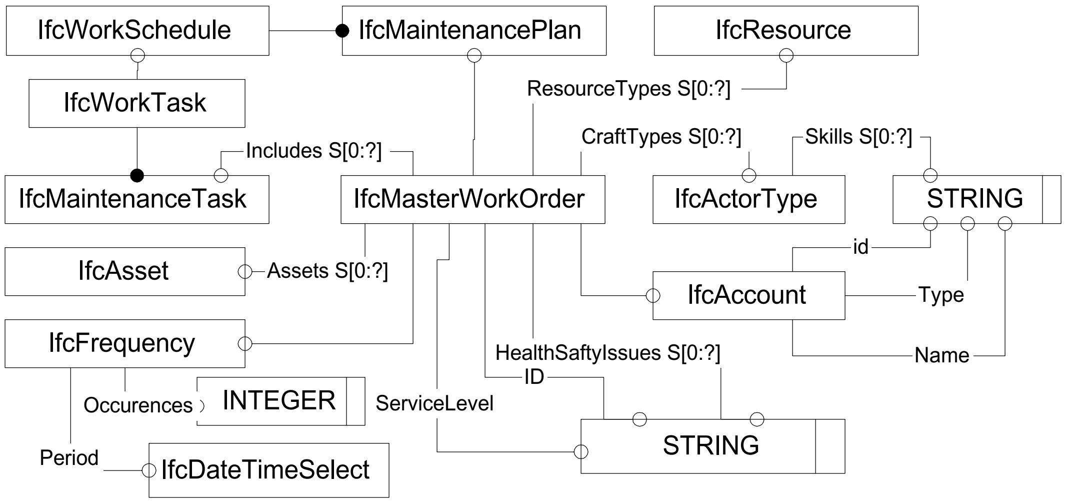

Fig. 6: IFC master work order

9 External library access

The use of the IFC property sets [IAI 1998b] is currently considered as the most relevant approach for external access of maintenance required data. Figure 7 depicts the basic state procedure of an external library access based on IFC models. However, the capabilities of this facility within the IFC Release 1.5.1 model are not sufficient [IAI 1998b]. In particular, the ability to reference a populated property set instance externally is not available. Figure 8 shows a conceptual IFC model proposal to enable external library objects to be referenced in a project using IFC property sets where both referenced library objects and property sets are registered and their links are retained.

To thoroughly deal with this problem, a support project is under way with the Building Research Establishment (BRE) [Nyambayo and Wix 1998] to enable the IFC property sets to access to external reference libraries. Whilst this is specifically targeted at maintenance information, it is potentially useful for any kind of information held externally.

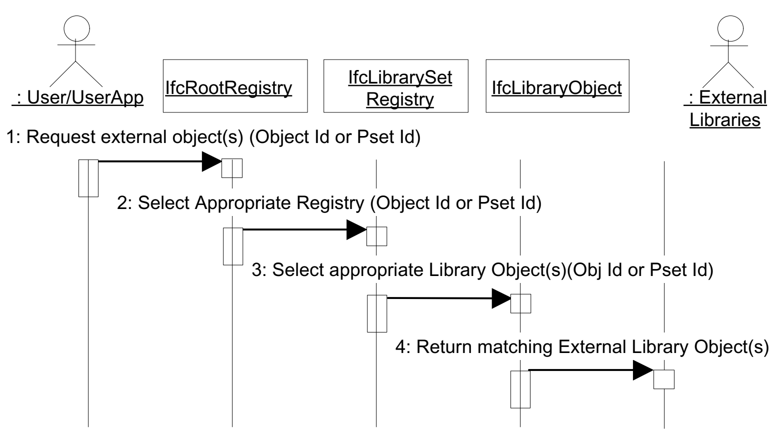

Fig. 7: External library access state procedure

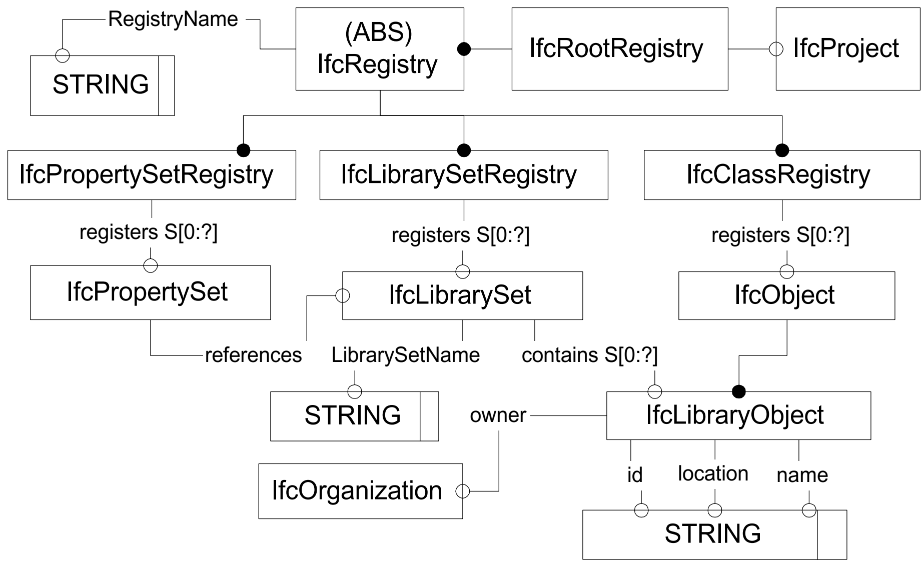

Fig. 8: IFC proposal for external library access using property sets

10 Demand maintenance, condition maintenance and small works

Even in best planned preventive maintenance programmes, a significant proportion of the work will be demand. Therefore, the model resulting from the project must also be able to accommodate work of this nature. Equally, maintenance programmes may be dictated by the current condition of assets. This could be termed "If it ain't broke, don't fix it" approach.

The condition of an asset may be such as to enable maintenance work to be planned or it may give rise to demand maintenance. Recording of condition is a vital tool in determining life cycle costs since it enables the application of predictive methods. Particularly important as a basis for the production are performance indicators, when the value of a given performance indicator may be used to trigger a maintenance event. At this stage, the project recognises the existence of such indicators but further work is required to establish the range of indicators that should be used.

Performance indication and life cycle considerations are important in determining when continued maintenance of an asset is no longer the most cost effective approach. In this circumstance, replacement is the more appropriate option and may be associated with other improvements as a 'small works' project. Whilst 'small works' is out of scope of current model development, its potential has to be recognised by a maintenance model so that feedback information can be used.

11 Design, construction and maintenance relationships

The advantage that interoperability offers is that project information, once created, remains available for any other process. For a project, we might express a hypothesis on 'conservation of information' such that:

'Information, once created, is not destroyed but can be used and transformed for other purposes.'

That is, information has a 'value entropy' in that, the further a project develops into its lifecycle, the more valuable the information becomes; it never becomes less valuable. The hypothesis can be demonstrated by Table 2 on an air-handling unit through principal life cycle stages. Thus, a key to reducing risk in maintenance is for maintenance applications to inter-operate with design and construction applications that understand the need to capture and make available relevant information.

Table 2: Design, construction and operation

Design:	Establishes a design parameter and sets down requirements for the configuration and performance of the air-handling unit. Even at this early stage, knowing the type of air-handling unit, the basic requirements of planned maintenance can be established.
Construction:	Selects the air handling unit to be used and places it in position. This adds specific information about the unit including manufacturer details that can be added to the more generic information from design. After generic information from design. After commissioning, the actual performance of the unit can be established and confirmed against design parameters.
Operate and Maintain:	All basic information requirements are available including warranties, parts requirements. Information about the maintenance performer can be added along with financial reporting.

12 Future work

This paper has focused on a number of concepts that are relevant to the development of conceptual models for FM in general and maintenance in particular. This is not a complete picture since what is presented is work in progress. FM consists of much more than maintenance as has been demonstrated and the IFC Object Model does already support some other processes. The range of coverage has to be extended and integrated.

Development of the maintenance model benefits from all of the known capabilities of STEP [ISO 1994] based modelling approaches and equally suffers from all of the well know limitations. Whilst developing models for static information exchange in the manner that is currently possible (and extending the potential via the use of IFC property sets) there is a need to develop a behavioral model and define the software interfaces that enable information sharing in a client-server environment. For this purpose, the project will be looking at the use of the Unified Modeling Language [UML 1997] as a potentially more effective way forward.

The maintenance process as it is being defined for IFC Release 3.0 is not complete. As the move is made to consideration of Release 4.0, the extent of the process will be extended and the degree of integration with the Reference Process Model of the IAI Client Group tightened. In particular, the work on Library development will be developed and work on aspects of financial reporting included. This latter item will have particular importance in connection with work on contract management and control.

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