A STRATEGY TO DEVELOP A FRAMEWORK FOR DISTRIBUTED INFORMATION MANAGEMENT IN THE AEC-FM INDUSTRY

Howard Leslie, .Ic2, h.leslie@ic2.com.au
6F-164 Burwood Road, Concord, NSW 2137, Australia
Yogesh Deshpande, Senior Lecturer, y.deshpande@uws.edu.au
University of Western Sydney, Locked Bag 1797, Penrith, NSW 2751, Australia

ABSTRACT

This paper reviews and analyses the problem of distributed decision-making in the Architecture, Engineering and Construction and Facility Management (AEC-FM) industry and at the operation and management of a supporting information system. These problems include uncoordinated information gathering, reporting and management, as well as multiple redrawing and re-keying of information, which lead to unnecessary costs, increased errors, and misunderstanding. While major advances have been made since CIDA articulated these problems fifteen years ago, particularly in relation to the Building Information Modelling (BIM), its call for easy access to standardized information relevant to each industry sector is yet to be fully answered. While individual industry sectors and organisations have made significant advances in their respective areas of concern, significantly less progress has been made when it comes to the access and exchange of information between sectors or over the life-cycle of a facility. In order to advance the agenda, this paper first takes a comprehensive look at the way the project decision-makers access, process and exchange information, and at how that data is managed over space and time. The paper then describes a strategy to develop a framework for an integrated system for information management that is comprehensive and well integrated, addressing the needs of all sectors of the industry and all phases of the facility life-cycle. The strategy also makes it possible to bring together all the diverse developments such as BIM, IFCs, IDEF, IFD, in the framework, thus helping to manage the information in all its myriad aspects. As many of the concepts raised here are similar to but slightly different from those in current circulation, the paper identifies and describes a number of key concepts used to formulate the strategy. The paper describes the proposed system in functional terms and outlines the simple demonstration packages within it that illustrate the wider picture and provide a context within which individual interest groups can act.
Keywords: Distributed information management, Performance-based project data, Product/Process data management. BIM

1. INTRODUCTION

The AEC- FM industry is under increasing pressure to improve the quality and value of its product, the efficiency and effectiveness of its processes and the accountability of its decision-makers. At the same time, buildings are getting larger and more complex, and building technology and material science is becoming increasingly complex and subject to error in specification, installation, operation, and maintenance. These, in turn, are leading to larger and more specialised project teams whose members have increasingly narrower views of the project and of their respective responsibilities towards it. The degree to which these decision-makers are able to communicate and coordinate their decisions and actions will directly determine the quality (fitness for purpose) and value (cost benefit) of the final product (Gokce et al, 2005).

The problems of information management (IM) include fragmented information gathering, reporting and management, as well as multiple redrawing and re-keying of information, which lead to unnecessary costs, increased errors, and misunderstanding (CIDA 1995, Zhu and Issa 1999, Brewer et al 2005). The industry also lacks effective collaboration and coordination of effort. While major advances have been made in the past fifteen years, such as BIM and IFC, CIDA’s call for easy access to standardized information relevant to each sector is yet to be fully answered.

Decision-making in the AEC-FM industry necessarily involves scores of individuals and organisations, separated by space and time, undertaking a series of decisions or actions (D/As) aimed at realising a common objective, viz. building and maintaining a facility. Establishing and maintaining information management systems (IMS) able to support such distributed decision-making (DDM) is a non-trivial task.

The rest of this section sets out the context in which the framework was developed. Section 2 sets out a number of terms and concepts behind the framework, Section 3 identifies three main threads that give the framework structure, and Section 4 relates them to the industry's production management matrix. Section 5 looks at an implementation strategy – that starts with establishing an industry agreed way of identifying and describing the entities whose data or details project decision-makers access, process and exchange. Section 6 outlines the future work and concludes the paper.

1.1 CURRENT IMPERATIVES FOR THE AEC-FM INDUSTRY

Distributed decision-making in AEC-FM, while not new, needs to cope with:

- *Increased specialisation* - In the past, members of a project team would have had similar backgrounds and thereby greater familiarity with and understanding of the work undertaken by other team members. Increased specialisation lead to narrower views of the project and, consequently, to lower familiarity with other aspects of a project making meaningful communication more difficult.
- *Time and cost constraints* - Compressed project time lines restrict a decision maker's ability to look more widely at the emerging products and obtain relevant information.
- *Rapid Changes in Information and Communication Technology* - ICT is playing an ever more pivotal role in the production, operation, and maintenance of the built environment. However, its exponential rate of change makes communications between Project Decision Makers (PDM) problematic and increases the risks of loss of important data.

1.2 STRATEGIC CONSIDERATIONS FOR INFORMATION MANAGEMENT

Summarising the points raised here (section 1.1), the design, construction, operation, maintenance, and eventual disposal of a facility is, in essence, a virtual enterprise that is spread over time and space. It may be regarded as an enterprise in which the project managers, as well as the individual decision-makers, enter and leave according to the need of the work at hand. An information and decision support system intended to support such an enterprise must address, among others, the following concerns. It should:

be inclusive – To be fully effective all industry sectors and all PDMs must be involved.

be proactive **–**Knowledge is expanding at an exponential rate. As noted above, the AEC-FM industry is large, complex, and evolving at an increasingly rapid rate. In this environment, it is difficult for a decision maker to keep abreast of change – even within their areas of specialization. On another level, ways need to be found that ensure that the outcome of one D/A is available to subsequent decision-makers, in a form and at a time that facilitates understanding and application within realistic time and cost constraints. It is essential that proactive information management is available on both levels.

be able to ensure timely access to application specific resources **–** proactive access needs to be complemented by delivery of relevant information as and when it is needed.

support compliance monitoring **–** In a DDM environment it will be common for one decision maker to set a 'performance objective' that can only be realised by D/As taken by one or more subsequent ones. The IMS will need to 1) ensure the PDMs taking these D/As are aware of the performance target and 2) monitor the outcome(s) for compliance. This will also provide the basis for a more formal regulatory compliance certification program.

support clash detection – In a DDM environment two or more PDM may, unknown to each other, seek to assign different (conflicted) 'performance targets' to an entity. The IMS will need to flag such instances to the PDMs concerned.

support the use of local terms and definitions **–** Local industry (e.g. Australian) has, over time, developed its own standards vocabulary which cannot be overridden by introducing international standards. Doing so invites not only significant direct costs, but introduces the not insignificant legal and operational costs of introduced translation errors, misunderstandings and omissions. The cost, let alone the disruption, would be prohibitive. The system must allow inclusion of current local usage while making it feasible for PDMs to move incrementally forward from there.

ensure data longevity – Important facility data is too commonly lost because the software used to create, process and store it was updated and the new system was not backward compatible. Data about a facility is needed for least the life of that facility – possibly 150 or 200 years. With the life cycle of ICT resources closer to 2-3 years, the framework system must ensure facility data is not lost or made inaccessible.

be able to utilize the latest technological developments – We agree with Davis's caution (2008) that technology should be an enabler rather than a driver of change in AEC practices. However, the industry should also be alive to the possibility of adopting the latest technological innovations such as Web 2.0 wherever and whenever they benefit the industry (Klinc and Dolenc, 2008).

1.3 CHANGE MANAGEMENT

Developing an IMS that takes these issues into consideration is one thing. Implementing and maintaining it is another. In doing so, the problem facing the industry is as much cultural as it is technical. The situation is further exacerbated by the fact that there is no agency with the authority to plan and direct change. A strategic framework is needed that –

- enables individuals and organizations to understand the overall objectives, to identify where and how their interests fit in, to identify opportunities and, hopefully, decide to become involved;
- recognises that not all components will be taken up or evolve at the same rate;
- can accommodate incremental and distributed development; and
- allows existing information systems to continue to function while content evolves, user needs and expectations change, and ICT resources are withdrawn and replaced with ones that are not be backward compatible.

In Davis's opinion (2008), technological changes will be more successful when researchers develop a fundamental understanding of how people change. To that end, we suggest that change management will become easier when simple demonstration packages are created to assist practitioners to judge the efficacy of the proposed changes and thereby motivate them to clearly and concisely identify their needs. This paper describes our use of such a strategy in the sections that follow.

2 DEFINITIONS

Stakeholders

Stakeholders are the individuals and organisations that have an identified interest in AEC-FM industry. The triangle in Figure 1 identifies the three key stakeholder groups that come together in the DDM environment. They are –

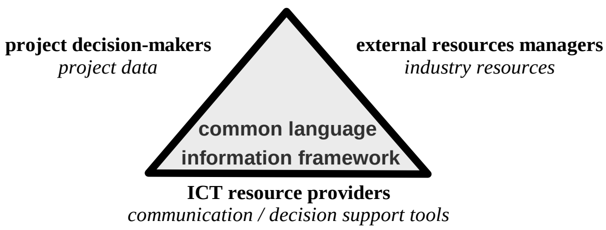

Figure 1 – Stakeholder Groups

External resource managers (ERM) – External resources include information (material ranging from building codes and standards, through to research findings, manufacturers' literature, specification text and construction details, to performance bench marks and office procedure manuals), tools and aids (computers and printers through to jack hammers and site cranes), products and materials (sinks and water heaters through to framing material and concrete), and consumables (power and water through to office supplies). ERM are individuals or enterprises that generate and/or manage an external resource (ER) with the intention of having it accessed and applied by one or more project decision-maker. In the AEC-FM industry these resources fall into two broad categories: those aimed at assisting a PDM to further define the problem, and those offering potential solutions. Stakeholders developing and managing these resources include:

- *building regulators* – concerned with building codes and standards,
- *industry associations* – concerned with supporting its members and improving the performance of their respective industry sector(s).
- *specialist information providers* – concerned with marketing selected industry knowledge such as reference specification text, best practice construction details, unit costs and rates, performance benchmarks,
- *manufacturers and suppliers* – concerned with technical literature associated with marketing products and materials,
- *researchers* – concerned with research and marketing their findings to industry,
- *office managers* – concerned with the functioning of an individual organisation and in-house manuals – office procedures, construction details, specification text – for internal use, and
- *individual project decision makers* – concerned with particular aspects of the industry and personal reference files, and,
- *people supporting the above*.

Project decision-makers (PDM) – individuals or enterprises that access and apply resources toward an objective. In the AEC-FM industry their decisions and actions traditionally result in the procurement, operation and maintenance of a particular facility or a component thereof. These stakeholders include:

- *building owners, asset managers* – primarily concerned with performance against the asset strategy.
- *users (corporate and individual), facility managers and maintainers* – primarily concerned with operational use and maintenance.
- *designers, documenters, and builders* – primarily concerned with physical procurement.
- *demolishers, disposers, and recyclers* – primarily concerned with demounting and management of the products and materials out of which a facility is constructed.

ICT resource providers – individuals or enterprises that provide ICT resources and support to members of the other two groups. The work of this group will range from the development and maintenance of user applications (data management tools, data access tools, decision-support tools, communication tools) through to system applications.

Project, Product, and Process

The stakeholders deal with –

- *projects* – sets of decisions or actions (D/A) intended to achieve an agreed outcome. In the AEC-FM industry, these outcomes range in size and scope from the design, construction, operation and maintenance of a facility (or a combination thereof) through to maintaining the lifts or replacing its light globes. While not necessary, projects are commonly contractually defined.
- *products* – an object or assembly of objects with a functionally identifiable purpose. Depending on the project focus, a product can be a manufactured item such as a basin or water heater, through to a building or complex thereof.
- *processes* – decisions or actions taken to advance the project. In the AEC-FM industry these processes include:
  - *production processes* – these processes change the description of the product – incrementing the facility description – from one state to another. For example, a production process might see a wall instantiated (during design), specified (during documentation), erected (during construction), or dismantled and its components disposed of (during demolition).

    To facilitate this sort of processing, the wall will need to be identified and described in a way that allows each stakeholder to process it from their respective area of interest/responsibility. There needs to be a common, industry agreed way of identifying and attributing each entity about which a project decision-maker seeks to access or exchange information and do so over their respective life cycles.

- *production management processes* – these support and facilitate production processes, by and large, by bringing together relevant resources – human (e.g. tradesmen with relevant certification and skills), tools, products and materials –at a given time and place to realise a project objective. Project management, construction management, and facility management are all forms of production management.
- *enterprise management processes* – D/As focused on the enterprise rather than the product at hand. For example, a contractor determining the order of construction in order to ensure a positive cash flow and thereby the financial viability of the enterprise. These processes are focused on the enterprise rather than the product and so, from the perspective of the information strategy or framework, are out of scope.

The D/A is the fundamental unit of a *process*. *Processes* increment *products* from one data phase to another. *Projects* simply identify who is responsible for taking a given D/A. In this paper the focus is on how best to facilitate the flow of relevant, application specific information from one D/A to another. Who takes a give D/A, or whether or not it is 'good', 'bad', or 'indifferent', while of concern to members of the project team, is of no consequence to the information system per-se.

3 APPROACH

Drawing upon points raised in Section 2, this section identifies three planks that are fundamental to the information and decision support strategy (IDSS).

The information system must be focused on the D/A

Put succinctly, the *project* establishes the scope of work, who is to be involved, and what their respective areas of responsibility are. As these will vary from project to project they cannot be used to give structure to the IMS . More stable are the *production processes* and their associated D/As that increment the *product* from one data stage to another – over the life of the project. It is the D/As – not the PDMs – that provide a matrix around which the IDSS is established.

The BIM is a pivotal component, but it is not sufficiently comprehensive.

The role and scope of the BIM and IFC have been clearly delineated by the National Guidelines for Digital Modelling: "BIM provides us with the potential to integrate the entire project information into digital database …" and that "this database is an integrated description of a building and its site comprising objects, described by accurate 3D geometry, with attributes the define the detailed description of the building part or element, and relationships to other objects…" (NGDM, 2009). (Howard, we need something similar on IFCs) Note especially that the use of the term *project* here for "a building and its site" is really equivalent to the term *product* as defined in Section 2.

On another level, the Guidelines note that the "development of IFCs has been driven from the software development side of the industry" and that their objective was to establish a single standard for information exchange that would reduce developments costs and improve the content and quality of the information that could be exchanged (NGDM, 2009) Acknowledging the need for a more comprehensive system of IM, they go on to note that the IFCs are intended to carry more than graphical data.

BIM and the IFCs are intended to describe a facility *(product)* over its life cycle. While this is pivotal to DDM, it is clearly too narrowly focused to meet the demands of IDSS.

Further work is required to establish how best to manage this additional data –for the purposes of this paper the necessary extension is indicated as "BIM+".

The language used to identify and describe the entities about which PDMs access, process, and exchange data need to be separate to that used to exchange this data between computer platforms.

An industry agreed way of identifying and describing the entities about which project decision-makers access, process and exchange data is central to IDSS. So too are standards that enable data exchanges between computer platforms. While both are critical to IDSS, the question arises as to whether they are, can be, or should be one and the same. This is a question in need of further examination. At present, they appear to be seen as one and the same. That is, the IFCs both define the entity and its attribute set, and establish the protocols needed to allow this data to be shared between software applications. The IFDs appear to be directed to extending the scope of this work. While supporting these initiatives, concern is raised that this is leading to two overlapping sets of descriptors. The first is peculiar to the local industry and underpins, among other things, its building codes and standards. The second set is global, emerging from these international initiatives. This will not be a problem in countries which, through their international commitments, see the vocabulary they use in their regulatory documents getting accepted in the internationally agreed protocols. It is, however, likely to be a major impediment in areas where the two sets are different. While local authorities are endeavoring to use ISO agreed terms in their documents, it is unlikely that they will cede control to an international committee. As a consequence it is likely that the industry in these areas will face two vocabularies – with the consequent need for manual processing, introduced errors, and additional costs. It is also likely to complicate and unnecessarily impede ICT take-up. There is a clear need to separate the vocabulary from the data exchange protocols.

Regardless of the eventual outcome of these deliberations, IDSS needs to start where the industry is now and to facilitate incremental change to get it to where (when it is finally determined) it needs to be. In Section 5 tools to start this process are introduced.

4 INFORMATION AND DECISION SUPPORT STRATEGY (IDSS)

In this section the arguments leading to the establishment of the IDSS are reviewed. To position IDSS in the real world, an indicative production management program is used to identify notional D/A, to map its inputs and outcomes, and finally to relate it to key external resources.

4.1 PRODUCTION MANAGEMENT

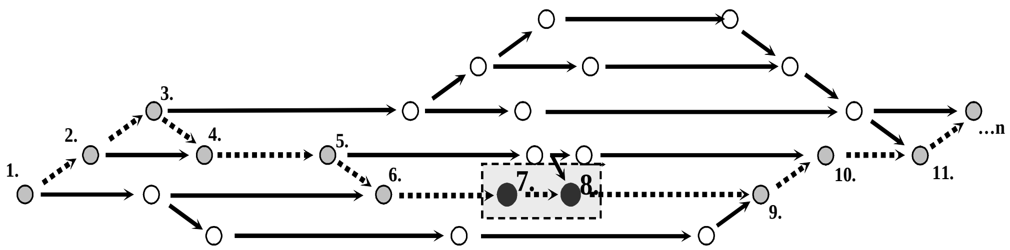

Figure 2 – Typical PERT chart for Production Management

Put simply, the *project* description determines the scope of works and establishes contractual arrangements that identify the PDMs and determine their respective areas of responsibility. A project management plan can be established to identify and sequence the D/As to be taken. For example, with reference to Figure 2, the link between nodes 7 and 8 represents a D/A. The nodes, respectively, represent the product's initial and incremented data states. A D/A, taken by one PDM, identifies a 'desired performance requirement' (control) that is added to the node 8 description. For example, node 7 might relate to a hand basin and contain, among other things, a set of desired features (style, color, cost, number of tap holes, etc), the second PDM (an expert in providing accessibility guidelnes for people with disabilities) might introduce an additional feature, say minimum dimension, to optimize access. The generic basin profile will be aggregated at node 8, and used in the next D/A to issue to basin manufacturers for them to submit compliant solutions (compliant basins). The selected basin's specific performance profile would be held in node 9.

4.2 INFORMATION ACCESS AND EXCHANGE

Writing about Information Exchange Architectures for Building Models, Eastman (1999) emphasized the importance of addressing information flow issues as distinct from the need to develop the appropriate semantics for representing building models. He supported his analysis with four imaginary but specific scenarios as illustrative examples. In software modeling terms, they could be regarded as 'use cases'. Eastman acknowledged that there would be a large number of use cases that would have to be considered for a fuller analysis.

In the following analysis, we adopt a much more abstract and hence generalized version of information access and exchange scenarios.

To start with, Figure 3 is a re-presentation of nodes 7 and 8, and the associated D/A using IDEFØ (Integrated DEFinition Methods. The initial data set is [1a] and the incremented one is [1b]. Internally prescribed 'performance requirements' (controls) such as the ones described above, are [2a and 2b]. A similar requirement, but set by an outside authority such as the building code (ER), is [5]. The call to and response by basin manufacturers (ER), is [6].

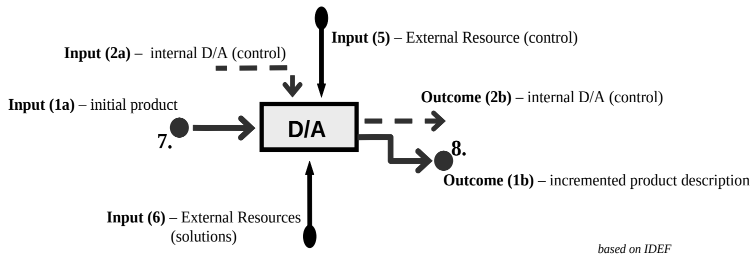

Figure 3 – Project decision or action point

Figure 4 identifies two *projects* (Project 1 and Project 2 which could be different phases in the life cycle of a given facility) and instantiates several D/As to identify three separate but related information exchange paths.

Path 1. Information access and exchange within a project

Within a *project* to two information threads between D/A nodes have been identified. With reference to Figure 4, they are –

- the shared *product* description [1], likely BIM+ based, and
- performance flagging [2].

Regardless of the number of *projects* involved or their respective contractual arrangements, the D/As required to increment the *product* from one data state to another remain the same (see Figure 3).

Path 2. Information access and exchange between projects –

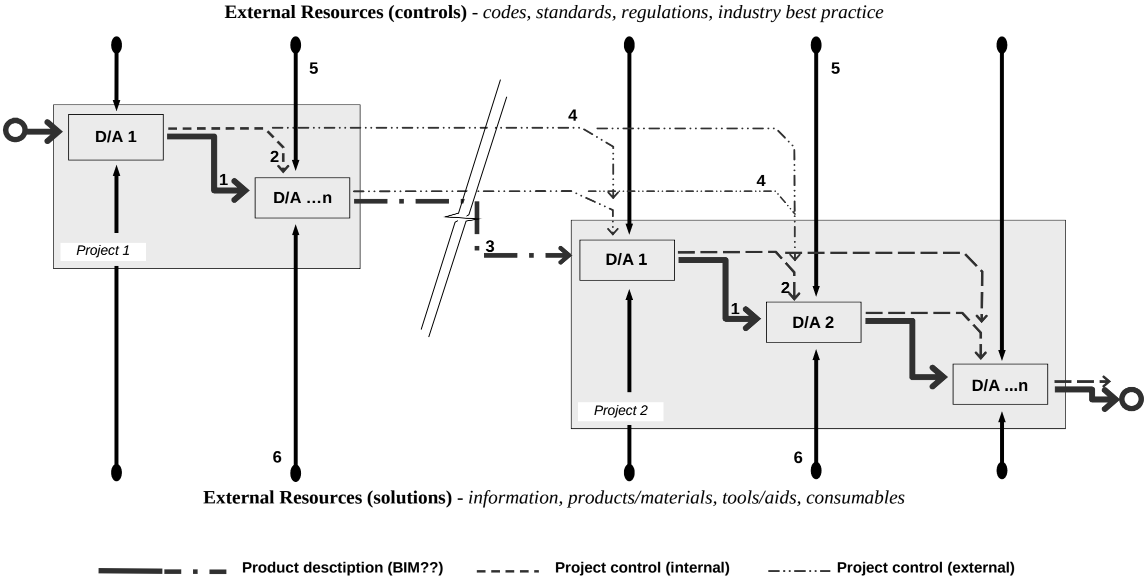

Figure 4 – Framework for Information Management

There are two paths (3 and 4) between Project 1 and Project 2, similar to those within a project. However, because each *project* could involve a different constellation of decision makers, these flows [3] and [4] will occur under different contractual arrangements – which may or may not influence what data is exchanged and how.

Path 3. Information access and exchange a project and external resources –
The third information thread is between the project and external resources developed and maintained by independent third parties. With reference to Figures 3 and 4, these external resource managers fall into two, not necessarily distinct, categories. Some [5] will seek to establish performance objectives, e.g. codes and standards, professional practice publications, specialist publications, and research papers to name but a few. Others [6] will proffer potential solutions, e.g. codes and standards, product and material manufacturers' catalogues, professional practice publications, industry association's publications and so on.

Other threads, such as feedback and clash detection have already been mentioned.

4.3 CONTROLLED VOCABULARY

Clear, concise communication along each of these threads will require an agreed way of identifying and describing the entities about which data is being accessed, processed and exchanged.

There is insufficient space here to go into the next phase of this work here. Suffice it to say key industry groups will be asked to identify – *production process* by *production process* – the entities and entity attributes they use. These will be harmonised with those used in the associated *production management processes* (refer Figure 2) and, as appropriate, incorporated into the Data Directory (see below).

To help the practitioners understand what is being proposed and thereby to be better able to pass comments and to identify the entities and entity attributes they will need simple demonstration software packages . Two currently under development are –

- *ABAccess* – an ER (control) package that might be developed by experts in the provision of access for people with disabilities to identify the features of an environment that will optimize access by a person with a given -disability profile.
- *Product catalogue* – an ER (solutions) package that might be mounted on a manufacturer's web site - that is able to receive the 'required performance profile' from the PDM, use it to search their

catalogue to identify one or more complying products, and respond with their 'actual performance profiles' – in a form that can be understood and, if desired, downloaded into the project dataset.

As the nature and structure of this local vocabulary becomes clear, it will be examined in relation to the current BIM and its IFCs to see how to bring them together in the IDSS framework. The next section briefly looks at how IDSS brings these together.

5 IMPLEMENTATION

Recognising the pivotal nature of BIM, but also that it is too narrowly focused to address all areas covered by IDSS, Figure 5 introduces BIM+. BIM+ is at this point a loose construct that identifies the need to examine just how classic BIM and IDSS, and internationally agreed IFCs and the locally developed DD datasets can be harmonised.

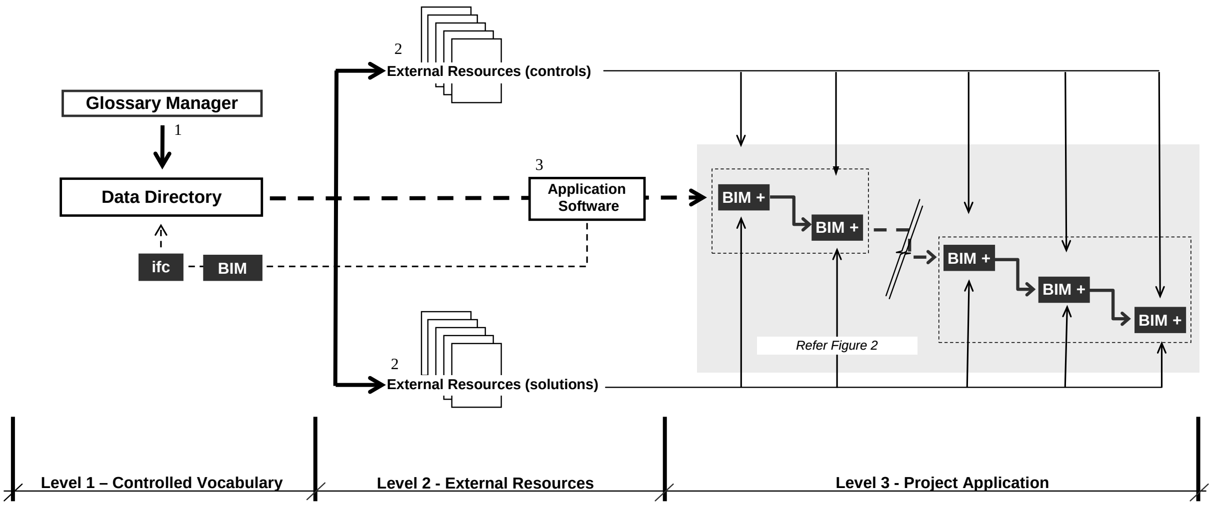

Figure 5 – Information and Decision Support Network

Strategically the network has three distinct levels. The first seeks to establish and maintain an industry agreed way of identifying and describing the entities about which the decision makers will access, process and exchange data. The second is concerned with ERs and how to package and make them available to the PDMs. The third level looks at the information flows identified in Figure 2 and considers how these resources can be proactively access by the PDM.

The intention is to establish tools to identify, bring together and to harmonise the terms and definitions currently used by the local industry. This will facilitate the creation of a repository in which the entities and entity attributes PDMs required for the successful conduct of a given *production or production management process* are registered and made available to ERM to package and present their respective resources to the PDM – in a form and at a time that will facilitate understanding and application within realistic time and cost constraints.

5.1 Glossary Manager –

While editing the 5th edition of the NCRB Glossary of Building Terms (Leslie and Potter, 2004) the first author brought together terms and definitions used in a range of industry reference documents and discovered that it was not uncommon to find terms with two or more definitions or, less commonly, different terms with the same definition. While some of these differences were simply grammatical, others were in direct conflict with one another.

Starting with the terms and definitions found in the industry's current documentation, the objective of the GM is to help the industry to establish, over time, an internally harmonized, agreed set of terms and definitions leading to improved communication and information exchange. In its current form, the GM highlights these multiple definitions. The strategy is to point out errors and conflicts, to make it easy for the industry to examine the options and to move to a preferred term. Where two or more industry sectors find they must use the same term (with different definitions) the terms will be differentiated in the GM – in a way that will appear as a simple term and definition when downloaded for inclusion in a publication. Over time, as the glossaries are revised, republished, or replaced the required industry agreed terminology will emerge.

Implementation –
A separate paper deals with the construction and technical details of this demonstration software.

5.2 Data Directory –

GM is the first step in identifying and defining the entities. The next one is to define their attributes to enable PDM to access, process and exchange information about them. This is the role of the DD.

The purpose of the DD is to establish a comprehensive, industry agreed, way of identifying and describing these entities over their respective life-cycles, and to do so in a manner that is fully compatible with the IFCs and capable of incorporation into BIM+.

Approach –
Notionally, to ensure clear concise communication in regards to a given process the decision makers simply have to agree the identifiers and descriptors to be used. On a practical level this agreement must be industry wide because –

- the outcome of one process is commonly input to another,
- these ‘new’ processes might involve a different constellation of decision makers, and
- external resources managers must prepare their ERs in advance of and without reference to specific processes.

Like the GM, developing a DD will be a long and involved process so there is a need for an overarching framework that will enable it to be managed over time. With new products, materials and processes constantly being introduced and old ones withdrawn, the system will need to be easily modifiable, and it should be immediately useable. Furthermore, so long as the system is incomplete, practitioners will find gaps. Routines must be available to the PDM that will enable them to instantiate the entity/entity attributes they require and to apply them to the work (*process*) at hand.

Implementation –
Unlike the GM, there is no need for industry agreement as to what entities or entity attributes are included in the registry. If a group of decision makers need to access, process or exchange data about an entity it needs to be in the system. It remains to the DD to provide the tools to make sure it is appropriately identified and is consistently described in the appropriate manner.

Demonstration DD software has been developed. In populating it, a number of *processes (production or production management)* will be nominated and the decision makers involved will be asked to identify the entities and their respective attributes that they require. The same routine will be used by practitioners to identify attributes that may be missing in the fully operational directory.

5.3 External Resources (2) and ICT resources (3)

These are third party resources and therefore beyond direct input by IDSS developers. Suffice it to say here that the demonstration software discussed in the previous section will be used to show ERM the potential of the strategic frameworks and the opportunities available to those who adopt it.

From an IDSS perspective the intention would be to assist ERMs –

- to draw from the DD the entities and entity attributes that are relevant to their particular their resource(s).
- to use these descriptors to key those resources so a PDM ‘call’ can be received, understood and proactively used to search for relevant input.

Where the DD does not contain the required entities or entity attributes, they would be asked to use one of the DD routines to enter them – thus enabling them to get on with the development of their resource and contribute to the development of the directory.

6. FUTURE WORK/DIRECTIONS AND CONCLUSIONS

Future work has, by and large, been identified in the body of this paper, its underlying objective being the development of an information management system able to support distributed decision making. Within this framework there are three threads. First, the nature of BIM+ as it is applied at the *project* and product levels. The second thread will be, to establish the respective roles, scopes and relationships between the internationally developed IFC, IFD and the entities and entity attributes developed and used by local industry and around which most of its codes and standards are developed. Finally, there is the work to be done with local industry to identify the entities and entity attributes they need to conduct of their respective *production* and *production management processes*. This as noted, will involve the development of a range of simple software demonstrations packages to help individual practitioners to understand what is being proposed and thereby to more precisely declare their respective needs; and to continue to develop and document IDSS.

ACKNOWLEDGMENTS

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