Improvements in the Effectiveness of Information Management in Construction Organisations

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IMPROVEMENTS IN THE EFFECTIVENESS OF INFORMATION MANAGEMENT IN CONSTRUCTION ORGANISATIONS.

By
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A dissertation thesis submitted in partial fulfilment of the requirements for the award of the degree Doctor of Engineering (EngD), at Loughborough University

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To begin with, I give all praise to Allah, the Lord of the worlds, the creator of the heavens, the earth and everything in them. My Lord, my King and the one I call on in the brightness of the day and in the darkness of the night; in public and in private; in misery and in joy; in sickness and in health.

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Finally, I extend my warm gratitude to you - the reader - for taking the time to read and study this work. I hope and pray that you find it interesting, thought provoking, enlightening and of immense benefit.

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ABSTRACT

Managing information effectively is crucial for improving processes within organisations. To this end, a more holistic approach is required which aligns the organisations information and technology needs with its people, processes and business model. This should shift the emphasis from collaborating on individual projects to a long term view of how best to support an organisation's business strategy. It also shifts the emphasis from managing information (storing information to exploit it) to managing with information (harnessing information to gain competitive advantage across the organisation).

This thesis is the culmination of a four year EngD research critically investigating improvements in the effectiveness of Information Management (IM) in construction industry based organisations. It begins with an introduction to the research, its aims and objectives, and then presents a detailed review of related literature about the subject matter and the methodology employed in conducting the research. The eight research tasks carried out using extensive, varied and appropriate methods including literature reviews, case studies, interviews, surveys and workshops are then explained based upon which a number of key recommendations are drawn.

The findings define IM as distinct from Information Technology (IT) and Information Systems (IS) and provide a critical insight into IM in construction industry based organisations including its strategic drivers, key influencers and barriers. It further highlights the four components of a holistic approach to IM as:

- **The Content Model** - the nature and structure of the content including metadata;
- **The Enterprise Model** - operational structure of the company including its business processes and information dependent activities;
- **Systems and Technology** - the most appropriate technological solutions in light of the defined content and enterprise models; and
- **Implementation and Change Management -** support for people and managing the transition into improved ways of working.

The findings show that a clear alignment between an organisations information needs and its operational processes is key to developing and implementing an effective IM strategy. It shows that a unified approach is more appropriate for organisations than a single approach as certain multi-dimensional context specific factors exist which influence the nature of each organisations needs and therefore most suitable solutions to address them. The findings also demonstrate the importance of metadata in integrating organisations and enabling a holistic IM Strategy. A standard IM framework is developed and validated which provides a structured and systematic approach for organisations seeking to develop suitable metadata standards to meet their needs. The holistic approach applied to a number of case studies provides novel insights into the use of metadata in information retrieval; the development of aligned information architecture and the creation of holistic strategies for improving knowledge sharing and innovation. The thesis concludes with a critical review of the research and a number of key recommendations for organisations, IM research and the wider construction industry. All the findings and insights have been and continue to be disseminated through a number of peer reviewed publications.

KEY WORDS

Information Management; Collaboration; Metadata; Strategy and Operations.

PREFACE

The research presented within this thesis was commenced in 2007 and completed in 2011 in partial fulfilment of the requirements of the Engineering Doctorate (EngD) at the Centre for Innovative and Collaborative Engineering (CICE), Loughborough University. The research was conducted within an industrial context and sponsored by Global Multidisciplinary Consultancy, Buro Happold.

The EngD is examined on the basis of a discourse (i.e. the thesis) supported by a minimum of three peer reviewed publications and technical reports. Presented within the appendix section of this thesis are three journal papers (1 accepted and 2 currently in review) and two conference papers all of which were authored by the candidate.

The main body of the text provides an in-depth overview of all the work undertaken, the findings and its implications. Specific details are explained within the papers included in the appendix section, each of which is duly referenced within the text by a paper Number (3 - 7) and the appendix number (1.0 – 5.0). The papers are an integral part of the thesis and should be read in conjunction with it.

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ACRONYMS/ABBREVIATIONS

3D	3 Dimensional
BIM	Building Information Model
BSI	British Standards International
CM	Content Management
CMS	Content Management System
DM	Document Management
DMS	Document Management System
ECM	Enterprise Content Management
EDMS	Electronic Document Management System
EngD	Engineering Doctorate
IEEE	Institute of Electrical and Electronic Engineers
IM	Information Management
IT	Information Technology
IS	Information Systems
ISO	International Organisation for Standards
KM	Knowledge Management
KP	Knowledge Portal
MOSS	Microsoft Office SharePoint Server
NAA	National Archives Australia
NISO	National Information Standards Organisation
QMS	Quality Management Systems
RE	Research Engineer
TASI	Technical Advisory Services for Images

LIST OF PAPERS

The following papers were produced in partial fulfilment of the award requirements of the Engineering Doctorate (EngD).

PAPER 1

Sheriff, A., Bouchlaghem, D., EL-Hamalawi, A. and Yeomans, S.G., 2008. **An Enterprise Content Management approach to Organisational Information Management.** In: *Proceedings of the CIB W65 Symposium, Transformation through Construction*, November 15th – 18th, Dubai, United Arab Emirates

PAPER 2 (INTERNAL TECHNICAL REPORT)

Sheriff, A. and Yeomans, S. 2009. **Critical review of Information Management in Buro Happold**, Internal Technical Report – (presented to the Design and Technology Board (DTB))

PAPER 3 (SEE APPENDIX 1)

Sheriff, A., Bouchlaghem, D., EL-Hamalawi, A. and Yeomans, S.G., 2011. **Developing a Metadata Standard for Multimedia Content Management.** *Journal of Architectural Engineering and Design Management* (Accepted)

PAPER 4 (SEE APPENDIX 2)

Sheriff, A., Bouchlaghem, D., EL-Hamalawi, A. and Yeomans, S.G., 2010. **Developing Facets for Facetted Search**. In: *Proceedings of the 6th International Conference on Innovation in Architecture, Engineering and Construction*, June 9 -11, Pennsylvania, USA

PAPER 5 (SEE APPENDIX 3)

Sheriff, A., Bouchlaghem, D. and EL-Hamalawi, A., 2010. **Developing a Corporate Information Architecture**. In: *Proceedings of the 10th International Conference of Computing in Civil and Building Engineering*, June 30th – July 2nd, Nottingham, UK

PAPER 6 (SEE APPENDIX 4)

Sheriff, A., Bouchlaghem, D., EL-Hamalawi, A. and Yeomans S.G. (under review). **Information Management in Construction Organisations – drivers, constraining factors and barriers**. Submitted to *ASCE Journal of Management in Engineering*.

PAPER 7 (SEE APPENDIX 5)

Sheriff, A., Bouchlaghem, D. and EL-Hamalawi, A., (under review). **Seven Lessons for Effective Information Management.** Submitted to *ICE Civil Engineer*

1 CHAPTER 1: INTRODUCTION

This chapter puts into context all subsequent chapters of the thesis highlighting the need for; aims and objectives; justification and the organisational context of the research.

1.1 BACKGROUND

The digital economy has fundamentally altered the nature of, and means through which work is carried out within organisations across all industries (Drucker, 1992). Information is now a central and strategic resource, a factor of production and in some instances the core deliverable (Earl, 2000; Feraud, 2000; Evans, 2000; Dilnutt, 2006). Much as the industrial revolution gave rise to new organisational forms, businesses will increasingly require a fundamental rethink of their operational models to enable them better harness information, develop innovative solutions, improve processes and gain competitive advantage (Evans, 2000; Marchand, 2000; Rezgui et al, 2010a). Within the construction industry, the Latham (1994), Egan (1998), Levene (1995), National Audit office (2001) and Business Round Table (2006) reports among many others called for a shift towards greater integration and collaboration among teams to gain improvements in underlying productivity (Koskella, 2000; Anumba et al, 2000; Yeomans, 2005; Craig and Sommerville, 2006; Shelborn et al, 2007; Jorgensen and Emmitt, 2009). Core to enabling improved collaboration is effective Information Management (IM), as information forms the core medium through which solutions developed are documented, communicated and shared with others (Bjork, 2002; Koskella and Dave, 2008). The need for organisations across all industries to adopt a more holistic view of information is highlighted in numerous research initiatives including Buchanan and Gibb (1998); Evans (2000); Marchand (2000); Bjork (2001); Murphy (2001); Delloitte (2002); Munkvold et al (2003); Rockley et al (2003); Dorgan and Dowdy (2004); Evgeniou and Cartwright (2005); and Paivarinta and Munkvold (2005).

Improvements in processes are obtained not simply by procuring Information Systems (IS) but by aligning information needs with business processes (a key point similarly argued by Davenport and Prusak (1998), Choo (2003), Koskella and Dave (2008) and Rezgui et al (2010a)). Achieving this requires an understanding of IM, its constituent components and how to develop solutions which align with and support long term business strategies. This shifts the emphasis from simply managing information (storing information) to managing with information (harnessing information to gain competitive advantage from it) the principal focus of this EngD research project.

1.2 THE INDUSTRIAL SPONSOR

This research was part sponsored by global multidisciplinary engineering design consultancy, Buro Happold. Founded in 1976 by eight partners led by the late Sir Edward Happold, the company has since grown to circa 1500 full time employees across 23 global offices. From its roots as a boutique structural engineering firm, the company now operates as a multidisciplinary consultancy with 27 disciplines across three principal business streams, *Buildings*; *Environment and Infrastructure*; and *consulting*. The 'Buildings' stream with disciplines such as Structural Engineering and Building Services is the largest and most operationally mature, offering lifecycle solutions for the building envelope. The 'Infrastructure and Environment stream' with disciplines such as Ground Engineering, Environment and Civil Engineering focuses on the engineering of urban spaces while the Consulting stream provides strategic design and advisory services to clients in areas such as business improvement, procurement and strategic master planning. Buro Happold acknowledges that being a consulting organisation, its competitiveness

lay in the depth of knowledge and understanding of key issues it deploys to create innovative solutions to meet client needs. Thus effective IM to support innovation and project delivery is deemed a business critical priority.

1.3 NEED FOR THE RESEARCH

Prior to this research, a previous Research Engineer (RE) within the research sponsor investigated collaborative working, particularly focussing on the use of ICT as an enabler. This was of critical importance to the sponsor as its increasingly digitised operations and processes requires the integration of large geographically distributed teams to deliver projects to time, budget and quality. Among the many findings and recommendations of that detailed study (see Yeomans, 2005) was the critical need for a more systematic approach to managing information. The author observed that the proliferation of working principles, standards, technologies and volumes of data make it ever more difficult to adopt a single efficient approach to managing information between companies and projects. As the volume of information generated and managed within organisations continues to grow, so does the need for an effective IM strategy to support processes and enable greater cross project and organisational collaboration. Despite the significant progress made within the research sponsor to improve collaborative working, a number of problems persisted which reinforced the need for this research, including:

- Inconsistent Quality Management procedures particularly for managing and categorising information across the organisation.
- Inability to understand the nature of information within the organisation and therefore how best to manage it.
- Large variety of non-interoperable IS in use across the organisation without an over-arching strategic theme.
- Inability to develop a co-ordinated approach for managing information on projects both internally and externally (with other external partners)
- Inability to leverage innovations developed in the various offices to support core operations such as marketing, Knowledge Management (KM) and project submissions.
- Without an integrated approach to managing information, internal groups were operating as distinct isolated units and unable to leverage/reintroduce innovative content generated on projects back into the organisation.

The findings from the extensive literature review conducted (presented in detail in Chapter Two) also emphasise the need for this research. In summary, the findings (see section 2.4 for references) showed that:

- IM research in the construction industry is primarily focussed on projects and/or systems (IS). There is a shortage of research into IM, its nature within construction industry organisations and how effective IM strategies can be developed and implemented.
- Limited research has been carried out on the development, maintenance and use of metadata within organisations.
- Insufficient practical guidance exist to enable organisations to develop suitable standards to meet their needs.
- There is also limited research into the practical application of holistic IM strategies which align information needs with business strategies within organisations and its impact on processes.

These are discussed in greater detail in Section 2.4.

Further research was therefore required specifically focussing on information to define how best to manage it and add value to global operations in a manner which builds on existing/emerging best practice procedures, technologies and techniques. As the findings of Task Two (presented in

Section 4.2) show, such challenges are by no means restricted to the research sponsor. Indeed with its geographical spread, multidisciplinary nature, size and nature of projects, the research sponsor is a typical case within a broader sample of large multidisciplinary consulting organisations observed to face similar challenges (as shown in Section 4.2). This research therefore provides such organisations with a more complete understanding of information vis-à-vis their global operations. It also provides specific targeted methodologies and tool kits for improving IM and adding tangible value to business operations, organisational processes, knowledge sharing and project delivery.

1.4 RESEARCH SCOPE

The initial research scope, as defined by the sponsor and guided by current knowledge in the area, was to develop a standard approach to grouping, classifying, naming and managing electronic data more effectively and consistently throughout the company and its projects; irrespective of office, work group, discipline or technology used. However, it became apparent through the first year of the research that managing information effectively goes beyond metadata alone. Hence the focus of the research was expanded to a more 'holistic approach' to IM. Holistic in the context of this research views IM across four key components:

- **The Content Model** - the nature and structure of the content including metadata;
- **The Enterprise Model** - operational structure of the company including its business processes and information dependent activities;
- **Systems and Technology** - the most appropriate technological solutions in light of the defined content and enterprise models; and
- **Implementation and Change Management -** support for people and managing the transition into improved ways of working.

The four components are explained in detail in Chapter Two. Given time and resource constraints, the research focused on the content model, while acknowledging the need to view information holistically to achieve the desired outcomes.

The term Enterprise Content Management (ECM) is also used to define such a holistic approach as in the works of Rockley et al (2003); Smith and Mckeen (2003); Munkvold et al (2006); and the Association of Information and Image Management (AIIM, 2010). This was initially adopted as the starting point for this research. However, the term was subsequently found to also be used to describe a specific suite of technologies and systems designed to manage information across organisations (McNay, 2002; Moore and Markham, 2002; Reimer, 2002; Gottlieb, 2005; Dilnut, 2006; Bridges, 2007; Sturdy, 2007). Thus to avoid potential misconceptions, the term ECM is not used in this research for describing a holistic approach.

In general, electronic information can broadly range from structured operational data; semi-structured content such as reports and drawings which emerge through the project delivery process; to unstructured content principally in the area of product development as illustrated in Fig. 1.1. This research is focused on explicit unstructured and semi-structured information and does not include structured data for business processes (such as numeric financial data managed within the Agresso software system) as such data is already managed via specialised software applications.

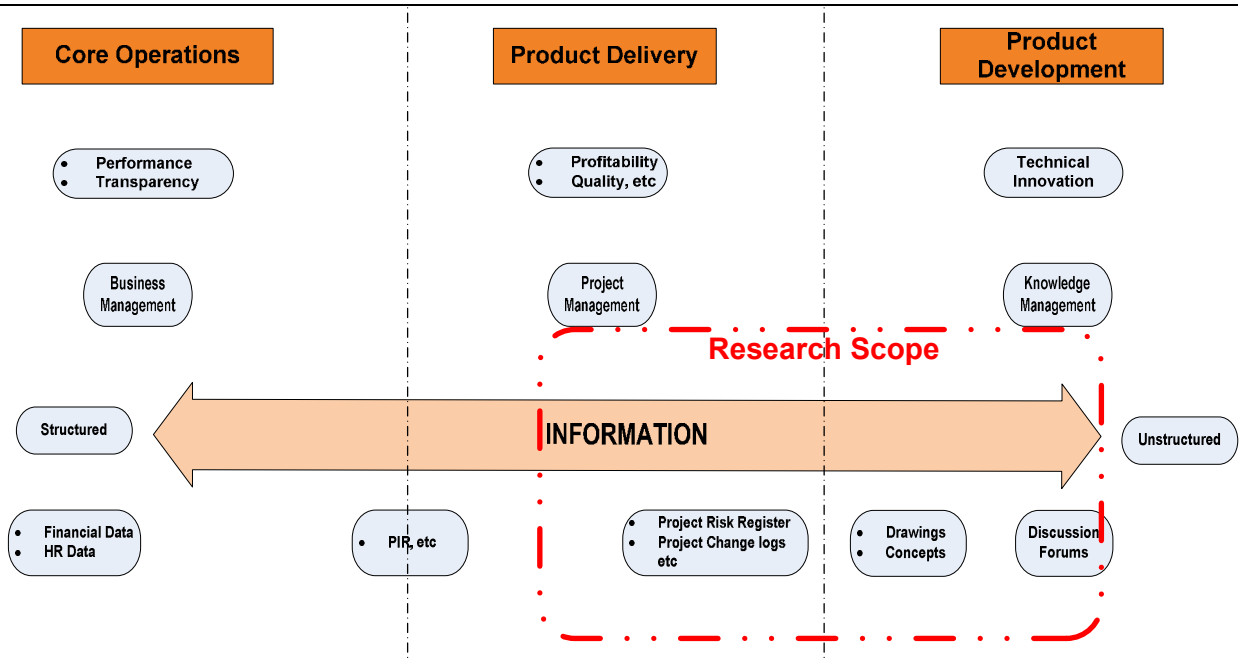

Figure 1.1: Research Scope

1.5 AIMS AND OBJECTIVES

The aim of this research was to investigate the nature, drivers, constituent components and application of a holistic approach to IM in construction industry based organisations. The five principal objectives were:

1.5.1 OBJECTIVE ONE - INVESTIGATE THE CURRENT STATE OF INFORMATION MANAGEMENT IN CONSTRUCTION ORGANISATIONS

This, the exploratory phase of the research, established a greater understanding of the subject matter, the issues of concern across the construction industry and the benefits and barriers to developing a holistic approach to managing information. The sub-objectives were to:

- Review the state of the art in IM;
- Identify the drivers for IM in construction organisations;
- Identify the critical factors which influence IM strategies in organisations; and
- Identify the barriers to effective IM in construction organisations.

1.5.2 OBJECTIVE TWO - INVESTIGATE THE STATE OF THE ART IN INFORMATION MANAGEMENT IN THE RESEARCH SPONSOR

This investigated current practice; specific problem areas; nature of content and the business needs of the research sponsor. A company wide information audit was conducted to identify:

- The type of content produced, used and hence need to be managed;
- The frequency of and media through which information is shared, exchanged and transferred; and
- The specific need, problem areas and areas of pull for IM.

1.5.3 OBJECTIVE THREE - DEFINE A METADATA STANDARD FOR INFORMATION MANAGEMENT

This focused on designing an appropriate metadata standard for enabling IM. The sub-objectives were to:

- Investigate the use of metadata in IM;
- Develop a metadata standard for IM in the sponsoring organisation; and
- Develop practical guidance for developing metadata standards in construction organisations.

1.5.4 OBJECTIVE FOUR – ASSESS THE APPLICATION OF A HOLISTIC APPROACH TO INFORMATION MANAGEMENT IN ORGANISATIONAL PROCESSES

This assessed the applicability of the principles of a holistic approach to IM on organisational processes. The sub objectives were to:

- Investigate the application of metadata in Information retrieval.
- Develop the Information Architecture for IM in a case study group within the research sponsor; and
- Investigate the application of a holistic approach to IM for managing explicit knowledge within the research sponsor.

1.5.5 OBJECTIVE FIVE – SUMMARISE THE RESEARCH AND IDENTIFY AREAS FOR FURTHER RESEARCH.

This, the final stage of the research synthesised the collective findings from all the tasks carried out to develop appropriate evidence based conclusions. The implications of these conclusions were then considered for the research sponsor, the wider construction industry and IM research. Following this, recommendations were proposed for areas for future research.

1.6 OVERVIEW OF TASKS CARRIED OUT

The research was carried out based on a 'whole to part to whole' approach (similarly adopted by Ruikar, 2004) in which a broad review of IM (Objective One) was followed by a more focused look at IM within the construction industry (Objective One) and then an even more focused study of the research sponsor as a case study (Objective Two). This provided the necessary contextual understanding of the problem and the solutions required. Similarly, developing the solution began with a focussed look at metadata (Objective Three), then the wider application of a holistic approach in a specific group (Objective Four) and then an even broader company wide application (Objective Four). The tasks carried out and their outputs are illustrated in Fig. 1.2.

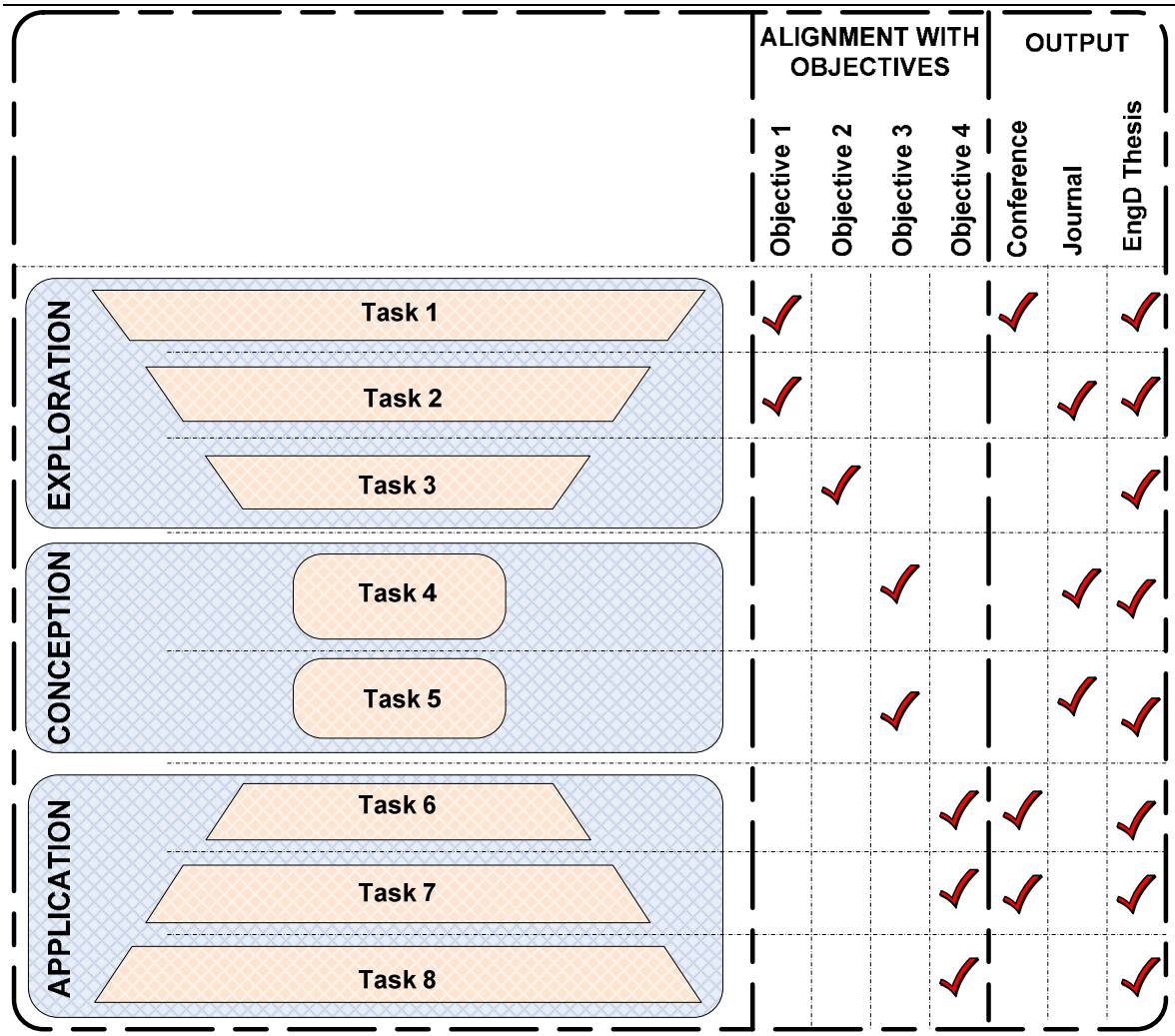

Figure 1.2: Relationship between Research Objectives

Brief summaries of the eight tasks carried out are presented below (and discussed in greater detail in Chapter Four).

1.6.1 TASK 1: REVIEW THE STATE OF THE ART IN INFORMATION MANAGEMENT

A detailed review of existing literature on IM and associated concepts such as KM and ECM was conducted to gain a better understanding of the subject area. The findings established that while IM is gaining significance in the construction industry with increasing regulatory and strategic drivers, addressing it holistically is relatively novel. It also better defined the holistic approach to IM, its compositions and its implication for organisations. Gaps in the literature were then identified which shaped the nature of all subsequent tasks. This was carried out between October 2007 and March 2008 then continually improved upon throughout the research.

1.6.2 TASK 2: REVIEW INFORMATION MANAGEMENT IN CONSTRUCTION ORGANISATIONS

Building on Task One, the actual state of IM in construction organisations was investigated to identify the drivers, influencing factors and barriers to its effectiveness. Being an exploratory exercise, interviews were carried out with a sample of organisations across the industry details of which are explained in Section 4.2. These were carried out between August 2008 and March 2009 then transcribed in verbatim (completed December 2009). The research design, methodology and findings are discussed in greater detail in Section 4.2, Paper Six (Appendix 4.0) and Paper Seven (Appendix 5.0).

1.6.3 TASK 3: CONDUCT INFORMATION AUDIT OF THE RESEARCH SPONSOR

A detailed Information Audit of the research sponsor was conducted to define the challenges in managing information within the organisation. In general, information audits can be broad exercises and include analysis of processes through which information products are created or used. This audit focused on understanding:

- The content classes across the organisation;
- The media used for sharing and transferring information; and
- Specific problem areas and information needs in relation to business processes.

Details of the specific methods employed and the execution process are explained in Section 4.3. The audit was completed in November 2008 then analysed and reported back to the research sponsor in February 2009.

1.6.4 TASK 4: DEVELOP A METADATA STANDARD FOR INFORMATION MANAGEMENT

Metadata gives structure to unstructured content allowing it to be retrieved and its context understood. This task created a metadata standard for IM in the research sponsor. A number of exercises were carried out to execute this including a review of existing standards, a desk study and a workshop. The findings were then analysed from which a metadata standard was developed initially for a multi-media library and subsequently for a company-wide metadata standard. The specific methods employed and the findings are presented in Paper Three (Appendix 1.0) and Section 4.4.

1.6.5 TASK 5: DEVELOP A GUIDE FOR DEFINING AN ORGANISATIONAL METADATA STANDARD

A key finding from Tasks One, Two and Three was the lack of guidance to enable practitioners within organisations, develop appropriate IM solutions to meet their needs. Drawing lessons from Task Four and similar existing methodologies, a 12 step IM framework is proposed to guide future developments of organisational metadata standards. This unique output from this research will aid other managers and professionals looking to develop metadata standards within their organisations. Successful evaluations were conducted with technical subject matter experts including previous members of the Dublin Core Metadata Initiative (DCMI), faculty members at the Harvard Business School and industry practitioners to validate its suitability, appropriateness, rigour and applicability to other organisations.

1.6.6 TASK 6: INVESTIGATE THE APPLICATION OF METADATA IN INFORMATION RETRIEVAL

The application of metadata in information retrieval was then investigated identifying the attributes required for a metadata driven facetted search solution. The findings showed that while a broad metadata standard is required and beneficial for improving the holistic approach to IM, not all the attributes within such a standard are also required for search. Though the attributes identified here are specific to the research sponsor, the principle is generic and applicable across other organisations, improving wider understanding of the development and implementation of appropriate facets for enabling facetted search. The methods employed and the overall findings are presented in Paper Four (Appendix 2.0) and Section 4.6.

1.6.7 TASK 7: DEVELOP A CORPORATE INFORMATION ARCHITECTURE FOR INFORMATION MANAGEMENT

This task focussed on the creation of the Information Architecture within a case study group (in the research sponsor), to assess the viability of a holistic approach to IM and its impact on specific processes. The case study approach adopted enabled extensive depth to be achieved, and all the group's processes to be reviewed in detail. The findings (explained in detail in Section 4.7 and Paper Five (Appendix 3.0)) improve general understanding of the development of Information Architecture to align with business processes.

1.6.8 TASK 8: INVESTIGATE THE APPLICABILITY OF A HOLISTIC APPROACH TO INFORMATION MANAGEMENT ON AN ORGANISATIONAL PROCESS

This involved the creation and implementation of a knowledge portal (KP) for managing explicit knowledge across a large organisation. The current approach to knowledge sharing was investigated to identify the key tasks, the participants involved, the nature of information and how explicit knowledge is managed through its life cycle. A more 'refined' approach was then designed and implemented using a new content model and appropriate technology suited to the research sponsor's business strategy and operational processes. The outcome of the study with the detailed findings demonstrating the application of a holistic approach and its impact, are explained in Section 4.8.

1.7 NOVELTY OF THE RESEARCH

The main novel insights from this research include:

- A detailed understanding of IM within the construction industry as distinct from IS and Information Technology (IT) including its Drivers, Barriers and Constraining factors;
- New knowledge on the experiences and lessons learnt from the development and implementation of IM strategies and solutions in construction organisations;
- The creation of a structured 12 step guide for developing an organisational metadata standard to support IM;
- The development of appropriate facets for a metadata based search solution demonstrating that not all attributes in a metadata standard may be required for information retrieval;
- The understanding that a single standard for metadata to support a multidisciplinary organisation may be both impractical and inappropriate. A basket of attributes built on a central core but customisable to suit the needs of the individual disciplines and projects across the organisations is more appropriate; and
- The presentation of two case studies which demonstrate the development and implementation of a holistic approach to managing information with its impact on processes.

In recognition of the insights from this research and the RE's achievements, the RE was invited to deliver a seminar at the Harvard Business School (HBS). This was held on the 14th of June 2010, at the Boston campus and had in attendance staff and members of the faculty of HBS. The seminar focussed on effective IM strategy in organisations. The RE presented the underlying theory of a holistic approach to IM, all the tasks carried out in this research and other projects carried out within the research sponsor.

The seminar was greatly received. Participants provided very positive (oral and email based) feedback on the overall quality of the research and commended the emphasis placed on clear alignment between IM and operational strategy. The guide for developing a metadata standard

(see Section 4.5) was also well received and was trialled for use by staff of Baker Library Services within HBS. Feedback from this form part of the validation carried out (presented in Section 4.5.3). Reflecting on the seminar, attendees also greatly applauded the "organisational dimension" adopted particularly the emphasis placed on effective Change Management as a component of a holistic approach to IM.

1.8 LIST OF PUBLICATIONS

A number of peer reviewed papers were published to disseminate the insights gained through the research project as summarised in Table 1.1.

Table 1.1: List of Publications

Paper No.	Paper title	Bibliographical Reference	Status
Paper 1	An Enterprise Content Management approach to organisational Information Management	Sheriff A, Bouchlaghem D, EL-Hamalawi A, Yeomans S.G. (2008). An Enterprise Content Management approach to organisational Information Management. In *Proceedings of the CIB W65 Symposium, Transformation through Construction,* November 15th – 18th, Dubai, United Arab Emirates.	Published
Paper 2	Information Management Audit of Buro Happold.	Sheriff A, Yeomans S.G. (2009), Information Management Audit of Buro Happold. (Internal technical report – submitted to Buro Happold)	Internal report
Paper 3; Appendix 1.0	Developing a Metadata Standard for Multimedia Content Management: A case study	Sheriff A, Bouchlaghem D, EL-Hamalawi A, Yeomans S.G. (2011). Developing a Metadata Standard for Multimedia Content Management. *Architectural Engineering and Design Management* (Accepted)	Accepted
Paper 4; Appendix 2.0	Developing Facets for Facetted search	Sheriff A, Bouchlaghem D, EL-Hamalawi A, Yeomans S.G. (2010). Developing Facets for Facetted Search. *In Proceedings of the 6TH International Conference on Innovation in Architecture, Engineering and Construction*, June 9 -11, Pennsylvania, USA.	Published
Paper 5; Appendix 3.0	Developing a corporate Information Architecture	Sheriff A, Bouchlaghem D, EL-Hamalawi A, (2010). Developing a Corporate Information Architecture. In *Proceedings of the 10th International Conference of Computing in Civil and Building Engineering,* June 30th – July 2nd, Nottingham, UK.	Published
Paper 6; Appendix 4.0	Information Management in Construction Organisations – drivers, constraining factors and barriers.	Sheriff A, Bouchlaghem D, EL-Hamalawi A and Yeomans S.G. (In review). Information Management in Construction Organisations – drivers, constraining factors and barriers.	In Review
Paper 7; Appendix 5.0	Seven lessons for effective Information Management.	Sheriff A, Bouchlaghem D, EL-Hamalawi A and Yeomans S.G. (In review). Seven Lessons for Effective Information Management.	In Review

1.9 STRUCTURE OF THESIS

This thesis is organised into five chapters:

Chapter 2 presents a detailed review of existing literature on IM with its key components. It also presents a detailed review of metadata and taxonomy.

Chapter 3 explains the methodology adopted in carrying out the research. The various perspectives and approaches available are presented following which the specific methods adopted in this study and their suitability for meeting the overall research objectives are explained.

Chapter 4 provides detailed descriptions of the eight tasks carried out, the specific methods employed, the analysis conducted and the findings from each task.

Chapter 5 outlines the key findings from the research. It also highlights the impact of the research findings on the sponsor, the wider construction industry and general IM research and practice. It then concludes with a critical review of the research and areas for further research.

1.10 SUMMARY

This chapter introduced the research highlighting the need for it, its aim, objectives, justification and outputs, thus putting the entire thesis in the right context. The extensive review conducted into the subject area is now presented in Chapter Two.

2 CHAPTER 2: REVIEW OF RELATED LITERATURE

This chapter presents a detailed review of existing literature on IM, positioning the research within the wider body of knowledge.

2.1 INFORMATION MANAGEMENT

Information is the product of the contextual understanding and interpretation of data. It is the essential medium through which knowledge, expertise, judgement, emotions and decisions held by individuals are expressed, shared and communicated with others (Davenport and Marchand, 2000). Hicks et al (2006) define IM to include the activities which support the information lifecycle from creation, representation and maintenance through to reuse. An information intelligent organisation is one which understands the value of information and can successfully search, find, assemble, analyse, use and reuse all forms of information products required for any of its tasks (Evgeniou and Cartwright, 2005). This is particularly important as competitive advantage today makes information core to obtaining operational efficiency (Christian, 2002; Chaffey and Wood, 2004; Hicks et al, 2002; Hicks et al, 2006; Laundon & Laundon, 2009). Being information intelligent requires a more strategic view of information as a corporate asset, aligning the information needs of the organisation to its business processes (Buchanan and Gibb, 1998; Brigl et al, 2005). It requires a fundamental rethink of information, its position within the organisation and its potency as a means of securing long term competitive advantage. It also requires information to be viewed in a holistic manner balancing an appreciation of technologies with the capabilities of people within the business to harness and use the information to improve performance (Marchand, 2000). To clarify its scope, it is necessary to differentiate between IM and associated concepts in both research and practice.

2.1.1 KNOWLEDGE MANAGEMENT

Hicks et al (2006) highlight significant research conducted into KM practices within organisations particularly explicit KM as synonymous or indeed interchangeable with IM. Davenport (2000) and Ghani (2009) relate this to KM being a key driver for improving IM. There are a plethora of definitions for KM including those by Webb (1998); Davenport and Prusak (2000); Carrillo and Chinowsky (2006) and Rezgui et al (2010a). Robinson et al (2005) define KM as the means through which knowledge (in the broadest sense) is captured, exploited and transformed for organisational use. Its continuous importance is predicated on the growing appreciation of the strategic significance of knowledge as a competitive resource in a modern economy (Egbu, 2004). Bishop et al (2009) argue that while knowledge can be codified, shared and exchanged, the scope of KM is much broader than IM as not all knowledge can or need to be codified. KM is therefore not synonymous with IM though similar processes, technologies and practices may be employed in both fields. IM can enable KM and is a significant component of it, but does not in itself represent a KM solution. IM also extends to the administration of content through its lifecycle which falls outside the scope of KM. This research thus considers explicit knowledge as a type of information and therefore a part of IM but the scope of this study and indeed IM in general is inherently different from KM in both research and practice.

2.1.2 INFORMATION SYSTEMS AND INFORMATION TECHNOLOGY

Also identified in the literature was the extensive research into IS including Document Management (DM) Systems as part of IM research. The three areas of IM, IS and IT are used interchangeably further amplifying this apparent lack of clarity (King et al, 1988; Marchand, 2000). For example, Maddison and Darnton (1996) present an approach to aligning IM with

organisational processes which puts emphasis on IS and IT, neglecting IM. Similar findings are apparent in the works of Robson (1994), Gyampoh-Vidogah and Moreton (2003), Froese (2005), Craig and Sommerville (2006), Dilnut (2006) and Hicks et al (2006). The result is a largely technological view of IM that excludes the organisational dimension. While all three areas focus on information (as shown in Fig. 2.1), the emphasis placed on certain themes make each a distinct field of study with different requirements. Marchand (2000) outlines these streams as:

- *IT* - primarily concerned with the infrastructure needed to manage information ranging from desktop based infrastructure to servers and networks;

- *IS* - focuses on the software applications which perform defined business functions ranging from design, manufacturing and production to accounting, human resource management and other associated processes within the organisation; and

- IM – focuses on content and the bits of information required to carry out distinct tasks/processes. It is strategy and process driven aligned to the various business units across the organisations. The emphasis here is on managing and leveraging content to support business processes.

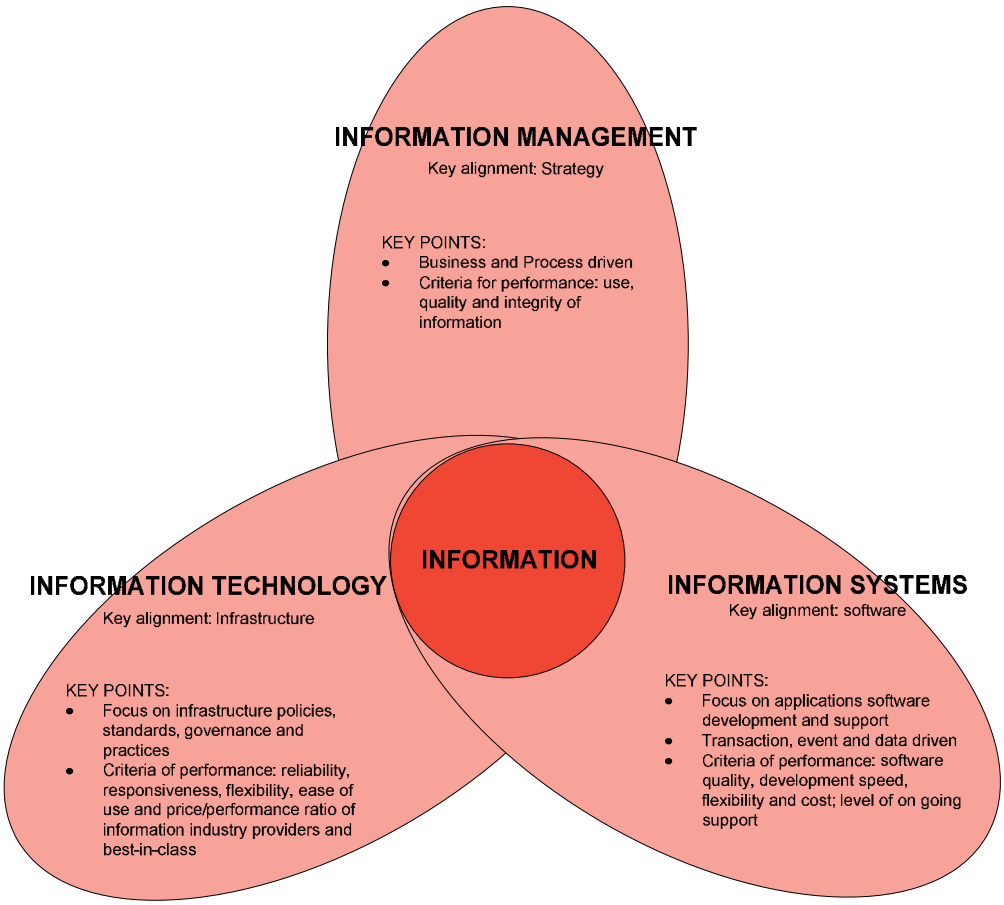

Figure 2.1: IM, IS and IT alignment (adapted from Marchand, 2000).

Each stream, with its distinct paradigm enables organisations to gain competitive advantage through technology i.e IT; software i.e. IS; or information i.e. IM (King et al, 1988; Hicks et al, 2006). Inter-relationships and interdependencies do exist between all the above streams and often it is impossible to view one stream in isolation. A successful IM strategy must often be accompanied by successful IT and IS solutions as they form the core media through which information is created, shared and stored. However, a focus on IT or indeed IS does not imply a focus on IM as neither IT nor IS focus on the content or information which an organisation creates or uses; its alignment with the organisations strategy or the behavioural dimensions of

managing information (all of which are the focus of IM). Thus while appreciating the need for and importance of IT and IS, this research focuses on IM.

2.2 HOLISTIC APPROACH TO INFORMATION MANAGEMENT

A holistic approach to IM involves the strategies, tools, processes and skills an organisation needs to manage all forms of recorded information through its complete lifecycle supported by necessary technological and administrative infrastructures (Boiko, 2002; Tyrvainen et al, 2002; Nordheim and Paivarinta, 2004; Munkvold et al, 2006; HP, 2007). Such an approach requires an appreciation of what information means to an organisation, how the organisation can best use, structure and exploit it to achieve desired results (Marchand, 2000; HP, 2007). Numerous technologies do exist which aim to enable this. However, critical to the success of a holistic approach is emphasis on corporate wide strategies and policies which guide the use and implementation of the appropriate technology (Paivarinta and Munkvold, 2005). In a detailed study of organisations conducted by Mckinsey & Co. and the London school of economics, Dorgan and Dowdy (2004) observed that investing solely in systems and technologies had little impact on productivity unless accompanied by operational changes in processes irrespective of a company's size, location, sector or past performance. Similar arguments are presented by Froese (2005), Koskella and Dave (2008) and Rezgui et al (2010a). Like any successful strategy, such a holistic approach should also remain dynamic and adaptable enough to support continuously evolving organisational cultures and business goals (Deloitte, 2002).

A number of drivers were identified for a holistic approach to managing information in the literature. These include:

- The need to improve collaborative working and knowledge sharing across organisations and with clients (Munkvold et al, 2003; Yeomans et al, 2005).

- The realisation that in a knowledge based economy, information is the key corporate asset and as such is crucial for improving competitiveness (Davenport, 2000; Moore and Markham, 2002; HP, 2007).

- The need to reduce waste (in time and resources) associated with the duplication of information and improve consistency across the organisation (Moore and Markham, 2002).

- The need to ensure regulatory compliance (Sprehe, 2005; HP, 2007).

- The need to improve productivity and manage business risks (Dilnut, 2006).

- The need to enable greater innovation and value creation across the organisation (Moore and Markham, 2002).

These are generic drivers not necessarily contextual to the needs of construction industry based organisations. Such contextual studies of IM in construction industry based organisations are rare.

2.3 COMPONENTS OF A HOLISTIC APPROACH

A holistic approach to IM consists of four key components a clear appreciation of which is essential to ensure the approach is contextual, appropriate and implemented effectively

(Marchand, 2000; Paivarinta & Munkvold, 2005; Bridges, 2007). These (as depicted in Fig. 2.2) are:

- *Content model; Enterprise model; Systems and Technology; and Implementation and Change Management*.

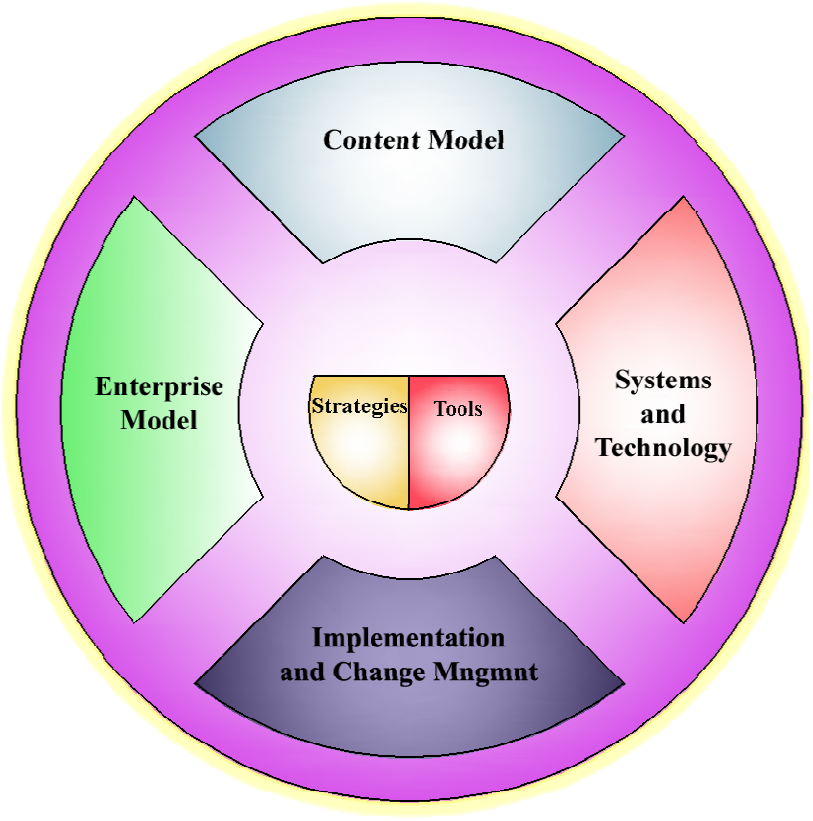

Figure 2.2: The Four Components of a Holistic Approach to IM

All four components are reviewed and presented in the sub-sections below, however only the content model is investigated in detail due to the specific context of the research project.

2.3.1 CONTENT MODEL

The content model refers to the nature of the content including its structure, attributes and suitability for the organisation's needs (Grosniklaus and Norrie, 2002; Paivarinta and Munkvold, 2005; Rockley, 2006). Simplistically, 'Content' is a bit of information created by an author e.g. words, phrases, sentences, drawings, charts, graphic images, etc contained within information products (Rockley et al, 2003). Therefore, it is argued that a document is an information product which contains content within. The focus of IM is not on managing information products in the form of electronic files or paper *per se*, but the content contained within each product. Thus key to defining a suitable content model is deciding on an appropriate level of granularity for the organisation's needs. Granularity refers to the lowest level to which a piece of content can be divided while still remaining meaningful and manageable (Rockley et al, 2003). Differences in content granularity have given rise to two distinct approaches to content in both research and practice each with its benefits and limitations:

1. **The Integrated Document Management Approach:** Here, information products such as documents are treated as individual autonomous entities, the focus being to support the information product through its lifecycle (Bjork et al, 1993; Stouffs et al, 2002). This includes research into DM, Electronic Document Management Systems (EDMS) and extranets.

2. **The Model-Based Approach:** Here, information is created and maintained as granular pieces of content (and not documents). Information products such as documents/drawings are then assembled from this dynamic content in the most appropriate format when required (Rezgui and Dabras, 1995; Rockley et al, 2003; Hamer, 2006). This includes research into Building Information Models (BIM), and Content Management (CM).

This research makes no attempt to place a preference for one over the other as each organisation's needs would inevitably dictate which approach will be most suitable. Information Audits are conducted to gain a clear understanding of the exact nature of an organisations content needs in lieu of its business strategy (Botha and Boon, 2003; Buchanan and Gibb, 2007) as similarly carried out by Theakston (1998); and Tali and Mnjama (2004). Two other critical aspects of a Content Model are Metadata and Taxonomies.

2.3.1.1 Metadata

Metadata are additional pieces of data or attributes which describe the context, content and structure of a piece of data, content, document or other bit of information and their management through time (ISO 15489: 2001). Bjork (2002) also describes metadata as "secondary information about content". The use of Metadata within a content/document library allows information to be more easily found, its source determined and its context understood, easing interpretation and enabling re-use (Burnet et al, 1999; Bentley, 2001; NISO, 2004; Day, 2006; Paganelli et al, 2006). While resource discovery remains one of the principal functions of metadata, others may include provenance, technical specification, functionality, terms of use, administration and demonstrating linkage or relationships (Technical Advisory Service for Images (TASI), 2006). Despite research conducted into metadata and its prolonged use, current standards are predominantly bibliographic in focus with very limited research on the use of metadata within organisations (Murphy, 2001; Paivarinta et al, 2002; Burnett et al, 1999; Karjalainen et al, 2000). A metadata standard is required to underpin a holistic approach to managing information. It creates a unifying framework for integrating multiple systems and improving the structuring, sharing and retrieving of information across the organisation as similarly observed by Bjork (2001); Haynes (2004) and Anumba et al (2008). International standards for descriptive metadata exist, the most prominent of which are the ISO 15836 and the BS1192:2007 (specific to the construction industry).

2.3.1.2 Taxonomy

Taxonomy is the logical conceptual structuring of information within a given environment (Woods, 2004; EEDO, 2006). It provides the basis for users to navigate through content collections, allowing organisations to make seemingly significant volumes of content readily accessible (Munkvold et al, 2003; Hienrich et al, 2005). There is a strong relationship between taxonomy and metadata with a taxonomy typically built with appropriate Metadata (Paivarinta and Munkvold, 2005). Metadata is simply descriptive information having no associated hierarchy or relationships. Taxonomies leverage metadata to organise content and create associations between attributes easing search and retrieval of vital information (Woods, 2004; Hienrich et al, 2005). Similar to metadata, designing a suitable taxonomy requires a holistic vision of the content to be managed, potential users (internal and external) and the overall business processes (Gottlieb, 2005). The term 'Information Architecture' is also used to describe taxonomy and the structuring of content. It refers to the set of principles guiding the organisation, navigation and searching of information to enable its management and retrieval (Dong and Agogino, 2001; Dilson, 2002).

Heinrichs et al (2005) argue that while taxonomies can be beneficial for organisations, the use of a central fixed classification scheme often becomes restrictive, belying the multidimensional nature of content, its subject matter and its users. Rather than a one dimensional taxonomy, the multi-dimensional perspectives metadata provides can be used to structure content in multiple ways enabling large data sets to be clustered around similar subject themes (Munkvold et al, 2003). This approach to the use of metadata is referred to as 'facetted classification'. Facets are orthogonal categories of metadata used to characterise content (Hearst, 2006; Yee et al, 2003). Each facet represents one dimension but in combination, multiple facets show several dimensions reflecting a broad range of user perspectives (Giess et al, 2008: Tevan et al, 2008). When applied in Information Retrieval, it combines the strengths of both free text search and structured navigation, and is increasingly adopted in library databases and e-commerce websites (Hearst, 2006; Broughton and Slavic, 2007; Ben-Yitzhak et al, 2008; Tevan et al, 2008). The evolution of faceted classification is most associated with S. R. Ranganathan who proposed the colon classification arguing that subjects can be viewed and classified from five intrinsic perspectives i.e. *Personality, Matter, Energy, Space* and *Time* (Ranganathan, 1969). Further extensive work has since been carried out expanding, modifying and refining these dimensions, a comprehensive account of which is provided by Giess et al (2008). Semantically enriched metadata attributes can also be used as facets to improve information retrieval within collaborative work spaces (Stouffs et al, 2002; Rezgui et al, 2010b). As all metadata attributes can be used as facets, the challenge in using a facetted approach is identifying what attributes will be most appropriate to meet the organisations needs. Findings from a detailed investigation into facetted classification in general and its application in information retrieval are presented in Section 4.6 and Paper 4 (See Appendix 2.0).

These constitute the content model. The other three components of a holistic approach are now presented below.

2.3.2 ENTERPRISE MODEL

The enterprise model is a process map of activities based on the detailed analysis of the organisation, its business processes (including all of its operations, partners, supply chain and customer networks) and their interaction with information throughout its lifecycle (Munkvold et al, 2006). It provides a clear view of the organisations processes. This is particularly important because the basis of any well defined IM strategy is a clear alignment with the organisations operational context including its business strategy, processes, goals and culture (McNay, 2002; Gyanpoh Vidogah and Moreton, 2003). Thus all the process which create, store, retrieve, review, update and distribute content must be reviewed and analysed, the outcome of which then provides a basis upon which a contextual IM strategy suitable to the needs of the organisation can be developed and deployed (Robson, 1994; Rockley et al, 2003; Gottlieb, 2005; Paivarinta and Munkvold, 2005; Hamer, 2006). It is an inclusive process requiring significant input from all stakeholders (Reimer, 2002).

2.3.3 SYSTEMS AND TECHNOLOGY

The primary function of technology within a holistic approach is to facilitate the effective implementation of the predefined strategy. Selecting the tool is thus based on the needs identified and the solutions developed for the other two components (i.e. the Enterprise Model and the Content Model). The importance of this contextualisation is emphasised by Schaeffer (2002) who warns that procuring the wrong software can be worse than procuring none at all. Along with functionality and scalability, any technology employed should be user-friendly, intuitive, usable and secure, conforming to the organisational quality management regulations (Munkvold et al, 2003). Information produced in often heterogeneous technology platforms will need to be shared, transferred, stored and managed independent of the applications with which it was

produced. Thus technology implementations should enable content integration while remaining flexible and scalable enough to cater for increasing content volumes and new information products to emerge in time (Reimer, 2002; Ross, 2003; Paivarinta and Munkvold, 2005; Munkvold et al, 2006;).

2.3.4 IMPLEMENTATION & CHANGE MANAGEMENT

A holistic approach may give rise to new or different ways of working that are alien to the end-users within an organisation. Consequently, along with the procedural and technological components, training, guidelines, standards, and Change Management are crucial to its successful implementation, adoption and maintenance (Munkvold et al, 2003; Paivarinta & Munkvold, 2005; HP, 2007). Supporting these behavioural changes may take time and will require effort but will ensure the approach to IM becomes embedded and thus sustainable (Davenport, 2000; Gyampoh-Vidogah and Moreton, 2003)

Together, the above represent the four components of a holistic approach to IM.

2.4 GAPS IN THE LITERATURE

A number of gaps were identified in the literature which further reinforce the need for the research. IM research in the construction industry is primarily focused on the project environment frequently highlighting the need for greater collaboration and co-ordination between stakeholders to improve productivity and performance (Bjork, 2001; Caldas and Soibelman, 2003; Anumba et al, 2004; Peansupap and Walker, 2005; Yeomans, 2005; Craig and Sommerville, 2006; Shelborn et al, 2007). As limited research has been conducted on IM from an organisational paradigm, there is insufficient clarity on the needs, drivers and barriers to managing information within construction organisations. Improving collaborative working is one such driver but remains a broad field with diverse yet inter related and often interdependent themes only one of which is IM (Jorgensen and Emmittt, 2009).

IM research in the construction industry also focuses on the use of IS sometimes to enable collaborative working (Murphy, 2001; Ahmad et al, 2002; Sripasert and Dawood, 2002; Munkvold et al, 2003; Froese, 2005; Peansupap and Walker, 2005; Craig and Sommerville, 2006). These include the vast amounts of work done on the use of EDMS, Content Management Systems (CMS), Extranets and similar IS to support the construction process. Though construction industry based organisations primarily work on projects, a merely project centric view does not represent all the information created, shared and managed within organisations nor does it empower organisations to manage cross project information. Managers also lack an understanding of the broader issues around IM, the type of information various people within their organisations need and want, and how to effectively implement such a strategy to support their respective organisations.

Construction Industry specific metadata standards do exist. For example the BS1192:2007 standard for collaborative production of project information provides a naming convention constructed using specific metadata fields. When trialled for use within the research sponsor, the metadata fields were found to be project centric, not reflecting the broad range of business needs within the organisation. The united classification for the construction industry (Uniclass) also provides a broad taxonomy of metadata attributes. This is however a subject specific classification system and is therefore not synonymous with descriptive metadata standards such as ISO 15836. There is also limited practical guidance to enable organisations develop suitable standards to meet their needs.

2.5 SUMMARY

This chapter presented an extensive review of IM literature, explaining the holistic approach with its four key components, thus positioning the research in the appropriate context relative to other works within the domain. Though a holistic approach is identified as being critical to the successful development and implementation of an IM strategy, this research focuses mainly on the content model. It however does so based on the organisational paradigm ensuring that the content, metadata and taxonomy are developed to suit the organisations business strategy. The chapter then concludes with a summary of identified gaps in the literature. The research methodology employed is now presented in Chapter Three.

3 CHAPTER 3: RESEARCH METHODOLOGY

This chapter presents the methodology applied to this research along with justification for its adoption.

3.1 INTRODUCTION

Research is a continuous process of careful and systematic investigation in a field of knowledge using appropriate and accepted scientific methods to gather factual material to solve identified problems, establish facts or define principles so as to establish reliable and valid knowledge about a phenomenon (Naoum, 2006). The procedures, and processes applied to such an investigation are defined in the research methodology (Clarke, 2000). Underpinning the design and execution of research is the design and selection of a workable, reliable, valid, unbiased and objective research methodology. This is by no means a trivial exercise and requires a careful consideration of the objectives of the research; the problem being investigated; the type of data required; the target sample; the methods most appropriate for collecting the data and the specific constraints of the research (Leming, 1996; Cavaye, 1996; Falconer and Mackay, 1999). Four inter-related perspectives influenced the design and execution of this research as shown in Fig. 3.1. Prior to outlining the methods applied to this research, it is important to introduce the philosophical principles of each perspective.

3.2 RESEARCH PERSPECTIVES

The four perspectives explored in this research are illustrated in Fig 3.1 and explained below.

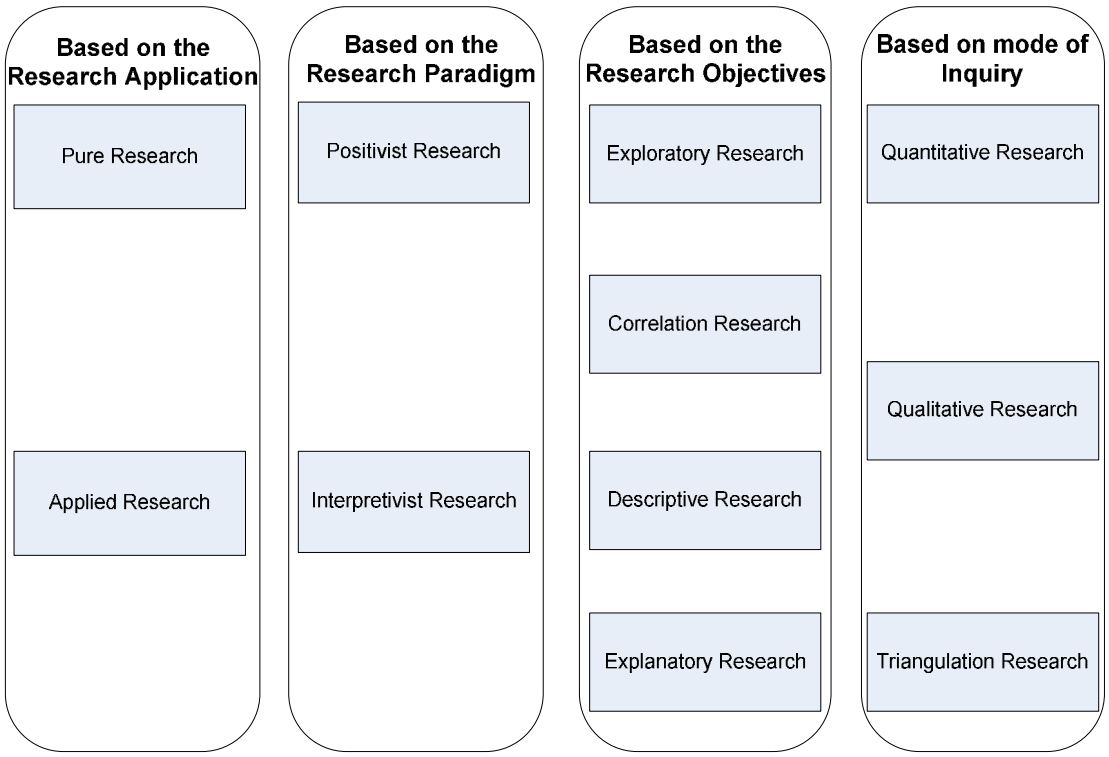

Figure 3.1: The Four Perspectives Explored in this Research

3.2.1 PERSPECTIVE 1: BASED ON THE APPLICATION OF THE RESEARCH

Research can be viewed as being either *pure* or *applied* based on its application. Pure research is abstract and involves the development, testing and validation of scientific theories and hypotheses which may not be directly applicable to either a present or a future practical scenario. The process and outcome of pure research could also contribute significantly to the development, examination and verification of research methods and procedures as standalone outcomes (Kumar, 2005). In contrast to the theoretic slant of pure research, applied research is practical and involves the application of existing and established research methods to solve defined problems and meet research objectives (Kumar, 2005). Thus through its practicality, applied research focuses on the use of research methods and not the research method itself.

3.2.2 PERSPECTIVE 2: BASED ON THE RESEARCH PARADIGM

Fellows and Liu (2005) define a paradigm as a theoretical framework explaining the systems and manners through which individuals view events and approach problems in a research study. Generally, two distinct research paradigms have evolved over time reflecting equally valid modes of thinking. These are: *the positivist paradigm* and *the interpretivist paradigm*

Positivism is rooted in the belief that the world conforms to certain fixed laws of causation and thus recognition is given only to non-metaphysical facts and clearly observable phenomena in both selecting appropriate research methods and interpreting research outcomes (Woods and Trexler, 2001). Critics (including Kumar, 2005) say positivism as a paradigm is somewhat idealistic and inappropriate for some forms of research, particularly that which is aimed at gaining insights into the meaning of outcomes.

In contrast to positivism, interpretivism hinges on the acceptance that reality is context dependent and therefore a situation is inevitably influenced by the participants involved in it (Fellows and Liu, 2005). It relies on giving meaning to, studying and analysing occurrences and their social structures within a defined context. Far from being absolute in its view of the world, interpretivism emphasises that being socially constructed, reality can be open to multiple interpretations both by the participants within it and the researcher studying it. Through these varying perspectives, new realities and new findings can emerge.

3.2.3 PERSPECTIVE 3: BASED ON THE RESEARCH OBJECTIVES

Based on the objectives of the study, four philosophical positions may be adopted for research. These are: *Descriptive; Correlation; Exploratory;* and *Explanatory*. The definitions and descriptions provided here are based on the work of Kumar (2005).

Descriptive research is aimed principally at explaining or illustrating the research problem and its solution being investigated within its defined context. Correlation research, seeks to investigate, discover or establish the existence or nature of the relationship between two or more variables/entities in a defined case. Emphasis here is placed on identifying such relationships and not how or why they exist. Where a relationship between entities or variables has been pre-established, explanatory research provides greater insight into this, clarifying why and how such relationships exist and its true nature. Finally, exploratory research investigates specific phenomena in which little is known to obtain greater insight.

3.2.4 PERSPECTIVE 4: BASED ON THE MODE OF INQUIRY

Research can also be viewed via three modes of inquiry. These are: *the Quantitative Approach; the Qualitative Approach; and the Triangulation Approach*.

The quantitative approach, typically modelled on the positivist paradigm, seeks to gather factual data in a quantifiable manner to test and measure variations in phenomena (Creswell, 1994). Numerical data is collected and analysed as statistically measurable variables to obtain results used to determine the validity or otherwise of a hypothesis (Blaxter et al, 2003).

In contrast, the qualitative approach builds on the subjectivity and context dependence of research phenomena (Naoum, 2006). Here, emphasis is placed on deriving meaning from experiences of the subject matter from the perspective of an active participant or a third party without quantification or measurement (Strauss and Corbin, 1998). It focuses on exploring issues and themes on a subject matter in detail emphasising more depth than breadth (Blaxter et al, 2003). Table 3.1 outlines the differences between qualitative and quantitative research.

Table 3.1: The Differences between Quantitative Research and Qualitative Research (Kumar 2005 pp 17 – 18)

	Difference with respect to	Quantitative research	Qualitative research
1	Underpinning philosophy	Rationalist	Empiricist
2	Approach to inquiry	Structured/predetermined methodology	Unstructured/semi-structured or open methodology
3	Main purpose of investigation	To quantify the extent of variation in a phenomenon or situation	To describe variations in a phenomenon or situation
4	Measurement of variables	Emphasis on some form of either measurement or classification of variables	Emphasis on description of variables
5	Sample size	Emphasis on greater sample size	Fewer Cases
6	Focus of Inquiry	Narrows focus in terms of extent of inquiry, but assembles required information from a greater number of respondents	Covers multiple issues but assembles required information from fewer respondents
7	Dominant research value	Reliability and objectivity	Authenticity but does not claim to be value-free
8	Dominant research topic	Explains prevalence, incidence, extent, discovers regularities and formulates theories	Explores experiences, meanings and perceptions
9	Analysis of data	Subjects variables to frequency distributions, cross tabulations or other statistical procedures	Subjects responses or observation data to identification of themes and describes these
10	Communication of findings	Organisation more analytical in nature, drawing inferences and conclusions and testing magnitude and strength of a relationship	Organisation more narrative in nature

A third approach called triangulation is an amalgamation of the two approaches in a study to obtain a multi dimensional view of a subject (Fellows and Liu, 2005; Shank, 2006). This amalgamation of quantitative and qualitative approaches implies that theories developed using one approach can be tested via the other. It enables the weaknesses of each method to be covered by the strengths of the other, thus strengthening the research findings and enabling cross verification of the research conclusion (Silverman, 2006).

3.3 SELECTED RESEARCH PERSPECTIVES

As the aim of this research was to investigate IM in the construction industry, all four research objectives were wholly 'applied' in nature (and not pure research). No attempt was therefore made to either create new methodologies or solve abstract problems. A purely positivist approach would have also proved inadequate. This is because the specific context of the research sponsor; its specific processes being investigated; and the individuals partaking in the study all had to be taken into account in executing the research, collecting the data and analysing its findings. As it was necessary to view the research through a context dependent lens, the interpretivist paradigm was adopted.

If viewed based on the objectives, it was clear from the overall aim of the research that none of the four approaches would solely be sufficient to address all four objectives. As Objective One was aimed at investigating the state of the art in IM, a descriptive paradigm was appropriate for carrying out the extensive literature review (Task One). However, to establish the state of current practice in IM within the construction Industry (Task Two), a more exploratory paradigm was adopted in the form of interviews with subject matter experts. Objective Two was also fundamentally exploratory as an investigation was conducted into the current state of IM practices within the research sponsor (Task Three). It's focussed nature and the probing required to identify certain phenomena meant that a descriptive paradigm would have been unsuitable, hence the exploratory paradigm was adopted.

An exploratory paradigm was also required for investigating metadata (Objective Three – Tasks Four and Five) and investigating the impact a holistic approach will have on specific business processes (Objective Four – Tasks Seven and Eight). Thus the whole research was mainly exploratory in nature. However, a sub-objective of Objective Four investigating the relationship between metadata and search (Task Six) was correlational, as a critical comparison between two variables was conducted.

3.4 RESEARCH APPROACHES

Fellows and Liu (2005) explains that the same approaches can be used across different philosophical perspectives. Thus, none of the approaches or methods of data collection described below is exclusive to any of the perspectives above. Selecting an approach may be on the basis of what most suitably meets the needs of the research and what type of data is to be collected. Five main research approaches are described below.

3.4.1 ACTION RESEARCH

Action research is built on the principle of direct intervention or involvement of the researcher in the process under study to identify, develop and evaluate potential interventions to a research problem (Bryman and Bell, 2007). It is immersive in nature and concerns itself with stimulating improvements in the quality of service and/or implementing remedies which impact on a given situation to gain results (Kumar, 2005).

3.4.2 CASE STUDY RESEARCH

Case study research involves the investigation, observation and analysis of an individual situation to probe a phenomenon deeply through multiple facets (Yin, 2003). Case studies are focused in nature enabling many specific details often overlooked by other methods to be explored (Denscombe, 2007). While attempts may be made to draw generalised conclusions

from case studies, care must be taken in doing so as this rests on the assumption that the case being studied is typical and thus transferable (Blaxter et al, 2003).

3.4.3 EXPERIMENTAL RESEARCH

Experimental research aims to test the relationship between known variables in a research study. It is adopted where an independent variable is manipulated under known and defined conditions to measure and capture its outcomes or impact on dependent variables (Blaxter et al, 2003). This may be conducted in either a natural or controlled environment (Fellows and Liu, 2005).

3.4.4 SURVEY RESEARCH

Survey research is based on the use of statistical samples of a set of cases within a study population to obtain data from which estimates or inferences can be made of the wider population (Thomas, 1996). If the sample is appropriately drawn from the study population, the data obtained is said to provide a representative indication of the likely response from the wider population (Naoum, 2006).

3.4.5 ETHNOGRAPHIC RESEARCH

Ethnographic research involves the active observation of activities, behaviours and phenomena by immersion into its case environment without any direct intervention by the researcher which may serve to influence the situation being studied (Genzuk, 2003; Fellows and Liu, 2005). Ethnographic research unlike action research is 'observation' based and does not involve direct intervention by the researcher.

3.5 SELECTED RESEARCH APPROACH

The nature of each objective implied that one overarching approach would not be appropriate for the research. Objective One with its focus on understanding the state of the art both within the general field of IM and also within the construction industry required a survey approach. Objectives Two and Three required focused and in-depth studies of a single organisation from within a sample of similar organisations without the direct intervention of the RE as a participant. Thus ethnographic, survey, experimental or action approaches were unsuitable. The tasks were therefore executed as case studies. Finally, meeting the sub-objectives of Objective Four required the RE to proactively (and iteratively) engage with end users in the planning, implementation, data collection and reflection on the specific tasks. Thus an action research approach was deemed most appropriate.

3.6 SELECTED METHODS OF DATA COLLECTION

A number of methods can be applied to collect data in a research project based on the approach to be adopted; the four perspectives employed (as outlined above); the objectives of the study and the skills of the researcher (Falconer and Mackay, 1999; Kumar, 2005). Only the specific methods adopted for this research are presented below. These included:

3.6.1 LITERATURE REVIEW

Literature review is an un-intrusive secondary method of data collection involving an extensive review of related research publications on a defined subject matter (Moore, 2000; Denscombe,

2007). Such a review provides preliminary insights into a subject area, including the gaps inherent there, hence forming a sound basis from which further research can be carried out (Blaxter et al, 2003).

An extensive literature review was carried out to meet the goals of Task One while also providing the essential basis for the subsequent execution of Tasks Two to Eight. Details on the subject matter(s) covered along with the design and execution of each task are explained in the relevant Sections of Chapter Four.

3.6.2 QUESTIONNAIRES

These are one of the most widely used methods of data collection. A questionnaire is a list of open (broad) or closed (concise) questions issued to respondents using various media for which appropriate answers are sought (Fellows and Liu, 2005: Denscombe, 2007). As questionnaires may be distributed in the absence of the researcher, Thomas (1996) argues that the layout, structure and language must be clear to respondents to be effective. Relative to other primary means of data collection, questionnaires can be less expensive and provide anonymity for respondents (which can be a very important factor depending on the research problem being investigated). However, questionnaires can also have very low response rates and may not easily allow the researcher to probe any interesting themes highlighted in response to a certain question on the survey (Fellows and Liu, 2005).

Objectives Two and Three were survey based studies that required responses to be obtained from a sample of the overall population. As first hand data was required, literature review was deemed insufficient. Interviews were inappropriate due to the large sample size and the nature of the problem being investigated. Questionnaires were therefore designed and employed. The design and distribution of the questionnaire across the sample are discussed in greater detail in Sections 4.3 and 4.6.

3.6.3 INTERVIEWS

Interviews involve the questioning of a respondent through discourse on a defined theme or subject area to obtain responses aimed at addressing a research hypothesis (Kumar, 2005; Naoum, 2006). They provide flexibility not common or possible with the more passive observation approach, the more structured questionnaire or the secondary document based approach. With its interactive nature, it can also enable the researcher to guide the discourse to a particular area of focus. Interviews could be personal (face-to-face) or via a medium (internet or telephone). The richness of data collected via interviews makes the process of analysing the outputs very lengthy and difficult. Generally, Interviews can be:

- Structured (using predetermined close ended interview questions);
- Unstructured (open ended, relying on a series of often open themes (not necessarily questions) to guide the discourse with respondents); and
- Semi-structured (which combines the benefits of both the structured and unstructured interviews) (Blaxter et al, 2003; Naoum, 2006)

Whilst document analysis was appropriate for the first task of Objective One, the primary data for the second task required the collection of first hand data from the target sample. Similarly, the nature of the subject matter, the opinions of the experts sought and the depth of the investigation needed made the use of a questionnaire (to obtain the requisite data) inappropriate. Thus interviews were carried out in line with the goals of Objective One (specifically, Task Two). Details on how this was done, the data obtained, the analysis conducted and the findings are explained in Section 4.2.

3.7 SUMMARY

This chapter provided a summary of the methodology employed in executing the research. It began by exploring the four research perspectives following which the adopted approaches and methods were outlined. The breadth of the research objectives implied that a combination of approaches was necessary to meet the needs of the research. The overall methodology that underpins this research is illustrated in Fig. 3.2.

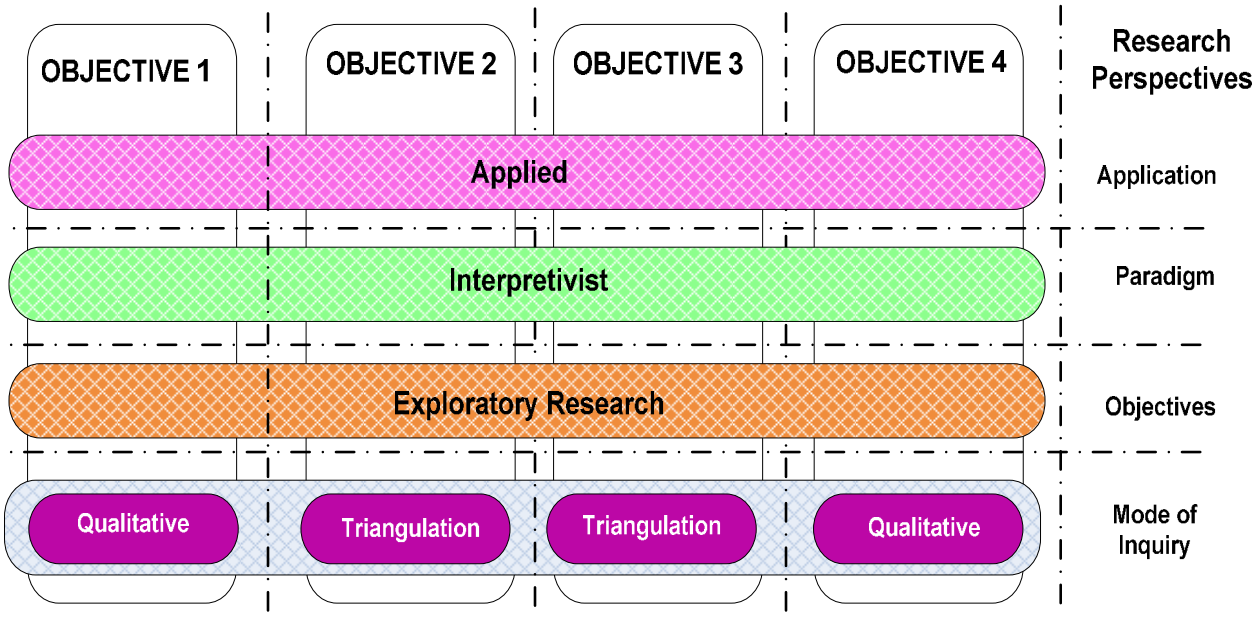

Figure 3.2: Summary of Research Perspectives

The particular methods of data collection for each objective are summarised in Table 3.2 below.

Table 3.2: Summary of Methods of Data Collection

	Objective	Task	Document Analysis	Interviews	Questionnaire	Mapping	Workshops
1	Investigate the current state of Information Management in construction organisations	Review the State of the art in Information Management	P				
		Review Information Management in Construction Organisations.	S	P			
2	Investigate the state of the art in Information Management practices in the research sponsor.	Conduct Information Audit of the research sponsor	S		P		P
3	Define a metadata standard for Information Management.	Develop a metadata standard for Information Management	P				P
		Developing a guide for defining an organisational Metadata Standard	S				P
4	Assess the application of a holistic approach to Information Management on organisational processes.	Investigate the application of metadata in information retrieval.	S		P	P	
		Develop a corporate Information Architecture for Information Management.	S	P		P	
		Investigate the applicability of a holistic approach to Information Management on organisational processes.	S	S		P	
Key	Primary Method	The main method of data collection.	P				
	Secondary method	Supplementary method used to complement the primary method.	S				

Details of the application of these methods and the findings from the tasks are outlined in Chapter Four.

4 CHAPTER 4: RESEARCH UNDERTAKEN AND RESULTS

This chapter outlines the specific tasks undertaken to meet the research objectives.

4.1 PRELIMINARY STUDIES

The RE spent the first year gaining a broad appreciation of the subject area through an in-depth review of related literature on IM. Six academic modules were also completed over two years (in fulfilment of the taught component of the EngD). These modules, particularly the modules titled 'Information Architecture' and 'Management Information Systems', significantly enhanced the RE's understanding of IM and its application in practice, thus complementing the EngD research. To effectively understand the research sponsor, its culture, structure, operations and needs, regular formal and informal meetings and workshops were held with key employees from middle to senior management. The RE also interacted with a number of internal steering groups such as the DM steering group, the Microsoft Office SharePoint Server (MOSS 2007) user panel and the Quality Management System (QMS) improvement group. 13 professional development courses/training sessions were also attended ranging from business analysis to information flow mapping and negotiation training all of which significantly enhanced the RE's technical and managerial competencies. The eight tasks carried out to meet the research objectives were executed in three phases as explained in detail below.

PHASE 1: EXPLORATION

The first phase of the research involved a detailed investigation into the nature of IM through three tasks. Task one involved a detailed literature review to define IM, its constituent components and identify any gaps in research and practice. Reference material was obtained from online databases and the learning facilities of Loughborough and Bath Universities. The findings (see chapter two) established that despite studies highlighting the need for a more strategic approach to managing information, limited research has been conducted into the organisational dimensions of IM. IM research in construction focuses on projects and not the organisational dimensions of Information (as discussed in Chapter two). The review while focussing on IM also covered associated concepts including KM; ECM; CM; and DM. Detailed findings from the review are presented in Chapter Two and Paper One (see Sheriff et al (2008)). Following the review, a more focused study was conducted to investigate the nature of IM in construction industry based organisations. The findings are presented in Section 4.2 below.

4.2 TASK 2: REVIEW INFORMATION MANAGEMENT IN CONSTRUCTION ORGANISATIONS

4.2.1 METHOD

Semi-structured interviews were carried out with IM experts from a sample of construction industry based organisations sourced from the annual Construction Industry ranking of the *Building* magazine (2008). As the sample size sought was principally illustrative in line with the principle of conducting case study research (Yin 2003), a non probability purposive sampling approach was used. 25 organisations were selected based on their status (defined as being consulting organisations) and size (defined as being medium to large consultancies). These consisted of architectural firms (14) and multi-disciplinary consultancies (11) all of which are headquartered in the UK with all but one having significant international operations. Experts responsible for IM in each organisation were specifically targeted through email requests, 10 of whom accepted.

In a study of sufficient sample sizes using non probability purposive sampling, Guest et al (2006) found that a sample of twelve was sufficient to establish a stable view of parameters, particularly if the research is aimed at describing perception or behaviour among participants. Romney et al (1986) similarly explain that even a sample of four may be sufficient to provide an accurate explanation of phenomena so long as they were experts in their field. Nine interviews were carried out with Senior Partners (2); Directors (2); Group Knowledge Managers (1); IT Systems professionals (3) and a Senior Business Analyst (1), all of whom were experts responsible for IM and/or KM within their respective organisations. The organisations involved in the research are described in Table 4.1 (note: the data on the number of employees was taken as of August 2008 when the sample was defined).

Table 4.1: Organisations Interviewed

	No of Employees	**Global Offices**	**Scope of Operations**	**Additional Notes**
Company 1	800	15	Multidisciplinary Engineering	Now part of a global company with 8500 employees
Company 2	3500	35	Construction Management and Multidisciplinary Engineering	
Company 3	10,000	92	Multidisciplinary Engineering; Architecture; Planning and Project Management	
Company 4	3000	30	Multidisciplinary Engineering and Project Management	Now part of a global company with 35,000 employees
Company 5	1000	15	Architecture; Product design and Planning	
Company 6	420	6	Architecture and Project Management	
Company 7	45	1	Architecture and Planning	
Company 8	2700	69	Consulting Services; Project and Cost Management	
Company 9	14000	150	Management Consulting; Multidisciplinary Engineering and Development consultancy	

All interviews were conducted face-to-face, with each lasting approximately 90 minutes, before being transcribed and analysed. The analysis was carried out using the thematic analysis process outlined by Boyatzis (1998) which involved detailed iterative reading of the textual data to identify appropriate themes. An initial list of 271 themes emerged (See Paper 6, Appendix 4.0). Based on the definitions of the codes used for each theme, a number were observed to be repetitive, while several others were found to be inter-related.

Further iterative refinements were carried out to aggregate and consolidate these into distinct selective codes as illustrated in Fig. 4.1. This consolidation process involved combining certain themes and grouping other associated themes together as categories. For example, the themes ‘improve collaborative working’, ‘save time’ and ‘consistent working practices’ were all identified and defined as part of the initial 271 themes. Following the consolidation process all of these were grouped into the theme ‘improve processes’ under the category ‘driver for IM’ based on their definitions, the context within which the responses were provided and the particular question asked. The final round of consolidation resulted in the creation of 33 themes across four core categories, all of which define distinct areas of IM. No further consolidations were apparent as all the categories had become saturated.

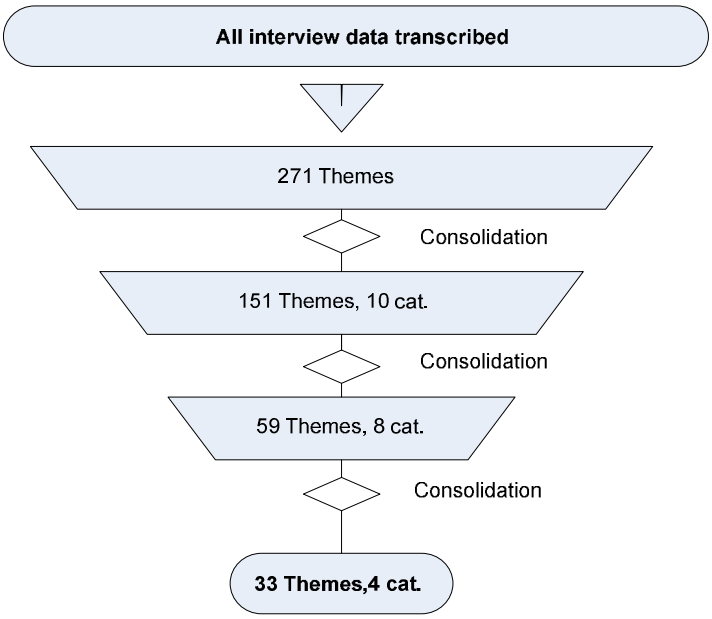

Figure 4.1: The Analysis Process

4.2.2 FINDINGS

The four categories identified through the consolidation process were: Drivers, Constraining factors, Barriers and Lessons Learnt for IM Strategies. These are discussed in extensive detail in Paper Six (see Appendix 4.0) and Paper Seven (see Appendix 5.0) and summarised below.

4.2.2.1 Drivers

The Drivers are the themes which show the principal impetus for developing a holistic approach to managing information in organisations. These are:

- **To improve the quality of products**. In the context of consulting organisations 'product' is the knowledge and information necessary to create a building; a form of infrastructure and/or advisory services;
- **To improve processes** through which tasks and activities are carried out across the organisation to increase efficiency; ensure consistency of practices and enable collaborative working;
- To enable the **transfer of learning** (experience, best practice and innovation) across the different parts of the organisation;
- To conform to **legal and regulatory requirements** within all operating markets; and
- To continually **mitigate existing and emergent risks**.

4.2.2.2 Constraining Factors

The Constraining factors (unlike drivers) are the factors which influence, shape or contextualise the nature of the IM strategy developed and/or implemented within an organisation. These were found to be:

Organisational Factors

- **The nature of the Organisation**: Such as the relative size of the organisation, its number of employees, distribution of offices (both local to a single country and globally) and number of distinct disciplines within an organisation; and

- The general direction of the company reflected in its broader **corporate strategy** including its areas of focus for growth and improvements; short/medium term targets and long term aspirations.

Project Factors

- The **Scope of services** offered by the organisation;
- The **diversity or variety of projects** the organisation executes; and
- **The diverse markets** in which the company operates with the specific operational, regulatory and cultural needs of each market.

Future Innovations

- Future changes in the way **processes and practices** are carried out, teams collaborate and organisations do work;
- **Evolving technologies with new types of content** including cloud computing and the use of Building Information Modelling (BIM); and
- Evolution and **improvements in organisational structure** and operating models of companies**.**

4.2.2.3 **Barriers**

Barriers to effective IM in construction organisations were found to be:

Organisational Barriers

- Project specific needs always take precedence over any organisational approach;
- Limited understanding among company leadership of the requirements, development and implementation of an IM strategy;
- Limited resources committed to identify, develop and implement an effective IM strategy.

Content and Technological Barriers

- Complicated Information Architectures are created/required to support IM within increasingly complex projects;
- Lack of understanding of the structure of new forms of content and how to develop/select appropriate content models and procure suitable systems to support these through its lifecycle;
- Inconsistencies in the use of metadata and the definition of attributes; and
- Poor performance of technologies and tools.

Construction Industry wide Barriers

- Lack of clear useable guidance for developing IM solutions particularly metadata standards to match the needs of construction industry based organisations;
- A shortage of professionals with the requisite skills to enable organisations develop and implement suitable strategies; and
- The nomadic project based nature of the construction industry, its resultant ways of working and the project specific standards that inevitably emerge, is often at conflict with strategic company wide solutions.

Cultural Barriers

- The difficulty in getting people to change their ways of working and adopt new methods;
- The fear among organisations that adopting an enterprise system may alter company processes to suit the way the system operates; and
- Poor willingness to share information and knowledge with others.

4.2.2.4 Lessons Learnt

Lessons for developing effective IM strategies are those themes which reflect insights from the various interventions, strategies and solutions developed and applied over time to improve IM within each of the sample organisations (see Paper 7, Appendix 5.0 for details). These include:

- A thorough understanding of the business and its inherent processes is required to define the needs and requirements for a holistic IM strategy;
- Organisations should not aim for a single approach but a 'unified approach' aimed at creating consistency while remaining flexible enough to accommodate diverse end user needs;
- The IM strategy should not be focused on or be specifically built around a certain piece of technology;
- Standards should be developed and deployed to support the evolution and implementation of the IM strategy;
- An effective implementation process is essential to guard against failure. User acceptance should be sought through confidence building measures including training, road shows and outreach events to make the solutions sustainable;
- Successful development and implementation of a holistic strategy requires buy in and clear support from senior management within the organisation; and
- Demonstrably adding value to the day to day tasks individuals carry out can ease acceptance and create user buy in.

The above findings provide a much richer understanding of the nature of IM in construction organisations. The conclusions drawn from these are summarised in Chapter Five.

4.3 TASK 3: CONDUCT INFORMATION AUDIT OF THE RESEARCH SPONSOR

The RE then conducted a detailed Information Audit of IM practices in the research sponsor. Boon and Botha (2003) define an Information Audit as the systematic assessment and investigation of the nature, use and flow of information in an organisation and its management through its lifecycle. The role and importance of Information audits in IM is explained in Section 2.3.1. Specifically, the sub-objectives of this audit were to:

- Define the types of content produced, used and hence, need to be managed;
- Identify the frequency of information sharing;
- Identify the media through which information is shared, exchanged and transferred; and
- Identify the specific needs, problem areas and areas of pull for IM.

4.3.1 METHOD

This study was carried out using the triangulation methodology, combining both quantitative and qualitative methods. First, a questionnaire was developed, built into the corporate intranet and administered online. The questionnaire consisted of 16 questions designed to address the four sub-objectives of the task as outlined in section 4.3. For a copy of the questionnaire, see Appendix 6.0. Five volunteers from within the organisation outside the target sample were used to trial the questionnaire to ensure it was clear, unambiguous and appropriate. The target sample size for the research was 800, representing half the total number of employees across the company. 372 responses across 29 disciplines and 15 offices (as depicted in Fig. 4.2) were received, providing a response rate of 46.5%.

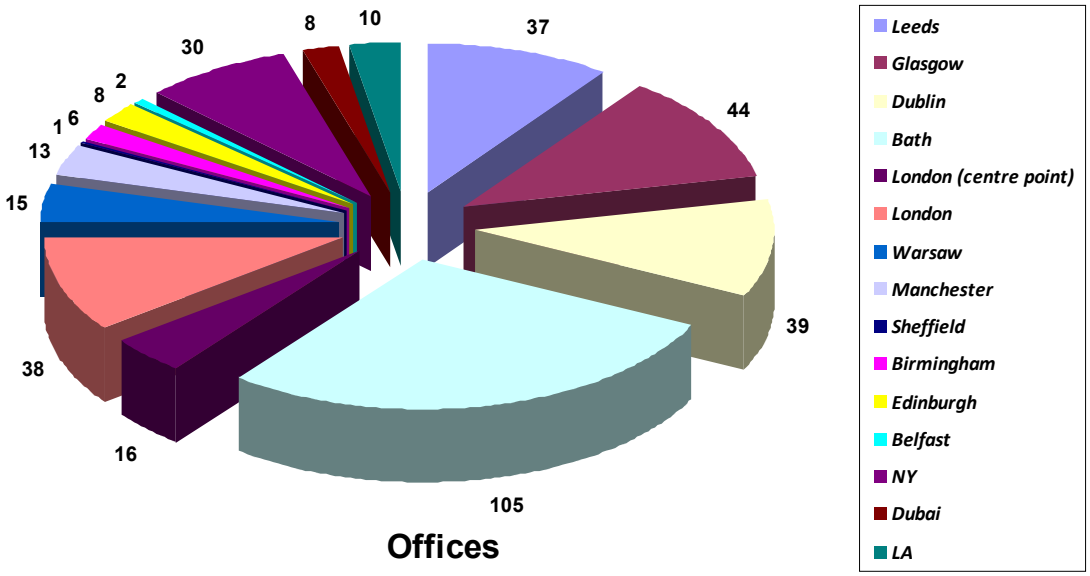

Figure 4.2: Distribution of Respondents

To compliment this, a series of workshops were held to investigate specific themes identified in the questionnaire. Due to resource and cost constraints, these were held in seven of the 15 offices with a total of 78 attendees. Emphasis was placed on the larger offices with a larger concentration of employees and a larger proportion of workload. Each workshop lasted three hours with half an hour additionally allocated to work with the attendees to explore and define possible short term solutions for the identified problem areas. Attendees were sought via email invitations sent out to each office detailing the objectives of the workshop, areas to be covered and the specific dates and times. To avoid misconceptions about the purpose of the workshop and the study being undertaken, the RE spoke to each participant prior to the workshop to re-emphasise its goals and those of the wider research. The findings are summarised below.

4.3.2 FINDINGS

4.3.2.1 Ease of Finding Information

59% of respondents felt improvements were needed across the company to enable them access the information they require to do their jobs as shown in Fig. 4.3. This question was asked in order to establish what sort of information respondents sought to retrieve in carrying out relevant tasks and if such information could be readily located and obtained as/when required. No significant variations were observed based on either the discipline, office or the length of stay of the employee, implying that the difficulties were fairly universal. This finding was further investigated during the workshops to ascertain the true nature of the problem; the specific improvements sought; and the sort of information respondents wanted to find.

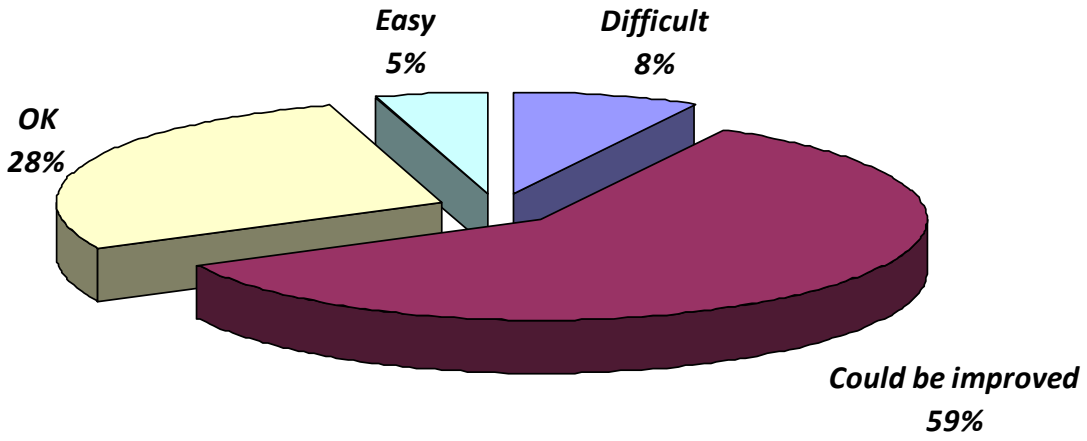

Figure 4.3: Ease of Finding Information

Five key inter-related areas were identified:

- **Knowledge Information** – including standards, guidance notes, experiences and tutorials to enhance individual competencies and improve the way tasks are done;
- **Project Information** – including specific drawings, reports, specifications created for specific projects;
- **Directory Information** – including details of people, projects and locations;
- **Processes and Procedures** – including how specific tasks should be executed; and
- **Forms and Templates** – including travel forms, finance forms and similar templates essential for core business processes.

During the workshop, a number of technological (e.g. poor quality search engine, slow internet connections), content related (e.g. inability of the search engine to search CAD files, no clear information architecture) and administrative (e.g. no clear governance policies for managing information) challenges were identified which impact on the ease of finding information. Aside 'project information', no systematic approach exists for managing and/or retrieving the information created, shared and delivered within the areas identified above.

4.3.2.2 The Groups of Content Produced

Respondents were also asked to identify the types of files they produced so as to provide a greater understanding of the nature of content within the organisation. Hicks et al (2008) identified 13 such groups in a study of IM in an Engineering SME. To ensure its applicability to this study, a scoping email was sent to 25 randomly selected employees asking for the type of files produced within their respective groups. All 25 responses listed content which matched the 13 groups, reinforcing their appropriateness. These were then built into the online questionnaire where respondents were asked to indicate the group of content they create, use or manage. A free textbox was provided to permit users to add other groups of content not reflected in the list. The only additional file type identified was the Geographic Information System (GIS) file type used for managing geographical information. The responses (as in Fig. 4.4) show textual content and spreadsheets as the most widely used group of content with audio content used the least.

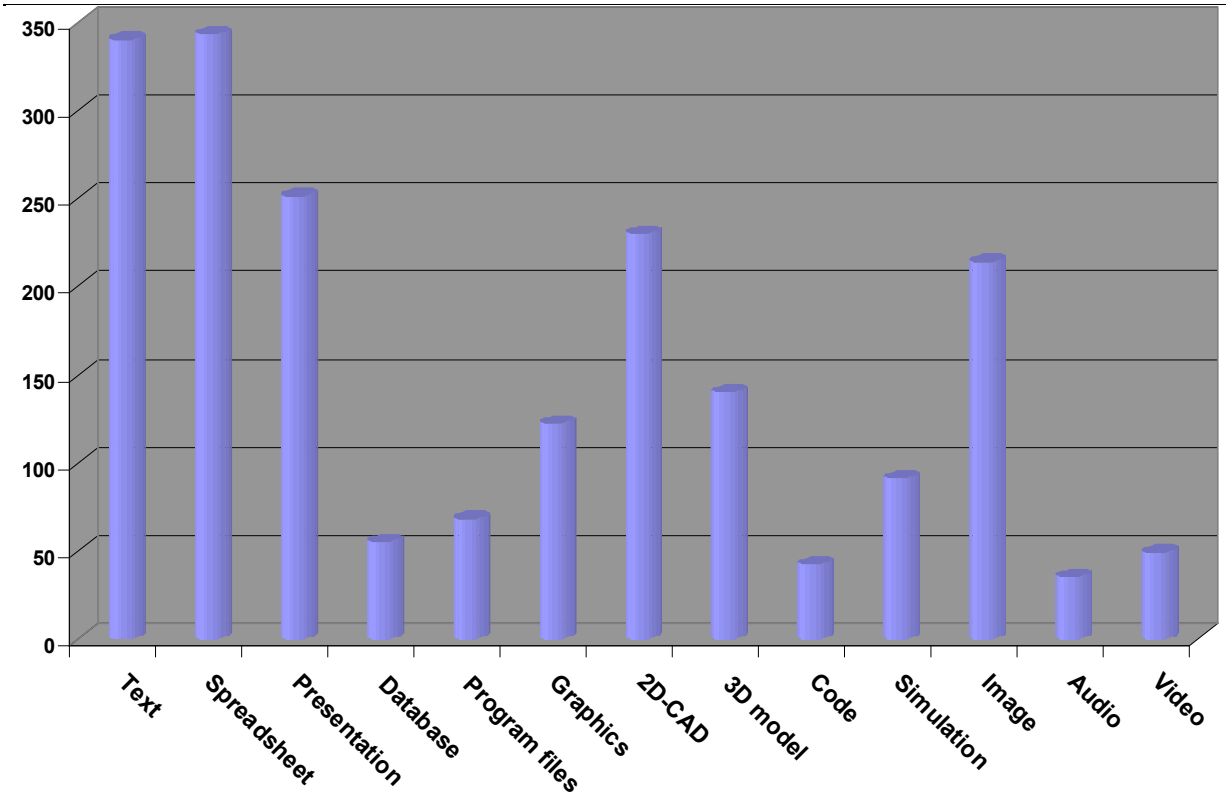

Figure 4.4: Content Classes in use across the Research Sponsor

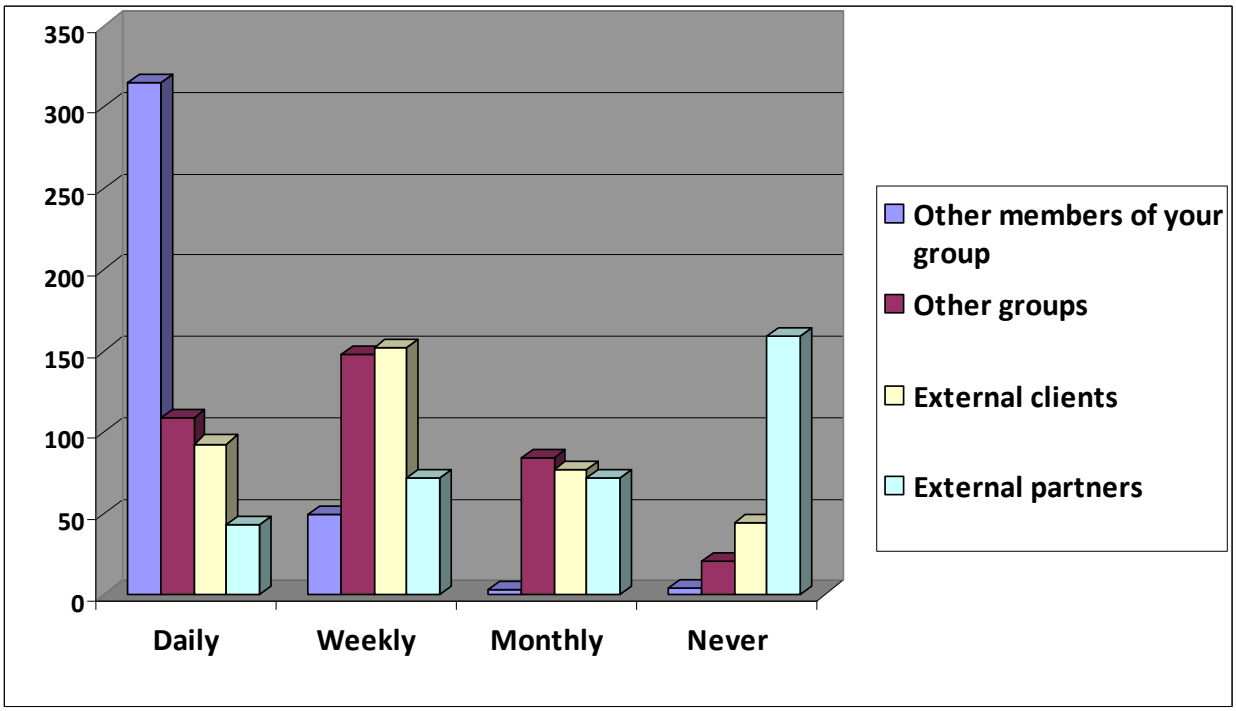

Figure 4.5: Rate of Information Transfer

4.3.2.3 The Rate of Transfer of Information

To assess the frequency of information exchange, respondents were then asked how often they transferred or shared information. 85% and 30% of respondents shared information with other members of their group and with other groups daily respectively. 40% share with other groups weekly; while 87% exchange information with external clients at least once a month as illustrated in Fig. 4.5. Such high volumes of information exchange underlie the highly

collaborative and multidisciplinary nature of the organisation and the need for an IM strategy that supports it.

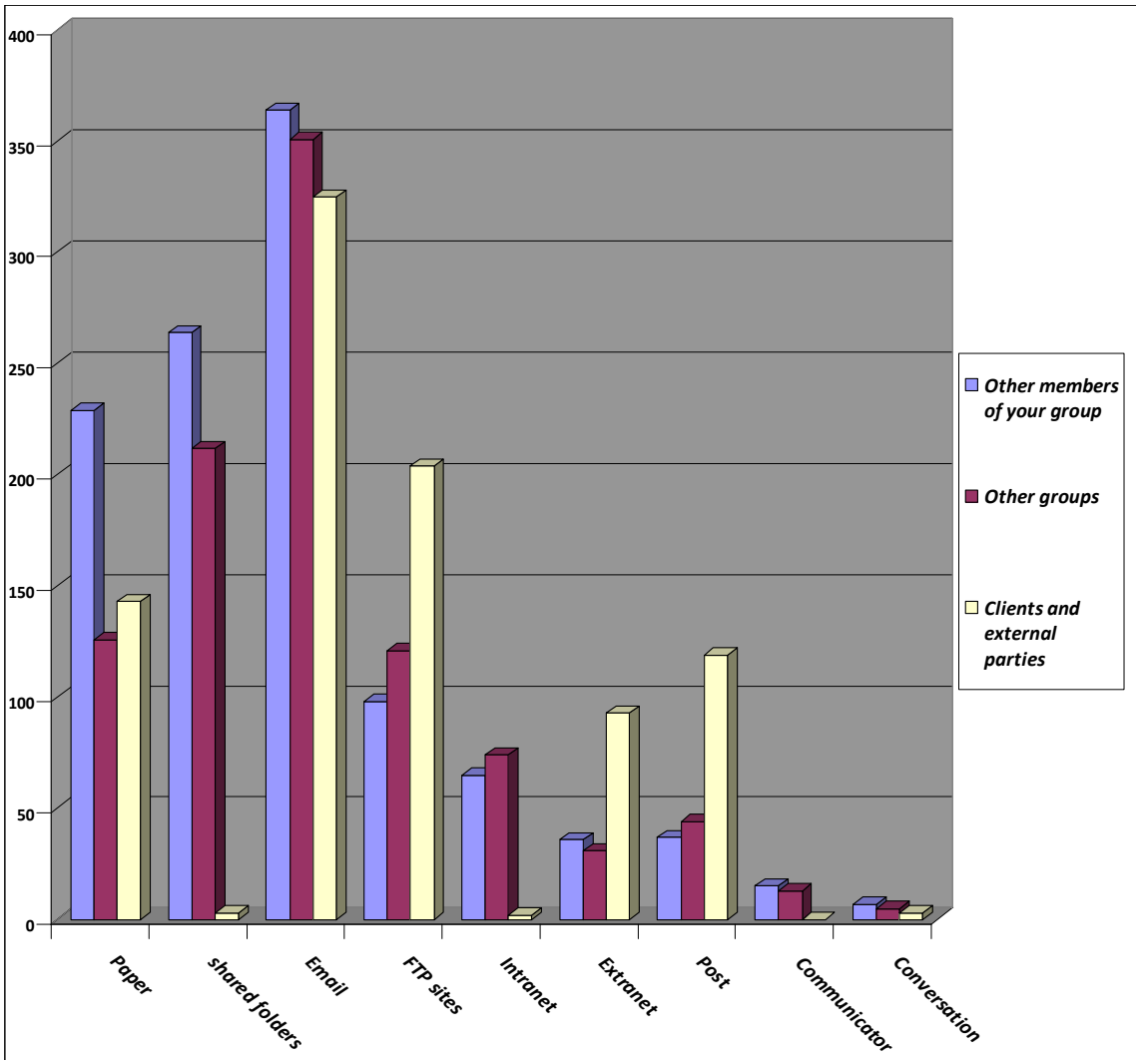

Figure 4.6: Media of Information Exchange

4.3.2.4 Medium of Information Exchange

Email was the single most used medium of information exchange as shown in Fig. 4.6. The primary justification for this (as explained by respondents in the workshops) was its ease of use. Also significant was the use of ftp sites in comparison to extranets. The responses show that only 27%; 9% and 10% of respondents used extranets to share information with external clients, other internal groups and other members of their own groups respectively. This in sharp contrast to the 60%; 34% and 26% who still use FTP sites for the same purpose. During the workshops, reasons provided for not adopting extranets include:

- Lack of awareness on how to deploy extranets on projects;
- The cost associated with the use of extranets relative to the free FTP site;
- Strong cultural attachment to the use of FTP's despite the known risks; and
- The ease of adoption for FTP's and email when compared to the time and training required to use certain extranet solutions.

4.3.2.5 Approaches to Naming Files

Respondents were asked about their approaches to naming content and use of naming conventions. Only 35% of respondents confirmed the use of the company wide approach either

exclusively or in combination with other procedures. Internal group specific conventions were most prevalent (42.1%). Such group specific conventions are developed to obtain consistency in IM within individual groups as the company standard was perceived to be inadequate. These views were observed to be broadly similar across all groups including project focused design groups (such as Structural Engineering and Building Services Engineering) and the more centre focused business services groups (such as marketing).

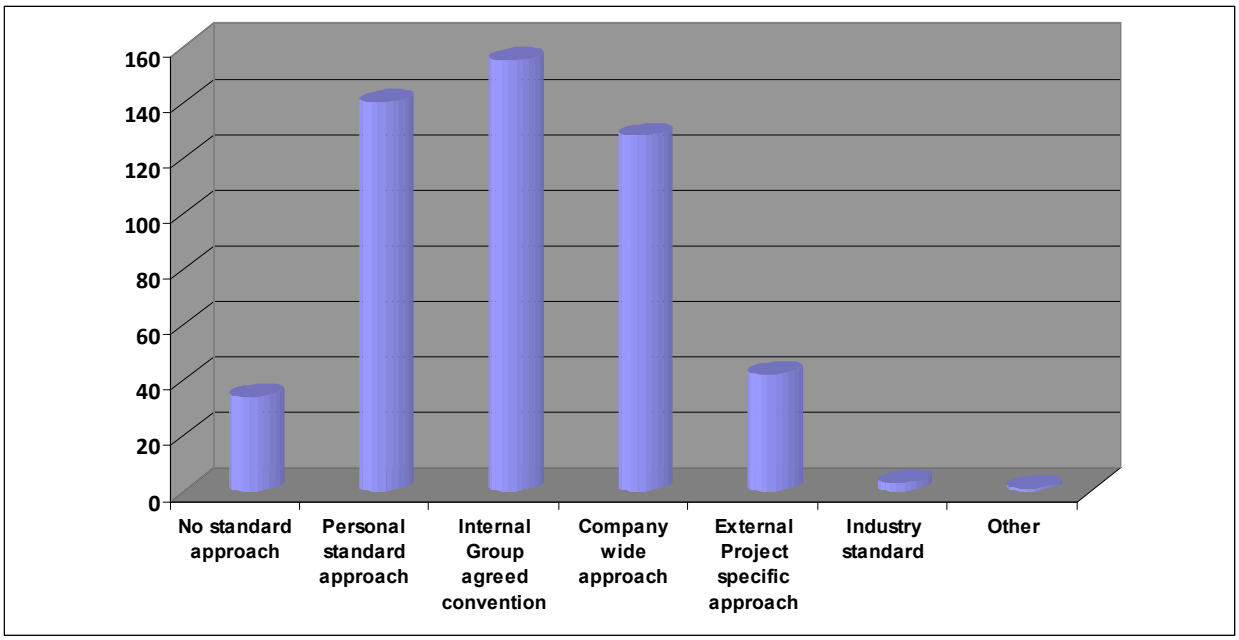

Figure 4.7: Method for Naming Files

A further 11% of respondents relied on external project specific approaches. This is due to project based company staff (often working on multiple projects concurrently) collaborating with external project teams where a standard method for naming files or even a medium for exchanging/managing information (i.e. an extranet) may be prescribed. The team typically adopt the project procedures and decline to use the company wide approach, which results in inconsistencies. This reason was provided in every workshop, questioning the feasibility or appropriateness of a single approach to metadata or naming content for the organisation.

A technical report with the conclusions and insights from this audit was submitted to the senior managers within the research sponsor. The findings are also summarised in Section 5.1.2.

PHASE 2: CONCEPTION

The next phase of the research focused on creating specific solutions to support IM for collaboration. The two tasks carried out focus on Metadata, a critical element of the content model. First, a metadata standard was developed, following which a generic IM framework was developed for guiding other organisations on how to develop similar standards to meet their needs.

4.4 TASK 4: DEVELOP A METADATA STANDARD FOR INFORMATION MANAGEMENT

Standardising a list of metadata attributes for use in an organisation is important to provide consistency and enable information to be managed through multiple contexts, processes and systems. This task aimed to define a metadata standard for IM within the research sponsor. The standard developed while generic and applicable across the sponsor was initially developed and applied to a multimedia CMS procured to support Marketing and Business Development. The objectives, methods employed, findings and recommendations of the task are discussed in extensive detail in Paper Three (Appendix 1.0) and are summarised below.

4.4.1 METHOD

The task was executed by the RE working alongside a team of eight user representatives and stakeholders within the research sponsor. These were volunteers from disciplines across the company deemed to be either the primary users; secondary users; or those actively managing the CMS to which the metadata standard was to be applied. Six such disciplines (one representative from each) were identified with two other individuals invited to join as their additional expertise in project delivery (as active end users) was important in informing the needs of the project. A case study approach was adopted due to the depth of understanding sought on specific company processes, the holistic investigation of metadata required and the scope of the project. Three complementary methods were used for the data collection. Two of these were carried out exclusively by the RE while the third (the workshop) was carried out with the end user representatives as active participants. First, a desk review was conducted to investigate the structure and metadata of the previous CMS (containing 4,000 images) to identify any embedded patterns in the way content was currently tagged. Since the previous CMS did not require strict adherence to any attributes, it was presumed that users tagged files in manners that made the most sense to them or enabled them to retrieve it quickly and effectively.

Parallel to this, a review of existing metadata standards was conducted to determine their suitability for adoption within the sponsoring company. None of the standards reviewed were found to be solely suited to the company's needs as they did not fully reflect the range of attributes required to support its operations. For example, the ISO 15836 did not include attributes required to support video files which was a core requirement for the company. Further analysis was therefore conducted to establish a baseline of common attributes from the standards reviewed. Paivarinta et al (2002) and Burnet et al (1999) conducted similar comparisons using 18 and six metadata standards respectively. As this exercise intended to build on such previous works, care was taken to identify standards which had not been used in their research to ensure no standards were repeated (thus duplicating the results) and new perspectives which have emerged since both studies were undertaken are accommodated. Only the ISO15836, included in both studies, was also included here as it has since emerged as the de-facto standard for descriptive metadata. The following standards were reviewed:

- **ISO 15836** – A ubiquitous standard for cross domain resource description often referred to as the de-facto standard for descriptive metadata (ISO15836: 2009).
- **Visual Resources Association (VRA) Core** – A metadata standard for describing images and visual content for the cultural heritage community (Technical Advisory Services for Images (TASI) 2006).
- **E-government Metadata Standards** – This lists the metadata elements and refinements used for information resources in the UK public sector (e-Government unit, 2006).
- **E-records** - A metadata standard developed for effective records management in the UK public sector (The National Archives 2002).
- **ISO 19115** – An international metadata standard for describing geo-spatial datasets (ISO 19115: 2003).
- **BS- 1192** - Set of standard procedures and methodologies for managing the production, distribution and quality of construction information (BS1192: 2007).
- **UK Learning Object Metadata (UKLOM)** – A standard for the interoperable description of learning objects i.e. any entity digital or non digital that may be used for learning, education or training (IEEE 2002).
- **New Zealand Government Locator Service (NZ-GLS)** – A standard metadata element set designed to improve the discovery, visibility, accessibility and interoperability of online information and services in a cross disciplinary information environment in New Zealand (Archives New Zealand 2004).
- **UK-Gemini** - A defined element set for describing geo-spatial discovery level metadata in the UK (e-government unit, 2004).
- **Australian Government Locator Service (A-GLS):** A standard metadata element set designed to improve interoperability and retrieval of online information and services primarily in Australia (National Archives of Australia (NAA) 2006).

Attributes which appeared consistently in over four of the now 11 standards (the 10 standards listed above and the baseline developed by Paivarinta et al (2002)) were captured resulting in a baseline consisting of 17 attributes. These are presented in Paper Three (See Appendix 1.0, Table 1).

A workshop was then held in which user representatives were provided with 14 randomly selected images and videos sourced from the existing library. The aim of the workshop was to identify the metadata attributes users would like to attach to each piece of content. In selecting the images and videos, the only criterion employed was to ensure they were broadly reflective of the variety of content in the library. The participants were all in the same room and were allowed to openly discuss their thoughts with each other throughout the process. As the exercise sought to aggregate all the desired attributes, no attempt was made to tally the number of times a single attribute was highlighted or its perceived level of importance. The results from the previous two studies were not shared with participants to avoid subtle influences on their choices. A total of 56 attributes initially emerged. Subsequent refinements were carried out to remove duplications, synonyms and attributes considered to be subsets of other attributes. Any attribute identified in two or all three of the three exercises was selected and placed into a final list. Those occurring in only one of the three exercises were included only after seeking a case by case justification from the user representatives. For example, ‘description’ occurred in only one of three activities but was included as it was deemed important by consensus.

4.4.2 FINDINGS

Following this analysis, it was observed that 15 of the 16 attributes identified in the desk study and 13 of the 17 attributes from the baseline matched attributes identified in the workshop; highlighting significant similarities between all the exercises. This continuous refinement

culminated in an agreed final set of 35 attributes (20 core attributes and 15 optional extensions) being currently used in the multimedia CMS (see Fig. 4.8). The full findings including the attributes identified, refinements undergone, and implications from this study are described in detail in Paper Three (Appendix 1.0).

MORE INFORMATION	
*Title	The Cube section illustration
*Description	Section illustration
*Keywords	Cube, section, illustration,
*Copyright / Notices	GMJ Design
*Content Type	Graphic, CGI
Access Rights	No restrictions
Creator	GMJ Design
*Contributor (Asset Loader)	
Project Name	The Cube
(*) Project Number (inc leading 0s)	009896
Associated Project Numbers	
Alternative Project name(s)	
Sector	Mixed use
Sub Sector	Commercial office, commercial residential, restaurant, hotel, retail
Disciplines	structural engineering, civil engineering, geotechnical enginnering, facade engineering,

Figure 4.8: Metadata Standard Implemented in Multimedia Content Management System

While the standard is appropriate for the Marketing and Business Development process, it also includes certain attributes applicable to only multimedia content. In light of this and to ensure the metadata standard reflected a more generic set of attributes usable across the company and thus underpin an overarching IM strategy, further refinements were carried out to remove attributes considered too specific to the needs of the multimedia CMS. Others such as 'Identifier' not previously included were also now introduced. This refinement was carried out in line with clearly identified business needs established from the detailed audit conducted in Task Three (see Section 4.3) and a critical analysis of business process and user needs carried out with all the user representatives. The refinement was carried out iteratively with the user representatives, until a final core metadata standard comprising of 32 attributes applicable to the whole organisation were defined as reflected in Table 4.2.

Table 4.2: The Metadata Standard Developed

	ATTRIBUTE	STANDARD (DUBLIN CORE)	CUSTOM	INDUSTRY STANDARD (BS 1192)	DESCRIPTION
1	Access rights		X		Information about who can access the resource and its security level.
2	Activity (or process)		X		The task to which the content is associated.
3	Business Region		X		The specific company business region in which the relevant office belongs.
4	Company		X		The company reflected in the theme of the content affiliated with or responsible for producing the content.
5	Content type	X			The nature or genre of the content (ISO 15836:2009).
6	Contributor	X			The entity responsible for providing the content (ISO 15836:2009).
7	Copyright	X			The nature of the rights held in and over the content (ISO 15836:2009).
8	Creator	X			An entity primarily responsible for making the content (ISO 15836:2009).
9	Date of event/activity/project		X		The date in which the theme or subject matter captured within the content occurred.
10	Date created	X			The date in which the content was created (ISO 15836:2009).
11	Date modified	X			The date in which the content was last modified (ISO 15836:2009).
12	Identifier	X			Unique Identifier attached to content (ISO 15836:2009).
13	Description	X			An account of the content of the resource (ISO 15836:2009).
14	Duration/coverage	X			The extent of scope of the content (e.g. time for video, size for images) (ISO 15836:2009).
15	File format	X			The digital manifestation of the content (ISO 15836:2009).
16	Disciplines			X	The discipline reflected in, affiliated to or primarily responsible for the subject matter reflected in the content
17	Key words		X		Words describing the content and/or its subject matter
18	Language	X			The language of the intellectual content of the resource (ISO 15836:2009).
19	Level			X	The floor of the building to which the content is applicable – if the building is horizontally split into multiple floors.
20	Location		X		The geographical position of the subject matter captured in the content.
21	Office		X		The specific office (of the company) reflected in, affiliated to or primarily responsible for the subject matter reflected in the content.
22	Project name		X		The name by which the project is formally known
23	Project number		X		The unique numerical identifier of the project affiliated with the content
24	Project sector		X		The specific work sector to which the subject matter of the content belongs.
25	Relation	X			A link to other content related to the subject matter of the content (ISO 15836:2009).
26	Source	X			(If different from contributor) the resource from which the content is derived (ISO 15836:2009).
27	Status			X	The state of the content in a related lifecycle.
28	Subject	X			The topic of the content of the resource (ISO 15836:2009).
29	Title	X			Name by which the content is formally known (ISO 15836:2009).
30	Version	X			The current or previous state of the content.
31	Expiry Date		X		The date from which the content seizes to be accurate and valid in its current state.
32	Zone			X	(If a project is split into specific areas) The segment of the project to which the content is applicable.

This standard has now been adopted and will be implemented in all current and future CMSs within the research sponsor. The encoding of the attributes to make them machine actionable will

be carried out by professionals within the IT department and is beyond the scope of this research. The output of Task Five below provides the procedure to be used to periodically review the standard and ensure that it remains fit for purpose, supporting IM in the long term

4.5 TASK 5: DEVELOP A GUIDE FOR DEFINING AN ORGANISATIONAL METADATA STANDARD

While some process methodologies for developing broader IM strategies (which may include metadata) do exist, there is limited guidance for organisations seeking to develop metadata standards to suit their needs. For example, the Designing and Implementing Record Keeping Systems (DIRKS) framework, provides a structured approach for developing Record's Management strategies and can be adopted for developing broader organisational IM strategies (NAA, 2001). It acknowledges the importance of metadata but provides no explicit guidance on how organisations can develop metadata standards either for specific projects or across the whole organisation. Similar limitations are apparent in the works of Lyytikainen (2004) and Bock (2005) both of whom focus on the development of contextual metadata but provide no step by step guidance to enable practitioners develop similar standards to meet their needs. Therefore, building on the lessons learnt from Task Four and additional extensive reviews carried out, this task was aimed at developing a practical framework through which organisations can develop appropriate metadata standards to meet their needs.

4.5.1 METHOD

A final workshop was held at the end of Task Four with the project team and user representatives to critically review the specific processes undertaken in developing the standard and its outcome. From this, a number of learning points emerged (all of which are discussed in detail in Paper Three, Appendix 1.0). The case study (presented in Section 4.4), lessons learnt and previous studies in this area including the works of Pairvarinta et al (2002), Lyytikainen (2004), Bock (2005) and TASI (2006) were then critically re-examined to identify the necessary steps for developing a metadata standard. The IM framework developed (as in Fig. 4.9) also reflects the following key characteristics of the DIRKS model (adapted from NAA, 2001).

- Generic and adaptable to suit any organisation;
- Multi-phased, focusing on steps and rationale for each step. It makes no mention of specific tools to adopt but allows each organisation to select the most appropriate tools to meet its needs;
- Systematic, providing an easily workable structure;
- Cyclical, accommodating a process of evolution and continuous redevelopment;
- Focused on the needs of end users and tasks it is aimed at supporting;
- Compatible with the principles of project management including project planning, resource management and change management; and
- Compatible with broader frameworks such as the DIRKS model which govern wider Information and Records Management processes of which developing metadata is only a part.

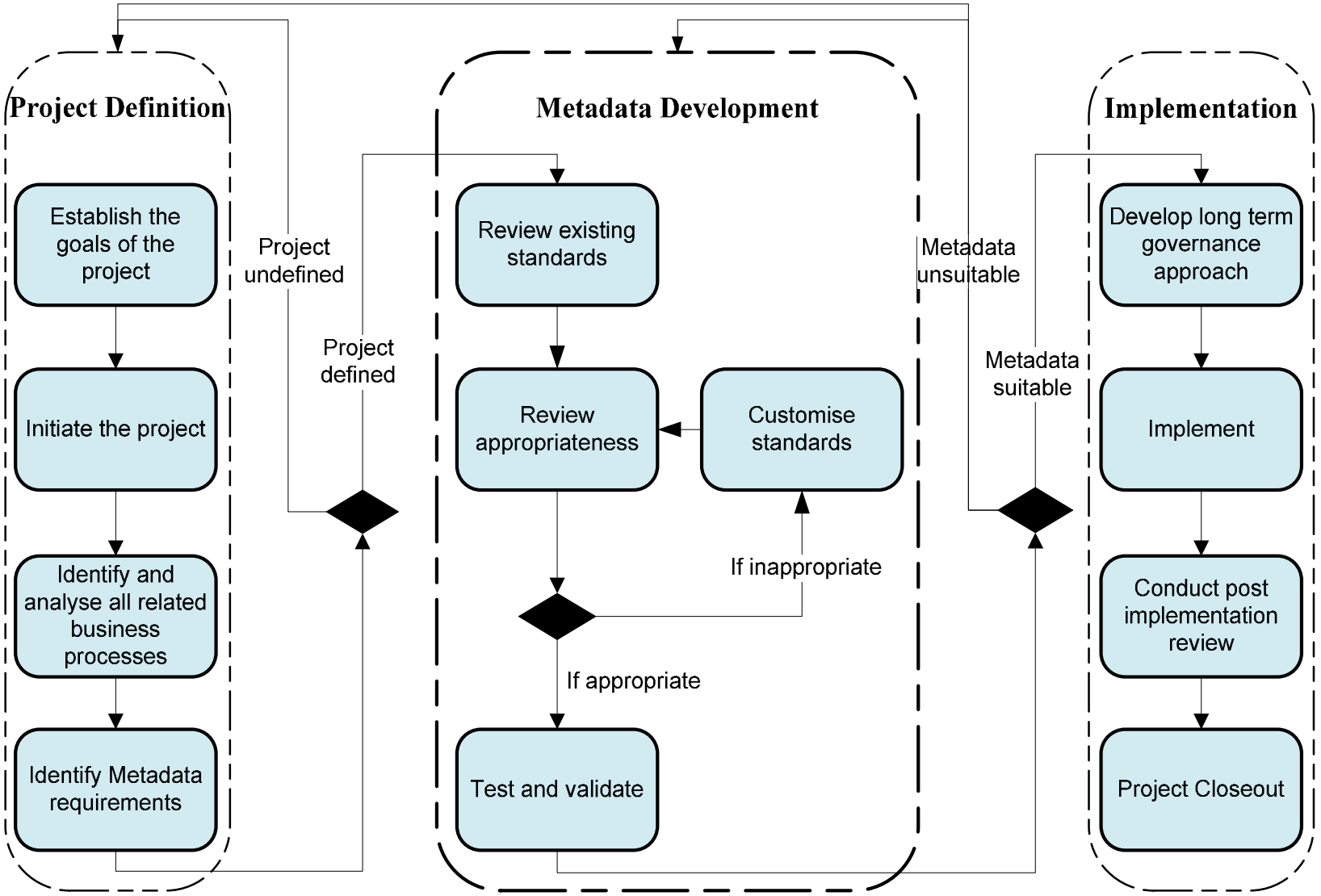

Figure 4.9: The IM framework for Developing an Organisational Metadata Standard

4.5.2 FINDINGS

The IM framework illustrated in Fig. 4.9 consists of the following 12 steps:

1. **Step 1: Establish the Goal of the Project:** The first step is to clearly define the intended goals of the metadata development project. This ensures the right steps are taken and appropriate resources are made available. It also enables strategic needs analysis to be carried out eliciting specific answers to questions such as:
    - Why should this project be carried out?
    - What is the desired outcome?
    - What is the scope of the project?
    - What business streams across the company will be affected by the project?
    - What specific content classes are intended to be managed?
    - Who are the target end users?

2. **Step 2: Initiate the Project:** Next, the goals should be translated into an actionable plan to articulate how the metadata development project will be managed from inception until completion. Here, the business case and communication plan should be developed including detailed justifications of the viability and cost of the project. A high level champion will need to be appointed to provide senior management support. A project delivery team will also need to be set up with a clearly defined mandate and responsibilities. In appointing the team, (depending on the scope of the metadata standard being developed) it is important to ensure that membership cuts across the functional breadth of the organisation to reflect the distribution of end users and gain their input. The resources available to the team (monetary and otherwise) through the lifecycle of the project should also be defined along with a timeframe for execution.

3. **Step 3: Identify and Analyse all Related Business Processes:** Having initiated the project, a detailed analysis of the business processes for which the metadata standard is required and the specific activities such processes entail should then be carried out. Metadata aims to contextualise content by supporting its use, discovery and management to support tasks. Hence this stage aims to identify what those tasks are for which the metadata is required (from an end user perspective). The outcome of this would also be used to validate the standard developed to ensure it is fit for purpose. This stage seeks answers to the questions:
    - What are the specific business processes for which the metadata is required?
    - Within each of those processes, what activities are carried out which require metadata?
    - What criteria should be used to determine what standards are appropriate for the company's needs?

4. **Step 4: Identify Metadata Requirements:** Based on the understanding of the process, the nature of metadata required should then be identified. It is important to maintain the order of the steps starting with an understanding of the processes, then building up a picture of the sort of metadata needed to support it. At this stage no details are required on the individual attributes. What is required are themes such as: subject metadata, Administrative metadata, regulatory metadata, retrieval metadata, workflow metadata etc.

These four steps constitute the 'Project Definition' phase. It serves to contextualise and position the metadata development project, ensuring that subsequent phases are both precise and adequate to meet the defined goals. Phase two is the 'Metadata Development' phase consisting of:

5. **Step 5: Review Existing Standards:** Standards should be reviewed to identify which (if any) can be adopted to meet the needs of the company and its business processes (as defined in phase one). As broad as possible a range of standards should be consulted either based on their international applicability; relevance to the organisation; relevance to the industry in which the organisation is based; and/or relevance to the type of content being managed. While these selection criteria may vary across companies and indeed projects, they need to be explicitly defined. Some key questions which should be answered here include:
    - What International/cross industry standards are available which meet the defined criteria (from Phase one)?
    - What Industry specific standards are available which meet the defined criteria?
    - What content specific standards are available which meet the defined criteria?

6. **Step 6: Review Appropriateness:** The individual attributes contained within each of the shortlisted standards should then be analysed in detail based on the specific needs defined in phase one to determine their suitability. Where a standard is deemed wholly appropriate and can be adopted with little or no customisation this can be carried on to the testing stage. Where customisation is deemed necessary, this activity saves time and resources by identifying those attributes which can be adopted (as a base minimum). These then serve as a good starting point from which the required customisation can be carried out. The metadata attributes adopted are also refined here, identifying variations such as compulsory and optional attributes; or automatic and manual attributes. The review process should be carried out iteratively until the developed standard is deemed appropriate.

7. **Step 7: Customise Standards:** Where no standard is wholly appropriate, the baseline developed should then be customised to create a bespoke standard which reflects the company's needs. This should begin with a clear understanding as to why the customisation is necessary. If carried out appropriately, this will result in a company specific metadata standard which takes into account such varying perspectives as business processes, archiving policies, Quality Management procedures, business structure, and so on. Each attribute identified here must be justified, highlighting why it is necessary and by whom, to ensure the standard developed remains fit-for-purpose. Various methods can be used for conducting this, including desk studies of existing repositories, workshops, questionnaires, etc. Irrespective of the method employed, the eventual outcome must be collectively reviewed by the project team accepted and signed off as appropriate prior to any testing or validation.

8. **Step 8: Test and Validate:** To ensure its suitability, the metadata standard should then be tested in various scenarios. These should be as varied as possible but should reflect the expected use cases for the completed standard. The object of this exercise is to scrutinise the standard for any loopholes and ensure the solution is robust enough to meet the needs of the company and its wider user community.

These four steps which constitute the 'Metadata Development' phase translate the project vision into a usable/actionable standard. If the standard developed is deemed suitable for the company (based on the needs defined in phase one) the project then proceeds to the final phase. If however the attributes are deemed inappropriate for the defined company needs, either more suitable attributes need to be defined (by repeating phase two), or the company needs and goals for the project need to be reassessed (by repeating phase one). The 'Implementation Phase' is the final phase of the project and consists of four steps.

9. **Step 9: Develop Governance Approach:** Governance ensures accountability and responsibility for the long term management of the metadata standard. This is necessary in

metadata development to ensure that it is continually updated to meet the future needs of the company and its users vis-à-vis evolving business strategies, working methods, processes, and regulations (Bentley, 2001; Sun Microsystems, 2005). It requires specific decisions to be made including (but not exclusively): how the standard will be managed in the future; who retains responsibility; how the quality of metadata input into the system can be ensured and what resources will be committed for this purpose.

10. **Step 10: Implement:** Next, the developed standard is encoded into the organisation's software systems to make it machine actionable. Also considered here are the visual interfaces; visualisation of the metadata in the system (as seen by the user); the interfaces for metadata entry; result visualisation and automating attributes. Beyond the technological implementation, training and policy guidelines developed earlier are also implemented here along with effective change management, all of which are required to facilitate a smooth transition to the use of the developed standard.

11. **Step 11: Conduct a Post Implementation Review:** The processes undergone and the outcome of the project should then be collectively reviewed to ascertain if the original project goals have been met. The reflection process also enables the lessons learnt to be recorded and disseminated thus improving the delivery of future metadata development endeavours. Feedback should be regularly obtained from end users to establish the state of use and the appropriateness of the metadata standard for their on-going needs.

The final stage is the formal close of the project thus concluding the process.

4.5.3 EVALUATION

Domain experts and industry practitioners were consulted to assess the rigour and practicality of the IM framework. These were identified and targeted based on their expertise in IM; their role within their respective organisations; and the multidisciplinary nature of their organisations. The same sampling technique used in defining the sample for Task two was adopted to define this sample. The approach and sampling is explained in detail in Section 4.2.1. Accordingly, 10 of the experts and practitioners previously interviewed were re-approached to conduct the validation; four of whom accepted.

To complement these, a number of domain experts with deep knowledge about the subject matter in both research and practice were specifically targeted for further validation. Some of these were experts affiliated to international initiatives such as the Dublin Core Metadata Initiatitive (DCMI), editors of International Journals on Information Management and international metadata consultants. In total, nine evaluations were carried out from October – November 2010 with:

- Lecturer in Information Science specialising in Metadata and taxonomy and former editor of the Journal of Library and Information Science;

- Research Director at a medium sized Information and Technology Company and former participant in the DCMI; and

- Manager at a research centre in a leading UK University and former participant in the DCMI.

- Metadata and Taxonomy Analyst at a US based world leading University. This followed a presentation delivered (on invitation) to members of the Faculty of Harvard Business School;

- Metadata Development and Implementation manager in a leading UK organisation and former consultant to FIFA and Joint Information Systems Committee (JISC);

- Enterprise Architect at a major global consulting organisation;

- Senior Consultant and member of the IM group at a large multi-disciplinary Engineering company;

- Director and practice Manager at a large Architectural practice; and

- Head of Information Management Systems (IMS) at a large Multi-disciplinary Engineering company.

All the evaluations were conducted face-to-face. It commenced with a brief presentation by the RE on the overview of the research and the steps taken to develop the IM framework (as described in Section 4.4 and 4.5). The IM framework was then presented with each step explained in detail. Copies of the IM framework were sent to each evaluator prior to the meeting to provide them sufficient time to conduct a thorough review. Following the presentation, a form was provided to capture all the feedback. All but one form was returned. The findings are summarised below.

4.5.3.1 Feedback

Overall, feedback was positive with all evaluators particularly impressed by the depth of alignment the IM framework necessitates between metadata and the overall IM strategy. The following were also observed:

- **On its ease of Use:** Seven of the eight evaluators agreed or strongly agreed that the IM framework is easy to use;

- **On its ease of Understanding:** Seven of the eight evaluators agreed or strongly agreed that the IM framework is easy to understand;

- **On its ease of navigation:** All eight evaluators agreed or strongly agreed that the format was easily navigable; and

- **On being error free:** All but one of the evaluators remained neutral on the error free nature of the framework.

These responses are illustrated in Fig 4.10 below

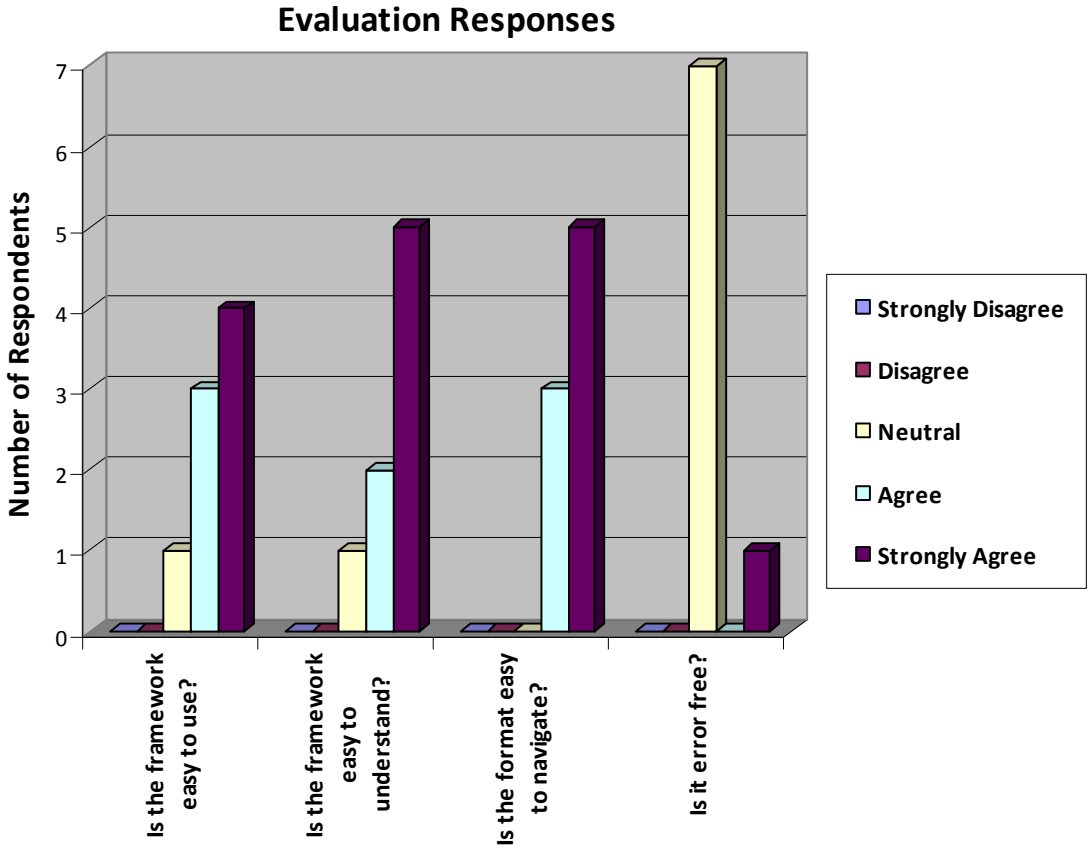

Figure 4.10: Evaluation Responses

4.5.3.2 Strengths of the IM Framework

When asked what impressed them most about the IM framework, the experts identified:

- Explicit focus on identifying and engaging with all stakeholders at all stages;
- Focus on governance prior to implementation is particularly positive as it provides explicit understanding and commitment to the maintenance and improvement of any standard while also rewarding its use. These make the solution sustainable;
- It ensures internal content metadata needs are matched with existing standards thereby facilitating interoperability and avoiding reinventing the wheel. This strengthens inter-organisational collaboration;
- The IM framework with its simplicity and iterative nature is easy to understand and implement. One evaluator however mentioned the risk that such an iterative process if inappropriately carried out can be expensive;
- The IM framework enables the contextualisation of metadata giving it a clear purpose – a critical point often overlooked in metadata implementations;
- The consultative and contextual approach the IM framework provides is particularly well suited to the diversity within multidisciplinary and/or multinational organisations;
- It provides sufficient management and control over the metadata development process;

- It ensures that any standard developed is clearly founded on user needs;
- It is scalable and adaptable, applicable at the project level and at the organisational level; and
- It is domain agnostic and therefore usable by organisations outside of the construction industry.

4.5.3.3 Areas for Improvement

When asked to identify further improvements to the IM framework, a number of suggestions were put forth including:

- Steps 5, 6 and 7 should not only reflect "customisation" but also "extension" of existing standards as these may sometimes be wholly adopted then extended to suit an organisations needs;
- To ease its adoption in practice, explicit convergence should be sought with project management methodologies such as agile engineering;
- Regular feedback loops should be sought to learn lessons and improve both the metadata standard and the IM framework;
- The inflection process to assess the organisational needs should also accommodate external needs to support wider cross industry interoperability;
- The governance while focussing on maintenance, on going support and ensuring the standard is adhered to, should also include explicit guidelines for users for data entry; and
- Step 9 (i.e. developing long term governance approach) should identify governance as being enterprise wide and not just specific to each project.

The IM framework (as presented in Section 4.5) has been amended to reflect all the above recommendations. One other suggestion not included was that the IM framework should explicitly mention the encoding schema to be used for implementing the standard within IS. This was not included as encoding schemas for metadata fall outside the purpose of the framework.

4.5.3.4 Limitations

Despite the overwhelmingly positive response to the framework, one significant limitation was identified. Its successful use relies on a good knowledge of content, metadata and business processes. Thus, though this framework is intended for practitioners, it will prove most useful for 'informed practitioners' with a sound understanding of IM and not necessarily be as easily adopted by 'general managers'. Recommendations to address this are provided in Section 5.4.

PHASE 3: APPLICATION

Phase three focused on a number of targeted implementations to assess the applicability of the proposed holistic approach to IM on organisational processes. First, metadata was applied to information retrieval through the use of facetted search. A wider study was then conducted to develop the Information Architecture for a case study group flexible enough to accommodate multiple processes and enable integrated project delivery. The final task, a much broader case study saw the development of a Knowledge Portal to support collaborative working and knowledge sharing. The tasks and their findings are summarised below.

4.6 TASK 6: INVESTIGATE THE APPLICATION OF METADATA IN INFORMATION RETRIEVAL

Facets are orthogonal categories of metadata used to characterise content (Hearst, 2006; Yee et al, 2003). For example, the metadata attribute 'discipline' can be used as a facet with values such as Structural Engineering, Acoustics etc. Each such facet represents one dimension of a piece of content. The use of metadata in information retrieval enabling large data sets to be clustered around similar themes is referred to as 'facetted search'. It combines the strengths of both free text (string) search and hierarchical navigation and is being adopted with increasing popularity and dependability particularly in library databases and e-commerce websites (Hearst, 2006; Broughton and Slavic, 2007; Ben-Yitzhak et al, 2008; Tevan et al, 2008).

Not all metadata attributes are suitable for use as facets in information retrieval. Thus for an organisation looking to adopt a facet based information retrieval approach to improve IM, a problem arises in identifying suitable attributes to use as facets in line with end user needs. This task sought to investigate the relationship between metadata and search preferences in collaborative work spaces. Though the specific attributes identified may only be applicable to the research sponsor, the findings and observations significantly improve the wider understanding of the application of metadata standards in IM and retrieval. The task discussed in extensive detail in Paper Four (Appendix 2.0) is summarised below.

4.6.1 METHOD

Two methods of data collection were employed. Firstly, the baseline created following the review of 11 international metadata standards carried out in Task Four (see Section 4.4.2) was adopted. To further ensure its appropriateness for this task, a number of additional attributes were introduced to form a new baseline of 20 attributes. These additions were sourced from the BS1192:2007 standard; or metadata already extensively used across the company with which most users were already familiar. An online questionnaire (the same questionnaire used to execute Task Three) was then distributed across the sample group asking which attributes users would like to use for search. The response rate and distribution of respondents are the same as Task Three as explained in Section 4.3.1.

Secondly, multiple project folders from a specific discipline group (Ground Engineering) within the research sponsor were investigated as a case study. Ground Engineering was selected because of: their willingness to partake in the study; their size (45 experts cutting across the different offices and business regions); and their involvement in multiple large projects spanning over 12 months from inception to completion. The four project folders were then analysed using the five steps for creating a faceted scheme as outlined by Giess et al (2008). The RE did not set

out to select only four projects, but observed that a saturation point had been reached. The four folders contained 265, 457, 253 and 359 files of various formats and content types. Thus a total of 1334 files were studied with an average of 333.5 files per project folder. Each attribute in the file/folder name was coded. As an example, a file named *061215 planning presentation-compressed.pdf* was encoded as: *Date* (061215); *activity/task* (Planning); *Content type* (presentation); *Comment* (Compressed). The order of the attributes was considered unimportant, as only the frequency of occurrence was required. Where certain attributes were used twice on the same piece of content, only one instance was counted. The results were then aggregated and analysed. The findings are explained in detail in Paper Four (see Appendix 2.0) and summarised below.

4.6.2 FINDINGS

4.6.2.1 Attributes Required for Search

Responses from the questionnaire indicated that not all attributes in the baseline would be preferred for search as illustrated in Fig. 4.11.

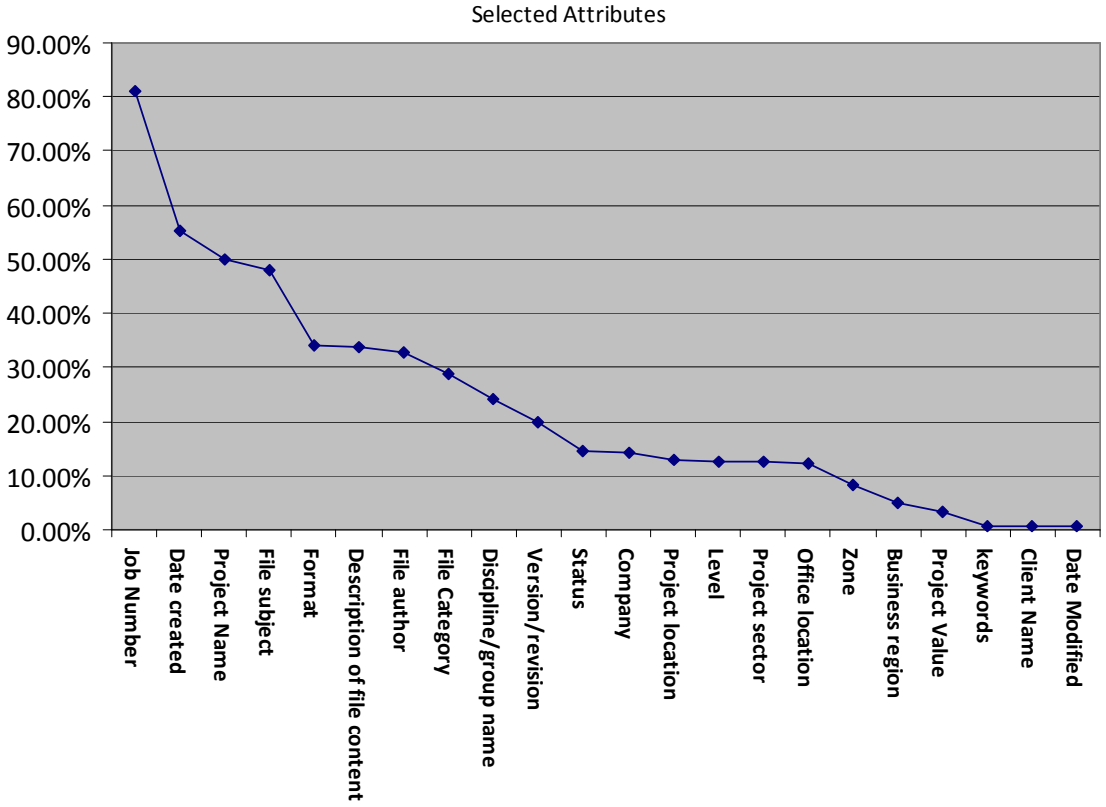

Figure 4.11: Metadata Preferred for Search

Job number (relating to a project) was selected as the most used attribute reflecting the fact that being a project based company, most content generated would be aimed at servicing the needs of projects. Date created, project name and file subject also feature prominently. Most significantly, nine metadata attributes out of the total of 20 account for 75% of end user needs across the sample. These are:

- *Job number;*
- *Date created;*
- *Project name;*
- *File subject;*

- *Format;*
- *Description of file content;*
- *File author;*
- *File category; and*
- *Discipline/region.*

'Description of file content' is a multiline narrative of the subject matter of the content and therefore unlike the others cannot be used as a facet. Thus a total of eight attributes meet 75% of respondents needs. Outside of these top nine attributes, there were distinct variations particularly based on disciplines. Respondents from certain disciplines preferred certain attributes over others. For example, respondents from the business development group all selected 'business region', while not selecting others such as 'Zone' and 'Level'. As multiple selections were permitted, it was observed that an average of five attributes was selected per respondent.

4.6.2.2 Metadata Used for Naming Folders and Files

The second exercise tested the validity of this pattern, the specific attributes identified and the correlation between personal naming habits and search preferences. It was observed that 25 attributes were used across the 1334 files studied, as presented in Table 4.3. While there were commonalities across all four project folders, certain key variations emerged. Some attributes were used extensively in some files and folders while not applied at all in others.

Table 4.3: Metadata in use in the Four Folders

Metadata	**Folder 1**	**Folder 2**	**Folder 3**	**Folder 4**
	Frequency	Frequency	Frequency	Frequency
Subject	216	337	214	264
Content type	98	174	144	147
Date	116	203	85	80
Job Number	125	102	70	74
Author	89	84	55	49
Activity	28	73	42	89
Revision	52	77	23	75
Group	46	16	41	10
Status	21	44	27	10
Project name	11	23	22	31
Company	5	38	15	7
Sub-job (Building name)	2	9	0	28
Comment	1	7	8	17
Identifier	0	16	0	15
Page no	0	24	0	0
Drawing No	0	9	0	15
Recipient	11	7	0	0
Reviewer	1	3	3	5
Material	0	10	0	0
Work stage	1	2	1	5
Issue no	0	0	0	8
Drawing Info	0	0	6	0
Zone	1	0	0	0
Level	1	0	0	0
Date modified	1	0	0	0

No single project folder had more than 20 attributes, with the total in each being 19, 20, 15 and 18 respectively. Also significant was that only 14 of the 25 attributes were used in all four projects. For example, 'Page number' was used up to 24 times within folder two but not at all in the other three folders. This suggests that while there may be a strong cross project correlation in the use of certain attributes, project specific requirements can drive the adoption of others. The average (based on the number of occurrences) was taken across the four project folders (as illustrated in Fig. 4.12).

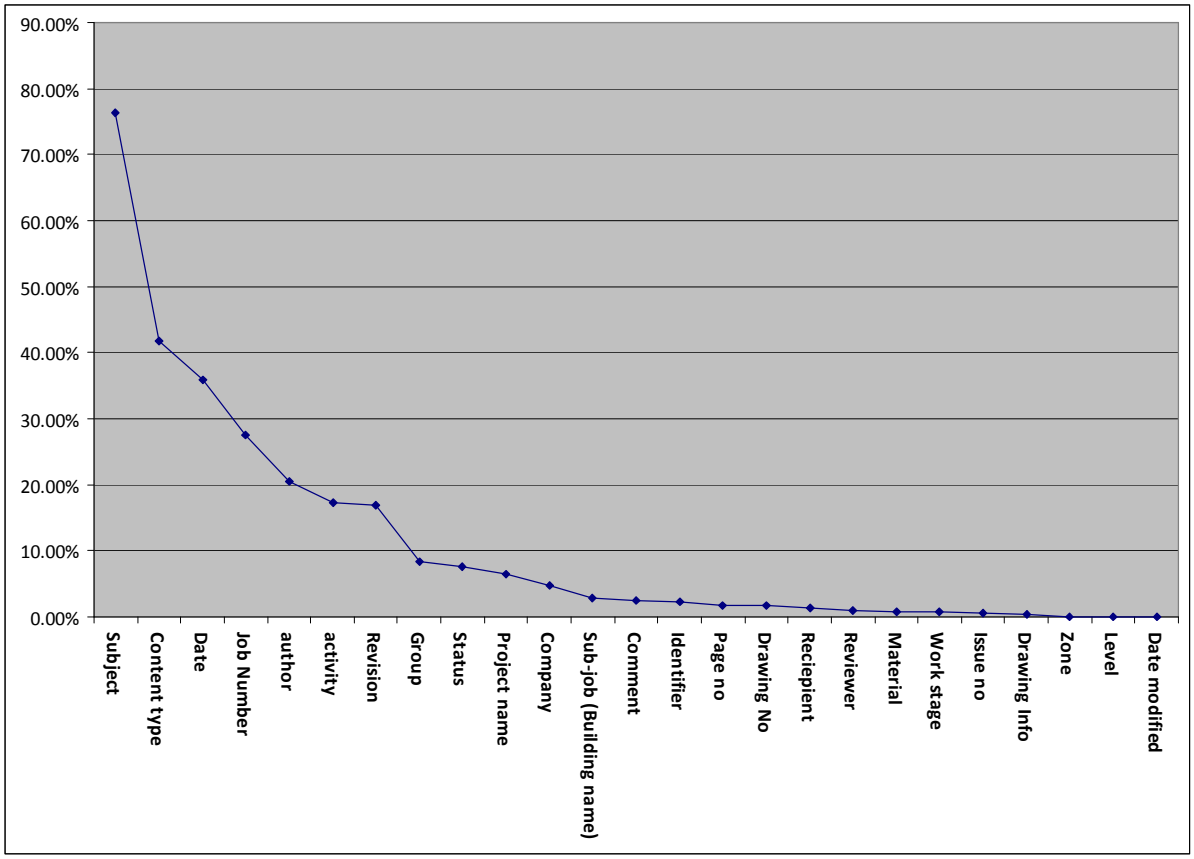

Figure 4.12: Based on the Averages from all Four Folders

The top eight metadata attributes used across the four folders were:

- *Subject;*
- *Content Type;*
- *Date;*
- *Job Number;*
- *Author;*
- *Activity/task;*
- *Revision;*
- *Status.*

These account for over 85% of the metadata used and thus can be considered the core attributes across the four project folders. It was also observed that these were rarely used in isolation but mostly supplemented with some additional attributes from the other 17. Each file (across all four folders) contained an average of seven attributes.

4.6.2.3 Comparison of Findings

There are strong similarities between the top eight attributes from both exercises as shown in Table 4.4. Six of the top eight attributes preferred for search (established from the survey)

matched the top eight metadata currently used for naming files and folders. Format is an automatic attribute which would have occurred on each file and therefore was not counted in Task Two (but included in the survey).

Table 4.4: Comparison of Task1 and Task 2

	From Project Folders		From Survey on Search	
1	Subject	Match	Job number	Match
2	Content type	Match	Date created	Match
3	Date	Match	Project name	
4	Job Number	Match	File subject	Match
5	Author	Match	Format	
6	Activity/process		File author	Match
7	Revision		File category	Match
8	Group/discipline	Match	Discipline/group	Match

Based on these findings, the following six attributes were proposed as the core facets for facetted search within the organisation:

- *Subject;*
- *Content type;*
- *Date;*
- *Job Number;*
- *Author;*
- *Discipline.*

A further option was provided to expand this core list to include:

- *Format;*
- *Project name;*
- *Revision/version; and*
- *Activity/process*.

Critically, this study highlighted significant practical factors which influence the use of metadata in multi-disciplinary teams and across diverse projects. The insights and conclusions from these findings are discussed in Chapter Five.

4.7 TASK 7: DEVELOP A CORPORATE INFORMATION ARCHITECTURE FOR INFORMATION MANAGEMENT

The RE then conducted a broader study applying the principles observed through the previous six tasks to the design and implementation of a holistic approach to managing information in a case study group within the research sponsor. Specifically the aim was to develop an appropriate Information Architecture (IA) for creating and managing content to support the group's business model, implemented using existing technology. A detailed account of this task including the challenges and outcomes is provided in Paper Five (Appendix 3.0) and summarised below.

4.7.1 METHOD

An action research based contextual design method was employed for this task. Contextual design is a user centred design approach where data is gathered in the field and the solutions are developed iteratively with the target customer group within their deployment environment (Hotzblatt et al, 2005). The case study group was a management consulting group within the research sponsor founded in 2001 with 27 full time staff, offering integrated strategic solutions for the built environment. Existing documents about the group, its structure; type of projects; inherent business processes; business strategy; target clients and markets of specialisation were reviewed extensively. This enabled an understanding of 'its business' and thus the type of solutions required to support its chosen method of operation. A further desk study was also carried out investigating the information repositories in use across the group. Six members of staff were then interviewed across five business streams to establish:

- *What they do (tasks);*
- *How they do it (Processes);*
- *What information they need to get their work done;*
- *What problems they currently face in IM; and*
- *How they will like to see information managed in the future.*

The collective outcomes were then analysed to develop the solution. This was an iterative process involving the project team and the periodic input of the Head of Collaboration and the Quality Manager from the research sponsor to ensure the solution developed conformed to the company's QA standards. The solution was presented to the group's representatives and project sponsor who confirmed it as being appropriate for their needs thus concluding the project.

4.7.2 FINDINGS

4.7.2.1 Existing Enterprise Model

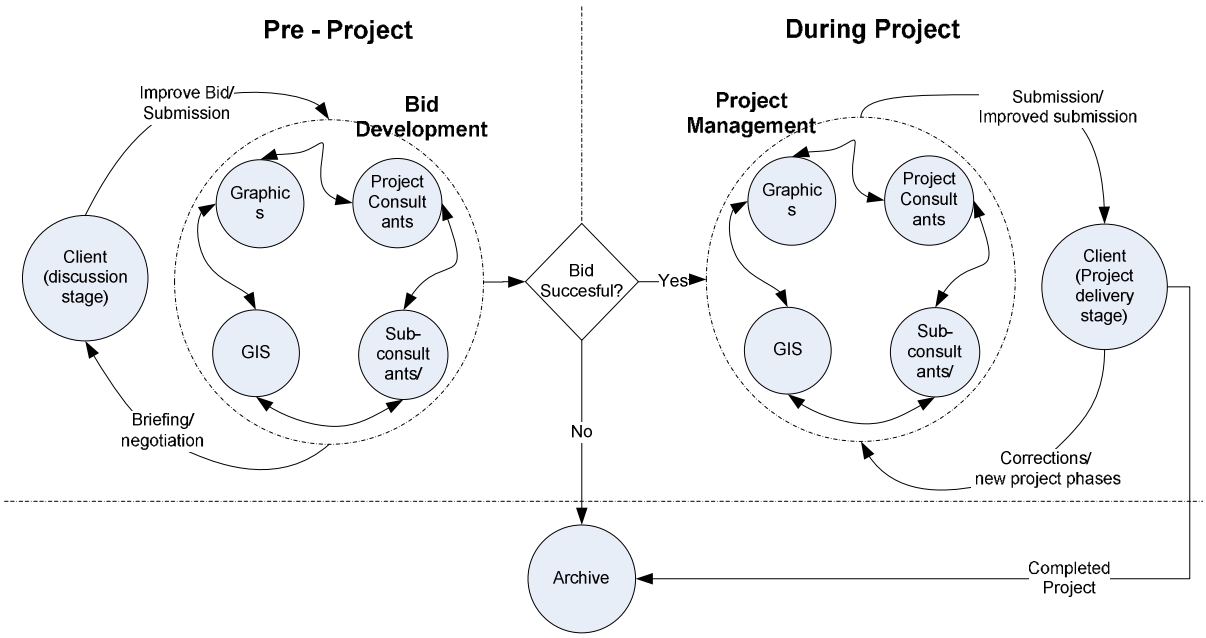

Figure 4.13: The Project Process

The group engages in two core activities, Project works and Group Management/Business Development. Project works (illustrated in Fig. 4.13) comprise the various tasks directly associated with bidding for, servicing the needs of or delivering a project. Being a project based organisation, this constitutes the primary activity and revenue stream for the group. Key information products delivered to clients include presentations, reports, visualisations (including

movies) etc of various technical themes. Group management/business development consists of the day to day tasks carried out to manage and run the operations of the group such as resourcing, marketing, learning and development, internal meetings, etc.

4.7.2.2 Existing Systems and Technology

Within the company, two repositories are used for storing electronic information:

- A collaboration site on the MOSS 2007 based corporate intranet; and
- The more widely used group specific local file share on the network drive.

Most content for both projects and group management/business development are stored in the local file share, providing relatively easy access to content via a familiar windows style environment. The corporate intranet site is fairly new and yet to be fully adopted. On an ad hoc basis (usually only to meet a specific need on a project) third party extranets are used. These mainly serve as conduits for information exchange and are often decommissioned upon project completion with all its data transferred back to the group network drive. No new systems were to be developed or procured through this task.

4.7.2.3 Refined Enterprise Model

The solution developed was based on the following principles established from the critical analysis of the groups' strategy conducted:

- The focus of the entire IM process should be on the information product being delivered to the client. The value proposition therefore must focus on producing 'what the client wants' in the most efficient and effective manner;

- Any proposed structure will be 'process driven' based on the workflow of the project delivery process and integrate disciplines;

- Files will be structured in a consistent manner based on the task being carried out and the information products associated with each of those tasks; and

- A move will be made where-ever possible away from folders to the use of metadata.

Following a detailed analysis of the group, seven interconnected yet independent information streams were identified (illustrated in Fig. 4.14). These were:

- **Group Management:** All content associated with managing the day to day affairs of the group organised according to the tasks being carried out;

- **Bids and Submissions:** All content from prospective projects;

- **Project Filing:** All content created received and shared to service the needs of a project;

- **Library:** For storing and sharing all explicit knowledge, exemplar material, etc;

- **Procedures and Guidelines:** All guidelines for the various (project and non-project) tasks;

- **Templates:** For generic content templates which individuals can build on and tailor to meet their specific needs; and

- **Archives:** For all content from the above information streams, no longer deemed to be in active use; but which holds value and can therefore not be deleted.

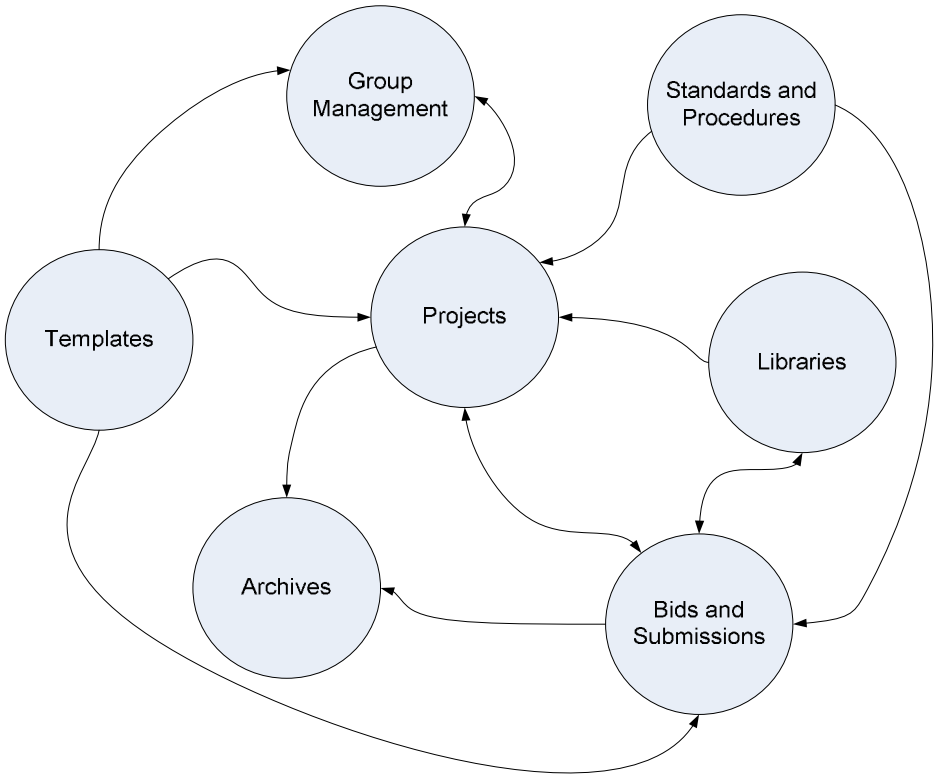

Figure 4.14: Relationship between Information Streams

4.7.2.4 Refined Content Model

The groups' project delivery process from start to finish was then mapped out to identify the tasks carried out and the individuals responsible for each task. This analysis was carried out in line with best practice for IM, particularly the BS1192: 2007. A more effective process was then designed and adapted into a standard folder structure for use on the shared network server as shown in Fig. 4.15. The overall structure and detailed workflow outlined are explained in greater detail in Paper Five (Appendix 3.0). The group management folder was similarly structured to reflect the tasks carried out by the business development teams. Metadata drawn from the standard created in Task Four (see Section 4.4) will be used extensively to contextualise the content and group the files within each folder as illustrated in Fig. 4.16.

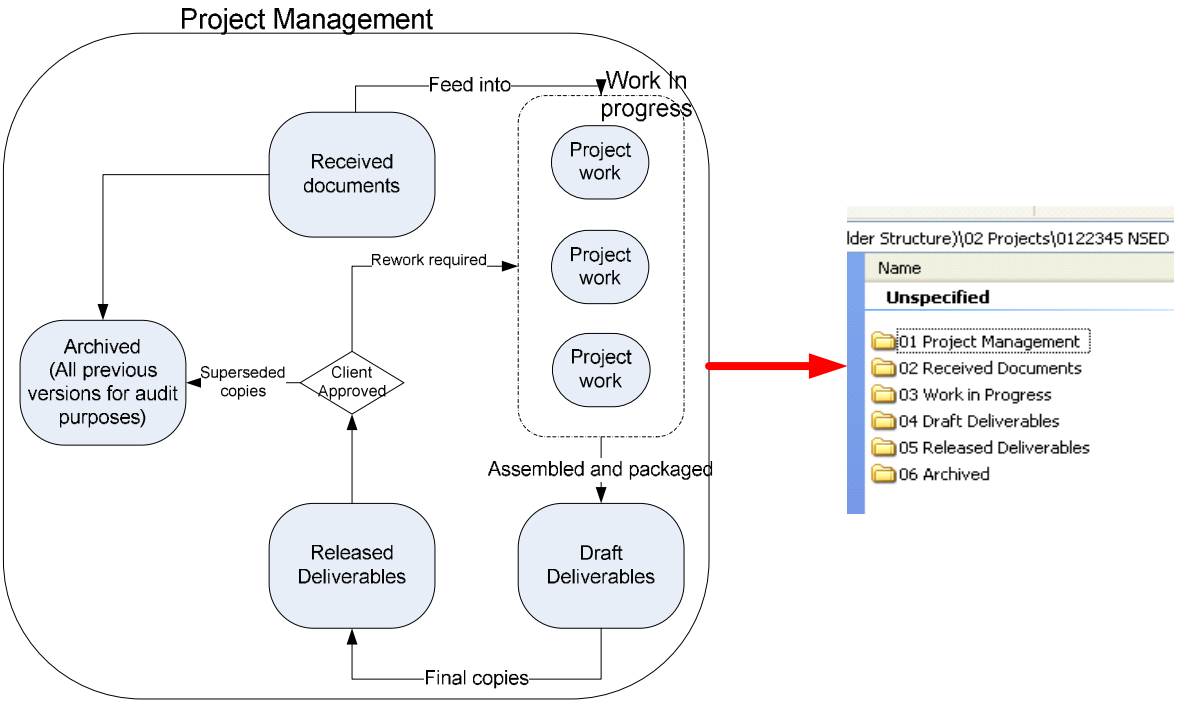

Figure 4.15: The Project Information Architecture

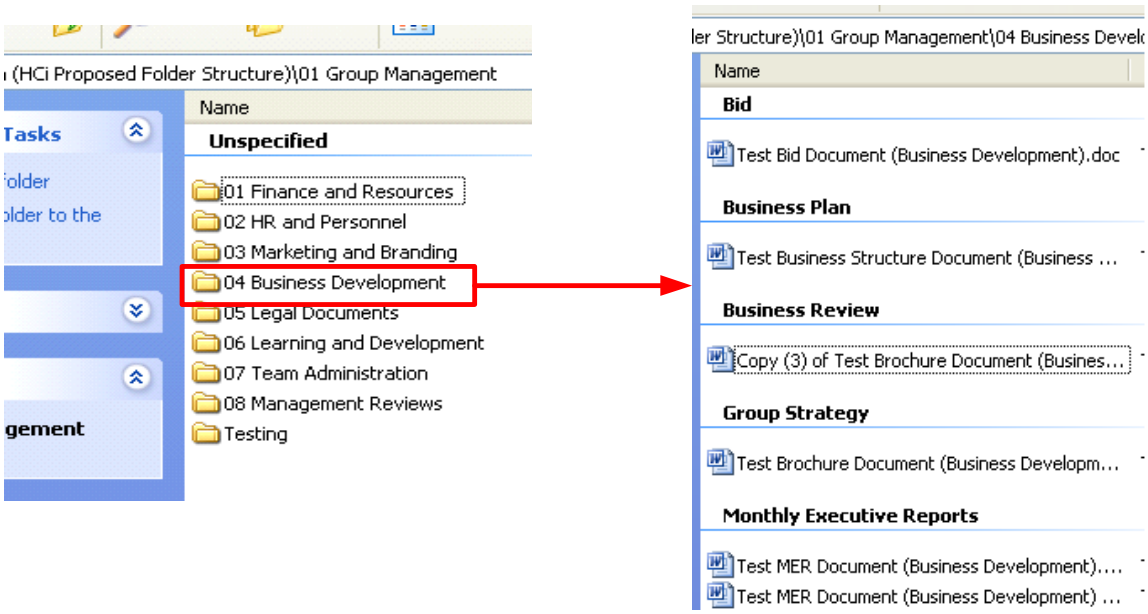

Figure 4.16: Folder Structure and Metadata for Group Management

4.7.2.5 Implementation and Change Management

The redeveloped IA was presented to and unanimously approved by the group following which the RE highlighted the need for sound change management to aid the transition from the previous approach to the new method. While this was beyond the scope of the task, the RE provided practical advice on how this may be carried out. Posters were created and displayed demonstrating the new process, its principles and simple tips to guide its use. Training sessions were also conducted for all team members. A 'how to guide' was also provided with tutorials ranging from inputting metadata; to creating new folder structures for new projects. This was aimed at both easing the learning process as well as helping to ensure consistency in the

application of the new standard. The project sponsor will carry out periodic reviews to monitor the long term use, identify (and remedy) any short comings and refine (where appropriate) the solution to meet the needs of the future. The implications of these findings and lessons learnt are discussed in detail in Paper Five (see Appendix 3.0) and Chapter Five.

4.8 TASK 8: APPLICATION OF A HOLISTIC APPROACH TO INFORMATION MANAGEMENT TO AN ORGANISATIONAL PROCESS

For the final task, the RE designed and implemented a Knowledge Portal (KP) to assess and validate the research findings on a strategic organisational solution. The KP is a collaborative web based workspace to enable employees create, aggregate and share innovation, ideas, experiences and expertise collectively and collaboratively. This task focused on the management of explicit content to enable KM within the KP and not on the wider KM strategy itself. The vision for the KP within the wider KM strategy is to serve as the platform which:

- Improves competency levels and understanding of technical subject matters among employees;
- Enables the evolution/sharing of best practice and standards; and
- Enables the creation and nurturing of new technical innovations.

Explicit knowledge (the principal focus of this exercise) in the research sponsor is "wisdom" obtained through the research into or the application of concepts on projects with links to additional information, suitable standards and resident experts. Prior to the KP, these were shared via cross office and cross disciplinary Communities of Practice (focusing on company wide subject areas) or Office based activities including lunch time talks. The three types of content used were documents (mainly MS Word, Email messages, PDF and Excel), images and web pages. These were stored in and shared via network drives (file shares) the MOSS 2007 based intranet and Email. Two previous KPs had been created prior to this but were no longer in use.

4.8.1 METHOD

As this task required the active involvement of end users, the action research based contextual research method employed in Task Seven (and explained in Section 4.7.1) was similarly adopted. The task was wholly executed by the RE working with a number of volunteers from around the company while the Information System (MOSS 2007 based intranet) in which the portal was created was set up by a senior IT developer within the research sponsor. First, an audit (as a desk study) was conducted of the existing methods through which collaboration and explicit knowledge sharing occurred across the company. This along with the audit previously conducted in Task Three (see Section 4.3) established the state of affairs including the subject matter(s) being shared, the content types and media used for sharing all of which were then critically reviewed. The portal was created and hosted in the MOSS 2007 based corporate intranet.

The implementation was initially focussed on a single office selected based on its size (400 employees); resource constraints and convenience. The RE sent a scoping email to the graduate community within the office (comprising 27 employees) to recruit volunteer participants. 12 volunteers across five disciplines came forth who along with the senior IT developer and the RE, formed the initial focus group of 14. A kick off meeting was held to among other objectives:

- *Define explicit knowledge in the context of their work*; and
- *Agree the aims, set up and execution of the project*.

There, the RE presented the Enterprise Model, the Content Model, the underlying system and the operating principles of the proposed portal. The KP was trialled over an initial three week period following which the group provided feedback on its nature, value and long term viability. The group also identified and proposed changes to make the KP more suitable to the company's needs. Weekly meetings were held to discuss progress and problems.

The trial commenced on the 1st of August 2009. At the end of the three week period, 200 new pages were created and a number of technical limitations (of the portal) were identified based upon which more functional and contextually appropriate add-ons were procured. Following a successful outcome, the trial was extended for a further five months. Additional volunteers also came forth expanding the group first to 24 across two offices; then to 40 across three offices and then to others outside the focus group. Following the trials and the overwhelmingly positive feedback to an email based questionnaire asking about its value to company projects and ease of use, the portal was formally made available to other offices on the 1st of February 2010. The insights from the task are summarised below.

4.8.2 SOLUTION DEVELOPED

4.8.2.1 The Enterprise Model

Following the audit of the current state of affairs in which the existing methods for sharing explicit knowledge were critically reviewed, a number of limitations were observed. Building on this, a more effective solution was proposed reflecting the following core principles drawn from the business needs (established in the audit) and the organisation's operational strategy:

- Knowledge and wisdom is not rigid and fixed but emergent, organic and continually refined;

- Knowledge sharing should be a communal activity integrating participants into a single multidisciplinary community with diverse interests;

- Concepts or topic areas do not exist in isolation nor should they be viewed from only a single perspective. The portal should be dynamic and robust enough to capture, aggregate and present diverse view points or insights on a subject matter;

- The portal should be an enabling environment in which all knowledge which teams and individuals consider valuable for their tasks can be created and shared;

- To minimise the administrative burden and create inclusivity, content should be 'crowd sourced', leveraging communities (experts and volunteers) to create, maintain and police its content;

- The portal should be easy to use and globally accessible to all employees; and

- The use of the portal should enable subject matter experts to evolve from being the sole sources of knowledge on a subject matter to being guardians of technical expertise tasked with ensuring the accuracy of content which may now be contributed to by all.

To avoid any misconceptions, the scope of 'knowledge' was also clearly defined as:

- Descriptions and definitions of concepts (with appropriate references and sources of further information):

- Details of relevant individuals, groups or communities with expertise on a concept;
- Guidance on how to perform functions and/or solve technical challenges;
- Overview of projects, activities carried out, key innovations developed and key personnel involved; and
- Lessons learnt from the practical adoption of concepts or the use of certain approaches and methods.

Based on the above, five inter-related focus areas were defined as illustrated in Fig. 4.17. These are:

- **Concepts:** Knowledge of subject areas or themes including guidance documents on their application on projects;
- **Skills:** The type and variety of skills available within the company to develop solutions using concepts applied on projects;
- **Project Information:** Content demonstrating the application of concepts within past projects;
- **Short Queries:** Quick short questions and queries on the application of concepts; and
- **People** (including groups and expert communities): Affiliated individuals and resident subject matter experts.

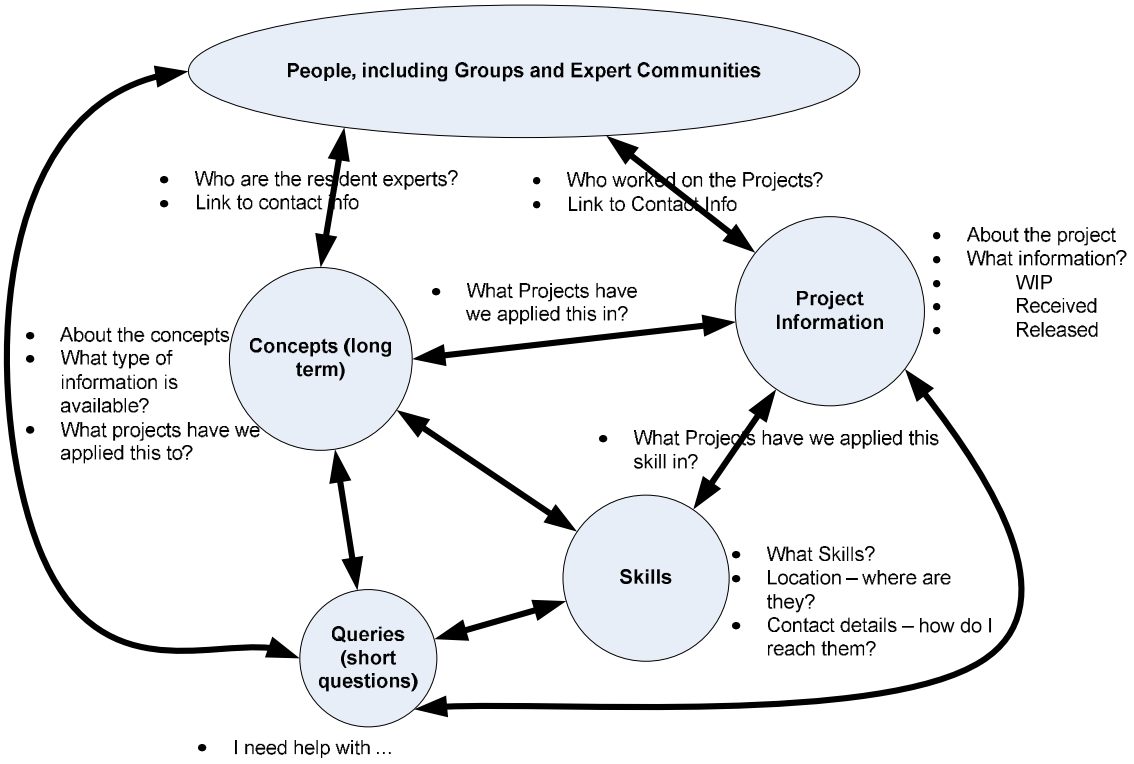

Figure 4.17: Knowledge Map with Focus Areas

4.8.2.2 Content Model

Wikis, Images and Documents are the three key content types used in the KP. A wiki is a simple web based dynamic page based on a simplified mark up language co-authored and co-created by a variety of users (Grace, 2009). Its malleable, dynamic and easy to manage nature makes it

suitable for supporting collaborative working. It enables multiple geographically dispersed individuals and teams to co-create, edit and improve content easily and quickly. In sharp contrast to hierarchical classifications, wikis also enable rich interlinking of pages promoting meaningful associations between various topics. Wikis are the main content type used within the KP, with documents (particularly text (PDF, word) spreadsheets (Excel) and drawings (2D CAD)) and images, all adopted to complement the content of the wiki pages. A standard set of metadata attributes sourced directly from the Metadata standard developed in Task Four (see Section 4.4.2) is also used to provide additional context, improve navigation and enable information retrieval. Similar to the findings from the previous two tasks, not all attributes within the standard were required here. However no new attributes outside of the standard were required or introduced and some attributes adopted in the KP differed from those adopted in the previous two tasks.

4.8.2.3 Systems and Technology

The KP was created as a site collection in the MOSS 2007 based corporate intranet. Three distinct content libraries were created for the three content types (wiki, documents and images). Each wiki page enabled vast amounts of content to be captured within relatively light files. When a page is edited or modified, alerts are sent to the original creator and all subscribers of the page thus enabling entire communities to aggregate around pages of common interest. A full audit history of pages including information about the creator, contributors, when such contributions occurred and the specific changes made are all captured within the system providing full transparency. Following the initial three week trial, 20 technical limitations were identified such as problems formatting tables and images; inputting symbols, formulae and other special characters, etc. These formed essential user requirements based upon which an add-on was procured which significantly improved the overall performance of the portal.

4.8.2.4 Implementation and Change

Knowledge sharing is a communal and collaborative activity. Therefore critical to its overall success is enabling users to converge around areas of mutual interest working together to create, share, sustain and incrementally grow both the quantity and the quality of content while continuously shaping it to meet their needs. During the broad implementation, significant effort was therefore made to adopt an entirely community based approach. Trial groups were set up on an office by office basis to ensure the communal and collaborative nature was upheld and reinforced. Lunch time presentations were also conducted introducing the KP, its structure and its method of use to participating offices. Each community then agreed on how it will be used and an initial area of focus. This invariably resulted in a slow and incremental implementation and change process which is still ongoing.

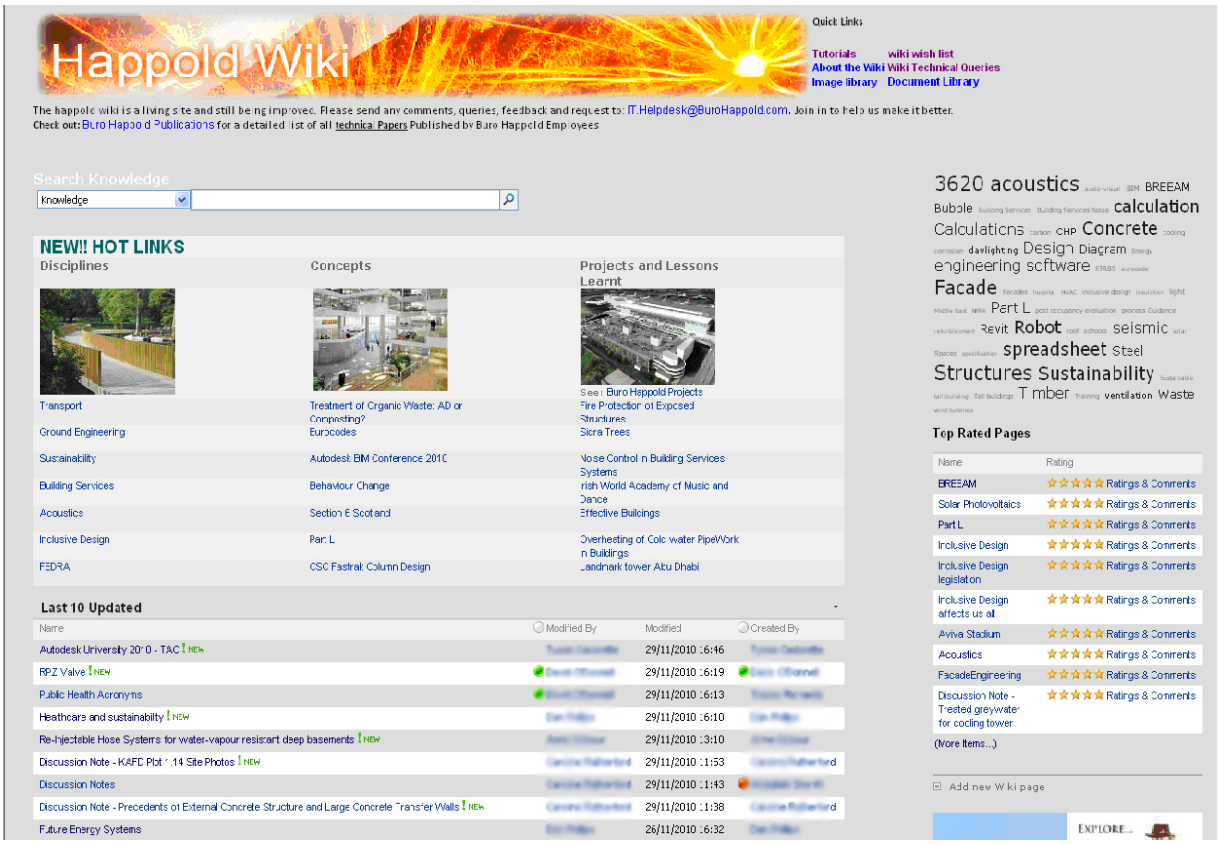

Figure 4.18: Knowledge Portal Home Page

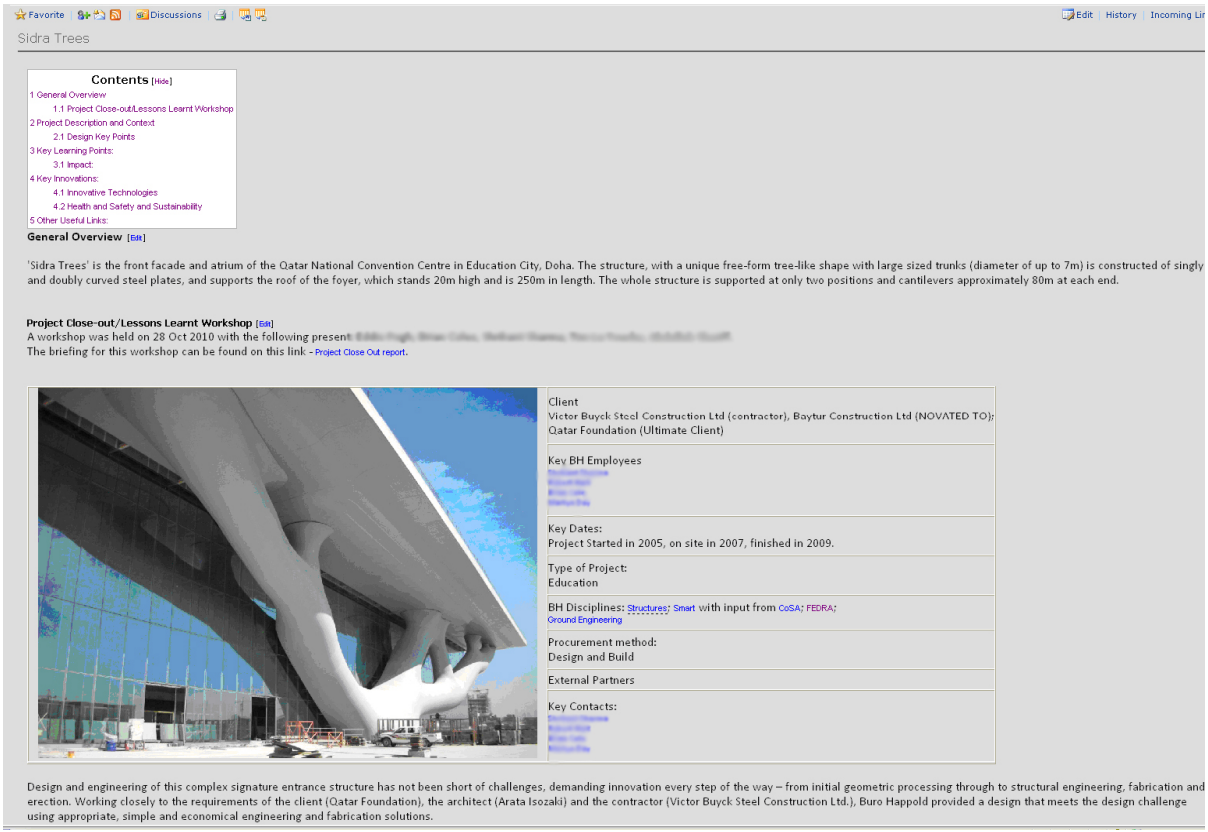

Figure 4.19: Typical Page on the Knowledge Portal

4.8.3 ADOPTION AND USE

The RE observed that the earliest pages created within the KP reflected individual areas of interest. For example, early trialists created vast amount of content on basic definitions of key engineering terms such as beams and columns. However, as user numbers grew, disciplines saw in its fluidity, ease of use, minimal administration costs and centralised nature a critical opportunity to rethink their business models. Accordingly, more recent adoptions show a clear strategic intent to use the KP as the epicentre of a more collaborative operating model.

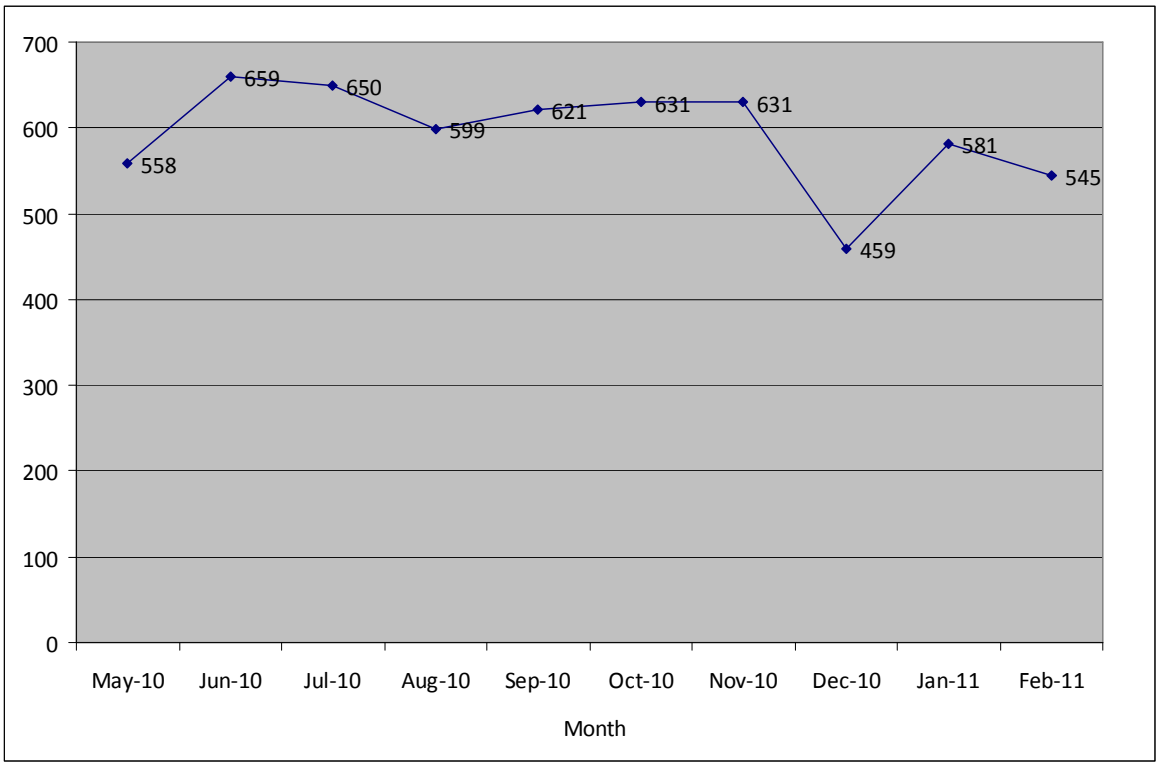

Figure 4.20: Monthly Usage Statistics

The monthly usage statistics for the 10 month period from mid May – February 2011 (as in Fig. 4.20) show significant uptake and recurrent use. It is however too early to measure if the project has been successful or not as only about 60% (total of 900) users have been formally introduced or encouraged to adopt it. In the long term, continuous improvements will be carried out to the portal, its underlying technology and its governance process to ensure it remains fit for purpose; supports collaborative working and adds quantifiable value to global business operations. The conclusions drawn from this task and its implications are discussed in Chapter Five.

4.9 CHAPTER SUMMARY

This chapter presented the details of the eight tasks undergone to meet the research aims and objectives. The conclusions drawn from these are discussed in Chapter Five.

5 CHAPTER 5: CONCLUSIONS

5.1 INTRODUCTION

This chapter presents the key conclusions from the research along with its impact on the research sponsor and the wider construction industry. The research process and its outcome are then critically evaluated following which recommendations are put forth for areas of future research.

5.2 KEY RESEARCH CONCLUSIONS

5.2.1 INFORMATION MANAGEMENT IN CONSTRUCTION ORGANISATIONS

IM is distinct from both IT and IS and focuses on aligning the content and information needs of an organisation with its operational strategy and business processes. The four components of a holistic approach to IM were identified as the Content Model; Enterprise Model; Systems and Technology; and Implementation and Change Management. These findings contextualised the research and defined the general subject area. The detailed investigation into IM practices within UK construction organisations (as described in Section 4.2) highlighted 33 themes across four categories which define the nature of IM in construction organisations. These are summarised in Table 5.1.

Table 5.1: Summary of IM in Construction Organisations

Drivers	Shapers	Barriers	Lessons Learnt
	Organisational Factors	**Organisational Barriers**	
1 Product Improvement	1 Nature of the Organisation	1 Project needs take precedence	1 Understand business needs
2 Process Improvement	2 Nature of the Corporate Strategy	2 Leadership	2 Develop a unified approach not a single approach
3 Transfer of Learning		3 Limited Resources	3 Develop a broad strategy not focussed on technology
4 Legal and Regulatory Requirements	**Project Factors**	**Content and Technological Barriers**	4 Develop and deploy content standards
5 Mitigate Risk	1 Scope of Project Services	1 Complicated Information Architecture	5 Develop an effective implementation process
	2 Diversity of Projects	2 New forms of content	6 Gain senior management support
	3 Diversity of Operating Markets	3 Inconsistencies in the use of Metadata	7 Actively demonstrate value to users.
		4 Poor performing technology	
	Future Innovations	**Construction industry wide**	
	1 Processes and Practices	1 Lack of guidance	
	2 Content and Technology	2 Skills Shortages	
	3 Organisational Structure	3 Nature of Construction Projects	
		Cultural Barriers	
		1 Resistance to Change	
		2 Fear of being driven by technology	
		3 Poor Sharing Culture	

It is important to know that inter-relationships exist between the various themes while contextual peculiarities of each organisation affect the extent to which any of the themes influence its overall IM strategy. For example, while all organisations were driven by the same five themes,

each organisation places emphasis on some over others based on its strategic needs. The themes are also defined and influenced by external factors, in particular the wider construction industry, its people, structure and working practices. Thus, while all the themes provide a better understanding of IM in the Construction Industry, they are all also a product of the specific context of the organisations being in the Construction Industry. Other conclusions drawn from this study include:

- Themes are predominantly organisational with limited technology related drivers, barriers or constraining factors. This re-emphasises that IM unlike IS or IT is not a technological but an organisational issue;

;

- Organisations are hindered by the shortage of the right skills to effectively develop holistic IM strategies which align their business strategies with the most appropriate content models, enterprise models, technological solutions and administrative infrastructures;

- In multidisciplinary/multinational organisations, defining a single approach to managing information using a single information system can be impractical and/or undesirable. Certain organisational, technological and environmental factors exist in each organisation which will require an approach focussed enough to integrate the organisation and support the overall corporate business strategy yet flexible enough to accommodate the differing needs of specific projects, tasks, disciplines, countries and products; and

- Measuring the effectiveness of an IM strategy should not focus on the targeted implementation of technology but on assessing the strategy's appropriateness for supporting an organisations tasks, processes and business strategy.

5.2.2 INFORMATION MANAGEMENT PRACTICES IN THE RESEARCH SPONSOR.

The focussed and in-depth audit conducted of IM practices in the sponsoring organisation captured the practical challenges in IM and the nature of end user requirements. Following the audit, a technical report with 14 problem areas and 18 recommendations was presented to the research sponsor and is currently being implemented. While some of these findings may be specific to the research sponsor, the following generic conclusions were reached:

- IM strategies should (among others) also improve information retrieval, enabling users to find and retrieve the right information to perform tasks as and when required;

- Various types of content are created, shared and therefore need to be managed within organisations. This re-enforces the need for a holistic approach capable of supporting such variety and not a single approach;

- Extensive information sharing occurs within organisations both internally (between individuals, disciplines and offices to support projects, share knowledge etc) and externally (with clients and project delivery partners);

- Lack of a clear IM strategy within an organisation can result in isolated and inconsistent practices for creating, naming and managing content which can make collaborative working difficult; and

- A well executed Information Audit is an essential first step in developing an IM strategy. It enables more contextually appropriate and informed decisions to be made on:
    - The required Information Architecture;
    - The groups of content within the organisation and how each is best managed; and

- The appropriate technology, systems and institutional framework to support IM in the organisation.

5.2.3 METADATA STANDARD FOR INFORMATION MANAGEMENT

Despite the importance of metadata in enabling IM, there is limited practical guidance for organisations looking to develop metadata standards to suit their needs. The findings from the two tasks carried out (see Sections 4.4 and 4.5) provide much needed insights into this process along with a detailed description of the metadata standard developed for the research sponsor. By exploring alternative approaches, Task Four (see Section 4.4) also addresses the question of what the appropriate starting point is in developing a metadata standard. The parallels between the standard developed, specific construction related standards (such as the BS1192:2007) and the ISO 15836:2009 standard (see Table 4.2) show that using existing international standards can be a suitable starting point. The following additional conclusions can also be drawn:

- Even in multidisciplinary organisations with diverse user needs, there is significant commonality across end user metadata requirements to allow for a metadata standard to be developed;

- No existing standard can be wholly adopted within an organisation without some level of customisation to suit its needs;

- Clarifying the target group at the outset would ensure the standard developed is focused on the specific needs of the end user and their associated business processes;

- The metadata standard and the process of developing it should not be driven by the technology used to implement it, but should be driven by end user needs and the functions which the technology is expected to serve; and

- The solution developed and the software with which it is implemented should be kept simple and usable to ensure user buy in.

No attempt is made to generalise the use of the specific attributes identified (see Table 4.2) across all organisations within the construction industry as it is acknowledged that each organisations needs may differ. However, the process for developing the standard (as captured in the IM framework – see Section 4.5) can be applicable to other organisations as the metadata standard was developed for an organisation typical in size and structure to other large multidisciplinary consulting organisations within the construction industry.

5.2.4 IMPACT OF A HOLISTIC APPROACH TO INFORMATION MANAGEMENT

The findings from the three implementations carried out (see Section 4.6, 4.7 and 4.8) re-enforced the conclusions from Task Four that contextual factors influence the use of metadata creating the need for some attributes while making other attributes unsuitable. The findings also show that having a metadata standard does not imply that every attribute must be used at all times. Instead, a metadata standard provides a 'basket' of attributes from which users pick and choose those most appropriate for their tasks. New attributes outside of the standard developed may also be required in certain situations to reflect specific needs. These additions, inevitable as they may be, will need to be built into the organisational standard to ensure that consistency is maintained. Other conclusions drawn from the three implementations are summarised below

5.2.4.1 Metadata in Information Retrieval

- Metadata provides contextual information about content which can enhance information retrieval and enable content to be structured into contextually appropriate groups;

- Not all metadata attributes required for CM are similarly required for Information Retrieval;

- Prescribing a single metadata standard for information retrieval applicable to all content across the company irrespective of discipline or project may be undesirable. Certain attributes may be universally desired while contextual factors influence the need for others. These contextual factors include:
    - The nature of content being managed;
    - The discipline to which the user belongs;
    - The specific role of the individual in the organisation; and
    - The project's specific requirements.

- There is a strong correlation between the attributes individuals use to name and manage files and the way they want to search for them. Individuals will name/tag their files and folders in the way that best helps them retrieve it. Critically analysing personal file naming patterns can be a suitable starting point for identifying suitable facets for use in information retrieval.

5.2.4.2 Information Architecture for a Holistic Approach to IM

Following the successful outcome of Task Seven (see Section 4.7 and Appendix 3.0), interviews were carried out with five members of the group to review the project and the solution developed. The interviewees described the solution as *"practical"* and *"intuitive"* with no *"apparent complications"*. Other observations include:

- The strong alignment between working practices (enterprise model) and the Information Architecture creates a sense of familiarity for users;

- The task based Information Architecture ensures all information produced in relation to a given task is aggregated in a single environment, aiding retrieval and auditing;

- The task based arrangements allows for scalability and is therefore capable of accommodating new tasks without fundamentally distorting the structure; and

- Workflow and task based Information Architecture allows for built-in quality control.

The task demonstrated the feasibility, practicality and appropriateness of a holistic approach to IM in a case study group.

5.2.4.3 Holistic Approach to IM in a company-wide Business Process

It is difficult to assess if the uptake and medium term success of the Knowledge Portal (KP) (Task Eight, Section 4.8) was solely due to the user centred approach to implementation; the content model; the system/technology; alignment with the company business strategy and cultural values; or the leadership style of the senior management all of which could be valid factors. Further research is required to investigate this. It was however clear that **all** the factors listed above **did** collectively contribute to the success of the project, reinforcing the fact that a holistic approach is required in implementing effective IM strategies. In this task, this needed a balanced appreciation of the systems and tools; the company processes and the appropriate

implementation model needed to create an effective solution. These findings are also broadly in line with the findings of Dave and Koskella (2009) who developed a KP for improving Knowledge sharing and innovation in a case study organisation.

Figure 5.1: Use of Metadata in the Knowledge Portal

The metadata standard developed in Task Four (see section 4.4) was also found to be fully applicable to the KP. The attributes were used to filter content into contextually appropriate facets as illustrated in Fig. 5.1 improving information retrieval. Though all the attributes were also obtained from the standard developed, not all the attributes from that standard were found to be directly applicable to the KP further re-enforcing all previous conclusions.

5.3 IMPLICATIONS OF FINDINGS AND CONTRIBUTION TO KNOWLEDGE

5.3.1 IMPLICATION FOR INFORMATION MANAGEMENT THEORY

There have been limited studies into the organisational dimension of IM, in particular the nature and structure of an effective content model. The findings and conclusions from this research have contributed to the subject area by:

- Defining IM (as distinct from IT and IS) and its applicability in the construction industry;
- Clarifying the four categories which constitute a holistic approach to IM;
- Identifying that in the organisational dimension, the measure of appropriateness for an IM strategy is the alignment of the approach to the operational needs of the organisation;
- Providing the 12 step structured IM framework to guide organisations in developing metadata standards to support IM; and
- Identifying the relationship between metadata and search preferences for enabling contextually appropriate facetted search;

5.3.2 FOR THE CONSTRUCTION INDUSTRY

This research project has:

- Defined the nature of IM in construction organisations including the key factors which drive, influence and are barriers to effective IM;

- Demonstrated that a 'unified strategy' and not a 'single strategy' may be more appropriate to the needs of multidisciplinary construction organisations;

- Showed that a holistic strategy often does not involve the use of a single system, but a suite of systems reflecting the diverse processes and content types in organisations; and

- Demonstrated that a process based Information Architecture is practical and effective.

5.3.3 FOR THE RESEARCH SPONSOR

- The specific implementations of the holistic approach resulted in significant improvements in three key areas:
    - IM, Knowledge sharing and Collaborative Working across all global offices;
    - Project delivery and the support of geographically displaced teams; and
    - Core operational processes such as business development.

- The metadata standard developed is now being implemented and used as the basis for integrating all IM Systems across the company;

- The audit (Objective Two) and the recommendations provided resulted in a greater understanding of the IM challenges faced and enabled more targeted solutions to be developed and implemented; and

- Facetted search using the facets identified is being implemented and has begun to yield improvements in information retrieval.

5.3.4 ADDITIONAL CONTRIBUTIONS

Based on the findings and insights from this research, a number of generic frameworks were created for developing effective IM strategies within organisations. The first framework (see Fig. 5.2) is a structured approach to designing, selecting and implement the most appropriate holistic approach (including Enterprise model, Content model, systems and technology, implementation and change) for collaboration within an organisation or on design projects.

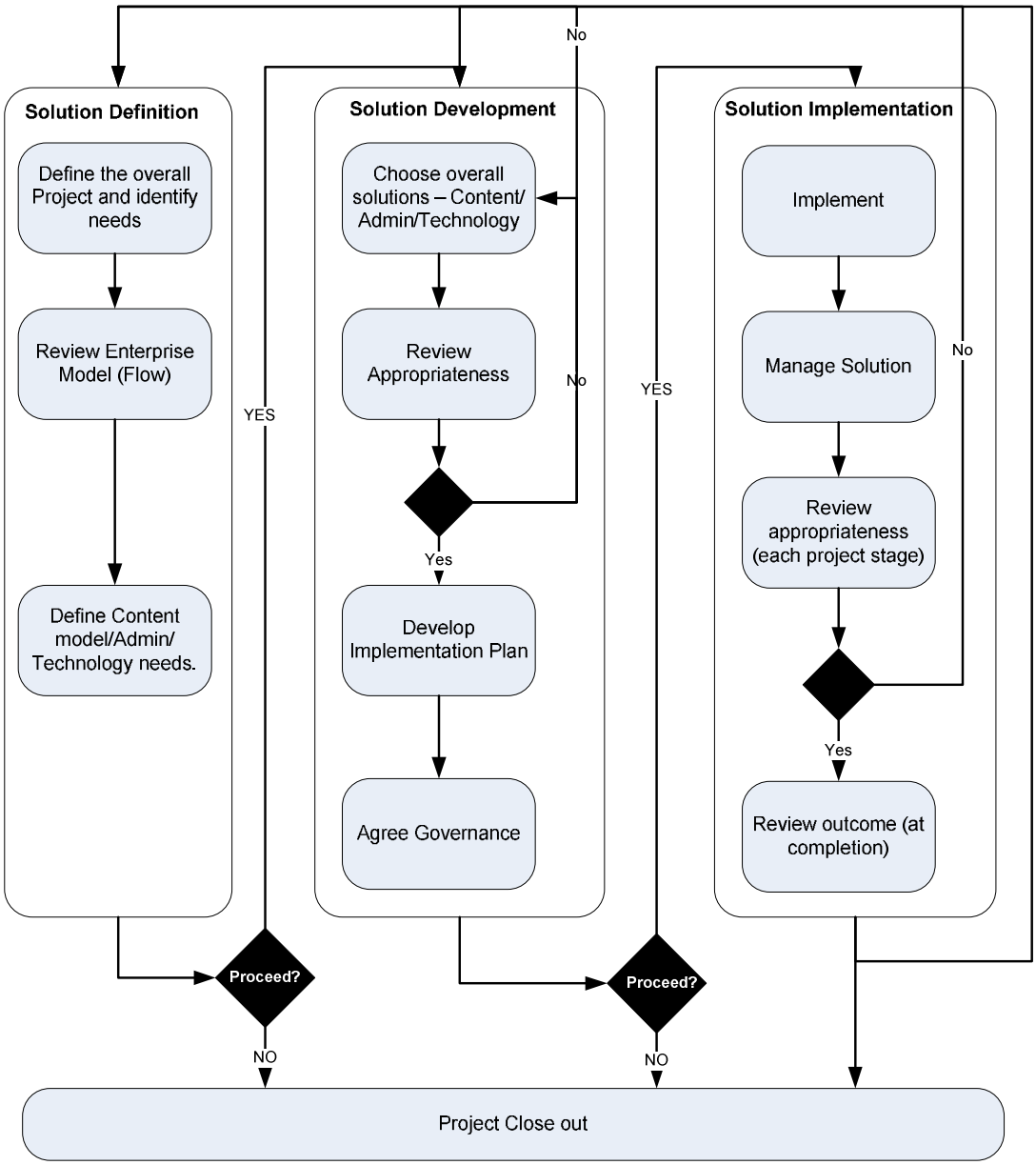

Figure 5.2: Project Information and Collaboration Framework

The second (Fig. 5.3) complements the first by focusing on the content model, mapping out the flow of information through the project lifecycle while at each stage eliciting responses to questions such as:

- What type of content will be produced, shared or received?
- Who are the consumers of this content?
- What system(s) is best used to store, share and manage that piece of content vis-à-vis the nature of the project?

Both frameworks were applied to a number of multimillion pound projects within the research sponsor demonstrating a direct application of the research findings and yielding improvements in IM, collaborative working and project delivery. The structure, development and implementation of both frameworks are however not discussed in this thesis.

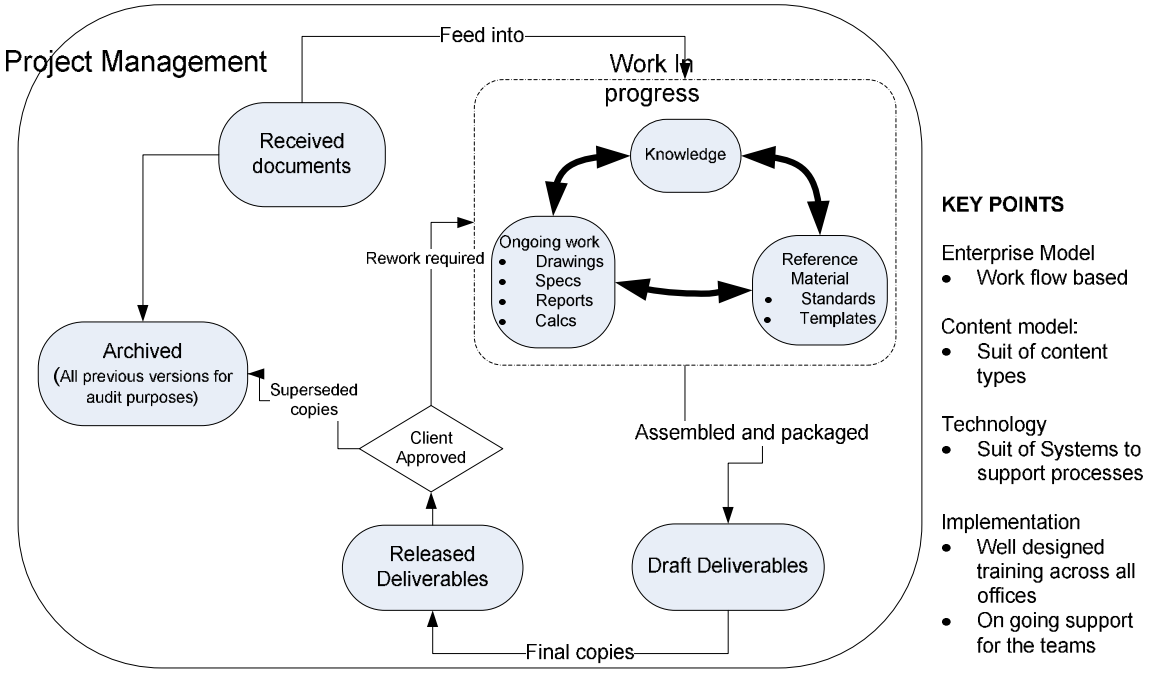

Figure 5.3: Generic Enterprise Model

All the research tasks and their areas of impact are summarised in Table 5.2.

Table 5.2: Tasks and their Impact

	Task	Impact of Tasks		
		Research Sponsor	**Construction Industry**	**Information Management theory**
1	Review of the state of the art in Information Management			P
2	Review Information Management in construction organisations		P	S
3	Conduct Information Audit of the research sponsor	P		
4	Develop a metadata standard for Information Management	P	S	
5	Develop a guide for defining an organisational Metadata Standard	S	P	P
6	Investigate the use of metadata in information retrieval	P	S	P
7	Develop a corporate Information Architecture for Information Management	P	S	S
8	Investigate the application of a holistic approach to Information Management on an organisational process.	P	S	S
Key	Primary	P		
	Secondary	S		

5.4 CRITICAL EVALUATION OF THE RESEARCH

This section discusses some limitations of the research project.

5.4.1 SCOPE OF THE RESEARCH

The case study method adopted implied that five of the eight tasks were principally focussed on the research sponsor. Though specific solutions developed, such as the metadata standard reflect attributes specific to the needs of the research sponsor, the insights obtained are company neutral and generally applicable to other similar organisations (i.e. medium-large global multidisciplinary consultancies) across the construction Industry. As an example, the IM framework developed as an output of Task Five (see Section 4.5) is inherently company and industry neutral. This is also evident in the feedback obtained from the subject matter experts to whom it was presented (see Section 4.5.3).

The research scope was influenced by the particular 'pain points' of the research sponsor i.e. how to manage information more effectively across the organisation. This however did not affect the quality of the study as the research sponsor was receptive to the need to ensure all relevant themes were investigated with exceptional rigour. The findings, though significantly insightful reflect only a part of IM as only the content model was investigated in detail.

5.4.2 RESEARCH PROCESS

Executing the research required the sustained balancing of different and sometimes conflicting industrial and academic requirements. To ensure insights obtained and the solutions developed were based on clear academic rigour, each task began with an extensive review of literature then a clearly defined methodology for its execution. Further evidence of this is that the outputs from most tasks were published in peer reviewed conferences and journals. Further research is required to assess the broad applicability of the research findings across other processes and organisations.

5.4.3 VALIDITY AND RELIABILITY OF THE DATA

Though the case study approach makes broad generalisations difficult, the findings are based on rigorous research methods and provide a deep understanding of the phenomena in question. All methods employed in capturing and analysing the data for each task were researched, designed and executed thoroughly and objectively. Multiple methods (triangulation) were used in some tasks to overcome the weakness of a single approach and strengthen the overall findings (as explained in detail under each relevant task in Chapter Four). Additionally:

- Document analysis (used in all tasks) was carried out in an unbiased and objective manner; and

- Where a questionnaire was used (as in Tasks Three and Six), extensive care was taken to ensure that the sample and respondents were broadly representative of the wider organisation.

5.5 RECOMMENDATIONS FOR FUTURE RESEARCH

Based on the research findings, a number of recommendations for further research are put forth:

- While this research focused on defining the elements of a holistic approach (the what), further studies are required to develop additional toolkits (the how) to enable organisations transition from tactical technological implementations to holistic approaches to managing information;

- The scalability of the holistic approach to larger samples, processes and/or organisations need to be further investigated;

- This research focused on the content model, but repeatedly observed that the successful implementation of even the most robust and well aligned content model can fail with poor implementation and Change Management. Further research is required to investigate Change Management and effective implementation processes for a holistic approach to IM;

- The implementations described in this research involve the use of existing systems and technologies. Further research is required to investigate the role and impact of new/emerging technologies on IM;

- New innovations, particularly the adoption of content such as Building Information Models (BIM) will invariably impact on IM. Further research is required to investigate such groups of content in the context of a holistic approach to IM;

- Further research is also required to develop appropriate metrics and Key Performance Indicators (KPI) for measuring the effectiveness of IM strategies and their impact on the processes they are designed to support; and

- The metadata standard developed is composed of 'un-intelligent' attributes. Further research is required into semantically enriched metadata and ontologies. This would enable metadata provide greater contextually appropriate meaning and reflect inter-relationships between attributes, content and subject matter. The use and potential of ontologies for improving IM and information retrieval have been explored in depth by Maedche et al (2003), Anumba et al (2008) and Rezgui et al (2010b) amongst others.

5.6 CONCLUSION

This thesis presents the findings from a four year Engineering Doctorate (EngD) research project into improving the effectiveness of IM strategy in construction industry based organisations. The findings define IM, its core components and its nature in construction organisations. It also concludes that effective metadata is critical to enabling a holistic approach to IM and provides a novel 12 step guide for developing metadata standards. The findings emphasise the need for a unified strategy comprising of a core standard which can be tailored to support diverse disciplines, process, content types, projects and systems within organisations. Such a strategy should be based on the business strategy, operational processes and specific needs of each organisation to ensure it is contextually appropriate. A holistic IM strategy informed by the various insights obtained through this research will enable organisations and project teams across the construction industry better leverage information to improve collaborative working, innovation, project delivery and their overall business operations.

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APPENDIX 1 DEVELOPING A METADATA STANDARD FOR MULTIMEDIA CONTENT MANAGEMENT: A CASE STUDY (PAPER 3)

Full Reference:

Sheriff A, Bouchlaghem D, EL-Hamalawi A and Yeomans S.G. (2011), Developing a metadata standard for multimedia content management, in Journal of Architectural Engineering and Design Management (Accepted)

Abstract:

Metadata is considered crucial for the organisation, management and retrieval of data within a content management system. While numerous works exist which define the critical nature and importance of metadata very little practical guidance is available with which organisations looking to develop metadata standards to meet their corporate needs can do so. This paper presents a case study in which a metadata standard was developed for an international construction industry based consultancy for managing content within a proposed multimedia library. Three parallel activities were carried out as part of the research methodology. A desk study was initially conducted to capture the metadata used in the previous library. A review of 11 metadata standards was carried out to obtain a baseline of suitable attributes. A workshop was then conducted with a sample of end users to further capture specific requirements. The outcomes from all three exercises were then analysed to obtain a company wide metadata standard. A further refinement was carried out to rationalise the list into a core set of attributes. A closeout workshop was then conducted with key participants to identify lessons learnt and review the outcome of the project. Drawing from these, this paper further adds to knowledge by proposing a 12 step guide to enable organisations develop similar metadata standards to meet their needs. The research outcome also shows that while existing metadata standards can be used as a starting point, no specific standard is comprehensive enough to meet the needs of an organisation without appropriate levels of customisation.

Keywords:
Metadata; Content Management; Information Management; Taxonomy; Enterprise Content Management

Paper type:
Journal Paper

1 INTRODUCTION

1.1 UNDERSTANDING METADATA

Metadata refers to additional pieces of data or attributes which describe the context and structure of a piece of data, content, document or other bits of information and their management through time (Bjoerk 2001; ISO 15489: 2001). The use of Metadata within a content/document library allows information to be more easily found, its source determined and its context understood easing interpretation and enabling re-use (Bentley 2001; Rockley 2003; NISO 2004; Day 2006). While resource discovery remains one of the principal functions of metadata, others may include provenance, technical specification, functionality, administration, content ratings and demonstrating linkage or relationships (Technical Advisory Service for Images (TASI) 2006). In order to fulfil these functions, Metadata should be seen to be application independent and clearly defined enterprise wide and used as a tool to facilitate interoperability between multiple systems as organisational needs warrant (Bjork 2001, Haynes 2004). Metadata can generally be seen to be of three types (NISO 2004; TASI 2006):

- Descriptive metadata which are used to find, identify and understand a piece of content examples of which include title, abstract, author, and keywords.
- Structural metadata which show and define relationships and associations between content or compound content made up of smaller bits of content, an example of which is relation
- Administrative metadata aimed at managing the lifecycle of content and associated technical information examples of which include date created, file type, file size and restrictions.

As Burnett et al (1999) explains, in the end, metadata should enable users to clearly answer two principal concerns i.e. what information is available and what information is useful.

1.2 EXISTING METHODOLOGIES FOR DEVELOPING METADATA STANDARDS

Content Management systems, whose key feature is descriptive metadata, are increasingly being used for managing electronic content within organisations (White 2005). While international standards for descriptive metadata attributes do exist, research aimed at defining metadata standards are predominantly bibliographic with very limited research on organisational metadata (Karjalainen et al 2000; Murphy 2001; Paivarinta 2002). In particular, no clear methodology exists with which organisations can develop appropriate standards to meet their needs. One such exception is the detailed case study presented by Paivarinta et al (2002) in which a metadata standard was developed for an enterprise wide Electronic Document Management System (EDMS) in Fortum, an international energy company. Similarities do exist between both studies particularly in the methodologies and the metadata attributes identified, all of which will be highlighted below.

Despite the shortage of research in this area, some process methodologies for developing broader information management strategies (which may include metadata) have been proposed the most prominent of which is the Designing and Implementing Record Keeping Systems (DIRKS) framework. The (DIRKS) methodology is a structured eight-step process that provides guidance to organisations on how to improve information and records management (National Archives of Australia (NAA) 2001). The eight processes defined can be understood thus: Step A contextualises the project and focuses on understanding the company, its business structure, nature of the market and industry regulation. Steps B and C gather specific record keeping

requirements and match with the business activities of the company. Step D then focuses on a state of the art review of the company, assessing the appropriateness of current record management policies, systems and procedures to meet the requirements gathered. Where deemed inappropriate, this is then followed by Stages E and F aimed at redesigning the whole strategy to address identified limitations and meet the company's strategy. Implementation and post implementation reviews are then carried out in Stages G and H to complete the model's lifecycle (NAA 2001; Hoffman 2006).

The DIRKS model is holistic incorporating aspects of electronic systems, human interaction and organisational behaviour (NAA 2001). While developed for the purposes of record's management, the steps outlined can be adopted for developing broader organisational information management strategies. The gap in the DIRKS model is that while metadata is acknowledged to be crucial in supporting the functionality of the records management system, it explicitly provides no specific guidance on how organisations looking to develop a metadata standard either for a specific project within an organisation or across the whole organisation can do so.

Bock (2005) also proposes a simple three step process for designing metadata with particular emphasis on metadata for Digital Asset Management (DAM) systems. The three steps begin with **capture** which involves aggregating and understanding the unique terms used by the target groups to describe digital assets in their respective business processes. Following this is **Curate** which involves a refinement of the set terms including the similarities and differences among them and determining which ones are important and why. The final step is **categorize** which involves defining the metadata sets that will be used for each group. This methodology while simple is focused entirely on the actual identification of metadata for a project and does not take into account other critical aspects such as implementation or even adoption of descriptive Metadata standard attributes. The methodology was therefore deemed inadequate and not holistic enough for developing a company wide metadata standard and the long term framework for its subsequent maintenance. Thus it could be said that despite these and similar frameworks, there remains limited references for practical guidance as to how organisations can develop metadata standards to meet their needs.

This research was carried out as part of a four year Engineering Doctorate program (EngD) into Enterprise Content Management (ECM) with a focus on developing an Information Management Strategy (IMS) for construction industry based organisations. This paper presents the outcomes of an exercise to define a metadata standard for a proposed multimedia library within an organisation (as a detailed case study). It begins by introducing the aim of the research and the organisational context. The methodologies adopted are then presented accompanied by details of the activities carried out. This is followed by a discussion on the findings and outcomes of the research along with the lessons learnt. Based on these, a step-by-step guide is proposed through which other organisations can similarly define metadata standards to meet their needs. It is anticipated that this guide while focused on metadata can and should be used to complement broader more comprehensive information and records management frameworks such as the DIRKS model. For reasons of anonymity, the case company involved in this research will be referred to as company A.

1.3 THE PROJECT SCOPE AND RESEARCH CONTEXT

Company A is an international construction industry based engineering design consultancy employing over 1800 staff in over 25 offices across the world. Serving multiple geographically dispersed projects, the company relies on information sharing and collaborative working to

ensure effective project delivery to meet client needs. To support core business processes (including marketing and bid management) a new multimedia library was required. Prior to this, a bespoke image library existed designed by an 'in-house' IT team approximately eight years ago. Being bespoke, it was designed with suitable functionality to meet the user needs of the time. Whilst the functionality was still considered relevant, the system had since developed some significant shortcomings.

As the company evolved both technologically and as a business, the use of higher resolution image formats and other multimedia file types such as videos etc have become prevalent, all of which the existing system with its functional, technical and storage limitations could no longer manage. To overcome this, users began to manage multimedia content in personal hard drives and project servers. This brought with it business risks which Company A was keen to mitigate. Using such compartmentalised storage solutions also meant that content stored in one environment was in-accessible to other staff who may have required it to fulfil their tasks (thus resulting in more business inefficiencies). The existing library also had limited search-ability and indexing capability. Its' simple functionality asked for users to provide very limited amounts of metadata while uploading content. While this was complimented by the use of keywords added by users, retrieving the required content was difficult which in turn negatively impacted on the usability of the library. The less the users were able to find content, the less confidence they had in the system and therefore the less likely hood that they would use the library in the future to either store or retrieve images.

In replacing the library, Company A also wanted to improve its overall workflow capability to optimise business processes. Rather than simply store content, the requirement was to provide a capability for assembling information products (i.e. documents, reports, bids etc) 'on-demand'. Currently the process for carrying out such tasks requires an Adobe in-design document to be created with the images saved to a local folder from which they are embedded into the document. The document is then sent to relevant parties in a zip folder for approval (with copies created) until approved. The favoured content on-demand approach would aim to reduce associated storage costs, optimise the flow of information, enable standardisation and save time. It was realised that core to meeting these requirements is the development of a robust metadata standard particularly to support search and retrieval, the principal thrust of this project.

2 RESEARCH METHODOLOGY

The objectives of this research were: to define a metadata standard for information management and retrieval within a case study organisation; investigate issues which emerge in the metadata development process; and identify a generic methodology which may be used to guide practitioners in creating appropriate metadata standards. A case study approach was adopted due to the depth of understanding sought of specific company business processes, the holistic investigation of the concepts required and the company specific scope of the project. Fundamentally though, this research is exploratory in nature seeking to explore patterns inherent in a specific activity carried out in a real life context (Yin 2002). Thus while a framework is proposed, no attempt is made at generalising the findings as it is acknowledged that the sample size is not sufficient to do so. The project was conducted by the researcher alongside a team of user representatives and company stakeholders. These were sourced primarily from the disciplines across the company deemed to be either the primary users of the system; key secondary users; or those actively managing the system. A total of eight such disciplines were identified with two others invited to join based on their additional expertise considered to be vital to the project. Care was taken to ensure broad user requirements across the company were sufficiently represented. At some stages, input from other users (outside of the group) was sought to either re-confirm the findings or gauge opinions on specific issues. Three

complementary approaches were adopted in line with the objectives of this project. These were: a desk study of the existing library; a literature review of existing metadata standards and a workshop with user representatives.

The desk review of the existing library was carried out to analyse the existing structure and metadata (if any) being used. This review was essential for obtaining a better understand of the nature of the problem and potentially to identify any embedded patterns in the way images were currently tagged. The findings were then mapped out and analysed using a mind mapping tool. Since the existing library did not require strict adherence to any attributes, it was presumed that users will tag files in manners that make the most sense to them or enable them to retrieve it best. This exercise was focused on identifying user metadata preferences, thus the frequency in which certain attributes were used was deemed unimportant and not captured. To complement the desk review, a parallel review of existing metadata standards was carried out to determine the suitability of existing standards for meeting the needs of the company. This review was carried out in close consultation with the company stakeholders and user representatives. Based on user requirements, the scope of the project, the peculiarity of business processes and terminologies within the construction industry, no standard was identified wholly suitable to the needs of the company. An analysis was then conducted to identify attributes which were common to the standards to establish a baseline from which an appropriate standard could be developed. Thirdly, a workshop was held with the project team and selected user representatives to identify their specific metadata needs and also to compare the findings with the outcome of the two exercises performed earlier. During the workshop, 14 images and videos were selected at random from a pool of 4,000 and presented to the user representatives. For each image, representatives were asked what metadata they would like to attach to the files (no suggestions were offered). The outcome of the previous two exercises was not communicated to them until the end of the workshop. After the workshop, all the metadata suggestions were aggregated into a spreadsheet. As with the desk study, the object of this exercise was not to identify the frequency in which certain attributes occurred but to capture all the attributes required.

A conscious attempt was made to ensure that the metadata standard developed was driven by user needs. Thus it was felt that no individual exercise from the above could be carried out in isolation and deemed to comprehensively reflect those needs. Due to the limitations of the existing image library and the fact it was no longer used by many groups across the company, the results of the desk study would be fairly limited. Studying the standards alone would also be inadequate as it did not and could not reflect the organisation's specific requirements and business processes. The workshop while accommodating user preferences would not have helped to facilitate interoperability between systems as it would lead to exclusively bespoke solutions to meet only the needs of this project. Thus all three exercises were necessary, providing the breadth needed to address the limitations of each singular exercise. To refine the findings, a comparison was then conducted on the collective outcomes of the exercises. Attributes featuring in two or more of the three exercises were considered to be important and retained while attributes featured in only one required justification by the end-users as to its perceived importance. Where such justification was not provided the attribute was removed.

Having obtained the standard, it was then observed that the full deployment of all the attributes may create a system too burdensome for the end users impacting on its effectiveness. A further refinement was therefore carried out by the project team re-organising the attributes into three tiers based on their perceived importance (tier one attributes were deemed critical and tier three attributes deemed 'nice to haves'). Prior to implementation, a further analysis was also carried out to identify which of the attributes could be automated and which would have to be manually input by the end users helping to further reduce the total number of attributes and completing the project. A project closeout workshop was then held with the project team to critically review the

outcome of the project, the steps undergone and the refinement process. Details from each exercise and the outcome of the research are outlined below

3 THE PROJECT

3.1 DESK REVIEW

The structure of the current image library with its nearly 4,000 images was studied in detail to reveal the following 15 attributes:

1. **Date** – The date in which the activity/event was carried out. On a project, the date reflects the date of specific activities ranging from early stage preliminary site visits to project closeout visits and even post occupancy appraisals. It provides an audit trail and useful context for the content of the image.

2. **Contributor** – The person/entity responsible for uploading the image unto the library. This sometimes differed from the person who took the actual image (see below) and is always a company employee.

3. **Source** – The person/entity credited for supplying the image. This could be either a company staff or an external photographer.

4. **Creator (or Photographer)** – The person/entity who created the image, sketch or drawing. This may sometimes be the same as the source but where sources were secondary, the creator often differed.

5. **Rank/position** – This was used in images relating to people and/or events. It relates to the job position of the individual(s) who appears within the image. These were either single individuals in which case specific titles were used (e.g. HR manager) or a group of individuals in which case a more collective title was used (e.g. graduate engineers).

6. **Group/team** – The discipline within the company to which the content of the image was attributed. For example, certain project images with pile foundations were also tagged with ground engineering (the group name responsible for or affiliated with the image).

7. **Office** – The specific office of company A associated with the content or subject matter of the image (and not the image itself).

8. **Business region** – The specific business region in which the office (as described above) is based and/or the business region with which the content of the image is associated.

9. **Keywords** (e.g. winter snow, Plug socket, etc) – Keywords were the most used attributes in the existing library as it allowed users to specify contextual terminology related to the content which would enable them retrieve it. The keywords used varied from subject-technical scientific terms including materials etc to general descriptive terms such as forest, summer, sunrise, and so on.

10. **Location** (including city, country and continent) – The geographical setting of the content within the image or the activity/individual associated with the image. In some instances only the city name was used while in others the country and indeed the continent was used. All geographical references in this instance were not done using GIS co-ordinates.

11. **Designer** – The individual/company or entity directly credited with creating the content captured in the image. This was predominantly used for Buildings, infrastructure, project images, monuments and similar physical structures.

12. **Content Type** – These are categories which reflect the genre of the content. Examples of these include sketches, drawings, presentations, Maps, and so on.

13. **Format** – This relates to the format of the image. This was automatically captured by the image library and it is unclear if users relied on it for image retrieval.

14. **Resolution** – The resolution of the image was used as a core metadata attribute with which high quality images were identified and retrieved.

15. **Access rights** – This relates to the sensitivity of the image and the permissions that define those who should have access to it.

16. **Copyright** – This was included as part of company policy to ensure that regulatory requirements are met and intellectual property was never infringed upon.

The existing image library was restricted in the number and nature of attributes it allowed users to add thus the findings from this desk study were incapable of being wholly reflective of user needs. Also, within both the project and generic sections, the library used a system of categories and sub categories to form two levels of hierarchy. No specific definitions were provided either to the researcher or to users uploading content into the library as to what the terms 'category' or 'sub-category' mean. This exercise observed that there was no apparent consistency in their use. What was apparent was that the attributes used in the hierarchy reflect similar attributes employed as metadata. Indeed some metadata attributes such as date of the event/activity were used frequently among the sub categories. As an example consider the sub-category "RedR day 9/12/05, 2005" (under the category 'Company events', RedR day is a company event). This reflects both the name of the event/activity and the date. In all such cases both attributes were counted as a single instance of metadata.

3.2 REVIEW OF EXISTING METADATA STANDARDS

3.2.1 IDENTIFYING THE STANDARDS

A review of metadata standards was then carried out to identify if any directly met the needs of the company and could be wholly adopted. Where such could not be identified, the exercise then aimed to develop a baseline set of metadata upon which the company standard could be built. As part of the standardised information architecture the company favours, preference was given to the use of external metadata standards as against developing bespoke solutions. Preliminary research suggested that no standard can be applied without modification to suit the particular company needs (TASI 2006; Paivarinta et al 2002). Two previous researches were carried out based on a similar review of available metadata standards. Paivarinta et al (2002) conducted a similar comparison using 18 metadata standards while an earlier study by Burnet et al (1999) was based on a comparison of six standards. As it was intended that this exercise would build on the baseline defined by Paivarinta et al (2002), care was taken to identify standards which had not been used in their research. This was to ensure that no standards were repeated (thus duplicating the results) and new perspectives which have emerged since both researches were carried out are accommodated. Only the ISO15836 included in both studies was also included

here. This is because it has emerged as the defacto standard for descriptive metadata. The following standards were reviewed:

- **ISO 15836** – This is based on the Dublin Core, a ubiquitous standard for cross domain resource description often referred to as the defacto standard for descriptive metadata (ISO15836: 2009).

- **Visual resources association (VRA) core** – A metadata standard for describing images and visual content for the cultural heritage community (TASI 2006)

- **E-government metadata standards** – This lists the elements and refinements used by the public sector in the UK to create metadata for information resources. It also gives guidance on the purpose and use of each element (e-Government Metadata Standard 2006).

- **E-records** - A metadata standard developed specifically for the purpose of effective records management in the public sector in the UK, it is built on the e-government metadata standards (The National Archives 2002)

- **ISO 19115** – An international metadata standard for describing geo-spatial datasets (ISO 19115: 2003).

- **BS- 1192** - Set of standard procedures and methodologies for managing the production, distribution and quality of construction information using defined processes for collaboration and specified naming procedures (BS1192: 2007).

- **UK Learning Object Metadata (UKLOM)** – A standard for the interoperable description of learning objects i.e. any entity digital or non digital that may be used for learning, education or training (IEEE 2002).

- **New Zealand Government Locator Service (NZ-GLS)** – A standard metadata element set designed to improve the discovery, visibility, accessibility and interoperability of online information and services in a cross disciplinary information environment in New Zealand (Archives New Zealand 2004).

- **UK-Gemini** - A defined element set for describing geo-spatial discovery level metadata within the UK (Cabinet Office 2004)

- **Australian Government Locator Service (A-GLS):** A standard metadata element set designed to improve interoperability and retrieval of online information and services with primarily in Australia (National Archives of Australia (NAA) 2006)

Taking into account the 18 standards already reviewed by Paivarinta et al 2002, it could be said that the baseline developed for this research reflects a secondary review of up to 27 standards.

3.2.2 THE ATTRIBUTES

Attributes which occurred consistently in over four of the now 11 standards (including the review of Paivarinta et al (2002)) were identified and earmarked as the baseline standard. These were:

No	Attribute	Number of instances
1	creator/ originator	11
2	Title	10
3	Description/ Notes/ Abstract	10
4	Date	10
5	Type	10
6	Format	9
7	Relation/ lineage	9
8	Accessibility/ Availability/ Rights	9
9	Subject	8
10	Identifier/ ID/ Drawing number	8
11	Language	8
12	Source/ Supplier	6
13	Coverage	6
14	Publisher	5
15	Contributor	5
16	Location	5
17	Status	5

Table 1: Baseline developed from review of existing standards

This baseline is similar to that established by Paivarinta et al (2002) as all but two of the attributes specified in their work were still dominant here. The absent attributes were Keywords and organisation. Three additional attributes not reflected in their work also emerged. These were: Source/supplier, coverage and status. A comparison with ISO 15836:2009 the most widely used descriptive metadata standard showed that all but one of the attributes in the standard are reflected here, with only two attributes i.e. Location and Status absent from it. The resulting baseline reconfirms the positions of Paivarinta et al (2002), CEN (2005) and TASI (2006) that the Dublin core metadata can be suitably used as an established baseline from which organisations can build their own metadata standards. However, a review of this baseline by the company project team clearly showed that there were other attributes specific to internal business processes and the construction industry not reflected here but which the users considered to be critical in effectively carrying out their tasks. Hence this did not reflect a comprehensive list of descriptive metadata suitable to the needs of the company.

3.3 THE WORKSHOP

To capture end user specific preferences, a workshop was set up in which user representatives from the different disciplines were provided with 14 randomly selected images and videos sourced from the existing library but reflecting the breadth of content. The attendees for the workshop were the user representatives described in section 1.4 above. In selecting the images and videos to use, the only criterion employed was to ensure they were broadly reflective of the variety of images within the library. The participants were all in the same room and were allowed to openly discuss their thoughts with each other through out the process. As the aim of this exercise was to aggregate all the desired attributes, no attempt was made to tally the number of times a single attribute was highlighted or its level of importance. The results from the previous two studies were not shared with the user representatives prior to this exercise to avoid subtle influences on their choices. In the end, a total of 56 attributes were identified. A subsequent refinement was carried out to remove duplications, synonyms and attributes which

were considered subsets of other attributes. Justification was also sought for each attribute the results of which are presented below.

4 FINDINGS

4.1 COMPARISONS OF THE THREE STUDIES

In analysing the collective outcomes, a comparative study was carried out between the three activities. It was observed that though the outcome of both the desk study and the baseline developed were not made known to the user representatives prior to the workshop, considerable similarities between all the outcomes emerged as reflected in table two below. Certain attributes matched each other by definition but differed in terminology. In these instances, the term deemed more easily understandable by potential users was chosen. In two instances, the term differed from those adopted in the standards. Differing with the recommendations of TASI (2006), it was believed that using terminologies adopted in standards but unknown to the user would make the solution more difficult for users. One such term was 'coverage' defined as the extent or scope of the content of the resource (TASI 2006). This was similar to file size. Instead of either definition, 'resolution' was adopted as users showed preference for seeking images not on the basis of its size but on its clarity and level of detail. 'Relation' which featured in the standards reviewed also matched 'related press articles'. However in this case, the former was used as its meaning was flexible enough to include a relation to other media or content outside the press articles suggested in the latter's definition.

	Attribute	**Workshop**	**Standards**	**Desk review**	
1	Access rights	X	X	X	
2	Bid outcome	X			Considered Important therefore included
3	Business Region	X		X	
4	Company	X			Considered Important therefore included
5	Content type	X	X	X	
6	Contributor (of image)	X	X	X	
7	Copyright	X		X	
8	Creator	X	X	X	
9	date of event/activity/project	X		X	
10	date image taken	X	X		
11	Date of commissioning (or use)	X			Considered Important therefore included
12	drawing no	X			Considered Important therefore included
13	Designer (architect)	X		X	
14	Description		X		Considered Important therefore included
15	duration for video/coverage for images	X	X		Considered Important therefore included
16	File format	X	X	X	
17	groups/disciplines	X		X	
18	Identifier		X		Not included - auto software generated not descriptive
19	Interesting space	X			Considered Important therefore included
20	key Company staff	X			Not included
21	key words	X		X	Considered Important

					therefore included
22	Language		X		Not included
23	Location	X	X	X	
24	Mood board	X			Not included
25	Office	X		X	
26	Professional/non pro/UGC	X			Considered Important therefore included
27	Project name	X			Considered Important therefore included
28	Project number	X			Considered Important therefore included
29	Project sector	X			Considered Important therefore included
30	Project value	X			Considered Important therefore included
31	Publisher		X		Not included - deemed inapplicable
32	Related press articles	X	X		
33	resolution	X		X	Considered Important therefore included
34	source of image	X	X	X	Considered Important therefore included
35	Subject		X		Not included - built into taxonomy and title
36	Status		X		Considered Important therefore included
37	staff name	X			Not included
38	Staff rank/position			X	Not included
39	Title	X	X		Considered Important therefore included
40	Type of video	X			Not included - related to content type
41	use (of structure)	X			Considered Important therefore included
42	Value	X			Considered Important therefore included
43	Version	X			Considered Important therefore included

Table 2: Comparison of Metadata Attributes

For each attribute reflected in only one of the three exercises, a case by case justification was sought for its inclusion. Most such cases emerged from the workshop as it was the principal medium through which company specific requirements were identified. Where the justification was deemed adequate by consensus, the element was retained and where it proved inadequate, it was removed. 'Description' occurred only in the standards reviewed (one of three) but was included as it was deemed important. Language and publisher were excluded as they were deemed inapplicable. 'Subject' was deemed to be reflected in the taxonomies and therefore not necessary in the metadata. Elements of the subject would also be reflected in the title and file name. 'Type of video' was excluded and it was deemed to be reflected within the content type attribute. A more difficult exclusion however was the 'identifier' attribute. While the identifier was considered important in uniquely naming content, it was also considered 'non-descriptive' and would not be used to either manage or retrieve content. Thus its exclusion was not on the basis of its usefulness which was fully acknowledged but on its 'non-descriptive' function. While excluded here, a conscious note was made to ensure that automatic software generated identifiers would be used within the system when implemented. With respect to similarities, 15 of the 16 attributes identified in the desk study matched the user requirements highlighted in the

workshops while 13 of the 17 attributes from the standards reviewed also matched the attributes identified during the workshop. Thus (without prior knowledge of the two activities) the outcome of the workshop was considerably similar to the outcome of both studies. The result of this refinement was a set of 35 attributes that reflected Company A's requirements as shown in table four below:

	Attribute	**Description**
1	Access rights	Information about who can access the resource and associated details of the documents security level
2	Bid outcome	(For bid content) – An indicator specifying if the bid for which the content was created and/or used was successful.
3	Business Region	The specific company business region in which the office identified above belongs.
4	Company	The Company reflected in the theme of the content affiliated with or responsible for producing the content.
5	Content type	The nature or genre of the content.
6	Contributor (of image)	The entity responsible for providing the content to the library
7	copyright	The nature of the rights held in and over the content
8	Creator	An entity primarily responsible for making the content.
9	date of event/activity/project	Date in which the theme or subject matter captured within the content occurred.
10	date image taken	date in which the content was created
11	Date of commissioning (or use)	The date in which the entity in the content was commissioned.
12	Description	An account of the content of the resource (ISO 15836:2009)
13	Drawing no	(for CAD drawings saved as multimedia content) Unique Identifier attached to a drawing
14	Designer (architect)	The entity/individual primarily responsible for creating the subject matter of the content
15	Duration/coverage	The extent of scope of the content (e.g. time for video, size for images)
16	File format	The digital manifestation of the content
17	groups/disciplines	The company discipline/group reflected in affiliated to or primarily responsible for the subject matter reflected in the content
18	interesting space	An indicator rating the innovative nature of the subject matter in the content. Typically reserved for buildings, structures and project content.
19	key Company staff	Key individuals within the organisation affiliated to the subject of the content
20	key words	Words describing the document's content
21	Location	The geographical position of the structure/event/entity captured in the image/video.
22	Office	The specific office (of the company) reflected in, affiliated to or primarily responsible for the subject matter reflected in the content.
23	professional/non pro/UGC	The technical status of the contributor of the image
24	project name	The name by which the project is formally known
25	project number	The unique numerical identifier of the project affiliated with the image
26	Project sector	The specific work sector to which the subject matter of the content belongs.
27	Project value	The total construction value of the project affiliated with the image
28	Relation	A link to any internally written press articles related to the subject matter of the content
29	resolution	The density of the image expressed in words (e.g. high resolution, medium resolution, etc)
30	source of image	(If different from contributor) the resource from which the content is derived.
31	Status	The state of the content in a related lifecycle.
32	Title	Name by which the content is formally known.
33	use (of structure)	The use to which the subject matter of the content is/was subjected
34	Value	A rating system showing the relative significance of the subject matter within the content or the content itself to the company
35	Version	The current or previous states of the content.

Table 3: 35 Metadata that form the standard for company A

5 IMPLEMENTATION

5.1 RATIONALISING THE ATTRIBUTES

In validating the appropriateness of the standard developed above, a total of six key potential users outside of the project team were consulted to review. The review process consisted of each person issued with the standard list and asked based on their role and the needs of their disciplines which of the attributes should be deployed. The responses from the reviewers suggested that while being comprehensive, the number of attributes where too many and will prove a challenge for users, ultimately impacting on the usability of the system. Also observed was that the integration of the proposed multimedia library into the wider IT infrastructure for the company would allow some attributes to be captured automatically either by the system (from the content itself) or as an existing attribute which can be drawn from other IT systems within the corporate enterprise architecture. Thus a further refinement was carried out by the project team to regroup the 35 attributes defined based on their importance, splitting the standard list into three tiers:

a) Tier one: Core attributes considered to be essential and therefore should be implemented immediately with the system. This also included important attributes required only for administrative purposes and not particularly descriptive metadata.
b) Tier two: Attributes required mainly to enhance the overall quality of metadata in the system and not critical to the effectiveness of the system.
c) Tier three: Attributes which though required add minimal value for the system.

Based on the levels of importance and to ensure the simplicity of use, it was decided that only tier one attributes will be deployed at the outset while tiers two and three will be long term additions to be deployed as the system reaches greater maturity. Thus the standard list of 35 attributes was reduced to an initial list of 20 as shown in table four below. These were then further analysed to identify those which could be automated and those which would have to be manually input into the system by users. For each of the attributes which could be automated, the team also identified its source (i.e. the internal system from which the data would be drawn). The outcome of this and the deployed metadata standard is presented in table four below:

	Tier 1 and 2 (Core Metadata)	**Note**
1	Title	Manual
2	Content type	Manual
3	Description	Manual
4	Key words	Manual
5	project number	Manual
6	Designer	Manual
7	Project Phase	Manual
8	Access rights	Manual
9	copyright Owner/Notifications	Manual
10	project name (Auto)	Auto-generated from internal systems
11	groups/disciplines (Auto)	Auto-generated from internal systems
12	location (Country and city) (Auto)	Auto-generated from internal systems
13	Sector (Auto)	Auto-generated from internal systems

14	Creator	Auto-generated from content
15	date image taken	Auto-generated from content
16	duration for (video) Coverage (for images)	Auto-generated from content
17	Contributor (of image)	Auto-generated from content
18	File format	Auto-generated from content
19	Resolution	Auto-generated from content
20	Version	Auto-generated from content

Table 4: Core Metadata for Multimedia library

5.2 LESSONS LEARNT

Having developed the metadata standard, a workshop was held with all team members to reflect on the activities carried out, the result obtained and to identify the lessons learnt. The key lessons were then captured by the researcher, analysed and summarised below.

Identify Stakeholders and their Needs

As it is crucial to ensure that the metadata used within the library meets the exact needs of the potential end-users, a preliminary review is required at the outset of the project to fully define its scope asking:

1. Who (in specific role/discipline terms) are the principal end users of the library? And who will be secondary end users?
2. What function would all end users be using the library for?
3. What metadata will be required to meet the specific needs highlighted above?
4. Of these metadata, what are the most important and which must be attached to all content?
5. What external regulatory or institutional requirements must be adhered to in defining this standard?

This stepped questioning process will result in a consistent definition of the project context which should be continuously referred to in order to ascertain if elements defined are sufficient, too much or indeed unnecessary for the purpose intended. The project team observed that such a stepped questioning process as outlined above was not properly followed at the outset resulting in a distinct lack of focus in the type of metadata attributes required. For example, at the outset of the project employees who will not be using the library were extensively consulted and provided broad requirements which conflicted with the aims of the project (e.g. attributes such as drawing issue number; CAD layering standards; etc were requested but these were not required as the multimedia library will not be used for managing drawing files). Thus refocusing on the core end user base ensured that such attributes were not included and the needs of the core end users were clearly focused upon. Drawing lessons from this, it is recommended that a focused stakeholder analysis be carried out right at the outset. It also promotes inclusiveness and enhances user buy in for the project.

Simplicity is Key

Participants unanimously identified continual simplification of both the number of attributes and the terminology employed as critical in ensuring that the metadata standard is both practical and pertinent with one participant remarking that *"if at first look the system does not appear clear and straightforward, myself and most other users would simply create a folder on my computer and store the images there"*. Such simplicity should be reflected in the terminologies chosen to define the attributes, the number of attributes selected, the taxonomy design, the design of the

interface, automation of certain attributes (to ease user input) and training provided. Participants also reflected that it was based on the teams resolve to ensure the solution developed was simple yet effective for the end user that the 35 attributes initially identified were refined even further to obtain a smaller subset.

Metadata standard must not be technology driven

To ensure its usability, the metadata standard developed should drive the system requirements and not vice versa. Participants observed that grounding the evolution of the metadata standard in the requirements of the users and their respective business processes rather than the specific technological platform will serve to ensure that the solution is truly reflective of end user needs. It will also ensure that the resultant standard aligns with the overall strategic IT architecture of the company and not dictated to by any technology. While it is too early to assess the success of the standard developed, it was anticipated that a technologically agnostic standard as developed here will enable interoperability between internal systems and facilitate true company wide collaboration.

Standards should be used wherever possible

Participants observed that considering the strength in similarities of the outcome from the workshop and the review of existing standards, the project should have begun simply with the review (or indeed the adoption of an existing standard) and using that as a baseline upon which to build subsequent refinements. This while providing a good starting point will also ease information exchange between systems within the organisation (and even external systems) as they would all be built to reflect similar metadata. Reflecting on the future, it was also noted that standardisation would also ease migration of content to any future platform without a significant loss of metadata.

Customisation may always be needed

Despite the adoption of external standards, customisation may always be required to meet specific company needs and reflect specific business processes unique to each company (a point also raised by Paivarinta et al 2002; CEN 2005; TASI 2006; Perlin 2006). In further explaining this point, participants noted the difficulty in balancing the extent of customisation to be carried out, as extensive customisation may be time consuming and provide limited value. While no clear means was identified to prevent this, a review of the case study showed that a second refinement was necessary to reduce the large number of attributes initially defined into a more focused set (a clear side effect of the extensive customisation carried out).

6 STEPS TO DEVELOPING ORGANISATIONAL METADATA STANDARDS

Based on the outcome of this case study, the specific processes undertaken and the lessons learnt (identified in the project closeout workshops) a guide is proposed depicting a process methodology for developing an organisational metadata standard. This is aimed at providing a usable framework with which Company A and other similar organisations could develop metadata standards to meet their needs. While based entirely on the outcome of the case study, the guide was also designed to reflect the following key characteristics (adopted from NAA 2001)

1. Generic and flexible enough to be adopted to suit any organisation looking to develop a metadata standard without being vague.
2. Multi-phased, focusing on steps to undertake and why those steps are essential. It makes no mention of specific tools to adopt but allows each organisation to select the most appropriate tools to meet its needs
3. Systematic, providing an easily workable structure
4. Cyclical, accommodating a process of evolution and continuous redevelopment based on a whole lifecycle concept
5. User centric and focused on the needs of end users and business activities across the organisation, thus building up from the overall objectives towards a workable solution.
6. Principles of project management including planning, resource management and change management are also reflected in the various stages of each process emphasising that the framework signifies an activity for which good management is deemed essential.
7. Compatibility with broader frameworks such as the DIRKS model which govern wider information and records management processes of which metadata development is only a part.

A total of 12 steps are proposed grouped into three key phases as below.

1. **Establish goal of the project:** The first stage is to clearly define and articulate the intended goals of the project. A clear understanding ensures the right steps are taken and appropriate resources are made available for the effective execution of the project. This scope matched with the goal of the project enables strategic needs analysis to be carried out eliciting specific answers to the questions:
    a. Why should this project be carried out?
    b. What is the desired outcome of this project?
    c. What is the scope of the project?
    d. What business streams across the company will be affected by the project?
    e. What specific content classes are intended to be managed?
    f. Who are the target end users?

2. **Project initiation:** Here the goals identified above are translated into a working plan to articulate how the project will be managed from inception until completion. The business case and communication plan are developed including detailed justifications as to the viability and cost implication of the project. A high level champion will need to be appointed to ensure top level support across the organisation. The project delivery team will then need to be set up with a clearly defined mandate and responsibilities. In appointing the team, (depending on the scope of the metadata standard being developed) it is important to ensure that membership cuts across the functional breadth of the organisation so as to reflect the distribution of end users across the company and gain their input. The resources available to the team monetary and otherwise through the lifecycle of the project should also be defined along with a timeframe for its execution.

3. **Identify and analyse all related business processes:** Having initiated the project, a detailed analysis will then need to be carried out of the specific activities undergone by end users in carrying out those business processes. This stage is crucial as metadata does not exist in a vacuum. Its purpose is to contextualise a given activity to support the discovery and management of content to support such activities. Hence this stage aims to identify what those activities are for which the metadata is required from the end user perspective. The outcome of this would also be used to validate the eventual standard developed to ensure it meets the intended goals. Thus, this stage answers the questions
    g. What are the specific business processes for which the metadata is required?

   h. Within each of those processes, what activities are carried out which require metadata?

4. **Identify metadata requirements:** Based on the understanding of the activities and process, this stage then identifies the nature of metadata required to achieve it. It is important to maintain the order starting with an understanding of the processes and from that building up a picture of the sort of metadata that would be needed to support it. At this stage no details are required of the individual metadata attributes. What are required are themes such as: subject metadata, Administrative metadata, regulatory metadata, retrieval metadata, workflow metadata etc.

These four steps constitute the project definition phase of the project giving it the appropriate direction required to execute the other phases. A clear definition is required at the end of these four steps to ensure the steps within the subsequent phases are both precise and adequate. The next phase is the Metadata development phase.

5. **Review existing standards:** Standards should then be reviewed to identify which could be adopted to meet the needs of the company and its business processes. A broad range of standards should be consulted and selected based on their internationalisation, perceived relevance to the organisation, relevance to the industry in which the organisation is based and/or relevance to the type of content being managed. While these selection criteria may vary across companies and indeed projects, they need to be clarified to ensure the right sets of standards appropriate for the project are reviewed. Some key questions which should be answered here include:
   i. What criteria should be used to determine what standards are appropriate for the company's needs?
   j. What International/cross industry standards are available which meet these criteria?
   k. What Industry specific standards are available which meet these criteria?
   l. What content specific standards are available which meet these criteria?

6. **Review appropriateness:** Having reviewed and identified potentially suitable standards, these then need to be analysed to determine their suitability for the needs of the project. This involves a detailed analysis of the individual attributes contained within each of the shortlisted standards above (as similarly carried out in the case study presented). Where a standard is deemed wholly appropriate and can be adopted with little or no customisation this can then be carried on to the testing stage. Where customisation is deemed necessary, this activity saves time and resources by identifying those attributes which can be adopted as a base minimum serving as a good starting point from which the required customisation can then be carried out. The detailed metadata elements agreed upon are also refined here, identifying variations such as compulsory and optional attributes; or automatic and manual attributes. The success of this stage requires the crucial input of end users to confirm the suitability or necessity of any of the attributes. Where customisation is carried out, the review process should be done iteratively until agreed as being appropriate.

7. **Customise standards:** Where no standard is appropriate, modification is carried out at this stage to make the standard reflective of the needs of the company. It should begin with a clear understanding as to why the modification was deemed necessary. The result is a company specific metadata standard which takes into account such varying perspectives as business processes, archiving policies, quality management procedures, business structure, and so on. Each attribute identified here must be justified, identifying

why it is necessary and by whom. This is to ensure that while additional attributes are included, the standard developed remains fit-for-purpose. Various methodologies can be used for capturing the elements required here including desk studies of existing repositories, workshops, questionnaires, and so on. Irrespective of the methodology, the eventual outcome must be collectively reviewed by the project team accepted and signed off as appropriate prior to any testing or validation.

8. **Testing and Validation:** To ensure its suitability, the metadata standard should then be tested around various scenarios within its anticipated scope of use. These scenarios should be as varied as possible. The object of this exercise is to scrutinise the standard for any loopholes and ensure the solution is robust enough to meet the needs of the company and its wider user community

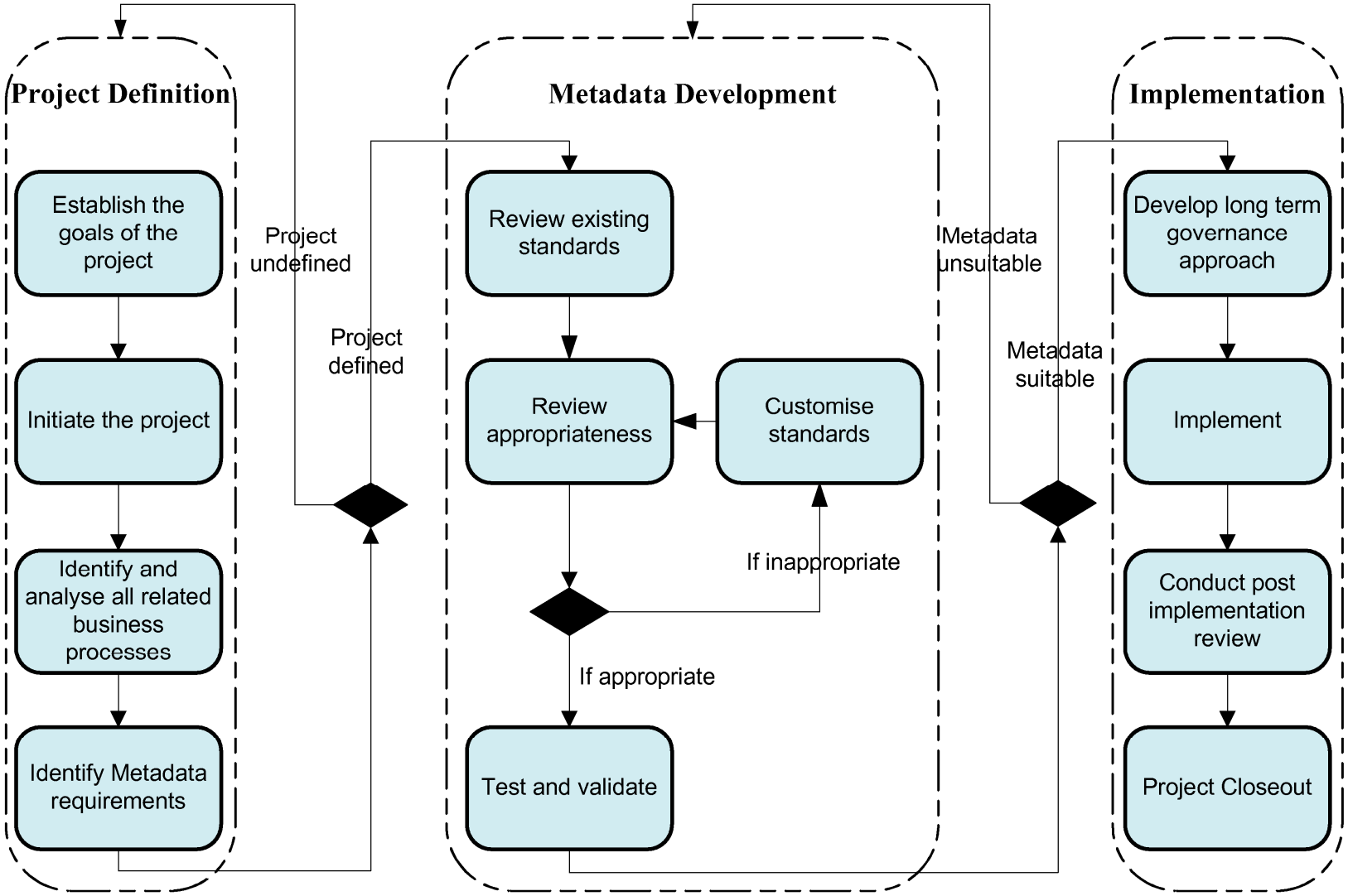

Figure 1: Steps for developing an organisational Metadata standard

These represent the four steps to be carried out at the Metadata development phase. This phase where details such as the individual elements and their associated definitions are developed represents the translation of the project vision into a workable standard. It should be noted that the case study discusses work carried out up to this stage (and does not include details of any actual implementation). Thus the next steps outlined below are anticipated steps as defined by the project workshops as well as findings from detailed literature reviews. They are currently being validated through the on going implementation process.

9. **Develop governance approach:** Governance enables the distribution of accountability and responsibility for the long term management of the metadata standard. This is necessary in metadata development to ensure that it is continually updated to meet the future needs of users and the company in light of changing business strategies, methods of working, processes, and regulations (Bentley 2001; Sun Microsystems 2005). Specific decisions will need to be made including (but not exclusively): how the standard will be managed in the future, who retains responsibility, how the quality of metadata input into the system can be ensured, etc (Paivarinta & Munkvold 2005). As responsibilities are assigned, resources will have to be committed for this purpose. Change management is a significant activity carried out at this stage aimed at facilitating a smooth transition to the adoption of the developed standard. It should be seen as a conscious activity required to ease user adoption and could significantly impact on the success of the project (Mathieu & Capozzolli 2002).

10. **Implementation:** This is the stage in which the developed standard is encoded into the proposed system. The reference here is to the visual interfaces and the actual representation of the metadata on the chosen system as seen by the user; and interfaces for both metadata entry and result visualisation including critical questions on: which of the attributes should be free text or automated. Beyond the technological implementation, necessary training and policy guidance developed earlier are also rolled out here in a suitable manner.

11. **Post implementation review:** Having implemented the developed standard, the processes undergone and the outcome of the project should then be collectively reviewed. This helps to ascertain if the original project goals were met. This reflection also enables the lessons learnt to be recorded to improve the delivery of any future metadata development endeavour. Also required here is feedback from end users to establish the appropriateness of the metadata standard developed to meet their needs.

12. **Project closeout:** This marks the formal end of the project and is carried out when the metadata standard is deemed functional and fully implemented. This also marks the beginning of the long term maintenance of the standard (as defined when developing the governance approach).

7 DISCUSSION

The standard developed through this exercise for Company A though specific to multi-media content, would form part of the broader metadata standards (to include all other unstructured content) also being currently developed. Looking through the 35 attributes, a significant observation is that many of the attributes are not unique to company A but similarly applicable to other organisations. Thus further analysis was carried out to investigate the similarities between the attributes based on their varying levels of standardisation. Accordingly, four significant groupings emerged. These were:

1. **Generic standard metadata** – Attributes reflected in existing cross industry standards – A total of 16 of these were identified. Example of such a standard is the ISO15836.
2. **Content Dependent Metadata** – Attributes required due to the nature of the content being managed within the system (in this case multimedia). These could be standardised across content classes. Content classes such as drawings, models etc can cut across companies and industries. Three attributes were identified here. An example of a content dependent standard is ISO 13567 (2D Computer Aided Design standards).
3. **Industry dependent Metadata** – Attributes required due to peculiarities in the industry/sector in which the company is based (in this case the construction industry). Two attributes were identified here. An example of such a standard is the BS1192:2007.
4. **Custom Metadata** – Attributes that reflect the specific needs of the company with all its processes, workflows, activities and quality management procedures. 14 attributes were identified here.

These groupings suggest that organisational metadata for all companies across industries cannot be standardised without some degree of customisation to suit particular company needs. This also sheds light on the challenge raised by Paivarinta et al (2002) of where the appropriate starting point is for defining organisational metadata. With 20 of the 35 attributes (and 13 of the 20 tier one attributes) in this study based on standards defined outside the context of the specific organisation, these results suggest that building up from existing standards may be a better starting point than developing wholly bespoke solutions. In this case, such an approach would have provided over 50% of the metadata required. Due to the focused case study approach adopted for this research, no attempt is made at generalising these findings as further research is still required to ascertain the universal validity of the results.

The 12 steps outlined above are proposed based on a retrospective analysis of the outcome of the project (from the workshop as well as a detailed process analysis conducted by the researcher and project team). Thus the project in its execution did not entirely adhere to the steps above but underwent iterative processes with significant challenges. While the goals of the project were clearly defined at the outset, the scope of who the target end users would be was not. Thus an immediate challenge was clarifying the scope of the type of attributes that would be most appropriate to the target group. It was observed that strictly clarifying the target groups at the beginning as being marketing and business development would've helped ensure the standard was focused to reflect of their business processes and needs.

The lack of extensive experience in the process of defining metadata within the organisation also meant that the project initiation process was a challenge. There was an initial lack of understanding of the true value of metadata and therefore the necessity of the tasks to be carried out. Thus the project manager begun first of all by enlightening the entire team of the necessity of the endeavour, the magnitude of work that will be required and the thinking required to execute it. Also, the team was assembled from across the company to include a project manager and representatives from all the user groups with the researcher providing guidance on metadata and taxonomy. During the closeout workshop it was observed that the cross disciplinary membership of the project team reflecting the actual end user groups ensured clarity in the requirements and the way the team approached all tasks. It also helped ensure that all the related business processes which the content library was procured to support were consistently reflected upon and referred to through the development process.

Another challenge faced was in reviewing the appropriateness of the developed standard. To ensure fresh perspectives were incorporated, a total of six individual users outside of the project team were consulted. Having reviewed the initial 35 attributes proposed, all six remarked that the list was "too long" and included attributes which they (individually and their respective disciplines) would not use. However, when asked to specify their preferred attributes, all selected

attributes from within the list and no new attribute was included thus confirming the comprehensiveness of the standard. Thus, the problem as they saw it was not as much the standard not being reflective of their needs but that as it also reflected the needs of other staff outside of their business streams, it appeared to be much broader than they anticipated. Also significant was that as the six individuals belonged to different business streams there were variations in their selections with some arguing for the importance of certain attributes to support their tasks and others seeing those attributes to be unimportant. The core 20 attributes to form the tier one attributes were generally accepted by the reviewers as being sufficient, with the understanding that with the maturity of the system, these could be expanded to include the other 15 attributes that make up the standard.

While the review described above helped to refine the attributes and ensure its appropriateness, there was still a need to test whether or not the attributes and the standard developed actually added value to end users when the system was fully deployed. This implementation process involving rolling out the software to the organisation is currently on going. Thus testing the appropriateness of the developed standard is to be carried out as part of the next phase of the research. As the aim of using metadata was to primarily facilitate information retrieval, the appropriateness of whether the standard is 'good' or not will be measured by whether:

1. Content is more easily retrieved from the system which uses the attributes (as compared to a system without the attributes);
2. Content is better organised in the system which uses the attributes than in a system without it; and
3. The metadata were truly reflective of the needs of the end user community? i.e. are these the right attributes? Are there any attributes required which are not captured?

8 LIMITATIONS OF THE STUDY

The focused cased study methodology adopted here enabled the exercise to be carried out in detail. However, it implies that the conclusions from this work while contributing to knowledge cannot be at this point generalised. Further research will need to be carried out along with other case studies to test the viability of the findings and the robustness of the framework in various contexts. The project and the metadata standards presented here are currently being implemented within the content management system therefore the findings of this study do not include a practical assessment of the actual implementation of the standard, the user response to this and its impact on information retrieval within the organisation. While validation was carried out with some end users, a practical assessment of the standard after its full implementation will be required to further validate the findings and the steps proposed. Also not assessed here is the impact the implementation process may have on the guide proposed.

The researcher and indeed the project team were constrained by limited resources and therefore unable to engage with a larger sample of users for the validation of the attributes, hence only six users were consulted. It is anticipated that a survey will be built into the system when launched to capture user feedback so as to improve the standard as part of the long term governance approach. As also explained, a workshop was conducted with the project team to review the outcome of the project. While this ensured collective perspectives were discussed then captured, it also served to limit the identification of individual problems, concerns and issues faced by each of the user representatives. In the future, these would perhaps be better captured via unstructured interviews.

9 CONCLUSION

This paper presented a case study in which a metadata standard for a proposed multi-media library was designed with the detailed processes undergone. The three tasks i.e. desk study,

review of existing standards and the workshop were explained along with their detailed findings. The resultant metadata standard developed was then presented with details of all the analysis carried out. Specific lessons learnt through the whole process were clearly outlined culminating with a proposed step by step guide for how organisations can develop similar metadata standards. As well as the case study presented, the findings add to knowledge by defining how the process of metadata creation can be more systematic. Other organisations looking to embark on similar endeavours can find within this study lessons to guide them through the process.

By exploring alternative approaches to developing metadata standards this study also addresses the question of what an appropriate starting point is in developing a metadata standard. The strong similarities between the baseline developed and the ISO 15836:2009 standard showed that using such standards would be a suitable starting point upon which to build an appropriate standard. Similarly the findings support the thesis that no specific standard is comprehensive enough to meet the needs of an organisation without appropriate levels of customisation. Such customisation should be built entirely around user needs and the processes which the solution is designed to support. While this exercise focused on multi-media content, it is anticipated that within company A it will be used to develop a wider metadata standard for all unstructured content (i.e. documents, drawings, models, simulations etc) to ensure consistency. Further research is needed to test and determine the practicality and suitability of the proposed guide for use by other companies within and outside the construction industry and also for managing other types of content beyond multimedia files.

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APPENDIX 2 DEVELOPING FACETS FOR FACETTED SEARCH (PAPER 4)

Full Reference:

Sheriff A, Bouchlaghem D, EL-Hamalawi A and Yeomans S.G. (2010), Developing Facets for Facetted Search, in Proceedings of the 6TH International Conference on Innovation in Architecture, Engineering and Construction, June 9 -11, Pennsylvania, USA.

Abstract:

For an organisation looking to implement a metadata based facetted search solution, a problem arises in identifying the right metadata attributes to be used as suitable facets to meet the needs of the end user community. This research presents a case study in which a metadata based facetted search solution was developed for a multi-disciplinary construction industry based organisation using the literary warrant approach. A review was first conducted of seven existing international standards to establish a baseline of suitable metadata attributes. This was then built into an online questionnaire capturing the requirements of the broad end user community. To further contextualise the findings, a detailed case study was then conducted into the file and folder naming patterns of a target group within the company. The collective outcomes were analysed from which six attributes were proposed to be adopted as facets. The findings show that particularly in multidisciplinary organisations, a basket of attributes tailored to the needs of each discipline may be more suitable than a single standard for facetted search adopted across the organisation. It also shows that indeed even within uncontrolled content management environments, there is a strong correlation between the file naming patterns of individuals and their respective search preferences, thus analysis user file naming patterns can be a useful basis for identifying and selecting the most appropriate facets to be used for facetted search.

Keywords:
Facetted Search; Information management; Information retrieval; Metadata

Paper type:
Conference Paper

1 INTRODUCTION

Obtaining business value from information requires organisations to successfully search, find, assemble, analyse, use and re-use content to support core business processes (Evgeniou and Cartwright, 2005). In pursuit of such strategic value, effective information retrieval has emerged as a significant need in organisations, particularly where enterprise wide information management repositories are in use. A significant component of any such information retrieval system is metadata. Metadata are additional pieces of data or attributes which describe the context and structure of a piece of content, document or any bit of information and its management through time (ISO 15489: 2001). The use of Metadata within a content/document library allows information to be more easily found, its source determined and its context understood, thus easing interpretation and enabling re-use (Rockley 2003; NISO, 2004; Paganelli et al, 2006). While metadata can enhance information retrieval, a simple search based solution often results in the retrieval of large data sets, not easily navigable by end users. Hence, an alternative approach adopted for organising information is via the use of taxonomies. A taxonomy is the logical structuring or classification of content hierarchically based on predefined rules (Munkvold et al, 2003; EEDO, 2006). Heinrichs et al (2005) argued that while taxonomies can be beneficial for organisations, the use of a central fixed classification scheme often becomes restrictive, belying the multidimensional nature of content, its subject matter and its users. Thus rather than a one dimensional taxonomy, the multi-dimensional perspectives metadata provides can be used to structure content in multiple ways enabling large data sets to be clustered around similar subject themes (Munkvold et al, 2003). This approach to the use of metadata is referred to as 'facetted classification'.

Facets are orthogonal categories of metadata used to characterise content (Hearst, 2006; Yee et al, 2003). Each facet represents one dimension of a piece of content, but in combination, multiple facets show several dimensions, thus reflecting a broad range of user perspectives (Giess et al, 2008: Tevan et al, 2008). The evolution of faceted classification is most associated with S. R. Ranganathan who proposed the colon classification. Rather than single dimensional classifications, he argued that subjects can be viewed and classified from five intrinsic perspectives, i.e. *Personality, Matter, Energy, Space* and *Time* (Ranganathan, 1969). Further extensive work has since been carried out expanding, modifying and refining these five dimensions, a comprehensive account of which has been documented by Broughton (2007) and Giess et al (2008). The application of facets to organise search results is referred to as 'facetted search'. This combines the strengths of both free text search and hierarchical navigation, and is being adopted with increasing popularity and dependability, particularly in library databases and e-commerce websites (Hearst 2006; Broughton and Slavic 2007; Ben-Yitzhak et al, 2008; Tevan et al, 2008).

A large number of attributes can be deployed as metadata in content libraries and any such metadata category can be used as a facet in facetted search. Thus, for an organisation looking to implement a metadata based facetted search solution, a significant problem is identifying the right metadata attributes to be used as suitable facets meeting the needs of the end user community. This paper presents the outcome of a study to define suitable attributes for a proposed metadata based faceted search solution to support information retrieval within a case study organisation. The objectives were:

1. To review existing standards and develop a baseline set of metadata attributes to be used across the company for search;
2. To investigate the relationship between metadata preferences and individual file naming patterns; and
3. To identify which of those attributes users will find most suitable for use as facets

The metadata explored here are descriptive metadata that reflect the context of the content and not detailed technical subject metadata. For anonymity, the case company involved in this research will be referred to as company A. Company A is an international construction industry based engineering design consultancy employing circa 1700 staff in over 25 offices across the world. Acknowledging that being able to retrieve information is key to facilitating effective and efficient project delivery, the company is looking to implement an enterprise search capability to enable unstructured content within all its federated network drives across all offices to be searched from within a single environment. The network drives are currently ungoverned and rely on users to name files and structure folders appropriately.

2 METHODOLOGY

The research was divided into two tasks. The first focused on establishing the metadata baseline, while the latter focused on exploring the relationship between individual file naming patterns and search preferences.

To execute task one, first a review was conducted of some existing international standards to identify common attributes from which a baseline could be established. A total of seven standards were reviewed, selected on the basis of their acceptance as international standards and their applicability to the construction industry. Attributes occurring in at least four of the standards were selected. A further refinement was then carried out in which a number of additional attributes, not reflected in the baseline, were added. These were obtained either from the BS1192:2007 standard; or metadata already extensively used across the company to which most users were already familiar. This was then developed into an online questionnaire built into the corporate intranet and distributed across the sample group. The questionnaire was designed and deployed as part of a larger case study to audit information management practices of Company A, and develop consistent metadata standard for use across the organisation. Only the findings with respect to facetted search are discussed in this paper. The target sample size was 800, representing just under half the total number of employees across the company (due to logistic and resource constraints, a sample of half the employees was considered adequate). A total of 372 responses were received which in lieu of the sample size, represents a response rate of 46.5%. Multiple responses were permitted for the questions allowing respondents to select as many attributes as they deemed necessary.

A case study method was adopted for task two. Using a warrant approach, a method of classifying content based on identified key concepts, terms and subject matter, multiple project folders from a specific discipline group, i.e. ground Engineering, were investigated. Ground Engineering was selected based on: their willingness to partake in the study; their size (45 experts cutting across the different offices and business regions); and their involvement in multiple large projects spanning over 12 months from inception to completion. The four project folders were analysed using the five steps for creating a faceted scheme as summarised by Giess et al (2008). The researcher did not set out to select only four projects, but observed that a saturation point had been reached. The four folders contained 265, 457, 253 and 359 files respectively of various formats and content types. Thus a total of 1334 files were studied with an average of 333.5 files per project folder. Each attribute in the file/folder name was coded, for example, a file named *061215 planning presentation-compressed.pdf* was encoded thus: *Date* (061215); *activity/task* (Planning); *Content type* (presentation); *Comment* (Compressed). The order of the attributes was considered unimportant, as only the frequency of occurrence was required. In cases where certain attributes were used twice within the same name, only one instance was counted. The results were then aggregated and analysed, the findings of which are outlined below

3 FINDINGS AND RESULTS

3.1 REVIEW OF EXISTING METADATA STANDARDS

To establish the baseline, seven standards were reviewed. Similar comparisons were conducted by Burnet et al (1999) and Paivarinta et al (2002) based on six and 18 standards respectively. As it was intended that this exercise would build on such previous works, care was taken to identify standards not used in their research to avoid repetitions (thus duplicating the results) and ensure new perspectives are accommodated. Thus, as well as the baseline established by Paivarinta et al (2002) the following standards were reviewed:

- *ISO 15836: 2009: Based on the Dublin Core, often referred to as the defacto standard for descriptive metadata;*
- *Visual Resources Association (VRA) Core: A metadata standard for describing images and visual content for the cultural heritage community;*
- *UK E-government Metadata Standards: This lists the elements and refinements used by the UK public sector to create metadata for information resources;*
- *ISO 19115: 2003: An international metadata standard for describing geo-spatial datasets;*
- *BS 1192: 2007: Standard procedures and methods for managing the production, distribution and quality of construction information, with defined processes for collaboration and specified naming procedures;*
- *UK Learning Object Metadata (UKLOM): A standard for the interoperable description of learning objects; and*
- *New Zealand Government Locator Service (NZ-GLS): A standard metadata element set for cross disciplinary information environments in New Zealand.*

Taking into account the other 18 standards already reviewed by Paivarinta et al (2002), it could be said that the baseline developed for this research reflects a secondary review of up to 25 standards. The initial baseline was found to not include specific construction industry attributes suitable to the nature of work carried out in the company. Therefore a second round of refinement was carried out to incorporate these based on the newly established BS1192:2007 and attributes already extensively in use within other systems across the company. To also avoid any ambiguity among potential end users, any metadata attribute currently used across the company which corresponds to an attribute from the above was used to replace it. Thus the final baseline adopted was:

	Attribute	**Source**	**Description**
1	File author	Baseline	An entity primarily responsible for making the content.
2	Job Number	Existing Company Metadata	The unique numerical identifier of the project affiliated with the content
3	File Category	Baseline	The nature or genre of the content.
4	File subject	Baseline	The subject matter upon which the content is based
5	Company	BS 1192	The Company affiliated with or responsible for producing the content.
6	Business region	Existing Company Metadata	The specific company business region in which the office belongs.
7	Office location	Existing Company Metadata	The specific office (of the company) reflected in, affiliated to or primarily responsible for the subject matter reflected in the content.
8	Discipline/group name	BS 1192	The company discipline/group reflected in, affiliated to or primarily responsible for the subject matter reflected in the content
9	Client Name	Existing Company Metadata	The name of the ultimate individual or entity for whom the work is being carried out.
10	Project Name	BS 1192	The name by which the project is formally known
11	Project sector	Existing Company Metadata	The specific work sector to which the subject matter of the content belongs.

12	Project location	BS 1192	The geographical position of the project associated with the content.
13	Project Value	Existing Company Metadata	The value in fees paid of the project affiliated with the image
14	Zone	BS 1192	The area or identified zone within a construction site upon which the document/content is based.
15	Level	BS 1192	The floor level on a construction project upon which the document/content is based
16	Version/revision	Baseline	The current state of the content reflected by the number of alterations carried out.
17	Format	Baseline	The digital manifestation of the content
18	Date created	Baseline	Date in which the content was created
19	Status	Baseline	The current descriptive state of the project defined by clear stages
20	Description of file content	Baseline	A short description of the subject matter within the content/document

Table 1: The baseline attributes identified and selected

These were then built into the online questionnaire, the findings of which are presented below.

3.2 QUESTIONNAIRE SURVEY RESULTS

Attributes required for search

From the questionnaire, users were asked which of the attributes on the list they would require for search. As Figure 1 shows, not all attributes were selected, with some significant variations immediately apparent. Job number was selected as the most used attribute reflecting the fact that being a project based company, most unstructured content created in company A will be directly or indirectly related to servicing the needs of projects. Date created, project name and file subject also feature prominently. The data also shows that the top nine metadata out of a total of 22 account for 75% of user's needs across the sample. These top nine facets are: *Job number; Date created; Project name; File subject; Format; Description of file content; File author; File category; and Discipline/region*

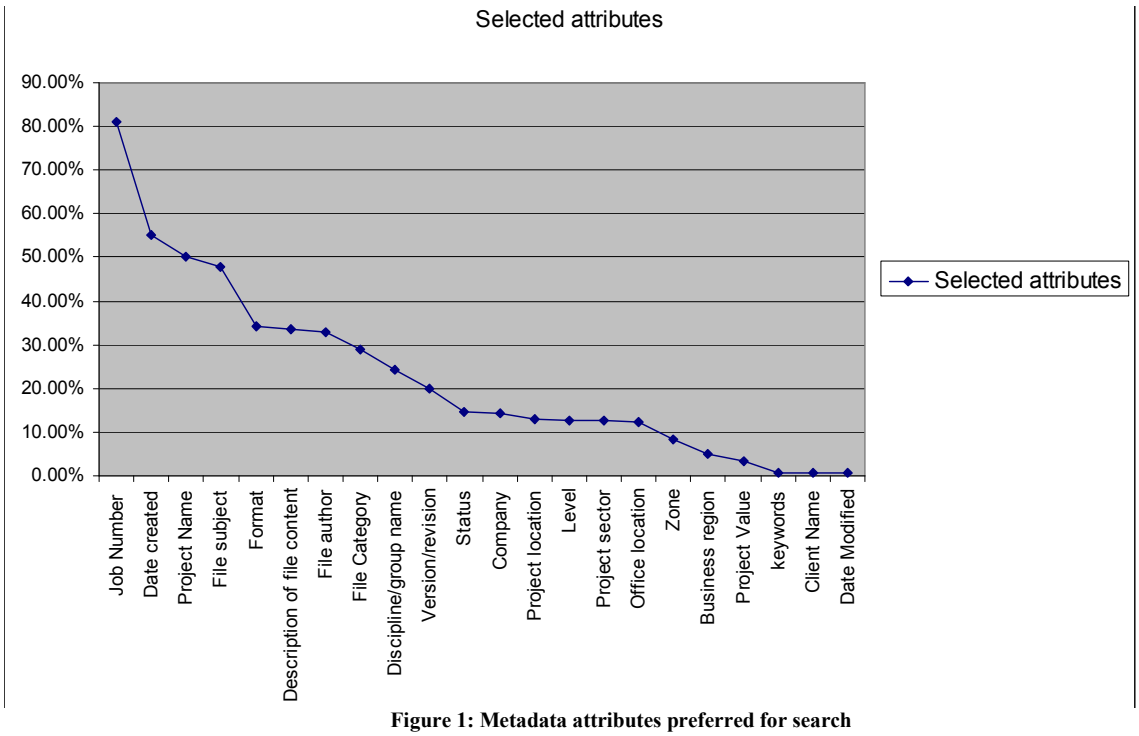

Figure 1: Metadata attributes preferred for search

'Description of file content' is a multiline narrative of the subject matter of the content and therefore unlike the others cannot be used as a facet. Thus by selecting the top 75% of responses, this reduces the total number of facets to a possible 8 out of 22, suggesting that while all the metadata proposed in this baseline may be used for a company wide metadata standard, only eight facets are required to form the basis of a core facetted system acceptable to all. It was also found that no user selected only one attribute to search with, as the average number of attributes selected was five. To further test the validity of the findings above and investigate the correlation between personal naming habits and search preferences, the current file naming patterns of a case study group within company A were studied. The findings of which are presented below:

3.3 METADATA USED FOR NAMING FOLDERS AND FILES

From the analysis conducted of the personal naming habits of the case study group across 4 projects (as described in section 2 above), a total of 25 attributes were found to be in use. While there were commonalities across all four project folders, certain key variations emerged with some attributes used a lot in some projects while not applied at all in others. The table below outlines the attributes and the frequency of their occurrence.

Metadata	**Folder 1**	**Folder 2**	**Folder 3**	**Folder 4**
	Frequency	Frequency	Frequency	Frequency
Subject	216	337	214	264
Content type	98	174	144	147
Date	116	203	85	80
Job Number	125	102	70	74
Author	89	84	55	49
Activity	28	73	42	89
Revision	52	77	23	75
Group	46	16	41	10
Status	21	44	27	10
Project name	11	23	22	31
Company	5	38	15	7
Sub-job (Building name)	2	9	0	28
Comment	1	7	8	17
Identifier	0	16	0	15
Page no	0	24	0	0
Drawing No	0	9	0	15
Recipient	11	7	0	0
Reviewer	1	3	3	5
Material	0	10	0	0
Work stage	1	2	1	5
Issue no	0	0	0	8
Drawing Info	0	0	6	0
Zone	1	0	0	0
Level	1	0	0	0
Date modified	1	0	0	0

Table 2: Metadata findings from the respective folders

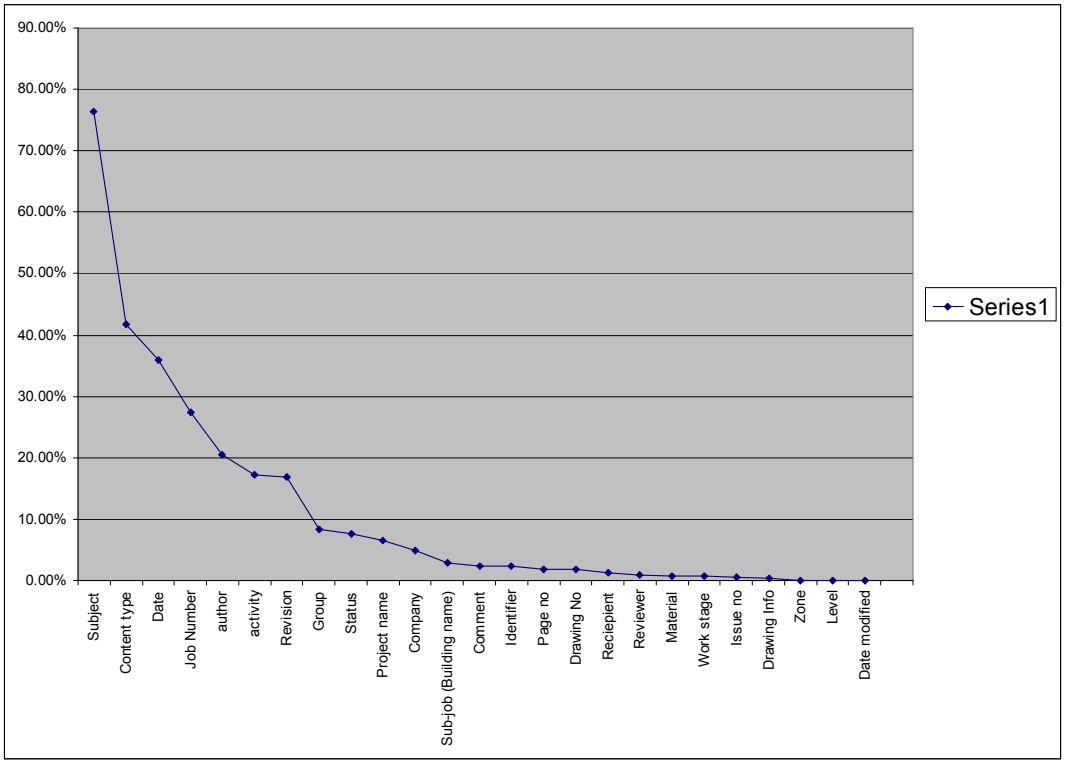

Figure 2: Based on the averages from all 4 folders

While a total of 25 attributes were used, no single project folder had more than 20 attributes, with the total in each being 19, 20, 15 and 18 respectively. Also significant was that only 14 of the 25 attributes were used in all four projects, with significant variations in the deployment and use of the other 9 attributes across them. For example, Page no was used up to 24 times within folder 2 but not at all in the other 3 folders. This suggests that while there may be a strong cross project correlation in the use of certain attributes, project specific requirements can drive the adoption of others. The average (based on the number of occurrences) was taken across the 4 project folders as reflected in Figure 2 above. Thus the top eight metadata attributes used across the four folders were: *Subject; Content Type; Date; Job Number; Author; Activity/task; Revision; Status.* These account for over 85% of the metadata used and thus can be considered the core attributes cutting across the projects. It was also observed that these were rarely used in isolation but mostly supplemented with some other attribute from the other 17. On average (across all 4 folders), each file contained seven attributes.

3.4 COMPARISON OF FINDINGS

A comparison was then conducted to assess the similarities and differences between the top 8 attributes identified in both exercises, presented in table 3 below.

	From Project folders		From Survey on search	
1	Subject	Match	Job number	Match
2	Content type	Match	Date created	Match
3	Date	Match	Project name	
4	Job Number	Match	File subject	Match
5	Author	Match	Format	
6	Activity/process		File author	Match
7	Revision		File category	Match
8	Group/discipline	Match	Discipline/group	Match

Table 3: Comparison between findings from the folder mapping and the survey responses

Six of the top eight attributes preferred for search (established from the survey) matched the top eight metadata currently used for naming files and folders. Format is an automatic attribute which would have occurred on each file and therefore was not counted for task 2 (but included in the survey). Based on the strong correlations established from this study, the following 6 attributes were proposed as the core facets for Company A, representing the preferences of over 80% of respondents: *Subject; Content type; Date; Job Number; Author; Discipline.* A further option was provided to expand this core list to include: *Format; Project name; Revision/version; and Activity/process*.

4 DISCUSSION

A total of 30 disciplines across Company A partook in the survey. Analysis conducted on the survey data showed that the top facets did not vary significantly across disciplines. Aside the top nine facets however, there were distinct variations as certain disciplines preferred certain attributes to others. For example, respondents from the business development group all selected 'business region', while not selecting others such as 'Zone' and 'level'. This suggests that the specific role of the individual within the company and their respective information needs impact on their choices and the attributes they considered relevant for search. Similarly observed from task two is that only 14 of the 25 attributes were used across all four projects. The use of the other 11 attributes varied considerably across the project folders showing that despite some levels of consistency, project specific requirements will influence the use of certain additional attributes over others. This shows that prescribing a single metadata standard for facetted search applicable to all content across the company irrespective of discipline or project is neither a desirable nor indeed practical solution. A more practical approach recommended to Company A is to provide a standard basket of metadata attributes, based on an agreed list from which disciplines pick and choose the attributes most appropriate to them, and then apply appropriately. This is also consistent with the findings of Bowker and Star (1999) and reflects the subjectivity of individual perspectives and content requirements in information classification. The list of acceptable metadata attributes however must be standardised companywide, not compromising consistency.

The similarities in the outcome of both studies confirm that within this case study group there is a strong correlation between the way individuals tagged and managed their files (the attributes from the project folders) and the way they wanted to search for them (from the survey), as individuals will name/tag their files and folders in the way that best helps them retrieve it. The extensive preference for certain attributes over others in both studies also show that even where extensive metadata standards are deployed within organisations, not all the attributes deployed and used would equally be required to form facets for facetted search. Hence this research demonstrates that for organisations looking to identify suitable facets for facetted search, a significant starting point would be to study filing patterns in existing repositories to establish the preferences of the target user community. Thus with 80% of users in company A relying on 20% of the attributes, identifying those key attributes as was done here, will help to ensure that facets deployed are applicable and contextual to the needs of the end user community. The core facets proposed and the recommendations put forth are currently being implemented within company A, to drive a stepped change in information retrieval.

5 CONCLUSION AND AREAS FOR FURTHER RESEARCH

This paper presents a case study in which a metadata based facetted search solution was developed to support information retrieval in company A. The findings show that in a

multidisciplinary organisation such as company A, a basket of attributes tailored to the needs of each discipline may be more suitable than a single standard for facetted search adopted across the organisation. It also shows that even within uncontrolled content management environments, there is a strong correlation between the file naming patterns of individuals and their respective search preferences. Thus analysing end user file naming patterns can be a suitable basis for identifying the most appropriate facets for use in facetted search.

It is important to recognise the limitations of this research. The findings while proving insightful cannot be easily generalised due to the limited sample size. Also, the nature of the work, the content types produced and the type of files studied in task two (and used to validate task one) reflect those of the ground engineering group, which may vary from the nature of the work carried out by other groups within company A and other similar construction industry based organisations. Thus further research will need to be carried out to ascertain if the patterns established are replicated on a broader scale. The findings are also currently being implemented within company A, built into a wider enterprise search program. Further research will then be carried out to further test the validity of the recommendations put forth and to test if the facets proposed did indeed match actual user preferences and result in improved information retrieval.

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APPENDIX 3 DEVELOPING A CORPORATE INFORMATION ARCHITECTURE (PAPER 5)

Full Reference:

Sheriff A, Bouchlaghem D and EL-Hamalawi A (2010), Developing a Corporate Information Architecture, in *Proceedings of the 10th International Conference of Computing in Civil and Building Engineering*, June 30th – July 2nd, Nottingham, UK.

Abstract:

Information architecture is the design of shared information environments to enable the creation, production, sharing, management, assembly, packaging and delivery of information products. This paper presents a case study in which the information architecture was developed for a group to improve the efficiency of its core business processes, facilitate greater collaborative working and reduce the risk of information loss, based on a 'client's information' paradigm. First, a review was conducted of the group to understanding its business and therefore what the best solutions would be to complement it. A series of interviews were then conducted with six staff of the key business streams to understand their tasks, problems faced, existing work flows for activities and any future requirements. The existing filing structures within the current information repositories were then studied to clearly understand the state of affairs and identify any inherent patterns. The results were then analysed, from which a standard information architecture supporting core organisational processes was proposed and implemented. The outcome shows that indeed a technology agnostic 'client's information' paradigm can be adopted for designing effective information architecture.

Key words:
Information Architecture; Taxonomy; Metadata; Information Management

1 INTRODUCTION

Information is the essential medium through which knowledge, expertise and judgement held by individuals and organisations is expressed, captured and shared (Davenport and Marchand, 2000). In the knowledge economy, this knowledge and expertise is applied to specific problems to obtain solutions, then compiled, packaged and delivered to clients as information products for a fee (Evgeniou and Cartwright, 2005). In ensuring that this process is carried out effectively within organisations, there is a need for an information architecture based upon which information products stored in repositories can be structured intuitively.

Information architecture is the set of principles guiding the organisation, labelling, navigation and searching of information within repositories to enable its management and retrieval (Dong and Agogino, 2001; Dilson, 2002). Earliest approaches to information architecture were focused on the individual and improving the way his/her information is managed or tagged (McGregor, 2005; Wang et al, 2007). The focus then shifted to collaborative working, and collective sharing of information either by various individuals within the same group or across groups (Yeomans, 2005). Collaborative working shifted the focal point from 'my information' to 'our information' with emphasis on greater integration and alignment of processes and tasks across individuals and groups (Chaudhry and Goh, 2005; Morville and Rosenfield, 2006; Wang et al 2007). In this vein, Dong and Agogino (2001) also presented a case study in which the information architecture was created for an institutional digital library. Missing is an appreciation of the role and needs of the client as the final customer to whom the information products are delivered.

A further shift is therefore required to move from the 'our information' paradigm of collaborative working to 'the client's information', where the focal point is the information delivered to the client. This is then matched with the appropriate processes, procedures and workflows to make the creation, management, production, sharing and packaging of the information to be carried out in the most effective manner, aligned to the core business strategies of the organisation(s) involved. This approach requires an understanding of the customer's value proposition (what products does the customer want?); the value stream (what tasks need to be carried out to deliver the product?); and the value chain (who are involved in creating and delivering the product?) in line with lean principles (Womack and Jones 2003). Can such a paradigm be used to improve the information architecture of a group or an organisation?

This paper presents a case study in which a 'client's information' approach for structuring information was employed for a case study group to improve the efficiency of their business processes, facilitate greater collaborative working across the group and reduce the risk of information loss. It begins by introducing the group; the specific activities carried out; the problems identified and the solution developed. It then concludes with a review of the project presenting the outcomes and limitations of the work, and some areas for future improvement. The case study group is a management consulting group offering integrated strategic solutions for the built environment. Founded in 2001, the group employs 27 full time staff and is part of a larger UK based multi disciplinary engineering design consultancy with 1800 employees. In its early days, due to its smaller size, there seemed to be no apparent need for robust structures for managing information. However with its continued expansion, this is deemed necessary, indeed crucial for its operations and the delivery of its increasingly international projects.

2 METHODOLOGY

A contextual design method was employed for this research in line with the principles outlined by Hotzblatt et al (2005). An initial meeting was held with the project board, comprising of staff from the group led by the project sponsor. A review of existing documents about the group, its structure, the nature of projects delivered, its inherent business processes, its business strategy,

its target clients and markets of specialisation, was then conducted all with a view to understand 'its business' and therefore what the best solutions would be to complement its chosen methods of operation and help it achieve its goals. A total of six members of staff were then interviewed across five business streams, to establish: what they do (tasks); How they do it (Processes); what information they need to get their work done; what problems they currently face in information management; how they will like to see information managed in the future.

To further complement these, the filing structure within its existing information repositories were also studied to clearly understand the state of affairs and identify any inherent patterns. The outcomes of all the above exercises were then analysed. Developing the solution was an iterative process involving the project team, and the periodic input of the head of collaboration and the quality manager from the wider engineering consultancy to which the group belongs. A total of five iterations were undergone. The approved solution was then presented to representatives of the group and to the project sponsor who confirmed that indeed the outcome was appropriate for their needs, thus concluding the project. Details of the findings and the solution developed are outlined below.

3 FINDINGS

3.1 CORE BUSINESS PROCESSES

Principally, the groups' business processes can be grouped in to two, i.e. Project work; and Group Management/Business Development. Project work relates to all the activities directly associated with bidding for, servicing the needs of or delivering a project. Being a project based organisation, this constitutes the primary activity and revenue stream of the group. The specific activities carried out for each project are inherently bespoke, varying based on the project requirements and the specific needs of the client. Key deliverables to clients throughout the project lifecycle are mainly presentations, reports, visualisations (including movies), etc of various technical themes. Group management/business development consists of the day to day tasks required to effectively manage and run the operations of the group. The areas of focus here are internal processes including resourcing, marketing, learning and development, internal meetings, etc.

Electronic information is stored within 2 principal repositories, a SharePoint site under the company wide intranet and a local network server specific to the group called 'Aslan'. Aslan is the most used platform, with most documents for both projects and group management/business development stored here. It provides quick easy access to all documents within a familiar windows style environment. The SharePoint site is fairly new and is yet to be fully adopted within the group. On an ad hoc basis, usually only to meet a specific need on a given project, 3rd party extranets are used. But these are mainly as conduits for information exchange and are most often decommissioned on completion of the project with all its data transferred back into Aslan.

3.2 IDENTIFIED PROBLEM AREAS

From the interviews and the analysis conducted, some problems identified requiring solutions include:

- There was no established or articulated procedure and filing structure for either project work or internal group management activities.
- Filing patterns on projects were entirely defined by the individual, making group working very difficult

- There was excessive duplication of information with often multiple versions of the same file present in multiple locations within the same project folder.
- There was insufficient quality control built into their procedures and/or systems potentially exposing the group to significant risks including the loss of information, or using incorrect information on a project.
- Auditing of projects are difficult to perform.
- Effective co-ordination of information exchange on projects was difficult.
- For individuals, finding and retrieving the right information required to their job at the right time was deemed 'very difficult'.
- In putting together the 'information products' delivered to the client, there was little understanding from individuals of the wider needs of other individuals along the information supply chain

4 DEVELOPING THE SOLUTION

A solution was proposed based on the following principles, in line with the client information paradigm adopted for this research. These principles were agreed upon by the project team

- The focus of the entire information management process should be on the information product being delivered to the client. The value proposition therefore must tend towards producing 'what the client wants' in the most efficient and effective manner.
- Any proposed structure will be 'process driven' based on the workflow of the project delivery process and integrate all the individual groups.
- Files will be structured in a consistent hierarchical manner within folders, based on the task being carried out and the information products associated with those tasks. This will integrate the team around the tasks.
- A move will be made where-ever possible away from folders to the use of metadata. Hence while the overall structure for folders will be task based, metadata will be used to further structure the files.

4.1 BUILDING THE FOLDER STRUCTURE

Six interconnected yet independent filing streams were required for the group as illustrated in figure one below.

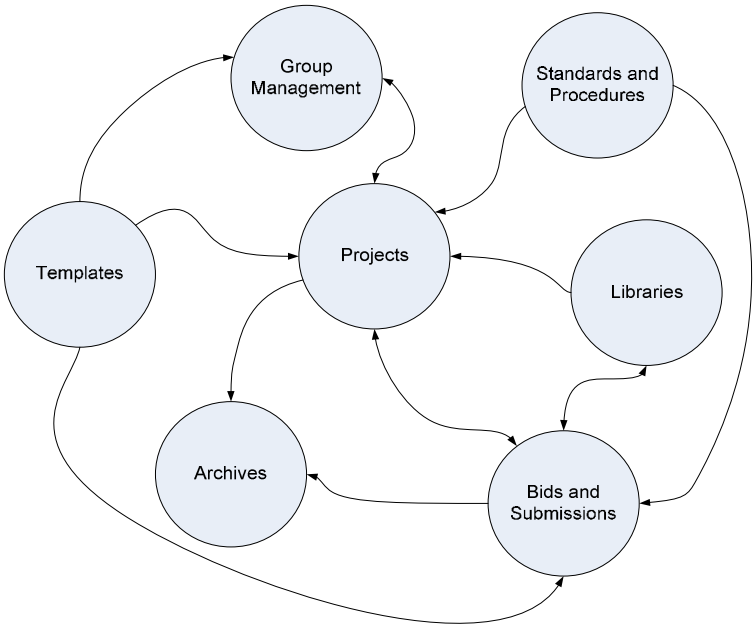

Figure 1 - Relationship between the 6 filing streams

- **Group management:** In which will be stored all content associated with managing the day to day affairs of the group organised according to the tasks being carried out. This complements the project filing and the templates stream;
- **Bids and Submissions:** In which will be stored all content for prospective projects. Successful bids become confirmed projects and are then transferred to the project filing stream. This stream complements the library, project filing and archive streams;
- **Project filing:** In which will be stored all content created for a project. This being the core of all the groups' content is complement by and complements all the other streams;
- **Library:** In which will be stored tacit knowledge, exemplar material, etc which all group members (across projects) will draw from to improve their competencies and share their learning. This complements and is complemented by the Project filing stream and the bids and submissions stream;
- **Procedures and guidelines:** In which will be stored all guidelines for tasks carried out across the group related to both projects and non-projects. Similarly, this complements the project filing stream and the bids/submissions stream;
- **Templates:** In which will be stored generic templates for standard content type produced by the group, which individuals can build on and tailor to meet their specific needs. This complements the group management, project filing and bids/submissions streams; and
- **Archives:** In which will be stored all non current content from the above filing streams, no longer deemed to be in active use or applicable, but holds value and should therefore not be deleted. This is complemented by the project filing and bids/submission stream.

In developing the project filing stream, the researcher began by mapping out the groups' end to end process of delivering a project from inception to archiving (excluding the bidding and submission stage, as this was unnecessary for this stream). These were then matched with the tasks carried out and the individuals responsible for each task. This analysis was carried out in line with best practice for information management, particularly the BS1192: 2007. Figure 3 above shows the workflow and its adaptation into a standard folder structure for use on the Aslan Server.

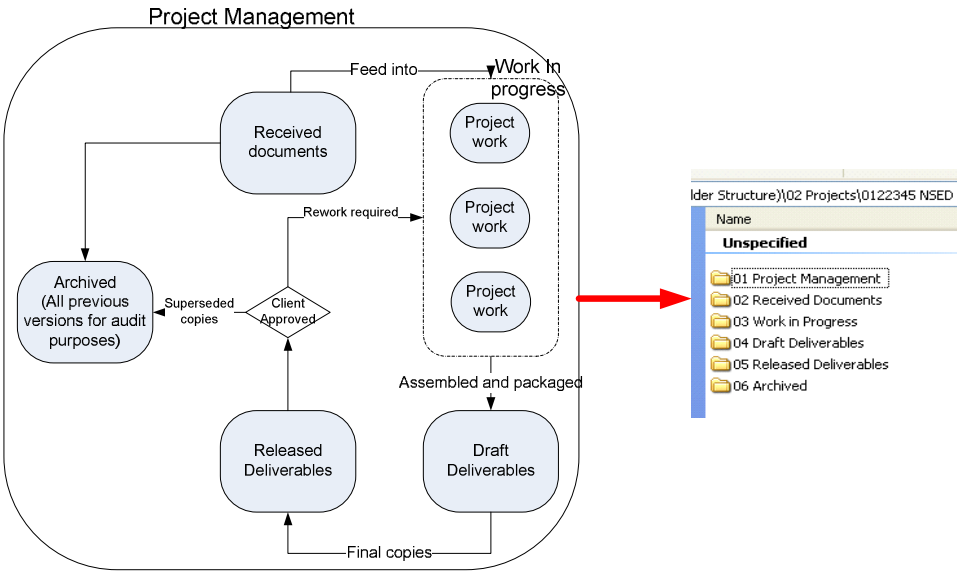

Figure 2 - The project filing workflow with the proposed folder structure

The project management folder will contain all documents that define the project or are required for managing it including the scope of works, project plan, invoices, schedule of work, etc. The received documents folder will contain all information received from the client and external parties through the life cycle of the project. Work in progress is the knowledge workshop environment where files are being worked on and thus not deemed ready to be either shared with

the client or released to be compiled into a report. This folder is further broken down based on the individual tasks being carried out across all the discipline streams. Work deemed to be good enough and signed off is then moved to the draft deliverables folder where the information product will be packaged by the graphics team. Here, the outputs from all teams are aggregated, merged with graphic material (images, sketches, etc) and developed into comprehensive reports. This is where the final product for the client is being created. The file formats at this stage are large open graphic files (e.g. In-design documents, quark documents, etc). When the product is approved and released, closed PDF equivalents of these are then placed in the released deliverables folder to keep a constant record of the most current deliverable released to the client. As the workflow in figure 2 suggests, modifications and alterations are common by clients through the project lifecycle. For each such corrected deliverable sent out to the client, the previous issue is then moved to the archives folder. The overall structure provides a near automatic audit trail through the whole life cycle of the project.

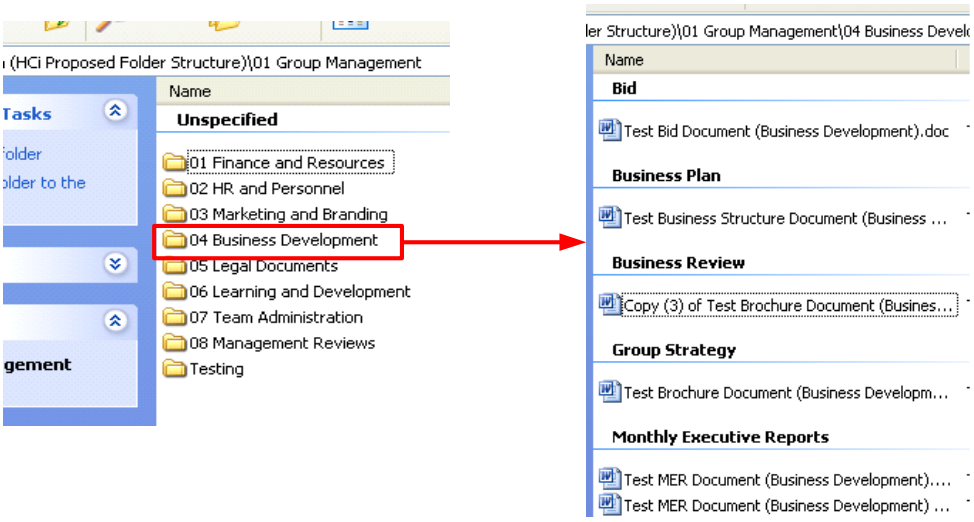

Figure 3 - The folder structure and metadata in the group management folder

The group management folder was similarly structured to reflect the tasks carried out by the internal business development team. Within each folder, metadata was used to arrange the files around the information products or content types deemed to be the respective outputs of the tasks, as shown in figure three below.

5 REVIEW OF PROJECT OUTCOME

Upon implementation, the project group was interviewed to review the outcome with the following positive highlights identified:

- The strong alignment between work procedures and information management methodology creates a sense of familiarity for the users.
- The task based information architecture ensures all information produced in relation to a given task is aggregated in a single environment, aiding retrieval and auditing
- The architecture developed was described by the interviewees as “practical” and “intuitive” with no “apparent complications”.
- The task based arrangements allows for scalability, capable of accommodating new tasks without fundamentally distorting the structure.
- Workflow and task based information management allows for in built quality control, in line with the company’s quality management standards.

Despite these, a few limitations were identified. These include:

- No clear measurements were taken prior to commencing the project, such as the time taken to retrieve data; level of dissatisfaction with existing system; or time wasted in not

finding the right information, making it difficult to quantify the impact of the proposed solution.

- The focus on using only the existing technologies meant that more suitable document management solutions were not investigated. Thus, Aslan the existing server was still used to implement the solution.
- Due to technological limitations, budget constraints and other similar factors, the focus was restricted to workflow improvement and developing a folder structure and not the entire information management process/structure such as standardised content types, automated workflows, Knowledge Management, etc which the group could have benefitted from
- There was no high level sponsor for this project within the group to protect its outcome, drive its comprehensive implementation and ensure its persistent use across the group.
- No continuous improvement plan was developed to continuously refine the outcome of the project beyond the 1st implementation stage

6 CONCLUSION

This paper presents the outcome of a project to develop the information architecture for a group within an international engineering design consultancy, demonstrating that a 'client's information' paradigm can be used to developing information architecture. This was achieved by re-engineering the group's information management process to reflect the core workflow for project delivery, and incorporating the use of metadata. Most importantly, this report adds to knowledge by demonstrating how customer focused information architecture was developed for a group in line with its market focus and business strategy. Despite its successful outcome, there are some limitations for which further research is required. The study while comprehensive in its approach is based on a small group with a singular strategic focus all located within a single office. It remains unclear if this impacted on the outcome and what the nature of that impact is. Thus further investigation is required to determine the scalability of the proposed solutions to other larger more geographically displaced groups. Also, the proposed architecture was tested and found suitable for use only on the existing server. Further research is required to investigate its performance when adopted for use in more sophisticated extranets and document management solutions. The impact of the solution also needs to be measured to quantify its actual effect in improving information management and project delivery in the group. The delivery of the project as described above is merely the 1st step; training and change management are still needed to ease the transition of staff into this new way of working to ensure it remains sustainable and suitable to the long term needs of the group.

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APPENDIX 4 INFORMATION MANAGEMENT IN CONSTRUCTION ORGANISATIONS (PAPER 6)

Full Reference:

Sheriff, A., Bouchlaghem, D., EL-Hamalawi, A. and Yeomans, S.G. (Under review). Information Management in Construction Organisations – Drivers, Barriers and Constraining Factors. Submitted to *ASCE Journal of Management in Engineering*.

Abstract:

The urge to improve collaborative working, knowledge sharing and operational effectiveness has made effective Information Management a growing priority for organisations in the Construction Industry. While significant research has been carried out in the construction industry on project Information Management, limited work has been carried out to understand Information Management from an organisational paradigm. This paper presents the findings of an investigation into the nature of Information Management within consulting organisations in the UK Construction Industry. Interviews were conducted with experts across nine large architectural and multidisciplinary consultancies, the outputs of which were analysed using thematic analysis. From this, 26 themes across three core categories classed as drivers, constraining factors and barriers which shape Information Management practices in construction organisations emerged. The findings show that Information Management is indeed of strategic significance to organisations and an organisational dimension is necessary to better align information needs with an organisation's operational processes. They also show that context dependent factors exist which shape the nature of Information Management in line with the specific needs of each organisation. Therefore, the effectiveness of an organisation's Information Management practices is not absolute, but relative to its level of alignment to the organisation's chosen mode of operation. The findings provide a much needed practical view of the complexities of Information Management, highlighting that particularly within multi-disciplinary organisations; a unifying approach is much more practical and appropriate than a single approach to managing information.

Keywords:
Information Management; Content Management; Document Management; Information Management Strategy; Strategic Management.

1 INTRODUCTION

Information is the product of the contextual understanding and interpretation of Data. It is the essential medium through which knowledge, expertise, judgement, emotions and decisions held by individuals is expressed, shared and communicated with others (Davenport and Marchand, 2000). Hicks et al (2006) define Information Management (IM) from an organisational perspective to include the activities that support the information lifecycle from creation, representation and maintenance through to communication and reuse. An information intelligent organisation is one which understands the value of information and can successfully search, find, assemble, analyse, use and reuse all forms of information products required for any of its tasks (Evgeniou and Cartwright, 2005). This is particularly important as competitive advantage today makes information a core requirement for doing business, improving organisational performance and obtaining operational efficiency (Christian, 2002; Chaffey & Wood, 2004; Hicks et al, 2002; Hicks et al, 2006; Laundon & Laundon, 2009). Being information intelligent requires a more strategic view of information as a corporate asset, aligning the information needs of the organisation to its business processes (Buchanan and Gibb, 1998; Brigl et al, 2005). It requires a fundamental rethink of information, its position within the organisation and its potency as a means of securing long term competitive advantage. It also requires information to be viewed in a holistic manner balancing an appreciation of technologies with the capabilities of people within the business to harness and use the information to improve performance (Marchand, 2000).

2 HOLISTIC APPROACH TO INFORMATION MANAGEMENT

A holistic approach to IM requires the integration of strategies, tools, processes and skills within an organisation to manage all forms of recorded information through its complete lifecycle from creation until deletion supported by necessary technological and administrative infrastructures (Boiko, 2002; Tyrvainen et al, 2002; Nordheim and Paivarinta, 2004; Munkvold et al, 2006; HP, 2007). Such an approach needs an appreciation of how the organisation can best use, structure and exploit information to achieve desired results across its diverse processes (Marchand, 2000; HP, 2007). Numerous technologies do exist which aim to enable this, however critical to the success of a holistic approach is emphasis on corporate wide strategies and policies guiding the use and implementation of the appropriate technology (Paivarinta & Munkvold, 2005). A holistic approach to IM consists of four key components a clear appreciation of which is essential to ensure the approach is contextual, appropriate and implemented effectively to support the organisation (Marchand, 2000; Paivarinta & Munkvold, 2005; Bridges, 2007). These are discussed in more detail by the authors in a previous publication (Sheriff et al, 2008). In brief, the components are:

- **The Content Model**, denoting the nature of the content, its lifecycle, structure, attributes, business applications and its suitability for the organisation. This also includes metadata and taxonomy.
- **The enterprise Model** based on an analysis of the organisation, its distinct operations, culture, partners and supply chain based on their interaction with information through time (also referred to as *process).*
- **Technological** needs to facilitate the implementation of the predefined strategy (also referred to as *technology and systems*).
- **Implementation & Change Management** to manage the transition and support the implementation of the strategy (also referred to as *people*).

Prior to presenting the findings, it is necessary to differentiate between IM and other associated concepts in both research and practice.

2.1 INFORMATION MANAGEMENT AND KNOWLEDGE MANAGEMENT

Hicks et al (2006) explain that significant research has been conducted into Knowledge Management (KM) practices within organisations, particularly explicit KM, as being synonymous or indeed interchangeable with Information Management. Davenport (2000) and Ghani (2009) relate this to KM being a key driver for improving IM. There are a plethora of definitions for KM including those put forth by Webb (1998); Davenport and Prusak 2000; Carrillo and Chinowsky (2006). Robinson et al (2005) define KM as the means through which knowledge (in the broadest sense) is exploited and transformed for organisational use. Its continuous importance is predicated on an increasing appreciation of the strategic significance of knowledge as a competitive resource in a modern knowledge economy (Egbu, 2004). Bishop et al (2009) argue that the breadth of KM includes soft or human components as well as hard or explicit elements. Thus while Knowledge can be explicit codified, shared and exchanged as information products, its scope is much broader than information as not all knowledge can or indeed would require codification. KM should therefore not be synonymous with IM. As similarly observed by Davenport and Marchand (2000), IM can enable KM and is a significant component of it, but does not in itself represent a KM solution. IM also extends to the administration of content through their lifecycle most of which fall outside the scope of KM, even though similar processes, technologies and practices may be employed in both fields. This research considers explicit knowledge as a type of information and therefore a part of IM but the scope of this study and indeed IM in general is inherently different from KM research and practice.

2.2 INFORMATION MANAGEMENT; INFORMATION SYSTEMS AND INFORMATION TECHNOLOGY

Also identified in the literature was the extensive research into Information Systems and technologies including Document Management Systems, as part of Information Management research. The three areas of Information Management (IM), Information Systems (IS) and Information Technology (IT) are frequently used interchangeably further amplifying this apparent lack of clarity (King et al, 1988; Marchand, 2000). For example, Maddison and Darnton (1996) present an approach to aligning Information Management with organisational processes which puts emphasis on IS and IT, neglecting IM. Similar findings are apparent in the works of Craig and Sommerville (2006) and Hicks (2007). The result is a largely technological view of Information Management that excludes the organisational dimension. While all three areas focus on information, the emphasis placed on certain themes make each a distinct field of study with different requirements and focus areas. Marchand (2000) outlines these streams as:

- *IT* is primarily concerned with the infrastructure of the organisation ranging from desktop based infrastructure to servers and networks, with emphasis placed on reliability, responsiveness, flexibility and ease of use of the various technologies;
- *IS* focuses on the applications and database software which perform defined business functions ranging from design, manufacturing and production to accounting, human resource management and other associated processes within the organisation; and
- IM relates to the information required to carry out distinct tasks/processes. It is strategy and process driven aligning with the various business units across the organisations. The emphasis here is on developing a suitable approach to managing and leveraging content to support business processes.

Each stream, with its distinct paradigm emphasises that organisations can choose to gain competitive advantage through technology (IT); software (IS); or information (IM) (King et al, 1988). Inter-relationships and interdependencies do exist between all the above streams.

However, a focus on IT or indeed IS does not imply a focus on IM as neither IT nor IS focus on the content or information which an organisation creates or uses; or the behavioural dimensions of managing information (all of which are the focus of IM). Thus while appreciating the need for and importance of IT and IS, this research focuses on IM.

2.3 INFORMATION MANAGEMENT IN THE CONSTRUCTION INDUSTRY

The Design and Construction process is composed of numerous stakeholders and participants working together as a "temporary enterprise" through a procurement process to develop and implement unique solutions to meet client needs (Caldas, 2003; Craig and Sommerville, 2006). The solutions resulting from this often complex interaction are developed through the creation and continuous exchange of information (Anumba et al, 2008). Due to the critical nature of this information for executing the task at hand, managing it has been identified as crucial to effective project delivery (Bjork 2001; Hicks et al 2002). Construction research into IM focuses on the project environment frequently highlighting the need for improved collaboration and co-ordination between stakeholders (Bjork, 2001; Caldas, 2003; Peansupap and Walker, 2005; Yeomans, 2005). Indeed, strides made in this area have given rise to emergent standards such as the BS1192:2007 standard for collaborative data environments.

While organisations in the Construction Industry primarily work on projects, a merely project centric view does not represent all the information created, shared and managed within organisations, nor does it enable organisations working on multiple projects to manage cross-project information. Neglected are the internal company specific IM challenges posed by increased digitization of corporate information. Managers also lack an understanding of the broader issues around IM, the type of information various people within their organisations need and want, and critically, how to develop and implement a suitable IM strategy to support their respective organisations (Davenport 2000). There exists a need to develop an effective inter project approach to support IM process within organisations. This paper looks presents the findings from a detailed study into IM in construction organisations. The specific methods employed and the findings from the research are presented below.

3 OUTLINE METHODOLOGY

A thorough review of related literature established the state of the art in IM; KM; Content Management; Enterprise Content Management and Document Management. Semi-structured interviews were then carried out with IM experts taken from a sample of organisations within the Construction Industry. As the sample size sought was principally illustrative (in line with a principle of conducting case study research (Yin 2003)), a non probabilistic purposive sampling approach was used to identify a sufficient sample. Twenty five organisations were targeted based on their status as consulting organisations within the Construction Industry; and their size as medium – large consultancies. All companies have headquarters in the UK with all but one having significant international operations. The annual Construction Industry ranking by the *Building Design* magazine (2009) was used to define the initial shortlist. These consisted of architectural firms (14) and multi-disciplinary consultancies (11). Experts within each of these organisations responsible for IM were specifically targeted with email requests, 11 of whom accepted.

In a study of sufficient sample sizes using non probabilistic purposive sampling, Guest et al (2006) found that a sample of twelve was sufficient to establish a stable view of parameters, particularly if the research is aimed at describing perception or behaviour among participants. Similarly, Romney et al (1986) also explain that even a sample of four may be sufficient to

provide an accurate explanation of phenomena so long as these four were experts in their field. In total nine interviews were carried out with Senior Partners (2); Directors (2); Group Knowledge Managers (1); IT Systems professionals (3) and a Senior Business Analyst (1), all of whom were experts responsible for IM and/or KM within their respective organisations. As purposive samples were sought (where participants are selected based on the research criteria) not probabilistic sampling, the sample size was considered sufficient to meet the research objectives. The organisations involved in the research are listed in table eight below (note: the data on the number of employees was taken as of August 2008 when the sample was defined).

	No of Employees	**Global Offices**	**Scope of Operations**	**Additional Notes**
Company 1	800	15	Multidisciplinary Engineering	Now part of a global company with 8500 employees
Company 2	3500	35	Construction Management and Multidisciplinary Engineering Consultancy	
Company 3	10,000	92	Multidisciplinary Engineering; Architecture; Planning and Project Management	
Company 4	3000	30	Multidisciplinary Engineering and Project Management	Now part of a global company with 35,000 employees
Company 5	1000	15	Architecture; Product design and Planning	
Company 6	420	6	Architecture; Project Management and	
Company 7	45	1	Architecture and Planning	
Company 8	2700	69	Consulting Services; Project and Cost Management	
Company 9	14000	150	Management Consulting; Multidisciplinary Engineering and Development consultancy	

Table 1: Organisations Interviewed

Semi-structured interviews were deemed the most appropriate medium of data collection in line with the type of data required and the paradigm adopted. To ensure the questions were clear, unambiguous and appropriate, a three page questionnaire was prepared and piloted with a sample of four individuals within a company similar in context to the sampled companies. This was carried out iteratively until the questionnaire was deemed suitable. All interviews were conducted face to face, each lasting approximately 90 minutes, after which each was transcribed then analysed.

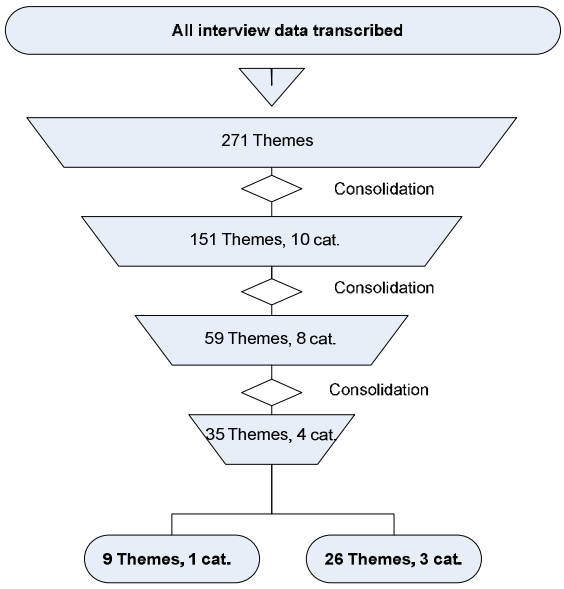

Figure 4: The Data Analysis Process

The analysis was carried out following the thematic analysis process as outlined by Boyatzis (1998). The process required the iterative reading (in detail) of the textual data to identify appropriate themes (the complete process is illustrated in fig. 1 above). From this, an initial list of 271 themes emerged. Based on the definitions of the codes for each theme, a number were observed to be repetitive while several others were inter-related. Further iterative refinements were therefore carried out to aggregate and consolidate these into distinct selective codes. This consolidation process involved combining certain themes and grouping other associated themes together as categories. This initially gave rise to 151 themes across 10 categories and then 59 themes across eight categories. The final consolidation carried out resulted in 35 themes across four core categories all of which define distinct areas of Information Management. No further consolidations were apparent as the categories had become saturated. The four categories are Drivers, Constraining Factors, Barriers and Lessons learnt. Only the findings from the first three categories (a total of 26 themes) are presented in this research. The core variable in this research is organisational Information Management with all the categories and themes aimed at explaining its meaning and its nature within construction organisations. The final 26 themes across the three categories are shown in table two below.

Drivers	Constraining Factors	Barriers
	Organisational Factors	**Organisational Barriers**
1 Improve Product	1 Size and Structure of the Organisation	1 Project needs take precedence
2 Improve Processes	2 Number of Disciplines	2 Leadership
3 Transfer of Learning	3 Corporate Strategy	3 Limited Resources
4 Legal and Regulatory Requirements	**Project Factors**	**Content and Technological Barriers**
5 Mitigate Risk	1 Scope of Project Services	1 Complicated Taxonomies
	2 Diversity of Projects	2 New forms of content
	3 Diversity of Operating Markets	3 Inconsistencies in the use of Metadata
		4 Poor performing technology
	Future Innovations	**Construction industry wide**
	1 Processes and Practices	1 Lack of guidance
	2 Content and Technology	2 Skills Shortages
	3 Organisational Structure	3 Nature of Construction Projects
		Cultural Barriers
		1 Resistance to Change
		2 Fear of being driven by technology
		3 Poor Sharing Culture

Table 2: Summary of the final themes and Categories

4 RESEARCH FINDINGS

The following section is divided into four parts. First a general overview of the current state of IM practices within all the organisations is presented to put the results in the appropriate context followed by details of all three categories.

4.1 GENERAL INFORMATION MANAGEMENT PRACTICES

Scope

The organisations differed in their overall perception of IM. For three organisations, it is not considered 'important enough' to focus on at an enterprise level. Instead the focus is on finding specific point solutions to address specific problems (mainly on projects). The other six interviewees however stated that IM was *"very important"* and sponsored at a strategic level across their companies. In the words of one interviewee *"Yes, Information Management is fundamental to what this business is about. That's what we're dealing with. We design buildings and the output of that for our business is information. How we manage that is critical to what we do and so it's certainly core to what we're doing"*. Another interviewee added "*Our company doesn't build anything, we are a pure consultancy so what we deliver to our client is information and that could be documents, drawings, reports, data, presentations, etc, a variety of media but its all about what we deliver to our client being information"*. Seven of the organisations also have a standard approach to structuring information to enable consistency across their project teams such that *"if one project team member moves projects, they land in another project that is broadly organised in a similar way"*. The extent of this however varied. In six of the organisations, it is firmly established practice, i.e. routinely carried out and accepted across the company, while for one organisation it is emergent practice, i.e. currently being developed and implemented with varying levels of maturity across the company.

Differences were also apparent in the relationship between IM and KM practices. All but one has distinct teams for each with limited mutual lines of reporting. For all however, there is a significant working relationship between both teams in agreeing, implementing and pursuing a collective vision for improving company performance. IM strategy and overall corporate strategy were also found to be linked in all the organisations. The nature and extent of this link however varied considerably from one organisation to the other. For four of the organisations it is a very direct link, with the IM strategy modelled to support their long term aspirations. For example, one interviewee explained "*All the reasons that we're doing this, relate back to the company 5 year plan, which is the operational strategy, so all of the rationale and hence the requirements support the corporate strategy*". For the other five, there is no conscious link but a more general organisational need to better manage information to improve front line project delivery processes. As one interviewee put it, *"It's never really been thought through in quite those clinical terms"*.

Use of Technology

Multiple technological platforms rather than a single enterprise wide solution are used by eight of the nine organisations to suit various needs. For example, five organisations use a web based Content Management System to capture and disseminate knowledge around the company while four organisations have a Document Management System for managing project documents. As an interviewee explained *"there isn't one tool, there's CAD, GIS, documents and email management and so on. It's a suite of systems"*. All the organisations regularly deploy extranets and ftp sites to meet project needs such as facilitating the exchange of information between

project teams. However, even where these are used, the primary storage medium in all but one of the organisations is the network drive.

The organisations also differed in the extent to which technology was used for managing electronic content. One interviewee explained that a decision was made to minimise the use of technology as they found few solutions that add value to their chosen methods of operation. Within five organisations however technology is extensively used to support core processes including enterprise-wide Knowledge Management Systems; Document Management Systems and Extranets. Generally, the following factors were identified as impacting on the selection of appropriate tools to meet company needs.

- The nature of the company's projects (either generally or specific demands of each project);
- The geographical distribution of projects and offices;
- Skill sets available to support the technology through its lifecycle;
- Previous experiences in using a similar technology;
- The distinct task or series of tasks to be carried out either across the enterprise or on projects (or both) which the technology is expected to support;
- The robustness and usability of the system; and
- The cumulative cost of procuring and maintaining the technology over time

Use of Metadata, taxonomies and Naming conventions
Naming conventions and not metadata are exclusively used in three organisations. Five organisations whilst also using naming conventions for projects, confirmed having a metadata and taxonomy standard either being developed or currently being implemented across the company. For one organisation however, a conscious decision was made to not use metadata. The interviewee explained *"I don't think that many people have found that categorising things is helping them a great deal in the design process if I'm being honest"*. The naming conventions used in the eight organisations were observed to be either entirely bespoke or variants of the BS1192:2007 standard. Similarly six organisations who anticipate a move towards the use of standard metadata enterprise wide explained that any standard they will use will be bespoke. As one interviewee explained *"yes it'll be designed to fit our internal needs but certainly fits within ISO 9001"*.

Details of the three categories; Drivers, Constraining factors and Barriers identified are presented below.

4.2 CATEGORIES 1: DRIVERS

The drivers are defined as those themes which form the principal impetus for developing a holistic approach to IM. The themes include:

Improve Product
Improving IM is perceived as being necessary for improving the quality of products offered to clients and building/sustaining competitive advantage. In the context of consulting organisations, 'product' was defined as knowledge and information necessary to create a building; a form of infrastructure and/or advisory services. Emphasising this priority one interviewee explained *"certainly a core principle of what our company is about is that we we're passionate about engineering and we want to drive our engineers and give them the tools to move the business forward and move forward as engineers, and therefore giving them access to the best practice that we developed on other projects"*.

Improve Processes

Another significant driver identified was the need for improvements in operations. The most prevalent reasons cited for this were to increase the *efficiency* of processes; ensure *consistency* of practices and enable *collaborative working* across the organisation and on projects. Efficiency was defined as *"saving time"; "reducing duplication" and "not having to reinvent the wheel every time a task is to be carried out"* where such tasks have been previously conducted in other parts of the organisation. Other reasons cited include the need to standardise processes; increase global accessibility to recorded knowledge/information and enable continuous improvement within their respective organisations. As captured in the words of one interviewee, this is necessary because *"the size of the firm implies that ad-hoc processes cannot be sustainably carried out in a cost effective manner"*.

Process improvement also aims to ensure consistent working practices across the organisation, a critical need highlighted by all interviewees. For example, one expert explained *"Better quality, better management of our product that goes out the door, requires better consistency. So if you deal with the London office, or if you deal with the Glasgow office, you get the same and I think that's important as well so that as a brand people say we always deliver this type of product and it's excellent"*. Corroborating this point, another interviewee added *"we've got 50 offices in the UK and probably 100 offices worldwide, so if everyone's working in their own little way it's going to cause you some sort of issues in terms of Information Management"*. Consistency also makes collaborative working across the different disciplines much easier and more effective. Such collaboration can be vertical by *"enabling people who are senior help people who are junior so you get that exchange of information and knowledge"* or horizontal, to support multi-disciplinary often non co-located project teams. As an interviewee explained *"what's happening now is that the firm is 10,000 people and you've got a project where you bring together people working in the Madrid office, the San Francisco Office, the Doha office and Newcastle office"*. Problems also get solved quicker as a holistic approach enables quicker access to the people and the resources needed to solve them.

Transfer of Learning

A critical need for organisations is to effectively disseminate solutions including innovations and lessons learnt across the organisation. Learning is essential for improving the competencies of employees as (in the words of one interviewee) it is only *"by looking back at what we've done in the past and building on that to make it better in the future"*. Here, transfer of learning is focussed on all solutions which improve the competency of employees by providing access to the global pool of knowledge and experience existing within the organisation. This category was greatly emphasised by interviewees from the larger organisations where diverse disciplines and non co-located teams are prevalent. For example, one expert explained *"in our parent company, we've got 35,000 people across the world who have got an awful lot of knowledge and you've got to remember that these are assets, these people and every day when they walk out at 5 or 6, all that knowledge walks with them"*. This organisations need to enable diverse employees leverage their collective expertise prompted a move towards a holistic strategy. The themes highlighted emphasise organisations perceive that in the generation of new ideas and the emergence of new knowledge and making it available to staff lay their competitive advantage. This was also found to be an integral part of one organisations strategic positioning as a centre of knowledge for external clients and partners. As the interviewee explained *"we want to be seen to be a learned organisation and a learning organisation which go together I suppose. It is quite a key thing for this company"*.

Legal and regulatory requirements

Legislation and regulatory requirements within operating markets often require organisations to improve IM practice. Two of the interviewed organisations had already faced legal challenges in which IM has proved critical. As one explained *"Previously we have had issues where we have*

needed to rely on something, a piece of information in the past and if we can't find it then we're in trouble. It's becoming more important now that we take care of that information". The direct impact of this was even more apparent in another organisation where the interviewee explained *"at the board level they are more aware of that now. They are more aware that we need a proper Information Management strategy…they've seen other companies in our sector that have fallen foul on legal things"*. Organisations also seek to attain quality management accreditations such as the ISO 90001 which are increasingly being required for winning new work. In the words of another interviewee *"as a team we are also very closely tied in with the quality management side of things. So the ISO 9001, 14001 which are specific quality management issues surrounding how you manage information. Once you get to a certain size the only way you're going to win work is if you have these accreditations. This is way you have got to do business"*.

Mitigate Risks

Improving IM practices is also seen as essential to reducing business risks. The risks identified here are process related mainly arising from misinformation; developing wrong solutions and potentially poor project/design management. These illustrations may be representative of the fact that all the sample are consulting organisations. On this, one expert explained *"risk is a big fact because it obviously drives a lot of what we're doing at the moment"*. Developing a holistic strategy was therefore seen as a means to address this business risk as another interviewee explained *"unless you have rigorous processes, you can't have that level of confidence, so it was about addressing the risk"*. These themes were highlighted by all the interviewees.

4.3 CATEGORY 2: CONSTRAINING FACTORS

Constraining Factors (unlike drivers) are the factors which shape or influence the exact nature of the IM strategy developed and/or implemented within organisations. These are grouped under three principal subcategories as explained below

Organisational Factors

Nature of the organisation

The relative size of the organisation, with its number of employees and distribution of offices, impacts on the perceived need, approaches to, implementation and governance of a holistic IM strategy. For example, implementation and governance is identified as being *"easier across the smaller organisations in comparison to other larger, geographically dispersed companies"*. Similarly, single offices (even large ones) were said to be *"significantly easier to develop solutions for"* than multiple offices even where those offices were within the same country.

In single discipline organisations undergoing similar processes across various teams, the structures and solutions required are consistently similar. In multidisciplinary organisations however, different ways of working are often required to suit the diversity of work/products. Emphasising this, one interviewee explained *"This organisation is broken down into separate businesses. While we do operate as a group, each business has its own quality management system that is not a technical system (i.e. not a technology) but it's like a procedural thing written down"*. Each discipline within a multidisciplinary organisation with its unique client deliverables; unique specialism on a project and unique tasks therefore have unique information needs.

Corporate Strategy of the Company

The wider corporate strategy of the company also influences the nature, appropriateness and/or evolution of the IM strategy. One interviewee explained, *"If we want to be double the size we are over the next X years, we have to factor that decision to the procedures and technology we*

have in place. In some ways this starts from the size of the business, the sectors we want to work in and the disciplines we want to operate in. That gives a general feel of the overall business and the direction we are heading in. Key to achieving this is Information Management". Thus the corporate strategy can serve to define the most appropriate IM strategy to support it. While this theme was consistent across all the interviewees, the extent of its influences was unclear as for example, it was unclear whether project specific requirements were a bigger influence than the broader corporate strategy.

Project Factors

The project based structure of construction organisations also impacts IM practices as one interviewee put it, *"we're very much project based and everything the company does is project by project literally and that very much relates to how we manage the information as well"*. Three factors identified here include:

Scope of Project Services

The scope of services offered by an organisation impacts on the feasibility of having a singular approach for managing information. For example, one organisation (a global architectural practice) focuses on conceptual design. The interviewee explained, *"What our clients are looking for is as many great ideas that we can possibly come up with in a short space of time, then present those ideas and develop that with them. So there is a general feeling that 90% of the information we create becomes abandoned quite quickly"*. He further added *"but another organisation might wish to store all of that information in a repository; support that by a database; tag and reference that information; and publish that through some kind of publishing portal. And although we do have the technology to do that, it (i.e. our information) is not structured in that way. So its not as if we are a manufacturer of widgets and we discovered a new way to take a penny off the cost of a widget and therefore we make that knowledge known"*. The fluid nature of work here, the speed at which information is created (and discarded); and the very limited need to re-use project information implies that the strategy adopted here will be different to that adopted by an architectural practice focussed on say detailed design. This theme resonated across all the other interviewees suggesting an association between the tasks carried out within an organisation; its inherent processes and the way the organisation either manages or needs information to be managed.

Diversity of Projects

A similarly influencing factor is the variety of projects an organisation engages in. With building design as an example, projects can range from large multipurpose complexes to single building components such as staircases. As one interviewee explains it, *"we do such a varying and wide range of things that to get some kind of commonality is very difficult and perhaps too difficult"*. This diversity is reflected in the bespoke nature of construction projects, with each project potentially involving unique thoughts, actions, solutions, delivery mechanism, partners, etc. Another interviewee explained *"Being a project based organisation we are very much influenced by the specifics of any given project and the strategy of our client and particularly the design team that might build up around that"*. Within a multidisciplinary company, this distinction can create more marked variations in practices as working in one sector may differ from another and thus impact on a single holistic strategy.

Diversity of operating markets

Metadata standards, operational requirements, regulations and practices may also differ in the various global markets some organisations operate in. This was particularly highlighted by all of the multinational, multi-disciplinary organisations, one of whom explained working practices *"need to vary according to their local market"*. Some such differences are in terminology and thus internal differences while others may be regulatory differences for which entirely different

approaches may be required. For example, one respondent explained *"we've got highways in the UK which means something different in America. As highways mean something different, transportation also means different things. So that is quite challenging"*. Another interviewee observed *"different parts of the world have different cultures and you have to respect that .... So again, it is difficult"*. Similar challenges emerge where organisations operate in diverse sectors and also different time zones even within the same market. One interviewee explained *"the problem our organisation has is that because we're quite a large organisation, we work off so many different sectors and clients all of whom have very differing requirements. The standards which we work to are just too complex, too varied for our enterprise content management system's CAD management tool (alone) to cater for"*. This invariably influences the nature of the IM solution required in the organisation.

Future Innovations

Emerging innovations in three key areas were identified as potentially impacting on the nature of IM strategy within organisations.

Processes and practices

Changes will invariably emerge in the future in the way tasks are carried out and people collaborate with each other both internally as well as across organisations. Organisations will also be driven to leverage the increasing capabilities technology will offer to streamline processes and make work easier for their staff. As an expert explained *"certainly for us now and looking into the future, one of the key challenges that I see we face is further streamlining our procedural things by just making it more straightforward continually. I think technology has moved on there and we have to kind of use that"*.

Content and Technology

Evolving technologies and new types of content will also impact on current approaches to IM. Particularly highlighted by the interviewees were innovations in Building Information Modelling (BIM), Geographical Information Systems (GIS) and cloud computing with its enhancement of Software-as-a-Service (SAAS). As one interviewee explained, the emergence of software as a service is particularly appealing to organisations *"because there is not a big upfront investment and perhaps somebody else is worrying about how do I keep that SQL database stable and do I have some redundancy in my design for this system? Whereas at the moment individual companies on their own have to solve all of those problems within their own IT departments, requiring their staff to become big and knowledgeable to be able to facilitate that"*. This method of working is already been applied to the use of Extranets and increasingly Enterprise Content Management Solutions.

Organisational structure

A challenge for IM is to remain continually malleable to support ongoing changes to the organisational structure. In the words of one interviewee *"The system is going to have to react to the business whichever way they change. For example we find that parts of the business merge each year. All these kind of things happen and will continue to happen. We acquire new companies on a regular basis to join the group"*. Similarly, as organisations continue to work in or source project teams from different parts of the world, the current approaches and strategies employed may not be adequate to support them. One respondent highlighted that *"certainly within our company, we have global groups and obviously with the sort of night/day situation around the globe, we can actually start to do never ending work if you like. Yes this will have a big impact"*. Another added *"As we consolidate the business in the future, more and more people are going to collaborate and use each other's information. I think it's just going to be a natural progression"*. Just as the current approaches to IM were designed to support the current

processes and structures of organisations, future evolution of the said management structures will invariably require an evolution of IM practices.

4.4 CATEGORY 3: BARRIERS

A number of barriers were identified which impact on a holistic approach to IM in Construction Organisations grouped under the four subcategories below.

Organisational Barriers

Project specific needs take precedence
Any procedure outside of project procedures is perceived as an unnecessary task with one interviewee observing *"they see the organisational way of doing things as needless red tape, where as the project is for client then of course I'll do that"*. This strictly project-to-project view implies that a holistic project agnostic approach, while adding value to the company in the long term, is seen as an immediate hindrance and therefore is not as easily justified or adopted. Tight project deadlines also create very little room for additional tasks that fall outside the specific needs of a specific project. This, experts explained, limits both the risk tolerance of employees in identifying/complying to new processes and also the rate at which process related innovations are adopted within the organisation. In the words of one interviewee *"You will naturally get barriers because everybody when they get a project is on shorter time frames to deliver it than before. So naturally the resistance is, I know how to do stuff now and you're telling me to reinvent it. That leaves me feeling exposed and that feels like too much risk"*.

Leadership
Senior leaders in some organisations whilst acknowledging the necessity of improved IM (mainly in response to increasing regulatory requirements) still don't understand what it actually means and how to develop/implement it. Describing this, one interviewee explained *"They see the importance of it but I don't think they fully understand it"*. Similarly, the diverse areas that need to be accommodated in understanding the complexity of the construction process; organisational needs/processes; IM and the right technology tool sets to support these require a different skill set which interviewees identified as uncommon in their organisations.

Limited Resources
The size of the implementation team relative to the task at hand can also limit the rate at which appropriate solutions are identified, developed and implemented. For example, in one organisation *"because the team was quite small, if you've got a problem it takes 95% of your effort [to solve], that's what you're focussed on"*. Similarly, another interviewee explained *"And certainly the hardest thing for us is that we can only deliver so much. The team is only so big and we can only do so much work"*. Resource constraints and the magnitude of work requires organisations to prioritise areas of importance as in the words of another respondent *"there is only so much time in the day you can work on these things so I have to prioritise them so again that is quite challenging"*.

Content and Technological Barriers

Complicated taxonomies
The complexity of projects can result in any taxonomy structure becoming complicated and difficult to use. For example, referring to their taxonomy, an interviewee explained *"there are a few areas where it's not entirely intuitive because our business is quite complicated. This means our taxonomy covers an awful lot of things from building control to where do I file information about bricks? etc"*. In response to the diversity of their business offerings, elaborate taxonomies

are designed to accommodate all the possible known scenarios are developed. These taxonomies while appropriate at the time pose a challenge with the growth in the volume of content; number of employees and the types of content managed. The result as one expert explained is that *"I spend all day kind of in and out of enormously deep folder structure system thinking there must be a better way of doing this"*. It can also affect the willingness to procure fit for purpose technology as it creates the fear that any enterprise system may not be able to cope with the company's specific requirements. On this, an interviewee explained *"It does have to be quite complicated or quite rich. It's partly why I feel quite nervous to going to someone like Union Square (a software provider). Its all just put it in the dust bin the tags will get you to it"*.

New forms of content

The continuous emergence of new forms of content such as BIM and GIS create challenges in the way content is currently structured in organisations. A lack of a clear understanding on the structure of these new forms of content and how to develop appropriate taxonomies, technologies and solutions to support them also hinders improved IM practices. A respondent explained *"Increasingly we're using 3D at an early stage and at the moment our folder structure and naming convention isn't quite rich enough to capture all of the 3D stuff"*. The current taxonomies are created to manage documents each of which is treated as a single instance of content. The emergence of single integrated models however makes the taxonomy previously developed no longer sufficient. This creates a problem for organisations unable to grasp how to restructure taxonomies to support this new content type as one interviewee explained *"Drawing in 3D, you have got the power to do cuts here or there. So how do you manage the outputs for that? We haven't really thought through that"*. This also impacts on the use of single enterprise wide solutions to manage all types of data as specialist applications were found to be incapable of being supported by general Document Management solutions.

Inconsistencies in the use of Metadata

Obtaining consistency in the definitions of certain attributes within a metadata/taxonomy structure particularly in large multi-disciplinary organisations can be difficult. This, five of the interviewees explained reflects the diversity of tasks; cultures; clients and markets their respective organisations worked in (all of which are constraining factors). For example, one expert explained *"what's certainly quite interesting in our organisation is that when we're talking about sectors, we have the idea that it's sort of commercial, residential, healthcare, that's what sectors mean to us. And if you talk to the holding company, sectors mean something completely different. So there could be that difference already existing and if you're trying to implement a metadata standard that is going to suit a company that is 7,000 strong, then yes you're going to definitely run into that problem"*.

Poor performing Technology

Even where the solution has been implemented, interviewees explained that technologies implemented often end up "*not doing exactly what they wanted it to do"*. It remained unclear to the researcher if this was due to the organisations not being clear about their original requirements; limitations in the ability of the technology to do what it said it would do; or expectations not being effectively managed through the procurement process, all of which can affect the perception of adequacy. Implicit in this is also an apparent lack of confidence from end users in the ability of the IT systems to support defined strategies. This was reinforced by a respondent who stated *"I think another thing is that we're talking about an IT system at the end of the day. Its never going to be perfect, you're always going to have down time; you're always going to have a server over heating or something"*. While for this organisation none of these problems have actually materialised, it was observed that all interviewees anticipated failure or inadequacy in the performance of IT systems, impacting on their confidence to implement a holistic strategy. Some problems however do materialise and as one interviewee explained, it is to be expected. *"We hit some real technical problems and I think you're always going to find*

that with a new IT system when a company is new to it, even though we've got a very skilled set of technical IT staff here". Similar challenges were highlighted by another respondent who explained *"we certainly had I think every technical issue you could throw in. We've just been absolutely besieged by technical issues"*.

Construction Industry wide Barriers

Lack of guidance

There is limited clear useable guidance on the process of developing and implementing an Information Management Strategy in Construction Industry based organisations. While clear standards such as the BS 1192:2007 have emerged that provide guidance on managing information through the project lifecycle, no similar solutions have been proposed for how IM can be aligned to organisational processes or how context specific metadata standards can be developed and implemented to suit an organisations needs. As an interviewee explained *"people have started to get hold of the fact that to make this work we're going to need things like standards. There are been precious few, either British or European or global standards around"*. The responses indicate that guidance is required because non-content specific standards, particularly metadata standards may not be suited to an organisations needs without requiring some form of modification. This does not include content standards such as IFC's.

Skills Shortage

There is a shortage of professionals with the requisite skill sets to enable organisations develop and implement the required strategies. Emphasising this, one expert stated that *"it is difficult to find the right people to fill these boxes. People that have the breadth of knowledge and interest in this area are quite hard to come across with the right personal and project management skills as well"*. This hinders the ability of organisations to make the necessary transition, as captured in the words of one interviewee who while acknowledging their challenges exclaimed *"I can't really see how we can; I can't see the transition at the moment"*.

Nature of Construction Projects

The nomadic project based nature of the Construction Industry, its resultant ways of working and the project specific standards that inevitably emerge, is often at conflict with the solutions developed to be applied internally within organisations. As one interviewee explained, organisations partnering on a project are faced with this challenge because *"they all have their own different dynamics and whilst we have our own internal standards, so do all of those organisations"*. This is particularly the case in the use of naming conventions and folder structures (or taxonomies) where as one expert put it, they often *"just have to go with the flow"* and by so doing undermine any established company procedures.

Cultural Barriers

Resistance to Change

Where new solutions have been developed and introduced, a recurring theme is the difficulty in getting people to change their ways of working and adopt new methods. The challenge here was summed up by one respondent who explained *"getting information on the system, capturing it at source and allowing people to view it in different forms isn't that difficult once you put the initial systems in place. What is difficult is getting people to use it. That's what our primary role at the moment is, it's people"*. One expert stressed that resistance to change is a difficult challenge because *"you can't avoid it. You can mitigate it but you can't avoid it. People feel they know exactly what their doing. And you can't tell them how to do it differently because they feel they are very intelligent"*. Similarly challenging is getting users to add/use the relevant metadata when introduced. On this an expert explained *"if you filled massive amounts of information for*

each document, yes you're going to be able to search for those documents, you're going to find them easily but you're only going to end up with 10 documents because people just won't do it".

Fear of being driven by technology
Similarly organisations sometimes fear that adopting an enterprise system may alter company processes to suit the way the system operates. The themes here highlight a certain wariness of enterprise systems among organisations. For example, a respondent elucidated *"There have been systems that we've looked at that have seemed exceptionally well. We've spoken to people who suggest that they worked well but quite often the companies have adapted to use the systems and we don't particularly want to do that. We much prefer the systems being adapted to suit the people, hence the preference for a bespoke solution"*. This does not imply a dependence on bespoke technological solutions but instead the need for solutions which align with and conform to the specific needs and business model of the organisation.

Poor sharing culture
The uptake of such an integrated vision is dependent on a willingness to share information, a culture which sometimes can be lacking within organisations. According to one respondent *"I think the problem we had was sharing information. You always get this knowledge is power and I quite like to share with other people around me, but I'm not going to put it out there"*. This was similarly echoed by others, one of whom explained the mindset of those who resist collaborative working to be that *"they think that they're bits of information is the most important bit and no one else can possibly understand it"*.

5 DISCUSSION

This research presents the findings from a detailed review of IM within organisations in the UK Construction Industry. The findings demonstrate that for consulting organisations, information includes explicit knowledge. It also shows that KM and IM initiatives are aligned (the extent of this alignment however was not investigated). Indeed, improving the sharing and the exchange of knowledge is a key driver for improving IM within consulting organisations. With respect to the drivers, while all the organisations were driven by the same five themes it was observed that organisations placed greater emphasis on some themes above others resulting in a different type of strategy for each company. For example, one organisation was driven more by the need to mitigate risks and conform to legal/regulatory requirements than it was by the need to transfer learning. Thus a workflow based Document Management System is currently being implemented. Two other organisations, with distinctly architectural leanings however, put more emphasis on improving the product and transfer of learning, thus making knowledge sharing a priority with little or no workflow related defined processes. These approaches are reflective of each company's business strategy. Consciously or unconsciously, all have placed emphasis on areas of strategic significance. No attempt was made to compare the findings across the organisations as the research did not aim to measure the relative maturity of IM and/or KM practices within Construction Industry based organisations. This is also reflective of the fact that strategies developed are likely to be so context specific that maturity is not a measure of appropriateness but a measure of how aligned the strategies are to the core strategic drivers for each organisation.

The Constraining Factors also affect each organisation in a different way resulting in differences in the type of solutions required and the modes of implementation (also making a like for like comparison inappropriate). Context specific factors often need to be accounted for in developing and implementing an IM strategy. These factors could range from the Constraining Factors which shape the exact nature of the strategy vis-à-vis the strategic needs of the organisations, to include solutions developed in response to specific barriers. For example, organisations which deployed Enterprise Content Management (ECM) solutions were not extending its use to CAD

files (both 2D and 3D models) due to the perceived inability of standard ECM systems to adequately manage large CAD files. The findings therefore illustrate that defining a single approach to managing information using a single enterprise wide system across multidisciplinary organisations can be both impractical and undesirable. As the Constraining Factors show, certain organisational, technological and environmental factors emerge which will require an approach focussed enough to align/support the overall corporate business strategy yet flexible enough to accommodate the differing needs of specific discipline groups. This also reflects the fact that despite often differing needs which make standardisation difficult, there are sufficient commonalities between diverse disciplines and processes within organisations which create both a need for and the basis of a holistic approach. Thus rather than a single approach, organisations instead require a 'unified approach' which focus on integration while remaining tailorable to the distinct tasks, projects, sectors, countries and products across the organisation.

The themes identified here are similarly identified in existing literature on IM albeit in diverse publications not particularly aimed at the Construction Industry. In a study of engineering SMEs Hicks et al (2006) identified a number of issues which impact on IM. The study focused on the barriers to IM and did not include constraining factors or drivers. The barriers were also focused more on IS and IT rather than purely IM or its organisational dimension. Similarly, Earl & Feeny (1998) identify the four strategic imperatives (drivers) for Strategic Information Management within organisations (particularly global organisations) as global efficiency; enable local responsiveness; transfer learning and enable external alliances (collaborative working across multiple organisations). While the drivers identified in that study are similar to the findings here, new themes have been identified here which are absent from that study. These findings are also context specific reflecting the peculiarities of the UK Construction Industry.

The themes which emerged from this study are organisational with limited technology related drivers, barriers or constraining factors. This re-emphasises that IM unlike IS or IT is not a technological issue. Indeed the challenge for organisations is having the right capabilities to appraise their strategic information needs; develop appropriate holistic solutions to support these; implement the strategy effectively and maintain it through its lifecycle. Appropriate technology can then be selected to best support the defined strategy as similarly observed by Gyampoh-Vidogah and Moreton (2003) as well as Hjelt and Bjork (2006).

6 CONCLUSION

This paper presents the findings from an investigation into the nature of IM in the UK Construction Industry reflecting the multidimensional nature of a holistic approach. The findings highlight the significance of an organisational perspective on IM and the increasing emphasis practitioners are placing on how information can be better managed to support their core processes. The findings also highlight that despite progress, organisations within the industry are hindered by the shortage of the right skills to effectively analyse and understand the various facets of a holistic approach to IM and hence develop appropriate solutions to meet their needs. Clear inter-relationships exist between the various themes identified in this study. For example, the cost of a solution is perceived as a barrier relative to the earning power of the organisation; the functionality of the system being procured; the business process for which the technology is intended and the perceived value of the innovation for the business. This interconnectedness between the various themes provides a more complete understanding of the themes and their influence on IM.

The themes are also defined by or influenced by external factors, in particular, the wider industry in which the organisations are based. The Construction Industry, its people, structure and working practices invariably influences the very nature and outcome of any strategy. For example, product improvement as a driver places emphasis on the need to improve both the

quality of services the organisation offers as well as the final product or built form emanating from actual construction activities. Thus, while all the themes provide a better understanding of IM in the Construction Industry, they are all in turn a product of the specific context of the organisations as being in the Construction Industry.

The findings highlight areas in which further research is required. Despite a realisation of the need to improve IM, the findings show that organisations within the UK Construction Industry do not have the requisite capabilities to effectively develop well aligned holistic IM strategies that support their overall operations. Further research is required to develop appropriate toolkits to enable organisations appraise their needs vis-à-vis the drivers, understand their current context; and then translate the outcome into targeted solutions that add value for their respective organisations. Further research is also required to develop appropriate measurement criteria for determining the effectiveness of IM strategies in organisations, not focused on the targeted implementation of technology but on assessing the 'suitability' of the strategy for supporting business processes.

In the future, it is anticipated that information will continue to emerge as critical to innovation and operation in organisations. New types of content and technological innovations will also demand new ways of working. Organisations able to better structure themselves to best leverage this information will emerge with greater competitiveness. Thus a holistic approach, defined by the themes identified in this study will undoubtedly be important in improving collaborative working and the operational effectiveness of Construction Industry based organisations.

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APPENDIX 5 SEVEN LESSONS FOR EFFECTIVE INFORMATION MANAGEMENT (PAPER 7)

Full Reference:

Sheriff, A., Bouchlaghem, D., EL-Hamalawi, A., Yeomans. S.G. (Under review). Seven Lessons for Effective Information Management. Submitted to *ICE Civil Engineer*.

Abstract:

Collaborative working improves operational effectiveness, knowledge sharing and project delivery all of which enable organisations to deliver value to their clients. This is particularly important as global business challenges will increasingly require the production of greater value from less resource. Achieving this in a knowledge economy requires improvements in both the processes and media through which often large volumes of information is created, shared and managed. Indeed organisations have over time developed and implemented various solutions ranging from point technology implementations to reorganising entire business processes to this end, with varying degrees of success and failure.

This paper presents a number of lessons captured from such endeavours, based on a detailed review of Information Management strategies within UK Construction Industry based organisations. Interviews were conducted with nine experts in large Architectural and Multidisciplinary Consultancies, the outputs of which were analysed and seven key themes emerged. The findings provide much needed practical insights for practitioners and managers developing and implementing Information Management strategies. Furthermore, they show that improving collaborative working and Information Management across organisations is not simply a matter of procuring technology. It requires a more holistic strategy which aligns information needs with the organisations operational strategy.

Keywords:
Collaborative working; Information management; Operational Improvement.

Paper Type:
Journal

1 INTRODUCTION

The Knowledge economy has fundamentally altered the nature of work and means through which it is carried out within organisations across all industries (Drucker, 1992). Information is now a central and strategic resource, a factor of production and in some instances the core deliverable (Earl, 2000; Feraud, 2000; Evans, 2000; Davenport and Marchand, 2000; Dilnutt, 2006). Much as the industrial revolution gave rise to new organisational forms, businesses will increasingly require a fundamental rethinking of their operating models to enable them better harness this information, develop innovative solutions, improve processes and gain competitive advantages (Evans, 2000; Marchand, 2000). Within the construction industry, the Latham (1994), Egan (1998), Levene (1995), National Audit office (2001) and Business Round table (2006) reports among many others call for a shift towards greater integration and collaboration among teams to gain improvements in underlying productivity in a world of increasingly scarce resources (Anumba et al, 2004; Yeomans, 2005; Craig and Sommerville, 2006; Shelborn et al, 2007; Jorgensen and Emmitt, 2009). Core to enabling this is effective Information Management (IM) as information forms the core medium through which solutions developed are documented, communicated and shared with others (Bjork, 2001; Koskella and Dave, 2008). Hicks et al, (2006) define Information Management (IM) to include the activities that support the information lifecycle from creation, representation and maintenance through to reuse. It is strategy and process driven focusing on content created, shared and managed to enable the effective execution of organisational processes.

Koskella and Dave (2008) argue that 'value' is created and obtained not simply by procuring IT and/or IS but by clearly aligning information needs to business processes. This is a critical distinction as it shifts the emphasis from simply creating and deploying technological solutions to harnessing information and rethinking processes to improve operations and gain competitive advantage. Such a paradigm shift is essential if improvements in productivity and effectiveness in the creation and delivery of goods and services are to be obtained within the construction industry (a more detailed review of IM, its nature, drivers, barriers and constituent components is presented by the authors in Sheriff et al (2010)).

This study presents a critical review of organisations where such implementations have taken place to identify key lessons learnt in developing and implementing effective IM Strategies. The paper is part of a broader study conducted at Loughborough University and a global multi-disciplinary Engineering Design Consultancy on IM for enabling collaborative working and business improvement in construction industry based organisations. The findings presented here will prove insightful for industry leaders, managers and practitioners working to improve business operations. Learning from such insights is crucial if productivity and innovation are to be improved across an industry faced with increasingly complex challenges and constrained resources.

2 METHODOLOGY

Semi-structured interviews were carried out with IM experts from a sample of construction related organisations sourced from the annual Construction Industry ranking of the *Building* magazine (2008). As the sample size sought was principally illustrative in line with a principle of conducting case study research (Yin 2003), a non probability purposive sampling approach was used. Twenty five organisations (14 architectural firms and 11 multidisciplinary consultancies) were targeted based on their business area (consulting organisations) and their size (medium – large consultancies). Nine interviews were carried out with Senior Partners (2); Directors (2); Group Knowledge Managers (1); IT Systems professionals (3) and a Senior Business Analyst (1), all of whom were experts responsible for IM and/or KM within their respective organisations.

All interviews were conducted face to face, each lasting approximately 90 minutes, then transcribed and analysed using the thematic analysis process outlined by Boyatzis (1998) which involves reading the textual data iteratively to identify appropriate themes. An initial list of 271 themes emerged some of which were observed to be repetitive and/or inter-related. Further iterative refinements were carried out to aggregate and consolidate these into distinct selective codes. This consolidation process involved combining certain themes and grouping other associated themes into categories. The final consolidation resulted in 33 themes across four core categories: Drivers, Constraining factors, Barriers and Lessons learnt all of which define distinct areas of IM. Only the lessons learnt (a total of seven themes) which reflect practical insights are presented in this paper.

3 FINDINGS

The seven lessons for developing and implementing a successful IM strategy were found to be:

3.1 LESSON 1: UNDERSTAND BUSINESS NEEDS

To develop an 'appropriate' strategy, a thorough review of the organisation is required to define and understand its overall needs. In the words of one interviewee *"I think it's definitely about looking at the business, its operations and needs, then supporting that with the solutions that best fits it"*. Reinforcing this, another interviewee explained *"It has always got to be about looking at how people do their projects, their daily work; how we operate as a business and making the system fit with that and that's how people are going to see the benefit. If it fits with the way they do work on a daily basis, helps them to do their work better, helps them to remove admin or mean less stuff that is not project time or directly concerned with their job then that's the way to go"*. Understanding business needs also implies that solutions emerge because the business sees a need for it. Such an approach will create a fitting and dynamic strategy strongly aligned with the organisations operations and its long term business strategy.

3.2 LESSON 2: DEVELOP A UNIFIED APPROACH NOT A SINGLE APPROACH

Organisations with diverse user needs should not aim for a single approach to managing information but for a 'unified' approach which effectively integrates its diverse needs. This requires a clearly defined common baseline on top of which any specific customisation can be carried out to ensure consistency is obtained while accommodating the day to day operational variations required within the different segments of the organisation. Achieving this relies on seeking consensus from business units across the organisation on working practices. This, interviewees highlighted, is of critical importance because *"if the strategy is not right and you don't have consensus on the strategy, whatever you put in place won't work"*. It requires different facets of the business to effectively work together including quality managers, technologists, designers, project teams, etc to develop the strategy; implement it, manage the change and support it through its lifecycle.

3.3 LESSON 3: DEVELOP AND DEPLOY CONTENT STANDARDS

Standards are required to provide a consistent federated approach to managing content across various projects, locations and technological platforms. With the diversity of projects and disciplines across the industry, interviewees observed that a single technological platform for

managing all types of content may not be appropriate for the various types of information created, shared and managed. An effective strategy, whilst unified to accommodate such diversity, must be underpinned by consistent standards to ensure all the parts work together as a whole. One such component that needs to be standardised is metadata. However, in carrying this out, experts observed the need to *"keep the number of attributes to an absolute minimum"*. This is not implying that metadata is unimportant, but the manual task of filling out attributes can serve to inhibit the uptake of any solution.

3.4 LESSON 4: DEVELOP A BROAD STRATEGY NOT FOCUSED ON TECHNOLOGY

To be effective, a good strategy should be much broader than software implementation. One expert highlighting his organisations shortfall in this respect explained *"It has always been a people company but I think we would certainly have saved some time in looking at technology and thinking it was going to solve all our problems, because there certainly was a time when everybody was selling Knowledge Management tool kits. It was perceived to be the answer to all your problems and in fact we found that it is not. It's an enabler and that's all that it is"*. Thus to be effective, organisations should view the IM strategy holistically to include a clear understanding of process alignment, the nature of content, metadata, taxonomy, change management and suitable technologies (as enablers).

3.5 LESSON 5: DEVELOP AN EFFECTIVE IMPLEMENTATION PROCESS

Even the most elaborate strategies will fail if poorly implemented. Three interviewees highlighted how doing workshops with end users at various stages throughout the process helped to create engagement and partnership. In one organisation, a series of workshops enabled users to grasp the gravity of the problem spurring a focussed discussion around possible solutions. As the respondent explained *"We wanted to create ownership, that they owned it, they came up with what they wanted, not 'we're told'"*. Similarly, a series of training sessions, road shows and internal publicity events may be required to better equip, communicate with and reach out to end users all of which help to break barriers to adoption. A respondent explained *"To get people aware of the systems we provided road shows, we talked to people in conference calls and we got local people in the offices to put things in place"*. Training, both at the outset and on an ongoing basis enables employees to understand what is required of them and make them comfortable with the process. In some organisations day long events were carried out in every office where it was mandatory for employees to attend. Others commissioned promotional videos, e-learning training modules, posters, commercial items, books etc all of which helped to communicate the importance of the new strategies developed and provide support to users.

Implementation is a continual and incremental process which takes time and effort. One interviewee reflected *"the lesson learnt is that it takes time and putting in the effort upfront in terms of getting the buy in and the consensus and a clear direction, vision for where you want to go. Spend as much time because until you get it, there's not point moving forward"*. This effort is required to ensure that solutions implemented are appropriate. New solutions will also result in changes to the way tasks are carried out which can take time to embed into normal working practice. As another interviewee highlighted *"it takes a while to bring about the change. We are dealing with human beings and an industry that is quite resistant to change"*.

3.6 LESSON 6: GAIN SENIOR MANAGEMENT SUPPORT

Successful development and implementation of a holistic strategy requires buy in and clear support from senior management within the organisation. As an interviewee observed, it is important to *"get buy in from the business. Make sure that they're on your side and they actually want to see improvements"*. Only a sustained eagerness to see through those improvements will ensure any solution developed is consolidated. This theme emerged from all the interviewees with some highlighting that this support should extend beyond tacit approval to actual explicit involvement throughout the process. For example, in one organisation where direct value was obtained from such direct involvement, the interviewee explained *"we've had several presentations done by directors on our Information Management strategy to the whole company, and if your graduate engineer or design engineer or senior engineer sees one of the directors standing up to sing its praises, they would want to be involved"*.

3.7 LESSON 7: ACTIVELY DEMONSTRATE VALUE TO USERS

An effective IM strategy will often require an organisation to rethink its working methods. Such changes need to be managed effectively, with confidence built up over time. An expert explained *"it is important to recognise it's a change in the way people work, and you can't just swop over overnight. I mean you can't expect people to just come in the next day and use the solutions. You can't impose it on them overnight"*. While there may be resistance to change at the outset, the experts observed that *"gradually as you talk to people they could see that it could improve performance and cut costs if you could actually get the information to them quicker"*. This requires trust, empowerment and working along side people over time. Often though, compliance may be best obtained through enforcement with one interviewee explaining *"we make sure that they get instructions. They get told that they have to use it, not by the IT team but by their business representative, the person who's responsible for quality management. So they know that they have to do it"*. Each organisation will have to decide what method works and aligns best with its corporate culture.

Demonstrably adding value to each individual's day to day tasks can ease acceptance. On this, an interviewee explained *"you can't just demonstrate the benefits to the company; you have to demonstrate benefits to the individuals that are going to do it as well"*. It creates buy in and through its direct applicability increases the willingness of employees to get involved in the wider process. The definition of 'value' however differs depending on the specific context of the employee and the type of work being carried out. For example senior management may focus on solutions that improve the overall business while more junior employees may focus on solutions which enable them to better perform their particular tasks.

4 DISCUSSION AND CONCLUSIONS

The seven themes identified above reflect insights from the varied experiences of a sample of construction industry organisations. The critical capability required to improve IM and achieve the operational improvements sought is being able to systematically analyse a company's, culture, operations, projects, disciplines, service offerings, etc to effectively define, select, procure, implement and maintain the most appropriate solutions. Clearly understanding business needs is therefore the essential starting point in developing an effective IM strategy. All the experiences also show greater value is obtained when IM strategies are aligned with strategic and operational business needs across the organisation and not simply on individual tasks, projects or systems.

As business needs also differ from one organisation to the next it is not possible or desirable to adopt a 'one size fits all' approach to IM across the construction industry. Certain organisational, technological and environmental factors exist which will require each organisation to develop for itself an approach focussed enough to integrate it (aligned with its overall corporate strategy) yet flexible enough to accommodate the differing needs of specific projects, tasks, disciplines, countries and products. Thus critical to obtaining the requisite business value is a clear appreciation of business needs and the context within which the organisation operates and developing suitable information based solutions to match these. Likewise measuring the effectiveness of the IM strategy should not be focused on the performance of technology but the extent of the IM strategy's alignment with and appropriateness for supporting the organisations tasks, processes and business strategy. Further research is required to develop appropriate metrics for measuring the effectiveness of IM strategies.

So how do organisations improve the effectiveness of information based processes? The findings presented here show that thinking about information as an organisational resource and not a technological solution can yield beneficial outcomes. The experiences show that focusing on a broad strategy that accommodates a view of process, people, technology and content will enable organisations to gain a wider understanding of their needs and develop the most effective methods of meeting them. Another insightful lesson is the importance of standards in underpinning strategies and solutions. As organisations are eco-systems such standards enable consistency to be achieved, facilitating interoperability and collaboration across diverse systems and processes.

These findings also positively influence the increasing use of Building Information Modelling (BIM) within the construction industry to gain operational improvements in both the quality and process of design, construction and operation of buildings. It shows that the value of BIM will be poorly exploited if viewed simply as a software capability that speeds up the design process. To be effective, BIM must be viewed as an enabler for a more integrated and collaborative project delivery process for the benefit of the project team, the organisations involved, the clients, end users and facilities managers. Thus procuring and implementing an advanced piece of software across an organisation does not equate to a well integrated BIM strategy.

For leaders and managers within organisations, tasked with business improvement in their respective organisations, these lessons show that IM should be operationally driven (i.e. by those involved in overseeing the successful execution of a process) and not technologically driven. Operationally driven approaches ask 'what solutions are required to achieve this operational purpose?' The output from such an organisational paradigm will be a solution that is fit for purpose, well aligned to the overall business strategy. This ensures that in the end, increasingly scarce resources are put to effective use to gain the required improvements in productivity sought by construction industry based organisations.

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APPENDIX 6 INFORMATION AUDIT QUESTIONNAIRE.

This survey is aimed at understanding the current state of Information Management within Buro Happold including the type of information created and shared. It is also aimed at understanding your requirements as end users with a view to proffering a solution that supports you, eases your work and satisfies your daily information needs.

1. What group do you work with?

Please specify	

Please tick as appropriate.

2. How easy is it to find the information you need to do your job?

	Difficult		OK		Could be improved		Easy

3. From the list below please select the types of files you produce.

1		Text files (e.g. MSword/ InDesign/ Notepad etc.)	7		2D-CAD files (e.g. AutoCAD/ Micro-station/ Revit, etc)
2		Spreadsheet files (e.g. MSExcel/ Lotus Notes etc)	8		3D model files (e.g. Rhino/ 3DS max/ Revit/ Sketchup/ Cinema 4D etc)
3		Presentation files (e.g. PowerPoint/ Flash etc)	9		Simulation files (e.g. IES/ Ansys/ Ecotect/ Flowvent/ CATT/ Easera/ Meplar etc)
4		Database files (e.g. MS Access etc)	10		Image files (e.g. Jpeg/ tiff/etc)
5		Program files (e.g. MS project/ Primavera etc)	11		Audio files (e.g. Sound-web designer/ Audicity/ Mp3, etc)
6		Graphics files (e.g. Corel/Photoshop/ Publisher/ MS Visio/ Illustrator/ etc)	12		Video files (e.g. avi/ Premiere/ After effects/ etc)
			13		Code files (e.g. VB/ Visual Fox PRO/ c++/ Java/ etc)

4. How often do you share/transfer information with the following?

		Daily	Weekly	Monthly	Never
1	Other members of your group				
2	Other BH groups				
3	External clients				
4	External partners				

5. What do you use to share/transfer information with the following?

		Paper	shared folders	Email	FTP	BH Intranet	Extranet	Post
1	Other members of your group							
2	Other BH groups							
3	Clients and external parties							

6. How would you describe your method for naming files?

1		No standard approach	4		Company wide approach
2		Personal standard approach	5		External Project specific approach
3		Internal Group agreed convention	6		Industry standard

7. If Industry standard, please specify.

8. Which of the following do you use to name your files?

1		File title	5		Client name	9		Date created
2		File author	6		Project name	10		Revision
3		Job Number	7		Project location			
4		Group name	8		Purpose of the file			

9. Please give an example of how you would name a file.

10. Do you use additional attributes (e.g. Title/subject/comments) to manage your documents?

1		Yes
2		No

11. If yes, which of the following attributes do you use?

1		File title	5		Project name	9		File Subject
2		File author	6		Project location	10		Date created
3		Job Number	7		Comments	11		Other (Please specify)
4		Client name	8		File Category			

12. Please select the additional information you would like attached to your files to help manage them better. For each, please specify your preference (Compulsory; Optional; or Not applicable)

		Compulsory	Optional	Not Applicable
1	File author			
2	Job Number (e.g. 022245)			
3	File Category (e.g. Sketches)			
4	File subject (e.g. Steel Joints)			
5	Company (e.g. Alan Smith)			
6	Business region (e.g. Middle East)			
7	Office location (e.g. Dubai)			
8	Discipline/group name (e.g. SAT)			
9	Client Name (e.g. Trump International)			
10	Project Name (e.g. Snow dome project)			
11	Project sector (e.g. Leisure and recreation)			
12	Project location (e.g. Cincinnati, USA			
13	Zone (e.g. Zone D)			

14	Level (e.g. 2nd Floor level)			
15	Version/revision			
16	Format (e.g. PDF, DWG)			
17	Date created			
18	Status (e.g. Fit for construction, approved etc)			
19	Description of file content			

13. Generally, how would you prefer to find information?

1		Free text search
2		Browsing
3		Both

14. How would you like to search for a file?

1		File author	11		Project sector
2		Job Number	12		Project location
3		File Category	13		Project Value
4		File subject	14		Zone
5		Company	15		Level
6		Business region	16		Version/revision
7		Office location	17		Format
8		Discipline/group name	18		Date created
9		Client Name	19		Status
10		Project Name	20		Description of file content

15. Any additional comments?

Thank you