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The Risk of Information Management Without Knowledge Management: A Case Study

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Abstract. This paper appraises the criticism that "Knowledge Management (KM) is little more than re-packaged Information Management (IM)" through analysis of the relationships and inconsistencies between IM and KM. This is supported by a case study of the loss of an UK Royal Air Force aircraft known as 'Nimrod' as reported in the Haddon-Cave Independent Review.

The first part discusses the research methodology adopted and analyses the literature including the theoretical characteristics and practical aspects of IM and KM. This is supported by logical models and relationship tables for comparison. The second part develops an analytical framework by applying evaluation criteria, based on principles for Through Life Management of information, to a case study to address the statement that "information is inadequate without knowledge."

The logical models and case study insertions uncovered important conclusions: (1) KM is frequently confused with IM and reliance on IM only can sometimes result in a disaster; (2) it is imperative to understand the distinctions between IM and KM as "management of knowledge" is concerned with socio-technical, hence human, aspects to a greater extent than IM; (3) IM should be considered as a prerequisite to engaging KM; and (4) KM should be perceived as the creation and management of knowledge as a human centred attribute that involves a learning and transformation process.

This paper systematically applies the derived logical models and analysis framework to a case study to better understand and illustrate the implications of Through Life Management of information and knowledge.

Keywords: Knowledge management; information management; tacit knowledge; defence sector; systems thinking; systems analysis.

1. Introduction

This paper critically appraises the criticism that "Knowledge Management (KM) is little more than re-packaged Information Management (IM)." The first part of the paper analyses and synthesises IM and KM through a literature review supported by the development of logical models of the definitions of IM and KM in addition to generating a relationship table to identify the commonalities and differences between these terms. The second part adopts an analytical stance by considering the Nimrod review, also known as the 'Haddon-Cave' report, as a case study to identify the implications of Through Life Management of engineering information and knowledge on such incidents. The Nimrod XV23 is a unique military aircraft that was lost on 2 September, 2006, on a mission over Afghanistan when it "suffered a catastrophic mid-air fire, leading to the total loss of the aircraft and the death of all 14 service personnel on board" (Haddon-Cave, 2009, p. 9). The review investigated the broader issues surrounding the loss of this aircraft. Further details of the review are provided in Sec. 5.1.

This paper concludes by discussing the importance of understanding the relationships and inconsistencies between IM and KM. Following the findings exposed by the logical models, the authors derived an analysis framework and applied this to the case study to understand and illustrate the relationships between chosen definitions through insertions from the Nimrod review.

2. Adopted Methodology

2.1. *Research philosophies*

Collis and Hussey (2003) have identified two distinct clusters of research paradigms or philosophies: (1) Positivistic and (2) Phenomenological. Positivistic research assumes that two independent researchers can arrive at the same conclusion using the standard research methods to study a phenomenon (Bryman, 2001). This, therefore, deals with precise measurements, whereas phenomenological research stresses the subjective aspects of human activity by focusing on the social reality; hence the

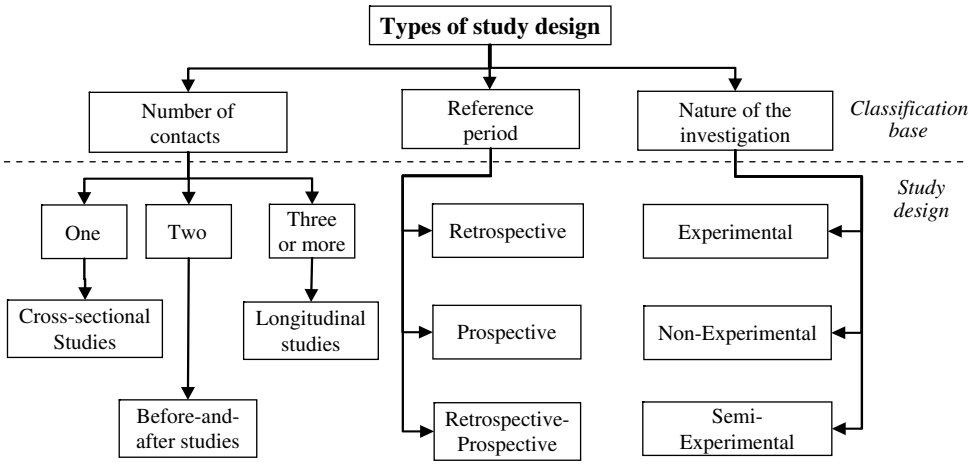


Fig. 1. Types of study design (Kumar, 2005, p. 94).

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meaning rather than the measurement of a social phenomenon (Collis and Hussey, 2003). This paper uses a phenomenological approach and considers an interpretive paradigm as a result of the socio-technical issues and human attributes arising from the case study.

2.2. *Research design and methods*

Research design helps to conceptualise an operational plan to complete a study and ensures "*control of variance*" through adequate procedures including valid, objective and accurate answers to the research questions (Kumar, 2005, p. 84). Determination of the number of contacts, reference period and the nature of investigation is important as shown in Fig 1.

Kumar (2005, p. 98) emphasises that the "reference period refers to time-frame in which a study is exploring a phenomenon, situation, event or problem." Retrospective studies investigate what happened in the past whereas prospective studies refer to likely prevalence in the future. Consequently, retrospective-prospective studies focus on past trends in a phenomenon as a means of studying and predicting likely behaviour in the future (Kumar, 2005, p. 99). This paper investigates a past aircraft incident through analysis of the historical material. Therefore, the current study is a retrospective study that uses a semi-experimental design considering the cause-and-effect relationship centered on management of information and knowledge in the case of the Nimrod crash.

Whilst methodology describes the underpinning philosophical approach to a particular research endeavour, research 'method' refers only to the various specific tools or ways data can be collected and analysed (Neville, 2005), e.g., a workshop, questionnaire; interview checklist; data analysis software, etc. The research methods adopted in this paper are described below:

- ***Literature review, synthesis and analysis*:** examination of IM and KM from different industries and perspectives through consideration of the principles and characteristics of both.
- ***Logical models*:** extraction of the relationships comprising the sentence or definitions of IM and KM to capture the intended meaning for intrinsic consistency and completeness (Dickerson and Mavris, 2009). This approach gives initial insight into the concepts of IM and KM.
- ***Case studies*:** insertion and analysis of the findings from the Nimrod review including the physical and organisational causes from an information and knowledge management perspective. The decoupling of information from knowledge is investigated to address the argument that "information is inadequate without knowledge."
- ***Triangulation*:** utilisation of a triangulation process that uses systematic iterations between literature review, logical models, case evidence, and intuition. This is considered to be relatively useful when the area of study, as in this paper, is 'fuzzy' and multidimensional (Pitt, 2007).

The next section reviews the current literature related to IM and KM.

3. Principles and Characteristics of IM and KM

3.1. *Key definitions: Data, information and knowledge*

As a useful starting point, it is important to consider the distinction that can be made between data, information

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and knowledge. Newell *et al.* (2002, p. 102) argue that data, information and knowledge are inextricably linked and Davenport and Prusak (2000, p. 1) emphasise that these terms are not interchangeable concepts, even though the differences between these terms are "often a matter of degree." It is important to understand the differences to guide the discussion.

Awad and Ghaziri (2004, pp. 33–36) define data as "unorganised and unprocessed facts" and information as "an aggregation of data that makes decision making easier" and knowledge as "understanding gained through experience or study." Little and Ray (2005, p. 132) highlight that it is usual to define information as "data with meaning." Mertins *et al.* (2003, p. 2) argue that the term 'knowledge' is still not easy to define and misunderstanding of the classifications of signals, data, information, knowledge and wisdom can lead to unproductive discussions as a result of the confusing distinctions. The different viewpoints can be due to the domain and context in which these terms are used. Knowledge is accepted as *actionable information* in the business context (Tiwana, 2002, p. 4) whereas knowledge is also defined as "a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information" in a more generic context (Davenport and Prusak, 2000, p. 5). Newell *et al.* (2002, p. 102) consider knowledge from an Information Communication Technology (ICT) perspective and regard knowledge as a means that enables interpretation of data and information. The authors have determined that the definition by Jashapara is the most comprehensive among a large number of definitions analysed, as discussed in Sec. 4.1.

> Data is "known facts or things used as a basis of inference" and hence data depends on context; information is "systematically organised data"; knowledge is considered as "actionable information"; and wisdom is the "ability to act critically or practically in a given situation" (Jashapara, 2004, pp. 14–17).

As the key distinctions between these terms are explained, we can move on to a discussion of the classification and characteristics of information and knowledge.

3.2. *Classification and characteristics of information and knowledge*

Most of the present literature refers to the Hungarian medical scientist and philosopher Michael Polanyi to understand the two commonly known knowledge types: tacit and explicit. For example, Newell *et al.* (2002, p. 3) and also Little and Ray (2005, p. 56) refer to Polanyi (1967) to emphasise that tacit knowledge resides within the individual (know-how) and is difficult to capture e.g., riding a bike, as opposed to explicit knowledge which can be expressed either verbally or in text form hence can be codified e.g., a recipe book. In addition, Tiwana (2002, p. 44) emphasises these two common types in addition to classifying knowledge along four key dimensions: (1) type, (2) focus, (3) complexity, and (4) perishability over time. In contrast, Awad and Ghaziri (2004, pp. 46–47) builds on Polanyi and classifies knowledge by procedural, declarative, semantic or episodic means where episodic knowledge is based on experiential information, or episodes.

Davenport and Prusak (2000, p. 102) discuss knowledge by focusing on knowledge generation, codification and coordination, transfer, and roles and skills. For example, knowledge transfer is characterised in terms of (1) *velocity* which is the speed that knowledge is disseminated, and (2) *viscosity*, which is the richness of the knowledge transferred (Davenport and Prusak, 2000, p. 102). These characteristics of knowledge and consideration of knowledge as a corporate asset have implications on a firm's knowledge capital. If these are compared to the information characteristics as defined by Zhao *et al.* (2007) as part of the Knowledge and Information Management (KIM) project, one can conclude the characteristics of both information and knowledge are not clearly defined. The seven key information characteristics with associated metrics to assist the measurement of information quality or value proposed by Zhao *et al.* (2007) are accessibility, usability, currency, context, accuracy, availability and relevance. Meanwhile Tiwana (2002, p. 45) identifies the components of knowledge as intuition, ground truth, judgment, experience, values, assumptions, beliefs and intelligence. In this case, one can see some differences between the two and conclude that knowledge is more associated with humans whereas information has technological implications.

The above characteristics should not be considered absolute as they entail subjective approaches derived from literature analysis and synthesis.

3.3. *Comparison of IM and KM principles*

Awad and Ghaziri (2004, p. 2) refer to KM as a "newly emerging, interdisciplinary business model that has knowledge within the framework of an organisation as its focus." They emphasise that KM involves people, technology and processes in overlapping parts. Definitions of KM are also presented from selected and classified sources

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to provide an overview of the most important and the most promising approaches of defining KM in terms of proportions such as strategy, technology and organisation (Maier, 2002). The three stages of KM are also identified as (1) intellectual capital; (2) the human and cultural dimensions; and (3) the content and retrievability stage by Koenig and Srikantaiah (2000). The successive key phases of these stages encompass lessons learned, communities of practice, and content management and taxonomies.

KM, which has been defined as "the effective learning processes associated with exploration, exploitation and sharing of human knowledge (tacit and explicit) that use appropriate technology and cultural environment to enhance an organisation's intellectual capital and performance (Jashapara, 2004, p. 12)" can become a key enabler in the context of complex organisations due to the multiple instances of collaboration, co-ordination and cooperation between the stakeholders. Awad and Ghaziri (2004, p. 8) also argue that KM is not based on information because information, which is context-sensitive, can become knowledge which is consensus-oriented after people use it in ways to create value.

Wilson (1997) states that IM deals with the value, quality, ownership, use and security of information in the context of organisational performance. Wilson (1997) also argues that the term IM is defined ambiguously in the literature from the different fields including Information Technology, Business and Management, and Librarianship and Information Science. Whereas, Orna (2004, p. 9) defines IM in the context of information policy as "the implementation of an information strategy in order to meet information objectives within the overall constraints of available resources." Bouthillier and Shearer (2002) tackled the question "is KM an emerging discipline or just a new label for IM?" and concluded that KM is still practical despite the vagueness of KM and its potential overlaps with IM in addition to its weak theoretical base. Their empirical evidence based study revealed that KM cannot be dismissed and further research is necessary to understand how knowledge is developed, gained and used in organisations hence within the society. As opposed to Bouthillier and Shearer's claim that KM overlaps IM, Orna (2004, p. 9) discusses some key differences, i.e. from a 'resources' perspective IM focus on co-ordination of information resources whereas KM is centred on the actual resources of knowledge and skills belonging to the people in the organisation.

Although the hierarchy of data, information and knowledge is well explained, the differences between IM and KM are not well-articulated. The authors, similarly to Orna (2004, p. 15), believe that organisations have to develop their own definitions of what constitutes knowledge and information to understand the elements of their know-how and information in order to decide on how to manage them. The literature review revealed mixed perceptions and reactions centred on IM and KM. Further research is necessary to understand the key differences, relationships and inconsistencies as these are not well-articulated. Logical modelling and assertions from a case study will be used to contextualise how information and knowledge is perceived and managed.

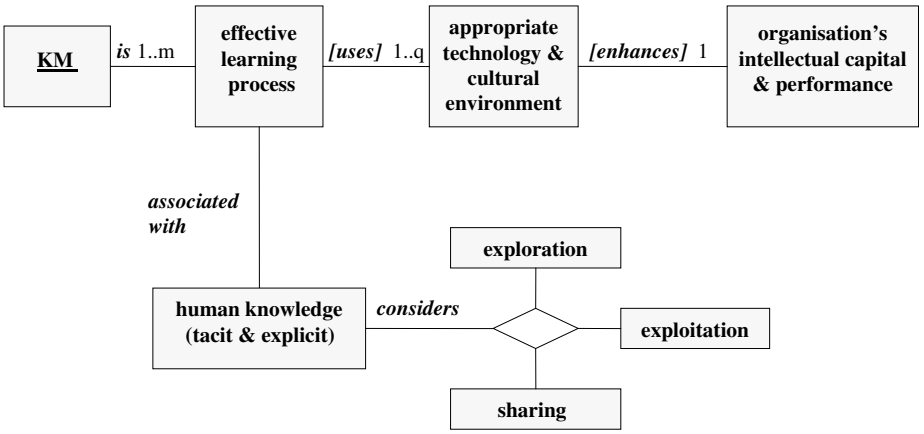
4. Logical Models

4.1. *Logical models of definitions*

Logical modelling can be used to reason about and assess the definitions of IM and KM to explore relationship between concepts, principles and terminology. Dickerson (2008, p. 1) emphasised that the objective of logical modelling is to "extract the relations that comprise the defined term by using a modelling language to derive a minimal model of relations (i.e. one that adds no new meaning) but that is complete and captures the intended meaning of the term (i.e. all intended relations have been captured)." The procedure involves listing all the key words that will be undefined and using a notation from UML (Unified Modelling Language) or SysML (Systems Modelling Language) to determine the relations hence meaning of terms. The natural language notation of this approach is summarised below (Dickerson, 2008, p. 2).

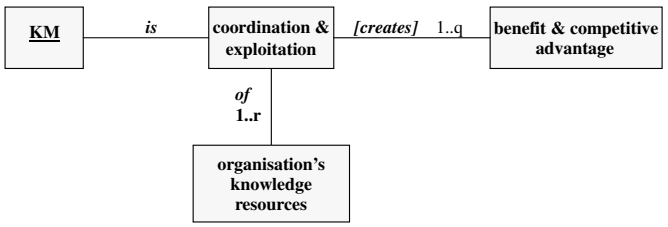
- Each *word in the definition* is italicised except for the defined term.
- The *defined term* is capitalised with bold font or underlined, not italics.
- The *key words* in the definition use: bold font or capitalised italics, not underlined.
- Other *words* in the definition use: bold font or not italics.
- Additional words (not in the definition) use: smaller font or not bold, not italics.
- Graphical notation include nouns which are placed in boxes; verbs and relations are placed on lines; solid boxes and lines are used for key words and other words from definition; and dash-dot graphics are used otherwise.

Logical models and relationship tables were developed to identify and better visualise the commonalities and differences through extraction of IM and KM entities and relationships. Four definitions of KM (Figs. 2–5) and IM



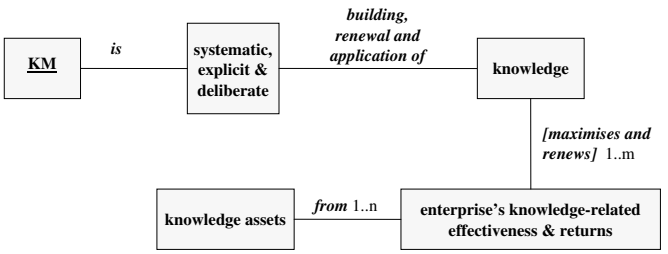
Definition: **KM** is the ***effective learning processes associated with exploration***, ***exploitation*** and ***sharing of human knowledge (tacit and explicit)*** that ***use appropriate technology and cultural environment*** to ***enhance*** an ***organisation's intellectual capital and performance***.

Fig. 2. Logical model for definition of KM by Jashapara (2004, p. 12).



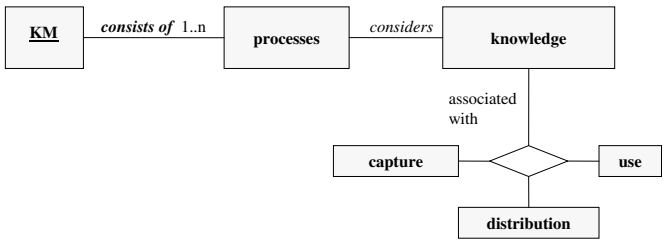
Definition: **KM** is the *coordination and exploitation of organization's knowledge resources, in order to create benefit and competitive advantage.*

Fig. 3. Logical model for definition of KM by Drucker (1999, p. 157).



Definition: **KM** is *the systematic, explicit, and deliberate building, renewal, and application of knowledge to maximise an enterprise's knowledge-related effectiveness and returns from its knowledge assets and to renew them constantly.*

Fig. 4. Logical model for definition of KM by Wiig (1997, p. 401).



Definition: **KM** *consists of processes to capture, distribute, and effectively use knowledge.*

Fig. 5. Logical model for definition of KM by Davenport and Prusak (2000).

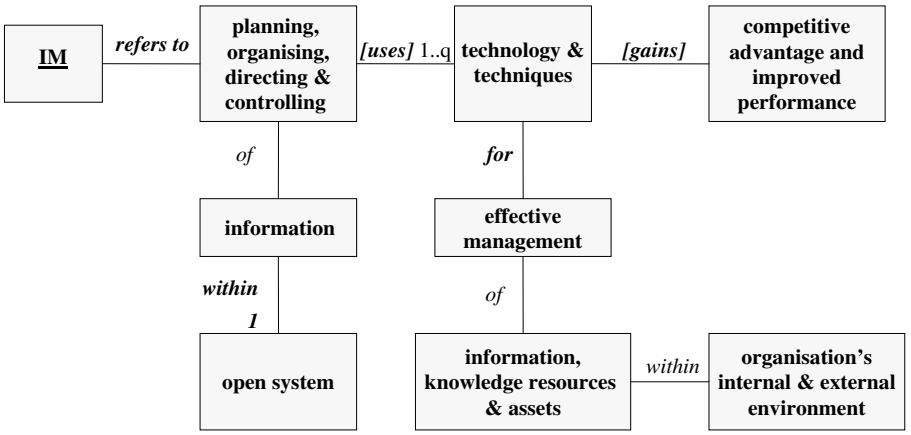


Fig. 6. Summary of the logical model of definitions in Figs. 3–5.

(Figs. 7–10) were considered as a result of the literature reviews. As a result of the analysis of the logical models, the authors decided to compare the rest of the definitions to that of Jashapara (2004, p. 12) as his definition has a different emphasis (Table 1). Jashapara's definition can be perceived as the creation and management of knowledge as a human-centred attribute that involves a learning and transformation process considering the environmental and cultural aspects.

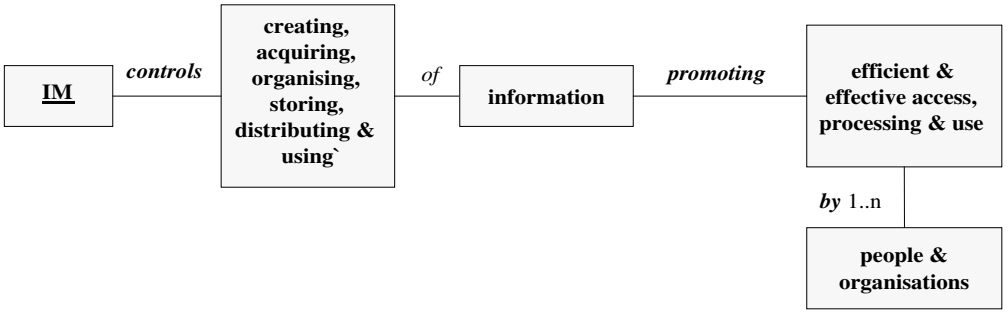
Comparison of Figs. 2 to 3–5 reveal that Jashapara's definition is about the management of knowledge and the rest of the definitions are centred on organising the knowledge resources. Definitions except Jashapara's consider knowledge to be explicit and do not distinguish between information and knowledge. Analysis of these logical models emphasises that individuals and organisations need to clearly state what they mean

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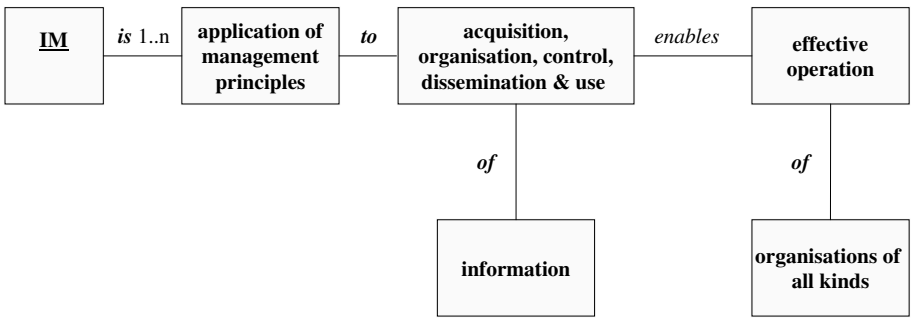
Definition: **IM** *refers to planning, organising, directing and controlling information within an open system, and the use of technology and techniques for effective management of information and knowledge resources and assets within the organisational internal and external environment to gain competitive advantage...*

Fig. 7. Logical model for definition of IM by Karim and Hussein (2008, p. 114).



Definition: **IM** *concerns the control over how information is created, acquired, organised, stored, distributed, and used as a means of promoting, efficient and effective information access, processing, and use by people and organisations.*

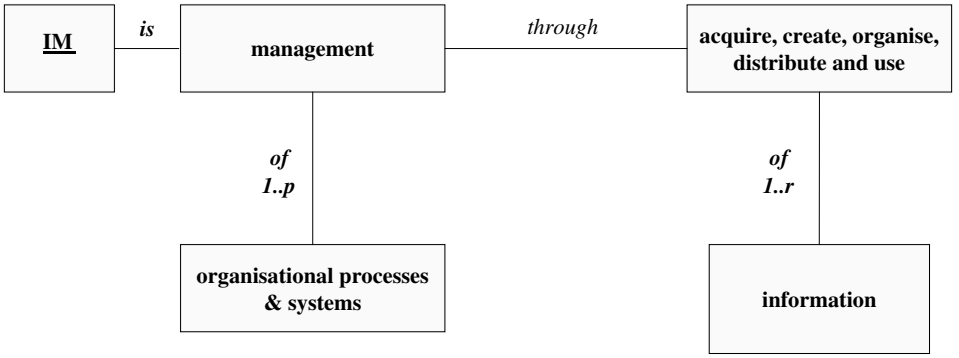
Fig. 8. Logical model for definition of IM by Detlor (2010, p. 103).



Definition: **IM** *is the application of management principles to the acquisition, organisation, control, dissemination and use of information relevant to the effective operation of organisations of all kinds.*

Fig. 9. Logical model for definition of IM by Wilson (1997, p. 187).

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Definition: **IM** *is the management of organisational processes and systems that acquire, create, organise, distribute, and use information.*

Fig. 10. Logical model for definition of IM by Choo (2002).

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by 'knowledge' as knowledge can have different types including explicit and tacit; and include concepts focusing on human, organisational and product-centric issues. The definitions due to Drucker (1999), Wiig (1997) and Davenport and Prusak (2000) in Figs. 3–5 respectively can be reduced to a simple logical model as shown in Fig. 6.

The logical models of IM and their comparison based on four definitions are shown next.

All the above definitions for IM can be reduced to a simple logical model as shown in Fig. 11.

The key learning from Table 1 is that a human-centric view of knowledge is not considered in most of the IM and KM definitions. IM definitions focus on organising, managing and using information to promote efficiency and therefore improve performance. Organisations can be misled as they ultimately manage information as apposed to knowledge ignoring the significance of the human-centric nature of KM including organisational learning, culture and ethics.

4.2. *Interim-conclusion*

Similar to the literature review, the logical models show that IM and KM share related concepts and the outcome of both are similar, i.e. enhancing organisational IC, performance and competitive advantage. Lueg (2001) also reports similar findings as both of the concepts involve collection and dissemination to the benefit of an organisation and its individuals. However, the authors' findings from the logical models illustrate a key difference. That is, IM deals with information (explicit), and KM deals with human knowledge (tacit and explicit). As the table and logical models show, all the definitions for IM are about the organisation of information resources and hence focus on explicit knowledge. However, KM, as defined by Jashapara, is concerned with the human and cultural attributes. This is different from the rest of the definitions as the rest only consider the explicit nature of knowledge. One can argue that these sample KM definitions apart from Jashapara are inadequate as they overlook the learning styles, cultural aspects and tacit nature of knowledge. Hlupic *et al.* (2002) also argue that KM involves both 'soft' and 'hard' aspects. Analysing the logical diagrams and the comparison table can lead to a conclusion that IM deals with more tangible, well-defined and structured facts whereas KM focusses on relatively intangible and ill-defined issues. Consequently, one can approach from a 'systems thinking' viewpoint and associate KM with a 'soft' approach which is more appropriate in fuzzy, ill-defined situations involving human beings and cultural considerations; from a similar viewpoint one may consider IM as a 'hard' approach that deals with well-defined technical problems, and hence involve logical rules to engineer solutions, i.e. data mining. In addition, KM as opposed to IM can be perceived as a learning process that is associated with the creation and management of knowledge through consideration of the cultural environment.

The next section uses insertions from a case study to examine IM and KM further.

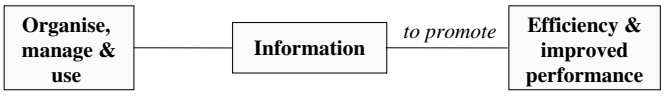


Fig. 11. Summary of the logical model of definitions for IM.

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Table 1. Comparison of Jashapara's (2004) KM definition to others.

	Knowledge management definitions			Information management definitions			
	Drucker (1999)	Wiig (1997)	Davenport and Prusak (2000)	Karim and Hussein (2008)	Detlor (2010)	Wilson (1997)	Choo (2002)
Jashapara (2004) (Differences)	KM defined as a learning process vs. coordination and exploitation of knowledge. Jashapara refers to the technology and cultural environment. Both consider a different concept of knowledge, i.e. human vs. organisational knowledge Drucker only refers to benefit and competitive advantage whereas Jashapara focusses specifically on IC	Type of knowledge considered differs, i.e. learning process (tacit and explicit) vs. building, renewal and application of knowledge (explicit only)	Human knowledge vs. knowledge. Jashapara focusses on creation and tacit nature of knowledge whereas the others consider only management after creation, i.e. the explicit nature of knowledge	Karim and Hussein mention the management of information resources and the use of technology and techniques to enable this whereas Jashapara refers to KM as a learning process considering tacit and explicit human knowledge	Similarly, Detlor deals with organising and management of information to promote efficiency and therefore improve performance whereas Jashapara focusses on people not just organisations	Wilson refers to organisations of all kinds whereas Jashapara refers to humans and also tacit nature of knowledge	Organising and use of information is mentioned again, i.e. management of information including its creation, organisation, distribution, use, etc. whereas Jashapara focusses on the transformation, e.g., learning process
Jashapara (2004) (Similarities)	Both have a specified outputs, i.e. deal with enhancing organisations performance	Jashapara refers to intellectual capital related outputs and Wiig focusses on enterprise return and effectiveness	Both mentioned the word 'process' e.g., one refers to KM as a process and the other mentions that KM consists of processes	Both consider the environment and have an output benefiting the organisation	The process of managing information or knowledge has similarities, e.g., exploitation vs. using, sharing vs. distribution	Same as Detlor — only the 'process of management' have similarities	Same as Detlor and Wilson — only the 'process of management' have similarities

5. Case Study

This section considers the Nimrod review as a case study to identify the implications on Through Life Management of engineering information and knowledge. The loss of the Nimrod aircraft was caused by a leak and ignition of fuel during air-to-air refuelling. This can be analysed through findings related to physical and organisational causes from an information and knowledge management perspective. The decoupling of information from knowledge is investigated to address the argument that "information is inadequate without knowledge." The difficulty of capturing the context in which information is used is also examined.

5.1. *The Nimrod review*

The Nimrod example echoes other major accidents, such as loss of the Space Shuttles Challenger and Columbia, and the King's Cross Fire according to the Nimrod review (Haddon-Cave, 2009). The review exhibits issues such as having an insufficient overall view of the entire system and the unheeded knowledge leading to problems with spotting risks and patterns. The Nimrod played an important role in maritime reconnaissance for over 40 years. The aircraft, XV23, was lost on 2 September, 2006, on a mission over Afghanistan leading to the deaths of 14 service personnel. The board of inquiry conducted a seven-month inquiry investigating the physical and organisational causes. The cross-feed duct fitted in the initial Nimrod in the 1960s design introduced a major potential risk of ignition to the aircraft. According to the 587-page review, the loss of Nimrod was avoidable, and detailed recommendations include a new approach to safety cases, new strategy centred on personnel, industry and procurement, and a new safety culture.

There was a widespread assumption that Nimrod was safe and therefore the safety case became a 'tick-box' exercise due to the aircraft being successfully flown for 30 years. Work was rushed and corners were cut which resulted in a defective product leading to misleading information that the task had been properly completed. Very long procurement chains led to a lack of conceptual thinking at the lower level of the procurement chain. For example, engineers developing parts were not aware of what they were used for. The long overdue replacement of legacy equipment dating back to 1940s technology also played a crucial role. Three major modifications were made to the refuelling system over a few decades. The information relating to modifications was not sufficiently heeded in the following years. The information centred on design flaws, previous incidents, and warnings were not actively assessed and employed. Issues discussed include the problems with interfacing between the customer and industry, lack of corporate memory, use of competent people, use of recognised standards, defining required skills and responsibilities, and having a learning culture.

The causes leading to this accident are examined from an information and knowledge management viewpoint in the next sections.

5.2. *Analysis framework*

An analysis framework is developed as a result of investigating the current approaches for Through Life Management of information and knowledge. This framework is applied to the Nimrod example through identification and analysis of the key insertions from the 587-page Nimrod review.

The approaches considered include the set of principles for Through Life Management of information that was derived in the Knowledge and Information Management (KIM)[1] project as shown in Appendix A. In the context of the Nimrod review, the KIM principles can "focus practitioners on the importance of managing information and knowledge, provide guidance to tool builders on supporting this management, and describe examples of best practice model that can be adopted by organisations" (McMahon *et al.*, 2009, p. 4). In addition, Dogan *et al.* (2009, p. 462) categorised the through life enterprise KM requirements by interacting with domain experts and stakeholders within the aerospace and defence industry (Appendix B). An IM assessment based on a matrix model was developed as a best practise model to ensure that government departments meet the required standards for effective collection, storage, access, use and disposal of information. The purpose of the assessment has been to "establish whether the key elements of the UK Ministry of Defence's (MoD's) knowledge, information and records policy and protocols are effective in meeting the needs of Defence in the twenty-first century" (IMA, 2009, p. 9).

An analytical stance was adopted to derive evaluation criteria supporting this framework. This pragmatic analytical approach considered the KIM principles on Through Life Management of engineering information; and the derived categories of through life enterprise KM requirements as shown in Appendix A and B. The criteria shown below are also aligned to UK Government's information matters delivery plan 2009−2010 which is centred

[1] The KIM project was a three-year, £5 million programme funded primarily by the Engineering and Physical Sciences Research Council (EPSRC) and the Economic and Social Research Council (ESRC) to look at the KM challenges associated with the move towards through-life product support.

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on building government's capability in managing knowledge and information (Stott and Ceeney, 2009).

- ***Criterion* 1 (*Governance*):** developing KM strategy; institutionalising KM; managing ownership, leadership; organisational structure, audits and policy; and succession planning.
- ***Criterion* 2 (*Configuration*):** records management; and capturing, interpreting, communicating, storing, accessing, presenting, representing, keeping and supporting information and knowledge.
- ***Criterion* 3 (*Assessment*):** parsimony; granularity; identity; uniqueness; usability; reusability; evaluation; portability; robustness; discovery; and design.
- ***Criterion* 4 (*Organisational Culture*):** organisational change and behaviours; sharing for advantage; demographics; training; learning culture; social and physical environment; retention of key skills; and trust.

The above criteria consist of a hybrid of the KIM principles and categories of through life enterprise KM requirements as identified by Dogan *et al.* (2009). Application of the analysis framework involved a procedure of examining the Nimrod review to identify insertions associated with the management of information and knowledge. These were then recorded so as to include the area of observation itself, the aspect associated with information, a description of how the area of observation was managed, and the outcome associated with the area of observation. The information tabulated in this way is drawn directly from the Nimrod Report.

5.3. *Findings*

The findings presented below follow the above criteria to structure the key implications as (1) describing the context of the observation within the Nimrod review; (2) the observation verbatim; (3) a table summarising the key insertions from the observation; and (4) discussions to address the argument that "information is inadequate without knowledge."

5.3.1. *Governance*

Governance issues, centred on the Nimrod Integrated Project Team (IPT), include the inappropriate delegation of tasks, e.g., tasks delegated to junior personnel without adequate supervision; unclear roles; and inadequate briefing at critical handover periods. The complexity of the aviation enterprise and successive organisational changes, i.e. overlying structure of the airworthiness regulation and delegation of responsibility indicated a number of weaknesses. Clear lines of accountability with an unbroken and logical delegation from the top through line managers and supervisors were recommended (Haddon-Cave, 2009, p. 570). Another example of a governance related issue is the routine outsourcing of safety cases. The following verbatim statement reflects the problems with delegation and routine outsourcing. Table 2 also examines these observations though analysis of how information and knowledge is managed.

"*The system of Letters of Delegation is imperfect… regulations are too complex…* (*p.* 477, *paragraphs* 19.21 *and* 19.20)."

Haddon-Cave comments on the system of letters that delegates authority for safety and airworthiness to lower ranks without sufficient oversight or monitoring.

"*Safety Cases are routinely outsourced by IPTs to outside consultants* (*p.* 535, *paragraph* 22.7)."

Haddon-Cave observes that Integrated Project Teams outsource safety cases to outside consultants who have insufficient practical knowledge of the aircraft or its operations and, as a result, provide voluminous quantities

Table 2. Governance related insertions from the Nimrod review.

	Observation	Information	Knowledge	How managed?	Outcome
Governance	Lines of accountability (regulations) and delegation	Regulations, practice or procedure being followed, i.e. on maintenance	Expert knowledge of delegated authority and regulations	No short and clear lines or chain of delegation and accountability	Convoluted and inappropriate delegation of tasks and structure of, i.e. airworthiness regulations
	Routine outsourcing of safety cases by IPTs to outside consultants	Voluminous quantities of safety case paperwork	Little practical knowledge of operating or maintaining the platform	No evidence centred on capturing essential practical knowledge; and knowledge and experience about the platform is lost	Decline in skilled and knowledgeable manpower; and long-term corrosive effect on the in-house abilities

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of paperwork that lacks the underpinning understanding to achieve the necessary quality.

The IPT's decision on some modifications was based on an imperfect understanding of the completeness of the hot air leak detection system. Routine outsourcing and delegation played a significant role. A holistic view supported by the contextual knowledge of engineers maintaining the system rather than depending entirely on explicit information is very important in this context. Practical knowledge of experts as opposed to using voluminous quantities of regulatory and safety case documents to make decisions indicate that importance of tacit and contextual knowledge and support the arguments that information, in this case, had become inadequate without knowledge.

5.3.2. *Configuration*

The configuration criterion focusses on records management including how information and knowledge is captured, stored, communicated, accessed, etc. Considering the Nimrod example, the mis-categorisation and classification of risks and hazards (e.g., tolerable when it was not) contributed to the incident as reflected in the following verbatim statement and Table 3:

> "*Mis-categorised Hazard H*73 (*the catastrophic fire risk represented by the Cross-Feed/Supplementary Conditioning Pack duct in the No.* 7 *Tank Dry Bay starboard*) *as 'Tolerable' when it plainly was not, and then marked it as 'Open' and 'Unclassified'…* (*p.* 260)."

Another insertion shown above refers to "not living documents." These are safety cases that languish on shelves or "stored in places or databases which are not readily accessible to those on Front Line who may benefit from access to them" (p. 35). Multiple upgrades lead to re-engineering at each incremental modification and the cumulative effect of design and installation changes to parts were not recorded properly or ignored in some cases. For example, some of the in-house management of the Maintenance, Repair and Overhaul (MRO) service, i.e. major upgrades are contracted to the industry but they require facilities and skills to minimise the configuration problems. The insertion above reflects the importance of appropriate management and delegation that focus on configuration, i.e. accessibility to information. Another example is the deficiency in fault recording including capturing evidence to mitigate the key dangers. A known history of damaged parts, e.g., seals of the fuel system existed. The importance of detailed recording of data and information and plans on future use were not understood during the system modifications. Therefore, configuration should not entirely focus on organising and using explicit representations as the lack of expert knowledge, i.e. to categorise risks and recoding data for future use, needs to be considered when handling information. This again emphasises the adequacy of knowledge in this context.

5.3.3. *Assessment*

Assessment focusses on using the KIM principles of Through Life Management of engineering information to analyse, i.e. evaluation, portability and robustness of information as described in Appendix A. This is closely associated to configuration and therefore explicit knowledge. The assessment insertions from the Nimrod review include the assessment of design regulations and standards in addition to consideration of the history of incidents. For example, the air-to-air refuelling modification was in breach of applicable design regulations and standards (Haddon-Cave, 2009, pp. 57–58, 107, 128). That is, the blow-off valves were located at positions where discharge of fuel

Table 3. Configuration related insertions from the Nimrod review.

	Observation	Information	Knowledge	How managed?	Outcome
Configuration	Categorisation of risk and hazards	Risk analysis data	Lack of expert knowledge to categorise	Inappropriately managed by unsuitable delegation and failure to check own safety management plan	Mis-categorisation of risks
	Not living documents	Safety cases documents	N/A	Information related to safety cases suffered on shelves and access to databases was problematic	Inaccessible information

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Table 4. Assessment related insertions from the Nimrod review.

	Observation	Information	Knowledge	How managed?	Outcome
Assessment	Known history of damaged parts, e.g., fuel pipe leaks	Guidance on leak rate	Insufficient overall view of the entire system and unheeded knowledge	No sufficient efforts to analyse the underlying causes of leaks and guidance to reduced the leak rate	No consolidation and assessment of history of risks
	Assessment of design regulations and standards	Documents on design regulations and standards	Establishment of a safety directorate to take responsibility	Legislation/ regulations did not sufficiently exist to ensure that minimum standards are maintained	Breach of applicable design regulations and standards, i.e. on flammables and cross-feed ducts

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Table 5. Organisational culture related insertion from the Nimrod review.

	Observation	Information	Knowledge	How managed?	Outcome
Organisational culture	Maintaining expert and corporate knowledge	Records on capturing knowledge of personnel retiring	Loss of (tacit) knowledge when experienced staff retire	No retention and transfer of knowledge i.e. sitting with NELLIE or a buddy system	Decline of expert and corporate knowledge
	Multifarious organisational change	Increasing documents on organisational and procedural changes	Institutional memory is lost as personnel or records are moved and replaced	Organisational and cultural changes were not easy to put in practice	Re-organisation trauma and distraction from safety

could pose a fire hazard. The fuel pipes were also located close to high pressure hot air ducts. In addition, there was no significant assessment of historical data about known incidents. For example, a history of fuel leak rates was known but information was not heeded as emphasised in the following verbatim statement and Table 4:

> "*There was insufficient emphasis on analysing fuel leak trends and, as a result, the four-fold increase in leak rates went unnoticed* (*p.* 66) *…increase in the leak rate in the Nimrod fleet in the* 23 *years before the XV*230 *accident…*(*p.* 86)"

The above insertions show no significant assessment and reuse of information about failures and maintenance. Although leaks from seals are inevitable and the systems design principles are used to mitigate against leak hazards, the critical information centred on routine fuel leaks was not captured and shared properly. Furthermore, the safety-related decisions mentioned above require maintenance of comprehensive records in addition to management of expert knowledge throughout the life of a platform. For example, the fuel pipe leakage was rated as 'improbable', that is remote likelihood of occurrence during the operational life of a particular fleet. Such ratings and hence assumptions lead to no comparison of historical leaks until after the loss of this particular Nimrod. This is not a simple access and assessment of information issue but rather a problem associated with unheeded expert knowledge. Information on its own is inadequate in this example.

5.3.4. *Organisational culture*

Dogan *et al.* (2009, p. 462) categorised the through life enterprise KM requirements and identified attributes (i.e. change, training, learning, trust) that relate to organisational culture via interacting with domain experts and stakeholders within the aerospace and defence industry

(Appendix B). These finding are used to assess management of information and knowledge within the context of organisational culture. In the case of the Nimrod review, expert knowledge was lost as a result of successive modifications to fuel systems and re-organisation trauma. This also led to a lack of corporate knowledge as reflected by the following verbatim statement and Table 4:

> "*There was a corresponding lack of corporate memory as to related incidents which had occurred in the past* (*p.* 149) *…theoretical, design, office-based experience is a far cry from the invaluable practical, hands-on experience that those flying or maintaining…* (*p.* 270)."

Another example considered is the learning culture (Haddon-Cave, 2009, p. 574), i.e. no professional body of training for competence management was in place. Learning from operational experience, e.g., sitting with NELLIE or a buddy system to transfer knowledge from experienced employees to newcomers could have helped the engineers to understand the context of modifications better.

A re-organisation trauma and distraction from safety was caused as a result of multifarious organisational change including a shift from purely functional to project oriented lines, outsourcing to industry, and loss of competent knowledge through defence reviews and financial cuts. The 'rolling up' of organisations to create larger and larger 'purple (tri-service)' and 'through life' management structures also contributed to this trauma (Haddon-Cave, 2009, p. 11). The tacit and human-centric nature of knowledge as opposed to simply organising the information resources (i.e. documents) needs to be understood and acknowledged by organisations. The inadequacies of only managing information in such situations needs to be understood.

6. Discussion

This paper tackled the relationships and inconsistencies between IM and KM. This was investigated from two perspectives; the first was to consider the definitions from the literature and the second was to explore the importance of the relationship through a case study. The first approach investigated different perceptions of IM and KM and was centred on consistencies and/or inconsistencies in the relationships. Having shown that, once properly defined, IM and KM are different concepts, the authors applied the concepts to the Nimrod case study to understand the relationships between IM and KM so defined.

The findings show that an overreliance on IM in the absence of KM can lead to disaster. Where KM is little more than repackaged IM the risk of misusing available information is increased. The authors comment that it is important to consider KM to be the "management of knowledge" and to value the tacit (human) knowledge that is implied thereby. The insertions from the Nimrod review, analysed above, are examples of information being used inappropriately because the necessary knowledge for its correct interpretation or implementation was missing.

Turning our attention to the derived analysis framework and Nimrod findings, the following examples emphasise that this is not only an information management matter but a "management of knowledge" issue paying particular attention to complexity and the tacit nature of knowledge.

- *Routine outsourcing and short-term two-year postings*: this had a detrimental effect in capturing essential practical knowledge of employees operating and maintaining the platform. This also influenced employees' ability to make lasting and positive difference whilst in post. The lack of vital operator and maintainer input and contextual understanding of the current practices contributed to the loss.
- *Problems with 'aged' legacy systems, attention to skills and decline of corporate knowledge*: the pool of engineers with the requisite specialist engineering skills who understood the corporate knowledge and records has diminished due to people retiring or moving to attractive jobs. Procedures should be put in place to retain skills on aged aircrafts.
- *Decline in the ability of the customer to act as an 'intelligent customer'*: the contextual knowledge of the customer is faded due to problems with retaining skills and experience of its employees as a result of organisational change.
- *Not living documents*: information related to safety cases suffered on shelves. Access to databases from front line employees and the data management processes was problematic.
- *Ownership and management of information related to risks and hazards*: suggestions were made to ensure that there is one owner who is responsible for collating information for each hazard. Analysing hazard descriptions to avoid misinterpretation was also recommended.
- *Sharing of best practice*: website and articles discussing and drawing attention to best practices focusing on safety can guide knowledge sharing.

The assertion and reasoning behind why information and knowledge become decoupled required in depth analysis of insertions. The framework including the criteria and the insertions table was derived through an analytical stance

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by evaluating the existing approaches. One can critique the analysis framework as it has not been validated through other case studies but the emphasis of this approach was to derive insertions to study the interdependence of knowledge and information management to guide the discussions. Additional work is required to analyse the policy, process and practice implications of using this analysis framework in helping to prevent such disasters.

7. Conclusion

Analysis of the literature generated arguments for and against the criticism that "KM is little more than re-packaged IM". For example, one can notice two main perspectives: (1) KM is more tied with socio-technical hence human aspects, and (2) IM and KM have overlapping parts that consequently complement one another. Other viewpoints also need to be considered as both IM and KM deal with very complex and rich situations involving people, technology and organisational processes. The authors also believe that it is helpful to considering IM as a prerequisite for KM. The Nimrod case study revealed that the use of criteria centred on principles for Through Life Management of information and knowledge to asses the role of IM and KM in such incidents can help to identify and understand the areas and functions that needs to be improved in a through life enterprise setting. The examples derived confirmed the importance of context, human expertise and the tacit nature of knowledge in preventing such incidents in a complex socio-technical environment. Managing knowledge is distinct when compared to IM. Through IM the value is sometimes lost, which can result in disasters such as Nimrod whereas through "*managing knowledge*" the socio-technical implications including the learning and transformation process are addressed. The case-based study provides support that the hypothesis was correct and hence KM is little more than re-packed IM.

The assertion and reasoning behind why information and knowledge become decoupled required in depth analysis of insertions. Consistent with Jashapara's definition, the authors consider KM as the management of knowledge as a human centred attribute that involves a learning and transformation process considering the environmental and cultural aspects to provide competitive advantage through enhancing an organisation's intellectual property and performance. To conclude, a similar assertion is also cited in the Nimrod review:

"*THE ONLY SOURCE OF KNOWLEDGE IS EXPERIENCE*"

(Albert Einstein, 1879–1955) (Cited in Haddon-Cave, 2009, p. 445).

Appendix A: Principles for Through Life Management of Information (McMahon *et al.*, 2009).

Principle 1. (The Principle of Parsimony): create record and retain information only if necessary.

Principle 2. (The Principle of Granularity): record information in a storable information object at a granularity appropriate for use and reuse.

Principle 3. (The Principle of Identity): give an information object a unique and persistent identifier.

Principle 4. (The Principle of Uniqueness): create an information entity once only and explicitly reference it everywhere else.

Principle 5. (The Principle of Usability): design an information object explicitly to achieve its intended goals.

Principle 6. (The Principle of Reusability): design an information object explicitly to maximise its potential for reuse wherever appropriate.

Principle 7. (The Principle of Evaluation): assess and assign the value of an information object throughout its life from creation to disposal.

Principle 8. (The Principle of Portability): create an information entity and its annotations systematically using representations supporting perpetual reuse.

Principle 9. (The Principle of Robustness): use robust methods to capture, create and manipulate information entities.

Principle 10. (The Principle of Discovery): actively employ the information repository as a resource for learning and discovery.

Principle 11. (The Principle of Design): design all aspects of IM to satisfy the organisation's current and future needs.

Appendix B: Categories for Through Life Enterprise KM Requirements (Dogan *et al.*, 2009).

KM Strategy	Organisational Culture
Knowledge capability	Trust
Institutionalise KM	Competencies
Governance/ownership	Retention of key skills/expertise
Funding/investment	Social and physical environment
Management structure	Learning culture/experience
Leadership/champion	Change

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(*Continued*)

KM Strategy	Organisational Culture
Succession planning and career paths	Sharing for advantage Language — meaning/usage
Transform tacit knowledge into explicit	Demographics Education/training Creativity

Knowledge Assessment	Knowledge Configuration
Knowledge about knowledge	How and what to capture?
Information distillation	How to interpret knowledge?
Cumulative property	How to communicate?
Time (freshness/staleness)	How to store and what to store?
Risks	How to access?
Value proposition	How to present or represent?
Maturity	How to choose what to keep?
Scale	Security or privacy
Rigour	Ontology
Quality	Support mechanism
Accessibility	
Capacity	
Lifecycle of knowledge	

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