

The Dissemination of Knowledge in Manufacturing Enterprises Using Intranet Based Knowledge Management System: An Example

N. Buniyamin and Z. Mohamad

Abstract — This paper reports the findings of research undertaken to investigate and improve the utilisation of knowledge in manufacturing enterprises based on literature reviews and case study carried out in a manufacturing enterprise in the United Kingdom. The research provided the evidence for 1) the need to manage, classify, categorise and map process knowledge and 2) the need for a Knowledge Management System (KMS) designed specifically for manufacturing enterprises based on knowledge mapping of the company's intranet to enable the timely exploitation, generation and re-utilisation of process data, information and knowledge. In addition, a prototype Knowledge Management System (KMS) designed specifically for manufacturing enterprises based on knowledge mapping is described. Further, an overview of knowledge management, knowledge mapping and a discussion of how manufacturing enterprises could be supported in the implementation of Continuous Improvement (CI) projects by efficient re-utilisation of knowledge via knowledge maps embedded with best practices and standard procedures is presented

Index Terms — Knowledge Management, Continuous Improvement, Manufacturing Enterprises, Knowledge Mapping

I. INTRODUCTION

In today's competitive world, manufacturing companies are required to perform at the limit of their performance of their performance capabilities in order to meet the demand for high quality products produced at minimum cost and very fast turn-around on orders. Due to the intensely competitive manufacturing environment, manufacturing managers are faced with the challenge to develop finely tuned, highly adaptable process capable of meeting the cost, quality, variability and time pressures imposed by the marketplace[1-3]. As a consequence, manufacturing organisations introduce and implement various systems, software and CI projects on the shop floor in order to improve process and machine performance with objectives to reduce manufacturing lead time and the achievement of a high level of process control. This phenomenon creates manufacturing organisations rich in process data, information and knowledge. The importance of re-using and sharing of organisational information and knowledge is now recognised and Knowledge Management Systems (KMS) have been identified as a tool that can provide competitive advantage to manufacturing organisations [4-6];[3] by enabling the diffusion of knowledge throughout organisations especially internet based KMS utilising knowledge maps [7-10].

Norlida Buniyamin is with the Faculty of Electrical Engineering, Universiti Teknologi Mara Malaysia, Shah Alam, Selangor, 40450, Malaysia (phone 603-55436082, email: nbuniyamin@salam.uitm.edu.my).

Zainuddin Mohamad is with the Faculty of Mechanical Engineering, Universiti Teknologi Mara Malaysia, Shah Alam, Selangor, 40450, Malaysia (email: zainuddin1@salam.uitm.edu.my)

As more knowledge and information is created, knowledge overload is now a problem face by many manufacturing enterprises due to not only the large volume of data, process information and knowledge generated daily but also that most organisations do not give enough attention to the termination of knowledge or to get rid of knowledge no longer useful or obsolete. A literature review and two case studies [5;11] have revealed that due to the high volume of data and information created, knowledge has been lost and not fully utilised in manufacturing organisations due to the lack of a formal structure to retain and promote the re-utilisation of existing information and knowledge. This indicates a need for a KMS to enable timely exploitation of process knowledge to improve both manufacturing capabilities and re-utilisation of organisational knowledge assets. Thus, a KMS in manufacturing organisations can be designed to be used to a certain extent as a performance monitoring system. A KMS will also create opportunities for other personnel to learn and thus improve the learning curve of the organisation at a faster rate [7;3].

Although the number of case studies that describe KMS implemented in organisations [12-14; 3;10] have increased in recent years, there does not seem to be any widely or generally accepted KMS framework or methodology for development or implementation of a KMS in an organisation especially a KM framework for manufacturing organisations [5;15]. However there are currently a growing number of researchers [for e.g. Beckett [16]; Jang[17]; Keane[18]; Kim[14]; Danskin[3]; Perez-Araos[10]) that attempt to link the use of process knowledge and KM to improve an organisation's manufacturing capability but the proposed systems has been found inadequate, especially as a tool to trigger the use of process knowledge to drive the implementation of CI within a manufacturing enterprise. For example issues such as how to link and present process knowledge in a manner that provokes

or drives users to use, share and seek new or related knowledge has not been well addressed. The maintenance of the KMS, the identification of the type of knowledge to be kept and the utilisation of the KMS content within a time frame is an important issue that has also not been significantly addressed [5].

II. KNOWLEDGE MANAGEMENT SYSTEMS

KM evolved from the practice of information management and the quality movement[19-20]. It is now accepted and widely practiced where its usage has realized benefits [20-23] KM is now also widely acknowledged as one of the most important factors for corporate competitiveness and recognised as a long-term strategic field [24-26;12;5;3]. It can thus be concluded that KM will become more significant in the future and will play an important role to enable a company to be competitive in the global market.

KM researchers usually categorise KMS by their strategies, processes or the functions. From the numerous definitions of KM processes, four basic KM processes or functions can be identified which are, knowledge creation, knowledge storing/retrieving, knowledge transferring, and knowledge use [27], although the name may change slightly for the same process from different researchers. [Refer to Davenport [21]; Balasubramaniam [28]; O'Dell [29]; Ribiere [30]; Stenmark [31]; Lee [23] for more details]. Similarly there are many definitions for data, information and knowledge and they are usually vague, imprecise and the relationship and interaction between the three entities have not been sufficiently covered [26;32]. For the research presented in this paper, the following definition for KM was accepted and the following terms and the relationship between the three entities (as depicted in Fig. 1) are defined based on the findings of Newman, Davenport, Armistead and Keane [33;2134;18].

“Knowledge Management can be viewed as strategies and methods of identifying, capturing, and leveraging knowledge to help a firm compete”. [29].

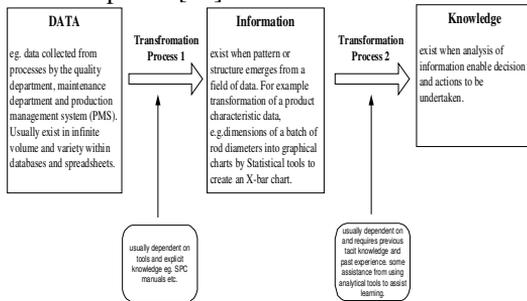


Fig. 1. Definition & relationship between data, information & knowledge.

From a KM benchmarking study, O’Dell [29] identified that the transfer of best practices is a key strategy practiced by all companies involved in the study. Best practice seems to be the most popular strategy and has been reported to contribute to successful KM implementation by several other researchers. For example, Johnson [35] reported that Texan Instrument (TI) successfully established a best practice sharing programme implemented in March 1995 to globally communicate best practice and knowledge sharing. The main reason for the popularity of best practice strategy could be that best practices can easily be described in an explicit form (in the form of explicit knowledge, which could be diagrammed in posters or described in manuals) and easily shared via the intranet. In the proposed KMS as described in section 6.0, best-practice knowledge sharing will be an important feature as it can contribute significantly to CI when implemented.

I. KNOWLEDGE MAPS

Researchers from various fields have identified Knowledge Maps (K-Maps) as a feasible tool or method to co-ordinate, simplify and navigate through complex information silos [36-37;7;8] K-Maps or knowledge cartography is a graphical representation of the intellectual and knowledge environment in an organisation to enable an employee or teams to

understand and utilise knowledge that is readily available in an organisation [38]. K-Maps have the same function as a geographical map. It can be in the form of an actual map or a cleverly constructed database which points to knowledge but it most cases does not contain knowledge. A knowledge map thus is a tool that guides or aids navigation through knowledge [39-40; 36].

Knowledge mapping can thus be accepted as a consciously designed communication medium using graphical presentation of text, stories, models numbers or abstract symbols between map makers and map users [36]. K-Maps usually define knowledge within particular areas of interest, using different formats and conventions. They identify particular concepts and how those concepts link together [41;38]. The use of K-Maps is an important feature within the Manufacturing Knowledge Management System (MKMS) proposed in this paper, as it is able to fulfil the requirement to make knowledge within a company’s intranet visible and easily readable by humans.

A. Knowledge Maps for an Organisation’s Intranet

The widespread image of the intranet is that of a repository of unstructured information and a useful tool that enable users to locate and interact with each other [32;57]. Thus the intranet enables individuals and organisations to communicate and have access to information, and knowledge consequently creating the opportunity to generate new knowledge [26]. Scott [42] did an analysis of reported implementations of intranets and generated a theoretically based model relating organisational knowledge to the intranet phenomenon and found that ‘An intranet is a “powerful tool” for institution-wide communications, collaborative projects, and the establishment of a sense of community on a manageable scale’.(Scott 1998)

The characteristics and capability of the intranet to connect employees and as a storage and sharing media, makes it a useful tool or media to implement a KMS. The fact that the existence of the intranet is now common makes it more attractive as no additional large sums of funds will be needed to implement the KM system within the company's intranet. This opportunity has been recognised by many organisations and there are currently many web based KMS implemented in organisations. Refer to Baladi [43], Lee[23,] Lewis [13]and Perez-Araos [10] for examples of web-based KMS.

Most world-class companies now have intranet systems within their organisation that are in general knowledge rich. The main function of a company's intranet is to aid and support knowledge sharing and communication across the organisation. Cottam [41] found that the main limitation for large knowledge rich websites on the intranet is that existing tools are not able to treat the knowledge rich website as a separate entity and that they lack the ability to support partitioning and organisation of knowledge. Cottam's findings were corroborated by results from the case study that included the investigation of a company intranet websites. The case study company's intranet website is intensely knowledge rich but the knowledge is stored in various databases and separate program storage areas which makes the knowledge invisible and thus inaccessible. The investigation revealed that data and knowledge utilization and storage within the company is inadequate and scanty. Most data that has been collected for example via SPC (Statistical Process Control) implementation have usually been filed away and not been fully utilized to drive CI especially on the shop floor. Improvements carried out within the company, for instance through projects carried out to improve set up times and quick change over on the shop floor is usually not well documented nor stored in a structured and logical way, thus risking the loss of this new knowledge when personnel retire or resign. The investigation

also showed that several actions and investigations for example capability studies (CS) of machines had to be repeated, as reports were lost due to poor or lack of storage structure. Most reports were in word documents or excel sheets filed in various folders within a general storage area on the company's intranet server. There are very few or no procedures to assist users in naming and filing reports. Important reports are sometimes filed on a user's personal hard disk only making the knowledge within virtually non accessible. These files, and thus the knowledge within, are then forgotten and eventually lost.

Knowledge also tends to accumulate and a high percentage of the accumulated and generated knowledge is not used or minimally utilized which makes its collection and storage a burden rather than an asset. A large amount of data and information that is no longer useful or obsolete is also usually kept within an intranet website as there is no formal procedure to terminate or get rid of the knowledge no longer useful. This investigation showed a need to identify which information or knowledge should be kept or terminated and that there is also a need for a tool such as K-maps to render the knowledge on the intranet visible and thus accessible by enabling easy navigation.

The case study also revealed the need to enable the visibility and navigation of knowledge and also to promote its use to support the implementation of CI projects to enable the company to remain competitive. It also revealed that existing knowledge and best practices on the shop floor were not adequately shared within departments or process lines due to poor dissemination. Thus, k-maps was chosen to be use within or closely with a KMS. These two terms are at times interchangeable as a K-map could itself be considered as a KMS if it is designed not only to aid visibility and navigation of knowledge but also to support and promote the use of knowledge by embedding procedures (and thus knowledge) within the maps itself, that is, it also provides

the knowledge.

II. SHELF LIFE OF MANUFACTURING PROCESS KNOWLEDGE

Manufacturing enterprises generate information and knowledge at a high rate [5]. New knowledge or information needs to be exploited within a certain time frame as knowledge within a manufacturing environment; especially knowledge linked to the manufacturing process is usually highly affected by time limits. Some manufacturing knowledge must be exploited quickly as it is generated for it to be useful as it will be rendered useless within days or weeks. The time span varies from days to years. Siemieniuch [44] calculates that in 50 years, only 3% of today's manufacturing knowledge will still be relevant. Even if this calculation is not wholly accurate, it can be concluded that there will be a significant amount of knowledge, which will become obsolete and thus should not be retained within an organisation to avoid the burden of storage.

If process knowledge which usually has a relatively short life span were not exploited within its useable timeframe period, the exploitation or use of the knowledge may not contribute as much to process improvements and the overall plant production productivity [5]. An engineer for example, who has both tacit knowledge, access to explicit knowledge and also current SPC control charts, could make better and faster decisions to implement improvements or changes on the current process to prevent the manufacturing of bad parts or parts out of specification. In this example, the engineer generates new knowledge from information obtained from SPC charts. The issue is not only what and how much knowledge should be made available but also how long information and newly generated knowledge should be kept and when should it be acted upon. The example above illustrated the need to identify the time frame or how long should SPC charts be kept by evaluating its usefulness within a timeframe.

A second problem that caused data not to be fully utilized is because departments within a company tend to work in isolation with poor communication across the functional boundaries [5;3]. Data and knowledge is not shared thus the potential of new knowledge created in one department that could improve the operations of another department is lost. By using the intranet as a platform for a KMS, it is planned to improve and promote the sharing of knowledge across departments to enable better and faster decision-making, by using standard process maps. The use of the intranet to promote sharing of data is well accepted. For example, Chang, Pyzdek and Thompson [45-47;10] found that the Internet and Intranet as a useful tool to share SPC and quality data and the distribution of knowledge between internal departments within a company.

III. RESEARCH BACKGROUND

The design of the MKMS (Manufacturing Knowledge Management System) presented in this paper was based on findings from literature reviewed and a case study research. The research was conducted in a car transmission manufacturing plant established in 1964 in Liverpool in the United Kingdom to produce and assemble light, medium and heavy car transmission. The plant operates on 3 shifts a day with approximately 750 machine tools and 700 production operators [5]. The main goal of this research is to develop a KMS that will improve the management of process knowledge that exist and is created in manufacturing enterprises. An empirical research approach was also carried out to:

- investigate and identify the type, categories and how knowledge is currently utilised, shared, stored and managed on the shop floor. This lead to an insight of how personnel from different departments interact and learn from each other when executing CI processes.
- identify the types and categories of knowledge used and created on the shop floor that will contribute

substantially to a manufacturing enterprise's competitiveness.

- to explore the usage of CI process and how to support and drive its implementation within the enterprise by making knowledge easily accessible within the organisation.

The triangulation of data sources collected via four proven data collection methods or techniques that are commonly used for collecting evidence in case studies [48-49] was adopted in this research. The methods were:

- Observation ■ Documentation
- Participant and observation ■ Interviews

The majority of the personnel that were interviewed in the study are from the production, quality control, finance and human resource departments. Examples of interviewees are the production control supervisor, a manufacturing engineer from each production line, two continuous improvement coordinators, process line superintendent etc.

1) *The Case Study*

The long-term objective of the proposed MKMS is to enable the management and interpretation of data, information and knowledge extracted from shop floor data, stored in a structured manner to allow easy access and sharing to support decision making. A well-designed KMS will for example, enable or facilitate information to be easily interpreted (thus creating new knowledge), access to tacit knowledge (which had been converted and stored as explicit knowledge) and the storage and retention and termination of knowledge. Termination of knowledge is important to avoid overloading the system with obsolete data and knowledge. It is hoped that a better utilisation of data, information and knowledge will contribute and support the drive to implement CI projects on the shop floor to

improve production process efficiency. To achieve the above, there is a need for a KMS framework designed specifically for the manufacturing environment. The knowledge base can be populated from on-going and future projects during normal production operations.

Although the notion to capture all knowledge within an organisation is appealing to many people, the literature reviewed by Hunt [50]; Cottam [41]; Kim [14] and the case study, demonstrated that the capturing of all knowledge is not only impractical but would also require a large amount of resources. Knowledge acquisition is expensive. Not all knowledge contributes to an organisation's competitiveness or if there is contribution, it is not of equal value. Thus identifying the appropriate knowledge to capture and limiting the amount of knowledge (without losing critical knowledge) that needs to be captured and mapped is an important issue.

B. What to capture and manage

The Process Knowledge Acquisition Framework (PKAF) developed based on the findings of the research is shown in Figure B. As depicted, in order to identify knowledge that could increase its competitiveness, an organisation should first identify strategies to achieve its goals and vision. For manufacturing enterprises these goals are usually to become more competitive by reducing production cost and improving product quality [5]. As a consequence, most of the strategies would be to improve production processes by implementing various quality improvement techniques and strive for improvement by implementing CI projects. The improvement from the implementation of these processes needs to be evaluated and if strategies are realised due to these CI processes, the knowledge created that has been proven useful should be embedded into the organisation so as to further enhance the organisation's capability. A KMS is thus required to promote the re-utilisation of this knowledge especially knowledge that is gained

from operational learning which has been shown to substantially contribute to an organisation's capability [5].

When a KMS framework is designed based on and around the PKAF, the framework controls or limits the amount of knowledge that needs to be managed while still ensuring that the core knowledge required to enhance an organisation's competitiveness in not lost but is embedded into the organisation thus enhancing its capability.

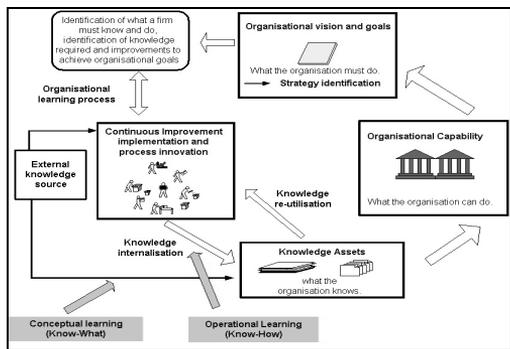


Fig.2. Process Knowledge Acquisition Framework (PKAF) for manufacturing enterprises.

IV. MKMS- MANUFACTURING KNOWLEDGE MANAGEMENT SYSTEM

The MKMS was designed to manage knowledge acquired based on the PKAF thus ensuring that the system focuses on the management of the core knowledge that has a high probability of contributing to the competitiveness of a manufacturing enterprise. The case study findings showed that a KMS has to manage two categories of knowledge and satisfy requirements of two types of users. One category of knowledge is knowledge that is used in day-to-day operations (as requested by technical users) and the other is long term knowledge i.e. knowledge that substantially effects the organisation's capability and future directions (as required by managerial users)[5].

From the above and combined with findings from the literature reviewed it can be concluded that a KMS will be more manageable and its success probable if it is

designed towards meeting the needs of the two groups of users. The knowledge and information as required by the two groups of users must be linked so as to enable the users to migrate from long term KM (organisational) to short term KM (process knowledge) when necessary. This will ensure less complexity in the categorisation methodology and make it easier to assign privileges and rights to users to gain access to specific knowledge and also to update the knowledge. The system developed is mainly targeted for use by personnel involved in the manufacturing process, which includes not only the day to day operations but also the implementation and execution of improvement and innovation processes to the actual manufacturing process and production area. The main target users are the manufacturing engineers, quality engineers and process line supervisors as well as any personnel involved in improvement processes. As a consequence, the MKMS framework is not only designed to map and store improvement processes but is designed to enable the support of day to day operations. This additional function of the MKMS is based on the findings from the case study and from the literature review which revealed that one of the main reason that existing KMS fails is due to users not using the system as it does not relate or integrate into the normal or day to day working practice [22;51]. Thus the MKMS could also to a limited extent support the day to day manufacturing operations by making data and knowledge easily available to provide support to technical staff in decision-making related to process manufacturing issues.

The MKMS is divided into two main sections. The first is where the users can easily access knowledge (e.g., how to carry out a CS) via maps that have been organised to guide the users through related processes and the relevant knowledge required to execute a process. The second is where the user can to a certain extent monitor the on going manufacturing process and related processes that are executed within manufacturing operations to control manufacturing quality. Within these maps, other than product

specifications and process line layout, users will have access to information that will support decision making in day to day manufacturing operations. Examples of information made available are the latest CS results, machine histories, maintenance schedule and production trend details of a machine in a process line. Links can also be made to enable SPC and OEE (Overall Equipment Effectiveness) data to be available.

A. The MKMS architecture

The MKMS framework as shown in Figure C is of a hierarchical structure, divided into layers. The system is accessed through the intranet via two routes, which are:

- a) through identified CI processes or
- b) via the manufacturing processes.

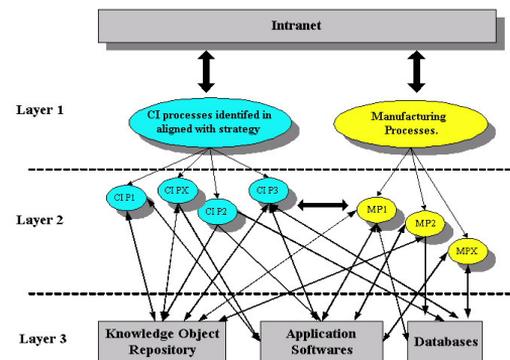


Fig. 3. MKMS framework

The two routes will enable the MKMS to operate not only as a KMS but also to a limited extent as a system that enables engineers to monitor manufacturing processes. Although the structure is divided into three main layers, each layer is at times further divided into sub-levels depending on the complexity of each map within the layers. Layer one, comprises of maps in the form of web pages that have the main function to enable navigation and visibility of knowledge within the organisation. Layer two comprises of the actual process maps which not only show how the process is to be carried out but it also points towards where further related knowledge can be obtained. In fact layer two maps are also a

knowledge entity as they not only guide but also teach users to performs or execute a task. The knowledge or process maps in level two are similar to maps developed by Warnick [52], Cottam [41], and Keane [18]. Maps in layer two are dependent on or supported by entities in layer three. For manufacturing processes, the execution of processes depicted by layer two K-maps requires data or information and in some cases related knowledge to enable its execution. The data and related knowledge are stored in layer three. For this research, the entities in layer three are termed as knowledge objects (KOs). Layer three comprises of the KOs itself which could be in the form of word documents, or graphic files. Software applications and databases pointed to by K-maps in layer two are also considered as entities in layer three. Table 1 shows examples of KOs in layer three.

TABLE 1
EXAMPLES OF KNOWLEDGE OBJECT TYPE

Examples of document type used in GFT	Examples of entity type in layer three (Knowledge objects)
<ul style="list-style-type: none"> • Minutes of meetings • Letters and e-mails • Reports of projects and processes executed • Charts for notice boards (graphic files) • Presentations and reports • Audio and video files • Software and machine manuals • Documents generated by other software applications (both external and 	<ul style="list-style-type: none"> .doc (Word document) .pdf (document file) .htm (HTML documents) .JPEG, .TIF, .bmp, .ps (graphic files) .PPT (Power point generated files) .MPEG (video file) .MP3 (audio file) .xls (Excel file) .dwg (AutoCAD drawing) .vs Visio files

internal) and databases.	
<ul style="list-style-type: none"> • Product specification charts and diagrams • Data and Process charts (e.g. QPS Sheets) 	

on CS related knowledge as these maps can be linked to external website within the WWW if required.

A1. The MKMS prototype

Figures 4, 5, and 6 are examples of k-maps embedded within a MKMS prototype developed to validate the MKMS framework. The K-Map in Figure D enables a user to select knowledge on how to execute CI processes in order to improve the FTT (First Time Through) rate of a manufacturing process in order to improve quality and reduce manufacturing cost. If the user clicks on the capability study (CS) icon as shown, a CS procedure or process map will be presented to the user. The CS procedure map depicts a formal process that the user must undertake to initiate an irregular CS implementation. An irregular CS is defined as a CS initiated by personnel who identified a need for a CS based on, for example, a sudden high rise in manufactured items that have to be scrapped or re-worked in a particular process line. The CS procedure map will not only guide the user through the process to initiate a CS but will subsequently guide the user to access the linked CS execution map that provides further knowledge on how to execute and implement a CS as shown in Fig. 5.

The CS execution map (Fig. 5) not only contains knowledge but further guides and enables users to access other related knowledge that is required to enable the execution of a CS. For example, the user can choose to obtain more information on how to execute a CS by clicking on the CS manuals and information icon. The user will then be directly linked to external websites to obtain more information

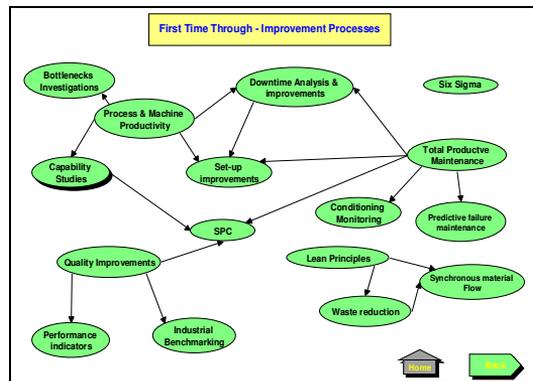


Fig. 4: First Time Through CI Process Knowledge Navigational Map

Fig. 6 is an example of a map that enables a user to monitor and access information related to a current manufacturing process. The user is presented with a detailed map of cell one (from a process line that have five cells) that provides details of machines and process sequence within cell one. This map enables the user to obtain the number of items manufactured by each machine in cell one on a daily basis by clicking on the daily build up chart icon and also to further select any machine within cell one to obtain more information that can be used to support decision making. For example the user can click the op10/20 icon to access the detailed OP10/20 machine-monitoring map. This layer two map is linked to KOs that provides information that can be used to support decision-making. The user can now easily access the linked documents related to the OP10/20 machine such as maintenance schedule and components/part specifications.

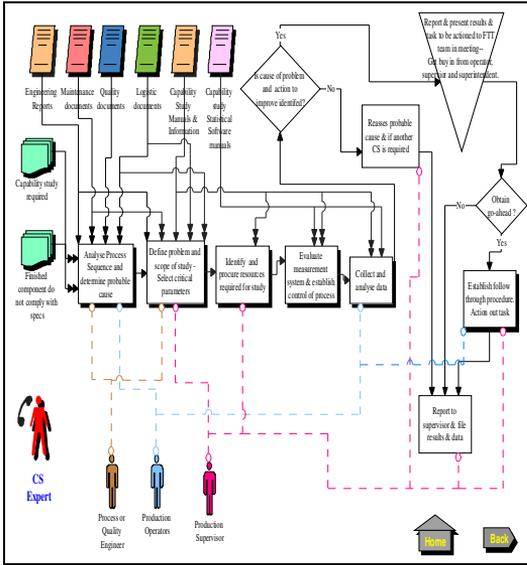


Fig. 5: Example of A K-Map- Capability Study Execution Map

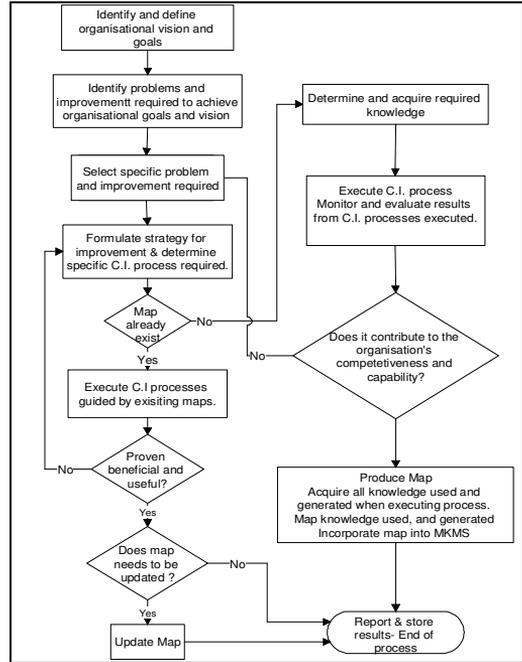


Fig. 7. MKMS Mapping Methodology

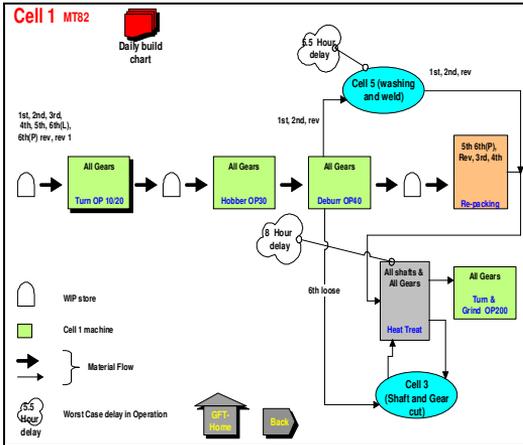


Fig. 6. Example of a Manufacturing Process Monitoring Map MKMS mapping methodology

Process maps are created when CI processes are carried out, and if proven useful should be embedded within the MKMS. Figure G depicts the process mapping methodology developed based on the researcher's experience during the development of the prototype MKMS and work by Eppler [38].

V. DISCUSSION AND CONCLUSION

The validity of the MKMS hierarchical framework was successfully demonstrated by the prototype MKMS. The prototype MKMS also demonstrated the need for a knowledge categorisation and classification method to enable better management of knowledge objects within a KMS especially in a manufacturing environment due to the large number of knowledge objects to be managed. The research have indicated that the termination of knowledge within a KMS must be seriously addressed in order to avoid overloading the system and that the KO's must be tag with attributes which will not only identify the type of KOs but also to be utilised as a flag to execute pre-defined task onto the KOs before it is embedded within a MKMS.

The research is now at a stage of developing a classification method for the KOs in layer three. Figure H shows a core ontology structure termed as Knowledge Object Ontological Framework (KOOF). The purpose of KOOF is

to facilitate the management of KOs by providing a classification method that enables attributes to be attached to the KOs in layer three of the MKMS. The attributes enable not only the identification of knowledge types but can also be utilised to act as flags to control pre-defined tasks that must be executed onto the KOs by the MKMS when necessary. KOOF enables KOs to be represented with attributes attached but do not specify how the KOs should be stored or managed. The management of each represented KO will be controlled within the MKMS embedded in the organisation’s intranet guided by the tagged attributes [5].

The development of KOOF is guided by previous work from Lee [53], Cottam [41], Chung[54] and Kim [14; 56] and is mostly based on the standardised ontology structure of PIF (Process Interchange Format and Framework)[53;55] as it offers an appropriate format since it was designed for similar functions. A notable difference between the KOOF and the ontologies that it is partially derived from is the definition of concepts and the types of attributes tagged to the entities described/represented, which corresponds to the domain in which this research is carried out that is, process knowledge in manufacturing enterprises. The identification

of the correct attributes is the important factor in the development of KOOF as it not only represents but also facilitates the management of KOs within the MKMS. For example the concept “CONTROL” was identified. This important concept guides the types of attributes that need to be tagged to specific entity types and groups in order to facilitate its management. Thus KOs described by this concept will for example be terminated or upgraded when necessary to avoid storage of old knowledge no longer useful. Figure H shows the hierarchical generic framework for KOOF and Figure I explains the key concepts of KOOF [5]. KOOF is still under development and the results of using KOOF in the development of the MKMS will be presented in a future paper.

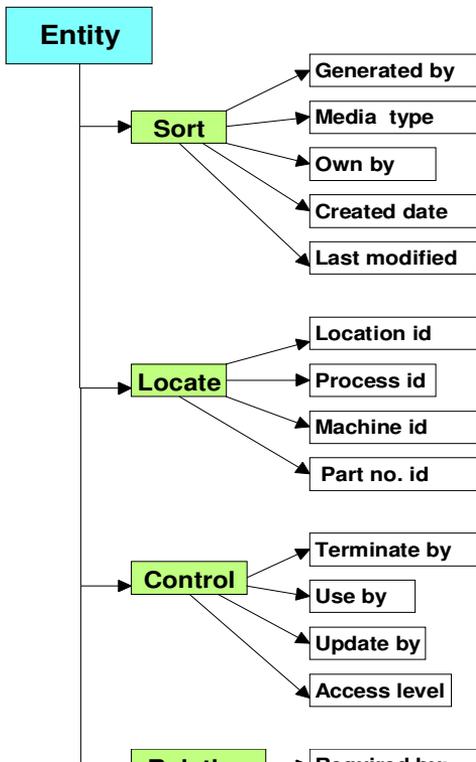


Fig. 8. Knowledge object ontological framework (KOOF)

TABLE II
KEY CONCEPTS OF KOOF

Concept	Description
ENTITY	Knowledge objects will be specified or classified into an ENTITY category with a specified set of attributes. The attributes will enable the identification and control of the ENTITY. KOs represented by similar ENTITY (i.e. with same attributes can be classified under an entity type).
SORT	Identifies the owner, when created, its creator and type of media of the entity.
LOCATE	Identifies the link of the entity to a machine, parts or process.
CONTROL	Identifies the type of task that has to be performed onto the entity such as the update period, or when the KO should be terminated (i.e. deleted from the system)
RELATIO N	Identify relation of the entity to other maps or users which was not the generator or producer of the entity.

ACKNOWLEDGMENT

University Teknologi MARA (UiTM) and Yayasan Felda for a research grant awarded to the authors in 2007.

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Norlida Buniyamin is an Associate Professor at the Faculty of Electrical Engineering of the University Teknologi MARA, Malaysia. She graduated from the University of Adelaide, Australia with a Bachelor Degree in Electrical and Electronic Engineering (Hons.) in 1985. She was a Research Fellow with the Malaysian Institute of Microelectronic Systems (MIMOS) before joining University Teknologi MARA in Malaysia as a lecturer in 1988. She then obtained a M.Sc. in Industrial Control Systems from the University of Salford, U.K in 1993 and a PhD. from the University of Manchester, Institute of Science and Technology (UMIST) in the U.K. in the area of Industrial Operations and Knowledge Management.



Zainuddin Mohamad graduated from Northrop University (USA) in 1984 with Bachelor degrees in Mechanical Engineering and Aerospace Engineering. He joined University Teknologi MARA (UiTM), Malaysia as a lecturer in the Faculty of Mechanical Engineering. Before leaving for a M.Sc. in Operational Research at the London School of Economics in 1994, he was a practicing engineer with the Public Works Department, Malaysia and a Development Officer with the Development and Maintenance department of UiTM.

