Communications tools in research projects to support Semi and Non Structured Information

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ABSTRACT

Innovation and thus the production of knowledge becomes a factor of competitiveness. In this context quality management could be complemented by knowledge management to aim the improvement of knowledge production by research activities process. To this end, after describing knowledge and information typologies in engineering activities, a knowledge management system is proposed. The goal is to support: (1) Semi-Structured Information (e.g. reports, etc.) thanks to the BASIC-Lab tool functions, which are based on attributing points of view and annotations to documents and document zones, and (2) Non-Structured Information (such as mail, dialogues, etc.), thanks to MICA-Graph approach which intends to support ex-change of technical messages that concerns common resolution of research problems within project teams and to capitalise relevant knowledge. For the both approaches, prototype tools have been developed and evaluated, primarily to feed back with manufacturing knowledge in the EADS industrial environment.

Keywords: Research activities, communication, knowledge management, concurrent engineering, Semi Structured Information, Non Structured Information.

1. INTRODUCTION

Nowadays, industrial companies need to follow and control the acceleration of technology progress to be able to maintain their product and service market position. Moreover, the control of innovation can put to market leading positions. One possibility of controlling technology progress is to harness some scientific activities. So to improve their competitive advantages, the research activities have to be rationalised. The same purpose could be followed, perhaps with less impact, by university laboratories.

The research activity implies managing information and knowledge. From these resources, new knowledge is produced, to become, itself, the resource of new researches. To improve this process, during the last years, some research organizations have been interested in quality management. However, research activities present specificities in terms of goals, resources, practices and organization which make them very different from the industrial activities. Indeed, quality management has been traditionally used in industry environment; its transfer to scientific environment is not automatic. In-deed the ISO standards describe as procedures the project structure with the different tasks to be carried out and the relevant documents to be produced. They are supported by a Product Data Management (PDM) package. However, preliminary information exchanged during research project is not managed by these systems.

The matter of research activities is knowledge. As a synthesis of different definitions dealing with the concept of knowledge [28], it is proposed: “Knowledge is the result of human experience and reflection based on a set of beliefs and residing as fictive objects in people’s mind”. In the context of this work, it is considered that knowledge in peoples’ mind is tacit. Brohm [4] argues that the notion of “explicit knowledge” is another expression for information which can be interpreted by receivers by using their expertise. Therefore explicit knowledge could be considered as information as long as it is possible to interpret this information. So, this paper focuses on information with the intention of supporting the management of knowledge.

In this article, research activities in university will be described and the implementation of quality management and knowledge management will be discussed. Starting from this analysis that highlights the importance of artifacts or intermediary results, and the information typologies, two approaches and their associated prototypes are proposed: BASIC-Lab and MICA-Graph. They intend to harness artifacts of information exchanges. The first one deals with Semi-Structured Information (reports, minutes, etc.) and the second one is intended to infer knowledge from Non-Structured Information (dialogues, e-mail, etc.).

This work has been carried out with seven Grenoble (France) university laboratories and in close collaboration with EADS (European Aeronautic Defence and Space) over the last six years and has been the topic of two subsequent PhD theses [13] [28] [8].

2. OBSERVATION OF THEORETICAL RESEARCH ORGANISM

The observation of research university laboratories has allowed to note that several characteristics of the research activity make difficult its management: the diversity of activities within a laboratory, the great quantity of records (digital reports and files in particular) to manage, the freedom granted to the researchers for the register or the traceability of their production, the multiplicity of working methods, the great turn-over of researchers, the multiplicity of activities that must be developed

in parallel, with various time delays, and that should be coordinated to lead to valid results, the difficulty to establish, from the beginning of a project, the precise characteristics of the re-search product (which could be a physical product or a conceptual product), etc. which explains the interest of having support practices during the research process, of capitalising the history of a project, of setting up procedures for the validation of results, etc. [20]
This knowledge production activity, according to the results of researches in sociology [34] and the reality observed, is usually developed in the form of more or less structured research projects. That is why it is important to study the issues of knowledge management while being based on the management of in-formation.
However, the information processing systems observed do not seek “the management and the circulation of distributed knowledge” [12]. For the surveyed laboratories, the approach selected is to facilitate the realisation of the activities by pro-viding a tool that makes possible to find documents or information and to organize those produced. In general, the documents resulting from the research process are not managed by these systems. The proposal is to use quality management to intro-duce the knowledge management principles, making it possible to capitalise the knowledge produced during research projects realisation. The objective is to improve knowledge production process. Thus, starting from the recommendations given by the AFNOR [1], a representation of quality management implementation could be proposed (Fig. 1).
This diagram emphasizes the importance of documentation throughout research process and thus of its management to support the process of knowledge creation. The subjacent idea is that there is knowledge produced throughout the research process, so it could be profitable to exploit this richness.

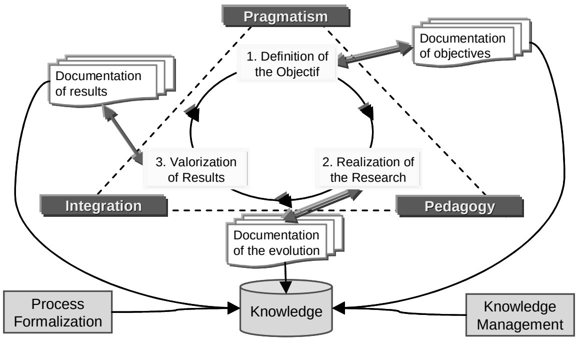


Figure 1. Implementation of quality management at research organizations

Thus, the result of this study is that there is a very important potential of capitalisation of the knowledge produced during the research projects realisation. By observing the representation of quality management (Fig. 1), knowledge, resulting from research projects, is already capitalised thanks to the existing valorisation mechanisms existing in scientific research. How-ever, a great amount of the knowledge produced during the re-search process remains barely capitalised. In this context, the concept of artifact seems to be useful. Michaux and Rowe [27] present the position of Groleau related to this concept, who “defines the artifacts as elements having a durable material form containing knowledge. Two elements seem important to retain in the design of artifacts. On one hand, distributed cognition considers that artifacts contain a part of the knowledge necessary to conclude a daily action with effectiveness: the other part being held in a complementary way by men... On the other hand, the intervention mode of these artifacts is the representation that they are able to convey. Indeed, the artifacts are often similar to objects (speed chart, paper-board, indicator on a data-processing screen or a measuring apparatus…).”
In the research context, during the daily action, observed within the research projects realisation, there is a great quantity of artifacts produced. Then, artifacts capitalisation could be used as a means to capitalise at least part of the knowledge resulting from the research projects realisation.
However, the capitalisation of the artifacts produced during re-search projects shows difficulties. In spite of the existence of several methods for the artifacts capitalisation, those are not adapted to the characteristics of research projects, especially because of the dynamic environment and the non repetitiveness of the project.
Then, ways to capitalise these artifacts like means to facilitate the realisation of other research projects are studied. However, there is a lack of adapted tools to the basic research activity, specially of tools focused on the capitalisation of the intermediate results (the artifacts). In this context, artifacts take the shape of pieces of information, so the information concept should be characterised.

3. INFORMATION TYPOLOGIES

The control of information is crucial in research activities. The term "control" can be characterised in terms of four main criteria: information structuring, sharing, access and knowledge capitalization [3].

Information Structuring
In order to meet the needs for accuracy in companies without going down to a too fine level of granularity, we choose an instructional design of information significance [14]. We then consider that the construction of a sentence corresponds to combined instructions formulated in term of variables, which provide a sense to a statement. Exchanged information is then an abstracted entity, a theoretical object that consists of:
- Linguistic components which build the significance of information starting from instructions. They are characterised by the clearness of their more or less structuring formalism that leaves the possibility of having or not various possible interpretations.
- Rhetoric components which bring a sense to information by adding of contextual information. This construction is characterised by the easiness in identifying information context.

We agree that an information system is structured when information has one and only one significance (with clear linguistic components) and a well-defined sense (with accurate rhetoric component).

The properties of this structuring enable us to define:
- Structured information (SI):
Linguistic components of SI are generally imposed. The employed formalisms are accurate and logic. They leave little place to interpretation. Rhetoric components of the SI are also imposed. They are clearly defined and have to be indicated to validate information. The transmitter has no choice in the SI type (design, text) and rules concerning the container, the con-tent and the circulation of SI. Consequently, all the receivers

have, thanks to the SI, the necessary information to carry out their tasks.

- Semi-Structured Information (SSI):
Linguistic components of SSI are little formalised. They can take the shape of texts, tables, and graphics. They can be hard to understand by all, but easier for direct receivers. Rhetoric components can be parsimonious. Indeed, the transmitter knows the receiver and adapts the level of granularity of rhetoric components according to the assumed knowledge of the context that the receiver has. The SSI is stored less long than SI because the context is not always associated with information. They can thus quickly become useless.

- Non Structured Information (NSI):
The NSI are very little formalised. The formalisation of the linguistic components employed depends on the degree of complicity between transmitter and receivers, which can leave place to a multitude of interpretations. The rhetoric components can be very light if they ensure a sufficient degree of relevance for the comprehension of information by the receiver. The NSI are essentially volatile because even if it is possible to preserve a piece of information, it is sometimes more difficult to remind the context.

Information Sharing
Information sharing is characterised by the ability of "pushing" information to one or several team members at the same time. The evaluation criterion is the ability to easily access information.

Information Access
Information access can be described as the ability to "pull" information to obtain a desired piece of information. An Information System may offer several ways for accessing information. The evaluation criteria are the ease and speed for accessing in-formation.

Knowledge Capitalisation
Knowledge capitalisation is characterised by the ability to store and process information for interpretation and later re-use, as suggested by the well-known knowledge management cycle model [30] (Fig. 2).

These information typologies (SI, SSI and NSI) will be useful to propose and build user support to master Semi-Structured Information with the BASIC-Lab approach and Non-Structured Information with the MICA approach, as presented in the next sections.

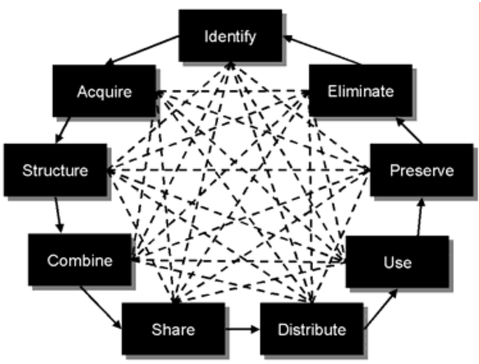


Figure 2. The knowledge management cycle model

4. BASIC-LAB APPROACH AND PROTOTYPE FOR BOTH THEORITECAL AND INDUSTRIAL ENVIRONMENT

According to Feldman [7], 80% of explicit knowledge in an enterprise can be found in documents. Thanks to ISO standards, the document names in project teams are clearly identified. Un-fortunately, their contents are not characterised in an explicit way and relevant facts can be lost. For that purpose, the BA-SIC-Lab approach and its illustrative prototype tool are proposed. It intends to have information content description indexed with meta-data and to attach annotations to documents or geographical document zones for a better content exploitation and sharing. These results are based on a case study per-formed at the EADS Corporate Research Centre [8] [9].

Information Structuring in the BASIC-Lab approach
In order to structure Semi-Structured Information in our context, it was decided to use the natural language for linguistic components. To structure the rhetoric components, it was proposed to use parts of the CIMOSA framework [33], and more specifically the "instantiation principles" with its three generic levels: generic level, partial level and particular level.

Generic level: According to the principle of the generic level, a research process framework model, structured in three phases, is proposed: to investigate, to focus and to deploy (Fig. 3) [9].

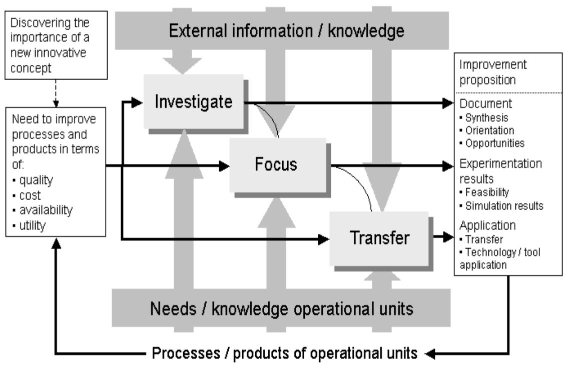


Figure 3. Objective oriented research process framework (adapted from Dureigne [8]).

Partial level: To structure the partial level, the use of the knowledge management cycle model (Fig. 2) is proposed.

Particular level: In the context of industrial research activities, to characterise a particular model, it is proposed to enrich content description by means of meta-data, which in fact could refer to [25]: about-ness and relevance. An ontology could be linked to these concepts and could be used to characterise the input and output of this kind of toolbox.
These three levels provide the basis for a proposal for a general model framework for industrial research activities organised as a three-layer architecture (Fig. 4).

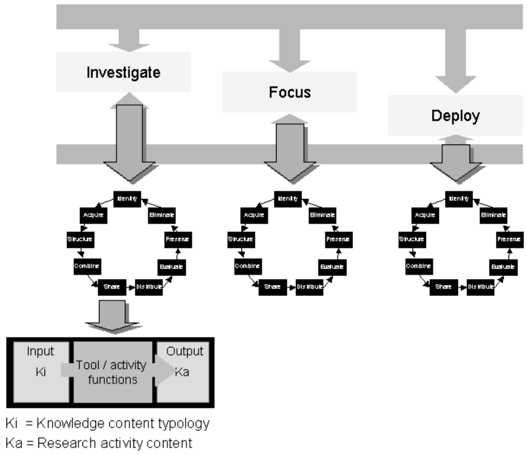


Figure 4: Knowledge management architectural framework for industrial research activities

Information Access in the BASIC-Lab approach
To access documents or document zones with their content description, both a retrieval module and full text search engines are used.

Information Sharing in the BASIC-Lab approach
The industrial researchers should also have the possibility to visualize the different documents and document zones according to cross sets of meta-data.

Knowledge Capitalisation with the BASIC-Lab approach
Thus, in the assembly module, actually studied, the industrial researcher can use the sharing module to elaborate new documents and perhaps new knowledge by integrating existing documents, document zones and content descriptions.

BASIC-Lab Tool
To validate the BASIC-Lab framework, a prototype specification and the realisation of a tool have been made (Fig. 5) [10]. The tool principles have been tested and validated by a small group of researchers. The experiment showed that the proto-type could support a better management of knowledge and in-formation flows, and supports the elaboration of new research results.

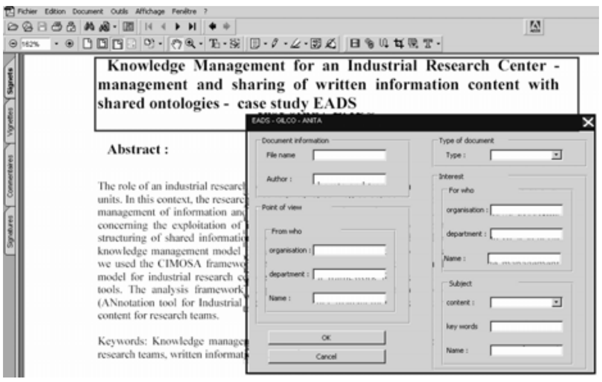


Figure 5. Annotation module in BASIC-Lab

Information Structuring: The prototype aims at supporting a researcher in his activity. For that reason, we have identified the different artifacts he deals with in it:
- Documents
- Annotations to documents or specific parts of them
- Document zones
- Information about colleagues
- Information about projects

For that reason, the prototype allows storing these artifacts in order to facilitate the access to it. For the moment, the proto-type focuses on the investigate phase, paying special attention to the bibliographical research done. Thus, a researcher starts by identifying an interesting document, which, if it is not al-ready in the prototype, can be stored in it for future re-use.
The analysis of the document will generate annotations made by the researcher. With traditional paper annotation or actual software tools, the value of expert time spending during annotation is hardly sharable and it is not an asset for the whole team; it remains a personal exercise. With the BASIC-Lab approach, the expert time spent on annotating is given a much higher value; the information is tracked and becomes potentially reusable.
In addition, as annotations can make reference to the whole document or to specific parts of it, the approach also keeps track of the documents zones that have been object of special attention by the researchers analyzing the document.
A further analysis of the activity has shown us that in addition to reading and annotating documents, a very important part of the activity implies linking information found on different sources, in order to make comparisons allowing knowing the state of the art on a given field. For that reason, it is necessary to introduce a new structuring element, which we named the concept, referring to the scientific concept around which experts often need to make this linking of information. Therefore, in the prototype, another structuring aspect that appears is the concept, which intends to reflect the contents dealt with by an expert.
The experts are then another structuring element. As a person performs every action, the prototype allows tracking them, facilitating each one to keep track of its own actions and artifacts. In this way, each person can easily access his documents, his annotations, the related document zones, the concepts he works with, and also the projects in which he participates.
In effect, as the activities are performed in the framework of more or less structured projects [34], it has proven very useful, to also structure information around projects. In the approach, it is considered that the different elements (documents, document zones, annotations and concepts) usually appear related to a project in which the researcher is involved. In consequence, the project is established as a structuring element, allowing put-ting together all the information used for its development.
Part of this information refers to the people participating in it. Therefore, this structuring element, the project, addresses an additional support to the activity. In addition to the support to the individual work done by each person, the structuring by projects, addresses the need of collaborative spaces, allowing putting together individual efforts and facilitating the sharing of information needed for the creation of new knowledge.

Information Access: The structuring elements aim at facilitating the access to the in-formation in the prototype. Therefore, the prototype has five modules:
- Documents
- Annotations
- Concepts
- Projects
- Researchers

Each module allows mainly three actions: Adding an element, seeing all the elements stored (for all the structuring elements, except for the annotations) or accessing a search engine, in order to define the search criteria (See Figure 6).

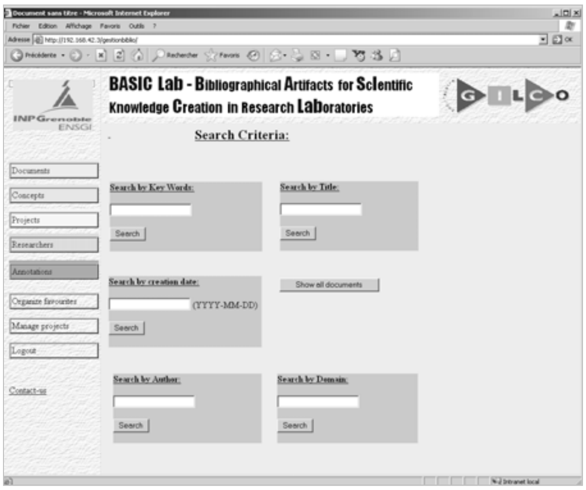


Figure 6. Documents search engine

One of the principles we have kept in mind is facilitating the identification of artifacts through several ways and, at the same time, aiming at identifying as many artifacts as possible. Thus, for example, the prototype allows truncated searches, which makes possible the identification of a higher number of artifacts. In addition, when searching for a particular artifact, Basic Lab presents the information of the search results, together with the information on the artifacts related to the identified possibilities. For example, when searching for a document, the prototype will present a table with the documents responding to the specified criterion, together with the information of the artifacts related to them. Thus, the table contains the following elements: Title, type of document, author, domain, projects where each document is used, concepts previously identified in the document. Figure 7 shows an example of the search results obtained.

Figure 7. Example of search results for a document search

A very important aspect regarding the access to information is that, if the digital file of the selected document is available, Basic Lab displays it through an Acrobat® window, which allows using its main functionalities of Acrobat® 5.0. In addition, all the related elements are also displayed (see figure 8).

Figure 8. Example of the information provided about a document.

The display of the related elements allows easily accessing information by "navigating" much in the way one does on the Internet (because the elements in the prototype are hyper-linked). In this way, it is possible to identify further

information related to the subject of research and find out, for example, the researchers working on similar subjects.
A special feature is that each element is linked to the person who introduced it. For doing it, Basic Lab demands to log in the system. This, in addition to facilitating the tracking of everybody's actions, allows building "favourites lists", where each person can register his favourite documents and concepts, facilitating the access to them.

Information Sharing: For the moment, all the information contained in the prototype is accessible to all the users registered in it. The principle we had in mind when allowing this open access to all the users was facilitating the sharing of information. Thus, everybody can see everybody else's annotations, documents, concepts and projects. In this way, these elements are accessible to all the users, facilitating the identification of important documents, diminishing the time spent for this identification and enriching their analysis, by being able to see other experts' insights. Also, the study of the knowledge available about a specific subject should be eased through the sharing of the information each user identifies on a given concept. This should help a richer view of the knowledge on a subject, as different people can study a same subject or concept, from a different perspective or domain.
In addition, we provided a way to infer the expertise domain of a person, by looking into the elements with which a given person works with. This should allow the users of the system to gain access to, not only the explicit information stored, but also to the implicit knowledge held by people, as we also provided contact information to be used as a way of facilitating direct exchanges of information and knowledge.
Another important scenario for the sharing of information is the development of projects. When developing projects, the people participating in it identify interesting materials for the activities of the project, whose sharing is desirable so the members work on the same knowledge base. For that reason, in Basic Lab, the members of a project may add information to it and access the information added by the other members. In addition, as projects present different magnitude levels, that sometimes imply containing smaller projects, in Basic Lab, the information in projects can be structured in the same way. Therefore, a project can contain a sub-project, and a member can participate in the general project and/or in one of more of the defined sub-projects. In the same way, every member can add information to the general project or to a specific sub-project, in order to share it with the other members.
Although in theory, this open access principle was conceived as a way to increase the amount of information available to each person, the tests revealed a different situation. According to the tests and interviews with users, the lack of barriers in Basic Lab makes them more careful with the information put into the system and somewhat reluctant to store it in it. Nevertheless, the possibility of accessing the information stored by others, mainly the documents, was greatly appreciated and seen as a way of enriching their activity without requiring a great amount of extra time for it (as it would be necessary without Basic Lab).

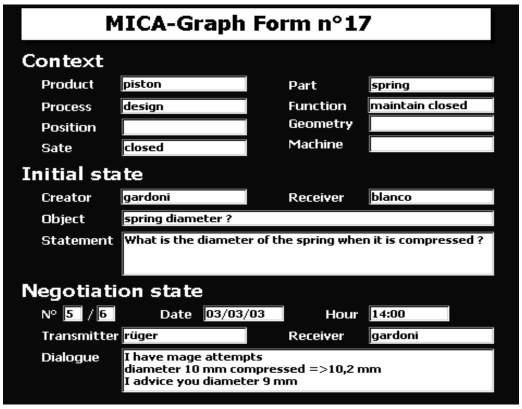
Knowledge Capitalization: In our approach, the capitalization of knowledge is addressed in two ways: The capitalization of artifacts, and the easing of the identification of knowledgeable people.
The capitalization of artifacts is eased by facilitating the re-aggregation of pieces of information. This re-aggregation is easily done through several ways. For example, a researcher can search all the annotations containing a specific word, look at a concept in order to obtain all the information that has been identified in relation to it, or go to a projects' space in order to see all the information used and created through the development of the project. This may be highly useful for preparing new documents, which usually involves mobilising information from several sources at the same time, and not working on individual documents as in the processing stage. As the information in the prototype is hyperlinked, accessing it is easily done. In addition, additional links can be added to each element in order to facilitate latter re-aggregation. The aim is facilitate navigation, identification and re-use of interesting elements, which means, capitalize fellows' added artifacts, but also facilitating future capitalization.
The identification of knowledgeable people is expected to be done by inferring the expertise domain of fellow researchers. As we mentioned, this could be made by observing the elements of a person. For example, a researcher whose favourite concepts are knowledge, knowledge management, cognition and learning should be expected to work in related fields. In addition, by looking into the projects in which he has participated, one could probably infer how experienced he is, and the potential usefulness of getting in touch with him. The principle we have used is that a researcher can acknowledge the areas of interest of one of his fellows by looking at information such as the preferred documents and concepts, the projects in which he participates and the annotations he makes. This information can constitute a kind of profile of each researcher of the organization. Moreover, neither creating nor updating this profile represents additional work because Basic Lab takes in charge the maintenance of the trace, as each researcher chooses and creates artifacts. In this sense, the inference of someone's expertise is completely done by each person. The prototype only provides some useful information in order to be able to do it.
Similarly, though the re-aggregation of information is facilitated, the prototype still presents each element individually and leaves an important amount of work to the researcher. For ex-ample, although a concept can be linked to a specific document zone, at the moment it is not possible to retrieve all the document zones related to a concept. This could be very helpful in certain cases, such as the preparation of literature reviews. Therefore, although the tool has shown its high potential for re-searchers, there are still several aspects to improve, in order to ease the researchers work.
Another aspect to take into account is that Basic Lab deals mostly with semi-structured information. However, in the context of research project teams, user interactions are mostly carried out via dialogues, this is the theme of the next section.

5. MICA-GRAPH APPROACH AND PROTOTYPE FOR BOTH THEORITECAL AND INDUSTRIAL ENVIRONMENT

To intend to master Non-Structured Information (NSI), as for the previous section, a framework is first built and a software prototype called MICA-Graph is then produced [15].

Information Structuring in the MICA-Graph approach
Information structuring in MICA-Graph should rely on two considerations:
1) for the linguistic components, the natural language formalism is used;

2) for the rhetoric or contextual aspects, the concepts of aboutness and relevance could be used again to keep partially the same interface as BASIC-Lab. However to take into account NSI, a more accurate characterisation of the context is needed. For this aim, the CIMOSA approach [33] is partly used for the problem at hand, especially, the concept of modeling views and the generation principle, which describe the behavior and the functionality of a system from various modeling viewpoints. For technical research environments, four main views are defined, namely co-operation, resource, product and process views.
The Co-operative View makes possible to take into account interactions. It is argued that the whole of the NSI constituting dialogues exchanged can be divided into topics of negotiation [2]. It was decided to gather the NSI concerning the same negotiation in one form, called MICA-Graph form (Fig. 6) that are made of three sections symbolising three states of negotiation: initial, negotiation and final states. In addition, these sections are made of free fields and pre-defined fields characterising an abstraction of the context by reusing the concepts of aboutness and relevance and adding, for technical environments, the three other views: namely, resource, product and process views [16].


MICA-Graph Form n°17

Context

Product: piston — Part: spring

Process: design — Function: maintain closed

Position: — Geometry:

Sate: closed — Machine:

Initial state

Creator: gardoni — Receiver: blanco

Object: spring diameter ?

Statement: What is the diameter of the spring when it is compressed ?

Negotiation state

N° 5 / 6 — Date 03/03/03 — Hour 14:00

Transmitter: rüger — Receiver: gardoni

Dialogue: I have mage attempts
diameter 10 mm compressed =>10,2 mm
I advice you diameter 9 mm

Figure 9. Schematic example of a MICA-Graph Form

Information Sharing in the MICA-Graph approach
All researchers of a project can have access, but not modify, the existing NSI.

Information Access in the MICA-Graph approach
Concerning textual information, a search engine is used for full text analysis or search criteria based on specified fields only.

Knowledge Capitalisation with the MICA-Graph approach
Thanks to the MICA-Graph software, Non-Structured Information can be tracked, it becomes possible to transform this NSI into shareable and re-usable explicit knowledge. Among several methods that can be used to process large quantities of linguistic data, text mining, and especially hierarchical clustering, has been selected [18]. The computer application produces clusters of important terms and suggests connections between the terms. These graphs can be completed or interpreted by an expert who will give a meaning to connections with semantic terms that could be similar to an argumentation or to a rule. Furthermore, these graphs can be translated into the form of IF/THEN expert rules to become tacit knowledge once validated.

MICA-Graph Tool
No groupware or CSCW (Computer Support for Collaborative Work) exists that can fulfill the needs expressed in the previous sections. To cope with its various functionalities, a tool was developed on the computers (PCs) using the company intranet and a data base system [13] (Fig. 10).

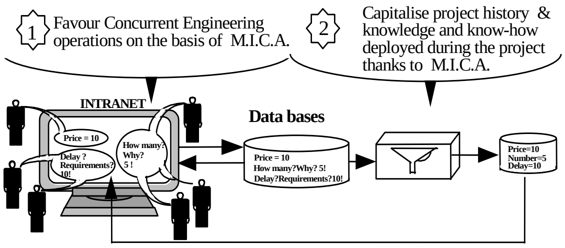


Figure 10. Principles of the MICA Tool

In this context, MICA-Graph acts as a communication tool that makes available a product history. The forms must then be processed to extract expert knowledge. After six months of experimentation at EADS, the MICA-Graph approach appeared to be successful. However, several major topics discussed in the perspectives section should be further investigated.

6. KNOWLEDGE MANGEMENT BASED ON BASIC-LAB AND MICA-GRAPH

Thanks to BASIC-Lab & MICA-Graph, information is tracked, respectively Semi-Structured Information and Non-Structured Information. We intend now to treat them to enable the users to create knowledge thanks to these pieces of information.

Knowledge versus Information
There are several definitions of knowledge (non-exhaustive list of definitions):
- According to Wiig [35] “knowledge consists of truths and beliefs, perspectives and concepts, judgements, expectations, methodologies and know-how”.
- Nonaka and Takeuchi’s definition [29]: “Knowledge is true and justified belief.”
- Turban [32] defines knowledge as an “information that has been organised and analysed to make it understandable and applicable to problem solving or decision making”.
- Davenport and Prusak [5], define knowledge as a mix of fluid experiences, values, contextual information and intuition that provides a structure to evaluate and incorporate new experiences and information. It originates and is applied in the minds of individuals.

We can recognise from the above definitions, that knowledge has something to do with concepts like “judgements”, “expectations”, “beliefs”, “experiences” and residing in the minds of individuals. Moreover, it seems to be a link between knowledge and the notion of “information” (definitions of Turban, Davenport and Prusak).
As a synthesis of the above definition we propose the following definition for knowledge: “Knowledge is the result of human experience and reflection based on a set of beliefs and residing as fictive objects in people’s mind” [11].
So on the case of Knowledge, it cannot directly be managed because it resides in an individual’s mind. The key difference between knowledge and information can be summarised by the

role played by the human beings [31]. In the case of knowledge, individuals play a prominent role as creators, carriers, conveyors and users. In the case of information, these same functions can happen “outside” humans and without their direct influence. From a management perspective, the important difference between information and knowledge is that information is much more easily identified, organised and distributed with technological support.
In this context, the challenge is to offer users the possibility to interpret the information in the right way. To this aim, rhetoric or contextual components play a key role.

Notion of Context

Edmonds [6] introduces context as the abstraction of these elements in the circumstances in which a model is learned. These elements are not used explicitly in the production of an inference or prediction when the model is later applied. That allows the recognition of new circumstances where the model can be usefully applied. Context emerges from heuristics and is linked to the possibility of the transference of knowledge via fairly simple models from the circumstances where they are learnt to the circumstances where they are applied. Researchers have to make a choice and produce partial models. The potential reuse of these models is determined by these three factors:

- Factors not included in the model are so constant that they can be ignored, the model is valid in any case.
- Factors not included in the model are not constant but its background features are recognised as identical to those learned so that the model can be used.
- Factors not included in the model are not constant and not learned. The model is not valid in another context.

Once we partially achieve to identify the right factors, to go through linguistic components thanks to ontology, to treat this huge amount of Semi-Structured Information and Non-Structured Information, to aggregate BASIC-Lab and MICA-Grap, etc. another problem will be encounter: How to better re-use the treated information?
With this aim in view, we are going to implement a case base reasoning system. Indeed, we already have the raw material to implement this type of system with our sample of previous solved exchanges. First, we are going to separate the problems records and the solutions records as cases. Then, we are going to use a component retrieval method, named free-text-based retrieval method, which comes from the information retrieval community [17]. In this method, the cases are represented as free-text-based documents, while a query component is described using keywords. The retrieval process is basically a look up of the keywords, but also of synonyms and antonyms thanks to ontology in all documents’ description components. The components with most matched keywords will be selected. Vector space and indexing technology are used to facilitate the organisation and matching of document [24]
We hope also to create favourable factors to the socialisation process [23]. This process transfers tacit knowledge in one person to tacit knowledge in another person [29]. This depends on having shared experience, and results in acquired skills and common mental models. Therefore, the implementation of the collective characteristic is crucial to create an information system that in addition to create new knowledge helps creating collective skills by implementing Nonaka’s theory.
Thanks to this improvement, we intend also to promote a collective way of working and create new skills.

7. CONCLUSIONS AND PROSPECTS

First of all, in research, quality management systems observed do not really address the knowledge management aspect in research, and the document management do not address the research artifacts. Therefore, we carried out an analysis of the activities realised during the research process and of the information used and generated by these activities. This analysis enables to define that a very important aspect for the capitalisation of knowledge resulting from research projects is the capitalisation of intermediate results.
The analysis of existing tools, showed that, in spite of the great possibilities they offer for knowledge management, there is a lack of tools that could facilitate the capitalisation of intermediate results issued from research projects. In fact, existing tools address mainly the management of the information container and hardly the management of the information contents.
For that reason, the BASIC-Lab approach and the MICA-Graph approach are presented in order to profitably support, respectively, the management of Semi-Structured Information and Non-Structured Information as a fundamental source of knowledge in order to share, assemble or combine basic knowledge elements to create new ones.
During experiments with the BASIC-Lab and MICA-Graph prototypes, it was identified that the resistance to their use was caused partially by: the transition from oral expression to writing practice, the non-existence of a common ontology, the transparency of information, the fear caused by the elicitation of knowledge, etc. However, day-to-day use with the BASIC-Lab and MICA-Graph prototypes proved to alleviate these resistances and to create links between the researchers, the result of which was to crystallize the efforts of all researchers.
Several perspectives issued from practice could be quoted for further research work: experimentation of the BASIC-Lab and MICA-Graph prototypes in other environments, in large team environments with the difficulty to manage several existing ontologies, experimentation of new technologies such as interactive screens or voice recognition tools, etc.
As other perspectives, we wish to list several crucial theoretical points to be handled: The next step will be to use case base reasoning, "rebuild" the decision-making process, the application of Return of Investment methods, etc.
These two lists are not exhaustive. These are topics that should be taken into account to undertake other experiments and before a generalisation attempt of the BASIC-Lab and MICA-Graph approaches can be made.

8. REFERENCES

[1] AFNOR, **Fascicule de Documentation FD X 50 – 550. Démarche qualité en recherche – Principes généraux et recommandations**, AFNOR, Paris, 2001.

[2] M. Baker, “A model for negotiation in Teaching-Learning Dialogues”, **Journal of Artificial Intelligence in Education**, 5-2., 1993, pp.199-254.

[3] E. Blanco & M. Gardoni, “Taxonomy of Information and Knowledge Management in a Concurrent Engineering Context”, **7th ISPE International Conference On Concurrent Engineering, CE'2000**, Lyon, July 2000, France, 2000.

[4] R. Brohm, “Bringing Polanyi onto the theatre stage: A study on Polanyi applied to Knowledge Management”, **ISMICK conference proceedings, Erasmus**

University, Rotterdam, The Netherlands, 1999, pp. 57-69.
[5] T.H. Davenport & L. Prusak, **Working Knowledge how organasations Manage What they know**, Harvard Business School Press Boston MA, 1998.
[6] B. Edmonds, “The Pragmatic Roots of Contextî, Modeling and Using Context”, The proceedings of CONTEXT, Lecture Notes in **Computer Science**, Vol 1688; 1999, Trento, Italy, pp. 119-132.
[7] R. Feldman, “Text Mining: Theory and Practice”, **4th World Congress on Expert Systems – Application of Advanced Information Technologies, ITESM**, Mexico City Campus, 1998.
[8] C. Frank, **Knowledge Management for an Industrial Research Center – case study EADS**, European PHD thesis INP Grenoble, 2003.
[9] C. Frank, & M. Gardoni, “A Knowledge Management System for Industrial Design Research Processes”, **International Conference on Engineering Design, ICED 03**, August 19-21, Stockholm, 2003.
[10] C. Frank & M. Gardoni,. “A Knowledge Management System for Industrial Research Activities: Case Study for IT Research Activities at the EADS Corporate Research Center”, **IJCAI International Conference on Artificial Intelligence**, Acapulco, Mexico, 2003.
[11] C. Frank & M. Gardoni, “The Management and sharing of information with ontologies – Case study EADS Corporate Research Centre”, **International Journal of Information Management (IJ Information Management)**, 25; 2005, p. 55-70.
[12] F. Gandon, R. Dieng, O. Corby & A. Giboin, “Web Sémantique et Approche Multi-Agents pour la Gestion d’une Mémoire Organisationnelle Distribuée”, **13ème journées francophones d’Ingénierie des Connaissances, IC’2002 Conference,** Rouen. 28 - 30 mai, 2002, p. 15-26.
[13] M. Gardoni, **Maîtrise de l’information non structurée et capitalisation de savoir et de savoir-faire en Ingénierie Intégrée. Cas d’étude Aérospatiale**, European PHD thesis INP Grenoble, 1999.
[14] M. Gardoni, C. Frank C & F. Vernadat, “Knowledge capitalisation based on textual and graphical semi-structured and non-structured information. Case study in an industrial research centre at EADS”, **Computers in Industry**, Volume 56, Issue 1, January 2005, p.55-69
[15] M. Gardoni, M. Spadoni, & F. Vernadat, “Harnessing non structured information and knowledge and know-how capitalisation in integrated engineering, case study at Aerospatiale Matra”, **Concurrent Engineering: Research and Applications, CERA Journal**, 8-4, 2001.
[16] M. Gardoni & E. Blanco, “Harnessing Non Structured Information in Integrated Design Team”, **International Conference on Engineering Design, ICED 03**, Stockholm, 2003, pp.19-21.
[17] B.U. Haque, R.A. Belecheanu, R.J. Barson & K.S. Pawar, “Towards the application of case based reasoning to decisionmaking in concurrent product development (concurrent engineering)”, **Knowledge-Based Systems Journal**, Vol 13, 2000, p.101-112
[18] D. Heesch, J. Hoare, M. Gardoni, D. Gillies & S. Rüger, “Content-Based Sketch Retrieval and Relevance Feedback”, **International Conference on Advances in Infrastructure for Electronic Business, Science, and Education on the Internet. SSGRR 2001 Scuola Superiore G. Reiss Romoli**, 06 - 12 August 2001, Aquila, Italia, 2001.
[19] A. Jaime, **From Quality Management to Knowledge Management in Research Projects: An Approach through the Management of Contents in Bibliographical Research**, PhD Dissertation, Institut National Polytechnique de Grenoble, 2005.
[20] A. Jaime, M. Gardoni & D. Vinck, “Capitalizing Knowledge at Research Organizations through Quality Management”, **Third European Knowledge Management Summer School: Knowledge Management in Action. September 7 - 12**, San Sebastian, Spain, 2003.
[21] A. Jaime, M. Gardoni & D. Vinck, “BASIC Lab: a software tool for supporting the production of knowledge in research organizations through the management of scientific concepts”, **Journal of Knowledge Management**, Volume 9, Number 6, June 2005, pp. 53-66(14).
[22] A. Jaime, M. Gardoni & D. Vinck. “From Quality Management to Knowledge Management in Research Organizations”, **International Journal of Innovation Management (IJIM)**, Accepted (publication expected on Volume 10, N2, June 2006 issue).
[23] R. Lopez, M. Gardoni & M. Tollenaere, “Retour d’experience sur la creation de connaissances et la competence collective approche appliquee au cas de l’entreprise Pechiney à St jean de Maurienne”, **Colloque du groupe de travail de gestion des connaissances et des compétences en Génie Industriel**, 2002.
[24] B. Magnini, “Use of a lexical knowledge base for information access systems”, **International Journal of Theoretical & Applied Issues in Specialized Communication**, vol. 5; 1999, p. 203 - 228.
[25] M.E. Maron, “On indexing, retrieval and the meaning of about”, **Journal of the American Society for Information Science**, 28-1, 1977, pp. 38-43.
[26] J. Moeschler, **Modélisation du dialogue (représentation de l’inférence argumentative)**, Paris: Editions Hermès, 1989.
[27] V. Michaux & F. Rowe, “Grille d’analyse des situations de coordination médiatisée par un système d’information informatisé“, **Coopération – Innocation - Technologique, CITE’2003 Conference**, 3 - 4 décembre 2003, Troyes. 2003.
[28] I. Nonaka, & H. Takeuchi, **The Knowledge-creating Company.** Oxford University Press, New York, 1995.
[29] I. Nonaka & H. Takeuchi, **The Knowledge-creating Company**, Oxford University Press, New York, 1995.
[30] K. Romhardt, **Die Organisation aus der Wissensperspektive – Möglichkeiten und Grenzen der Intervention**, Gabler, Wiesbaden, 1998.
[31] JC Terra & T. Angeloni, “Understanding the difference between Information Management and Knowledge Management”, **IAMOT Conference Proceedings**, 2003.
[32] E. Turban, **Expert Systems and Applied Artificial Intelligence**, Prentice Hall College Div, 1992.
[33] F.B. Vernadat, **Enterprise Modeling and Integration: Principles and Applications**, London: Chapman & Hall, 1996.
[34] D. Vinck, **Sociologie des Sciences**, Paris: Armand Colin Editeur, 1995, pp. 154–155.
[35] K. Wiig, **Knowledge Management Foundation**, Arlington: Schema Press, 1993.