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Introducing new technologies in organisations - business model perspective

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ABSTRACT

This paper presents a knowledge model to enhance the process of introducing new technologies in organisations. The central principle is to convert external knowledge, constituting the technology from the supplier (universities, R&D, other organisations), into internal knowledge, constituting the technology integrated in the organisation. Two types of knowledge must be transferred: tacit and explicit knowledge. Four knowledge domains must be represented when introducing a new technology: Technology Core (constituents of the technology), Transformation Processes (transformation processes of the constituents in products and/or services), Products and Services Space (knowledge associated with products and/or services realisable with the new technology) and Organisational Environment (internal and external environment of the organisation). Technological and organisational actors map specific and shared knowledge on these domains. We developed this model as a tool to be used by project management introducing new technologies. It allows to represent knowledge of the process and to coordinate the actor's actions. Introduction of superplastic forming technology illustrates the model.

Keywords: knowledge model, business process modelling, reengineering, superplastic forming, technology introduction.

1. INTRODUCTION

Mastering a new technique, or a new technology has always been decisive for a human organisation. For example, the mastering of iron technology by northern countries participated in the conquest and the final destruction of the Roman Empire. Also, during the beginning of the first industrial revolution, mastering the steam technology to produce mechanical work gave a major advantage to the nations possessing it. Today, at the edge of the 21^{st} century, mastering key technologies, changing at an ever increasing pace, is a matter of survival for industrial organisations, and by causal effects, for the well being of nation's citizens. Consequently, if an industrial organisation is able to build superior capabilities in introducing and in rendering productive the new technology, it will have a decisive advantage over its competitors[1].

A. Rolstadås (ed.), *Benchmarking — Theory and Practice*

In this paper, we propose an organisational approach, based on enterprise knowledge modelling[2], to help introduce a new technology in an organisation. A special attention is being paid to knowledge integration concerning the different actors involved in introducing the technology.

1.1. Knowledge transfer

The key issue in introducing a new technology is to take the reachable external knowledge (knowledge not owned by the organisation) related to the technology and to transform it into internal and usable knowledge. Reachable external knowledge consists of information the supplier of the new technology (R&D or external supplier) can provide about it. There are two types of knowledge to transfer: explicit and tacit knowledge. Nonaka[3] identified four mechanisms used to convert knowledge(learning), from the source to the receiver:

Source's knowledge →	Convertion mechanism →	Receiver's knowledge
tacit	socialisation	tacit
explicit	combination	explicit
tacit	articulation	explicit
explicit	internalisation	tacit

Figure 1. Knowledge transfer.

Usually, transfer and integration of tacit knowledge bring most of the problems in mastering the new technology because this kind of knowledge is not explicitly defined. These problems result principally from the lack of inter-functional skills[4], from the isolation between the different functions (design, manufacturing, marketing, finance,...) or departments in the organisation. Reducing the partition between the different functions of the organisation is of primary concern in the work we realised.

An example illustrates the model that could be applied on introducing superplastic forming technology (SPF) in a typical aircraft manufacturing organisation (Airbus, Boeing, MDD).

> Superplastic Forming: titanium-aluminium and other superplastic alloys, metal forming technology. Aerospace industry uses SPF technology for forming parts which shape requires high deformation (from 100% up to 1000%). This characteristic allows to significantly reduce the number of parts (reached with high deformation potential) and the weight (reached with high resistance and toughness of Ti-Al alloys) of an assembly.

In the following pages an integrated knowledge model of the technology, composed of 4 inter-connected knowledge domains is introduced. The purpose of this model is to bring a coherent perspective of the technological knowledge, tacit and explicit, to the actors involved in introducing the new technology.

2. INTEGRATED KNOWLEDGE MODEL

The aim of building an integrated model is:
- to give a common reference and understanding to the actors;
- to coordinate the actions of the actors in the organisation's environment[5].

The model is based on **four invariants** domains characterising the technology as part of the enterprise's processes. They appear as inter-connected knowledge domains (as shown in figure 2):
- Technology Core (TC), domain of the constituents (physical laws, equipment) associated to the technology;
- Transformation Processes (TP), domain of the transformation processes (operating modes, tasks) required to convert the constituents of the technology into products and/or services (PS);
- Products & Services Space(PSS), domain where knowledge converge on the PS obtainable from the technology;
- Organisational Environment(OE), domain linking the technology to the organisation's environment (social, ecological, organisational, market opportunities, investment's capability).

Each domain is developed in the following pages.

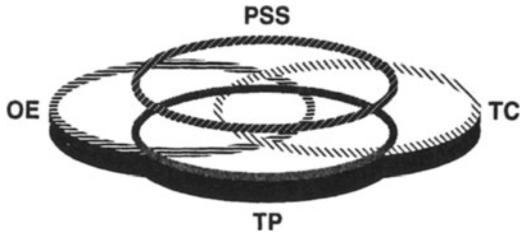

Figure 2. Interconnected knowledge domains.

2.1. Technology Core

Broustail & Fréry[6], classify a technology in one or a combination of these fields: materials, energy (source and energy converter), information, life (biology and living phenomenon control). A consistent knowledge model of a technology must describe any technology belonging to these fields.

The Technology Core knowledge domain is concerned with the elements that the organisation will transform into products or services. Each actor will apply differently this definition to its organisation and to the function he belongs to. It depends on the perspective it has on the technology.

Each actor in the organisation must define which elements (knowledge, tools, information system) will be transformed or used, for the realisation of PS. A typical manufacturing organisation has 9 types of actors directly related with technological processes: design, logistic, maintenance (after-sales services), manufacturing, process planning, procurement, production, quality control and R&D. They are called **technological actors**. The nature and the integration of these functions differ from one organisation to an other. For non-manufacturing organisations, a different decomposition of the actors is necessary, but the fundamental principles remain unchanged.

Knowledge mapping in the domain

When introducing knowledge respective to a new technology in the technology core domain, the actors must acquire specific (respective to their activity) knowledge and shared knowledge about the technology, as shown in figure 3. All actors must map on a common area these two types of knowledge to help determine the cognitive interactions.

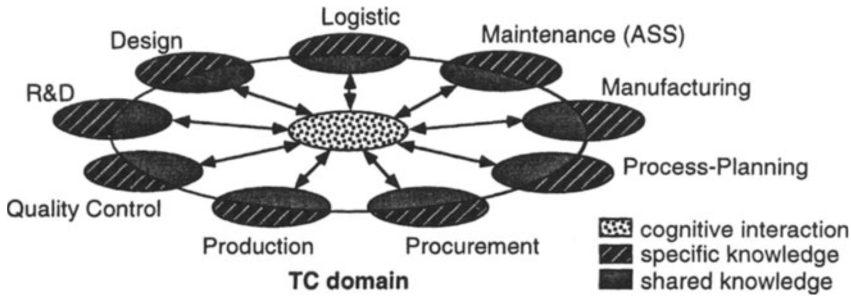

Figure 3. Actors mapping knowledge on TC domain.

Table 1
Technology Core domain of SPF technology

Actors (techn.)	**Specific Knowledge**	**Shared K**		
design	CAD systems and other design capabilities available	1	2	3
logistic	transportation resources (trucks, planes,...) available	-	-	3
maintenance	maintenance equipment (ultrasonic probes) available	1	2	3
manufacturing	manufacturing presses available	1	2	3
process planning	automated-process-planning systems available	1	2	3
procurement	procurement systems available	-	-	3
production	production planning systems available	-	-	3
quality control	inspection equipment (non-destructive techniques) available	1	2	3
R&D	testing procedures available to determine range of properties of SPF parts	1	2	-

1- material properties (maximum tensile stress, shear stress, density);
2- communication standards for exchanging geometric model (STEP, SET, VDI);
3- communication standards for production information.

Table 2
Transformation Processes domain of SPF technology

Actors (techn.)	**Specific knowledge**	**Shared K**		
design	how to use CAD systems and other design capabilities to produce SPF parts	1	2	3
logistic	how to schedule the transportation resources (trucks, planes,...) conveying the SPF parts	-	-	3
maintenance	how to use maintenance equipment (ultrasonic probes) to determine SPF parts to be changed	-	2	3
manufacturing	how to operate the manufacturing presses to produce SPF parts	1	2	3
process planning	how to operate the automated-process-planning systems of SPF parts	1	2	3
procurement	how to operate the procurement systems with the SPF materials (sheet metal of aluminium-titanium alloy)	-	-	3
production	how to operate the production planning systems with the new charges induced by SPF parts	-	-	3
quality control	how to inspect (with non-destructive techniques) the new SPF parts	1	2	3
R&D	how to apply testing procedures to determine ranges of properties of SPF parts	-	2	-

1- How to transform the sheet metal titanium-aluminium alloy material into a SPF part;
2- How to exchange geometric information concerning the SPF parts with the chosen communication standards;
3- How to exchange production information concerning the SPF parts with the chosen communications standards.

All the information is not necessarily available at the beginning of the constitution of the layer (for example, manufacturing does not know the die characteristics of a press until the part's geometry is defined). The mapping of TC domain is realised concurrently with the other layers (see section 2.5).

The state of the information system (information technology and communication environment between the actors within the firm) determines the quantity and the quality of the knowledge representation achievable. To be effective, management must support team work and create an environment that sustains communication.

Table 1 illustrates a non-exhautive list of TC knowledge (specific and shared) representation of SPF technology introduction in a typical aircraft manufacturing organisation. Three examples of shared knowledge are shown (corresponding to number 1,2 and 3), they are described below the table. The filled spaces mean that the corresponding actor partakes this knowledge. For example: design, maintenance (ASS), manufacturing, process planning, quality control and R&D share the material properties' knowledge.

TC represent which tools, standards and procedures are available for implementing the technology and generating PS. A similar approach can be used for all the technology domains.

2.2. Transformation Processes

The Transformation Processes domain contains knowledge explaining how the building blocks of the technology core layer are transformed in PS. The technological actors map knowledge in a similar form as in the preceding domain.

In this domain, technological actors introduce the know-how: training of the actors on the standards and procedures, the equipment, the different systems to be used. Table 2 presents the TP domain of SPF technology introduction. It contains specific TP knowledge and shared TP knowledge.

2.3. Products & Services Space

The Products & Services Space domain is the "valorising" domain of the technology knowledge model, where PS are developped. At the limit, the technology to be introduced is not important by itself for the organisation, all is important is the result obtainable from it: PS for customers. Usually, when the decision maker selects a technology to introduce, he already supposes there is potential development of PS from it. Therefore PSS layer, in a sane technology development process, is the initiating knowledge layer (focus on customer needs). Initiating knowledge in this layer is partial and the complete PSS layer will result only from the development of the 3 other layers, concurrently with it.

The interest of representing knowledge in the PSS domain, is to give the technological actors a common knowledge platform to maximise the opportunities to develop marketable PS from the new technology. Nowadays, many manufacturing organisations still develop PS punctually, case by case or randomly with a new introduced technology. The designer usually realises a part or a few ones, when the opportunity arrives, with the technology. The organisation does not fully exploit the development space (all the possible PS realisable with the technology) of PS. Systematising and organising the development space of PS, obtainable from the technology, enhances competitive strength of the organisation by increasing the offering of new PS in a shorter delay.

Table 3
Products and Services Space domain of SPF technology

Actors (techn.)	**Specific Knowledge**	**Shared K**		
design	determination of design resources (man/hours, material) utilisation to realise the SPF parts	1	2	3
logistic	scheduling the transportation resources (trucks, planes,...) for conveying the SPF parts to be realised	-	-	3
maintenance	verify that maintenance procedures (ultrasonic testing) are usable by the customers (airlines) for the SPF parts to be realised	1	2	3
manufacturing	determination of manufacturing resources utilisation to produce the SPF parts	1	2	3
process planning	determination, with automated process-planning systems, of the process planning to realise the SPF parts	1	2	3
procurement	determination of the supplied goods (aluminium-titanium alloy metal sheet), with the procurement systems, necessary to realise the SPF parts	1	-	3
production	determination of production planning of the new charges induced by SPF parts to be realised	-	-	3
quality control	determination of inspection procedures (with non-destructive techniques) to apply to the SPF parts to be realised	1	2	3
R&D	application of testing procedures to determine ranges of properties of the SPF parts to be realised	1	2	-

1- definition of SPF parts geometry space (realisable geometry);
2- determination of which geometric information (and when) to transfer between the technological actors;
3- determination of which production information (and when), about SPF parts, to transfer between the actors.

2.4. Organisational Environment

In this domains is mapped knowledge linking the technology to the organisation's environment (internal and external). At this level intervene **organisational actors**: top management (Executive Officers), marketing, human resources, finance. The role of these actors, in the model we propose, will be to verify that:
- the organisation can provide financial and human resources to ensure the realisation of PS;
- the PS to be issued from the new technology, respond to market needs, to external constraints (environmental, political, economical) and to strategic objectives of the organisation.

These actors link the PS, by then, the technology, with the reality of the organisation and the market. They must monitor and predict perturbations that can originate from the introduction of the new technology in the organisation.

OE domain is the common place where the technological and the organisational actors interact. Communication between these groups of actors is of primary concern. The establishment of a cognitive model helps to consolidate the two groups by allowing a better vision of the issues resulting from technology introduction.

Table 4 contains examples of specific and shared knowledge related to organisational actors and technological actors (knowledge interface of the two types of actors).

Table 4
Organisational Environment domain of SPF technology

Actors (org.)	**Specific Knowledge**	**Shared K**		
top management	strategic objective of improving weight savings by using better materials like SPF	1	2	3
finance	return on investments with the new SPF products enhancements	1	2	3
marketing	market demand for SPF products	1	2	3
human resources	human resources redistribution caused by SPF products development and production (hiring, transfer of personal)	1	2	3
technological actors interface		1		3

1- definition of SPF parts to be realised (integrated frame, integrated door panel, integrated keel);
2- SPF products in accordance with strategic planning of the organisation;
3- determination of which production information (and when), about SPF parts, to transfer between the actors.

Organisational actors must establish a compromise between:
- the amount of allocated resources to be well informed (investigation on politics, economy, ecological consequences, employees motivation);
- and the level of awareness desired, of the consequences (positive and negative) of introducing the new technology in the organisation.

2.5. Development planning of knowledge mapping

The planning of the knowledge mapping, within domains is hard to define because there is no optimal general solution. The solution comes from a case by case analysis and the experience the actors have. Usually, as already discussed, when actors introduce a technology, they anticipate PS development from it. Therefore, it seems logical that the PSS layer initiates the knowledge building process. After the initiation, the actors map in the four domains, including PSS, concurrently and with highly linked coordination between them. Project management (using the knowledge model) intervenes at this level to coordinate the actions of each actor (technological and organisational) and for optimising the allocated resources (delay, development cost, operating cost, services). The model can be use to represent the knowledge belonging to the technology and the organisation, giving the actors a better understanding of the relations linking them.

2.6. Synthesis of the process

Figure 4 summarises the process of introducing a new technology by using knowledge model representation.

1- At the beginning of the process, the technology is external knowledge (explicit and tacit) to the organisation.

2- During the process, the actors (technological and organisational) map knowledge on the four domains by transforming explicit and tacit knowledge belonging to the technology (external) into specific and shared knowledge (internal). Sufficient resources (human, financial) are prerequisite in order for the project to progress.

3- After the actors have introduced the technology (technology is integrated in the organisation), the organisation can provide PS to customers.

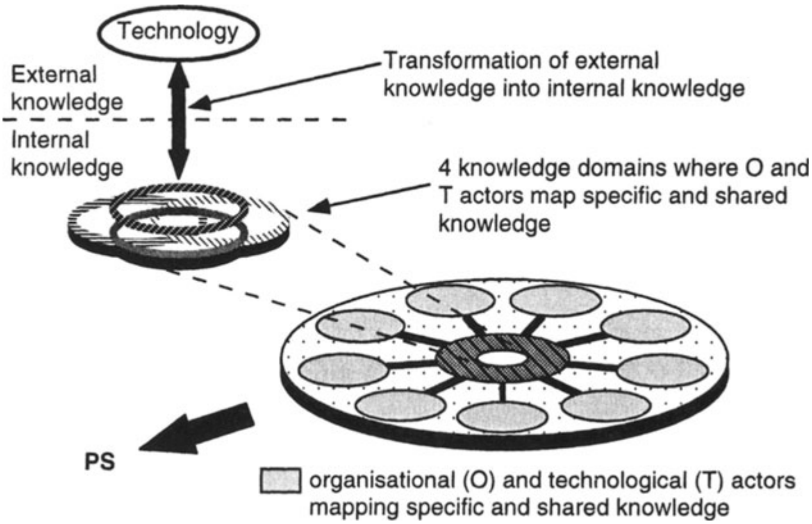

Figure 4. Synthesis.

3. CONCLUSION

Mapping the knowledge belonging to the process of introducing new technology in 4 domains (Technology Core, Transformation Processes, Products & Services Space, Organisational Environment), allows to construct a better view of the actions the actors have to perform. Giving a clearer representation of the knowledge to be developed for introducing a new technology helps the actors to partake it. By formalising and by taking into account the whole process (not only unrelated tasks), the actors will improve coordination and simultaneisation of their activities. The major aspect this integrated model can bring to its users, is the **rise in coherency** of the actions in the process. This coherency results from the establishment of knowledge references (by mapping on the four domains).

Rethinking business processes is the base of reengineering[7]. The knowledge model introduced in this paper stimulates this rethinking by envisioning the introduction of technology as part of the whole business process of the organisation.

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