A hybrid method to develop a knowledge management system

Aitouche Samia, Mouss Mohamed Djamel, Mouss Kinza,

Laboratory of automatics and manufacturing, Industrial engineering department, University Hadj Lakhdar – Batna – Algeria
samiaaitouche@yahoo.fr, d_mouss@yahoo.fr, kinzmouss@yahoo.fr

Kaanit Abdelghafour, Boutarfa Youcef and Rezki Djamil

Laboratory of automatics and manufacturing, Industrial engineering department, University Hadj Lakhdar – Batna – Algeria
k_abdelghafour@yahoo.fr, y_boutarfa@yahoo.fr, d_rezki@yahoo.fr

Abstract—**The question is the understandability and usability of a method to develop a knowledge system. A method could be the most pertinent, but it might not have a guideline to allow its appliance. CICM (Comprehensive Intellectual Capital Model) is an algorithmic guide to develop a knowledge system. To make it more pertinent, we compared it to GERAM (Generalized Enterprise Reference Architecture and Methodology) requirements, knowing that GERAM is an ISO standard (ISO 15704) of engineering of enterprise. We deducted strengths and weaknesses of CICM. We proposed ACICM Model which is an improved CICM Model, contributing to its change, to become closer and for some criteria to go beyond to the requirements of GERAM. ACICM is more convivial and pragmatic, so more chosen by designers of knowledge management systems. Based on weaknesses of the method of performance scorecard SKANDIA, we proposed an adaptation by enrichment of its set of indicators to be more suitable to developing a knowledge management scorecard, to give (ASKANDIA). A hybridization of ACICM, ASKANDIA and business intelligence leaded to propose SKACICM method. We applied SKACICM on a cement company to develop e-knowledge management system ameliorating performance by a rate of 26%.**

Keywords-knowledge management; business intelligence; CICM Model; ACICM; SKANDIA; ASKANDIA; SKACICM.

I. INTRODUCTION

The emerging field of knowledge management addresses the broad processes of locating, organizing, transferring and more efficiently using information and expertise within an organization. New market forces and infrastructure changes have prompted an interest in knowledge management.

Knowledge management is the name of a concept in which an enterprise consciously and comprehensively gathers, organizes, shares, and analyzes its knowledge in terms of resources, documents, and people skills. The benefits of knowledge management are focused on improving decision making, reducing cost of employee training, and increasing versatility of the workforce. The aim is to collect explicit and tacit knowledge to develop an e-knowledge management system to ameliorate the performance of manufacturing system. First, a succinct literature review of the most recent works in knowledge management. We tried making an easy usable method (method with clear guidelines) more pertinent. We improved existing methods using proposed matamodels to

propose a new method; we used to develop a knowledge management system. Finally, we discussed the contributions of the new system.

II. RECENT WORKS IN KNOWLEDGE MANAGEMENT

The main objective of Mehralian [5] is to develop and prioritize the most important indicators of intellectual capital in knowledge-based industries. The highest ratios are particularly positive work environment, the ratio of investment in R&D (research and development) and the number of R&D projects in the structural capital, while considering the relational capital. In his work, Lin [6] implies that, in addition to the direction of the market using innovative practices, the high-tech industry should focus more on market knowledge and knowledge management to customers. In contrary, we focused on capitalization of existing knowledge in the company especially the externalization of the tacit ones from the minds of company experts to share them and to improve tangible and intangible efficiency of the company. Khalid et al. [12] found that technology reshapes human behavior and it is the key of implementing knowledge management. In our proposed method, cultural change is necessary to ensure the success of implementing knowledge management. CommonKADS is a method we applied in thermal power plant [13] to externalize tacit knowledge, it presented insufficiency in its modeling language and the absence of implementing tool. We applied SKANDIA in cylinder manufacture [14], to develop a dashboard for human resources of cylinder manufacture. The indicators of SKANDIA were insufficient to cover all managerial aspects of the manufacture. Therefore, we adapted SKANDIA, adding a set of important indicators.

III. GERAM (GENERALIZED ENTERPRISE REFERENCE ARCHITECTURE AND METHODOLOGY)

GERAM has been developed by the IFAC/IFIP3 task force [8]. formed at the IFAC World Congress in 1990. It is a framework for the unification of various methods of several domains to support enterprise engineering and integration. It comprises methods from industrial engineering, control engineering, and information systems. It represents a framework rather than a modeling method comprising process models and modeling languages. The GERAM components describe requirements concerning

GERA: Generalised Enterprise Reference Architecture

GERA — Defines — Generic concepts — In — Enterprise Engineering and integration projects

Classified

-Human oriented concepts

Classes of concepts

In

Interoperate — Sub-class concepts — As 1 — Qualities — Of 1

Technology elements — As 2 — Capabilities

-human roles
-the way in which human roles are organized
-capabilities and qualities of humans

Of 2

Human

Is

Enterprise resource

Know-how — Possessed — Human

Retension and reuse

Knowledge — Encapsulate — Models — During — Phase

Is

Of 3

Enterprise Asset

Enterprise

EEMs: Enterprise Engineering Methodologies

My be expressed

In the form of a process model or structured procedure with detailed instruction for each enterprise engineering and integration activity

Describes 4

Process of enterprise engineering and integration

employs

Utilise

Implemented

EMLs: Enterprise Modelling Languages

Defines 4 — Generic modelling constructs for enterprise modelling — Creates and uses

Enterprise models

In

Construct — Will provide — Modelling language

To describe and model 1 — Sunctional contents

To describe and model 2 — Human roles

To describe and model 3 — Operational processes

GEMCs: Generic Enterprise Modelling Concepts

Defines and formalises — Most generic concepts of enterprise modelling

MBDW 3   MBDW 2   May be defined in way 1

Ontological theories — Glossary — Some forms of metamodel

Defining   Describes 5

Built inside   Improves — Relationship among modelling concepts

Usefulness of enterprise models — Meaning (semantics) of enterprise modelling languages

Analytic capability of engineering tools

Through them

PEMs: Partial Enterprise Models

Are referred to — May concern — May cover — Part or whole of typical enterprise

Literature
-reference models
-type reference architectures

Enterprise entities
-products
-projects
-companies

May present these from

Various points of views
-data models
-process models
-organization models

PEMs: Partial Enterprise Models

Are 1   Are 2   Are 3   Capture

Reusable models   Paradigmatic models   Typical models   Caracteristics common to enterprise

Capitalize on

Model libraries — Allow to be reused — Previous knowledge

Developing

Modelize

Make more efficient — Models — From — Scratch

Components of enterprise

-skills and competencies of humans in enterprise operational and management
-operational processes (functionality and behaviour) and

EETs: Enterprise Engineering Tools

Support

Processes of enterprise — By implementing — Engineering methodology

Supporting — Modelling languages

Engineering tools — Should provide for 1 — Use enterprise model

Should provide for 2 — Design enterprise model

Support

Used to build

EMs: (Particular) Enterprise Models — Represent — Particular enterprise

Include

Can be expressed using — Various designs

Enterprise modelling languages

-models prepared for analysis
-executable models to support the operation of enterprise

May consist of — Several models

Describing

Various aspects

Enterprise Modules: (EMOs) — Can be utilized in — Implementation of enterprise

-human resources with given skill profiles (specific professions)
-type of manufacturing resources
-common business equipment or information technology infrastructure (software and hardware) intended to support the operational use of enterprise models

Special emphasis — IT infrastructures — Have — Service of IT infrastructures

Will provide 2   Will provide 1

Model driven operational support   Model portability and interoperability

By providing 2   By providing 1

Realistic scenarios — Provides — Real time access to enterprise environment   Integration infrastructure

For 1   Be helpful   Across

Model validation and verification   Engineering tastes of model update and modification   Heterogeneous enterprise environments

For 2

Simulation — Based on — Artificial data

Used to implement

GERAM METAMODEL

Used to implement

EOSs: (Particular) Enterprise Operational systems — Support

Implemented in

Particular enterprise model — Identifies — Enterprise modules

Provides — Used in

System specification   Implementation of the particular enterprise system

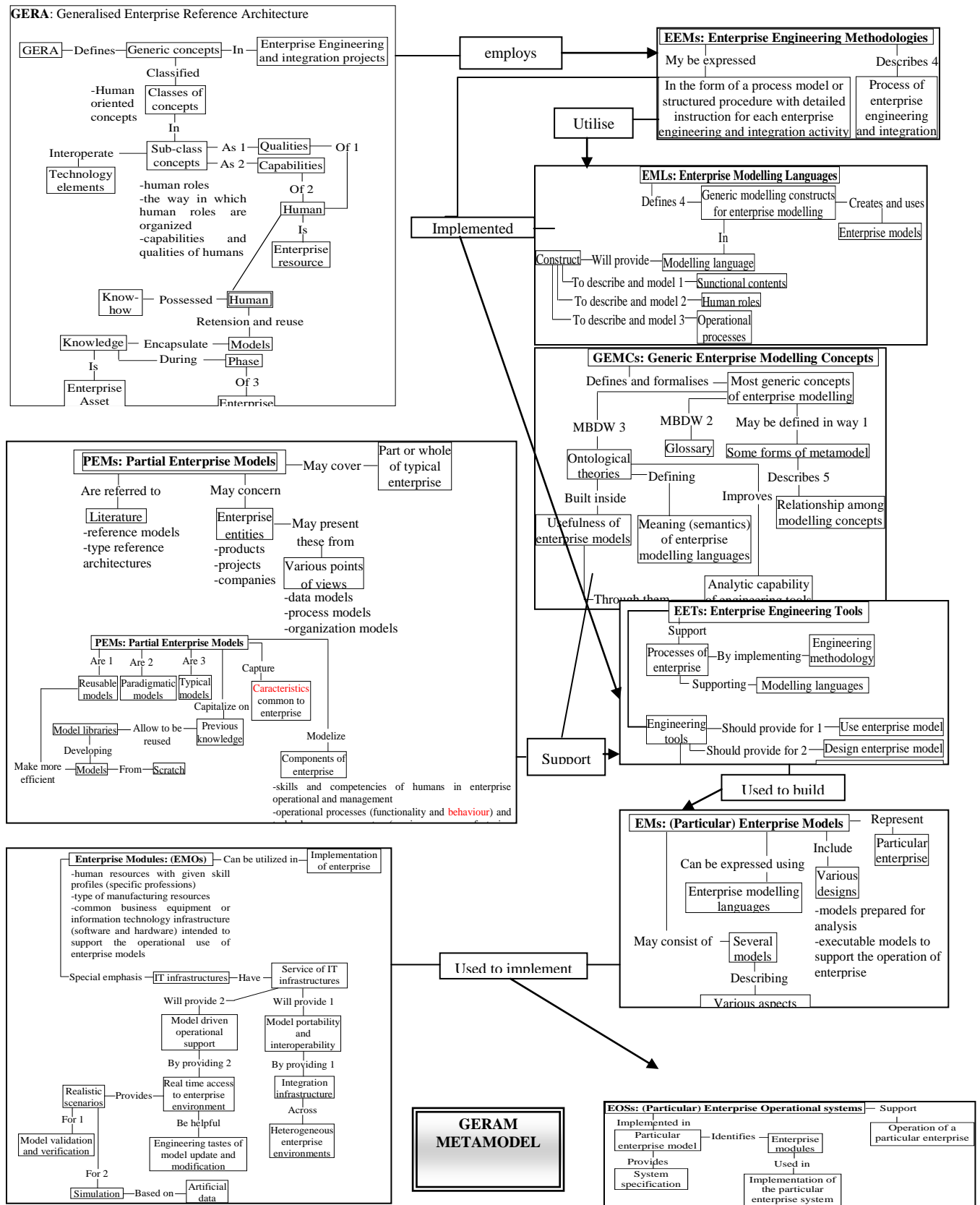Operation of a particular enterprise

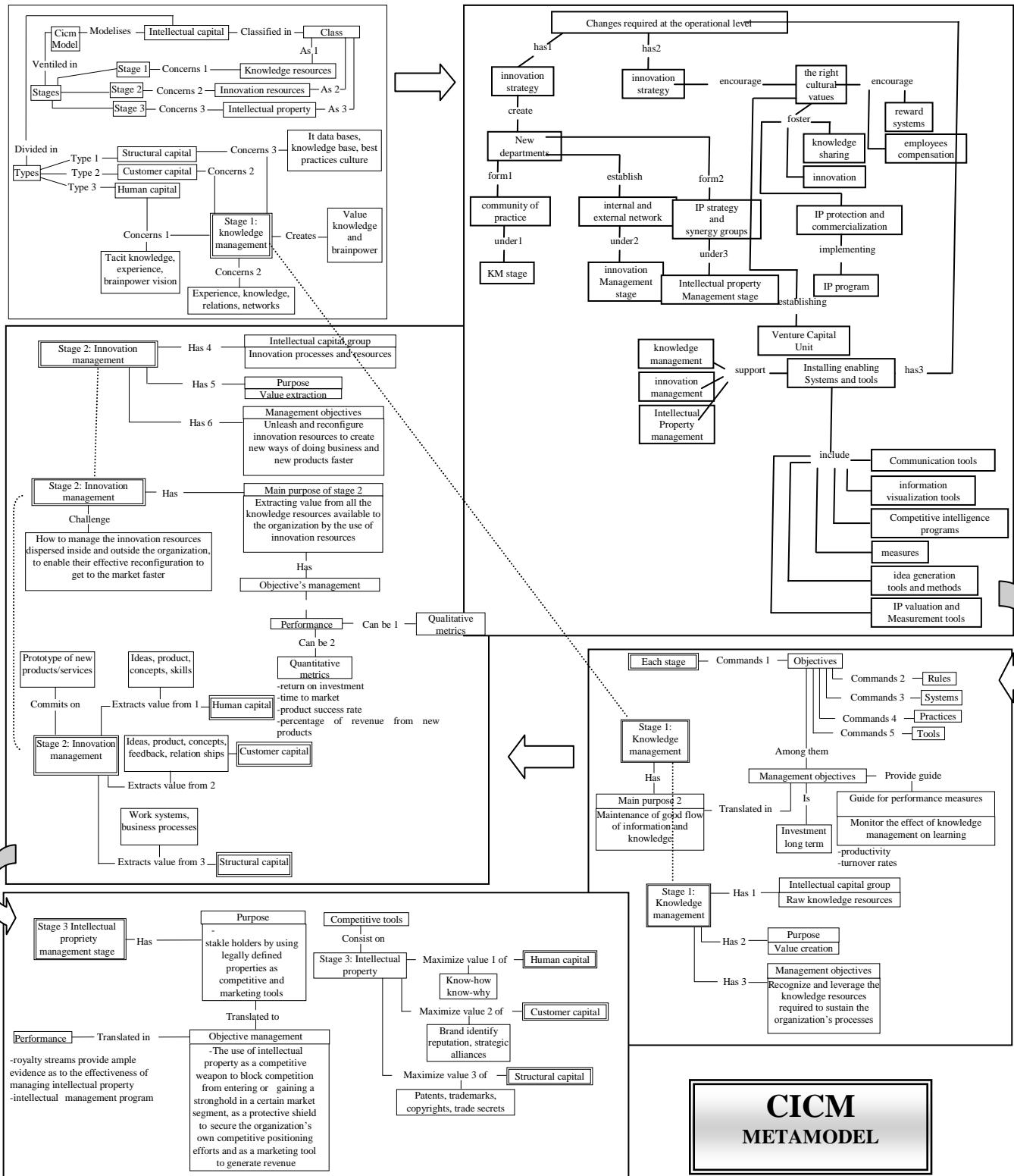Figure 1.   Proposed metamodel of requirements and their relationship of GERAM reference

Figure 2.   Proposed metamodel of the three stages of CICM model

reference architecture, modeling language, process model, tools, and enterprise models. We proposed an original metamodel (Fig. 1) defining the role and goals of GERAM.

A metamodel is the analysis, construction and development of the frames, rules, constraints, models and theories applicable and useful for modeling a predefined class of problems. As its name implies, this concept applies the notions of meta and modeling.

IV. CICM MODEL

The CICM model was developed by Al-Ali [9] to provide a comprehensive framework for the management of intellectual capital regardless of its function in the business cycle, and whether it is a resource, a process or a product. The CICM model is based on the idea that creating value from intellectual capital follows the same business process or cycle like other tangible resources and assets. It provides a framework that enables management to understand the relationship between the various disciplines and approaches that pertain to intellectual capital management, understand the various practices and services that developed under the banner of intellectual capital management and know where each of these practices fit under the three stages (knowledge management, innovation management and intellectual property management). Based on its weakenesses deduced from its comparison to GERAM requirements, we ameliorated it to give ACICM model. To perform this comparison of GERAM and CICM, metamodels are proposed in Fig. 1 and Fig. 2. This comparison consists to check whether CICM model satisfies GERAM requirements

V. AMELIORATION OF CICM MODEL AGAINST GERAM REQUIREMENTS

In Table 1, the ameliorations of CICM model are proposed, based on confrontation of metamodels of GERAM requirements and CICM model. The relation between the metamodels is wheather the CICM metamodel is included in the GERAM one.

TABLE I.   AMELIORATIONS OF CICM MODEL AGAINST REQUIREMENTS OF GERAM

GERAM requirement	Conformity of CICM Model to GERAM requirement	Amelioration of CICM Model to give Ameliorated CICM Model (ACICM)
Metamodel	Not provided	Proposal of metamodels; GERAM and CICM ones
glossary	Not provided	Proposal of glossary containing all semantics used in proposed ontology and metamodels
Semantics and ontological foundation	Not provided	Proposal of an ontology which will be presented in subsequent work
Human centered modeling language	CICM is by definition human centered model for management of intellectual capital	We integrate Management of human resources in designing and accompanying the change involved by the new manner
Relationship between level of description and level of machine orientation for a selection of modeling language	Not specified modeling language for description	UML (unified modeling language) is recommended to guarantee this link. We propose for UML at its turn a new diagram, we called expertise diagram, which the role is to structure and save the expertise of experts and share it with the whole of enterprise
Kinetic representation (phases)	More Dynamic than static, very structured in kinetic phases	Proposal of detailed metamodels for each process and for each step of the process of the three stages, concerning components or structure needed for the accomplishment of the processes and steps example the step 3 (Fig. 5) of the process 3, of the knowledge

		management stage. It's possible recursively to perform it for all the guide step by step of CICM model
Model can be shared, reused and kept up to date	The time line isn't explicit in but implicit in saving knowledge, experience and share it and transform it in skills	We proposed a new concept which is a master plan for knowledge management with a timeline and eventual costs and value added to the enterprise. This plan should be prepared before applying the Ameliorated CICM.
Maintenability of models in different views in case of change	The difficulty in identifying which step to revise	The proposed three levels of abstraction will make revising easy, we aren't obliged to revise all levels of abstraction, only the physical, or logical one except if the change is radical, we revise the conceptual level
Performance and to_be_state views	Performance view is insufficient and not explicit	Adapted SKANDIA (SKANDIA) proposed offers this view in the three stages of ameliorated CICM (ACICM); knowledge management stage, innovation management stage and intellectual property stage.
Linkability between views	Use organization, information, functional, and resource views	We proposed a fifth new view; the knowledge view and create diagrams for it.

VI. ADAPTATION OF SKANDIA (ASKANDIA)

Skandia Navigator is an early model to analyze intangible assets, pioneered by Edvinsson [11] at Skandia enterprise. It comprises a holistic view of performance and goal achievement with respect to intangibles. It's built of 5 focus areas or perspectives, each capturing different areas of interest: financial focus, customer focus, human focus, process focus and renewal and development focus. Fig. 3 shows globally, the adaptation of SKANDIA to be a quantitative method of controlling performance by enrichment of its book performance with new set of performance indicators to be up to date and to be more convivial to world business. In process 2 of SKANDIA, we proposed to use value explorer. For the third stage of intellectual capital management, which is intellectual property stage, we proposed a suitable method; intellectual asset valuation.
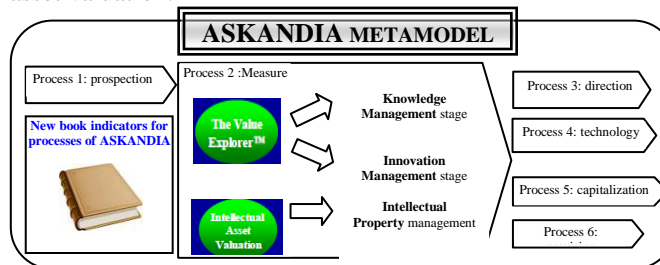

Figure 3.   Proposed metamodel of ASKANDIA

VII. HYBRIDIZATION OF ACICM, ASKANDIA AND BUSINESS INTELLIGENCE TO GIVE SKACICM

Fig. 5 shows the principle of the hybridization proposed of two ameliorated methods, ASKANDIA and ACICM, described in the precedent sections, that consists in the use of ACICM to develop the three stages of a system of knowledge management (knowledge management, innovation management and intellectual property management), and performance evaluation using ASKANDIA. A system of business intelligence was integrated to our developed system to allow to the company to be all the time competitive and resistant to environment change. Fig. 4, from the left to the right, explains the processes and their steps in the knowledge management

SKACICM KINETIC METAMODEL

Preparatory level

Process 1: Formulation of Knowledge-Based (or IC) Vision

Step 1: Leadership Formulation.

Step 2: Alignment with the Vision of Key People.

Step 3: Communicate to All Levels

Process 2: Cultural Audit and Transformation

Step 2: Effect Cultural Change on Executive and Departmental Levels

Step 3: Cultural Change Across the Whole Organization

Strategy level

Process 3: Knowledge Audit

Step 1: Stocktaking of Knowledge Resources

Step 2: AnalyzingAudit Findings

Step 3: Mapping Knowledge Resources

Step 4: Mapping Internal and External Knowledge Flows

Process 4: Strategizing Knowledge Management

Step 1: Identify Knowledge Strategies to Fill Gaps

Step 2: Understand the Various Variables That Knowledge Strategies Address

Step 3: Assess Need for Innovation versus Replication in Critical Business Processes

Process 5: Communities of Practice

Step 2: Form a CoP Council at the Central or Business Unit Level

Step 3: Assess the Case for Forming a Certain CoP

Step 4: Launching the CoP

Process 6: Best Practices

Step 1: Submission of Best Practices to the Review Committee

Step 2: Assessment, Approval and Dissemination

Step 3: Local Assessment, Application and Reporting

Knowledge management stage

Process 7: Knowledge Base and IT Architecture

Step 1: Design the Architecture

Step 2: Design the Knowledge Centers

Step 3: The Development of Taxonomies for the Knowledge Base

Step 4: The Choice of Enabling Technological Tools

operational level

Proposed Process 8 : Scorecard of Knowledge management using **ADAPTED SKANDIA for all levels** of the business

BUSINESS INTELLIGENCE

Preparatory level

Process 1: Getting Started and Gap Analysis

Step 1: Discovering the Innovation Portfolio

Step 2: Examining the Idea Generation Process and Culture

Step 3: Determine Where to Start

Strategy level

Process 2: Deciding on Innovation Strategies

Step 1: The Innovation Strategy

Step 2: Competitive Intelligence

operational level

Process 3: Innovation Portfolio Mix

Step 1: Create a Classification

Step 2: Diversify the Portfolio Mix

Step 3: Allocate Resources

Step 4: Identify the NPD Stages and Gates

Process 4: Structural Changes for IM

Step 1: Developing Competence Centers

Step 2: Create and Manage an Alliance Portfolio

Step 3: Tap Internal and External Resources to Form Project Teams

Process 5: Employee Implementation of Ideas and the Right Culture

Step 1: Encouraging Idea Submissions and Implementation

Process 6: Idea Banks and Employee Innovation

Step 1: Idea Submission and Building the Database

Step 2: Assessment

Step 3: Prepare Idea Reports

Process 7 : Implementing the Lead User Method for Breakthrough Innovation

Step 1: Project Planning

Step 2: Finding Lead Users

Step 3: Concept Generation and Development

Process 8: Technology Management Methods

Step 1: Uncover Competition's Past Patenting Trends and Anticipate Future Moves

Step 2: Assess Strengths and Weaknesses of Competition's Technological Position.

Step 3: Decide on Projects in the Innovation Portfolio.

Proposed Process 9: scorecard of innovation management

BUSINESS INTELLIGENCE

Innovation management stage

Strategy level

Process 2: Choosing Competitive IP Strategies

Step 1: Define the Competitive Purpose

Step 2: Combine between Short- and Long-Term Competitive IP Strategies.

Process 1: IP Audit and Portfolio Creation

Step 1: The Audit

Step 2: Create the IP Portfolio

Step 3: Value Transference Strategies

Process 3: Choosing Commercialization IP Strategies

Process 4: Building the IP Portfolio: IP Strategy Units

Process 5: Leveraging the IP Portfolio: IP Synergy Teams

operational level

Process 6: Making IPM the Job of Everyone: The IP Program

Step 1: The IP Literacy Guide

Step 2: The Detection Program

Step 3: The Clearance Program

IP Search
Assess blocking IP
Infringe
Yes
Assess scope
Narrow
Wide
No
Assess Validity
Design around
License
Proceed
Yes
No
No
Yes

Process 7: Designing Valuation and Assessment Tools

Step1 : Assessment and Qualitative Measures.

Step2 : Valuation and Quantitative Measures

Proposed Process 8 : scorecard of intellectual property management using **ADAPTED SKANDIA** (quantitative measures using the method **intellectual asset value** of Sullivan)

BUSINESS INTELLIGENCE

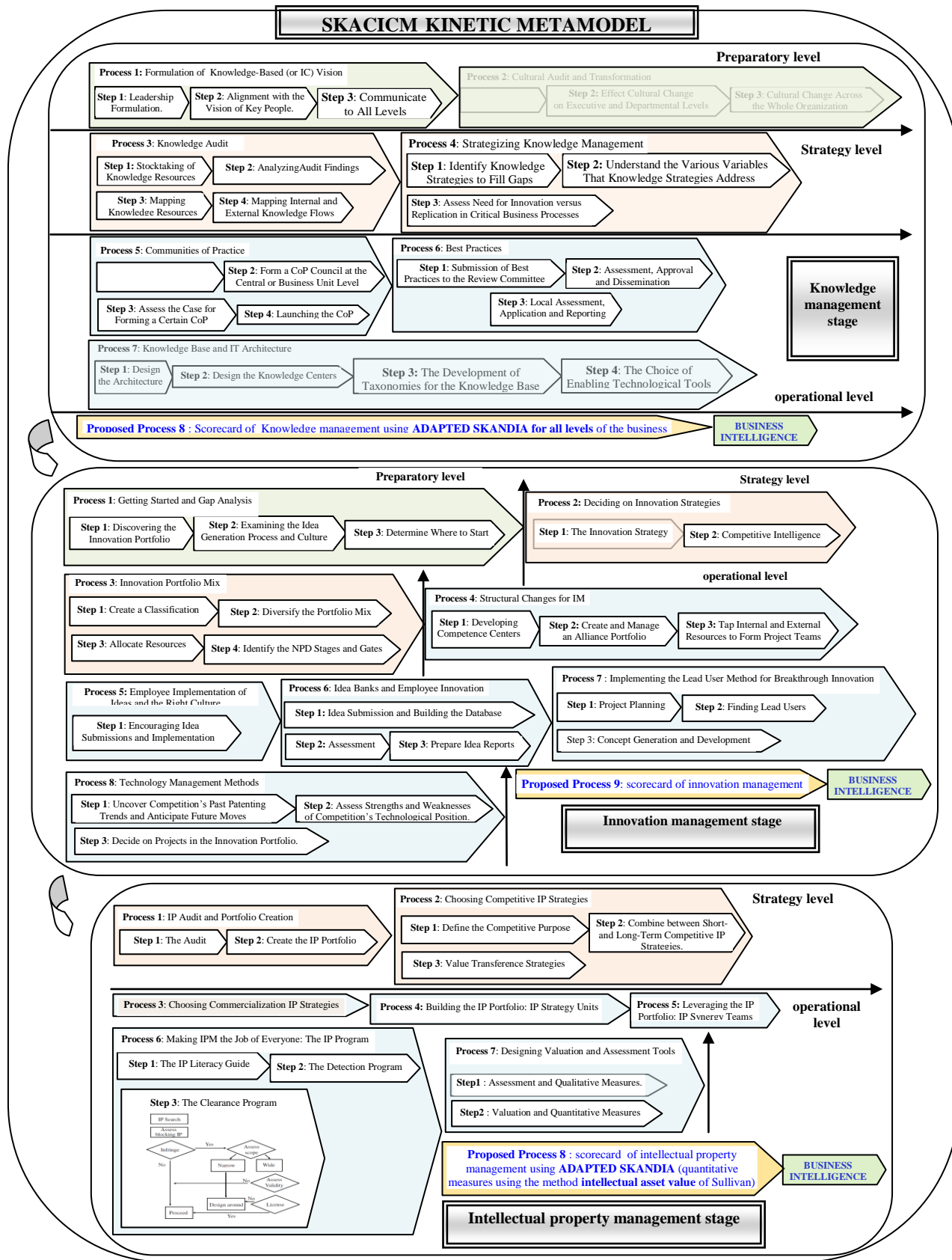**Intellectual property management stage**

Figure 4. SKACICM kinetic Metamodel

stage. It's constituted by seven processes; formulation of knowledge-based vision, cultural audit and transformations to knowledge audit, which an important step is consisting to mapping knowledge resources, mapping internal and external knowledge flows. Next, it consists to find strategies to fill gaps of knowledge, defining communities of practice and best practices. Finally, implementation of the knowledge base on information technology architecture after its design.
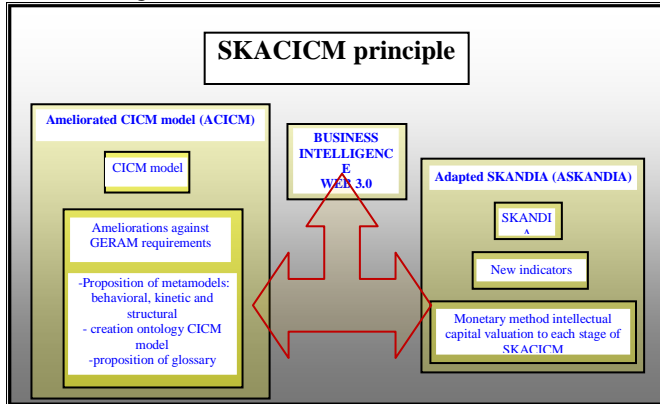

Figure 5.   SKACICM principle

VIII.   DEVELOPMENT OF KNOWLEDGE MANAGEMENT AND INNOVATION SYSTEM USING THE PROPOSED METHOD; SKACICM

The stages of SKACICM method was applied in cement company SCIMAT to develop a flexible tool to gather, share knowledge between the members of the communities of practice. Fig. 6 is an extract from database scheme; it shows a part of complexity of the structure of information and knowledge needed for the knowledge management.
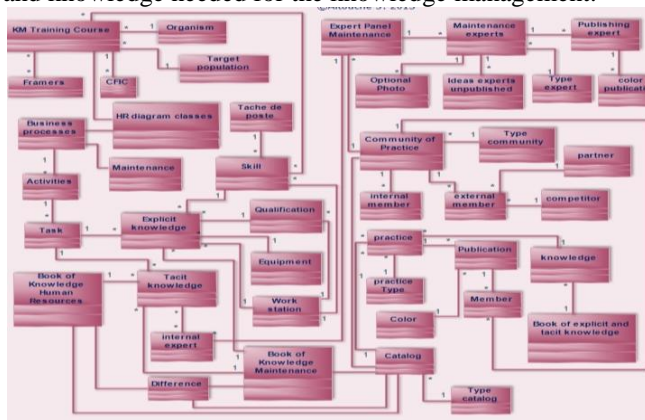
Figure 6.   Extract from database scheme

Five communities of practice were created; maintenance, human resources, SCIMAT community which is the sum of all communities of the company. Two extended communities were created; SCIMAT with its partners, SCIMAT with University. Further, a special community will be created, namely, SCIMAT with its competitors. Difficulties are expected when creating this community

because of the nature of the relationship between them, and the conflict of their interests.
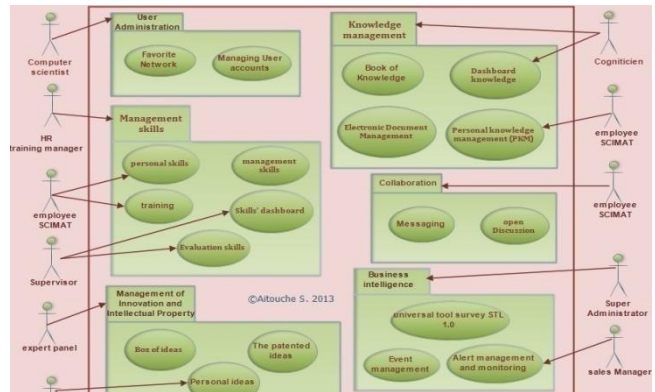
Figure 7.   Functionalities of developed knowledge management system

Among the functionalities of Knowledge management system (Fig. 7); learning module, where the members of concerned community can consult knowledge books. We proposed knowledge books, in maintenance and human resources, containing the explicit knowledge and the tacit knowledge externalized from experts of the company via brainstorming, brainwritings, questionnaires and interviews.

The module "Electronic Document Management" allows the findings of electronic archived documents, plans; this makes it easy the research of documents without going to document center to retrieve documents wasting in sometimes hours.   The module "business intelligence" allows the managements of new events, alerts and surveys keep company up to date. The module "collaboration and innovation" allows a communication, sharing of knowledge and ameliorates the creativity of the members of community. The novelties are proposed by a member of community, reviewed by a panel of experts and published if the new idea is accepted. The published idea should be applied by the other members of community and voted. If the vote gives more than 60% of acceptation, it becomes good practice and if it gives more than 75%, it becomes best practice. Then, we add the practice to the catalog of good and best practices (Fig. 8), and so on. This approach will improve innovation and bring wealth to the company.

Figure 8.   Knowledge and innovation management

IX. RETURN OF EXPERIENCE OF DEVELOPPED KNOWLEDGE MANAGEMENT SYSTEM

A. Return of experience of professionals, extra studied company SCIMAT

A satisfaction questionnaire was used for the professionals extra the company SCIMAT; 72% of users are satisfied by the functionalities of the developed system. 51% of them consider that it is directly usable by other manufacturing system without arrangements. Modules to improve according to the questionnaire are the skill management and the electronic management of documents.

B. Return of experience at the studied company SCIMAT

At SCIMAT, 83% of users are satisfied by completeness of the developed system. 61% of them consider that it is directly usable by other manufacturing systems without arrangements. Module to improve according to the questionnaire is the security of the system, which we should strengthen. The users of company are more satisfied because of their participation and validation during the development of the system of e-knowledge management.

X. CONCLUSIONS AND LIMITS

The analysis performed in this paper has shown that the metamodels are helpful to designer to refer to need easily. This comes from the readability of the metamodels. Furthermore, the ontologies and glossaries are which we expect to develop for ACICM. It could not satisfy the all requirements of GERAM because ACICM model is an enterprise engineering methodology which is only a component of GERAM and not a complete Enterprise architecture and methodology, certain requirements couldn't be analyzed in this work. A detailed analysis will be done based on detailed metamodels, in further work. All of these stages processes and steps seem long to apply, in contrary; they are very useful for the understandability of SKACICM.

Contributions of the developped knowledge management system are summarised in:
- It provides the ability to manage its knowledge, ideas and personal skills.
- Stored knowledge is a competitive advantage that improves performance in terms of quality and profitability. It allows company improvement performance of 26.82% after its operationalization.
- A business intelligence system allows internal and external audit to prepare company for contingencies.

For supporting the change, and accompany the developed system, we recommand to the company:
- Integrating the competency-based approach because it encourages the training according the new needs.
- Recruitment of a knowledge engineer.
- Set the new recruits lining with experts.
- Appeal to retirees if necessary to train new employees

- Encourage reflective practitioners because they are experts of the future.

As perspectives of our work, we foresee apply SKACICM in more industrial systems to argue its strengths, and at the studied company we foresee:
- Make the extension to other departments.
- Integrate existing expert systems.
- Improve the generator polls for automatic statistical interpretation.
- Quantification of intellectual capital for concrete gratification.

The developed knowledge management is still to complete by the other communities of the company, create their knowledge books and practices' catalogs.

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