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Procedia Engineering 132 (2015) 54 – 61

Procedia Engineering

www.elsevier.com/locate/procedia

The Manufacturing Engineering Society International Conference, MESIC 2015

R&D&i Management System in Distributed Manufacturing Systems

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Abstract

The R&D&i has become a key strategy to ensure competitiveness in a global market. New business models and Distributed Manufacturing Systems (DMS) arise as a form of adaptive response to new market situations.
Although R&D&I is incorporated at the strategic level, a lack of information about the management of R&D&I in distributed centers, theirs activities or organizational structure is detected.
The aim of this paper is to propose a methodology to implement the Management System (MS) of R&D&I in a Distributed Manufacturing System and enhance the knowledge in relation to this topic. In turn, the management of these activities may differ from the existing manufacturing and their Quality Management System (QMS) so the quality will be discussed in terms of research, development and innovation.

Peer-review under responsibility of the Scientific Committee of MESIC 2015

Keywords: Distributed Manufacturing Systems; DMS; R&D&i Management Systems; R&D&i-MS

1. Introduction

Nowadays, economic growth and productivity are increasingly based on knowledge and information. Global competitiveness and changing user needs are leading to new market situations where centralized, sequential

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Peer-review under responsibility of the Scientific Committee of MESIC 2015
doi:10.1016/j.proeng.2015.12.479

manufacturing and traditional control mechanisms are considered little flexible to respond new market demands such as, shorter life cycles, more complex products and increased flexibility. In this way, new business models and Distributed Manufacturing Systems (DMS) arise as a form of response adapted to new market situations [1].

However, since not only organizational change is sufficient to maintain competitiveness in a globalized environment. Research, development and innovation (R&D) of new products, processes and services become a key strategy to respond to a reality subjected to constant change. Therefore the management of R&D&i becomes a key factor for the organization. The creative, homogeneous nature of these activities may differ from existing manufacturing and their management systems such as the Quality Management System (QMS).

Therefore R&D and new business models are strong starting point for the future development of organizations. The aim of this research is to propose a methodology to implement the R&D&i Management System (R&D&i-MS) in a Distributed Manufacturing System and expand knowledge in relation to this topic. In turn, the management of these activities may differ from existing manufacturing and Management System (QMS), so that Quality will be treated in terms of R&D&i.

2. Research methodology

To reach the main objective of this work, different research approaches are established. On the one hand, literature review was performed to analyze what exists in relation to distributed R&D. On the other hand, the main elements of the management system of R&D&i are set through the analysis of standards family group of UNE 16600 and a based implementation methodology is proposed. Later, differences and similarities are established between the R&D&i-MS and QMS by different approaches. The conclusions drawn will be reviewed in new business models, DMS and further to extended or distributed organization. All these approaches will be the starting point for the proposed methodology.

3. A brief survey on Distributed R&D (D-R&D)

Due to new market demands in a globalized environment, traditional business models based primarily on a central headquarters, lose potential. Nowadays, organizations worldwide are located beyond the corporate headquarters, distribution facilities. It is therefore not surprising that in a review of the literature, when talking about R&D in distributed organization appears, in most cases, linked to the concept of internationalization [2-6]. Companies are positioned at a level beyond the nation to ensure competition in the global market to locate their R&D activities in centers of technological excellence.

Internationalization is therefore the subject that relates the R&D to DMS in extended organization. Common to all researches appear different forms of organization adopted by distributed international R&D companies. In some, there is more emphasis on transition models, resulting from the current demands of the environment [2,3]. Moreover, other researches focus on the various archetypes according to the orientation adopted by the organization on R&D [3-6]. In all of them, distribution versus coordination is reflected, and it is clarified the importance of knowledge creation and transfer.

Despite various international research and development typologies studied by several authors, little information on how to manage the different distributed R&D centers, the dynamics of the organization or its organizational structure is provided. It is therefore the aim of this work try broaden knowledge in the field of management of R&D in the current context.

4. R&D&i Management System

An analysis of the existing set of standards of UNE 16600 is performed. It highlights the standard UNE 166002:2014 R&D&i management system requirements [8]. Through its implementation and enforcement, organizations can certify their R&D&i Management System (R&D&i-MS). Through the study of the standard, the main elements of the management system are established. The context of the organization, executive management, leadership and culture of R&D&i play a key role in success of the system. On the other hand, operating, evaluation and improvement processes must take into account the uncertainty involved research, development and innovation

activities. There are new tools related to the management of intangible assets such as knowledge. Technology Watch (TW), Competitive Intelligence (CI) and technology transfer require special attention. These new tools help to systematize processes that have always existed in research organizations. After the analysis of the standard and applying the methodology PHVA, principal elements of the R&D&I management system are graphically represent in Figure 1. From the identification of all, the basis for the development of this work is established.

To implement the R&D&I Management System in a company with a single location, each of the elements described above should be identified and treated. As discussed so far, it is proposed four principal elements in the R&D management model: executive management, support, R&D&i activities, measurement, analysis and improvement.

The executive management is considered the key driver in the development of the system. In turn, the support should be defined. It is considered essential to establish the type of structure, the hierarchical structure for example or internal organization as the R&D Management units, R&D units and the relevant responsible for these units. It stands the responsible of TW/CI and technology transfer to ensure intangible resources, which are essential for the different phases of the research and development activities. It is pointed out, that apart from the organization and tangible resources are equally important intangible ones such as knowledge, intellectual and industrial property. The set of all them, are the support system and the base of research, development and innovation activities.

The R&D&i activities, have their own specific characteristics. The understanding of its nature is essential for the implementation and use of the management system. A part of the operational processes themselves established in the standard, it is also important to understand that the management, protection and exploitation of knowledge is the base of MS in combination with the fundamental involvement and conviction of each person working for the organization.

The measurement, analysis and improvement of each single process is particularly complex in R&D projects and activities. There is a risk factor inert due to their nature so the methods considered appropriate to evaluate the performance and efficiency of all processes must be established. It thus provides the information necessary to improve the system. Thus, based on the analysis and reflections an implementation methodology is proposed. It is used to transfer the extracted concepts to a R&D distributed system.

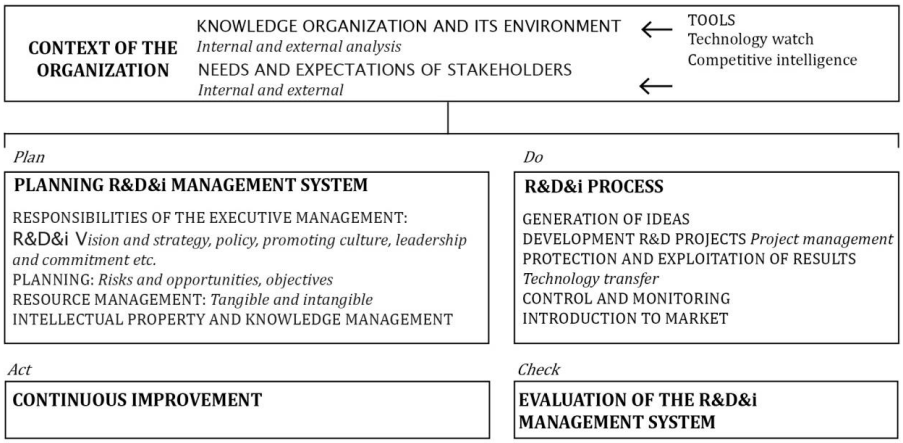

Fig. 1..Main elements of R&D&i Management System.

5. Comparison between QMS and R&D&i-MS

Currently, companies worldwide are under a concept of widespread and entrenched quality. Through the standard ISO 9001:2008 [9], organizations demonstrate its ability to provide products or services that meet customer requirements. However, organizations running with a Quality Management, want to incorporate R&D&i activities

and implement the corresponding management system. To clarify the possible differences or similarities derived from the exposed situation the MS R&D&i and QMS are analyzed by different approaches.

5.1. Comparison between standards and QMS implemented

A comparison between UNE 166002:2014 [8] and UNE ISO 9001:2008 [9] is performed. It is intended to identify those common requirements and specific for each activity. It can be extracted quickly those who are exempt from a common classification: Vision and strategy, Promoting innovation culture, Intellectual property and knowledge management, Collaboration, Technology watch and competitive intelligence

It begins to draw a profile about the specific elements of the MS R&D&i. As a reflection, the items listed in the above table can be grouped under two broad concepts: knowledge and leadership as a way to foster a culture of innovation.

On the other hand, a QMS implemented in an organization is focused in the manufacture of its products, in this particular case. The manufacturing processes are established and controlled in order to meet customer needs. Improvements are introduced to both, the product and for the processes themselves. As stated above question arises as what involves incorporating research, development and innovation within an organization under this culture of quality applied to their products, processes or services. For it, is discussed below certain characteristics of the R&D&i.

5.2. Characteristics of the R&D&i.

Through the literature analyzed, own and specific characteristics of R&D are grouped under three concepts: quality, nature and knowledge in R&D. These reflections are considered important for the aim of this work:

- Quality: Evidence of the effectiveness of quality systems in R&D comes from various sources [10-13]. In each one benefit and new capabilities that provides quality in R&D is emphasized. The new mentality and perspective that should acquire in quality concepts to effectively manage R&D is also raised.
- Nature: in other researches is examined how the R&D&i activities behave according to their specific nature [14,15,16]. Several studies point out the difference between the activities directly related to each of these systems, arises that the differences between R&D and other characteristics of the organization. It is argued that not manufacturing processes, as R&D, differ from them in three ways: the direct involvement of customers in the delivery of services, non-repetitive processes and intangible outputs recognized [17,18]. In addition, another study describes the nature often speculative, intensive, high-risk and non-sequential of R&D activities [19]. Even after the introduction of quality systems monitoring and measuring any impact remains a controversial activity, given the often non-repetitive processes, its multiple objectives and competing priorities [20-23]. Distinctions are also identified in the contextual level of existing standards, the innovative spirit of R&D&i is often more experimental than report iterative and continuous manufacturing improvements [24]. All these distinctions suggest that the adoption of a quality system within an environment of R&D often requires a different management style than those used in manufacturing environments.
- Knowledge: As stated in some studies, leading to all these comments about the different nature of R&D, its implicit emphasis on creation and use of knowledge. The strategic importance of knowledge is not only practice itself to do R&D. It should also take into account the potential opportunities being provided. Also, knowledge is considered by some authors epistemic rather than technical and in other it established that is located under different context and always it is provisional [25-26].

Therefore, it is thought that if knowledge varies from context then adoption of routine quality systems can be recommended only in a very specific location, though still under modifications. This contradicts the mantra of quality that calls to standard patterns of activity.

6. R&D&i in Distributed Manufacturing Systems

This section is introduced with the description of new business models and their manufacturing systems in order to analyze the R&D&i in these organizations to finally establish an implementation methodology for the situation described.

These new business models, in turn, require a number of requirements to their manufacturing systems. Thus, the so-called Next Generation Manufacturing Systems (NGMS) and Advanced Manufacturing Systems (AMS) arise [29]. Different paradigms act as approach for researching on NGMS. Under the paradigm of Distributed Manufacturing, the manufacturing system is considered as a set of autonomous entities, heterogeneous cooperative and integrated harmoniously. In the case of extended enterprise production system is comprised of a network of partners with a strong individual specialization [29].

Thus, the assumption of an extended company formed by different entities is set. Each one has autonomy but needs the cooperation and harmony to exploit synergies and have common objectives. In this model apart from its own manufacturing activities of research, development and innovation are incorporated under the same concept. In the entities or units of R&D&i under the paradigm of distribution /integration, each one work with some autonomy but coordinated and harmonized in cooperation with other entities, the common goals are achieved through individuals ones. Synergy is used. In particular, a centralized R&D company changes from a control center to R&D units with equal rights and duties. The connections and relationships between them, allowing better use of skills available, contribute to specialization and reduce the risk of duplication. Each unit in the network is specialized in a product area, component or technology in particular. Due to the accumulation of knowledge in a particular field of specialization, this unit assumes a leadership role as a competence center. The unit is responsible for the entire process of creating value, not only related to a R&D product. Thus, potential markets and areas of application of the product is best known. The unit is responsible for the coordination, generation and marketing products worldwide. Some of these examples of R&D in distributed enterprise are treated by some authors [30,31].

7. Methodological proposal

Under this concept of autonomy with hints of cooperation, coordination and harmony, the implementation of R&D&i MS should also be influenced by this new perspective. It aims to establish a methodology to help identify those most important aspects to consider in a distributed enterprise. As a reflection of the analysis carried out so far two essential concepts are extracted: Integration/distribution; paradigm in which distributed systems are evolved; and Nature of the R&D&i . Along with these concepts, development of work and the literature reviewed, a number of issues related to R & D management are identified. The proposed methodology identifies and proposes three main elements, from which carried out the implementation of the R&D&i-MS: Support, Knowledge and R&D&i activities. These are considered the key to the implementation of a management system in a distributed organization.

The proposed methodology considers crucial analysis/diagnosis phase based on the three-pronged approach. Due to the added complexity in distributed enterprise, along with the characteristics of R&D&i, discussed above, the proposed phase is considered the key to help the understanding of the performance of the management system. Through this analysis/diagnosis phase, identification of the elements is facilitated. Subsequently the establishment/implementation phase is set. In this phase is carried out the implementation Management System elements in a distributed organization.

Therefore, the following phases are proposed in the methodology: Initial Approach, Analysis/Diagnosis (triple approach), and Establishment/Implementation. The methodology is reflected in Figure 2.

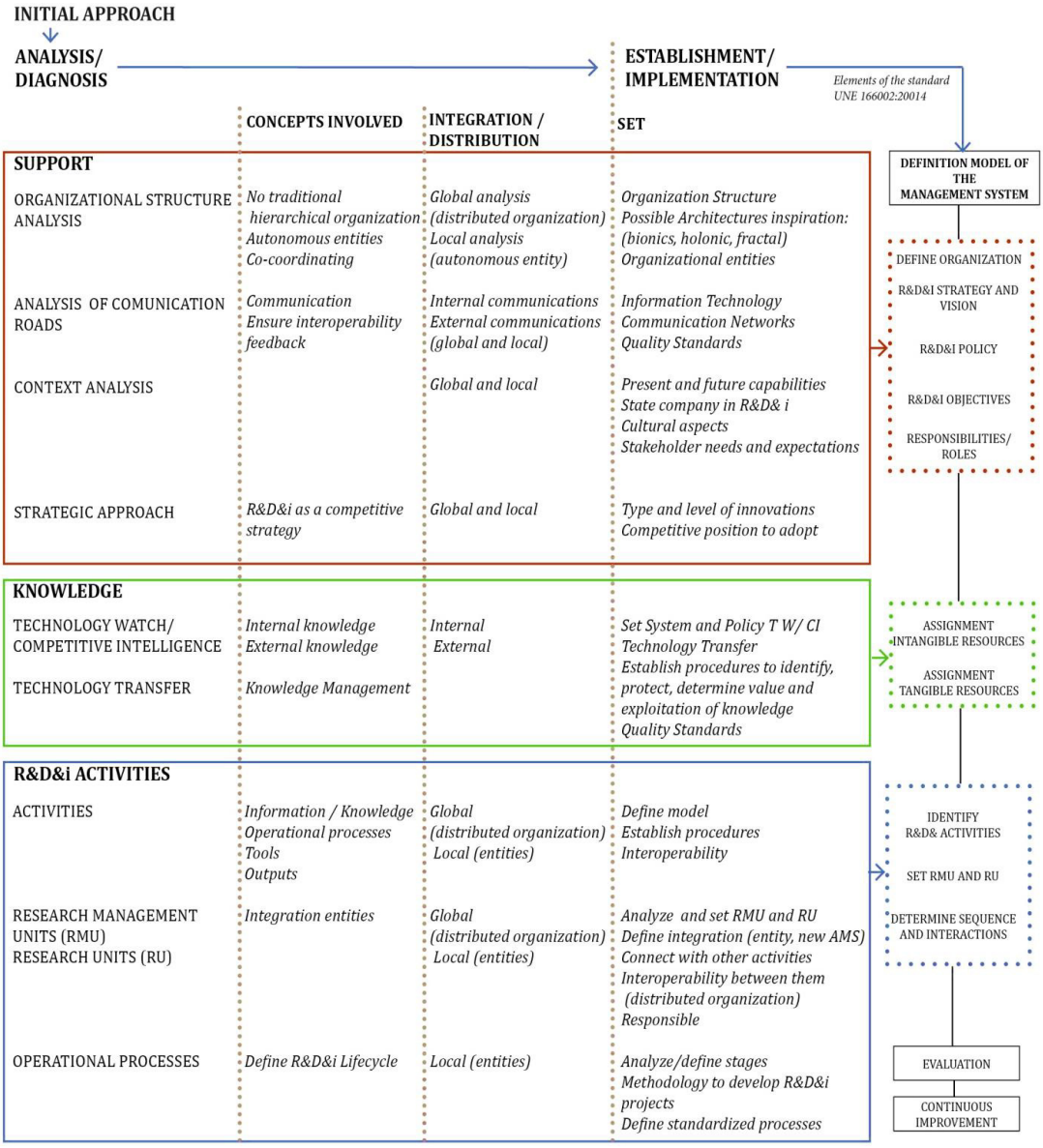

Fig. 2. Methological proposal

The three phases are appreciated. In regard to the Initial Approach phase, incorporate the R&D and its management system, born from the conviction and commitment of executive management. At this stage, managers must create and maintain a commitment to the implementation project management system, being actively involved in the process and understanding the fundamentals of quality management in this area.

At the Analysis/Diagnosis phase, three-pronged approaches are identified Support, Knowledge and R&D&i activities. In turn, each tries to analyze several key elements considered in this methodology. A distinction is made between to understand the twice concept integration/distribution characteristic of DS. It emphasizes the dual perspective to take when delve into each element of the MS.

In the establishment/implementation phase are collected the elements or tools available as the result of the above analysis focused. Through each of them, represented with different colors, is carried out the implementation of the elements of the standard UNE 166002:2014. It aims to establish a concordance between the proposed methodology, according to a distributed organization, and the model proposed in the standard. This methodology poses the need and importance of thorough analysis across this triple approach, considered essential to the understanding the R&D&i Management System in a distributed organization.

8. Conclusions

Distributed R&D&i has demonstrated its potential across different geographical locations to search for science, foreign technology, new markets and new products. In turn, the Distributed Manufacturing Systems have demonstrated their flexibility and ability to adapt to the new demands of the environment thanks to its autonomy and coordination. The juxtaposition of both is the basis for ensuring future production, growth and competitiveness in the market.

It has not been found in Technical Literature references on R&D&i Management Systems in the new emerging business models as well as in their distributed systems.

The implicit nature of the R&D&i is reflected in the creation and use of intangible assets such as knowledge, becoming the aspect for managing these activities. In turn, the problem that arises is the difficulty to measure and manage knowledge due to its being temporary and localized among others. All this together with experimentation, creativity and inhomogeneous processes characteristic of these activities can become a controversial activity to manage and control.

Individuality, autonomy and cooperation of distributed systems, needs a support to ensure interoperability and integration structure. Knowledge, Support and R&D&i activities are identified as the key elements to implement the Management System of R&D&I in a DS. All under the two concepts, integration/distribution and Nature of R&D&i

The traditional Quality Management System should be adapted to R&D&i activities. The repeatability, control and iterative improvement that address quality systems are possible thanks to the nature of the manufacturing process. Quality in R&D&I should be oriented to the effective exploration and exploitation of the knowledge, defined as one of the key elements of the proposed methodology. Therefore the adoption of methods to control and monitor them should correspond to its own characteristics adapting the principles of quality to each specific situation

Acknowledgements

This work has received financial support from the Andalusian Goverment (PAIDI) and form the European Union.

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