

Enhancing R&D&i through standardization and certification: the case of the spanish construction industry

Mejorando la I+D+i mediante la normalización y la certificación: el caso del sector de la construcción español

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Abstract

The advance of a community is often measured by its investment in Research, Development and Innovation (R&D&i). Western economies assume the need to investigate new techniques, materials and processes to improve the efficiency and sustainability of each productive task. Standardization and certification of R&D&i projects and management systems become suitable tools to optimize results, considering the international policy to encourage R&D&i activities. Therefore, companies seek to verify to the public administration the final destiny of the resources to R&D&i activities, obtaining fiscal advantages through the overall process. Even though construction is a highly significant industry in developed and developing economies, construction companies invest little in R&D&i compared to other sectors. The link between standardization and innovation remains a significant knowledge gap in the construction management field. In this paper, the international state of affairs regarding standardization and certification of R&D&i activities is described, highlighting the innovative characteristics of the Spanish standards UNE 166000. The results of an analysis of the Spanish construction industry, regarding standardization and certification, are also presented and discussed. This new set of standards could be a reference for other countries, always working jointly with the families ISO 9000 and 14000.

Keywords: Innovation, certification, construction, standardization, management

Resumen

El grado de desarrollo de una comunidad es medido, a menudo, por su inversión en investigación, desarrollo e innovación (I+D+i). Los países industrializados asumen la necesidad de investigar nuevas técnicas, materiales y procesos con objeto de alcanzar una mayor eficiencia y sustentabilidad en cada tarea productiva. La normalización y la certificación de la gestión de proyectos o sistemas de I+D+i supone una herramienta adecuada para optimizar los resultados, sobre todo cuando es una política internacional el incentivo de las tareas de I+D+i. Las empresas buscan acreditar ante la administración pública los recursos destinados a la I+D+i, obteniendo ventajas fiscales a lo largo de todo el proceso. A pesar de que el sector de la construcción es importante en todas las economías desarrolladas y en vías de desarrollo, las empresas constructoras invierten poco en I+D+i comparativamente con otros sectores. La relación entre la normalización y la innovación sigue siendo una asignatura pendiente dentro del campo de la gestión de la construcción. A lo largo del presente artículo se analiza la situación internacional en materia de normalización y certificación de actividades de I+D+i, señalando el carácter innovador de las normas españolas UNE 166000. Se exponen los resultados de un estudio sistemático destinado a conocer la situación actual en el sector de la construcción en España, referente a la normalización y a la certificación. Esta nueva familia de normas podría servir como referente para otros países, siempre funcionando conjuntamente con las series de normas ISO 9000 y 14000.

Palabras Clave: Innovación, certificación, construcción, normalización, gestión

1. Introduction

The construction sector represents approximately 10% of the Gross Domestic Product (GDP) in developed countries (Crosthwaite, 2000; Janssen, 2000). Values for the European Union (EU) range from 7.6% in Sweden

and Poland to 19.8% in Ireland; production in construction in the Euro zone accounted for more than one billion Euros (10^{12} €) in 2006 (SEOPAN, 2007).

The construction industry has not been analyzed

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as broadly as other sectors (formerly agriculture, and now manufacturing and services), although it is exemplified as non-innovative by many scholars (Tucker and Borcharding, 1977; Shenhar and Dvir, 1996; Jones and Saad, 2003; Blayse and Manley, 2004; Taylor and Levitt, 2004). For instance, R&D&i management and its results related to the construction sector, particularly patents, are much lower than other productive sectors, such as science-based production intensive and specialized suppliers (Pavitt, 1984; Tidd et al., 2001; Greenhalgh and Rogers, 2006). However, other authors have drawn attention to the characteristics of the industry as opportunities that can be managed to enhance innovation in one way or another (Tatum, 1989; Groak, 1994; Slaughter, 1998; Gann, 2000; Miozzo and Dewick, 2002; Winch, 2003; Lu and Sexton, 2006). More recently, several books have highlighted the importance of innovation in the construction sector: Gann (2000), Jones and Saad (2003), and Manseau and Shields (2005).

Instead of construction industry, Gann and Salter (2000) defined the concept of construction process. This process involves five long-established phases: feasibility, design, construction, operation, and divestment (adapted from Stuckenbruck, 1981). The tangible product is the built infrastructure. Nam and Tatum (1988) identified the main features of the final product: immobility, complexity, durability, costliness, and high degree of social responsibility. Gann and Salter (2000) also contributed to the idea of a project-based industry materialized by firms that work through projects. For each phase of the process, different sorts of projects are needed; thus, specialized project-based companies arise. The key point that they stress is the need for integration of project and business processes in order to obtain successful innovation within project-based firms that are involved in the delivery of complex products and systems.

Spain is one of the major countries in the EU concerning the volume of production in the construction sector, along with Germany, the United Kingdom, Italy, and France (SEOPAN, 2007). The most important Spanish construction companies are also awarded good contracts in Europe and America. Still, Spanish construction industry is especially non-innovative (Villar-Mir, 2001). In general, Spanish spending on R&D&i activities, as percentage of GDP, is half of the EU and one third of that of the United States (CICYT, 2003). When referring to construction, Spanish investment in innovation is approximately eight times less than the EU average (Villar-Mir, 2001). Additionally, until some months ago, no initiative had

been taken to prompt innovation in the industry, as it happened during last decade in the United Kingdom through the Latham (1994) and Egan (1998) reports, and the later Movement for Innovation (<http://www.constructingexcellence.org.uk>).

Taking to the practice some of the proposals made by Gann (1997) and applying the commitments adopted by the European Union in Lisbon in 2000 (CICYT, 2003), the Spanish government launched the program Inventiveness-2010 (Ministerio de la Presidencia, 2005) to bridge the gap of R&D&i with western economies. This way, enterprises that invest in R&D&i activities can obtain fiscal incentives. Additionally, public administrations are rewarding construction companies in the bidding process if these companies show proof of their R&D&i activities; this incentive can total 25% in the final score of the bidding (Ministerio de Fomento, 2006).

In this paper, we present a new scenario where innovation is seen as another business management process capable of being systematized; thus, innovation can undergo standardization in accordance with an external certification body. First, the apparently exclusive terms of innovation and standardization are assessed. Later, the new Spanish normative UNE 166000 is outlined, mainly from two approaches: R&D&i projects and R&D&i management systems. The current scenario of R&D&i management in the Spanish construction sector, focusing on standardization and certification processes, is highlighted from a survey developed for construction companies. Finally, the main conclusions of our work are stated.

2. Innovation versus standardization

Currently, the construction sector applies flexible processes and holistic methods (Winch, 2002; Jones and Saad, 2003). Project management is the usual way of managing work in design and construction companies; nowadays, this is viewed as an innovative way of management in other sectors too (Hobday, 2000; Blindenbach-Driessen and van den Ende, 2006). Flexible, holistic and project-based approaches encourage innovation, but they are to a certain extent opposed to standardization. Thus, as engineers, we should ask ourselves two questions: first, is innovation compatible with standardization?, and second, is it possible to standardize innovation?

Kondo (2000) affirmed that innovation and standardization are not mutually exclusive. He proposed

that manuals should be oriented to beginners for training or to experienced workers for know-how. In this same line of thought, Edum-Fotwe et al. (2004) presented a case study of a British public administration that manages innovative solutions for the health sector by means of standardization; standards offer the baseline for reliable performance, whereas significant elements of innovation are identified and added to the standards.

Nevertheless, several papers have described the relationship between innovation and quality management. Kanji (1996) created a simple model where each kind of innovation undergoes the quality management process to become successful innovation; several examples are given to illustrate the idea. Keogh and Bower (1997) presented a case study to detect links between quality management and innovation in the oil and gas industry. Bossink (2002) investigated the supportive use of quality tools in the management of innovation, concluding that these quality tools, being the ISO 9001 standard among them, are very useful for the management of innovation.

Prajogo and Sohal (2006) examined the relationship between Total Quality Management (TQM), differentiating strategy and innovation performance. The implication is that other resources (particularly innovation) can complement TQM more effectively in order to improve business strategy, achieving a high level of performance. TQM can also influence the innovative culture of a firm (Santos-Vijande and Alvarez-Gonzalez, 2007).

Figure 1 summarizes the relationships between quality and innovation management as well as their integration in business management. Quality and innovation management processes can be improved with the help of standardization, but knowledge management is not yet a standardized process. Thus, construction companies have tools that allow them to improve business management in order to enhance their competitiveness. However, even though companies have enough experience managing quality processes, it is decisive for them to address their innovation and knowledge management processes.

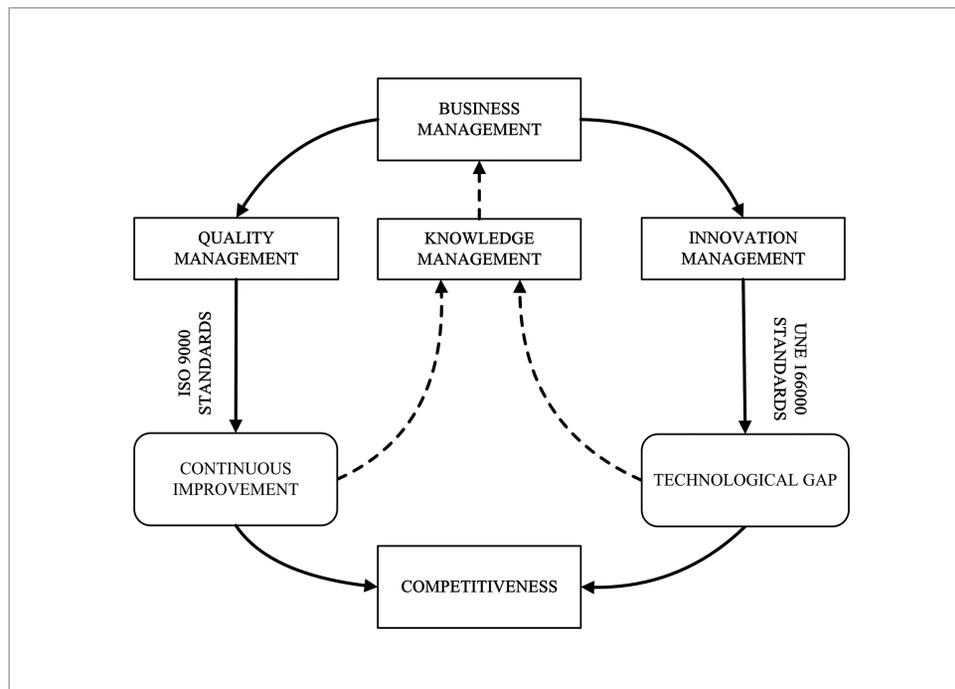


Figure 1. Quality, innovation and knowledge relationship within the company. Source: authors' elaboration

In 1989, the British Standards Institution (BSI) issued the standard BS 7000-1 “Design management systems: guide to managing innovation”; it was republished ten years later. This standard recommended, “the development of innovative and competitive products that will satisfy customer’s perceived and talent needs in the long term future” (p. 1); it goes beyond design management, but it does not address continuous improvement. However, more than a typical standard, BS 7000-1 can be considered as an academic report addressing key issues in innovation management related to engineering design: roles, types, processes, organization, tools and techniques. Another standard, BS 7000-4 (“Design management systems: guide to managing design in construction”, published in 1999 by BSI), dealt with specific issues on managing design in construction. Three main features must be highlighted from the analysis of these British Standards. First, their scope is product design (even the BS 7000-4 focused on construction). Second, they provide a framework for managing innovation, but not in a systematic way. Finally, they rely on the ISO 9001 standard for complementary support.

The ISO 9000 and 14000 standards series can serve as a basis for continuous innovation; many companies now apply these standards to their business processes in the construction industry (Koehn and Datta, 2003). In western and developing economies, most companies generate innovative products or processes, not only in the construction industry but also in other sectors. However, the main difficulty becomes continuous and methodical innovation; random efforts and bright ideas are not enough. Innovation has reached a critical point where it is not a gift anymore but a professional asset; thus, it must be planned, organized, directed and controlled, as any other managerial activity (Correa et al., 2007). According to these authors, systematic innovation offers many advantages for project-based companies in the construction sector:

- Efficient exploitation of resources and know-how.
- Improvement of organizational activities.
- Achievement of previously established goals and objectives.
- Differentiating factor for competitiveness and business status.
- Technology transfer.
- Tax deductions.

- Enhancement of employee motivation.
- Enrichment of stakeholder satisfaction.
- Identification of changes and new opportunities through technological watch.
- Integration with other ISO standards (mainly the 9000 and 14000 families).

3. Une 166000 standards

In order to induce systematic innovation in the Spanish economy, the experimental standards UNE 166000 were issued in 2002 by AENOR (the organism responsible for developing Spanish standards). In 2006, the main standards were edited in a final version. The terminology and definitions are those recognized internationally by the Oslo Manual (OECD, 1992), the Frascati Manual (OECD, 1993) and the Bogotá Manual (Jaramillo et al., 2000). This new normative aims to systematize R&D&I management, especially in medium and small enterprises. These standards include:

- UNE 166000: 2006. “R&D&i management: terminology and definitions of R&D&i”.
- UNE 166001: 2006. “R&D&i management: requirements for R&D&i projects”.
- UNE 166002: 2006. “R&D&i management: requirements for R&D&i management systems”.
- UNE 166003 EX: 2003. “R&D&i management: competence and evaluation of R&D&i project auditors”.
- UNE 166004 EX: 2003. “R&D&i management: competence and evaluation of R&D&i management systems auditors”.
- UNE 166005 IN: 2004. “R&D&i management: application guide of UNE 166002: 2002 EX to equipment sector”.
- UNE 166006 EX: 2006. “R&D&i management: technological watch system”.

Certification can be obtained for innovation projects (UNE 166001) and for innovation management systems (UNE 166002). The former may focus on planning or execution. The latter is thought to develop the integration of R&D&i within the quality management systems ISO 9001. Nowadays, these standards are mainly used in Spain; they have also recently been introduced in Mexico, Brazil, Italy, and Portugal.

In view of the role of government as a regulator of the industry (Gann, 1997), Spanish central government, following the Inventiveness-2010 programme, evaluate innovation through the bidding process for works and service contracts; the measurement of innovation is based on UNE 166000 standards. The pace of innovation in the industry is increasing, even though it will take some time to reach the Euro Zone average. For instance, at the end of 2005, there were 42 certified companies, but none of them was a construction company; only one was a supplier for the construction sector. At the end of 2007, there were 10 favorable applications from construction-related firms: of these, 8 contractors, 1 quality control company and 1 consultant firm (AENOR, 2008).

4. Certification for innovation projects

The standard UNE 166001 is a reference for defining, documenting and developing R&D&i projects. It includes the relevant aspects of managing the project and exploiting its results. This standard aims to facilitate the systematization of R&D&i projects. Thus, any organization, especially medium and small enterprises, can identify innovative activities, develop and document them in a methodical way to obtain a sound and well regarded achievement in innovation. Furthermore, this innovation can be certified and displayed for acknowledgment whenever necessary. Companies pursue fiscal and tax incentives in order to improve resources, products and processes. In these R&D&i projects, results may differ significantly from the initial goals, even though the outcome can be of better value if they lead to more innovative results. Outcomes from R&D&i can be incremental or radical; modifications of something already existing or completely new; products or processes; or oriented to consumption, industry or management.

A potential innovative project requires a person in charge, with well-defined tasks. Then, the R&D&i project is documented as follows: (1) main report; (2) scope of work; (3) budget; (4) document control; (5) project monitoring; and (6) exploitation plan. The main report includes summary, methodology, goals and planning to assess them, impact and opportunity regarding R&D&i. The current state-of-the-art of the product, process and

technology is also summarized. Foreseen scientific and technical advances, intellectual property protection, laws, and regulations affected are emphasized as well.

Scope definition comprises the work breakdown structure and the product breakdown structure or, in other words, the organizational hierarchy of project tasks and project results, respectively. This definition also includes the allocation of human resources, the identification of critical milestones, risk assessment, supervision of project tasks and results. Displaying flowcharts, either bar charts or network charts, is recommendable.

The project budget is based on cost estimation and previous scheduling. Resources, task duration and their relation through the work breakdown structure are required to obtain actual costs; cost traceability is also essential. Document control and project monitoring end the project management cycle. Project monitoring, according to this standard, demands regular reports to explain results, costs and deviations.

Finally, the UNE 166001 requires the exploitation of results in order to use, disseminate and protect them. The plan includes the identification of the new product or process, the definition of stakeholders and markets interested in their use, the protection of outcomes (if appropriate), the economic exploitation of results, the estimated costs in accordance with several scenarios, and the benefits of the project related to business competitiveness.

Figure 2 illustrates the certification process for R&D&i projects. The process starts when the company sends an application form and documentation to the certification body. The application is then processed and the documents analyzed; the certification organization then reports on compliance with UNE 166001, and an external expert is selected (if required). This expert evaluates the project and submits a technical report; if it is favorable, the certification body issues the proposal for certification.

This standard classifies innovation projects into two types: those based on content and budget, or those based on content and execution. The former are projects that have not yet been implemented, but the company is interested in showing its innovative contents to clients or any other stakeholder affected. The latter comprises projects under execution or already implemented.

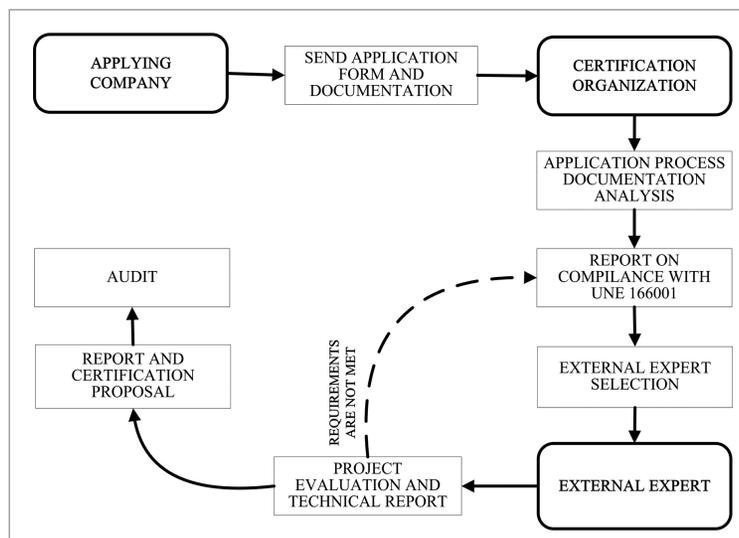


Figure 2. The certification process for R&D&i projects. Source: authors' elaboration based on AENOR (2006)

5. Certification for innovation management systems

The standard UNE 166002 sets up the bases for systematization of R&D&i in companies. It also acknowledges certification by an independent organization. This norm is designed to integrate R&D&i management systems with other management systems already existing in the company: quality (ISO 9000), environment (ISO 14000) or health and safety (OHSAS 18000). The requirements of UNE 166002 standard are based on process management, using the well-known methodology PDCA (“plan-do-check-act”); these requirements are general and applicable to every enterprise, whatever its type or size. Five major features are developed in the standard: R&D&i management system and model; stakeholder responsibility; resources management; R&D&i activities; and measurement, analysis and improvement. These features are explained in the following paragraphs.

A model of R&D&i process must be established, documented, implemented and maintained by the organization. A management system is also needed to improve the effectiveness following the requirements of UNE 166002. Documentation compiles statements of R&D&i policies and goals, internal procedures and control records. Procedures include planning, operation and monitoring of R&D&i activities. It is necessary to control documents and records in a similar way as stated in ISO 9001 standard.

Executive officers must agree to develop, implement, improve and review the R&D&i management system. They must analyze and meet the expectations and necessities of the different stakeholders (Gann and Salter, 2000; Blayse and Manley, 2004): suppliers, clients, employees, shareholders, regulatory bodies, and so on. Policies, planning and responsibilities are put into action with reliable communication channels and a sound organizational hierarchy. The R&D&i management unit is defined to run the system and the R&D&i projects; under certain circumstances other subordinate R&D&i units can develop specific projects, using new technologies or generating knowledge.

R&D&i management needs skilled resources that should be properly allocated. Personnel motivation and training are essential to achieve the goals. Material resources and infrastructure are also key elements in this scheme.

There are several tools provided by the standard to develop R&D&i activities: technological watch, technological forecast, creativity, and internal and external analysis, among others. Additional activities proposed include identification and analysis of problems and opportunities; analysis and selection of R&D&i ideas; planning, monitoring, and control of project portfolio; technology transfer; R&D&i products; purchasing; R&D&i process results; and protection and exploitation of R&D&i activities results.

Finally, the company schedules, plans and implements the monitoring process, which includes the measurement, analysis and continuous improvement of the R&D&i management system and the execution of its activities. They can be perfectly integrated in the quality management processes described by the standard ISO 9001.

The certification process for R&D&i management systems is shown in Figure 3. Once the applying company sends the application form, the certification body analyzes the documentation, visits the company's headquarters and performs a preliminary audit of the system. If the requirements are not met, then a second audit will be proposed to the company. If the company obtains certification, annual audits will monitor the system, and certification will be renewed every three years.

- The organizational hierarchy regarding R&D&i management.
- The degree of compromise of R&D&i policies and strategies.
- The percentage of certifications on R&D&i management and its relationship with other certifiable management systems (mainly quality, ISO 9000, and environment, ISO 14000).

To facilitate satisfactory results, a Poisson Test was carried out with the intention of obtaining a representative sample of every subpopulation. The diversity of the companies that work in the sector according to their size and type was taken into account. Nevertheless, the data attached correspond to the total aggregate to compare these with other productive sectors in the future, even in other geographic areas. 105 out of 120 companies responded to the questionnaire. Taking into consideration the total size of the population, the confidence level is 95% and the sample error is $\pm 3.7\%$.

Among the results obtained, we should state that 32.4% of the companies have a specific department for the management of R&D&i. However, a significant fact is the year those departments were created: most were established in 2005 (see Table 1).

6. Innovation management in the spanish construction industry

In order to know the current scenario of R&D&i management in the Spanish construction sector, a survey was developed in 2006 taking into account a representative sample of construction companies. The questionnaire had three main items to determine:

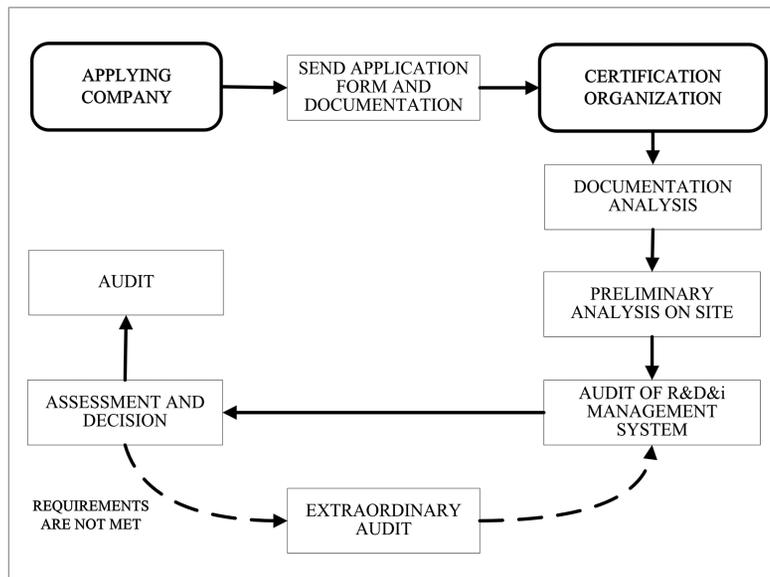


Figure 3. The certification process for R&D&i management systems. Source: authors' elaboration based on AENOR (2006)

Year	Number of companies
2002	3
2003	5
2004	8
2005	18

Table 1. Year of establishment of the department of R&D&i management

Another notable factor is related to the certification of R&D&i management (see Table 2): 5% of the companies hold a certificate from an acknowledged organization, whereas 14% of them have begun the certification procedure. These data highlight the entrepreneurial system's positive reaction to the new scenario.

Distribution	Number of companies
Companies not certified	80
Companies seeking certification	15
Companies certified	5

Table 2. Distribution of companies regarding certification

Regarding the type of certification obtained, it is important to realize that the number of companies certified with R&D&i management systems (UNE 166002) match the number of certifications for R&D&i projects (UNE 166001). This fact implies that companies want to establish and consolidate R&D&i management systems, and certifying R&D&i projects by themselves may not be enough. Therefore, companies aim to obtain certification in R&D&i management systems, looking forward a true assimilation of these systems within the company.

7. Conclusions

A spontaneous and random approach to innovation is not viable any longer; on the contrary, a systematic attitude to innovate is foreseeable. Standardization and innovation are compatible concepts. Standards play a crucial role in the definition of market conditions in many industrial sectors, accelerating technological and organizational change while improving

innovation performance. Standards also promote innovative products and services by providing stable references for the development of new innovative solutions and by creating large-scale markets. Two styles of standardization are analyzed in the paper: BS 7000 and UNE 166000. On the one hand, the BS 7000-1 standard clarifies terms related to innovation and gives details on methodology; however, it is only a guide to manage innovation and it does not go further. On the other hand, the UNE 166000 series establishes a certification procedure for companies; requirements are defined and steps identified, not only for specific projects but also for management systems. An additional feature of UNE 166002 is its compatibility with ISO 9001 and 14001; thus, these management systems (R&D&i, quality and environment) can be combined.

Innovation is also a process, thus it can be standardized as any other business process. In Spain, a change of attitude towards innovation is now taking place in the construction sector. Likewise from our analysis, there is a steady growth in implementation of R&D&i management systems, and a tendency towards certification, as with the previous ISO 9000 and ISO 14000 series of standards; this trend is basically due to the competitive advantage and the fiscal incentives that construction companies can obtain. Furthermore, R&D&i management is being valued in public works' bids as an added factor to the traditional ones: price, duration and quality. In fact, the Spanish government uses UNE 166000 standards as a tool to measure the innovation in the companies. These standards are gradually certifying companies. Thus, the standardization of innovation in the Spanish construction industry may prove extremely effective in the near future to systemize new knowledge in novel constructive procedures. The UNE 166000 set of standards could be a reference for other countries in order to enhance innovation, not only in the construction industry but also in the country's economy

For project-based companies, it is critical to improve business management and hence increase competitiveness. Standardization can enhance quality, innovation and knowledge management processes. To this end, competitiveness can be attained through improvement in quality and steps up through the technological gap. To complete the cycle, knowledge management should also be standardized and integrated into the other processes of the company.

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