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Standardised innovation management systems: A case study of the Spanish Standard UNE 166002:2006

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ABSTRACT: This paper describes the experience of a Spanish manufacturing firm that implemented the UNE 166002:2006 standard, which is the first in the world to offer a certifiable standardised management system for innovation. After a brief review of innovation management in general, the paper describes the history, objectives, and content of the UNE 166002:2006 Spanish standard and the family of standards to which it belongs. The paper then presents a case study of the implementation of the standard in a manufacturing company, describing the benefits and difficulties of the implementation as detected by the company personnel involved. The paper concludes with a discussion of the desirability and feasibility of creating an international innovation management standard and a new generation of innovation management processes based on a standard for innovation.

KEYWORDS: innovation management, innovation management system, UNE 166002, standardisation, systematic innovation, R&D, new products.

SISTEMAS DE GESTIÓN DE LA INNOVACIÓN ESTANDARIZADOS: UN ESTUDIO DE CASO SOBRE LA NORMA ESPAÑOLA UNE 166002:2006

RESUMEN: Este artículo describe la experiencia de una empresa de fabricación española que ha implementado la norma UNE 166002:2006, que es la primera norma en el mundo en ofrecer un sistema normalizado de gestión de la innovación certificable. Tras una breve reseña sobre la gestión de la innovación en general, el documento describe la historia, objetivos y contenido de la norma española UNE 166002:2006 y la familia de normas a la cual pertenece. Posteriormente, el artículo presenta un caso de estudio de la aplicación de la norma en una empresa manufacturera, describiendo las ventajas y dificultades de la implementación detectadas por el personal de la empresa en cuestión. El documento concluye con una discusión sobre la conveniencia y viabilidad de crear un estándar internacional de gestión de la innovación y la aparición de una nueva generación de procesos de gestión de la innovación basada en un estándar para la innovación.

PALABRAS CLAVE: innovación; gestión de la innovación; sistema de gestión de la innovación; UNE 166002; estandarización; innovación sistemática, I+D; nuevos productos.

SYSTÈMES STANDARDS DE GESTION DE L'INNOVATION: UNE ÉTUDE DE CAS SUR LA NORME ESPAGNOLE UNE 166002:2006

RÉSUMÉ : Cet article décrit l'expérience d'une entreprise de fabrication espagnole qui a implanté la norme UNE 166002:2006, première norme au monde offrant un système normalisé de gestion de l'innovation certifiée. Après un résumé de la gestion de l'innovation en général, le document décrit l'histoire, les objectifs et le contenu de la norme espagnole UNE 166002:2006 et le groupe de normes à laquelle elle appartient. L'article présente ensuite un cas d'étude d'application de la norme dans une entreprise de manufacture et décrit les avantages et les difficultés d'implantation détectées par le personnel de l'entreprise concernée. Le document conclut para une discussion sur la convenance et la viabilité de créer un standard international de gestion de l'innovation et l'apparition d'une nouvelle génération de processus de gestion de l'innovation basée sur un standard d'innovation.

MOTS-CLEFS: innovation, gestion de l'innovation, système de gestion de l'innovation, UNE 166002, standardisation, innovation systématique, I+D; nouveaux produits.

SISTEMAS DE GESTÃO DA INOVAÇÃO PADRONIZADOS: UM ESTUDO DE CASO SOBRE A NORMA ESPANHOLA UNE 166002:2006

RESUMO: Este artigo descreve a experiência de una empresa de fabricação espanhola que implementou a norma UNE 166002:2006, que é a primeira norma no mundo a oferecer um sistema normalizado de gestão da inovação certificável. Depois de uma breve resenha sobre a gestão da inovação em geral, o documento descreve a história, objetivos e conteúdo da norma espanhola UNE 166002:2006 e a família de normas à qual pertence. Posteriormente, o artigo apresenta um caso de estudo da aplicação da norma em uma empresa manufatureira descrevendo as vantagens e dificuldades da implementação detectadas pelo pessoal da empresa em questão. O documento é concluído com uma discussão sobre a conveniência e viabilidade de criar um padrão internacional de gestão da inovação e a aparição de uma nova geração de processos de gestão da inovação baseada em um padrão para a inovação.

PALAVRAS CHAVE: inovação; gestão da inovação; sistema de gestão da inovação; UNE 166002; padronização; inovação sistemática, I+D; novos produtos.

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Introduction

The general objective of this descriptive paper is to explore the possibility of standardising innovation management. Although, at first glance, it might seem that increasing the degree of standardisation in innovation management implies reducing the room for innovative creativity, we could argue that standardisation and innovation are complementary (rather than opposed) concepts (Kondo, 1996, 2000). In one hand, the argument against standardisation in innovation management is, of course, that too much discipline, including a strong focus on process management and a rigorous orientation towards customers' demands, endangers the creativity of participants, as every activity in the innovation process becomes part of a rigid bureaucratic routine. On the other hand, the argument in favour of standardisation in innovation management is that too much freedom allows people to deploy their creativity to create mere gimmicks that have no real prospect of realisation or market success (Gassmann et al., 2006). Between these two extremes of freedom and standardisation, Nambisan (2002) has argued that "firms need to structure their product development environment such that a fine balance is achieved between overall flexibility... and the focus and direction [needed to ensure product development effectiveness]."

Several authors have contended that there is a positive relationship between innovation and standardisation. Edum-Fotwe et al. (2004) presented a case study that showed how innovative solutions were achieved in the British health sector by means of standardisation, thus maintaining a baseline of reliable performance in health care. Kanji (1996) proposed a simple model of the relationship between innovation and quality management in which innovations undergo quality-management processes to become successful innovations. Keogh & Bower (1997) presented a case study in the oil and gas industry that showed a positive relationship between quality management and innovation.

Other authors have reported that quality standards (such as ISO 9001) and quality-management systems (such as TQM) have positive effects on the management of innovation and the innovative culture of a firm (Prajogo & Sohal, 2006; Santos-Vijande & Álvarez-González, 2007). For example, Pellicer et al. (2008) stated that the ISO 9000 and 14000 standards can serve as a basis for continuous innovation in the construction industry. Moreover, Pellicer et al. (2008) have contended that a change of attitude towards innovation is now taking place in the Spanish construction sector as Spanish companies seek to establish and consolidate innovation-management systems by obtaining certification under the relatively new UNE 166002:2006 standard for research and development and innovation (R&D&I) management system.

Such standardised innovation-management systems have now begun to appear by analogy with developments in quality management over the years. Such R&D&I systems offer norms or guidelines for organisations that wish to boost their innovation capacity by implementing new or improved innovation management systems. This study analyses and reports upon the application of one of the few existing standards of this type: the UNE 166002:2006 standard. This standard aims to systemise innovation to stimulate R&D&I activities in general, as well as helping to achieve better management of such projects in a structured and systematic way. The overall aim is to foster a culture of innovation in organisations, especially small and medium-sized enterprises (SMEs), thus increasing their innovation capacity.

The remainder of this paper is organised as follows. After a brief description of the historical development of innovation management and the development of innovation management systems in general, the paper describes the UNE 166000 family of standards. The paper then pays particular attention to the UNE 166001:2006 and 166002:2006 standards, which represent the standards that organisations can actually utilise in their innovation projects and innovation management systems. The paper then presents a case study of the implementation of the standard in one of the few companies to have done so. The case study describes the implementation process itself, and follows this with an assessment of the difficulties and benefits found in the case. The paper concludes with a discussion of the desirability of the creation of an international innovation management standard.

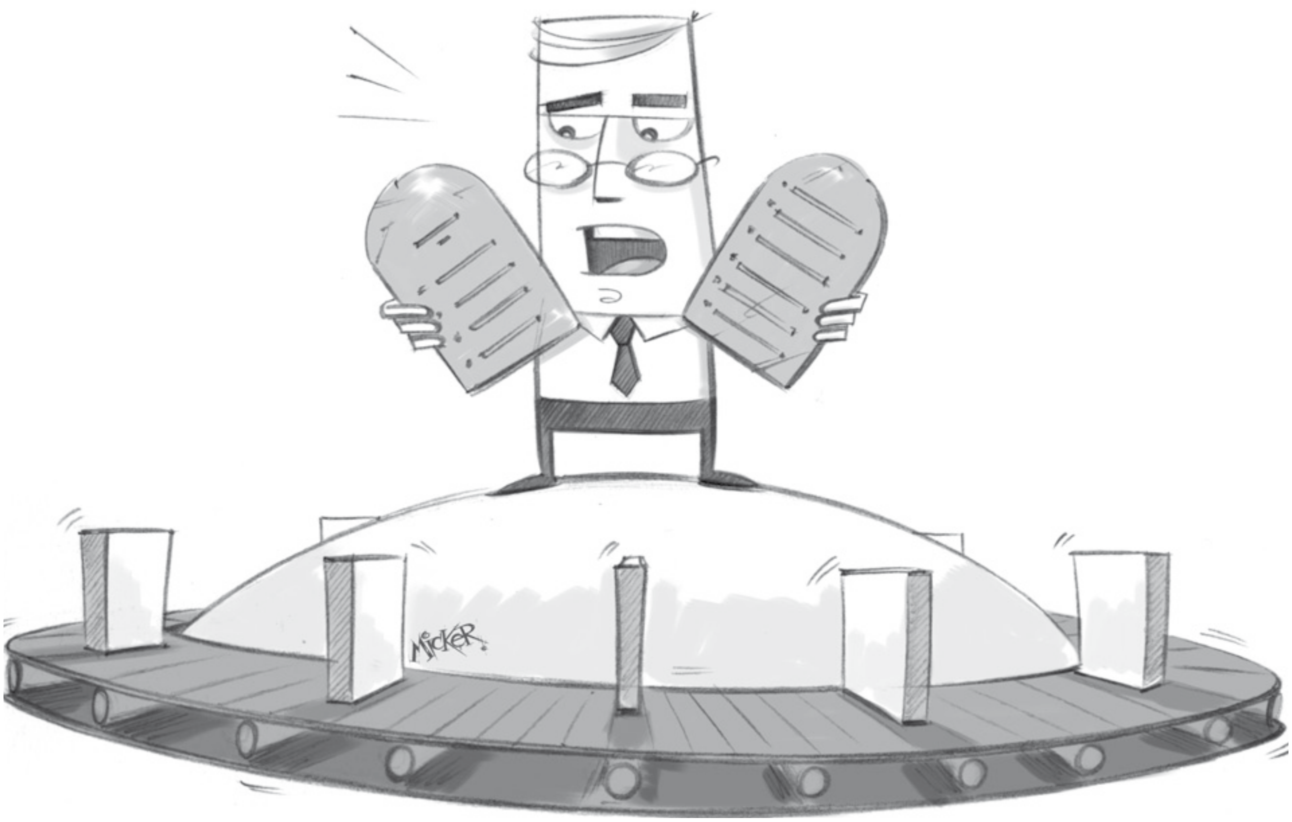
Conceptual framework

Historical development of innovation management

Because innovation is recognised as essential for competitiveness, since Schumpeter (1934) was the first to affirm that economical development is boosted by innovation, many theoretical models have been proposed in recent decades with the aim of analysing the innovation process within organisations and enhancing the generation of innovative products and services. These models have included the early linear model proposed by Rosseger (1980), the well-known and successful models of Kline (1985) and Cooper (1989, 1994), the less-known models of Barclay et al. (1994), Peters et al. (1999), and MacGregor et al. (2006), and, more recently, the contingency model of Drejer (2002), and the interactive chain model adapted to the knowledge economy as suggested by Caraça et al. (2007).

From an historical perspective, Rothwell (1994) has identified five generations of innovation processes. The 'first generation' of innovation processes (1950s to mid-1960s) linked rapid employment creation and rising prosperity after the Second World War with new developments in products. Freeman et al. (1992) have expressed the opinion that this was a time when innovation was perceived because of a 'technology push' through a linear innovation process that proceeded to the marketplace.

The 'second generation' of innovation practices, identified by Rothwell (1994), occurred during the late 1960s to early 1970s and coincided with the era of diversification, scale economies, new products based on existing technologies, and a good balance between supply and demand. The innovation process at this time can be characterised as a 'market pull' process, which, according to Hayes & Abernathy (1980), tended to focus only on incremental innovations, with more radical innovations being lost. It was during this time, from the mid-1960s onwards, that the first studies of innovation management were published. These studies represented the first step in the development of operational tools for improved management of R&D (Archibald, 1976; Francis, 1977; Lanford, 1972; Souder,



1973; Davies, 1970; Allen, 1977). Subsequently, the focus was on the development of methodologies for the strategic direction of innovation. These later evolved into such tools as: (i) the portfolio models of Little (1981), and Roberts & Berry (1985); (ii) benchmarking techniques for the performance of various technologies by S curves (Foster, 1986); (iii) the classification of new technologies according to their maturity and competitive impact (Roussel et al., 1991); and (iv) systems of technological monitoring (Morin, 1985).

During the 'third generation' (early 1970s to mid-1980s), a large number of empirical studies (Myers & Marquis, 1969; Langrish et al., 1972; Rothwell et al., 1974; Schock, 1974; Szakasits, 1974; Utterback, 1975; Rothwell, 1976; Rubenstein et al., 1976; Cooper, 1980) concluded that neither 'technology push' nor 'market pull' were sufficient to describe the innovation process; rather, innovation was posited as a combination of the two, as suggested in Kline's (1985) chain interactive model. According to this model, the innovation process at this time focused on cost reductions in economic conditions of reduced demand and more competition. The models developed during this period sought to address such issues as how the competitive position could be improved with technology (Kantrow, 1980); how technology could be integrated into corporate strategy (Katteringham & White, 1984), for example whether it was better to innovate as a leader or follower and the practicalities of innovation (acquiring licenses, technology cooperation, and internal R&D). These developments laid the theoretical foundations for a technology-based strategy of innovation (Porter, 1983).

The 'fourth generation' (early 1980s to early 1990s) models of the innovation process are essentially based on those of the 'third generation', with the addition of an increased focus on various other factors–including technology strategy (Peters & Waterman, 1982), information technology (Bessant, 1991), global strategy (Hood & Vahlne, 1988), strategic alliances (Hagedoorn, 1990) and time-based strategies (Dumaine, 1989). These strategies for innovation recognised the competitive Japanese performance compared with Western countries (Drucker, 1985), which had come about as a result of technological imitations, 'just-in-time' (JIT) production procedures, and an emphasis on quality control using integrated and interactive procedures of intensive information exchange with functional overlaps (Graves, 1987). During this period, a change in views about the nature of technological innovation came to be regarded as dynamic rather than static (Tushman & O'Reilly, 1997). This evolution was accompanied by a change in perceptions about the fundamental role of technology, which was no longer considered to be about the transmission of information, but rather about the generation and accumulation of knowledge (Cohen & Levinthal, 1990; Winter, 1987; Nieto, 2003).

All of these developments have led to the fifth generation Innovation Process (Rothwell, 1994) where innovation became an important (indeed, an essential) contemporary business practice. Innovation is now recognised as critical to an exceedingly wide range of activities that impinge on business success, including: (i) accelerating the development of technology-based new products; (ii) increasing flexibility and adaptability; (iii) organisational change for business success; (iv) enhanced awareness of environmental issues; (v) a greater focus on customer satisfaction and efficiency; and (vi) the accumulation and management of corporate knowledge through systems integration and networking (SIN) (Rothwell, 1994; Gupta & Wileman, 1990; Rothwell, 1994; Peters, 1988; Spiker & Lesser, 1995; Nonaka & Takeuchi, 1995).

Development of innovation management systems

The precedents for management systems in the field of quality management have obvious implications for the possible development of these kinds of management standards in the field of innovation. Although the philosophy behind quality management had first been developed in the 1960s, it was not until 1989 that the International Organisation for Standardisation (ISO) published the first version of the ISO 9000 family of standards for so-called 'quality management systems'. Although there has been (and continues to be) a great deal of debate about the real impact of these standards on the quality of products and services in organisations that have implemented them, there seems little doubt that the advent of the standards has at least motivated a greater number of organisations to become involved in the general philosophy and aims of quality management.

The question therefore arises as to whether similar developments could happen in the field of innovation as a result of the development of 'innovation standards'. Some indications point that this could be so–especially in the contemporary environment when terms such as 'innovation', 'research & development', and 'innovation management' are so frequently on the lips of politicians, policymakers, and business leaders. In this environment, the development and implementation of new standards in the area of innovation management would enable organisations to: (i) improve innovative capacity; and (ii) demonstrate such improvement to the outside world (using certification under such a standard as a marketing tool to develop new business, just as was the case with such standards in the field of quality).

In recent years, the first sets of standards for innovation management have begun to emerge. One of the first was the UNE 166002:2006 research and development and innovation (R&D&I) management standard (originally in Spanish: *Gestión de la I+D+I: Requisitos del Sistema de Gestión de la I+D+I*), which was developed by the Spanish Association for Standardisation and Certification (AENOR). The standard reflects the vast amount of documentation, information, and knowledge that needs to be managed in any management system of innovation and R&D. In view of the complex nature of the process (as briefly canvassed in the literature review of the historical development of innovation management presented above), a need for a framework of standards, guidelines, and methods to assist organisations with regard to innovation management is apparent. This article states that the UNE 166002:2006 R&D&I management standard is a significant milestone in the development of innovation management; as such, it deserves detailed analysis.

The UNE 166000 family of standards

Brief history.

In September 1992, the European Committee for Standardisation (CEN) created the 'CEN-STAR committee', which aimed to draw up European standards for R&D&I activities and thus benefit from the synergy that was perceived to exist between such activities and the standardisation process (Pérez, 2002). Eight years later, in 2000, the Spanish standards authority (AENOR) created its own technical standards committee (AEN/CTN 166), which consisted of relevant professionals in the field of R&D&I, including representatives from business (large and small), public bodies, universities, technology centres, business associations, and R&D&I support organisations (Malvido, 2002). The committee was made up of six working groups: (i) terminology and definitions of R&D&I activities; (ii) standardisation of R&D&I projects; (iii) standardisation of R&D&I management systems; (iv) auditing guide for R&D&I management; (v) qualification of R&D&I auditors; and (vi) standardisation in the R&D phase (Benavides & Quintana, 2003). The committee (AEN/CTN 166) determined that standards should be created in Spain to help companies, especially SMEs, in the following specific areas (Tejera, 2002):

- structuring and developing R&D&I projects;
- establishing R&D&I units, or optimising existing ones, by setting up management systems (patents and demonstrations of advantageous market positioning) to prevent the loss of knowledge generated by their R&D&I activities; and

- standardising new concepts and ideas that are generated by R&D&I activities.

It was also felt that the new standards would make it easier for government to offer appropriate tax incentives for R&D&I activities.

Against this background, the UNE 166000 family of standards was created to cover R&D&I management in Spain. The first standards of the series were published in April 2002, for a trial period of four years, after which AENOR published the definitive versions. Figure 1 is a schematic representation of the set of standards in this series and the relationships between them and other related management standards and systems (Mir, 2007).

Groups of UNE 166000 standards.

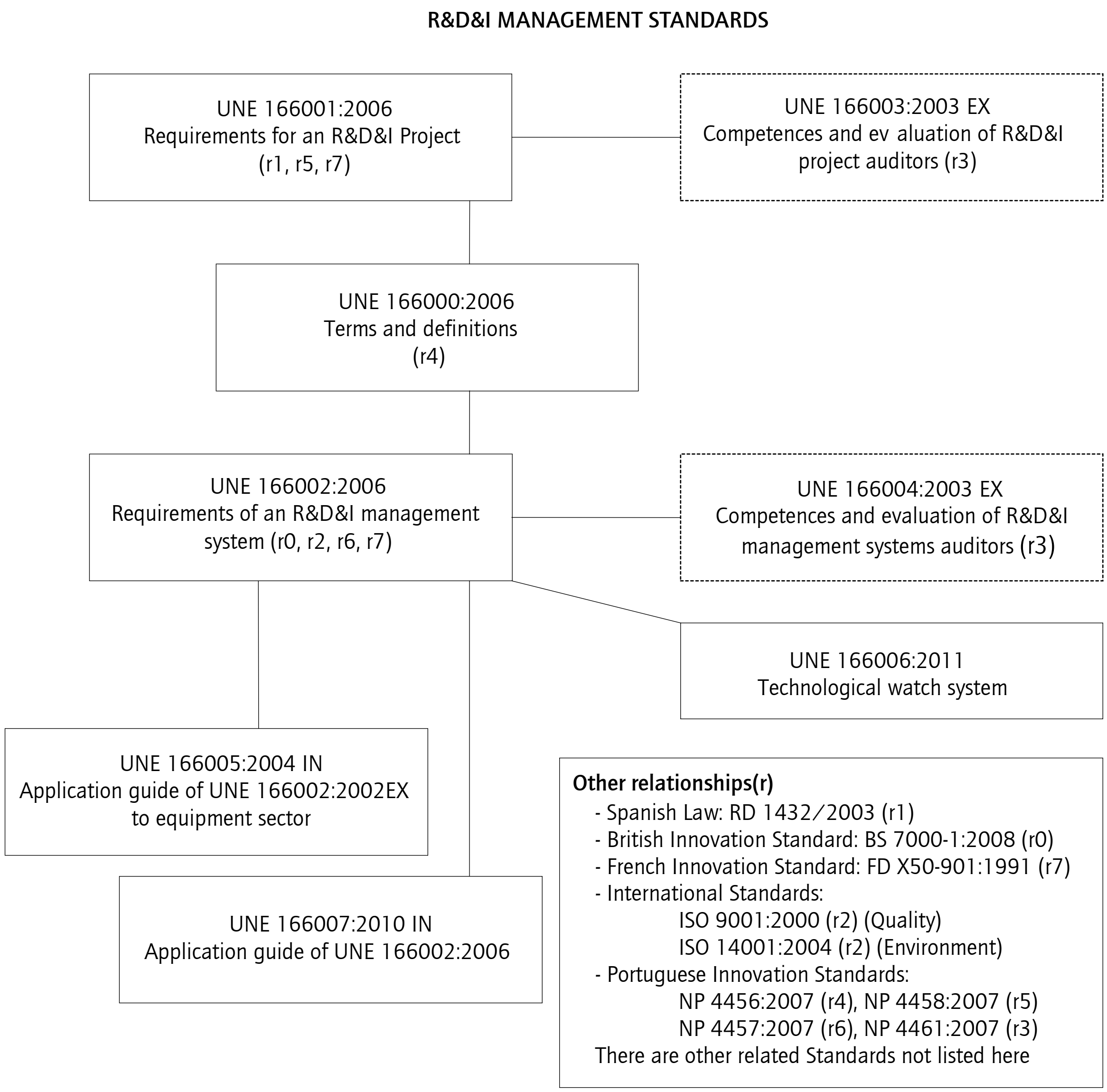
As with other standards, such the ISO 9000 family of quality standards, the UNE 166000 series of standards for innovation management provide the terminology and definitions that other sets of standards that might be developed and implemented apply. Such is the case of the first standard, which was entitled:

- UNE 166000:2006 R&D&I Management: terminology and definitions of R&D&I activities (AENOR, 2006a).

Subsequently, a second group of standards was developed, which consists of:

- UNE 166001:2006 R&D&I Management: requirements for a R&D&I project (AENOR, 2006a) and

FIGURE 1. Scheme of the family of UNE 166000 standards and relationship with other systems



Broken lines indicate a now-defunct standard.
Source: Adaptation of the scheme by Mir (2007).

- UNE 166002:2006 R&D&I Management: R&D&I management system requirements (AENOR 2006b)

A third group consists of:

- UNE 166003:2003 EX R&D&I Management: Competences and evaluation of R&D&I project auditors, and
- UNE 166004:2003 EX R&D&I management: Competences and evaluation of R&D&I management systems auditors

UNE 166001:2006 and 166002:2006 standards.

The second group (UNE 166001:2006 and 166602:2006 R&D&I Management) is the most important in the series because the members of this group represent the standards that organisations can actually utilise in their innovation projects and innovation management systems. The content of these standards can be summarised as follows:

- *UNE 166001:2006:* The main objective of the UNE 166001:2006 standard is to facilitate the systemisation of activities in R&D&I projects. It also aims to define, document, and develop R&D&I projects, and to improve communication to interested parties. It can be applied to a wide variety of R&D&I projects, whatever their complexity, duration, or technological area. UNE 166001:2006 consists of the following main parts: (i) introduction; (ii) objectives and scope; (iii) requirements (responsibilities, reports, innovation and novelty of the project, protecting ownership of the results, legislation, planning, risk and critical points management, budget, estimate and control of costs, monitoring of the project); (iv) exploitation of the results (identification of a new product or process, potential market, economic exploitation, benefits of the project); and (v) requirements for legislated tax deductions (AENOR, 2006a; Mir & Casadesús, 2008).
- *UNE 166002:2006:* The aims of the UNE 166002:2006 standard are: (i) to boost R&D&I projects in organisations; (ii) to provide guidelines for managing R&D&I activities efficiently; (iii) to ensure that activities that might generate the organisation's own technologies and patents are not lost; (iv) to boost R&D&I activities as a competitive advantage; and (v) to help in planning, organising and monitoring R&D&I units that help to save resources and improve motivation and involvement of employees. This standard can be used by any kind of organisation, from any sector.

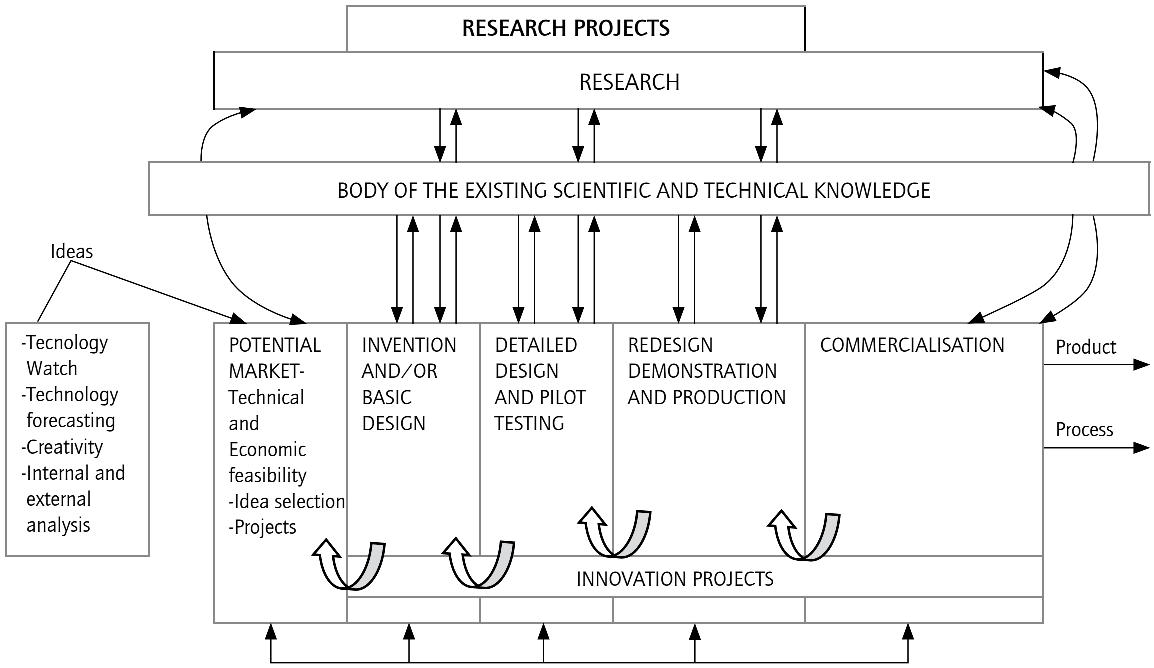
In the official 'Introduction' to the UNE 166002:2006 standard, reference is made to an innovation process model that is to be used by companies when implementing the standard. This model, which is illustrated in Figure 2, is a 'chain-linked model' that has been modified by the inclusion of certain activities in addition to the elements proposed in the original 'chain-linked model' of Kline (1985). These activities include 'technology watch', 'technology forecasting', 'creativity', 'external and internal analyses', 'technical and economic feasibility', and 'ideas selection to generate projects'. According to Benavides & Quintana (2003), these new activities are included in accordance with a strategic view of the management of technology, as indicated in the introduction to the UNE 166002:2006 document: "The adoption of an R&D&I management system should be a strategic decision by the organisation" (AENOR, 2006b).

Thus, according to the model proposed by UNE 166002:2006 based on Kline (1985), the innovation process can follow various interrelated (and not mutually exclusive) pathways. The main pathway begins with the potential market (or 'market pull'), whereby the company uses various activities ('technology watch', or 'technology forecasting', or 'creativity', or 'internal and external analysis' and 'identifying problems and opportunities') to identify ideas that will satisfy new market needs or improve its current products, processes, and organisation. Having analysed these ideas and having selected those that are technically and economically feasible, the potential projects are then prioritised. Any given project then undergoes various stages: (i) basic design; (ii) detailed design with prototypes; (iii) pilot trials; (iv) production; and (v) commercialisation. There is continuous recirculation along this path through the different phases of a project, and in any one of the phases, it might be necessary to resort to external technological knowledge (AENOR, 2006b).

According to the standard, the innovation management system should be implemented at three levels: (i) top-level establishment of innovation policies and objectives by the management team; (ii) second-level establishment of innovation management measures and cooperative relationships (in accordance with the pre-defined policies and objectives); and (iii) third-level establishment of the processes and procedures of individual work (in accordance with the measures decided at the first two levels). All three levels should be supported by: (i) a suitable documentation system (preferably electronic) (Mir & Casadesús, 2008); (ii) an effective organisational structure that defines responsibilities and tasks in terms of the available human resources; and (iii) appropriate physical space, equipment, infrastructure, and physical resources (Benavides & Quintana, 2003).

By carrying out innovation activities in the systematic way set out in the UNE 166002:2006 specifications, innovation projects will emerge, which the UNE 166001:2006

FIGURE 2. Modified Kline Innovation Model



Source: Adapted from AENOR (2006b).

Standard will certify. The link between the two standards is thus explicit.

UNE 166003:2006 and 166004:2006 standards.

The third of the aforementioned groups provides the standards for auditors to evaluate projects and management systems. Initially, two standards were developed– UNE 166003:2003 for projects and UNE 166004:2003 for management systems. Of these, the former was abandoned as a potential standard in 2006; the latter died in 2009.

Subsequent UNE 166000 standards.

The process of creating standards continues. For example, two more standards have been derived from the UNE 166002:2006 standard, one of which is still in its experimental phase:

- UNE 166005:2004 IN *R&D&I Management: Guidelines for applying the UNE 166002:2002 Standard in the capital goods sector*: A specific application of UNE 166002:2006 with a focus on capital goods and fixed assets; and
- UNE 166006:2011 EX *R&D&I Management: Technology Watch System:* A development of the 'technology watch' tool, which is considered to be of vital importance in the R&D&I process.

In addition to these standards, all of which have been officially published or they are in the experimental stage, there is also a new standard: UNE 166007:2010 IN *R&D&I Management: Guidelines for applying UNE 166002:2006.* The aim of this standard is to guide companies in the implementation of UNE 166002:2006.

Links with other standards.

The links among the UNE 166000 standards are not confined to internal links within this family of standards; nor are the links confined to external links with the legislated Spanish regulations regarding R&D&I. In fact, the UNE 166002:2006 standard was designed by analogy with the international quality-management standards, ISO 9001:2000 and ISO 14001:2004, in a manner that facilitates the incorporation of both the quality standards and the innovation standards into a single integrated management system (IMS). Moreover, as Figure 1 shows, there are also links among some of the Spanish standards and others created in other countries-such as the BS 7000-1:2008 standard in the United Kingdom (BSI, 2008), along with adaptations of the Spanish standard in such countries as Portugal, Mexico, Brazil, and Italy. A user-oriented innovation management standard (DS-hæfte 36:2010) is also developed in Denmark (AFNOR, 1991; IPQ, 2007)

Against this background, in 2007, the CEN Technical Board created BT/WG 201 *Research, Development and Innovation*

Activities to study the feasibility of developing relevant European Standards and to prepare a draft business plan for a possible future technical committee. BT/WG 201 subsequently made certain recommendations, which resulted, in 2008, in the creation of CEN/TC 389 *Innovation Management* under the leadership of AENOR. CEN/TC 389 will work on the standardisation of tools to improve innovation management, as well as relationships with research and development activities (Mir & Casadesús, 2011).

Case study: Implementation of the UNE 166002:2006 Standard in a manufacturing company

Background.

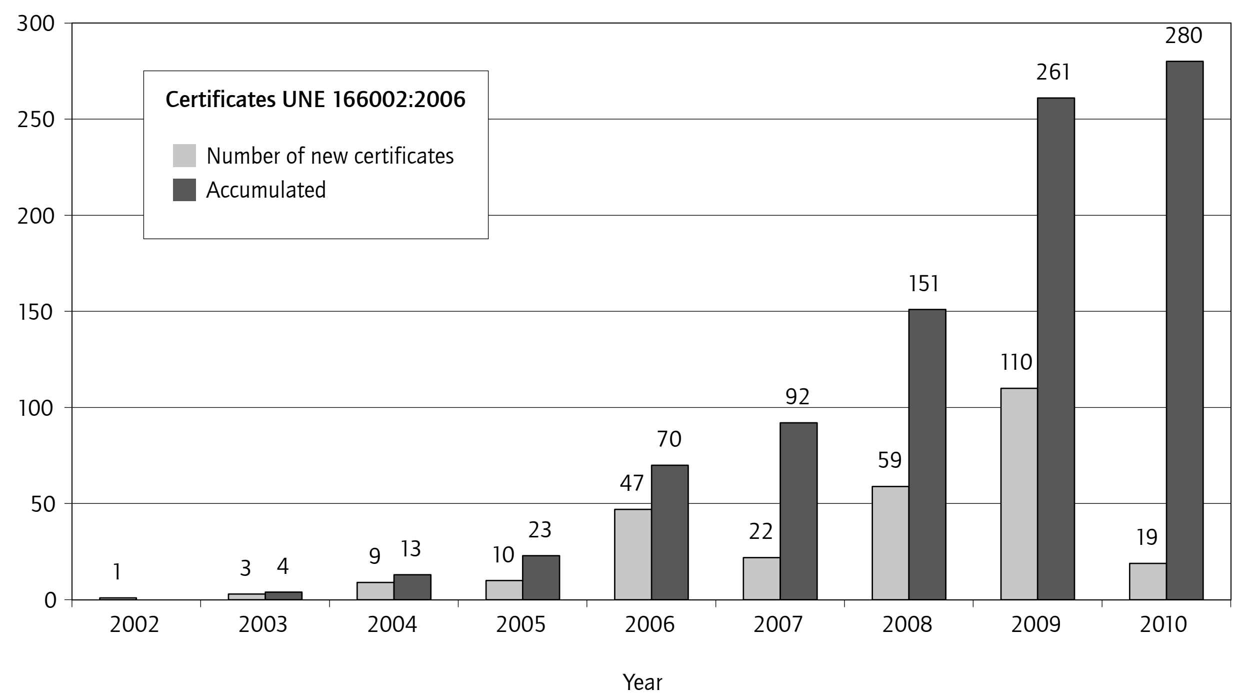
The case study concerned a Spanish manufacturing company that produces and sells metal components for the electronic and lighting market. The firm's activities also include the design of new products and the redesign of manufacturing processes. The company is one of the first 10 Spanish companies to have successfully implemented UNE 166002:2006 and received certification under the standard.

The firm has 170 employees with various qualifications and experience, including seven technical or industrial engineers. The company had earlier achieved quality and environmental certification under ISO 9001:2000, ISO 14001:2004, ISO-TS 16949:2002, and EMAS, but there had previously been no specific management system for R&D&I. Prior to the implementation of the UNE 166002:2006 standard, R&D&I tasks had been conducted in a sporadic and ill-defined fashion.

The UNE 166002:2006 standard was chosen for analysis in the case study, rather than the UNE 166001:2006 standard, because the former is more 'global' in nature and covers all of the tasks involved in the innovation process. In contrast, the UNE 166001:2006 standard provides certification for only isolated innovation projects, rather than a full management system.

Figure 3 shows the number of new certificates and accumulated certificates issued under the UNE 166002:2006 standard in Spain from 2002 to 2010. The majority of certified firms have achieved certification in the past two years is apparent. Given that two years is not sufficient time for the innovation performance of these firms to be assessed after implementation of the standard, this study decided to focus on a case study of one of the first ten organisations that were included in a pilot implementation program of the experimental version of the standard–the UNE 166002:2002EX. The organisations in that pilot program were 'guinea pigs' during the implementation process as the difficulties and advantages of the imple-

FIGURE 3. Number of certificates UNE 166002:2006 evolution from 2002 to February 2010



Source: The authors.

Note: Before of the current issue of UNE 166002:2006, there was the experimental version, the UNE 166002:2002EX, from 2002 to mid 2006.

mentation became apparent. The present authors have been monitoring the firm in the case study (and some other three cases) since the implementation; however, only the case study described here was considered mature enough to be representative of the influence of the UNE 166002:2006 standard on the innovation performance of a firm.

Although the present study is based on only one case, the findings of the in-depth examination of this single case reveals some interesting procedures and provides some useful conclusions for other companies considering the implementation of an innovation-management system in accordance with the requirements of the UNE 166002:2006 standard. The findings also provide a starting-point for consideration of future research in a wider range of cases. As several authors have attested and demonstrated, a single case study in new areas of research, if conducted with sufficient rigour and depth, has the potential to provide insights and knowledge that are not accessible with other research methodologies (Eisenhardt, 1989; Eisenhardt & Graebner, 2007; Siggelkow, 2007; Yin, 2003).

Implementation of the UNE 166002:2006 standard

Preliminary steps.

In accordance with the recommendations of the standard, the company ensured that the decision to implement an R&D&I management system came from senior levels of the management hierarchy, with full support from the lower-level managers who were required to administer the necessary resources. Once this managerial support had been achieved, the following sequential actions were taken to implement the standard: (i) establishment of a team and someone responsible for implementation; (ii) evaluation of the need for an outside consultant; (iii) arrangements for periodic meetings of the team and the outside consultant; and (iv) identification of the tasks to be completed in the agreed timeframe and those responsible for their completion.

With regard to the fourth point, the tasks to be carried out were identified as follows:

- detailed reading of the UNE 166000:2006 and UNE 166002:2006 standards;
- self-evaluation of the company's 'innovation culture' through analysis of patents, confidentiality policies, resources assigned to innovation, development of products, creative capacity, knowledge management, and so on;
- generating a statement of the company's policy (and declaration of the management's commitment) regarding R&D&I objectives;
- establishment of the R&D&I management unit (which coincided with the implementation team noted above);
- analysis of the company's existing quality and environmental standards (ISO 9001:2000 and ISO 14001:2004) with a view to integrating coincidental aspects of these standards (generalities, documentation, control of registries, management responsibility, policies, planning and objectives) with the new R&D&I standard;
- drawing up the procedures and formats for the registry in strict accordance with the guidelines set out in the UNE 166002:2006 standard;
- defining the company's innovation process by drawing up the format of the documents that are exclusively for R&D&I in accordance with the needs of the company and the requirements of the standard (using IDEF0, see Figure 4);
- integration of the R&D&I management system in the pre-existing management system by incorporating the R&D&I process (and its indicators) into the map of processes as a new strategic process;
- modification of the common formats that already existed in previous systems so as to incorporate R&D&I-related aspects;
- modification of the procedures that interacted with the R&D&I process to bring them up to date with the new map of processes;
- adaptation of physical and computer support (as previously used for quality and environment management systems) to make it suitable for setting up and maintaining the R&D&I system in addition to the other management systems;
- verification (in successive meetings) that the assigned tasks have been completed within the agreed time;
- first review by management;
- conducting an internal audit with a view to adjusting and improving the implemented system;
- planning and execution of an official audit for certification by an accredited organisation; and
- publishing of the results of the implementation and certification within and outside the company.

It was anticipated that the whole implementation process would take six months, and that it would require the participation of an external consultant, a company employee in charge of the project full time, and six people from different departments working on it part time.

Outline of innovation management process.

Figure 4 presents a schematic diagram of the company's innovation management process. The implementation included the following four basic aspects:

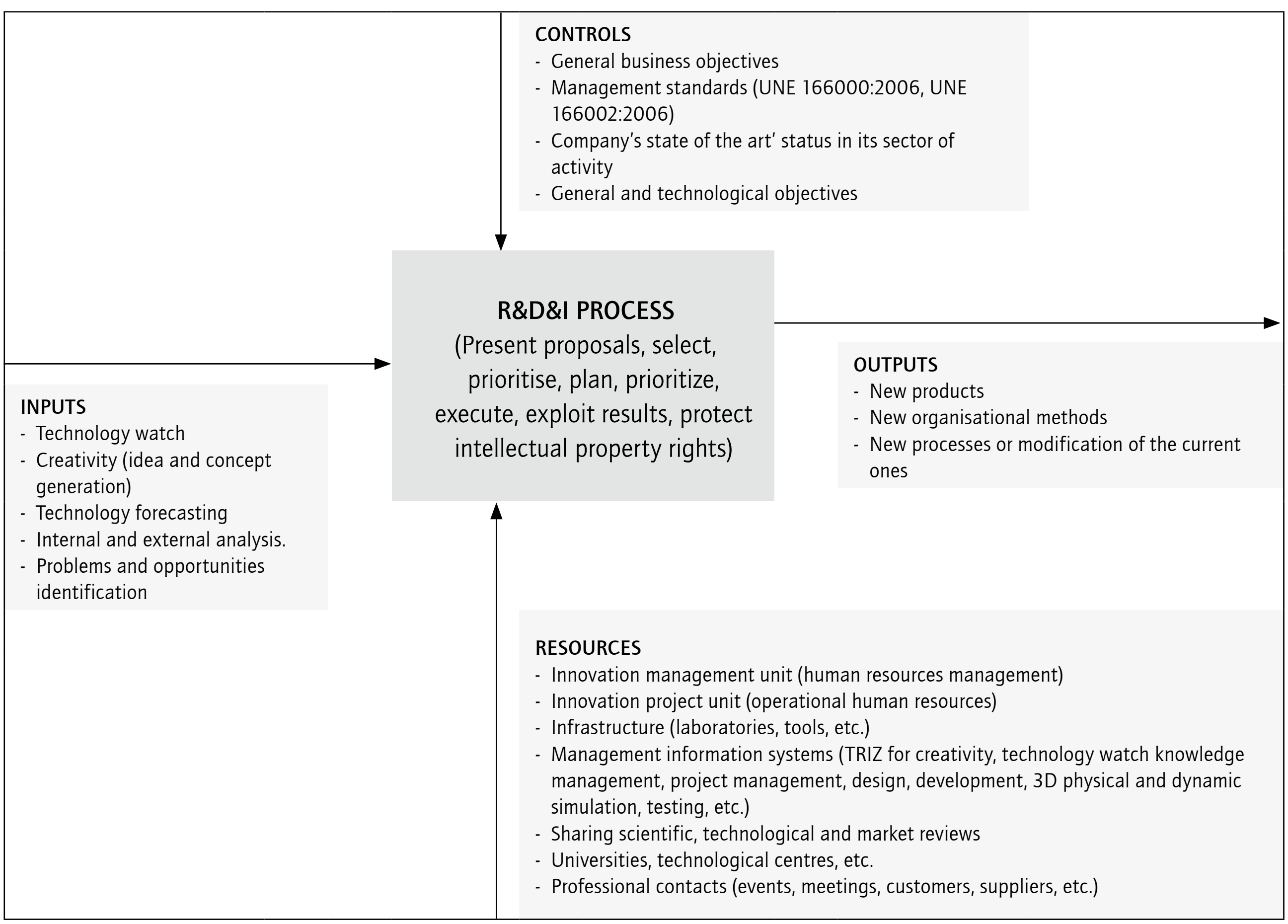
Input: Five basic sources of innovation in the company were used to generate new ideas for innovation projects: (i) technology watch; (ii) creativity; (iii) internal and external analysis; (iv) technology forecast; and (v) analysis of problems and opportunities.

Resources: Seven main categories of resources were utilised to convert the input (above) into viable output: (i) the innovation management unit; (ii) the innovation project unit; (iii) the company's own infrastructure (laboratories, production systems, etc.); (iv) information systems (technology watch, creativity support, project management, knowledge management, etc.); (v) scientific resources (articles, patents, etc.); (vi) universities, technology centres, etc.; and (vii) other professional contacts (conferences, suppliers, etc.).

Controls: The entire innovation process was controlled by: (i) the implemented management standards (UNE 160002:2006, supported by UNE 166000:2006); (ii) the company's 'state-of-the art' status in its sector of activity; and (iii) the company's general and technological objectives. To manage these objectives, indicators (time, investments, and costs) had to be defined for the innovation process as a whole, as well as for each specific project. These objectives and indicators were periodically revised to achieve continuous improvement of the management system.

Output: The output of the innovation process essentially consisted of new products, new organisational methods, or new processes. However, such output was subsequently reworked by evaluating the results in terms of: (i) analysis of the global objectives achieved against the general objectives of the system; (ii) evaluation of successes and failures; and (iii) initiation of corrective action for deviations that exceeded the limits (with regard to investments and/

FIGURE 4. Diagram of an Innovation process



Source: Adaptation of Mir (2007).

or deadlines) as set out in the objectives. Moreover, the output (new products, new organisational methods, and/or new processes) was exploited beyond the immediate commercial needs by: (i) applying the policy of confidentiality defined in the objectives; and (ii) patenting the product if necessary.

Implementation of innovation management process.

The innovation process described above was utilised to produce output from input in general accordance with the four principal steps defined in UNE 166002:2006: (i) proposals for innovation projects; (ii) selection of projects; (iii) planning and execution; and (iv) exploitation of the results (AENOR, 2006b). In this case study, the following activities were undertaken:

Principal step 1: Collection and selection of ideas for new R&D&I projects from the five sources noted above; presentation of proposed R&D&I projects with estimated evaluations;

Principal step 2: Selection of projects on the basis of weighted criteria (return on investment, difficulty, risk, urgency, technical and economic feasibility, future, impact on value added to assets, environmental and social impact, legislation, and so on);

Principal step 3: Definition of selected projects in terms of specifications, quantifiable objectives, responsibility of participants, and planning; execution of projects (design, redesign, prototyping, testing, and so on); maintenance of the project portfolio; and

Principal step 4: Exploitation of the results and protection of intellectual property rights.

Special features of this case study.

Information technology (IT) played an especially prominent role in this case study in providing support for the tasks of 'technology watch', 'technology forecast', 'creativity', and 'knowledge management'. Several well-known systems can be used to provide support for these kinds of tasks–such as quality function deployment (QFD), failure mode and effects analysis (FMEA), and Six Sigma. However, the case company in the present study utilised a less-known system called 'TRIZ' (Altshuller & Shapiro, 2000), which is a Russian acronym for the theory of resolving inventive problems (*Teoriya Resheniya Izobretatelskih Zadach*). Despite its being somewhat unconventional, the TRIZ system is now being implemented in commercial software programs (Mir & Casadesús, 2008), one of which was used in this case.

The company utilised a computer-aided innovation (CAI) program based on the TRIZ method to generate new concepts from existing scientific and technical knowledge in patent databases and scientific and technical encyclopaedias that were already incorporated in the software. The company also used the tool to analyse technological tendencies and carry out technology forecasts (Mir & Casadesús, 2008).

The company employed a specific toolkit for 'technology watch' and 'knowledge management'. This software included parameters drawn from various websites (technology websites and websites of the competition, customers, associations, and technology centres) that generated automatic alerts if there were any changes in one of the earmarked websites or in previously marked subjects of interest. Likewise, the software included functions that enabled it to manage and share the company's accumulated knowledge. Every time a particular user introduced information on a subject that was of interest to another user, an automatic message was generated –thus enabling knowledge collected by various users to be shared (Mir & Casadesús, 2008).

Benefits and problems of implementation

Improved monitoring and documentation.

The main benefit noted by the company after implementing UNE 166002:2006 was that it improved the firm's monitoring of the whole R&D&I process by means of better documentation. This diminished the risks and uncertainties associated with R&D&I projects, especially in the initial phases of research and development. It also facilitated the optimisation of resources in accordance with the firm's general strategic objectives.

The benefits of enhanced monitoring and documentation were of importance when the company was reviewing the project indicators and, if necessary, changing the tasks of the project. Changes in projects were chiefly motivated by scientific or technological divergence from the predetermined objectives of each goal, although divergences in terms of financial costs and deadlines provoked changes in projects. Indeed, some projects were even abandoned altogether. According to Marrifield (1977), all projects have a critical 'decision point', at which uncertainty has diminished substantially and significant spending has yet to be made; however, other authors, such as Albala (1975), have suggested that decisions about the continuation of a project should not be limited to the critical 'decision point' but should be made on the basis of repeated evaluations throughout the life of the project as uncertainty decreases. The case company in the present study adopted the latter view during implementation of the R&D&I standard by means of periodic reviews of the project portfolio. The enhanced monitoring and documentation of the standard allowed new projects to enter the system continuously in response to changing conditions (with regard to clients, suppliers, competitors, laws, technology, and so on), while simultaneously enabling the company to drop certain projects that had initial forecasts of success revised downwards.

Despite the apparent benefits of increased information, the company was nevertheless aware that care must be taken to avoid an excess of documentation and consequent 'infoxication' (Mir & Casadesús, 2008), that is, an overdose of information that renders the receiver incapable of understanding and assimilating it. In this case, the information technology that was employed, together with the company's previous experience of this potential problem with its implementation of the ISO 9001:2000 and ISO 14001:2004 standards, enabled it to avoid the implementation of an excessively bureaucratic system in this case study.

Effect on innovative capacity of the company.

Table 1 presents an analysis of six indicators referring to the innovative capacity of the company from 2003 until 2006. The certification in accordance with the standard (which was still in its trial stage at that time) was carried out at the end of 2003. It is clear from Table 1 that the innovative capacity of the company since then has improved, especially in 2004.

Table 1 shows a slight downward trend, beginning in 2005, despite higher investment by the company in R&D&I activities, and an increase in the personnel involved. The explanation for this is that the projects in this company usually lasted at least two years, with the average being three years and lasting as long as ten years (BSI, 2008). This means that, after a year in which a large number of new projects were initiated, such as 2004, the innovative capacity for the following years was reduced (assuming no change in resources available as people were occupied with the projects that had already been initiated). Although we could better this analysis if we conducted it over a longer period, we can reasonably infer that the implementation has been decisive in the increased R&D&I activity in this case company. However, we know that the initial growth in R&D&I that has been detected cannot be attributed solely to the implementation of the innovation management standard.

Summary of advantages and disadvantages

Table 2 summarises the advantages and problems of implementing an innovation management system based on the requirements of the UNE 166002:2006 standard. As detected by the people who implemented the standard, the advantages significantly outweighed the problems.

Finally, for these advantages to be realised, the participants from the case company insisted that a good 'innovation culture' is an absolute prerequisite. Senior management must accord innovation the importance it deserves and must establish a suitable organisational structure to achieve an efficient and effective management system. Moreover, the participants in the implementation process insisted that an appropriate space must be set aside to stimulate creativity. Such a space must be far removed from the bureaucracy that could otherwise be counter-productive to this kind of activity. Nevertheless, the ideas that are generated in the creative process must be formally registered to ensure that key knowledge is retained and analysed to focus subsequent efforts on projects that are best suited to the strategies of the company.

Discussion: Towards an international standard?

The standard discussed in the present study was created for use by Spanish companies within the framework of

TABLE 1. Indicators to evaluate the innovative capacity of the company being analysed

	YEAR			
INDICATOR	**2003**	**2004**	**2005**	**2006**
Number of proposed innovation projects presented	26	29	20	22
Number of project specifications to evaluate	17	17	17	11
Number of innovation projects accepted and launched	13	17	10	6
Number of patents as a consequence of innovation projects	0	0	1	2
Number of people dedicated to R&D&I tasks	1	1	2	3
Percentage of turnover invested in R&D&I tasks and projects	0.95%	1.82%	2.8%	2.17%

Source: The authors.

TABLE 2. Advantages and problems of implementing an innovation management system based on the UNE 166002:2006 Standard, in a company in the manufacturing sector

ADVANTAGES	PROBLEMS
1. Help in decision-making concerning the assignment of investment and initiation of R&D&I projects. 2. Better planning, documentation, management and monitoring of R&D&I projects. 3. Strengthens innovation culture in organization. 4. Facilitates the harnessing of know-how in the company. 5. Better-organised documentation. Structured and criteria-led organisation of information and projects, with better monitoring and control of said projects. 6. Standardisation of the formats used. 7. Compatibility with other management standards: ISO 9001:2000, ISO 14001:2004, etc. 8. Existence of support software using TRIZ method for creativity, technology watch and forecast, as well as the knowledge management that made these tasks easier. 9. Certification is good for corporate image as well as a seal of excellence that can be publicised. 10. Facilitates relations with government agencies in order to receive subsidies, soft credit or to justify tax deductions for R&D&I projects. Companies with this certificate get higher evaluations. 11. Increases the innovative capacity of the company.	1. Difficulties in adapting for people with little culture of innovation. 2. May lead to a great deal of bureaucracy, difficult to maintain if not rationalised. 3. Makes creativity difficult; the process is too automatised because ideas sometimes emerge at unexpected moments without planning 4. Makes organisational integration difficult; innovation is a horizontal function that is everywhere, but not in any specific place. 5. Sometimes it is not given the importance it should be given. 6. It means an extra audit each year 7. There is the danger of *infoxication*: too much information, indigestion, impossibility of assimilating it, or the existence of information that is of no real use if the system is not implemented in a conscious and serious way.

Source: Work of the authors based on the case study.

specific national legislation that enables organisations to qualify for tax deductions if they are able to prove their innovative capacity (although not necessarily through UNE 166001:2006). Funding is also available in Spain for some of the costs of implementing innovation management systems according to Standard UNE 166002:2006 (MITYC, 2007a, 2007b). In other countries, steps are being taken to create or adapt standards with the same objective of enhancing innovative capacity in firms. These developments raise two questions:

Should an international standard for innovation management be created?

If so, who should create it?

With regard to the first question, the contention of the present study is important that these processes be standardised, especially when they involve third parties (such as suppliers, technology centres, universities, government bodies and so on). Standardised procedures will facilitate more productive working relationships and enhanced communication among the involved parties. Moreover, with the increasing globalisation of many markets, it is more likely that participants from a variety of countries will be involved in any given project, which again points to the importance of shared standards and practices.

Compliance with such a standard will also lead to a firm obtaining a certificate of excellence that will enhance its corporate reputation and facilitate its acceptance as a partner in future R&D&I projects (both nationally and internationally). In this regard, experience with the ISO 9001 quality standard suggests that one of the advantages of ISO 9001 certification was that it provided evidence to other companies and clients that the products and services provided by the certified company were of high quality, thus stimulating confidence and facilitating entry into new markets. By analogy, certification in accordance with the UNE 166002:2006 standard would provide distinctive evidence that the certified company possessed verifiable innovative capacity and a positive culture with regard to R&D&I. Such a certificate would thus give confidence to potential partners in deciding upon collaborative arrangements in R&D&I projects –especially in an international context.

It is thus apparent that an international standard for R&D&I would be advantageous for firms engaged in R&D&I. With regard to the second question (that is, the question of who should create such a standard), the answer would seem to be the International Organisation for Standardisation (ISO). If an organisation such as the ISO created and backed an international standard, this would add prestige to the standard and to the organisations certified under it. The ISO has a proven capacity for developing and monitoring regulations of this type, and its involvement would have a significant impact internationally. Moreover, the ISO would be able to take steps to integrate a new R&D&I standard with its two most commonly used international standards –the ISO 9001:2000 quality-management standard (with more than 900,000 certifications, according to ISO, 2007) and the ISO 14001:2004 environment-management standard.

Indeed, the integration of certain elements of these standards was demonstrably one of the main advantages found in the case studied here. Nevertheless, despite the obvious advantages of ISO involvement, it is noteworthy that the ISO does not yet have a working group in this field, and nor does it appear in the immediate objectives of Committee 176, which focuses on systems of quality management.

Before concluding this discussion it is appropriate to raise two further questions for consideration–both of which require further research beyond the present study. First, even if it is possible to standardise such a complex, contingent, and uncertain process as R&D&I (as this case study has demonstrated), the question arises as to whether the use of such a standardised system to manage innovation actually improves innovation capacity and business performance. The present study has produced some tentative evidence that this might be so, but a greater number of case studies from a variety of settings is obviously required to answer this question with any degree of certainty.

Secondly, a fundamental question to be addressed is whether the implementation of such a standard brings with it a 'culture of innovation', or whether successful implementation requires such a culture to be present *before* the standard is implemented. Again, other cases of implementation in a wide variety of setting need to be analysed before this question can be answered.

Conclusions

This study has examined the history and implementation of the Spanish UNE 166002:2006 standard for innovation management. This standard, which is based on the innovation model by Kline (1985), is one of the few standards for innovation management available in the world. Other countries have developed some standards of a similar nature, such as the BS 7000.1:2008 standard in the United Kingdom, along with adaptations of the Spanish standard in such countries as Portugal, Mexico, Brazil, and Italy. Denmark is also developing a user-oriented innovation management standard. A European technical committee has been created recently to study the feasibility of an innovation management standard for the European Union, but no international organisation, such as the International Organisation for Standardisation (ISO) has published a set of standards with the same objectives.

Because the UNE 166002:2006 standard was not published in its definitive form until 2006, there have been no empirical studies of its impact. In particular, there have been no empirical analyses of the question raised by Kondo (1996, 2000), who pondered whether standardisation is opposed to (or complementary to) creativity and innovation.

Having briefly described the history and features of the standard, the present paper has reported on the case of a Spanish manufacturing company that has successfully implemented the UNE 166002:2006 standard. It is apparent from this case study that the standard encourages innovation and improvement in procedures for internal transfer and assimilation of technology, as well as facilitating improved results in terms of innovative products and services. Following the implementation of the standard, the case company now has the capacity to detect emerging technologies (or existing technologies not yet applied in its sector), and to assimilate and develop these technologies to strengthen its future innovation activities and enhance its competitiveness.

However, we also detected some problems. In particular, the quantity of documentation required for implementation was sometimes onerous, and some personnel (especially those with a low level of 'innovation culture') experienced difficulties in adapting to the new management system. If the company in this case had not had prior experience with other management system standards (ISO 9001:2000, ISO 14001:2004, ISO-TS 16949:2002, and EMAS), these difficulties would certainly have been more significant.

An inherent weakness of this study is that it was limited to only one case of implementation. However, the implementation of innovation standards is only in its infancy; indeed, by May 2006 only 42 companies were certified under this standard in Spain (Mir & Casadesús, 2008), and although there are near 300 certified companies, most of them have achieved certification in only the past two years. In these circumstances, it is difficult to conduct empirical studies by any method other than a case study. Nevertheless, it is apparent that the results of the implementation were positive, according to the experience of the personnel of the studied company.

More research is obviously required to examine the impact of this specific standard, and to investigate the possibility of generating similar standards at an international level. In the meantime, the debate about whether standardising innovation is prejudicial or beneficial to innovative capacity will continue; indeed, the debate will be resolved only when empirical studies have demonstrated whether, in the various companies in which these kinds of standards have been implemented, improvements in their innovative capacity have (or have not) been made.

Some conceptual conclusions can also be drawn from a comparative analysis of the standard against the literature. *First*, it would seem to be appropriate to dispense with the term 'R&D&I management system', which is used only in Spain and other Spanish-speaking countries, in favour of the more general term 'innovation management system'. The latter is a more holistic expression that is more in keeping with international usage and the contemporary state of the art. *Secondly*, the chain-linked innovation process model (Kline, 1985) that is used in the standard is now rather dated; it might perhaps be appropriate to dispense with this model in favour of other including (more recent) conceptualisations–such as the concepts of 'open innovation' (Chesbrough, 2003), 'user-centred innovation', and 'customer-oriented innovation' (von Hippel, 1986; Herstatt, 2002), among others.

Finally, at the beginning of the second decade of the second millennium, it is interesting to speculate whether innovation management is at the threshold of a new generation of innovation processes–perhaps even the starting-point of the 'sixth generation' of innovation processes. As previously noted, Rothwell (1994) proposed a 'five-generation' (5G) framework for the development of innovation. The 'sixth generation' (6G) of innovation processes could thus be constituted by the 5G model (Rothwell, 1994), but with the additional feature of now being managed through a standardised management system (based on the UNE 166002:2006 standard, or similar subsequent standards).

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