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Exploring EN 9100: current key results and future opportunities – a study in the Spanish aerospace industry

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ABSTRACT

This study analyses if the objectives of the EN 9100 framework, EN 9100 standard, and its certification schema developed by the International Aerospace Quality Group have been reached and if they have been beneficial for aerospace companies. Fewer studies have been conducted on the EN 9100 framework than on other standards, and studies on the compulsory component are also rare. This in-depth interview study aims to address that gap. Case selection is conducted by identifying experienced actors in the sector, high-level managers from all layers of the Spanish aerospace supply chain (Tiers 0, 1, and 2), and certified auditors. The results show that the framework has been beneficial for the companies, even though some of its objectives – such as sharing best practices and cutting additional customer requirements – have not been achieved. Opinions regarding the framework's benefits vary according to the supply chain level. The most favourable view is found in larger companies, all of which highlighted company motivation as a prime factor. These firms consider that EN 9100 is not focused on innovation but on improving the effectiveness and efficiency of the established strategy.

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EN 9100; ISO 9000; benefit; motivation; aerospace industry; innovation

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1. Introduction

The aerospace industry is very important to the European and the Spanish economies, as it employs more than 54,400 people and had a turnover of €9,700 million in 2015 (ICEX., 2016). Europe's aviation sector hired an estimated 2.6 million people and contributed $193 billion to its GDP in 2016 (ATAG, 2017).

The aerospace industry combines very high safety requirements with a highly globalised supply chain. Supervising this exceedingly complex subcontracting network while complying with safety and quality obligations is a big challenge for aircraft manufacturers. Amidst these challenging conditions, EN 9100 certification was born in the early 1990s.

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The EN 9100 standard and its certification schema comprise a quality management framework that is a basic requirement for companies seeking to work in aerospace, regardless of whether they manufacture raw materials, elemental parts, or motors. Tier 0 firms include aircraft, satellite, and defence materials manufacturers (e.g. Boeing, Airbus, Embraer, Airbus Defence, Space). Tier 1 firms include manufacturers of parts, structural assemblies, and equipment. Tier 2 and 3 firms include smaller-scale operations.

The standard's first issue was published in 2000. It is difficult to assess the impact of the certification in the industry even though certification is mandatory for any company seeking to enter the aeronautical business. Adapting company processes to the standard's requirements implies significant investment because it not only regulates the quality system but also largely structures the functioning of the company.

Considering the large commitment companies need to make, it is important to examine whether the objectives with which this certification framework was conceived by the International Aerospace Quality Group (IAQG) have been reached and to analyse the benefits obtained by the Spanish aerospace industry. Fewer studies have been conducted on EN 9100 certification than on other standards (Del-Castillo-Peces et al., 2014b; Grijalvo & Prida, 2005, 2006; Gutiérrez, 2008; Murga, 2002; Prado-Román et al., 2013; Vilar, 2003), and research on the compulsory component is scarce (Del-Castillo-Peces et al., 2018). Instead, the research has tackled other significant industry issues, like innovation and quality management.

The study is based on 14 semi-structured interviews with key actors occupying positions of high responsibility within the Spanish aeronautical sector, covering all supply chain levels and certifying schema. The authors' intimate knowledge of aeronautical companies helped us to choose the questions carefully and achieve meaningful and insightful results.

The findings show that the respondents generally believe that the framework has been beneficial for the companies, even though some of its objectives – such as sharing best practices and cutting additional customer requirements – have not been achieved. Regarding the benefits obtained by the Spanish aerospace industry, all of the interviewees highlight the importance of company motivation, and the views on the pros and cons of the certification vary depending on the firm's supply chain level. Finally, the respondents claim that EN 9100 is not focused on innovation but on improving the effectiveness and efficiency of the firm's established strategy and processes.

The rest of this paper is organised as follows. Section 2 describes the paper's theoretical framework. Section 3 details the methodology. Section 4 presents the results of the study. Finally, section 5 discusses the main conclusions.

2. Theoretical framework

2.1. Literature review methodology

The literature review covers quality management in general and the two specific research areas, EN 9100 and ISO 9001. The research focused on peer-reviewed journals and was carried out in two phases. In the first, papers potentially relevant to the

Table 1. Number of relevant articles found.

	Web Of Science	Research Gate	Mendeley	Science Direct
ISO 9001 benefits	215	>250[1]	390	2665
ISO 9001 satisfaction	162	>250[1]	397	1313
ISO 9001 objectives	241	>250[1]	286	2850
EN 9100 benefits	1	16	1	31
EN 9100 satisfaction	0	13	1	14
EN 9100 objectives	4	14	1	26

Source: Authors.

study were identified in the most common research databases (Web of Science, Research Gate, Mendeley, and Science Direct) and on websites like those of the IAQG and the Spanish Association for Standardisation (AENOR). The search, which used several relevant keywords, revealed differences in the references regarding the two standards (see Table 1).

In the second phase, papers were filtered based on their contribution. The identified papers were assessed against a list of main contents relevant to the research (preference was given to highly-cited journal publications), and the more recent papers were selected. In addition, a detailed analysis of paper contents was carried out, and the papers were categorised according to their alignment with the study's goals. Two relevant papers were found, which form the main basis of the study: Del-Castillo-Peces et al. (2017) and Prado-Román et al. (2018).

2.2. Aerospace quality systems framework

The aerospace industry has always been at the forefront of the development of quality management systems, and its standards are much higher than those in other industries, except the automotive sector (Gutiérrez, 2008), because safety is the main attribute underpinning its activities, which means that aerospace products are subject to strict requirements regarding quality and reliability (Thomas, 2006).

Moreover, in the aeronautical industry, as in most industries, increased subcontracting has increased the need for the supervision of subcontracted companies. This supervision is carried out through audits, among other tools. Initially, manufacturers performed second-party audits. They required extensive investment due to the globalisation of the supply chain and increased task outsourcing. During the 1990s, a trend emerged favouring the development and adoption of schemes based on third parties, wherein audits were carried out by independent entities that certified the validity of the quality system (Grijalvo & Prida, 2005).

As subcontractors worked with several customers, they received countless quality system audits, and were often guided by different requirements. Even though the US Department of Defence had adopted ISO 9001, the aerospace community felt that it was not industry-specific. They considered it too open for interpretation and believed it did not take regulatory requirements into account. In 1998, some of the largest national manufacturers, suppliers, and aerospace associations in the United States, Asia, and Europe came together under the auspices of the IAQG to promote initiatives for achieving quality improvement and cost reduction for the benefit of the global industry (Bonnard, 2014).

As a result of this joint industry effort, two initiatives were developed:

- the EN 9100 standard, which includes, in addition to all the ISO 9001 requirements, specific aerospace requirements, best practices, and industry performance metrics.
- the Industry Controlled Other Party (ICOP) scheme based on a third-party system in which i) external companies controlled by the IAQG are responsible for audit and certification; and ii) information related to audit results, inspections operations, and best practices are shared within the industry.

The EN 9100 framework, promoted and controlled by the large manufacturers in the sector, spread quickly throughout the entire aerospace supply chain. IAQG regulations do not permit industry actors to work with a supplier that is not certified (Grijalvo & Prida, 2005).

However, implementing the EN 9100 standard entails investments of money, time, and organisational resources, both initially and during the maintenance stages. These investments are generally greater than those needed for the generic ISO 9001 standard, as EN 9100 includes additional requirements (Del-Castillo-Peces et al., 2014a). These investments do not guarantee the profitability of the company, as was concluded by the research on EN 9100 (Del-Castillo-Peces et al., 2014a, 2017; Prado-Román et al., 2018).

Therefore, the first objective of this research is to assess the achievement of the objectives for which EN 9100 was created – specifically, those affecting company performance most directly, like the deployment of an integrated methodology for continuous improvement based on sharing best practices and the standardisation of customer requirements. The study also seeks to determine if the quality level of Spanish companies is higher today than at the end of the last century. The literature review offers a greater insight into other standards, mainly ISO 9000 (Calvo-Mora et al., 2015; Gotzamani & Tsiotras, 2001; Heras et al., 2002; Martínez-Costa et al., 2008; 2009; Martínez-Costa & Martínez-Lorente, 2003; Melão & Guia, 2015; Santos et al., 2016; Tarí et al., 2012; Terziovski et al., 2003; Terziovski & Power, 2007). None of the studies focuses on the aerospace industry, and their findings cannot always be extrapolated to this industry due to the differences across sectors (Llach et al., 2011).

The scarcity of studies on the benefits of EN 9100 certification and the fact that the mandatory component within the aerospace supply chain has been paid scant attention (Souza et al., 2014) or has been ignored entirely (Del-Castillo-Peces et al., 2018) have driven the second research objective: to analyse whether the certification is beneficial for companies and whether a company's reasons or motivation for obtaining it can affect its benefits.

Studies on ISO 9000 classify its benefits in terms of the type of motivation (internal vs. external; Bernardo et al., 2015; Sampaio et al., 2010; Tarí et al., 2012) or in terms of whether the company's decision was reactive or proactive (Rodriguez-Escobar et al., 2006). These studies assert that, when the motivations for standard implementation are only external or the decision is reactive, there is a higher risk that the company will not acquire new capacities because the standard's philosophy

may not be properly adopted. Moreover, it could be difficult to achieve a sustainable competitive advantage (except that of not being excluded from the market) because ways of working will be misaligned with standard requirements; moreover, audits may trigger a costly ad-hoc effort at adaptation, which may be purely aesthetic. However, internal motivations or proactive decisions can generate a higher internal development of the principles; this could lead to greater operational and organisational improvements, greater quality levels and customer satisfaction, and ultimately more financial benefits.

Finally, its unique access to people with high expertise in quality, the aeronautics sector, and its supply chain enables this study to tackle another important issue facing aeronautical companies about which little research has been done: the relationship between quality and innovation and the future of that relationship in aeronautics.

There is no universal definition of 'innovation' in the literature. According to the Organization for Economic Cooperation and Development (OECD), innovation can be defined as the implementation of a new or significantly improved good, service, or process or a marketing or organisational method in business practice, the workplace, or in external relations. It is possible to distinguish between incremental innovation, based on the firm's current technical capabilities and characterised by small changes, and radical innovation, based on changes in the firm's current technological trajectory and organisational competencies (Manders et al., 2016).

Few studies have examined how the EN 9100 framework contributes to innovation, and findings on the ISO 9000 standard are contradictory (Manders et al., 2016). Researchers such as Singh and Smith (2004) found no relationship, while others such as Prajogo and Sohal (2001) and Leavengood and Anderson (2011) have suggested that quality management might have a negative influence on innovation due to the hindrance of procedures such as standardisation activities. However, most of the results show a positive influence on innovation, quality management principles, and practices; they suggest that continuous improvement, a customer focus, and mutually beneficial supplier relationships enable knowledge creation, which fosters product and process innovation (Martínez-Costa & Martínez-Lorente, 2008; Sadikoglu & Zehir, 2010; Santos-Vijande & Álvarez-González, 2007; Simón & Yaya, 2012), especially incremental innovation (Manders et al., 2016). The Plan-Do-Check-Act cycle has allowed companies to develop fast and efficient processes in critical areas; it is frequently introduced with little support from advanced technologies and without the need for radical approaches to human resource management (Davenport, 1996). Once improvement becomes standard, new plans are put in place to make new advances. Radical improvement is attempted when incremental improvements have proved ineffective in achieving the ultimate goal of customer satisfaction.

Quality management also promotes the development of multiple communication channels, developing an extensive and close network of knowledge creation that occurs at all levels of the organisation. According to Moreno-Luzón et al. (2000), practices like process management and teamwork enable internal learning and thus process innovation. Mas-Verdu et al. (2010) assert that customer orientation and cooperation with suppliers promote collaborative relationships and enable the acquisition and assimilation of external knowledge, leading to process innovation.

Table 2. List of interviewees.

SC tier position	Role within the company	Years of experience in the sector
TIER 1	Management – Quality Systems	31
TIER 1	Management – Quality	23
TIER 0	Supply Chain Quality Management	34
TIER 2	Management – Quality	16
TIER 1	Management – Quality	34
TIER 0	Supply Chain Quality Management	43
TIER 0	Supply Chain Quality Management	43
TIER 1	Management - Manufacturing Quality	21
TIER 0	Supply Chain Quality Management	22
TIER 2	Management – Quality	18
EQA	Auditor AEA 9100	38
TIER 0	Management – Supply Chain Quality	43
TIER 2	Management – Quality	15
EQA	Auditor AEA 9100	39

Source: Authors.

However, a systematic review of the literature on how quality management influences product innovation reveals that quality management could inhibit the development of an organisational culture that fosters and supports innovation. González-Cruz et al. (2018) argue that this will depend on the managerial motivation for implementing quality management and the strategy followed by the firm.

Therefore, analyses of the relationship between quality and innovation require a consideration of the motivation (internal or external) driving the implementation and maintenance processes.

3. Research methodology

An in-depth interview study was designed to address the research objectives. It involved representatives from all the layers in the aerospace supply chain (Tier 0, Tier 1, and Tier 2), including certified auditors. Case selection was conducted by identifying established, experienced actors in the sector. The interviewees have an average of 30 years of experience working in the sector, which precedes the standard deployment; thus, the sample provides perspectives on the differences between before and after the certification (see Table 2).

Some interviewees are Experienced Quality Auditors (EQA) at one of the five authorised certifying companies in Spain, which were certified once the standard was developed. Several others are quality directors of Tier 1 companies, with facilities in Europe and America, and members of the Spanish Association of Defence, Aeronautics and Space Technologies (TEDAE) board. Quality directors of smaller companies (Tier 2) were also approached to provide other perspectives, including supply chain quality managers from Tier 0, who have witnessed the growth in volume and complexity of subcontracting in the Spanish ecosystem and have seen the external companies they work with evolve.

In the research, priority was given to weighing the gathered testimonies heavily, rather than establishing a statistical measure of the deployment of these practices. This approach requires a profound analysis rarely achievable through quantitative

Table 3. Example of interview protocol.

Benefits obtained from certification and importance of motivation
What were the main reluctance found within your organization when implementing the QMS according to the 9100 certification?
In your company, was certification addressed as: a) an external requirement that had to be accomplish or b) as an internal need of a tool to improve the quality system?
If answer is a) Do you think that despite this, it has taken deep root among the global operation of the company? If answer is b) Do you think it has comes up to the expectations?

Source: Authors.

study methodologies, based on a large amount of observations that are more useful to determine the occurrence and frequency of a certain phenomenon (Yin, 2011). This allows the research subject to be seen not through a single lens but through many, enabling the researcher to understand the different facets of the phenomenon (Baxter & Jack, 2008). Additionally, Eisenhardt (1989) explains that, when theories are to be constructed or improved, especially when the phenomenon is not fully known or is in its early stages, it is not adequate to apply a longitudinal change process analysis, as the theoretical perspectives have a slight empirical basis.

The interviews were semi-structured using a protocol (see Table 3) that includes short answers facilitating the analysis of subjects with open questions, providing depth to the conversation. Qualitative data are rich and nuanced (Weick, 2007), allowing researchers to dig more into behaviours, perceptions, and relational mechanisms that would be otherwise difficult to observe. Subjects were approached from different angles, allowing a better understanding of the interviewee's point of view, and the interviewees were asked for their opinion about quality management, its role in the innovation process, and future trends.

A total of 14 interviews were conducted between February and March 2018, and their length varied from 15 minutes to an hour, for a total of 9.5 hours. Once all interviews were transcribed, the analysis focused on grounding the coding of the main recurring topics that emerged from the interviews (Glaser & Strauss, 1967; Holton, 2010).

Among the coding methods available for this type of study, the structural coding method was chosen for the first cycle and axial coding was chosen for the second, after which the major trends were identified in the data using concept coding. MAXQDA2018.2 (https://www. Maxqda.com/) was used for data management.

Structural coding is applicable for studies with multiple participants and is suitable for interview transcription (Corbin & Strauss, 1990; Saldaña, 2009). It acts as a structuring tool that generates an index and tags based on the questions posed to the interviewees. From its output, the portions of the text related to the general themes of the study were identified (Saldaña, 2009). Building upon those categories, 479 segments with 88 different codes, the second codification cycle was performed using axial coding (Saldaña, 2009). Axial coding was employed to identify relations among the categories and subcategories found during the first coding cycle, specify their dimensions, and build a texture of relationships around the axis of the 13 categories found. While the first part of the coding divides the data, the second part reassembles them and gives them coherence (Charmaz, 2006).

Table 4. Example of cross classification of codes and categories.

Positive aspects of the EN 9100 framework
EN 9100 innovation
Homogenization benefits
Benefits identification of weak points
Beneficial certification
Improvements in planning
Improvements in risk management
… … ..

Source: Authors.

After this step, concept coding was performed, creating four groupings amongst the different categories. This conceptual coding assists in carrying out a cross-study of the responses obtained and categorised in the previous step, finding trends in the data obtained (see Table 4), and adding context.

Lastly, after the study examined the codes and their recurrence through the texts, made comparisons among the categories and groupings, and conducted an exhaustive analysis of the texts and segments chosen, it generated the findings described in the next section.

4. Results

4.1. Findings: general view

The overall opinion about the current validity of the quality principles is positive (12 out of 14 interviewees are positive), and most (11 interviewees) thought the certification scheme had been beneficial for companies. The favourable view of the standard is mostly found in the larger companies, for which certification does not imply requisite work apart from their quality system; moreover, its obligatory requirement for companies within their supply chain has eliminated the need for periodic quality system audits. Smaller companies tend to feel that certification demands compliance with several requirements that are not always adapted to their needs, and also that financial and workload burdens have been transferred onto them.

Conversely, there is consensus about the improvement/quality level of companies in the Spanish aeronautical sector and certification's contribution to this improvement (11 interviewees) – particularly due to the standardisation of processes and forms of work (eight interviewees) but not due to best practices being shared between companies (11 interviewees), indicating that companies tend to keep their know-how secret. Furthermore, some interviewees (five) highlighted the fact that there are still many customer requirements regarding the quality system that would be eliminated within the EN 9100 framework.

The effective implementation of continuous improvement has more defenders (nice interviewees) than detractors (six), but this is subject to varied interpretations, as will be seen later. Additionally, almost all the interviewees highlighted motivation as a key factor that drives the certification process.

Finally, one noteworthy negative aspect is the decoupling of certification from innovation development (nine interviewees). The vast majority of the interviewees do not see a relationship between quality and innovation (nine interviewees), and, when asked about the future of quality, most pointed to APQP (Advanced Product Quality

Planning), which seeks the total integration of quality principles from design to series manufacturing throughout the entire supply chain.

4.2. Specific results: analysis and discussion

4.2.1. Achievement of EN 9100 objectives

The introduction of continuous improvement as a frequent practice is positively valued (9 interviewees), though one interviewee finds it to be positive in some aspects and not efficiently applied in others. Five participants do not perceive a systematic or efficient application of it in their companies.

The research shows that the principles that created EN 9100 certification are still valid today and that continuous improvement has become part of the certified companies' mindset, although some participants (those at the highest layers of the supply chain) find it more effective than others. This could be because continuous improvement activities usually involve actions affecting the firm's overall way of working, requiring resources (specifically financial) for implementation that small businesses often do not have. However, smaller companies do have greater flexibility and speed of action in implementing improvement actions.

These results are in line with the EN 9100 research (Del-Castillo-Peces et al., 2014a, 2014b) and ISO 9000 studies (Martínez-Costa et al., 2008a; Terziovski & Power, 2007). Quality improvement is a long-distance race; after implementation, a firm has to continue investing resources for the gradual establishment of the quality principles, which brings us back to the external motivations for adherence to the standard. The regulations governing access to the aerospace market can force reactive decisions (Souza et al., 2014).

Contrarily, the general opinion amongst the interviewees (11) is that best practices are not shared in the sector. Spain's forums, such as IAQG's OASIS site, TEDAE meetings, and the HÉLICE foundation, are not found to be efficient in this regard, and no tools are deployed to achieve the objective. It is perceived that companies are fearful of losing competitiveness by doing benchmarking and have been most outstanding in the achievement of the IAQG's objective. In other countries, this is done more frequently, so the issue could be partially cultural (Mcdermott & O'dell, 2001).

Another unachieved objective is the reduction in the number of audits. A common complaint at all supply chain levels is the excessive number of audits needing to be carried out and received from either clients or official bodies, such as the European Union Aviation Safety Agency (EASA). The interviewees think it is necessary to find a way to rationalise this issue without diminishing product safety levels because audits can involve an enormous resource consumption. However, EN 9100 quality system audits are rare; audits for NADQAP certification, products, industrial capacity, and manufacturing of the first or last item are more common.

4.2.2. Improvement of quality levels in companies since 2002

Most of the participants (11 interviewees) see improvement in the general quality level within aeronautical manufacturing companies in Spain and identify the EN 9100 certification framework as the prime contributor to this improvement.

In Spain, the EN 9100 standard deployment started in 2002. There was a strong development of the Spanish Airbus supply chain at this time, in which more responsibility was gradually handed over to sub-tiers. In the beginning, suppliers were provided with materials and work orders, but the full management of the work package slowly developed, and companies that started as simple workshops now have several sites and autonomous operations.

As a result, these deployments have brought about a general quality increase. Most of the interviewees see this improvement as at least partly a consequence of the certification, while others (4 interviewees) consider that EN 9100 has not played a key role in this improvement and point to the general development of the sector during these years. One interviewee from the Tier 1 group does not perceive any improvement at all, not because the level is low, but because it is stable. This opinion is aligned with ISO 9001 research that shows that time does not influence the appearance of positive effects (Gotzamani et al., 2006; Terziovski et al., 2003). According to these studies, when the motivation for implementation is almost exclusively external (i.e. ensuring that the company will not be excluded from the market), this benefit appears immediately after certification is obtained, so the time elapsed would have no influence.

Nevertheless, most of the participants find that the framework has been beneficial for the companies. The standard provides a minimum level of quality within the sector that creates a base to build upon and provides a common language, due to the unification of work processes in the industry. These results are in line with the work of Thomas (2006), Grijalvo and Prida (2005, 2006), and Del-Castillo-Peces et al. (2014a). They are particularly relevant for the industry given that packages are increasingly subcontracted and the supply chain is becoming increasingly complex since the flow often works in different directions regardless of whether the supplier is Tier 0, Tier 1, or Tier 2.

4.2.3. Benefits obtained from certification

Most of the interviewees (11) believe that certification has played a beneficial role for Spanish aeronautical companies. The approach to process management provided by the standard was highlighted (10 interviewees) for its significant contribution to firms' work processes, efficiency, and growth. This result aligns with those for other quality frameworks (Calvo-Mora et al., 2015; Melão & Guia, 2015; Tarí et al., 2012).

Other highlighted benefits include the harmonisation of different ways of working (8 interviewees). This is linked to characteristic elements of quality assurance, such as the approach to prevention and system control based on planning, documentation, and the use of statistical methods (Grijalvo & Prida, 2005; Gutiérrez, 2008). Other benefits that stand out are the increase in customer satisfaction and trust in the companies (8 interviewees) due to the customer-centric focus fostered by the standard. It is also remarkable that almost every interviewee from Tier 0 highlighted the improvement in customer satisfaction, as they are the main customers of the supply chain.

In general, the certification is perceived as being more valuable for larger companies due to the costs of quality surveillance for the lower layers of the supply chain. Large corporations do not have any problems when they have to face EN 9100 audit

requirements, while small companies find them excessive. This is perceived as a lack of adaptability of the standard, which provides only a minimum set of requirements to work upon, forcing small companies to engage in many procedures that do not always add value (Melão & Guia, 2015). These results are consistent with Rodriguez-Escobar et al. (2006), as it is more difficult to achieve positive results in small enterprises because they usually lack resources, and the initial costs and investments required to obtain certification are proportionally greater.

However, it is also possible to find studies (Prado et al., 2013; Terziovski et al., 2003) indicating that company size is not relevant and that the benefits are similar for all types of enterprises since they depend on other factors, such as the level of the internal development of quality principles. Gotzamani and Tsiotras (2001) argue that the benefits for small companies should even be higher: Since their initial quality level is sometimes lower, the opportunities for improvement are greater.

However, it is not clear that the certification has led to a decrease in company expenses. Four interviewees claim the standard is financially beneficial, specifically through a productivity increase. Three think there is no cost decrease because the number of audits has not decreased or because the focus of the standard has not reach.

Other noteworthy benefits include overall product improvement (four interviewees) and traceability and safety (two interviewees). Some interviewees claim that the framework has contributed to the identification of weak points, competitiveness increases, and planning improvements. These results are aligned with the objectives pursued by the framework – end-customer satisfaction through supplier–customer chains throughout all business processes, from processes related to the development, planning, or design of new products, applying the same concept of customer focus but internally (Grijalvo & Prida, 2005). Only one participant believes that risk management has improved, which is remarkable considering how long the standard has contained wording highlighting this aspect.

One of the themes discussed during the interviews was whether they considered that the certification can help provide more penetration power to the quality function inside the companies; the answers mostly point to awareness within the firms. This highlights the relevance of the firms' motivation for the certification and the role of management within the quality management system.

4.2.4. The importance of motivation

Almost all of the interviews (13) say that the motivation behind certification is a relevant factor in success. The interviewees claim that, when companies become certified with an improvement philosophy and try to make the most of the tools certification provides, it reflects on the firm's quality level (11 interviewees) and conditions the benefits obtained from the certification (9).

This result is in line with the EN 9100 research of Rodriguez-Escobar et al. (2006) and the ISO research of Bernardo et al. (2015), Sampaio et al. (2010), and Tarí et al. (2012). They find that, if a company is looking for a certification that serves as an entry to the aeronautical sector, the philosophy of the UNE EN 9100 standard will not be acquired properly, and the level of implementation will be relatively

low in these enterprises, and may be purely aesthetic. Nonetheless, if ways of working are aligned with the standard, the company can receive benefits from the certification in terms of improvements in organisational processes, operations, and human resource management.

A recurrent theme (9 interviewees) is that management involvement is vital for achieving the right motivation inside the company. Top management needs to reinforce the role of quality as a global function inside the company, not as a department focused on document generation.

4.2.5. Innovation vs. quality and 9100 certification

Nine interviewees see no relationship between quality management and innovation in the companies, and do not see how the certification collaborates with innovation. This general opinion across all the supply chain levels may be related to the common assumption that innovation is equivalent to technological innovation (Govindarajan & Kopalle, 2006), either in the development of new products and services or the incorporation of new functionalities into existing ones (Williamson, 2010). Moreover, reengineering, which consists of the complete redesign of business processes with the support of investments and the application of information technologies (Hammer & Champy, 1994), is considered a dominant quality tool for radical innovation (Jackson, 2003).

Although these concepts are not wrong, the reality is that they describe only one of the meanings of innovation. According to the OECD, innovation can refer to the product, the process, the market, or the organisation. Even though definitions of 'innovation' differ, they all have a common point: Innovation is anything that implies a change, which generates uncertainty about the result.

All those interviewed agree about the improvement philosophy certification provides. The EN 9100 framework, comprising a systemic set of management principles as well as practices and tools, acts as a source of knowledge creation and change; hence, it is possible to talk about 'incremental innovation'. However, the literature shows that, when companies are focused on improving the effectiveness and efficiency of the established strategy and current processes, it is difficult to create a culture of innovation (Birkinshaw et al., 2008; Walker et al., 2008).

This assessment is aligned with the interviewees' opinions about the future of quality. Most point to the APQP methodology, which was developed within the automotive industry by the Automotive Industry Action Group (IAAG) to establish a common method of planning, developing, and manufacturing products (Mcdermott, 2017). The APQP proposed the integration of quality principles from design to series manufacturing focused on the product, not the quality system, and applied to each of the products individually or to product families. Its use can change the way the company works, since all departments related to the design, development, manufacturing, and logistics of products must work together (Oberhausen et al., 2018).

More than half of the interviewees do not find that the EN 9100 framework can help in this development. However, several tools already used in quality management and required by the 9100 certification are integrated in the APQP, such as Design Failure Mode and Effects Analysis (DFMEA), Process Failure Mode and Effects

Analysis (PFMEA), and First Article Inspection (Pop et al., 2018). Each of the phases of the PDCA cycle is based on risk management, as is the new edition of the EN 9100 (Quality One, 2019).

Another interesting fact related to the interviewees' opinion is that, at the end of 2016, the IAQG published through the SAE a new standard, the 9145 Aerospace Standard APQP and Production Part Approval Process (PPAP), which is only a guide, not a certification schema, aiming to standardise the requirements for product development using these methodologies.

5 Conclusions

This study examines the EN 9100 framework, which is mandatory for any company seeking to work in the aeronautical business within the Spanish aerospace industry. The framework implies not only a significant investment but also the adaptation of company processes. It is important to determine whether the objectives with which this framework was developed have been reached. Considering the motivations (internal or external) driving the firms' implementation and maintenance processes, this study explores the benefits obtained by the Spanish aerospace companies and their innovation initiatives.

Regarding the first objective, the findings show that the EN 9100 standard and ICOP schema developed by the IAQG have been beneficial for the companies, even though the view depends on the company size. The most beneficial view is found in larger companies, for which certification has removed most of their supplier audits, while smaller companies consider that economic and workload burdens have been moved onto them because the standard is not adaptable and customers have many additional requirements.

Moreover, there is a consensus about quality level improvements among Spanish companies. However, this is not always perceived as being due to the certification; some interviewees consider it due to normal industry development and the companies' learning curves. The research shows the positive effects on processes and task standardisation and the effective implementation of continuous improvement, even though best practices are not shared between companies.

Regarding the second research objective, if the EN 9100 framework has been beneficial for aerospace companies, the study shows that it has played a positive role within the industry but that the benefits depend on how the framework has been approached by companies. If considered as a mere requirement or adhesion to a norm, EN 9100 implementation will be merely an inconsistent set of patches and bureaucracy, with no value-added and a loss of time and money. When well-understood and -applied, however, the EN 9100 framework can create synergies and generate a continuous improvement atmosphere.

Both approaches, internal and external motivation, have an impact on the benefits accruing to the company. It would be interesting to assess the effects of top management's support for one philosophy or the other, as this will influence incremental innovation and therefore the competitiveness of the company.

In terms of future research, further studies could extend the geographical scope of this study, since all interviewees belong to the Spanish aerospace industry, which may limit the study's generalisability. Future studies could also consider the Delphi method, a structured communication technique relying on a panel of experts such as this study drew upon but developed as a systematic, interactive forecasting method.

We hope that our results may serve as a starting point for future studies on the diffusion pattern and adoption of models and tools of business management. On the practical side, these findings can help managers focus their priorities and should be of interest to organisations involved with this type of framework, such as accreditation organisations, certifying bodies, and business consultants.

Note

1. Research gate site does not return the number of found articles after a search therefore the author chose to count up to a sufficiently relevant amount.

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References

ATAG. (2017). *Europe: Aviation benefits beyond borders*. Retrieved August 10, 2020, from https://aviationbenefits.org/around-the-world/europe/#:~:text=The%20aviation%20sector's%20spending%20with,contributed%20%24111%20billion%20to%20GDP

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report*, *13*(4), 544–559. https://nsuworks.nova.edu/tqr/vol13/iss4/2

Bernardo, M., Simón, A., Tarí, J., & Molina-Azorín, J. (2015). Benefits of management systems integration: A literature review. *Journal of Cleaner Production*, *94*, 260–267. https://doi.org/10.1016/j.jclepro.2015.01.075

Birkinshaw, J., Hamel, G., & Mol, M. J. (2008). Management innovation. *Academy of Management Review*, *33*(4), 825–845. https://doi.org/10.5465/amr.2008.34421969

Bonnard, A. (2014). *International Aerospace Quality Group (IAQG)*. http://www.ltas-cm3.ulg.ac.be/AERO0023-1/ConceptionIAQG.pdf

Calvo-Mora, A., Navarro-García, A., & Periañez-Cristobal, R. (2015). Project to improve knowledge management and key business results through the EFQM excellence model. *International Journal of Project Management*, *33*(8), 1638–1651. https://doi.org/10.1016/j.ijproman.2015.01.010

Charmaz, K. C. (2006). *Constructing grounded theory: A practical guide through qualitative analysis*. SAGE.
Corbin, J., & Strauss, A. (1990). Grounded theory research: Procedures, canons and evaluative criteria. *Zeitschrift Für Soziologie*, *19*(6), 418–427. https://doi.org/10.1515/zfsoz-1990-0602
Davenport, T. H. (1996). *Innovación de procesos reingeniería del trabajo a través de la tecnología de la información*. Díaz de Santos.
Del-Castillo-Peces, C., Mercado-Idoeta, C., & Prado-Román, C. (2017). Determining factors of the benefits derived from the implementation of 9100 standards. *Management and Business Administration*, *XX*(1), 69–82.
Del-Castillo-Peces, C., Mercado-Idoeta, C., & Prado-Román, C. (2014a). Aseguramiento de la calidad y satisfacción con sus resultados: una aplicación a la implantación de la Norma EN 9100 en el sector aeroespacial español. *Esic Market Economics and Business Journal*, *45*(1), 75–96.
Del-Castillo-Peces, C., Mercado-Idoeta, C., Prado-Román, M., & Del Castillo-Feito, C. (2018). The influence of motivations and other factors on the results of implementing ISO 9001 standards. *European Research on Management and Business Economics*, *24*(1), 33–41.
Del-Castillo-Peces, C., Mercado-Idoeta, C., Prado-Román, M., & Soto, F. (2014b). Standards EN-9100 and ISO-9000 in the Spanish aerospace sector. *Revista Venezolana de Gerencia*, *19*(67), 410–434.
Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, *14*(4), 532–550.
Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. New Brunswick, USA: Aldine Transaction Publishers
González-Cruz, T. F., Roig-Tierno, N., & Botella-Carrubí, D. (2018). Quality management as a driver of innovation in the service industry. *Service Business*, *12*(3), 505–524. https://doi.org/10.1007/s11628-017-0360-7
Gotzamani, K., Theodorakioglou, Y., & Tsiotras, G. (2006). A longitudinal study of the ISO 9000 (1994) series' contribution towards TQM in Greek industry. *The TQM Magazine*, *18*(1), 44–54.
Gotzamani, K. D., & Tsiotras, G. D. (2001). An empirical study of the ISO 9000 standards' contribution towards total quality management. *International Journal of Operations & Production Management*, *21*(10), 1326–1342.
Govindarajan, V., & Kopalle, P. (2006). Disruptiveness of innovations: Measurement and an assessment of reliability and validity. *Strategic Management Journal*, *27*(2), 189–199. https://doi.org/10.1002/smj.511
Grijalvo, M., & Prida, B. (2005). La implantación de las normas EN 9100 y el esquema de certificacion "Other Party" en España. *DYNA*, *LXXX*, 37–41.
Grijalvo, M., & Prida, B. (2006). Normativa y esquemas de certificación en los sectores aeroespacial y de la automoción. Estudio comparativo. *DYNA*, *LXXXII-2*, 47–52.
Gutiérrez, E. (2008). UNE- EN 9100:2003. Gestión de la calidad en el sector aeronáutico. *Forum Calidad*, *1*(97/08), 27–30.
Hammer, M., & Champy, J. (1994). *Reingeniería de la empresa*. Paramón.
Heras, I., Dick, G., & Casadesus, M. (2002). ISO 9000 registration's impact on sales and profitability. *International Journal of Quality & Reliability Management*, *19*(6), 774–791. https://doi.org/10.1108/02656710210429618
Holton, J. A. (2010). The coding process and its challenges. *The Grounded Theory Review*, *9*(1), 21–40.
ICEX. (2016). *SPAIN: Business opportunities in aerospace*. Retrieved August 10, 2020, from http://www.investinspain.org/invest/wcm/idc/groups/public/documents/documento/mde1/mzy3/~edisp/doc2015367125.pdf.
Jackson, B. (2003). *Gurús Anglosajones: Verdades y Mentiras*. Ariel.
Leavengood, S., Anderson, T. R. (2011). Best practices in quality management for innovation performance. *Proceedings of Technology Management in the Energy Smart World (PICMET)*.

Llach, J., Marimon, F., & Bernardo, M. (2011). ISO 9001 diffusion analysis according to activity sectors. *Industrial Management & Data Systems*, *111*(2), 298–316.
Manders, B., de Vries, H. J., & Blind, K. (2016). ISO 9001 and product innovation: A literature review and research framework. *Technovation*, *48*, 41–55.
Martínez-Costa, M., Choi, T., Martínez, J., & Martínez-Lorente, A. (2009). ISO 9000/1994, ISO 9001/2000 and TQM: The performance debate revisited. *Journal of Operations Management*, *27*(6), 495–511.
Martínez-Costa, M., & Martínez-Lorente, A. (2003). Effects of ISO 9000 certification on firms' performance: A vision from the market. *Total Quality Management & Business Excellence*, *14*(10), 1179–1191.
Martínez-Costa, M., & Martínez-Lorente, A. R. (2008b). Does quality management foster or hinder innovation? An empirical study of Spanish companies. *Total Quality Management & Business Excellence*, *19*(3), 209–221.
Martínez-Costa, M., Martínez-Lorente, A., & Choi, T. (2008a). Simultaneous consideration of TQM and ISO 9000 on performance and motivation: An empirical study of Spanish companies. *International Journal of Production Economics*, *113*(1), 23–39.
Mas-Verdu, F., Ribeiro, D., & Roig, S. (2010). Regional development and innovation: The role of services. *The Service Industries Journal*, *30*(5), 633–641. https://doi.org/10.1080/02642060802398085
Mcdermott, R., & O'dell, C. (2001). Overcoming cultural barriers to sharing knowledge. *Journal of Knowledge Management*, *5*(1), 76–85. https://doi.org/10.1108/13673270110384428
Mcdermott, R. (2017). *What is APQP? QualityTrainingPortal*. Retrieved March 10, 2019, from https://qualitytrainingportal.com/resources/apqp-resource-center/what-is-apqp/
Melão, N. F., & Guia, S. M. (2015). Exploring the impacts of ISO 9001 on small- and medium-sized social service institutions: A multiple case study. *Total Quality Management & Business Excellence*, *26*(3-4), 312–326. https://doi.org/10.1080/14783363.2013.822193
Moreno-Luzón, M. D., Peris-Bonet, F. J., & González-Cruz, T. F. (2000). *Gestión de la calidad y diseño de organizaciones Teoría y estudio de casos*. Prentice-Hall.
Murga, J. (2002). Experiencia de ITP en Calidad. *DYNA*, *77*(7), 32–36.
Oberhausen, D., Cox, J., Parsons, S. (2018). *Supply chain management handbook webinar*. https://elsmar.com/elsmarqualityforum/attachments/apqp_overview_webinar_7nov2018_-scmh-pdf.24210/
Pop, A. B., Ţîţu, M. A., Oprean, C., Ceocea, C., Sandu, A. V., & Ţîţu, Ş. (2018). Contributions concerning the possibility of implementing the APQP concept in the aerospace industry. In *MATEC Web of Conferences* (Vol. 178, p. 08013). https://doi.org/10.1051/matecconf/201817808013
Prado-Román, C., Del-Castillo-Peces, C., & Mercado-Idoeta, C. (2018). A study on external and internal motivations and its influence on the results of implementing EN 9100 standard. In E. Díez-De-Castro & M. Peris-Ortiz (Eds.), *Organizational legitimacy* (pp. 255–269). Springer.
Prado-Román, C., Del-Castillo-Peces, C., Mercado-Idoeta, C., & Soto, F. (2013). Los resultados de la implantación de la norma EN 9100 en el sector aeroespacial español. *Revista Galega de Economía*, *22*(1), 151–176.
Prajogo, D., & Sohal, A. (2001). The multidimensionality of TQM practices in determining quality and innovation performance an empirical examination. *Total Quality Management & Business Excellence*, *15*(2), 205–220.
Quality One. (2019). *APQP | Advanced Product Quality Planning | Quality-One*. Retrieved March **10, 2019,** from https://quality-one.com/apqp/
Rodriguez-Escobar, J., Gonzalez-Benito, J., & Martínez-Lorente, A. (2006). An analysis of the degree of small companies' dissatisfaction with ISO 9000 certification. *Total Quality Management and Business Excellence*, *17*(4), 507–521.
Sadikoglu, E., & Zehir, C. (2010). Investigating the effects of innovation and employee performance on the relationship between total quality management practices and firm

performance: An empirical study of Turkish firms. *International Journal of Production Economics*, *127*(1), 13–26. https://doi.org/10.1016/j.ijpe.2010.02.013

Saldaña, J. (2009). *The coding manual for qualitative researchers* (2nd ed.). SAGE Publications Ltd.

Sampaio, P., Saraiva, P., & Guimaraes, A. (2010). A classification model for prediction of certification motivations from the contents of ISO 9001 audit reports. *Total Quality Management & Business Excellence*, *21*(12), 1279–1298. https://doi.org/10.1080/14783363.2010.529367

Santos, G., Costa, B., & Leal, A. (2016). Motivation and benefits of implementation and certification according ISO 9001 – the Portuguese experience. *International Journal of Engineering, Science and Technology*, *6*(5), 1–12. https://doi.org/10.4314/ijest.v6i5.1

Santos-Vijande, M. L., & Álvarez-González, L. I. (2007). Innovativeness and organizational innovation in total quality oriented firms: The moderating role of market turbulence. *Technovation*, *27*(9), 514–532.

Simón, A., & Yaya, L. H. P. (2012). Improving innovation and customer satisfaction through systems integration. *Industrial Management & Data Systems*, *112*(7), 1026–1043.

Singh, P. J., & Smith, A. J. R. (2004). Relationship between TQM and innovation: An empirical study. *Journal of Manufacturing Technology Management*, *15*(5), 394–401. https://doi.org/10.1108/17410380410540381

Souza, J. P. E. D., Alves, J. M., & Silva, M. B. (2014). Quality improvement in the aerospace industry: Investigation of the main characteristics. *International Review of Mechanical Engineering*, *8*(5), 893–900.

Tarí, J. J., Molina-Azorín, J. F., & Heras, I. (2012). Benefits of the ISO 9001 and ISO 14001 standards: A literature review. *Journal of Industrial Engineering and Management*, *5*(2), 297–322. https://doi.org/10.3926/jiem.488

Terziovski, M., & Power, D. (2007). Increasing ISO 9000 certification benefits: A continuous improvement approach. *International Journal of Quality & Reliability Management*, *24*(2), 141–163.

Terziovski, M., Power, D., & Sohal, A. (2003). The longitudinal effects of the ISO 9000 certification process on business performance. *European Journal of Operational Research*, *146*(3), 580–595. https://doi.org/10.1016/S0377-2217(02)00252-7

Thomas, K. T. (2006). Quality management system for defence aeronautical industry. *Defence Science Journal*, *56*(1), 21–30.

Vilar, J. (2003). La implantación de la norma EN 9100 en EADS-CASA. *UNE Boletín Mensual de AENOR*, *177*, 42–45.

Walker, H., Di Sisto, L., & McBain, D. (2008). Drivers and barriers to environmental supply chain management practices: Lessons from the public and private sectors. *Journal Purchasing Supply Management*, *14*(1), 69–85.

Weick, K. E. (2007). The generative properties of richness. *Academy of Management Journal*, *50*(1), 14–19.

Williamson, P. (2010). Cost innovation: Preparing for a 'value-for-money' revolution. *Long Range Planning*, *43*(2–3), 343–353.

Yin, R. (2011). *Applications of case study research*. SAGE Publications Inc. https://www.sagepub.com/sites/default/files/upm-binaries/41407_1.pdf