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EUROPEAN STANDARDIZATION FOR THE MANAGEMENT OF SPACE-RELATED PROJECTS

Summary. A project is a temporary endeavour designed to produce a unique product, service or result, with a defined beginning and end (usually constrained by time, funding or deliverables), which is undertaken to meet unique goals and objectives, typically to bring about beneficial change or added value. Space projects involve a complex process and usually take many years to be developed. The development of complex project requires the cooperation of several organizations, which share a common goal: namely, to create a product that satisfies the consumer's needs (technical performance) within cost and schedule constraints. To reach this goal, corresponding technical activities, as well as human and financial resources, need to be organized and coordinated in a well-organized manner. Project management is the discipline of initiating, planning, executing, controlling, and finalizing the work of a team in the achievement of specific goals and meeting specific success criteria. This involves the application of knowledge, skills, tools, and techniques to project activities in order to meet project requirements.

The paper is a review of how issues related to space management requirements has been addressed in Europe.

Keywords: space project; project management; standardization.

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1. INTRODUCTION

The importance of standardization to space activities in Europe is growing, as the EU, the European Space Agency (ESA), national space agencies and European industry are faced with new technical challenges involving more demanding economic constraints. Through a more efficient and effective use of space technologies and space-based applications and services, standardization has a role to play in boosting the competitive position of the European space industry in the world market, notably by increasing the product range and thus decreasing prices, as well as helping SMEs to enter certain segments of the space market. Space standardization supports the uptake of space-based innovative services and applications.

Standardization is seen as a way to decrease the risk of failure, guarantee the technological reliability of space products/components, and reduce development and operational costs. Since European space production is split between several countries, the development of "standardized" working procedures can help reduce some of the inefficiencies present in the value chain [3, 24].

Standardization is generally viewed as a process that drives commercial viability and success. Successful companies recognize that developing and using standards represent the path to remaining competitive and producing quality products [9].

Standards promote innovation because they allow for an early market uptake of innovative products and services, which enabling technology transfer and facilitating research. Standards also typically ensure interoperability between different devices and services, allowing for innovation to take place "on top of innovation". Standardization allows different individuals, firms and institutions to coordinate their resources with regard to a particular technology or methodology [15, 25].

The purpose of this paper is to present a review of European standardization activities and deliverables for management used in the planning, monitoring, and controlling of space-related projects.

2. STANDARDIZATION IN EUROPEAN SPACE POLICY

European space policy is defined in Communication COM (2007) 212 Final [2], which indicates the priority tasks associated with the use of space applications, achieving the objectives of EU policies, and meeting the needs of businesses and European citizens. It also sets out standards, which represent some of the factors determining the legal framework that is specific to the space sector. The Commission, according to the communication, reserves the right to ask European standard-setting organizations to conduct a systematic assessment of what standardization will be needed in the future, in support of the legal framework.

Standardization, together with certification, is also referred to in Regulation (EC) No 683/2008 [23] with regard to Galileo and EGNOS, indicating that certification and standardization are inherent elements of these programmes.

Communication COM (2013) 108 Final, published on 28 February 2013 [3], highlights the growing importance of standardization in Europe with respect to space and places new demands on the EU, ESA, national space agencies and European industry regarding new technical challenges. It underscores the importance of effective space standardization as a tool to support the uptake of space-based innovative services and applications. As space missions are also a risky business, where technology is pushed to the limit and where there is very limited opportunity to correct problems that were not identified before a launch,

standardization is seen as a way to decrease the risks of failure, guarantee the technological reliability of space products/components, and reduce development and operational costs. Finally, since European space production is split between several countries, the development of "standardized" working procedures is indicated as a means to reduce some of the inefficiencies currently present in the value chain.

Issues related to the European space policy and standardization activities are also included in the Council Decision of 3 December 2013 [4]. The pre-normative research and standard setting, in the context of prioritizing "societal challenges", are recognized as activities supporting innovation. Standardization, alongside processing, archiving and validation, was also recognized as an area in which to allow greater use of data obtained in space. The development of worldwide standards and interoperability guidelines, and the promotion of the acceptance and deployment of European solutions outside Europe, were identified as activities that could enhance the competitiveness of European industry. On the topic of the space industry and research community, as well as strengthening European non-dependence in space systems, it is emphasized that standardization should be supported in order to optimize investments and develop access to market.

3. EUROPEAN STANDARDIZATION FOR SPACE

European standardization is a voluntary activity, based on voluntary cooperation between industry, businesses, public authorities and other stakeholders. There are three European standardization organizations (ESOs) that have been officially recognized by the European Union and by the European Free Trade Association as being responsible for developing and defining voluntary standards at a European level:

- The European Committee for Standardization (CEN) is responsible for developing European standards and other technical specifications in relation to a wide range of products and services in all areas of economic activity with the exception of electrotechnology and telecommunications.
- The European Committee for Electrotechnical Standardization (CENELEC) is responsible for developing European standards and other technical specifications in the electrotechnical engineering field.
- The European Telecommunications Standards Institute (ETSI) produces globally applicable standards for information and communications technologies, including fixed, mobile, radio, converged, aeronautical, broadcast and Internet technologies.

The majority of European standards produced by these ESOs are developed to address specific needs that have been identified by potential users. About one fifth of all European standards are developed following a standardization request (mandate) from the European Commission (EC) to the ESOs. This request asks for European standards or European standardization deliverables to be drawn up and adopted in support of European policies and legislation. European standards/standardization deliverables, even though developed under a Commission request and for European legislation, remain voluntary. However, when European standards are adopted, national standardization bodies are expected to transpose them into identical national standards and withdraw any conflicting national standards [13].

The EC has an obligation to identify strategic priorities for European standardization for the upcoming year. This obligation is a consequence of Regulation (EU) No 1025/2012 [22].

In 1996, the ESOs received the first mandate, namely, EC Mandate M/237 [12], which was primarily organizational in nature as its aim was to establish rules for cooperation between the ESOs and the European Cooperation for Space Standardization (ECSS). This mandate obliged the ECSS, CEN, CENELEC and ETSI to develop an overall strategy of standardization work to meet the needs of the space industry, including identifying areas where standardization activity should be carried out on a European level and those that should be conducted on an international level, as well as identifying those specifications that should obtain the status of a European standard and those that remain within the exclusive sphere of the ECSS. At the same time, it was admitted that the subsequent transposition of selected international standards as European standards was possible.

The second EC Mandate M/415 [10] was issued in June 2007. This mandate set out the standardization work programme for the space sector, clearly pointing out that standards developed under this mandate should ensure an adequate level of security for space equipment and services, as well as provide support for European projects and European space industry. It was part of a European space programme, with its implementation divided into two stages. The first step was a feasibility study, whose task was to determine the current state of the standardization aerospace needs by prioritizing future work and identifying the participants who should be involved in this work in individual thematic areas. In the second stage of the programme, for each thematic area identified in the first phase, standardization needs and a comprehensive programme of standardization work were developed.

To respond to EC Mandate M/496 (addressed to the CEN, CENELEC and ETSI to develop standardization regarding the space industry, i.e., Phase 3 of the process) a joint CEN-CENELEC Technical Committee on 'Space' (CEN/CLC/TC 5) [11] was created in 2011. Meanwhile, the CEN and CENELEC have established close cooperation with the ECSS, which brings together the ESA, several national space agencies and Eurospace (representing the European space industry).

3.1. European standardization activities for space project management

The ESA has a strong commitment to support the ECSS. The ultimate goal of building user-friendly standards for all European space activities is to minimize life cycle costs, while continually improving the quality, functional integrity and compatibility of all elements of a space project. This goal is achieved by applying common standards for project management and for the development and testing of hardware and software. During the development process of ECSS standards, the ESA Requirement and Standard Division acts as the ECSS' central secretariat [9].

The ECSS intends to achieve formal status for a selected part of its standards (as appropriate) as European standards (ENs) by the CEN in order to increase the efficiency of the European space industry and strengthen its international competitiveness. Currently, a large majority of the European standards and standardization deliverables for space project management are developed by the ECSS [26].

The set of European standards/standardization deliverables relating to space project management include the only one prepared by the working group comprising the CEN, CENELEC and TC 5, namely, EN 13290-1:1999 Space Project Management: General Requirements - Policy and Principles [17], which presents and describes the documents produced for the management and direction of the technical scope of activities associated with the strategy and execution of aerospace projects. It also defines fundamental management rules for the implementation of space project realization, as well as the ability to use these

rights to all individuals participating in projects including, for example, space agencies, and industrial and scientific laboratories.

The other standards originate from documents and standards prepared by the ECSS.

The ECSS' system is a set of standards, handbooks and technical memoranda for ECSS users, comprising a comprehensive set of documents addressing all essential aspects of the three major branches:

- Project management
- Engineering
- Product assurance

The objectives, policy and organization of the ECSS, together with its architecture and documents, are presented in ECSS-P-00C [7]. The current architecture of European standards for space systems is depicted in Fig. 1, while detailed architecture of ECSS space system management standards is presented in Fig. 2.

The management branch of the ECSS responsible for standards/standardization deliverables defines the process requirements to be applied to overall project activities during the life cycle.

The ECSS-M series standards are characterized by the fact that, in order to meet the expectations of the consumer in the most cost-effective way, they may be tailored to the specific characteristics and constraints of a space project in line with ECSS-S-ST-00, ECSS System: Description, Implementation and General Requirements [8].

ECSS-M-00 Space Project Management: Policy and Principles [5] is the top-level document in the management branch, which provides an introduction to the domain, content and architecture of the management standards. It also covers common topics, such as tailoring, risk management and overall project management. It is designed to facilitate the elaboration of a management system, which is appropriate to the project in which it is implemented, compatible with existing structures and flexible enough to adapt to necessary changes throughout the phases of the evolving project, as well as to new projects.

EN 16601-10 [17] (ECSS-M-ST-10) Space Project Management: Project Planning and Implementation describes the key elements for project planning and implementation, while specifying the top-level requirements and products. It encompasses all of the processes carried out in order to plan and execute a space project, from initiation to completion, at all levels in the customer-supplier chain in a coordinated, efficient and structured manner. The project management plan, as described in this standard, defines the project management approach and methodology to be used throughout the life cycle of the project, together with an overview of all the elements of project management disciplines. This standard includes normative and informative annexes. Annex A contains the requirements for a project management plan, which should be prepared by each supplier in the customer-supplier chain. Annexes B to E, as well as Annex A, are normative and specify respectively the product tree, the work breakdown structure, the work package description and the progress report. Annexes F to H are informative and provide details about the delivery of ECSS management branch documents per review, the delivery of other management documents, and the determination of the appropriate work breakdown structure. The following European standards were superseded by this standard: EN 13290-2:2001 Space Project Management: General Requirements - Project Breakdown Structure; EN 13290-3:2001 Space Project Management: General Requirements - Project Organization; and EN 13290-4:2001: Space Project Management - General Requirements Part 4: Project Phasing and Planning, developed by the CEN, CENELEC and TC 5.

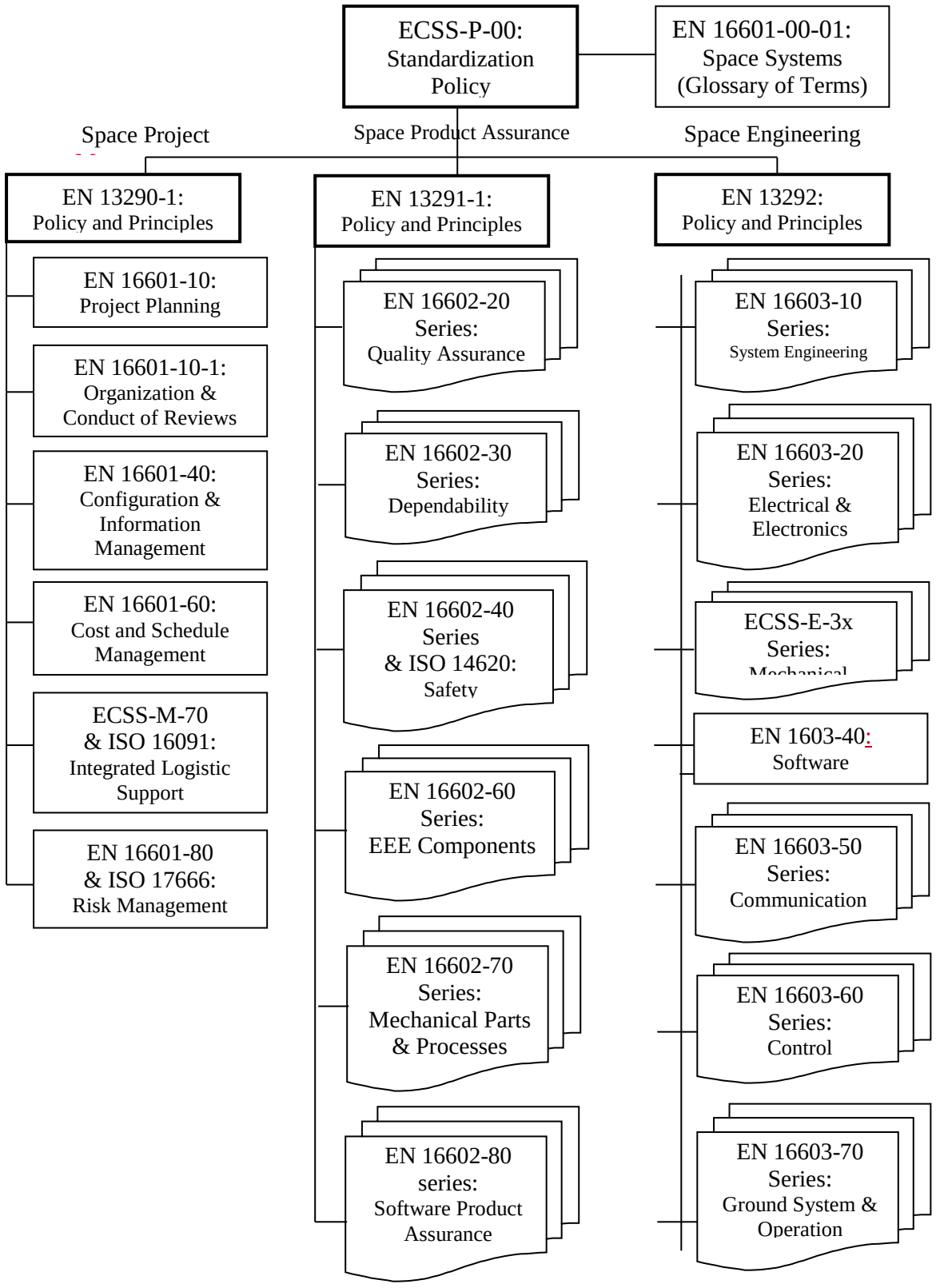
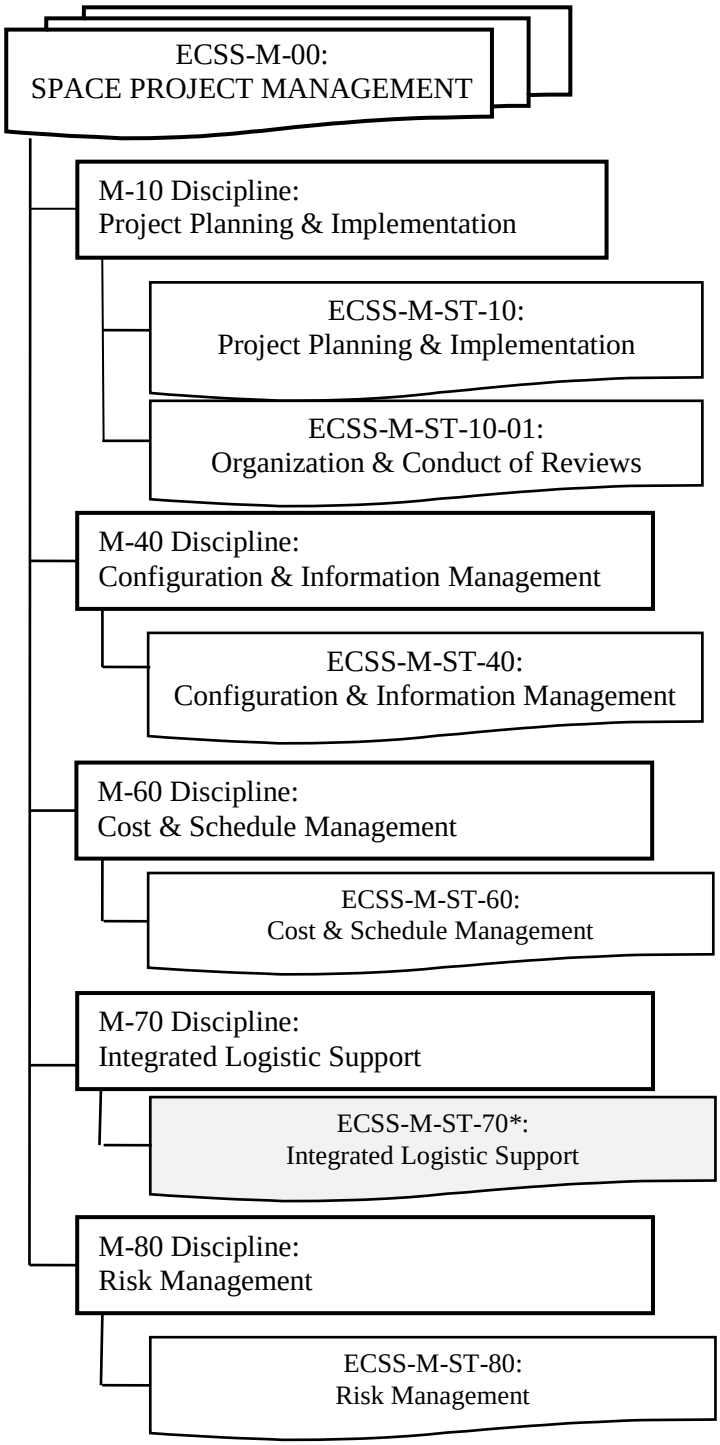


Fig. 1. Architecture of European standards for space systems [14]



*Ongoing update of an existing document

Fig. 2. Architecture of ECSS space system management standards [14]

EN 16601-10-01 (idt ECSS-M-ST-10-01) Space Project Management: Organization and Conduct of Reviews, as developed by the CEN, CENELEC and TC 5, replaced EN 14093:2002 of the same title. This specifies the means for identifying and structuring all of the activities and information required in project review, and provides the information outputs and activities necessary to complete the process and a check list of activities and information required for each of the project reviews, as identified in the ECSS standards, concerning the project management. This standard is divided into two main parts: the first part presents the processes, while the second provides detailed requirements. It also specifies, in annexed document requirement definitions (DRDs), what the requirements specified in this standard apply to, and how they affect the supplier and customers at all levels [18.

EN 16601-40 (idt ECSS M-ST-40) Space Project Management: Configuration and Information Management describes the processes and the requirements for managing the information/documentation and configuration regarding the products within a space programme or project. The importance of configuration management has been recognized in light of its incorporation within most of the main safety standards, including IEC 61508 and DO-178B, as well as more general quality guidance, such as ISO 9000. Configuration management is essential for system safety, as it helps to ensure that requirements and constraints, which are identified in earlier stages of development, are preserved through subsequent modifications. Configuration management consists of procedures and processes that are intended to ensure the consistency of a product with both functional and non-functional requirements throughout the development and operational lifecycle. This standard is structured into two main parts: the first part presents the processes, while the second provides detailed requirements. Annexed DRDs specify the expected configuration and information/documentation management documentation [19].

EN 16601-60 (ECSS-M-ST-60) Space Project Management: Cost and Schedules Management defines methods for the optimization of the use of human resources, facilities, materials and funds, thereby ensuring a successful completion of the project. It defines principles and requirements that are both common and individually specific for cost and schedule management [20].

ECSS-M-70 Space Project Management: Integrated Logistic Support is a document that describes the set of management requirements needed to identify and provide of logistical support. The aim of these requirements is to ensure that the consumer can operate and maintain a product under the expected operational conditions for the expected lifetime. This document describes the fundaments of integrated logistic support and sets out management requirements for integrated logistic support, logistic support analysis, support elements and information management [6].

EN 16601-80 (ECSS-M-ST-80) Space Project Management: Risk Management is the latest, but the most important, in a series of European standards for space project management. Risk management is placed in a key position among the standards defining management practices. The objective of this standard is to define the principles and requirements for integrated risk management on a space project. It explains what is needed to implement a project-integrated risk management policy by any project actor, at any level (i.e., customer, first-level supplier or lower-level suppliers). The aim of project risk management is to identify, assess, reduce, accept, and control space project risks in a systematic, proactive, comprehensive and cost-effective manner, taking into account the project's technical and programmatic constraints. This standard contains a summary of the general risk management process, which is subdivided into four basic steps and nine tasks [21, 24].

4. SUMMARY AND CONCLUSIONS

A common feature of ECSS standards is that requirements are defined in terms of what must be accomplished, rather than in terms of how to organize and perform the necessary work. Such an approach allows for existing organizational structures and methods to be applied where they are effective, and for structures and methods to evolve as necessary without rewriting the standards.

The European standards architecture for space project management reflects the architecture of ECSS documents. This is because the significant majority of European standards regarding this topic concern the implementation of ECSS standards. Such an approach facilitates the organization and retrieval of requested information within the system of ECSS and EN standards.

The principle applicable to numbering EN standards, when implementing ECSS standards, enables easy identification of the relationship between them.

A feature common to all these deliverables is that they can/should be tailored to the specific characteristics and constraints (requirements of a particular profile and circumstances) of a space project/programme.

A recommended seven-step process for the preparation and application of tailoring, in order to establish the applicability of ECSS standards and their requirements on a project, as well as apply tailoring as necessary, is described in ECSS-S-ST-00 [8].

The series of EN (ECSS) standards for management should be applied to engineering and product assurance standards in space projects and applications.

European standards, in accordance with the agreement on technical cooperation between the ISO and the CEN, namely, the Vienna Agreement, should be harmonized with international standards where appropriate. The agreement sets out two essential modes for the collaborative development of standards: the mode under the ISO lead and the mode under the CEN lead, in which documents developed within one body are submitted for the simultaneous approval by the other [1].

Despite the aforementioned agreement, it is still possible to find some international standards for space programme/projects management, which are almost identical (for example, EN 16601-80 and ISO 17666 for risk management).

The situation is similar with respect to ECSS standards (for example ECSS-M-70 and ISO 16091 for integrated logistic support), despite the fact that the ECSS Technical Panel maintains a liaison with the ISO's Technical Committee 20 and Subcommittee 14: Space Systems to harmonize and complement actions, while ESA member states are taking part in developing ISO standards [9].

A good example of the active involvement of the CEN and ESA member states in developing ISO standards is the newly proposed work item ISO/AWI 21886 Space Systems: Configuration Management. In this case, Germany will consider the adoption of EN 16601-40:2014 Space Project Management - Part 40: Configuration and Information Management (identical to ECSS-M-ST-40C) as an international standard, rather than creating a new document.

European and international standards are reviewed on a regular basis to ensure that they take account of the latest scientific, technological, regulatory and market developments. The review process is a good opportunity to decide whether the topic should be subject to an international or European standard.

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