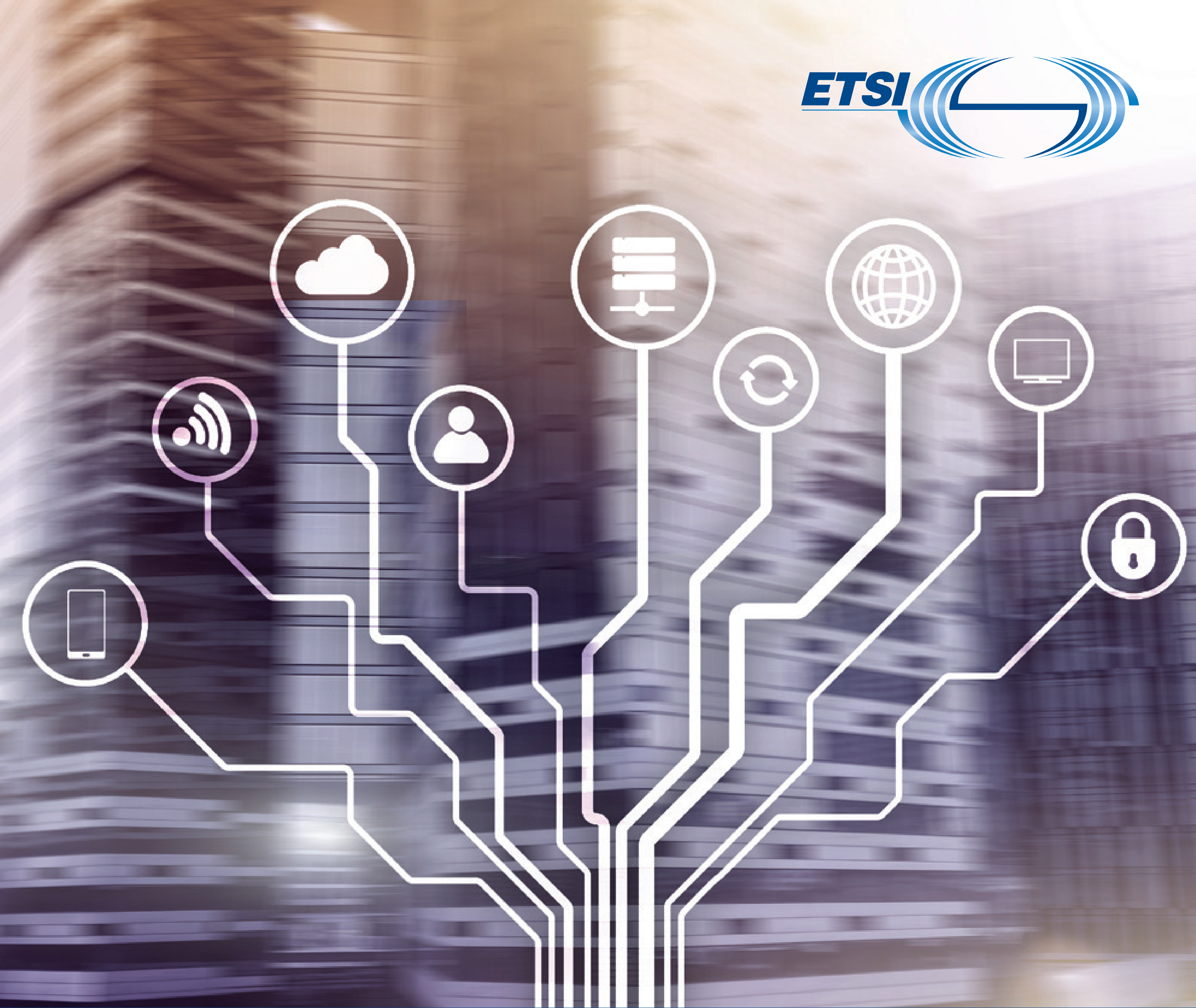

UNDERSTANDING ICT STANDARDIZATION: PRINCIPLES AND PRACTICE

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Association à but non lucratif enregistrée à la Sous-Préfecture de Grasse (06) N° W06100487

ISBN: 978-2-7437-3602-6 (PDF version)

PREFACE

With the support of the European Commission, ETSI has run a project to develop teaching materials to facilitate education on ICT (Information and Communication Technology) standardization, and to raise the knowledge level of ICT standardization-related topics among lecturers and students, in particular in the fields of engineering, business administration and law, in higher education. For this purpose, ETSI recruited a group of experts from different sectors, including standards organizations, academia and consulting companies. All of the experts have been actively involved in current standardization production and/or research, within the area of ICT.

To advance education about ICT standardization, the attractiveness of the topic among lecturers and students should be improved. Comprehensive and up-to-date teaching materials constitute a major way to convey the value and raise awareness of standardization. To provide high value for teachers and students, our main objective was to create a textbook and accompanying teaching/learning materials for standardization education that are tailored to the requirements and challenges of the ICT sector.

This project started by identifying best practices in education about standardization of ICT, the learning objectives and most appropriate teaching methods and tools. For this reason, the group of experts, who co-authored this textbook, carried out an intensive desktop research, and more than 25 interviews with leading international experts in standards education. The analysis of the information generated led to the design of the textbook structure and the accompanying learning material, including slides, visualizations, quizzes and case studies.

Readers of this book are not required to have any previous knowledge about standardization. They are introduced firstly to the key concepts of standards and standardization, different elements of the ecosystem and how they interact, as well as the procedures required for the production of standardization documents. Then, readers are taken to the next level by addressing aspects related to standardization such as innovation, strategy, business, and economics.

The contents of the book can be read in different ways. It can be read from cover to cover in a linear way, or readers may only focus on the specific chapters they are interested in. This is supported by the modular structure of the textbook, making the single chapters self-contained units that can be studied independently of other chapters. Each chapter begins with a list of learning objectives and key messages about what they will be learning in that particular chapter. For lecturers, this could be regarded as "meta-contents" to help decide which chapter of the book suits better the module or topic they are teaching.

The teaching resources comprise this textbook, which conveys the main theoretical knowledge. The text is enriched with examples from real standardization practice to illustrate the key theoretical concepts. Furthermore, the book includes case studies, where the 'case' can be a standardization document, an event or action, or a company that implemented a particular practice that is related to standardization. Each case study is intended to make readers reflect on a subset of the book's learning objectives and messages, and it could be potentially used by lecturers as a building block for further learning activities more tailored to their particular teaching needs. Case studies also enable students to better see the application of the concepts learned and allow a classroom environment that promotes group discussion and interaction among students. Finally, each chapter includes a quiz to be used as a self-assessment learning activity.

Furthermore, each book chapter includes a glossary and list of abbreviations, which are useful in any learning context and indispensable in order to better understand and recall standardization knowledge. Finally, chapters have their corresponding summary and references.

Alongside the textbook, the project has produced a set of slides that are intended to serve as complementary teaching materials in face-to-face teaching sessions.

In addition to its use in undergraduate and Masters courses, the book consists of advanced topics that can serve as a starting point for graduates and PhD students interested in standardization research. The book also serves as guide or a checklist for experts already active in standardization activities by providing them with arguments for the justification and improvements of standards activities from a management point of view.

This book has been intended to reach all potentially interested readers, including those with disabilities. Hence, ETSI, the authors, and the publisher have committed themselves to ensure the accessibility of the book and its contents. For all interested parties there is also an electronic version of the textbook as well as the accompanying slides that can be downloaded for free from the ETSI website (www.etsi.org).

With the hope that all readers enjoy the learning process by using the textbook and the teaching materials, ETSI and the group of authors would welcome any comments and feedback that aims at improving the current materials. In addition, the authors would like to thank all contributors to this piece of work.

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FOREWORD

Step into any ETSI committee meeting, and you will encounter individuals with a wealth of professional experience, both in their technical areas, and in standardization processes. They acquired their technical knowledge through education, training and life-long learning. But where did they get their standardization skills? It is unlikely they received much formal education or training in standardization, beyond attending short courses run by standardization bodies, such as our ETSI Seminar.

However, standardization is not merely a technical subject. Standardization has become a key business process in the ICT industry. In our industry we talk of networked innovation and platform technologies. Software is modular and increasingly open source, while common components are found in many disparate products. Furthermore, companies make extensive use of patent protection for their innovations. In this environment, the path to commercial success for ICT products and services is often through standardization. Standardization enables common components, provides the platform technologies, unlocks a global market with all the attendant economies of scale. Standards essential patents may also release the value in protected innovations. This business-oriented view of the importance of standardization is not widely recognized, and hence it is often missing from our business and legal education.

To try to remedy this situation and prepare a new generation of standards professionals, ETSI, with the support of the European Commission and the EFTA Secretariat, has commissioned the development of teaching materials for a comprehensive education course on ICT standardization. This material could be used in a standards-focused module in engineering and scientific education. Parts of it could also be used in business and legal education. It could also be integrated into in-company training courses. The material, a textbook and a comprehensive set of slides, will be available from the ETSI website free of charge, and is designed to be adapted by lecturers and teachers according to their specific needs.

The teaching material has been developed by a team composed of researchers, lecturers and standards professionals. Indeed, some team members fulfil all three roles. This work expresses their independent professional opinion and does not form an official ETSI teaching on the subject of standardization. This teaching material is being trialled in universities and we expect its usage to grow. Please provide us with feedback as we plan to update it over the coming years. But mostly, I encourage you to use it, learn from it, teach others and share your knowledge of this important aspect of our ICT industry.

Luis Jorge Romero
Director General
ETSI

1 INTRODUCTION

Standards support our everyday life much more than we may think. Actually, we owe much of the progress in our modern life to standardization. Without standards, our life would not be as organized as it is today. We would have difficulties in doing basic things that we now take for granted. Imagine if the times or the track width of trains were not standardized, or imagine if we were not able to use our mobile devices once we are out of the reach of our operators' networks, for instance abroad.

Thousands of years ago, society recognized the importance of standardized measurements. Weight and distance, or length, cannot be measured without a common reference system agreed upon by people and institutions, in other words a system that is standardized. With technological progress, the need for standardization grows. The rapid progress in the area of information and communication technology (ICT) could not be achieved without the advances in standardization. Standardization and standards boost progress and create a basis, upon which technology can evolve.

Though important, ICT standardization and its methods remain a topic that is not easily accessible. It seems that this field is becoming increasingly limited to the expert and remains mysterious to the non-expert. So far, there is research published in the area, but there is no textbook that makes the topic easy to digest by the interested student. We believe that standardization, in particular in the area of ICT, deserves more attention. The principles of ICT standardization should be taught in class in order to convey essential knowledge to students about such an important field.

This textbook is an attempt to make ICT standardization accessible and understandable to students. It covers the essentials that are required to get a good overview of the field. The book is organized in chapters that are self-contained, although it would be advantageous to read the book from cover to cover.

The second chapter provides a high-level overview of the scope and process of standardization, while introducing the main subjects that are covered in detail in subsequent chapters. It is a synthesis of the basic concepts mainly expressed in a simple and example-based way.

In Chapter 3, readers are introduced to the key concepts that will guide them through the tricky landscape of standardization. In particular, they will learn about Standards Development Organizations (SDOs), and the mechanisms that support their cooperation and coordination.

Chapter 4 addresses several topics related to the development of high-quality formal standards. The process of producing standards is described in detail and illustrated with several examples. As standards are written by standardization experts, the chapter describes their roles in the standardization process as well as the technical and personal skills that enable them to carry out their daily tasks. Chapter 4 also describes the main activities and responsibilities of the standardization experts and how they interact with their peers, inside the standardization group and within their own organizations.

To be successful in a competitive marketplace, companies need to be innovative. They have to constantly look for new opportunities for innovation. Chapter 5 deals with the interdependencies between innovation and standardization. Whereas innovation is understood as the result of a creative process, standards rather represent stability and identification of common grounds. Those aspects are—at least at a first glance—not necessarily conducive to innovation. Standards are the result of many years of knowledge gathering and structuring. As such, standards represent an important source of codified knowledge. Although they are crucial to the company's success, many companies do not see the relationships between standards/standardization and innovation. Chapter 5 will, in particular, focus on the so-called innovation potentials in standardization, in other words the aspects that make standardization conducive to innovation.

Chapter 6 looks at participation in standardization from the perspective of an organization interested in getting involved, looking both at strategic and technical aspects. The chapter also deals with the operation of standardization efforts and organizations, including voting, and the impact of external influences. The chapter concludes with information regarding how to select standards and specifications for a given application.

Decisions related to Intellectual Property Rights (IPR) have a significant impact on a company's business success. Given a new technology, companies can choose from a menu of possible options: either go for patenting, do standardization, implement a mixed strategy or keep their technologies secret. To be successful in the market, companies have to make the right decisions in order to capture the value of their innovations: to patent, to standardize, or to pursue a mixed strategy? Chapter 7 tackles this issue by introducing a decision tree that helps an informed decision be made, once a new product or technology is created.

Chapter 8 provides an in-depth analysis of the economic contribution of standards. Standards are an important instrument in the diffusion of new technologies and technological know-how and contribute significantly to economic growth. Although our world is strongly reliant on standards, their real effects on the economy are less obvious. Like patents, standards are carriers of codified knowledge and can provide companies with state-of-the-art knowledge. This chapter also analyses the role of standards in public procurement. Governments use standards in the context of public procurement to improve transparency and guarantee a high quality of public services. Companies who are willing to apply for public tenders need to comply with the indicated standards. Thus, the government can indirectly encourage the adoption of standards by companies, and therefore support the innovative strength and technological progress of a nation.

2 INTRODUCTION TO STANDARDS

This chapter aims to provide a high-level overview of the scope and process of standardization, while at the same time introducing the main subjects that will be covered in greater depth and detail in the following chapters.

It is an initial introduction to the basic concepts of the book by using examples. The chapter can also be used standalone for providing the fundamental knowledge on standardization to a general audience.

This chapter has the following objectives:

a) to identify what standards are, what they are not, and how they impact everyday life;

b) to explain what benefits standards bring and what undesired drawbacks they may imply;

c) to introduce the complex international standardization landscape, where multiple organizations operate and collaborate to create standards;

d) to briefly explain the structure of the standards development process;

e) to provide hints about the use of standards; i.e., how to select relevant standards and how to go through standards documents.

LEARNING OBJECTIVES

- Students should grasp how standards—generally defined as "widely agreed ways of doing things"—are needed to guarantee the interoperability of "things", which is essential to the functioning of our technological world;
- Students should understand the role of Standards Development Organizations and how their structured approach to standards development benefits innovation, trade and society; they should also realize that ill-conceived usage of standards and the standards development process has its drawbacks;
- Students should get a glimpse of major SDOs active in the ICT sector;
- Students should understand the main basic concepts of the SDOs' processes and the characteristics of the main deliverables.

2.1 BASICS OF STANDARDIZATION

2.1.1 INTRODUCTION

The online Cambridge dictionary provides the following definitions for the term "standard": "a pattern or model that is generally accepted" (example, "This program is an industry standard for computers") and "a level of quality" (example, "This piece of work is below standard/is not up to standard."). As we will see in the next part of this chapter, both definitions may apply to the specific purpose of our work.

DEFINITION

For the time being, we will primarily stick to the first definition, which, in an even more general and informal way, can be expressed as such: a "standard" is "a widely agreed way of doing something". Depending on the specific area of application, "doing something" may be replaced by, for example, "designing a product", "building a process", "implementing a procedure", or "delivering a service".

Clearly, "standard", i.e., "largely agreed and common" ways of doing things provide many benefits; our technological world simply would not work, or, at least, it would be harder and more uncomfortable to make it work without "standards". In fact, let us think about how we, computer users, would be in difficulty if each computer maker used a different way of arranging keys on a keyboard, or if each producer of computer peripherals used its own specific connectors or, even, its own protocol[1] (Figure 2.1). On the one hand, we, as users, would be confined to choosing from a restricted selection of compatible devices and, on the other hand, computer and peripheral makers would be forced to pre-select, by design, the counterparts they want to interoperate with.

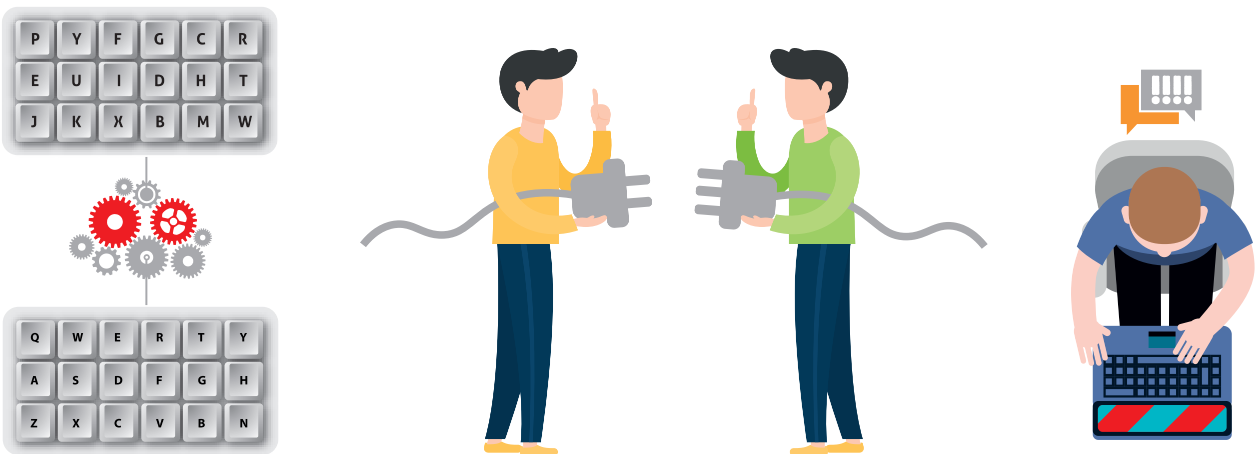

Figure 2.1: *Technologies would not work without standards.*

1 *Here, "protocol" means the set of messages that two devices (in this case, a PC and a connected peripheral) need to exchange to interoperate. The protocol defines the messages to be exchanged to perform a certain action (for instance, to send a document from a PC to a printer), their logical content and format, as well as their sequence.*

Looking at the examples above, which, as described in Section 2.1.2, could be extended to a wide variety of other fields, it is evident how a common and agreed "way of doing things" is largely beneficial to all players in a business sector.

Such convergence towards common and agreed-upon solutions can happen with two different processes, which can be a first criterion to classify "standards". Indeed, we may distinguish between two main different types of standards, according to the way they are born: "de facto standards" and "formal standards".

A "de facto standard", also known as "standard in actuality", arises when a winning solution is widely and independently adopted by different industries within a market segment and products developed on such a basis are widely accepted by customers.

EXAMPLE

Some examples of "de facto standards" are:

- The most widely used keyboard layout (QWERTY) dates back to 1864, when it was patented by Christopher Sholes. The later Dvorak version (1936, by August Dvorak) was intended to increase typing speed, but owing to the already consolidated position of QWERTY, was not as successful (though natively supported by most modern operating systems).
- HD DVD (High Definition Digital Versatile Disc) and Blu-ray Disc are two digital optical formats for new-generation DVDs suitable for high-definition content.

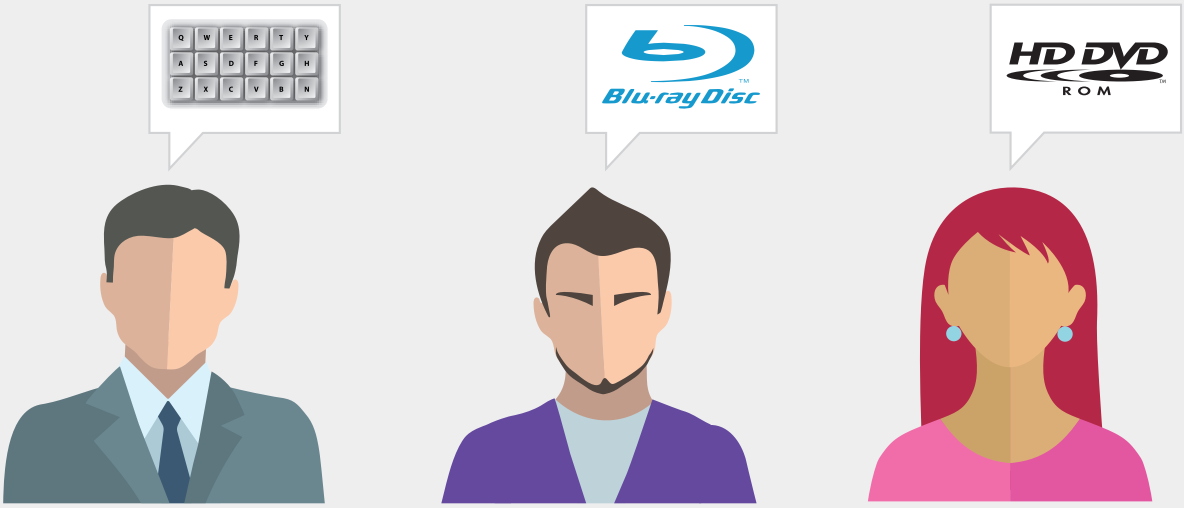

***Figure 2.2**: De facto standard*

Differing from "de facto standards", "formal standards" are produced by Standards Development Organizations (SDOs).

SDOs are organizations whose statutory purpose is to develop standards and that put in place formal well-defined procedures to guarantee a fair development process.

Figure 2.3 shows just a few examples of SDOs, which include, for instance, ISO (International Organization for Standardization), IEC (International Electrotechnical Commission), ETSI (European Telecommunications Standards Institute), and ITU (International Telecommunication Union). More examples of SDOs and a description of their objectives and operations are provided in Section 2.1.3 and later sections.

Figure 2.3: *Examples of SDOs*

De facto standards can become formal standards, if and when they are published by a SDO. Examples of these standards are HTML (HyperText Markup Language), developed in the early '90s by Tim Berners-Lee at CERN in Geneva, Switzerland, and constantly maintained by the World Wide Web Consortium (W3C), and PDF (Portable Document Format), created by Adobe Systems in 1993 and later formally standardized by ISO (ISO 32000, ISO 19005-1:2005).

2.1.2 STANDARDS IN EVERYDAY LIFE

Formal and de facto standards affect our everyday life, as many technologies, products and services are based on established standards. Later in this section, we provide a few remarkable examples that highlight the strong link between our everyday life and standards. We also quote some of the most prominent SDOs. Note, however, that more detailed information about these organizations' scope and history can be found in Section 2.3 and in Chapter 3.

EXAMPLE

Example 1 – Smartphone browsing.

One of the actions that we do most frequently today is surf the Internet, especially by making use of mobile devices such as smartphones. Figure 2.4 highlights some of the technological components that enable a smartphone user to browse the Web in the same way as through a wired desktop computer. If we look at the number of different devices (such as smartphones, mobile and wireless network equipment, and servers) and software modules (communication protocols, browsers, and web server applications) involved that have to interoperate to support this familiar scenario, despite being produced by different vendors, the importance of a shared and interoperable technical approach is clear. In fact, as shown in Figure 2.4, there are many formal standards that provide the basic reference design rules for the implementation of the main components that populate this scenario. Some of these standards are related to the user equipment regarding its hardware characteristics, also taking into account safety issues. Other standards cover connectivity among user devices and mobile and wireless networks as well as the overall functionality of the same networks. Lastly, a number of other standards are related to the functionality of the Internet and the protocols to support web browsing.

Smartphone producers can refer to ETSI and CEN-CENELEC standards for radio and telecommunication terminal equipment, which set essential requirements for safety and health, electromagnetic compatibility and the efficient use of the radio spectrum.

As far as mobile network interfaces and functionality are concerned, smartphone makers and mobile network equipment makers and operators will likely refer to the 3rd Generation Partnership Project (3GPP), which constitutes the leading organization for the development of globally accepted solutions. 3GPP is the SDO that defined the widely popular "third generation" UMTS and "fourth generation" LTE protocols to support data exchange over a mobile network. Similarly, to support data connectivity through wireless area networks, smartphone makers and equipment makers can refer to the widely used Wi-Fi and Bluetooth technologies, which are standardized by the IEEE and the Bluetooth Special Interest Group (SIG), respectively.

Compatibility and interworking issues are particularly challenging in the Internet environment, where a complex infrastructure needs to support information exchange among a wide range of heterogeneous devices and software applications. For this reason, despite the continuously evolving nature of Internet technologies, there is a need to establish common rules that ensure interoperability[2].

The main contributor to the definition of standard solutions for the operation of the Internet is the IETF, whose self-imposed mission (IETF, 2018) is "to make the Internet work better by producing high quality, relevant technical documents that influence the way people design, use, and manage the Internet".

IETF standards cover the basic functionality of the Internet, including, among others, node addressing[3] and naming[4], data traffic routing[5], traffic management[6], and network security. Major IETF contributions include Internet Protocol "version 4" and "version 6" (IPv4 and IPv6), OSPF (Open Shortest Path First) and BGP (Border Gateway Protocol) routing protocols, and the IPsec (IP Security Architecture). As a complement to IETF standards, the World Wide Web Consortium (W3C), defines protocols for web functionality; W3C develops standards for languages widely used to build web pages, such as HTML (HyperText Markup Language) and XML (eXtensible Markup Language), which foster the interoperability of different platforms on the Internet.

Lastly, always with the aim of ensuring interoperability, standard activities also apply to tools for developing web content and applications. One notable example is ECMA and ISO collaboration to develop a standard scripting language that is the base for the popular JavaScript technology, used to build interactive web pages and provide online software applications.

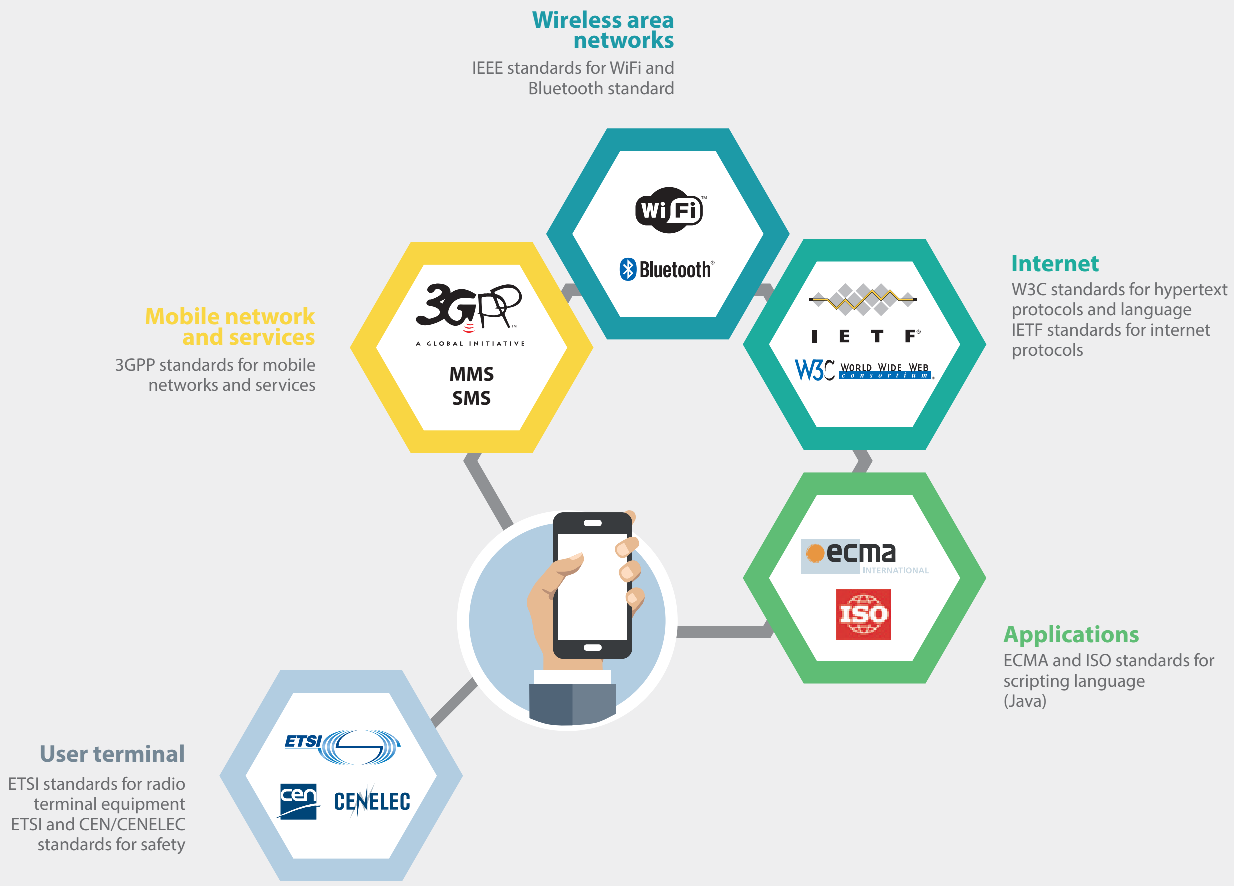

Figure 2.4*: Standardization enabling smartphone web browsing.*

2 *For our purposes, we can define "interoperability" as the ability of different devices or software applications to exchange data and use the information that has been exchanged. This implies that interoperable devices or software applications share common protocols (as defined in Section 2.1.1).*

3 *To give an example, we can say that each Internet device (such as a desktop or laptop computer, server, scanner, printer, modem, router, smartphone, tablet or smart TV) is assigned an address (called an IP address) that uniquely identifies the device within its network. Every message transmitted over an internet network contains a "source IP address" (i.e. the IP address of the device that generated the message) and a "destination IP address" (i.e. the address of the destination device) and the network infrastructure is responsible for getting the message from its source to its destination.*

4 *An Internet device can be assigned a device Internet name (such as www.etsi.org), which uniquely identifies the device within its network. The Internet infrastructure includes specific mechanisms for the name resolution service, i.e., to remap the device name into the relevant IP address. This mechanism lets us surf the Internet by using an easy-to-remember string instead of an alphanumeric IP address to identify our target device.*

5 *By routing we mean the set of mechanisms used within the Internet infrastructure to determine what path a message has to follow through the network to get to its final destination, identified by the "destination IP address".*

6 *Traffic management aims to optimize the performance of the Internet network. It may include provisions to classify and prioritize traffic, so as to guarantee that the portion of traffic that belongs to a certain class complies with determined performances (for instance, having a fixed maximum network transit delay).*

Example 2 – Using a Personal Computer.

Unlike the example described above, a stand-alone PC appears to be a relatively "simple" and self-contained object that each manufacturer could build using its own proprietary technology. Yet, in this case as well, a design approach based on common standards has many benefits. It allows basic components from different providers to be used interchangeably, to simplify connectivity with external peripherals and networks, and to guarantee its users a safe and environmentally compatible product. As a matter of fact, a 2010 paper (Biddle & al., 2010) identifies 251 technical interoperability standards implemented in a laptop computer, and estimates an actual total number (including aspects of quality, safety, performance, measurement, environment, accessibility, design process, manufacturing process and electromagnetic compatibility) that might well be over 500. Out of the 251 identified standards, "202 (80%) were developed by SDOs and 49 (20%) by individual companies" (Biddle & al., 2010). Figure 2.5 shows only a few of the standards that may be involved. They include JEDEC for building hardware components; INCITS and VESA's standards for memory, storage and display components; and PCI to interconnect heterogeneous cards; mechanical, physical, and software interfaces to plug and connect peripherals and networks, such as IEEE's Wi-Fi and Ethernet; the IETF's protocol stack; HDMI for audio/video peripherals and USB for a wide range of devices; and basic software tools such as compilers for ISO C/C++ programming languages. This gives an idea of the complexity of the standardization environment in a product that has become part of everyday life. Most likely, however, with the advancement oftechnology in recent years, the figures presented may have significantly increased.

***Figure 2.5**: PC-related standards.*

Example 3– Switching on a light.

A simple action like switching on a light bulb actually involves a complex system to produce and dispatch electrical energy. Such a system is segmented into areas such as generation, high-voltage and long-distance transport/transmission of energy, and medium- and low-voltage distribution to end users, which belong to different administrative domains. For instance, the owners of the generators are usually different from the transmission line operators and distributors. All the listed players must interoperate to guarantee the balance of the whole system, in other words to balance energy demand and production, and must guarantee the availability of their own infrastructure, as whatever failure in the generation-transmission-distribution chain would cause a disruption of the service provided to clients. Furthermore, the clients themselves, who may also be small energy producers when they inject self-generated renewable energy into the network, may contribute to the stability of the whole system, by both limiting their energy intake from the network or injecting excess production into the network, according to the infrastructure actual needs.

Another critical aspect of energy infrastructures lies, of course, in safety and environmental issues. It is essential to ensure that the deployment and operation of both the generation-transmission-distribution infrastructure and the equipment on customer premises are not harmful to individuals and the environment.

The need to manage all the above-listed issues has made the electric ecosystem one of the most subject to standardization; standards cover many aspects, from the definition of architectures and protocols for system and service monitoring and management to the safety rules for installation of electrical supply and appliances in buildings (Figure 2.6). The main SDOs involved are IEC and CEN-CENELEC; with the latter specifically focusing on Europe.

Work to standardize the electricity system is nowadays even more fervent, as it needs to cope with the envisaged evolution towards the so-called Smart Electricity Grid. The Smart Grid consists, basically, of the widespread usage of Information and Communication Technology (ICT) for the implementation of new real-time automated control mechanisms to improve the reliability, efficiency and environmental sustainability of the electricity system. Such evolution, which requires a deep reconsideration of the design and operation of current and more traditional energy systems, has triggered various joint initiatives among SDOs traditionally involved in the electricity and ICT sectors; one of the most valuable examples, at European level, is constituted by the joint ETSI and CEN-CENELEC Smart Grid Coordination Group (CEN-CENELEC, 2018).

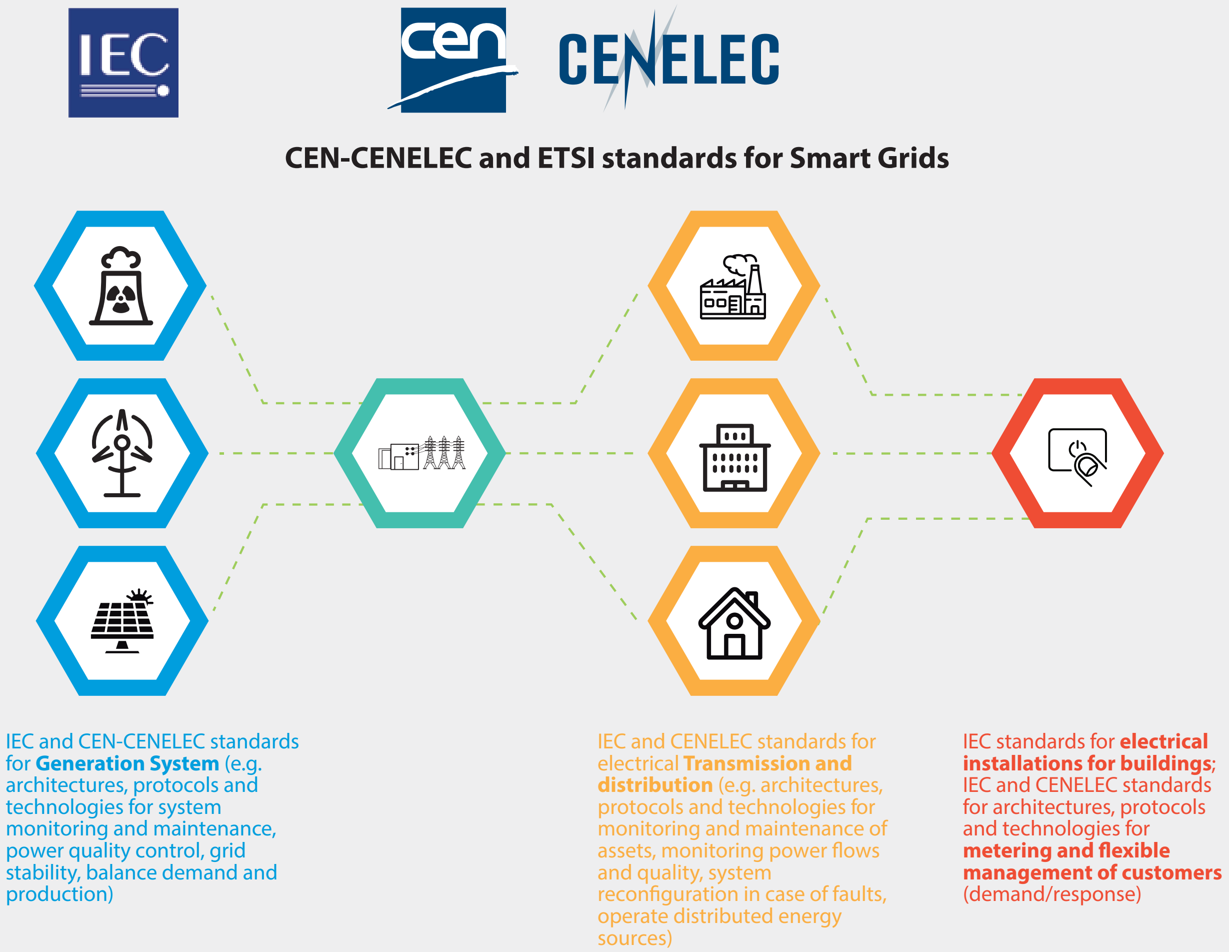

***Figure 2.6**: Power generation, transmission, distribution and utilization components.*

2.1.3 FORMAL STANDARDS

The focus of the next parts of this chapter is on "formal standards", with the aim of describing their main characteristics. Therefore, in the following and unless otherwise explicitly stated, when referring to "standards" we mean "formal standards".

DEFINITION

A standard defines requirements, specifications, guidelines or characteristics for a determined material, product, process or service. Standards are developed by SDOs, which involve selected stakeholders in the item to be standardized, such as manufacturers, providers, consumers and regulators, with possible contributions from academics and professional users. SDOs put in place procedures to guarantee a fair standards development process, which is aimed at building consensus among the stakeholders involved (Figure 2.7) and ensuring the quality of the final deliverables.

The two main concepts that we can identify in the preceding definition and that are worth noting to highlight the main characteristics of a "standard" are "consensus built" and "fair development process".

By "consensus built" we mean that standards are the products of negotiation among all involved (and relevant) stakeholders, aimed at establishing a general agreement and the absence of sustained opposition to substantial issues.

By "fair development process" we mean that the consensus building is regulated by procedures that aim to ensure that all involved parties are able to express their views and to reconcile any conflicting arguments. The process includes, for instance, provisions to publicize SDO internal body activities to stakeholders and to set up formal reviews and approvals for all deliverables.

***Figure 2.7**: Consensus reaching.*

Another main characteristic of "standards" is the fact that their adoption is on a "voluntary basis". This feature makes "standards" different from "regulations" (Figure 2.8). In fact, whereas conformity with standards is voluntary, regulations are compulsory. Regulations are defined by appointed authorities, which rule determined territories/markets. An item (product, service, process, etc.) that does not meet the requirements of regulations is not allowed to be sold or used on the territory/market where those regulations apply. On the contrary, non-compliance with standards does not restrict the distribution of an item "by law".

Although there is a distinction between "standards" and "regulations", they may sometimes be linked. In fact, regulatory authorities often (fully or partially) reference established standards in regulations, as this simplifies and accelerates regulatory work, leveraging the directions of established and widely agreed best practices defined in standards.

A third main characteristic of standards is their "limited focus". As a matter of fact, standards are aimed at defining a minimum set of requirements for an item (product, service, process, etc.) in order to make it meet certain well-defined objectives, for instance to guarantee a certain degree of interoperability or to define a minimum level of performance. Standards are not intended to be a set of thorough design rules that are aimed at constraining the development of an item (Figure 2.8); many "standard-compliant" implementations of the item are possible. In this respect, standards do not substitute the designer and should not limit (at least in principle) the designer's potential to create innovative contributions in the development of new products or services. They rather give a guide and some rules useful for assuring a minimum level of interoperability and quality to the final result.

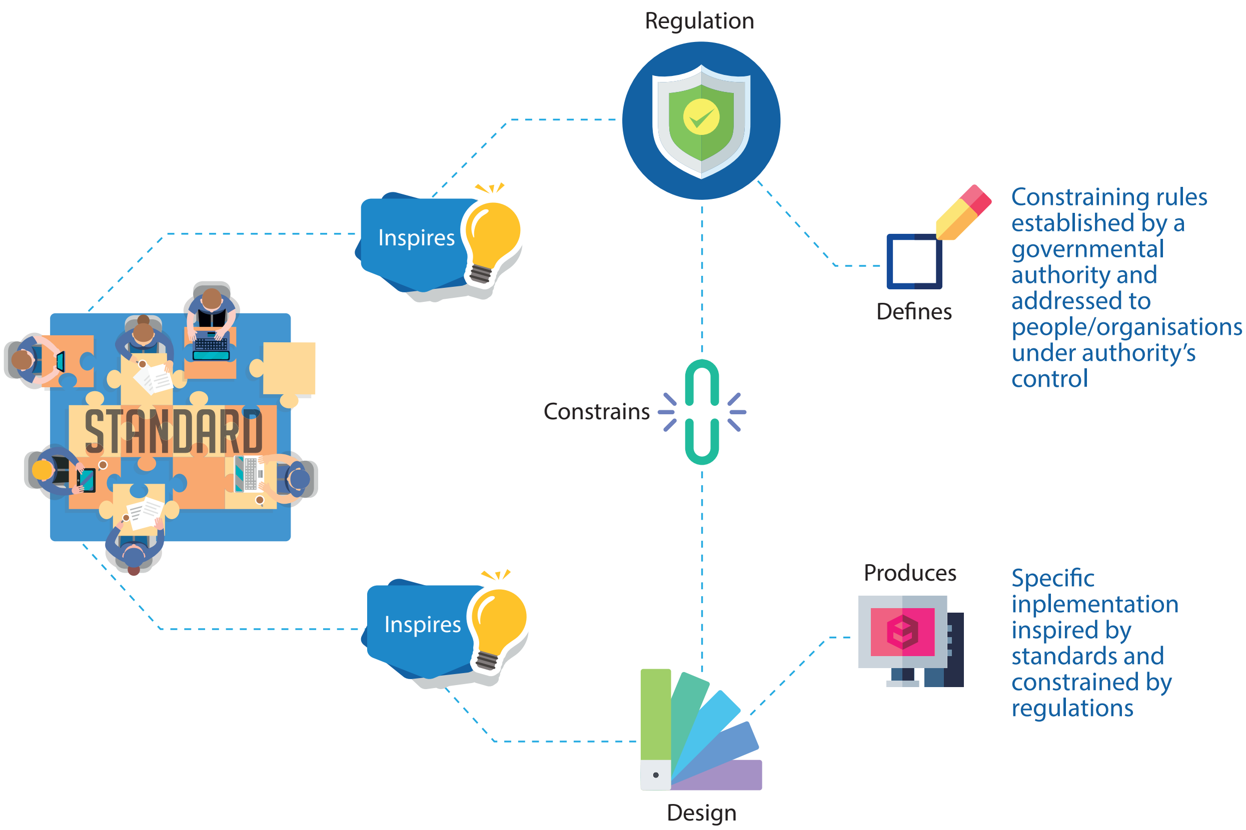

***Figure 2.8**: Standards and regulations*

2.2 BENEFITS AND RISKS OF STANDARDIZATION

2.2.1 BENEFITS

As a consensus-built set of rules/definitions for doing something, standards benefit sustainable innovation and the economy as a whole. Standards can be used in a large number of cases to meet a diverse range of needs. They can provide a common language for defining product, service, and process requirements. They can help identify reference performance indicators concerning the safety, environmental and technical characteristics of products, giving the opportunity to set (at least) a minimum reference level of acceptability. They can ensure the correct interworking of different parts of complex systems. They can define common test and measurement procedures, allowing a fair comparison of quality and performance among different products from different producers.

At a glance, we can identify three broad areas that can greatly benefit from standards: innovation, environment/safety and the economy.

Figure 2.9: *Standards benefit innovation*

Standards strongly benefit innovation by promoting the interoperability of products, services, and processes. A standard, by steering the activity of designers, gives producers the opportunity to:

- reduce development time: by setting basic product requirements, standards provide designers with valuable references that offer a set of consolidated solutions for many key issues;
- reduce design costs: by steering design activities, standards provide a shorter development time, with fewer design errors and consequent re-design;
- reduce risks: standards allow a product to be designed according to market-driven and largely accepted rules, for increased product success rate;

- improve quality: standards define already proven solutions that push up the potential quality of results;
- decrease time-to-market: this effect is a consequence of shorter development times and the assured level of conformance with market needs;
- open cross-border markets: interoperability guaranteed by standards ensures that products manufactured in one country can be sold and used in other locations;
- attract more customers: by giving them the tangible perception of reliable and effective products in an open and competitive market.

To summarize, the above positive effects of standards facilitate the uptake of innovation in the marketplace and concretely enhance the company's propensity to innovate.

***Figure 2.10**: Standards benefit the environment and safety*

Standards benefit the environment and safety by defining requirements, which become widespread in the industry and often referenced by normative regulations and labelling systems. In fact, standards have many positive effects:

- the process of making products more sustainable and safer becomes less expensive and faster if this process is supported by standards, which provide consolidated guidelines, within reach of a broader range of companies;
- the labelling that refers to standards/regulations can communicate the level of quality of the products/services in a common, unambiguous and understandable way, promoting company and product images with customers;
- standards typically facilitate the creation of regulations, which impose constraints for safety and sustainability.

EXAMPLE

One example, among many, which is worth mentioning in this respect, is the universal/common charger for mobile phones. Until the second decade of the 21st century there were no common rules about mobile phone chargers. Each producer—and sometimes each phone model—had a different power supply with a different connector. This situation resulted in a lot of waste, a number of inconveniences to the customer, including cost, difficulty in finding replacements, and unclear performance indications, especially concerning energy efficiency during use and especially when on standby (when chargers were plugged in, but not connected to the phone). In 2009, the ITU-T produced the L.1000 Recommendations (inspired by and harmonizing preceding ones from the GSM Association, the Chinese Ministry of Industry and Information Technology and the Korean Telecommunications Technology Association [TTA]), which specified the physical reference structure (in terms of connectors) and main electrical characteristics, including energy efficiency and safety, of the universal charging solution. Nowadays, most mobile phones (and often also other equivalent equipment in terms of energy requirements) use interchangeable power supplies, with real advantages for users (cost, performance, safety) and the environment (waste, pollution).

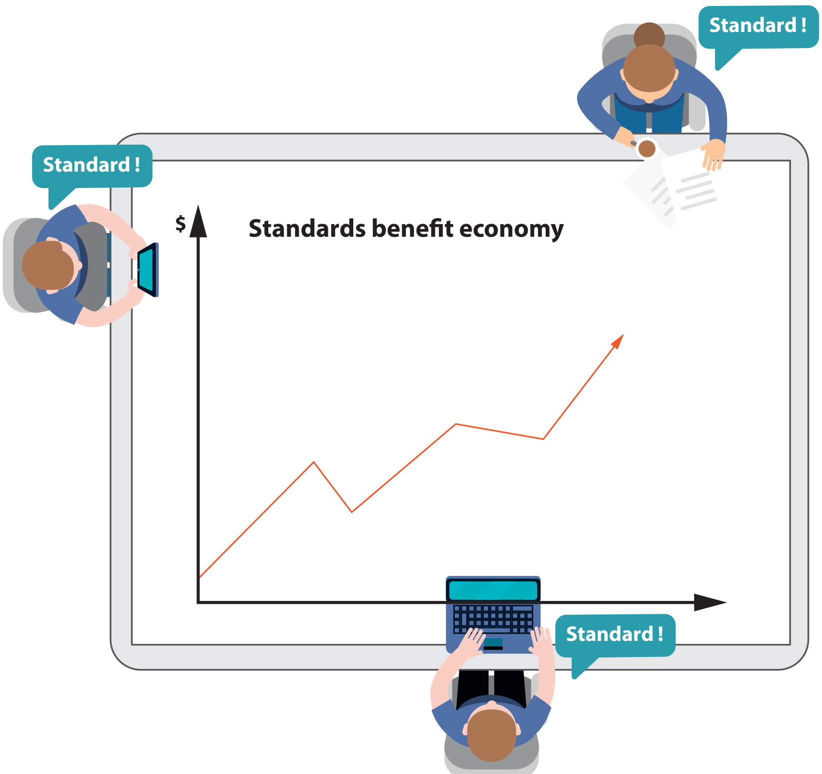

Figure 2.11: *Standards benefit the economy*

Standards benefit the economy by incentivizing investments, as standards ensure the stability of the technology over a reasonable period of time, enabling economies of scale, encouraging greater and fairer competition, and facilitating trade thanks to common approaches among countries.

In the majority of relevant technological contexts, the presence of a standard actively contributes to the consolidation of new technologies and to identifying evolution paths that are able to preserve past investments, which is a critical aspect, especially in a rapidly evolving sector such as ICT. These kinds of actions make investments more affordable and facilitate their quick return. Beyond their evident (although not always effective) effect against geographical and political barriers, standards can also significantly increase collaboration opportunities among the companies that came together to produce them. Moreover, they can tangibly contribute to opening up essential opportunities for small and innovative enterprises, mainly because of investment cost reduction, better revenue opportunities, but also, and possibly especially, thanks to better accessibility to some key (standardized) technology solutions that standards can very often guarantee.

The positive effects that standards have on innovation, the environment and the economy are reflected in benefits for both industries and society.

Standards benefit industries (especially newly established ones, as well as Small and Medium Enterprises), by driving and facilitating the development of new technologies, and by ensuring fair competition and potentially large market penetration.

As depicted in Figure 2.12, on the one hand, the positive effects of standards on innovation encourage the development of new advanced products/services, owing to reduced risks and investment and increased market opportunities. On the other hand, the growth in the safety and sustainability of products and production processes makes competition fairer, as a consequence of common and testable targets/ requirements (defined by standards) and the reduction of non-compliance risks (mainly for safety but also, in part, for sustainability). The benefits to the economy and business, with cost reductions, increased efficiency, and an enlargement of trade and potential markets, complete the picture, in which standards really can operate as an effective market booster, especially for new and innovative companies.

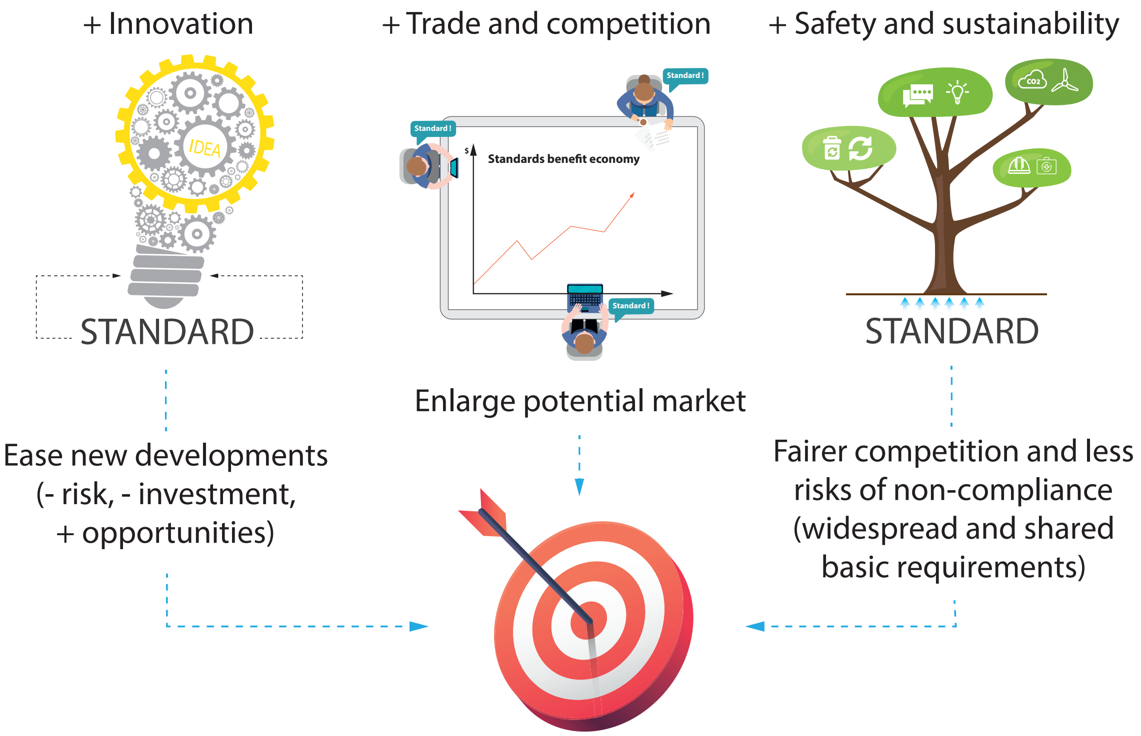

***Figure 2.12**: How standards can benefit industries.*

On the other hand, the general benefits that standards have on innovation, the economy and the environment are reflected in society too, i.e. among communities and individuals (Figure 2.13).

As depicted in Figure 2.13, by boosting innovation, standards help satisfy people's tangible and intangible needs, while contributing to improving their quality of life. Moreover, by fostering the sustainability and safety of products and production processes, standards contribute to enhancing people's health and safety as well. Finally, by favouring fair competition among industries and the reduction of final product costs, standards can enlarge customers' choice and ensure best "value for money".

As a final consideration, it is also important to note how standards can support regulations. Many countries reference standards in legislation to determine rules about the safety, quality or environmental compatibility of objects, services and procedures. This approach has many advantages for legislators. They are able to access the specific technical expertise and the resources of the standard makers and can take advantage of the higher (compared to laws and regulations) update frequency of the standards. The relationship between legislators and SDOs can also be explicit and formally stated as part of the creation of laws and requirements, with mandates for developing standard-supporting specific guidelines.

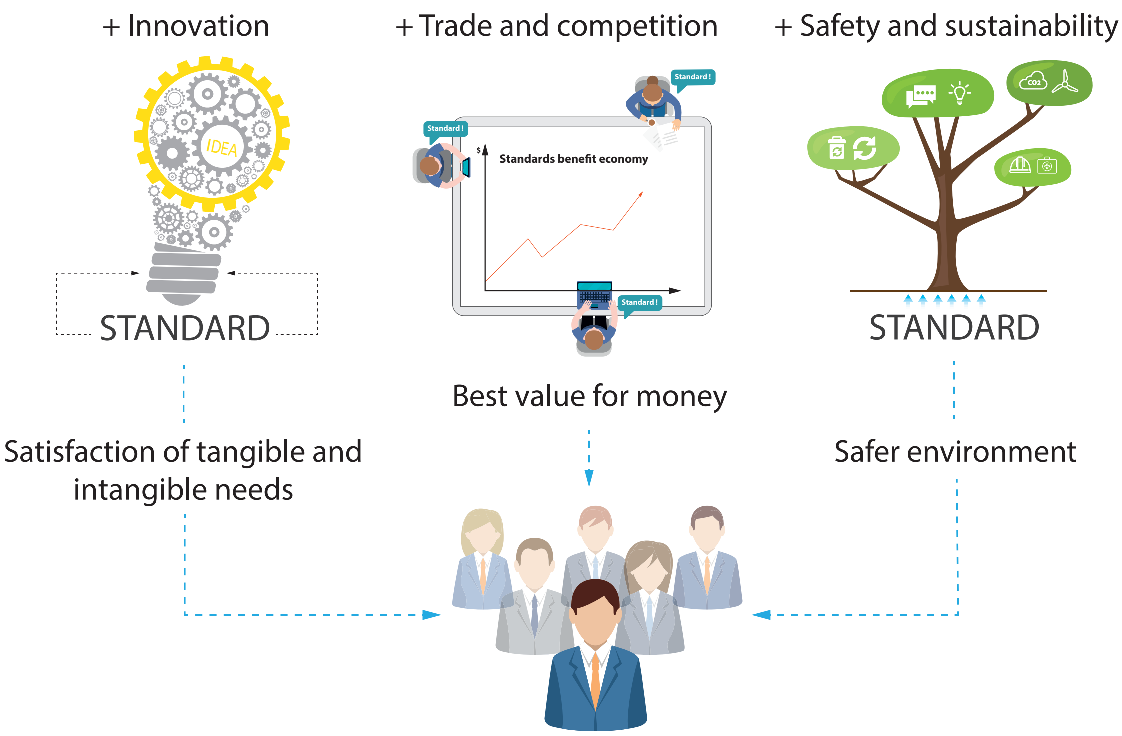

Figure 2.13: *How standards benefit society (for both individuals and groups).*

Figures 2.12 and 2.13 give an initial, but concrete view of the relevance and the positive effects of standards on both people and the market. Additional and more detailed information about this topic can be found in the next chapters and mainly in Chapters 5, 7 and 8 where relationships among standards, innovation, business and society are extensively discussed.

2.2.2 RISKS

Using standards may also imply some drawbacks and risks. In the following paragraphs, some of the most well known risks and drawbacks are listed and briefly discussed; moreover, we also present some indications about how SDOs tackle them to reduce their potentially negative occurrence in different contexts.

Figure 2.14*: Standards and innovation*

Especially, but not only, in the scientific arena, there is often the feeling that standards can jeopardize innovation as, when established, they could limit or delay the introduction of new innovative (disruptive) solutions in the market. This drawback mainly comes from the consolidation effect that standards have in some contexts, especially in technology-oriented ones. In this condition, a standard makes access to the specific technology easier, but at the same time (if successful) also makes a solution a semi-obligatory choice (Figure 2.14), and more difficult to change or evolve. If this effect does not stop innovation completely, it may significantly slow down the innovative evolution. Furthermore, introducing innovation into standards (i.e. developing new standards based on innovative technologies) may be complex given the very nature of SDOs. As a matter of fact, the same procedures SDOs put in place to ensure the fairness of the standards development process and to get the largest consensus among stakeholders may require a long time to converge to the final solution.

This real adverse effect can be reduced or even eliminated if the creation of the standard, and particularly its evolution, is strictly related to and driven by the scientific and industrial research environment, which can actively contribute to evolving standards according to the most relevant technological innovation. This situation can already be found in many ICT contexts, which may also be market driven, such as Mobile Radio Networks, starting from 2G up to the future 5G, where standards are continuously evolving and innovation is not slowed down but, on the contrary, encouraged and boosted by standardization. In order to mitigate risk, SDOs usually actively involve academics and researchers in the development of standards. They also often establish and support open expert groups to explore innovation and generate new standardization initiatives, including the evolution of current ones.

Figure 2.15*: Influence of special interests on standards*

A second possible risk, often feared by both consumers and companies (especially SMEs) is the fact that standards might jeopardize fair competition among industries and countries, as SDOs may be politicized, or unduly influenced by "special interests".

In general, it is natural and unavoidable for all (or at least most) of the participants in the standard creation process, to try to uphold the interests of the organizations (companies, country, etc.) that they represent. To minimize this risk, the main actions that SDOs put in place are, on the one hand, to enlarge the participation in the standardization processes to include the maximum number of eligible and competent contributors and, on the other hand, to set and apply fair and transparent rules in managing the standards development processes. Enlarging the participation in standards is a key point to guarantee fairness. Those who do not participate cannot protect their interests. Indeed, this can easily apply to small companies. However, they have the possibility to organize themselves in groups and be represented in the standardization arena without excessive investment. A second aspect to be considered is related to the right balance between effectiveness and fairness. In fact, a large number of participants in a standard might make consensus more difficult and time consuming, increasing the standard's time-to-market and causing possible failures. In this respect, the role of SDOs is relevant in order to manage all these aspects in the right way and to drive the organization towards the right balance of fairness, technical excellence and timing.

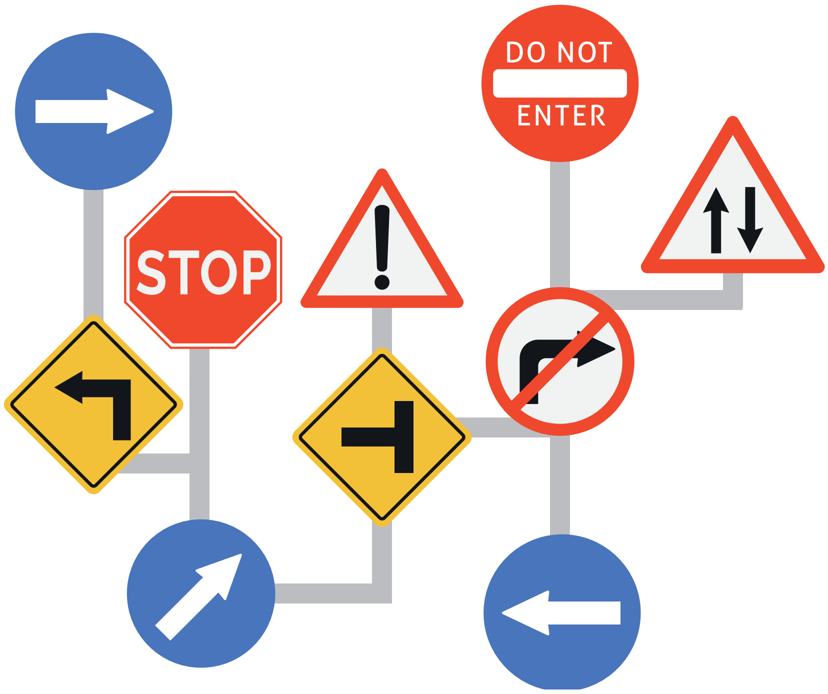

***Figure 2.16**: Influence of special interests on standards*

The importance of standards in modern times has led to the creation of a large number of SDOs, often (at least partially) overlapping in terms of interests and goals and which may even, in some cases, act as competitors. In this context, a diversified standardization landscape can lead to inconsistencies, as standards produced by different SDOs might cover the same topic or be partially overlapping, but offer different solutions. These situations may potentially lead to the production of inconsistent or, at the very least, redundant requirements that could strongly jeopardize the benefits of standardization. Additionally, an uncoordinated and uncontrolled proliferation of standards/SDOs can feed, at least in principle, the previous risk of "unfairness" because some SDOs could be "misused" to support local or specific interests. There are two main actions that aim to mitigate this possible negative behaviour. The first is by the users of and contributors to the standard, who need to carefully choose the most appropriate SDO. The second, this time by the SDOs, is to promote liaisons among SDOs and to increase collaboration and joint coordination actions.

The three issues presented and discussed are just some of the potential drawbacks of standardization. Other risks and drawbacks will be described in the following chapters of the book. However, if the above-mentioned risks are correctly and effectively managed, the negative effects of standardization will become negligible, and the positive effects will more than outweigh the negative ones.

2.3 STANDARDIZATION LANDSCAPE

A fundamental point for effectively dealing with standards and standardization is represented by the knowledge of the standardization landscape. A minimum level of understanding of at least the main SDO types, objectives and relevance is essential to be able to select the correct documents (if you are or want to be a user of standards) or to choose the suitable context to contribute to (if you are a potential contributor to standards). The key role played by this kind of knowledge is also amplified by the size of the ICT standardization landscape, considering that the number of SDOs active around the world is currently quite large and the relationships among them are often quite complex. In this section, we start by introducing a basic classification of SDOs and a general overview of the ICT standardization ecosystem with summary descriptions of some of the most relevant players in the field. A detailed and rather in-depth analysis of the standards world is reported in Chapter 3, where the reader can find a more comprehensive and detailed picture.

As a basic classification to approach the landscape here, we can consider three possible categories of SDO types:

- by geographical coverage;
- by type of affiliates;
- by technical scope of activities (as per each SDO's statute).

Considering that the selection/identification of a suitable SDO is very frequently related to the geographical location of the interests of the standard user/maker, the geographic "coverage" is the first and most simple type of classification. In this respect, we can distinguish three types of SDOs:

- International SDOs
- Regional SDOs
- National SDOs

DEFINITION

International SDOs have members worldwide, including representatives of National or Regional standard bodies, and their deliverables have worldwide coverage.

EXAMPLE

As main examples of this category in the ICT field (with some not only restricted to this field), we can cite (see Figure 2.17) the International Telecommunication Union (ITU), the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC).

***Figure 2.17**: The logos of the three reference international SDOs*

ITU (www.itu.int) was founded in Paris in 1865 as the International Telegraph Union. It took its present name in 1934, and in 1947 became a specialized agency of the United Nations. ITU is organized into three Sectors (http://www.itu.int/en/about/Pages/whatwedo.aspx): the Radiocommunication Sector (ITU-R), the Telecommunication Standardization Sector (ITU-T) and the Telecommunication Development Sector (ITU-D). Its headquarters are in Geneva (Switzerland), but it also has many area and regional offices distributed around the world. It includes state members, sector members, and associates from industry, international and regional standard organizations, as well as academia, who are organized in study groups. The ITU-T sector deals with the interoperability of ICT by covering all aspects of electronic design and test specifications. ITU-R coordinates the use of the global radio spectrum and satellite orbits, and ITU-D promotes fair and affordable access to telecommunications and helps stimulate social and economic development.

ISO (www.iso.org/home.html) is an independent, international non-governmental organization founded in 1946, when delegates from 25 countries met at the Institute of Civil Engineers in London and decided to create a new international organization "to facilitate the international coordination and unification of industrial standards". Today it brings together members from more than 160 countries and includes hundreds of technical committees and subcommittees in charge of developing standards. The ISO Central Secretariat is located (like ITU) in Geneva, Switzerland. National members are often represented by corresponding national SDOs. For example, the American National Standards Institute (ANSI) is the United States' ISO representative. ISO standards cover several market sectors such as ICT, healthcare, energy and automotive.

Founded in 1906, the **IEC** (www.iec.ch) prepares and publishes International Standards for all electrical, electronic and related technologies, collectively known as "electrotechnologies". It is based in Geneva like the ITU and ISO and has one local site in each continent. The IEC's members are National Committees, which appoint experts and delegates from industry, government bodies, associations and academia (http://www.iec.ch/dyn/www/f?p=103:5:0##ref=menu). Since 1987, most of the activities related to ICT are conducted jointly with ISO in Joint Technical Committee 1 (ISO/IEC JTC 1, http://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID:3387).

The three above-mentioned organizations have established a well-defined set of relationships and agreements and typically operate with quite a high level of coordination on the various topics, often with joint initiatives.

DEFINITION

Regional SDOs include members (industry, academia and national SDOs) from a set of countries that usually share, or are interested in promoting, common practices and regulations.

EXAMPLE

In this category, we can find, for example, the European Committee for Standardization (CEN) and the European Committee for Electrotechnology Standardization (CENELEC), the Pacific Area Standards Congress (PASC), and the African Regional Organization for Standardization (ARSO).

***Figure 2.18**: The logos of some international/regional SDOs*

Both CEN and CENELEC (www.cencenelec.eu) are organizations in charge of developing standards that set out specifications and procedures for a wide range of products and services in Europe. The members of CEN and CENELEC are the National Standards Bodies and National Electrotechnical Committees of all EU member states, plus associated nations (such as Iceland, Norway, Switzerland, and Turkey). European standards approved by CEN and CENELEC are accepted and recognized at least in all of these countries. CENELEC focuses on standardization in the electrotechnical engineering field, in close collaboration with the IEC and ETSI. CEN also works to remove trade barriers for European stakeholders, such as industry and service providers.

PASC (pascnet.org) was established in 1973 and includes most of the countries in the Pacific areas. Its main objectives are to strengthen ISO and IEC international standardization programmes and to improve the ability of Pacific Rim standards organizations to participate in these programmes effectively, to improve the quality and capacity of standardization in economies of the region and to support the improvement of economic efficiency and development through the promotion of standardization.

The African Organization for Standardization, formerly ARSO (www.arso-oran.org), was founded in the 1970s under the Organization of African Unity (OAU). The main goals of this organization are to harmonize national and/or sub-regional standards as African Standards, to initiate and coordinate the development of African Standards (ARS) with reference to products that are of particular interest to Africa, such as agriculture and food, civil engineering, chemistry and chemical engineering, and to encourage and facilitate the adoption of international standards by member bodies.

DEFINITION

Finally, at individual-country level, we find National SDOs (NSDOs), which issue country-specific standards and collaborate with International and Regional SDOs.

EXAMPLE

A large number of such entities have been set up. European NSDOs are listed on the CEN website (standards.cen.eu/dyn/www/f?p=CENWEB:5) (see, among others, the German Deutsches Institut für Normung [DIN], the French Association Française de Normalisation [AFNOR], and the Italian Ente Nazionale Italiano di Unificazione [UNI]).

Notable NSDOs from outside of Europe include the American National Standards Institute (ANSI, www.ansi.org), the Japanese Industrial Standard Committee (JISC, http://www.jisc.go.jp/eng/index.html) and China's Standardization Administration (SAC, http://www.sac.gov.cn/sacen/).

In addition to the classification for geographical relevance, SDOs can be also characterized with respect to the type of affiliation, i.e. by considering the type of members that they include and organize/represent. In this respect, we can identify:

- Standard initiatives,
- Professional organizations,
- Industrial fora.

DEFINITION

The standard initiatives are built by SDOs to coordinate standardization efforts on particular subjects.

EXAMPLE

Relevant examples in the ICT area include the 3rd Generation Partnership Project (3GPP) and oneM2M.

***Figure 2.19**: 3GPP logo*

3GPP (www.3gpp.org) brings together, in a partnership project, SDOs operating in the telecommunication field in countries and regions across the globe (Association of Radio Industries and Businesses [ARIB], Japan, Alliance for Telecommunications Industry Solutions [ATIS], USA, China Communications Standards Association [CCSA], ETSI, Telecommunications Standards Development Society [TSDSI], India, Telecommunications Technology Association [TTA], Korea, Telecommunication Technology Committee [TTC], Japan) and provides their members with a shared environment in which to produce the reports and specifications that define mobile radio technologies. 3GPP covers cellular telecommunications network technologies, including radio access, the core transport network, and service capabilities and hooks for non-radio access to the core network, and for interworking with Wi-Fi networks.

Figure 2.20: *OneM2M logo*

The purpose of oneM2M (www.onem2m.org) is to develop technical specifications, which address the need for a reference Machine-to-Machine Service Layer that can be embedded within various hardware and software. One of oneM2M's main goals is to actively involve organizations from M2M-related business domains, such as telematics and intelligent transportation, healthcare, utilities, industrial automation, smart homes, etc. The main SDO partners in this organization are the same as 3GPP with the addition of the Telecommunications Industry Association (TIA), USA.

DEFINITION

Professional organizations bring together independent professionals to promote best practices and innovation in specific areas.

EXAMPLE

Two relevant examples of this affiliate type come from the Americas: the Internet Engineering Task Force (IETF) and the Institute of Electrical and Electronics Engineers Standards Association (IEEE-SA).

Figure 2.21: *IETF logo*

Based in Reston, Virginia, the IETF (www.ietf.org) is the governing body of the Internet and has the support of other national and international standards bodies. The IETF defines the basic standard Internet operating protocols such as TCP/IP (Transmission Control Protocol/Internet Protocol), the reference communication language for the Internet. There are five main principles that underpin IETF work: (1) an open process, in other words any interested person can participate in the work, (2) technical competence, (3) volunteer core, (4) rough consensus, and (5) running code. The IETF operates as part of the Internet Society (ISOC), a non-profit organization founded in 1992 to provide leadership in Internet-related standards, education, access, and policy. Moreover, it is controlled by the Internet Architecture Board (IAB), which is both a committee of the IETF and an advisory body of the Internet Society.

Figure 2.22: *IEEE logo*

IEEE-SA (standards.ieee.org) is a primary SDO with a large number of active technical standards, ranging from wireless communications and digital health to cloud computing, power and energy, 3D video, electrical vehicle standards, and the Internet of Things. It was created by the Institute of Electrical and Electronics Engineers (IEEE), the American association of Electrical and Electronics Engineers. It brings together and organizes members from all over the world.

DEFINITION

Industrial Fora are primarily established by industries that coordinate their efforts on specific subjects to accelerate, complement or promote the development of a standard.

EXAMPLE

Examples in this category include: the Broadband Forum, the World Wide Web Consortium (W3C) and Zigbee Alliance.

Figure 2.23: *Broadband Forum logo*

The **Broadband Forum** (www.broadband-forum.org) is a non-profit industry consortium dedicated to engineering smarter and faster broadband networks. The main aim of this forum is to define best practices for global networks, enable new service and content delivery, establish technology migration strategies, and engineer critical device, service and development management tools in the home and business IP networking infrastructure.

***Figure 2.24**: W3C logo*

The **W3C** (www.w3.org) mission is to lead the World Wide Web to its full potential by developing protocols and guidelines that ensure the long-term growth of the Web. W3C is directed by Tim Berners-Lee, inventor of the World Wide Web.

***Figure 2.25**: Zigbee logo*

The **Zigbee Alliance** (www.zigbee.org), established in 2002, is an open, non-profit association of members coming from businesses, universities and government agencies. Its activities are focused on developing and promoting standards for low-power and open global wireless networks focused on monitoring, control and sensor applications, by also ensuring that quality Zigbee products are available for product manufacturers and their customers through a certified programme.

***Figure 2.26**: ECMA logo*

ECMA (European Computer Manufacturers' Association; https://www.ecma-international.org/) was founded in 1961 by major multinational computer hardware manufacturers present in Europe. Whilst the brand name has been kept, nowadays ECMA's membership has grown: it includes companies and academies from around the world. ECMA specifically focuses on standardization topics such as hardware, software, communications, consumer electronics, media, storage and environmental subjects. ECMA actively contributes to the work of other SDOs, by submitting its own standards to ISO, IEC and ETSI for approval and publication.

***Figure 2.27**: Bluetooth logo*

The Bluetooth Special Interest Group (https://www.bluetooth.com/) was established in 1998 by five founding companies. It currently has around 33,000 member companies. The Bluetooth SIG has standardized and is currently maintaining and improving the widespread namesake technology for connecting devices over a short–range wireless personal area network.

The third and last classification type relates to the SDO's technical scope of activities (according to each SDO's status), which is fundamental when searching for a standard for implementation. However, it can often be a complex task, considering the wide range of activities in which many entities are involved and the rather intricate relations among SDOs across different topics.

EXAMPLE

Table 2.1 provides the typical technical scopes of activity of some of the main SDOs. Moreover, a non-exhaustive overview of the Information and Communication Technology ecosystem, where International, Regional and National SDOs, Professional Organizations, and Industrial Consortia collaborate through liaisons and Global Initiatives, is represented in Figure 2.28.

ORGANIZATION	TYPICAL TECHNICAL SCOPE OF ACTIVITY
ITU-T	Interoperable telecom specifications including architecture, services, protocols, addressing/numbering plans.
ISO	ICT architecture (OSI model), services, protocols including application layer protocols.
IEC	Electrotechnical standards, incl. connectors, electrical safety and tests.
ETSI	Interoperable ICT specifications including architecture, services.
CEN	ICT architecture (OSI model) services, protocols incl. application protocols.
CENELEC	Electrotechnical standards, incl. connectors, electrical safety and tests, electromagnetic compatibility.
IEEE	All LAN specifications: IEEE 802.xx, including cabled LANs, Token Ring and Bus, Wireless LANs (WLAN), e.g. Wi-Fi.
IETF	All Internet-related specifications, including protocols, generic applications, addressing rules (IP, URL, etc.).
ECMA	Media specifications, ICT specifications fed into ETSI, ISO/IEC, IEEE, etc.

***Table 2.1**: SDOs and technical scope*

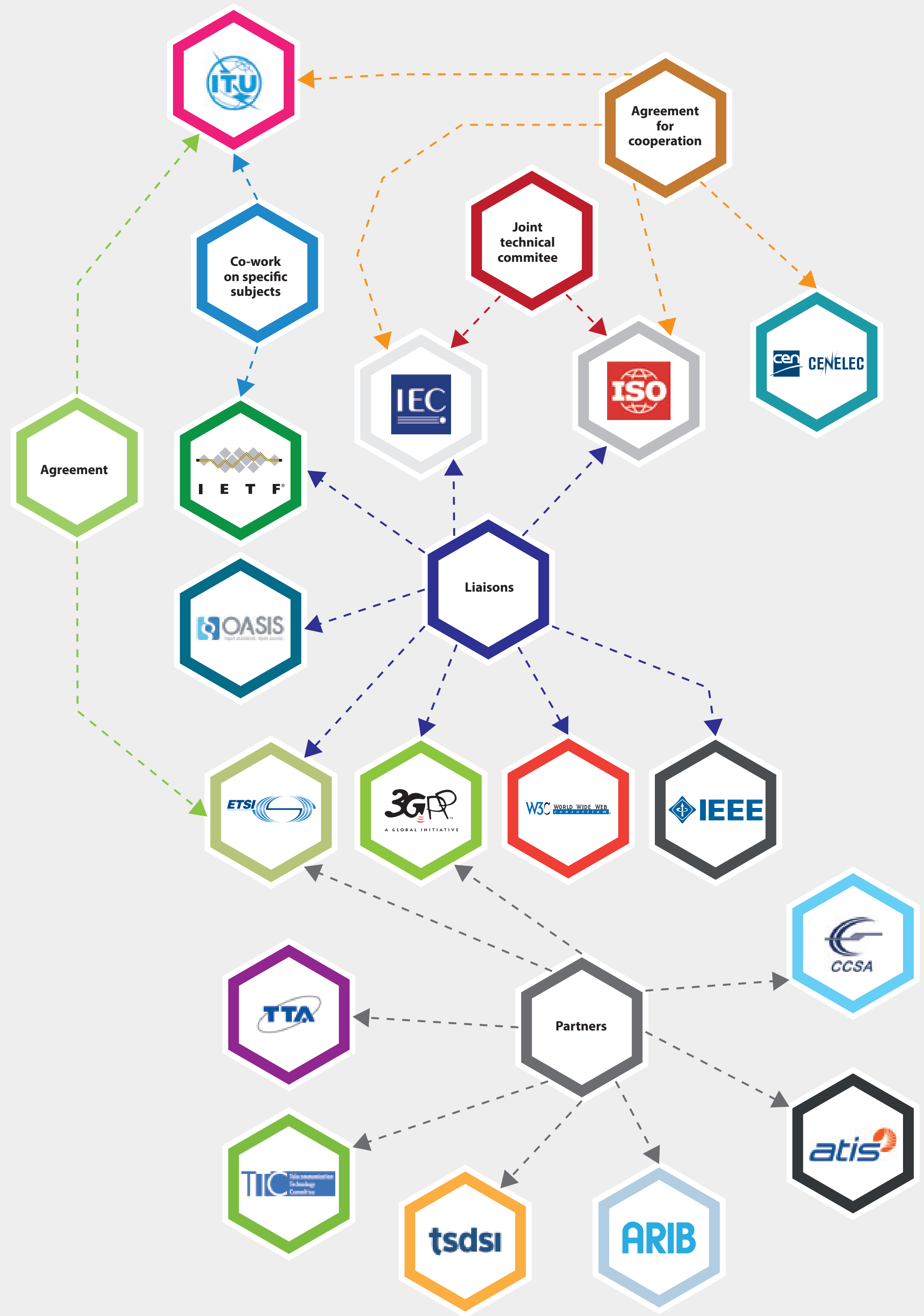

***Figure 2.28**: An overview of the ICT Standardization ecosystem*

2.4 THE STANDARDIZATION PROCESS AT A GLANCE

2.4.1 STANDARD–DEVELOPMENT PROCESS

Each SDO sets up its own specific internal organization and procedures to control the life cycle of standards documents. Yet some common features can be noted among various SDOs' procedures, which imply a shared understanding of best practices. A more detailed description of these procedures is presented in Chapter 3.

This chapter summarizes and describes the most basic steps of a generic standard life cycle management procedure (Figure 2.29)

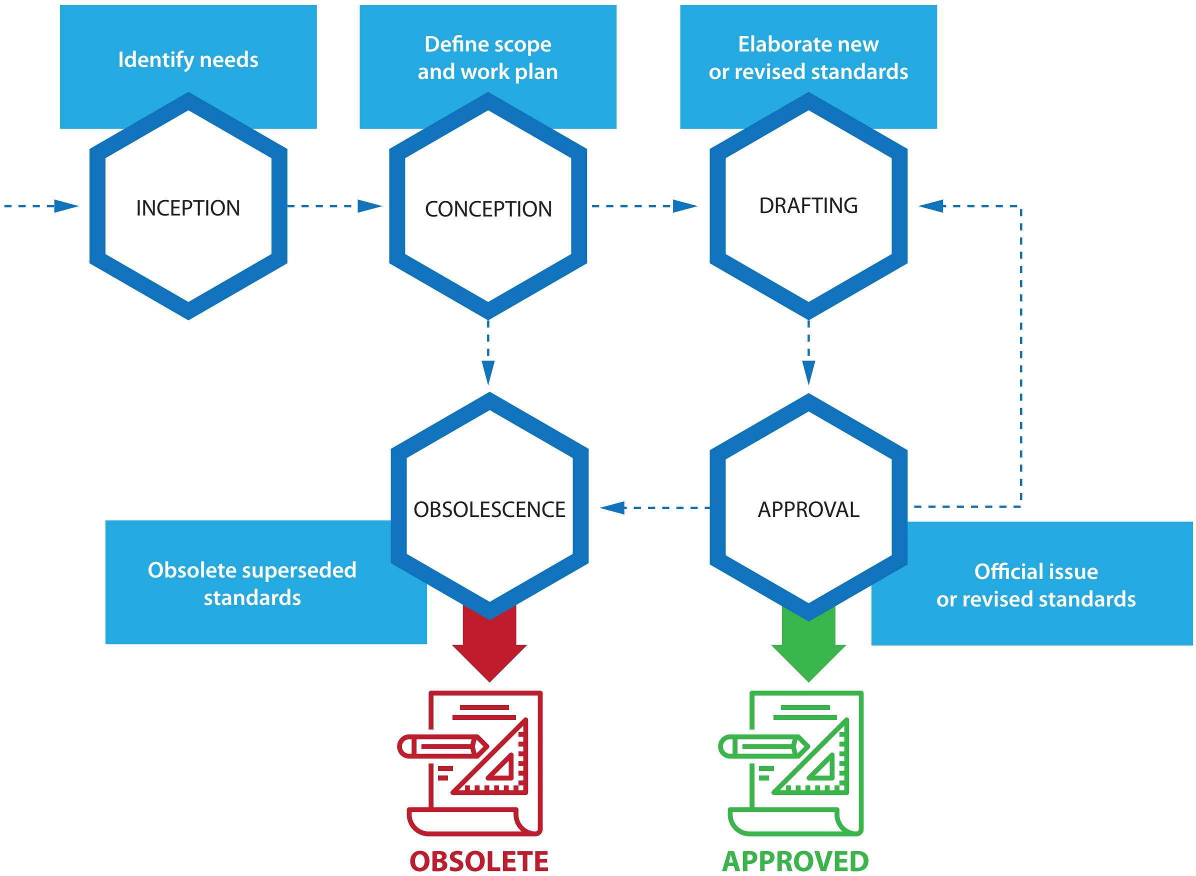

***Figure 2.29**: Standards life cycle*

Step 1 consists of the "Inception phase", which is related to the identification of the need for a new standard and the consequent initiation of the standardization work. New standardization work starts with the submission of a proposal to the SDO. The procedure for submitting a new standardization activity varies from one SDO to another and depends on the SDO's nature and internal organization (as described in Section 2.3).

EXAMPLE

For instance, in ITU-T, proposals for new standardization actions can only be submitted by ITU-T members, who represent ITU member states or associated organizations such as industries and academia. Members can address the request to the relevant Study Group (SG) (ITU-T, (c)), i.e. the internal ITU-T established body responsible for technical activities in the relevant area.

In the case of ETSI, the initiative can be taken by a single ETSI member (administrative bodies, NSOs, industries, research bodies and academia). Proposals can also come (ETSI, 2018 (b)) (ETSI, 2016) from components of established ETSI Technical Bodies (TB[7]), Special Committees (SC[8]) and Industry Specification Groups (ISG[9]) and, lastly, from government bodies such as the European Commission (EC) or the European Free Trade Association (EFTA). Proposals compliant with the mandate of an already established TB are first addressed to the relevant TB; other proposals with a broader impact, which suggest a new TB or could change TB scope, have to be submitted to the ETSI Board[10] or, if the proposal involves ETSI Partnership Projects (EPP7), to the ETSI General Assembly[10].

A further example worthy of note is the IETF, which relies on straightforward and non-bureaucratic internal processes. The IETF has no formal membership: there is no application form or fee and participation is reserved to individuals (legal entities, i.e. organizations of any kind, are not eligible as members), who can simply register for and attend IETF meetings. An individual can submit a proposal for an IETF specification by participating in the relevant IETF Working Group (WG), either by joining and contributing to the WG mailing list or by attending periodic WG meetings. As an alternative, an "Internet Draft" can be uploaded directly to the online IETF "Internet Drafts Directory" to make it available to the community for informal review and comments (IETF, (c)). To increase the effectiveness of the process, the IETF encourages members to organize unofficial "side meetings" (IETF, 2012), where "groups of interested individuals hold informal get-togethers to discuss and develop their ideas" (IETF, 2012), gather preliminary consensus and develop more stable proposals.

After the inception phase, the proposal for a new standardization action needs to have some form of formal approval from the involved SDO. Subsequently, the SDO needs to prepare a detailed plan for the actual work to be done, while defining how it is to be carried out within its own organization, the time schedule, the final target outcomes, and the allocation of relevant resources. This step (Step 2) is represented in Figure 2.29 by the "Conception" block.

The actual implementation of the Conception step largely varies depending on the internal organization of the involved SDO.

7 *ETSI includes three different types of Technical Body (TB): Technical Committees (TC), which are semi-permanent entities in charge of standardization activities relevant to a specific technology area; ETSI Projects (EP), which are similar to TCs, but are established on the basis of a market sector requirement rather than on a basic technology; ETSI Partnership Projects (EPP), which ETSI establishes with other organizations to achieve a defined standardization goal.*

8 *A Special Committee (SC) is a semi-permanent entity organized around a number of standardization activities addressing a specific technology area or related topic. Special Committees tend to handle coordination, requirement gathering, and very specific support activities rather than drafting standards and specifications.*

9 *An Industry Specification Group (ISG) is an association of industries that share ETSI membership or that have applied for membership; it corresponds to an industry forum built under the auspices of ETSI.*

10 *The GA is the highest decision-making body in ETSI and is composed of the representatives of all ETSI members. The GA delegates day-to-day management activities to the ETSI Board.*

11 *Working Groups are the primary mechanism for development of IETF specifications; they are created to address a specific problem or to produce one or more specific deliverables and are organized in areas; to date, there are seven areas (application and real time, general, Internet, operation and management, routing, security, transport) structured in more than 100 WGs.*

EXAMPLE

For instance, in ITU-T, the involved SG may approve the proposed action by consensus among participants and consequently associate it with an existing or new "study question" and assign the work to a specific Working Party (WP[12]) within the same SG. The team working on a certain "question" is known as the "rapporteur group", which is chaired by the relevant rapporteur. Considering the guidance from the SG, the team determines what recommendation documents and plans are required. The team also does the editing work.

In ETSI's case, if the proposal can be managed at TB level, the relevant TB can approve it by consensus and open a new dedicated Work Item (WI[13]) if at least 4 members commit to supporting the work. The new WI is publicized via the ETSI Website. Members that disagree with the item can oppose its adoption within a 30-day period. Otherwise, the WI is definitively adopted.

Once the new standard proposal has been accepted and the actual work is started, the relevant standardization documents enter a "drafting" phase (refer to Figure 2.29). This phase implies a lot of technical and editorial work that is carried out according to the specific body's internal workflow rules. Once the documents are considered mature and stable, they transit into an "approval" phase (see Figure 2.29) to be officially released. If the outcome of the approval process is negative, a document may transit more than once between the two phases.

EXAMPLE

For instance, in ITU-T, each SG develops its own work plan that includes periodic meetings, where the draft standards prepared by WPs are reviewed to track their development and assess their maturity (ITU-T, (c)). Once a document is considered mature, the SG/WP gives its consent for it to move to the "approval" phase. The approval procedure can follow one of two different paths (Fishman, 2012): the Traditional Approval Process (TAP) for standards having policy or regulatory implications, and the Alternative Approval Process (AAP) for all other standards. When AAP is chosen (ITU-T, (a)), the "consented" document is published on the ITU-T website and ITU-T members may review and comment on it. If only editorial comments are received within a four-week period, the document will be considered approved. If members submit substantive comments, the document is sent back to the SG, which sets up a "comment resolution process" to produce the definitive version of the document. TAP (Fishman, 2012) is a longer procedure (see the next chapter for descriptions) in which ITU-T member States play a decisive role.

At ETSI, standards development is carried out within relevant TBs and ISGs, which operate under the provisions of the ETSI directives (ETSI, 2018 (b)) and the guidance of the appointed Chairmen. The evolution of draft standards is regularly revised and tracked against the originally established Work Programme. Once a document is considered stable, it is submitted for approval from the relevant TB or ISG. The following approval steps depend on the type of the standard. As a matter of fact, ETSI may produce a range of different documents (ETSI, 2018 (c)) (ETSI, 2018 (b)), which may have different content and impact, as far as standard-related documentation is concerned.

12 *Each SG manages a set of "study questions" that correspond to various technical subjects within its area of responsibility. "Study questions" are assigned to WPs, which include the experts who edit standards documents.*

13 *A WI consists of a specific standardization task; it normally results in a single standard, report or other document.*

ETSI Standards (ES)[15] are approved by all ETSI members by means of the "Membership Approval Procedure". Following committee approval, the document is sent to the ETSI Secretariat, which distributes the document to ETSI members, who can approve or reject the document. European Standards (EN)[14] follow a more complex approval procedure that requires a "public enquiry", followed by a weighted vote reserved for national delegations. Technical Specifications (TS) and ETSI Group Specifications (GS)[15] are approved at committee level. After approval, TSs/GSs are issued to the ETSI Secretariat that will publish the standard.

At the IETF, document drafting is usually performed within WGs, with the strong involvement of WG chairs. WG chairs steer the drafting activities, moderate WG discussions, identify when the WG has reached enough consensus on a specific topic in order for editors to proceed by consolidating it in the draft (published in the online Internet draft directory), selecting meaningful contributions and discarding inappropriate content. Once the draft has reached a good maturity level, the WG recommends its Area Directors (Ads)[16] to proceed to approve it as a standard (IETF, 2013). The request is submitted to the IESG, which will notify the IETF community of the pending IESG consideration of the document to permit a final review by the whole community for a limited period of time. The notification is referred to as "Last-Call notification". It is sent by e-mail to the IETF Announce mailing list. Anyone can submit comments. After the received comments have been revised, the IESG makes its final determination of whether or not to approve the draft, and notifies the IETF community of its decision via an e-mail sent to the IETF Announce mailing list. If the draft is approved, the document is published in the RFC (Request For Comments[17]) directory and deleted from the Internet draft directory.

Once published, a standard is still to be considered a "living" document subject to maintenance and updating, which may be just editorial or even substantive. While editorial maintenance is usually managed as a routine activity within the working group that produced the standard, the introduction of major modifications that impact the content of the document requires the same steps to be followed as for the production of a brand new standard.

The final phase of a standard's life cycle corresponds to its withdrawal due to obsolescence. A standard withdrawal procedure is triggered following the assessment that new standards already developed or being developed are replacing one or more established standards. Once withdrawn, a standard is usually still retrievable in the SDO's repository, in order to keep track of normative evolution, although the standard itself is flagged as "no longer in force".

14 *The formal output for standardization at the European level; it is intended to meet needs specific to Europe and requires transposition into national standards, or it is produced under a mandate from EC or EFTA*

15 *ETSI Standard (ES), and ETSI Technical Specifications (TS) contain normative provisions on specific subjects; the difference between ESs and TSs lies in different approval rules; TS, which has a faster approval path, is preferred when there is a need to reduce the time to market (i.e., when the standard is considered urgent). ETSI Group Specification (GS), which may include normative or explanatory material, or both, are produced by ETSI Industry Specification Groups (ISGs). ETSI EN, ES, TS standards are produced by Technical Committees or ETSI Projects.*

16 *Each IETF Area is managed by one or two Area Directors.*

17 *This is the traditional term that refers to IETF standards.*

2.4.2 MAIN CHARACTERISTICS OF A STANDARD

As already explained, standards define some specific characteristics for a specific item (which may be, for instance, a material, a product, a procedure, a process or a service), in order to make such an item meet certain well-defined objectives (which may relate, for instance, to performance or interoperability). We have also seen that they do not aim to fully characterize the items they are dealing with, but just to accurately define the minimum set of characteristics to ensure the defined objectives are met.

SDOs take specific measures to make their standards effectively fit the above-listed scopes and objectives, which means ensuring that documents are clear, unambiguous and not unnecessarily over-prescriptive, and that they only stress the essential requirements for the compliance of the item they are addressing.

In order to ensure that standards have the above-listed characteristics, SDOs define their own guidelines and rules to steer the standards writing process.

Standards writing rules differ from one SDO to another. Yet, as a summary of the indications from various SDOs (refer, as examples, to ISO (ISO, 2016) and ETSI (ETSI, 2013) directions), we can identify some general characteristics that a well-written standard needs to have. In the following section, there is a brief description of such characteristics; further and more detailed examples are provided in Section 2.5.3.

Standards must be written while taking the users and the document objectives into account. The user is expected to have technical competence and expertise in the field the standard is related to. The document content should strictly focus on the essential according to the objectives of the standard. The focus on the defined objectives aims to prevent authors from indulging in adding details that, although they may add clarity to the subject and provide additional information to readers, could also produce unnecessary prescriptions.

As a result, standards usually contain little supporting general information about the subject they address (it is usually limited to a short introduction) and, as a consequence, they turn out to be very complicated to non-expert readers and have little instructional value (which they are not intended to have).

The objectives of the standard will be explicitly and clearly stated in the document. This statement provides readers with a concise summary of the subject and the area of application of the standard. Objectives will be put in the relevant context, by describing their rational and possible correlations with other related standards.

Standards must be clear and unambiguous. This implies that documents need to have a well-defined structure, to help readers retrieve relevant information. The language must be plain and sentences must be meaningful and as short and concise as possible. Usage of lists, tables, pictures and specialized notations (i.e. special formalisms to describe requirements) is strongly encouraged, as it adds clarity to the requirements. Though specialized notations may be obscure to newcomers, they are expected to be clear to target readers with the required expertise.

Standards must clearly distinguish among mandatory parts (which actually define the mandatory requirements for the relevant item to be considered compliant), simple guidelines (something the item is expected to comply with, but which is not mandatory), permissible characteristics (alternative provisions that the item may or may not comply with) and further limited additional parts included for information purposes. This can be achieved in different ways; for instance, by using specific and codified vocabulary, or by segregating content with different impacts in different document sections.

References to other standards have to be carefully organized, so that it is possible to distinguish normative references (i.e., other documents that are directly referenced within normative provisions in the main body of the standard) from informative references (that provide additional information for clarification purposes).

All requirements in a standard (be they requirements, recommendations or permitted characteristics) must be non-redundant and consistent among themselves and with the requirements quoted in the other related standards. Necessary and non-redundant mean that requirements must consist of the minimum set that fully specifies the characteristics of the standardized item according to the objectives of the standard. Consistency may sound like an obvious goal, yet guaranteeing consistency among a (possibly large) set of different standards requires great competence and commitment from the authors. At the same time, when the item to be standardized is complex and demands a large set of requirements, care has to be taken to avoid even partial contradictions among these requirements.

Furthermore, requirements must all be testable, at least in principle. This does not mean that it has to always be practically possible to design and perform tests to check the fulfilment of each requirement, but that the description of requirements has to be properly worded, according to its scope, and provide all information needed to implement (possible) relevant tests. This also implies that standards need to accurately state the possible conditions (if any) that constitute prerequisites for the applicability of the requirements, and the latter must specify the terms of compliance for the item with the required accuracy, depending on the objectives.

EXAMPLE

For clarification, we can consider an example provided by ETSI (ETSI, 2013). Let us compare the following alternative wording for a requirement: a) "When the equipment receives a SERVICE_REQUEST message, it shall respond immediately with a SERVICE_ACK message"; b) "When the equipment receives a SERVICE_REQUEST message, it shall respond with a SERVICE_ACK message within 30 ms". Requirement (a) is not testable, as it lacks necessary information ("immediately" is evidently an inaccurate term). On the contrary, requirement (b) is testable, as it correctly and accurately describes the test conditions ("receiving a SERVICE_REQUEST") and expected behaviour ("respond with a SERVICE_ACK message within 30 ms").

2.5 USING STANDARDS

This section provides a basic overview of the various steps that an individual has to follow to identify and use the standards that are relevant to a specific topic of interest.

These steps can be summarized as follows:

1) Select the relevant SDOs involved in the development of a standard related to the specific item;
2) Identify SDO documents relevant to the item;
3) Understand the selected documents' structure and formalisms.

The following sections expand upon and explain these steps.

2.5.1 SELECTING RELEVANT SDOS

As already analysed in Section 2.3, the standardization world is rather crowded and includes various types of organizations that may compete or, ideally, collaborate to produce standard reference documents for a broad set of subjects.

SDOs generally produce high-quality technical material that can provide valuable input. In practice, when trying to simplify the search for standard references to define the characteristics of a certain feature, it is worth prioritizing and focusing on the most relevant subset of SDOs and selecting them on the basis of the classification criteria provided in Section 2.3:

a) Technical scope;
b) Geographical scope;
c) Type of affiliation.

TECHNICAL SCOPE

As described in Section 2.3, each SDO has its own particular technical scope, which derives from its official statute, in other words from the common objectives that the members pursue when they participate in making standards. The SDO's technical scope constitutes the main criterion for the identification of standard reference for a certain item. For instance, if an item is related to telecommunication technology, then ITU-T, ETSI, IEEE and the IETF (see Section 2.3) represent, each for specific aspects, potential references. On the other hand, if the item is related to energy technology, then references may be IEC, CENELEC, and IEEE.

GEOGRAPHICAL SCOPE

Whereas SDOs themselves do not constrain the geographical scope of their specifications, we have seen in Section 2.3 how each SDO, due to its membership and statute, may be classified according to its geographical area of influence as international, regional or national. When a new item is to be developed, and standard reference is needed, relevant SDOs are those whose geographical scope encompasses the geographical market at which the item is targeted.

TYPE OF AFFILIATION

As already explained in Section 2.1.3, there is no hierarchy among SDOs, and compliance with standards is on a voluntary basis. Section 2.2.1 also explains how standards can sometimes be translated into (or constitute the basis to develop) binding regulations. Therefore, SDOs that have country representatives as members should be given special consideration, as policymakers can steer the action of these SDOs and exploit them as a privileged source of regulatory provisions[18].

18 *As an example, refer to Section 2.4.1 for the description of how ITU and ETSI deal with the development of standards that have regulatory implications.*

The above-described criteria for the selection of SDOs that are relevant to a certain item is only a simplification. The selection process is actually more complicated and dynamic. In some cases, there may be overlaps among various SDOs, especially with respect to technical scope, because of historical reasons. Sometimes SDOs that share the same technological area can independently develop different (and not necessarily fully aligned) specifications for the same subject. Furthermore, there may be borderline items that may fall into more than one technological area covered by more than one SDO. For instance, IEC and CENELEC standardize telecommunication protocols that are applicable to the control of energy systems, and as such, they partially overlap with the traditional standardization areas of other SDOs. In addition, an SDO's technical scope changes over time, as it can be enlarged to include new technologies.

This sort of competition among SDOs may also produce temporary standard misalignments. Still, SDOs actively cooperate to fix existing and prevent new divergences by setting up common study groups and collaboration instruments, such as liaisons or common standard initiatives (see Section 2.3), and by providing one another with mutual contributions.

Because of the complexity of the standardization institution landscape, SDO activities and relationships need to be continuously monitored to keep the whole picture up to date.

EXAMPLE

For some of the SDOs already introduced in Section 2.3, the following Table 2.2 summarizes the main classification criteria and their main existing contributions to other SDOs.

ORGANIZATION	HEADQUARTERS	GEOGRAPHICAL SCOPE	DOMAIN OF ACTIVITY	AFFILIATE ORGANIZATIONS / MEMBERS	OTHER SDOS IT CONTRIBUTES TO
ITU	Geneva (CH)	International	Telecoms /ICT	National SDO / Industries / Academia / Government bodies	ISO
ISO	Geneva (CH)	International	ICT	National SDO	ITU
IEC	Geneva (CH)	International	Electrotechnical	National SDO	ITU
ETSI	Sophia Ant (FR)	International (European regional recognition)	Telecoms/ICT	National SDO / Industries / Research Institutes / Government bodies	ITU
CEN	Brussels (BE)	Regional (Europe)	ICT	National SDO	ISO
CENELEC	Brussels (BE)	Regional (Europe)	Electrotechnical	National SDO	IEC
IEEE	New York (US)	International	ICT		
ELECTROTECHNICAL	Professionals	ISO			
IETF	Fremont (US)	International	ICT	Professionals	ITU and ISO
ECMA	Geneva (CH)	International	ICT	Industrial Companies	ISO

***Table 2.2**: SDO classification example*

2.5.2 IDENTIFYING SDO DOCUMENTS

Once the relevant SDOs for a specific item have been identified, the next step is the selection of relevant documentation. SDOs produce whole sets of standards, which may include various types of informative documents besides the true formal standards that are available via their websites. Depending on the SDO's specific policy, access to standards may be free or subject to some restrictions. For instance, ITU-T, ETSI and the IETF guarantee free access to published standards, while IEEE or ISO require the payment of a fee. ITU-T and ETSI limit access to draft standards to selected and accredited personnel of their members, while the IETF ensures free access to draft documents.

SDO websites usually provide search tools to allow users to navigate through all of their filed documents, which may belong to different categories, such as, for instance, technology roadmaps, product/service requirements, product/service technical specifications, regulations produced on behalf of regulatory bodies and product/service test specifications. SDOs usually assign a different document code to each category, so that it is possible to identify the topic covered by the documents just from their codes.

EXAMPLE

Table 2.3 includes a few examples of the different documentation produced by some major SDOs, such as ITU-T (ITU-T, 2006), ETSI (ETSI, 2018 (a)) and the IETF (IETF, (b)).

ITU-T	ETSI	IETF
Publications from ITU's Telecommunication standardization sector (ITU-T) are coded with format X.nnn, where X describes the document domain, e.g.: A – Organization of the work of ITU T B – Means of expression: definitions, symbols, classification C – General telecommunication statistics D – General tariff principles E – Overall network operation, telephone service, service operation and human factors F – Non-telephone telecommunication services G – Transmission systems and media, digital systems and networks	ETSI produces a range of publications, each with its own particular purpose, which is encoded in the first two letters of the document's code; e.g.: EN – the document is intended to meet needs specific to Europe and requires transposition into national standards, or the document is required under a mandate from the European Commission (EC)/European Free Trade Association (EFTA). ES and TS – the document contains technical requirements (the difference between ESs and TSs lies in different approval rules) EG – identifies guidance to ETSI in general on the handling of specific technical standardization activities TR – the document contains explanatory material	The IETF's official documents are named RFCs. "RFC" stands for Request for Comments, and this name expresses the IETF's approach to standardization: "the Internet is a constantly changing technical system, and any document that we write today may need to be updated tomorrow". The IETF does not code documents' scope and objectives in their RFC identifier system, which is simply a progressive number.

Table 2.3*: Examples of standards classifications*

Because of the complexity and extent of SDO activity, retrieving the right documentation by navigating SDO sites, even when they support users with search engines (which, for instance, allow documents to be searched for based on a subject or keywords), is not an easy task. As such, when it comes to collecting documentation, it is necessary to continuously monitor SDO activities, in order to stay up to date about the evolution of their document base.

2.5.3 UNDERSTANDING THE DOCUMENTS' STRUCTURE AND FORMALISM

In Section 2.4.2, we introduced the main characteristics of a standard and highlighted how SDOs ensure that their documentation is as clear as possible, in order to avoid any reader misunderstanding. In this section, we provide some hints about how readers need to approach standards. In the following, we deal in particular with ITU-T, ETSI and IETF document writing rules.

A first basic element that a standard must include consists of a clear statement of its objectives and area of application. This statement is usually put in the introductory part of the document.

EXAMPLE

Different SDOs implement the introductory part in slightly different ways.

ITU-T (ITU-T, 2016) instructs authors to include, at the beginning of the document, some introductory material that needs to include a mandatory summary paragraph. The summary must be included "before the main body of the recommendation" to "provide a brief overview of the purpose and contents […], thus permitting readers to judge its usefulness for their work". The summary may be optionally integrated into the following introduction section, which is used to "provide information that the author deems appropriate and that is not already provided in the Summary". The summary and introduction sections are not numbered. The first numbered section of the recommendation (i.e., in ITU-T terms, the first "clause") is the so-called scope, which specifically aims "to define, without ambiguity, its intent or object and the aspects covered, thereby indicating the limits of its applicability".

Similarly, ETSI (ETSI, 2015) includes an unnumbered foreword paragraph at the top of its standards. It is intended to be a "required, informative element" that provides information about, for instance, the technical body that prepared the deliverable, the approval process the document followed, possible relations between the deliverable and other ETSI standards and, where applicable, the main changes the current version of the deliverable is introducing with respect to the previous version. The foreword section may be optionally followed by executive summary and introduction sections, which summarize the contents of the document and give information about the "reasons prompting its preparation". The foreword, executive summary and introduction sections are not numbered. The first numbered item of the document is the scope, which "defines without ambiguity the subject of the ETSI deliverable and the aspect(s) covered, thereby indicating the limits of applicability of the ETSI deliverable or particular parts of it".

It is worth noting that in both ITU-T and ETSI documents, information about scope and applicability can be derived, as explained in Section 2.5.2, from the document code on the first page.

IETF documents (IETF, 2014) must include an abstract section "that provides a concise and comprehensive overview of the purpose and contents of the entire document". The abstract is followed by the introduction section, which is considered the first section of the document body. The introduction "explains the motivation for the RFC and, if appropriate describes the applicability of the document, e.g., whether it specifies a protocol, provides a discussion of some problem, is simply of interest to the Internet community". In RFCs, the use of the title "Introduction" to name such a section is recommended, but "authors may choose alternative titles, such as overview or background". The IETF also includes a specific "Status of this memo" section in the introductory part of its documents, which clarifies many basic characteristics of the documents, namely the document category[19] and what review process the document was subject to.

19 *The category can clarify if the document is, for instance, an "Internet Standard" or defines "Best Current Practices" or has an "Informational" purpose only.*

Further fundamental information that a standard needs to include is a list of other reference documentation the standard is related to. Most often, standards include references to other documentation produced by the same SDO or by others. This documentation either provides informative material, such as supplemental information to assist the understanding of the documents, or references documents that provide normative provisions, which are mandatory to claim compliance with the standard.

EXAMPLE

In ITU-T (ITU-T, 2016) recommendations, normative references are listed in the References section, included as the second clause of the recommendation (just after the scope clause). Informative references are, instead, collected in a bibliography section arranged at the end of the recommendation.

Similarly, ETSI deliverables (ETSI, 2015) list references in their second clause (again, after the scope clause); the reference clause is split into two sub-clauses that respectively include normative (clause 2.1) and informative (clause 2.2) references.

In IETF RFCs (IETF, 2014), references are grouped in the specific references section, which "must indicate whether each reference is normative or informative". Note that an IETF RFC not only lists other documents that possibly provide references but also explicitly quotes, just at the top of the document, the list of other RFCs that the document makes obsolete.

SDOs also need to take provisions to ensure that requirements are clear and unambiguous. Such provisions include, for instance, strictly discriminating, within a standard, normative sections from simply informative ones, as well as using codified vocabulary and specific formalisms to clearly express requirements and to highlight, within a normative section, what is actually a requirement, a recommendation (desirable, but not compulsory), a permissible characteristic (alternative provisions that may or may not be met) or parts included for information purposes.

EXAMPLE

The structures of ITU-T, ETSI and IETF documents are designed to take account of the above provisions and ensure a clear separation between the document body, including the normative part, and the scope statement, list of reference documents, and any annexes which may be normative or informative. One of these provisions that aims to make the requirements clear is to include the definitions of the concepts and terms to be used in the standard, after the description in the introductory part.

For instance, ITU-T (ITU-T, 2016) specifies that all standards need to include a definition section, to appear as the third clause of the body of the document and giving "the definitions necessary for the understanding of certain terms used in the recommendation". ITU-T also specifies that the fourth clause of each document needs to list "in alphabetical order all the abbreviations and acronyms from throughout the recommendation". Furthermore, clause 5 of ITU-T documents is reserved for defining or referencing special notations used throughout the recommendation.

Similarly, ETSI (ETSI, 2015) specifies that definitions, symbols, and abbreviations must be listed in the third clause of the body of its recommendations; the clause is split into three sub-clauses (numbered 3.1, 3.2 and 3.3), each devoted to one of the three item types.

As an additional provision to differentiate between normative and informative text, some SDOs define different aims for the different sections of their documents, and specify whether they can contain normative requirements or just informative parts and other content.

EXAMPLE

As an example, ITU-T (ITU-T, 2016) clarifies that the introductory part of its recommendations—the part that comes before the scope section as explained above—does not include normative requirements. Mandatory requirements are contained in the main body of recommendations, from clause 6 onwards. In ITU-T recommendations, any annexes, which may expand some matters and are referred to within the main body, are considered to "form an integral part of the recommendation" and therefore may include normative requirements.

In the same manner as ITU-T, in ETSI deliverables (ETSI, 2015), the actual text of the standard starts from clause 4, while preceding parts do not contain normative requirements. Any annexes may or may not include requirements. The content of an annex is clearly stated by adding an indication close to its heading, which identifies it as normative or informative.

Unlike ITU-T and ETSI, the IETF does not provide strict guidance on how to structure RFCs to include parts that explain definitions and acronyms (even if it is a common practice) and segregate normative and informative contents of a document. With respect to acronyms, the IETF (IETF, 2014) just recommends the "expansion of abbreviations on first occurrence".

As a further provision to clarify the text of requirements and discriminate normative from informative parts, as well as to distinguish different requirement types (for instance, mandatory or desirable), SDOs take particular care in defining some specific wording conventions, which may differ from one SDO to another.

EXAMPLE

For instance, ITU-T (ITU-T, 2016) strictly rules "the use of the words 'shall' and 'must' and their negatives 'shall not' and 'must not'", which are verbs reserved "to express mandatory provisions", "i.e., if certain values and/or parts of a recommendation are essential and the recommendation will have no meaning if these values and/or parts are not strictly respected or adhered to".

Similarly, but even more accurately, ETSI (ETSI, 2015) defines the actual intended meaning of various verbal forms. ETSI specifies that "shall" and "shall not" are used "to indicate requirements strictly to be followed in order to conform to the standard"; usage of verbs "must" and "must not" is, on the contrary, not allowed. Verbal forms "should" and "should not" are used to indicate "that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required, or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited". Moreover, verbal forms "may" and "need not" are used to indicate permitted behaviours or values; "can" and "cannot" "are used for statements of possibility and capability, whether material, physical or causal"; "will" and "will not" are "used to indicate behaviour of equipment or sub-systems outside the scope of the deliverable in which they appear"[20]. Finally, verbal forms "is" and "is not" have to be used only "to indicate statements of fact".

20 *"For example, in a deliverable specifying the requirements of terminal equipment, these forms shall be used to describe the expected behaviour of the network or network simulator to which the terminal is connected." (ETSI, 2015)*

Also, the IETF defines strict terminology to express different levels of requirement (IETF, 2014) (IETF, 1997). In RFCs, some capitalized words may be used for this purpose. "MUST", or the terms "REQUIRED" or "SHALL", mean that the definition is an absolute requirement of the specification. "MUST NOT", or the term "SHALL NOT", mean that the definition is an absolute prohibition of the specification. "SHOULD", or the adjective "RECOMMENDED", mean that "there may exist valid reasons in particular circumstances to ignore a particular item, but the full implications must be understood and carefully weighed before choosing a different course". "SHOULD NOT", or the term "NOT RECOMMENDED", mean that "there may exist valid reasons in particular circumstances when the particular behaviour is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behaviour described with this label". Finally, "MAY", or the adjective "OPTIONAL", mean that "an item is truly optional", in other words that "one vendor may choose to include the item because a particular marketplace requires it or because the vendor feels that it enhances the product, while another vendor may omit the same item".

Besides strict document wording rules, SDOs may use suitable formalisms to better clarify requirements. Such formalisms may take the form of simple tables, graphical descriptions such as block diagrams or, in some cases, actual formal languages.

All of these provisions are usually allowed (or even encouraged, in some cases), provided that the chosen formalism, such as block diagrams or formal language syntax, is extensively and unambiguously described within the standard or in further documentation that the standard refers to (i.e. that is appropriately included in the list of "normative" or "informative references").

EXAMPLE

Different SDOs may also have different approaches when considering the usage of formal languages to express standard requirements.

For instance, IETF IESG (IETF, 2001) acknowledges that formal languages are useful tools and does not prohibit their usage. However, it recommends that standard developers continue using English, with formal languages left as a supporting mechanism.

On the contrary, ITU-T (ITU-T, (b)) and ETSI (ETSI, 2018 (d)) promote the extensive usage of formal languages in standards "in order to produce precise and unambiguous formal specifications, which are essential to the quality of the recommendations and their implementations".

2.6 SUMMARY

This chapter introduced some basic concepts and definitions about standards, which the following parts of the book will deal with in greater detail.

Firstly, a very intuitive and practical definition of "standards" has been provided, together with some examples of how standards are widely applied by industries. Then, the chapter gave an overview of the aims of Standards Development Organizations (SDOs), the positive economic and societal impacts their job has, as well as the possible risks and drawbacks an ill-conceived standards development process might bring. This was followed by examples of major SDOs, mainly active in the ICT area and, lastly, a basic description of the characteristics and structure of processes and deliverables for a generic SDO was provided.

Key messages which should be retained from this chapter include:

- In the technology field, standardization to some extent is required to make things developed by different makers interwork
- Standards may arise either simply because a certain technology asserts itself on the market, so as to become a natural choice for many manufacturers (de facto standard), or because they are developed by organizations that are built for that purpose (formal standards developed by SDOs)
- The main characteristics of SDOs: they work by building consensus among participants; they follow self-imposed formal standards development procedures to guarantee consensus building and quality deliverables.
- SDO standardization effort benefits innovation, trade and environment; yet there are risks of disadvantages, which SDOs need to manage.
- The standardization landscape is crowded. There are many SDOs, with no hierarchical relationship, whose activities may overlap; however, SDOs work to set up liaisons or common standardization initiatives. SDOs may be roughly classified by geographical coverage, by type of affiliates and by technical scope of activities.
- Each SDO sets its own specific internal processes to develop standards; nevertheless, different SDO processes have common features that allow a generic standard document life cycle to be drawn up.
- SDO deliverables have some specific characteristics: they are specialized documents, intended for expert people; they must be clear and unambiguous and include only necessary, non-redundant and consistent requirements. SDOs ensure these characteristics are achieved through strictly defined document structure and drafting rules.

2.7 QUIZ

1 - WHICH OF THE FOLLOWING STATEMENTS APPLY TO A "DE FACTO" STANDARD?

(See Section 2.1 for hints)

a) *it usually has very little impact, as it is recognized only within a restricted community of users;*

b) *it is based on a winning technologic solution, which is widely and independently adopted by different producers/providers within a market segment and products developed on such basis are widely accepted by users/customers;*

c) *it has been agreed through a formal process by members of an established organization.*

2 - WHICH OF THE FOLLOWING STATEMENTS APPLY TO A "FORMAL" STANDARD?

(See Section 2.1 for hints)

a) *it has been developed through a fair process and by consensus by members of an established organization;*

b) *it establishes mandatory characteristics of a product to be put on the market;*

c) *t strictly and fully rules the design of an item.*

3 - WHAT IS THE DIFFERENCE BETWEEN "REGULATIONS" AND "STANDARDS"?

(See Section 2.1 for hints)

a) *none, as standards "regulate" the characteristics of products;*

b) *regulations define a set of characteristics an item needs to have to access a regulated market, while compliance with standards is on voluntary basis;*

c) *standards only provide a set of best practices to design/develop a specific item and cannot cover critical issues (such as safety or security) that are governed by regulatory bodies.*

4 - HOW ARE REGULATIONS AND STANDARDS RELATED?

(See Section 2.1 for hints)

a) *standards and regulations are the same thing;*

b) *standards are sometimes turned into regulations;*

c) *standards are often referenced by regulations.*

5 - WHAT DO STANDARDS PROVIDE TO PRODUCT DEVELOPERS/DESIGNERS?

(See Section 2.1 for hints)

a) *a thorough set of design rules they are forced to comply with;*

b) *references for a high-quality design;*

c) *a minimum set of requirements in order to make the product meet certain well-defined objectives.*

6 - HOW DO STANDARDS BENEFIT INNOVATION?

(See Section 2.2 for hints)

a) *by defining the products' characteristics related to the most critical aspects, so as to reduce design risks and time;*

b) *by inspiring designers with innovative ideas;*

c) *by constraining designers' choices, so as to speed up the design phase.*

7 - HOW DO STANDARDS BENEFIT THE ENVIRONMENT?

(See Section 2.2 for hints)

a) *by enforcing mandatory safety and sustainability characteristics for marketable products;*

b) *by defining widely shared safety and sustainability requirements for products, often publicized to customers through proper product labelling;*

c) *by forcing designers to follow detailed design rules that ensure products meet determined safety and sustainability requirements.*

8 - HOW DO STANDARDS BENEFIT THE ECONOMY?

(See Section 2.2 for hints)

a) *by restricting market access to only standard-compliant, high-quality products;*

b) *by enabling economies of scale, encouraging wider and fairer competition and facilitating trade thanks to the definition of widely shared practices;*

c) *by freezing technological evolution, so as to allow producers and customers to get the best return from their past investments in established products.*

9 - HOW DO STANDARDS BENEFIT INDUSTRIES?

(See Section 2.2 for hints)

a) *by facilitating the development of new technologies, by ensuring fair competition among industries and by enlarging products' market penetration opportunities;*

b) *by ruling market access of new products, as they define a mandatory minimum set of requirements that new products must comply with;*

c) *by pacing the technological evolution, so as to consolidate market positions of established industries.*

10 - HOW DO STANDARDS BENEFIT SOCIETY AND INDIVIDUALS?

(See Section 2.2 for hints)

a) *by ruling the market introduction of innovative products, so as to guarantee safety and environmental sustainability;*

b) *by establishing a minimum level of performances for any new product entering the market;*

c) *by promoting innovation, a safer environment and a more competitive market.*

11 - COMPLETE THE TABLE BELOW BY DEFINING THE CHARACTERISTICS OF THE LISTED SDOS ACCORDING TO THE CLASSIFICATION CRITERIA DEFINED IN THE FIRST ROW:

(See Section 2.3 for hints)

SDO	GEOGRAPHICAL COVERAGE	TYPE OF AFFILIATES	MAIN TECHNICAL SCOPE
ISO			
ITU			
ETSI			
3GPP			
IETF			
ECMA			

12 - LIST THE MAIN PHASES OF THE GENERIC STANDARD LIFE CYCLE AND SUMMARIZE WHAT THEY ARE FOR:

(See Section 2.3 for hints)

PHASE NUMBER	PHASE NAME	WHAT IT IS FOR (SCOPE, MAIN ACTIVITIES INCLUDED IN THE PHASE)
1		
2		
3		
4		
5		

13 - IDENTIFY THE TWO CHARACTERISTICS, FROM THOSE LISTED BELOW, THAT DO NOT DESCRIBE A NORMATIVE REQUIREMENT PART OF A STANDARD:

(See Section 2.4 for hints)

a) *clear, concise and unambiguous;*

b) *widely explained by means of extended examples;*

c) *expressed by means of specialized notations;*

d) *defined by means of references to other standards;*

e) *well justified by means of an extended technical dissertation;*

f) *testable: the description has to be worded so as to provide all needed information to implement (possible) relevant tests.*

14 - DESCRIBE THE TYPICAL CONTENT OF THE VARIOUS SECTIONS OF A GENERIC STANDARD LISTED BELOW:

(See Section 2.3 and 2.5 for hints)

SECTION	CONTENT
SCOPE / ABSTRACT	
REFERENCES	
DEFINITIONS	
BODY OF THE DOCUMENT	
ANNEXES	

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2.8 GLOSSARY

- De facto standard: A de facto standard, also known as standard "in actuality", arises when an established solution, not developed through a standardization process put in place by an SDO, is widely and independently adopted by different industries within a market segment and products developed on such basis are widely accepted by customers.
- International SDO: An SDO that has members worldwide, including representatives of National or Regional standard bodies, and their deliverables have worldwide coverage.
- Formal standard: A standard developed by an SDO.
- Industrial forum: An organization established by industries that coordinate their efforts on specific subjects to accelerate, complement or promote the development of a standard.
- National SDO: An SDO that issues country-specific standards and collaborates with International and Regional SDOs.
- Professional organization: An organization that brings together independent professionals to promote best practices and innovation in specific areas, and that may act as an SDO.
- Regional SDO: An SDO that has members (industries, academia and national SDOs) from a set of countries that usually share, or are interested in promoting, common practices and regulations.
- Standard: In general, a widely agreed way of doing something. More specifically, in the technological/industrial environment, a model or norm to which a certain item is aligned; a set of prescriptions, specifications, guidelines or characteristics for a determined material, product, service, process or procedure.
- Standards Development Organization (SDO): An organization devoted to developing standards and that puts in place well-defined procedures to guarantee a fair development process, which is aimed at building consensus among involved contributors and ensuring the quality of the final deliverables.
- Standard initiative: An organization that multiple SDOs put in place to coordinate standardization efforts on particular subjects.

2.9 LIST OF ABBREVIATIONS

- 3GPP: 3rd Generation Partnership Project
- AAP: Alternative Approval Process
- AD: Area Director
- ANSI: American National Standards Institute
- ARSO: African Organization for Standardization
- BGP: Border Gateway Protocol
- CEN: Comité européen de normalisation—European Committee for Standardization
- CENELEC: Comité européen de normalisation en électrotechnique—European Committee for Electrotechnical Standardization
- CERN: Centre Européen pour la Recherche Nucléaire—European Organization for Nuclear Research
- DVD: Digital Versatile Disk
- ECMA: European Computer Manufacturers' Association
- ETSI: European Telecommunications Standards Institute
- IEC: International Electrotechnical Commission
- INCITS: InterNational Committee for Information Technology Standards
- ISO: International Organization for Standardization
- ITU: International Telecommunication Union
- JEDEC: Joint Electron Device Engineering Council
- HD DVD: High Definition Digital Versatile Disc
- HTML: HyperText Markup Language
- IEEE: Institute of Electrical and Electronics Engineers
- IETF: Internet Engineering Task Force
- IP: Internet Protocol
- Psec: IP security
- HDMI: High Definition Multimedia Interface
- ICT: Information and Communication Technology
- LTE: Long Term Evolution
- M2M: Machine to Machine
- NSDO: National Standards Development Organization
- OSPF: Open Shortest Path First
- PASC: Pacific Area Standards Congress
- PDF: Portable Document Format
- SDO: Standards Development Organization
- TAP: Traditional Approval Process
- UMTS: Universal Mobile Telecommunications System
- VESA: Video Electronics Standards Association
- W3C: World Wide Web Consortium
- WG: Working Group
- WI: Work Item
- XML: eXtensible Markup Language

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3 THE STANDARDS ECOSYSTEM

In this chapter, readers are introduced to key concepts of standardization:

- The types of standards development organizations (SDOs), and the standards they produce;
- The three major geographical scopes of SDOs (international, regional and national), as well as the mechanisms supporting their cooperation and coordination;
- The reuse and reference of standards by other standards and official documents, including adoption and transposition.
- The main types of documents published by recognized SDOs;
- The conventions used to name standards and the typical information contained in a standard's name;

LEARNING OBJECTIVES

- Students should understand and apply the different criteria for establishing the classifications of standardization documents and the organizations producing them, especially in the ICT arena.
- Students should understand the differences among national, regional and international organizations, as well as the necessary agreements among them aiming to improve the efficiency of standardization efforts. In addition, students should understand that the coordination of standardization activities among SDOs with different scopes has beneficial aspects from business and legal perspectives.
- Students should know about how specifications from industrial consortia are transposed into standards; also, students should understand that marketing organizations produce specifications and suites with the objective of assessing and validating the conformance to a standard and enabling interoperability between products. The notion of regulations and how they may refer to standards is also relevant.
- Students should become familiar with the naming conventions of different SDOs and be able to extract and identify several characteristics of a document from its name, including the title, the SDO that published/adopted the document, the type of standardization document, whether or not the document belongs to a family of standards, whether it is a harmonized standard, the version of the standard, as well as the date/year the document was published.
- Students should become familiar with the differences between types of standardization documents in terms of their scope and addressed stakeholders, whether they contain requirements (normative documents) or simply provide information, as well as the process leading to their approval/publication. Also, it is important to know about which organizations may produce which type of document, and the definition/purpose of each type of document, which may differ across organizations.

As introduced in Chapter 2, the standardization landscape is rich and complex. Its very first definition of "standard" was rather generic: "a widely agreed way of doing something". But then it clarified that, in our context, proper standards are formal documents that are produced by organizations with expertise in the field, which at the same time may be categorized according to their geographical scope, among other characteristics. As described there, hundreds of standards, by dozens of organizations, are needed for a Personal Computer to run.

The current chapter aims to provide some basic concepts to help readers find their way around the standards ecosystem.

3.1 TYPES OF ORGANIZATIONS AND STANDARDIZATION DOCUMENTS

This section provides readers with key concepts and examples of organizations and standardization documents.

Figure 3.1*: The complex ecosystem of standardization organizations and the documents they produce*

3.1.1 RECOGNIZED SDOS

Some standards development organizations (SDOs) are officially recognized by regulation systems as providers of standards. They are known as recognized SDOs. They publish standards when a specific societal need is identified; sometimes the corresponding governmental authority invites them to address a topic in the need of standardization. Recognized SDOs have robust and documented processes for building consensus and approving standards. Some authors refer to these organizations as official SDOs.

EXAMPLE

Regulation (EU) No 1025/2012 of the European Parliament and of the Council designates CEN, CENELEC and ETSI as the European Standards Organizations (ESOs).

Besides the officially recognized SDOs, there are well-respected and long-existing SDOs that are not officially recognized by regulation systems, but have well-established procedures to ensure the quality of their standards (e.g. W3C, OASIS, IEEE, OMG).

EXAMPLE

IEEE counts on a specific board (the IEEE-SA Standards Board) to coordinate the development and revision of IEEE standards. This includes approving the initiation of standards projects and reviewing them for consensus, due process, openness, and balance. IEEE 802 is just an example of an IEEE family of standards with a significant impact on society. 802 standards deal with local area networks and metropolitan area networks.

EXAMPLE

European standard EN 301 549 on ICT accessibility requirements, produced by the official European Standards Organizations (ESO), makes explicit references to Web Content Accessibility Guidelines (WCAG), published by W3C.

3.1.2 FORMAL STANDARDS

A formal standard is a document that has been approved by a standards development organization. Sometimes, authors refer to formal standards simply as "standards".

Sometimes experts take formal standards into account when putting together regulation, since they provide guidance on technical details and are the result of well-established and documented procedures. In some situations, governments invite recognized standards organizations to produce standards in support of specific policies or legislation. As an example of this policy, the European Commission invites the European Standardization Organizations (ESOs) to produce formal standards through Standardization Requests. About a fifth of all European standards are developed following a standardization request (a.k.a. mandate) from the European Commission to the European Standardization Organizations (ESOs). The process can be summarized as follows:

- Draft requests are drawn up by the Commission through a process of consultation with a wide group of interested parties, including social partners, consumers, small- and medium-sized enterprises (SMEs), industry associations and EU countries. Before being formally sent to the ESOs, they are submitted to the Committee on Standards of the Regulation (EU) 1025/2012 for a vote. If the outcome of this vote is positive, the Commission adopts the request as a Commission Implementing Decision.
- The European Standards Organizations (ESOs), which are independent organizations, have the right to refuse a mandate if they do not think that standards can be produced in an area. Due to the preceding consultation process, however, standardization requests are rarely refused.
- The standardization requests issued by the European Commission are available in a database of mandates.

Furthermore, regulation may make explicit reference to a specific standard. In those cases, the referenced standard is called a "de jure" standard. However, some authors use the term "de jure" standard to refer generally to formal standards.

On some occasions, the only way to comply with regulation is by complying with the referenced standards. Other times, compliance with the standard remains voluntary: the standard is just an officially accepted way to comply with regulation, but there may exist alternative ways to do so. However, anyone choosing the latter would be required by authorities to prove that the alternatives chosen fulfil the requirements in the regulation.

EXAMPLE

In 2005, the European Commission sent a standardization request, called Mandate 376, to the ESOs (CEN, CENELEC and ETSI). Mandate 376 was an instruction to assist with the harmonization of public procurement practices in Europe by developing a standard that specifies the functional accessibility requirements for publicly procured ICT products and services, so that they can be used by citizens with and without disabilities.

The main output resulting from Mandate 376 was the standard EN 301 549 "Accessibility requirements suitable for public procurement of ICT products and services in Europe", published in 2015. This standard contains requirements that, when fulfilled, ensure that ICT products and services are accessible to people with and without disabilities.

One year after the standard was published, the "Directive (EU) 2016/2102 of the European Parliament and of the Council of 26 October 2016 on the accessibility of the websites and mobile applications of public sector bodies" was approved. Article 4 of Directive (EU) 2016/2012 is entitled "Requirements for the accessibility of websites and mobile applications" and reads:

"Member States shall ensure that public sector bodies take the necessary measures to make their websites and mobile applications more accessible by making them perceivable, operable, understandable and robust."

Furthermore, the Directive references standard EN 301 549 as follows:

- "content of websites that fulfils the relevant requirements of European standard EN 301 549 V1.1.2 (2015-04) or parts thereof shall be presumed to be in conformity with the accessibility requirements set out in Article 4 that are covered by those relevant requirements or by parts thereof."

Does the latter mean that ensuring compliance with EN 301 549 is the only way to be in conformity with the accessibility requirements set out in Article 4? It probably does not. What it means is that the relevant clauses of EN 301 549 should be considered as the minimum means of putting the requirements in Article 4 of the Directive into practice (i.e. Perceivability, operability, understandability and robustness of a website or of a mobile application). In effect, there might be alternatives to the standard that also allow compliance with these principles. However, anyone using them should demonstrate their validity for this purpose.

SDOs may produce different types of standardization documents, each with its own particular purpose, and with a specific approval processes. This strategy is useful to address different societal needs. Sometimes, documents are produced with the aim of becoming national or international standards. These documents will require the highest level of excellence in terms of maturity and consensus. In other cases, certain societal or industry topics may benefit from having a standardization document as a reference, even if that topic has not reached the highest level of either maturity or consensus. In any case, an SDO may produce a document that is useful for that particular purpose, by means of a shorter and more flexible way than the one a higher level standard would demand.

3.1.3 DE FACTO STANDARDS

Let's have a look at the following ICT-related items:

- PDF: a document format created by Adobe Systems.
- HTML: a language for describing the structure and content of Web pages. It was originally created by Tim Berners-Lee and is currently published and maintained by W3C.
- Microsoft Windows: an operating system that became an industry standard, and so did its specifications (e.g. the Microsoft Web Services Security specification, WS-Security).

What they all have in common is that they have had a huge impact on society, as they are used by millions of users… They are called "de facto standards". They are common practices adopted by the market, which are not the result of any standardization process.

According to Maxwell (2006), a de facto standard is a custom or convention that has achieved a dominant position by public acceptance or market forces (for example, by early entry into the market), and that usually has the attractive characteristic of having been validated by market processes. This effect was analysed by Utterback and Abernathy, who introduced the "dominant design" concept in the mid-70s (Abernathy and Utterback 1978). They identify key technological features that become a de facto standard. Dominant designs may not be better than other designs; they simply incorporate a set of key features that sometimes emerge due to technological path-dependence and not necessarily strict customer preferences. In Chapter 5, de facto standards are dealt with in the context of dominant designs and innovation.

De facto standards may be adopted as standards by recognized SDOs, like in the case of HTML (see the example below) and PDF (ISO 32000-1:2008 Document management—Portable document format—Part 1: PDF). Furthermore, de facto standards may considerably influence formal standards.

EXAMPLE

Tim Berners-Lee described HTML publicly for the first time in 1991. HTML is the language that enables documents to be used and shared by users across the Internet. It was originally composed of 18 elements, which web browsers interpret so that humans can interact with documents containing text, images, other media, and links to other HTML documents.

Later on, the IETF published "HTML 2.0", the first time HTML was published as a standard. Since 1996, the World Wide Web Consortium (W3C) has been in charge of maintaining the HTML specification. It was in 2000 that a recognized SDO (ISO/IEC) published HTML as ISO/IEC15445:2000.

3.1.4 PUBLIC AND PRIVATE ORGANIZATIONS

Usually, public organizations are created by treaties. This is the case of ITU, an agency of the United Nations. Hence, ITU is an example of an official, public organization. However, officially recognized organizations are not necessarily public. In fact, most of them are private. For instance, ETSI is a private, not-for-profit organization. Other examples of official organizations that are private are ISO, IEC, CEN, CENELEC, and ANSI.

Some non-official standards organizations were created as industrial consortia to produce standards. For instance, C2C-CC and W3C are industrial consortia created, respectively, by vehicle- and web-related companies.

3.1.5 OPEN STANDARDS

Openness of standards is not a precise concept. It comprises a set of aspects regarding how standards are written, approved, published, implemented and maintained. According to the Openstand initiative, there are five principles involved (Dardailler and Jacobs 2012):

- Cooperation between standards organizations. Respectful cooperation between standards organizations, whereby each respects the autonomy, integrity, processes, and intellectual property rules of the others.
- Adherence to the following characteristics:
  - Due process: Decisions are made with equity and fairness among participants. No one party dominates or guides standards development. Standards processes are transparent and opportunities exist to appeal decisions. Processes for periodic standards review and updating are well defined.
  - Broad consensus: Processes allow for all views to be considered and addressed, such that agreement can be found across a range of interests.
  - Transparency: Standards organizations provide advance public notice of proposed standards development activities, the scope of work to be undertaken, and conditions for participation. Easily accessible records of decisions and the materials used to reach those decisions are provided. Public comment periods precede final standards approval and adoption.
  - Balance: Standards activities are not exclusively dominated by any one person, company or interest group.
  - Openness: Standards processes are open to all interested and informed parties.
- Collective empowerment. Commitment by affirming standards organizations and their participants to collective empowerment by striving for standards that:
  - are chosen and defined based on technical merit, as judged by the contributed expertise of each participant;
  - provide global interoperability, scalability, stability and resiliency;
  - enable global competition;
  - serve as building blocks for further innovation; and
  - contribute to the creation of global communities, benefiting humanity.

- Availability: Standards specifications are made accessible to all for implementation and deployment. Affirming standards organizations have defined procedures to develop specifications that can be implemented under fair terms. Given market diversity, fair terms may vary from royalty-free to Fair, Reasonable, and Non-Discriminatory conditions (FRAND conditions).
- Voluntary adoption: Standards are voluntarily adopted, and it is the market that determines success.

How can we determine whether a standard or an SDO complies with the principles of open standardization? What are the pros and cons of standardization openness? Let us consider some questions put forward in Maxwell (2006) and Cerri and Fuggetta (2007).

- How open is the process of choosing to develop, and ultimately developing, the standard? Who can participate and under what terms? Does the process ensure that all participants can affect the standard? Is the process well documented? Who owns and manages the standard? Is there a single party that has special rights to it?
    - Pros of openness: Opening the effective participation in the standardization process to any company or individual will minimize the possibility of the standard reflecting only the interests of a limited set of stakeholders. Also, having representatives of civil society on board will contribute to addressing consumer needs such as privacy, security or cost. Furthermore, this approach will contribute to interoperability, allowing different services, applications and networks to communicate with one another.
    - Cons of openness: the higher the level of participation, the more difficult it is to reach consensus, and therefore, the more likely it is that the standard will not be approved in time to address the needs of a rapidly changing technological context.
- Is the standard publicly disclosed in its entirety? Is the document publicly available, either free of charge or for a nominal fee? What terms and conditions govern its implementation? Does the standard contain proprietary technology that must be licensed? Will royalties be charged and on what basis will they be determined? Is it possible to extend and reuse the standard in other open standards?
    - Pros of openness:
        - As an example of the benefits of having publicly available, free-to-use standards, the growth of the Internet would not have been as rapid without universal availability of TCP/IP protocols or HTML.
        - The European Commission defines ICT lock-in (European Commission 2013) as the situation where public authorities enter into contracts with providers of ICT in order to use an ICT product or service for a certain period of time, and the public authority cannot easily change providers once this period of time has expired because not every piece of essential information about the system is available for efficient takeover by another provider. According to the results of a survey by the European Commission (Galasso 2015), among the countermeasures to tackle ICT lock-in, the most used is "to define ICT strategies and architectures on open source and open standards".
    - Cons of openness: It is indeed difficult to develop standards with no proprietary technology involved, for instance in the case of existing technologies that have proven to solve a technological issue. Hence, there is intense debate within SDOs about whether to include proprietary technology, and how this should be done.

3.1.6 CLASSIFICATION OF ICT STANDARDIZATION DOCUMENTS

Standardization documents can be classified according to many approaches, such as the ICT aspect addressed by the document, to name only one. Below is a list of categories and representative examples, in agreement with de Vries (2006) and Hatto (2013).

Terminology standards. These documents compile structured vocabularies, terminologies, code sets and classification systems that most ICT systems rely on, e.g.:

- ITU-T E.800 Definitions of terms related to the quality of service.
- ISO/IEC 17788:2014 Information technology – Cloud computing – Overview and vocabulary

Measurements or test methods. These documents define the objectives and guidelines for testing ICT. They define roles, processes and techniques for testing and measuring. In addition, they provide guides for test planning, implementation and reporting. Examples of such standards are:

- IEEE Std 299-2006 IEEE Standard Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures
- ETSI ES 203 228 V1.0.0 (2015) Environmental Engineering (EE); Assessment of mobile network energy efficiency

Specifications. These documents contain a detailed and formal description of a set of characteristics or requirements that are relevant to a specific item. Examples of specifications are:

- ISO/IEC 10918-1:1994 Information technology—Digital compression and coding of continuous-tone still images: Requirements and guidelines
- EN 55 024 European immunity requirements for information technology equipment

System architecture. Documents that support the formal description of ICT systems and their components, characteristics and processes. For example:

- ISO/IEC/IEEE 42010:2011 Systems and software engineering—Architecture description.

Reference models. These documents inform the design of the architecture of ICT systems according to a given model, for example:

- ISO/IEC 7498:1994 Preview. Information technology—Open Systems Interconnection,
- W3C Recommendation, 15 December 2004. The Architecture of the World Wide Web, Volume One.

Software and networking standards. There are documents about computer software, including programming languages (e.g. C++ is published as ISO/IEC 14882), Application Programming Interfaces (API) (e.g. ISO 17267 on API for navigation systems for intelligent transport systems), communication protocols (e.g. Wi-Fi IEEE standards), file information and formats (e.g. RFC 8259 JSON).

Quality assurance. These documents provide requirements for managing the quality of projects or systems, such as:

- IEEE 730-2014 – Software Quality Assurance Processes.

The above classification is not strict in the sense that one document may be allocated to more than one category, for example:

- Requirements standards may include testing procedures to assess whether the requirements are met,
- Documents where systems or reference models are described may include the vocabulary involved,
- Software standards may include requirements.

Horizontal and vertical standards. Another broad classification of standards is related to whether a standard is horizontal or vertical (de Vries 2006). Vertical standards apply to different aspects within an industry sector or entity. Horizontal standards, however, address aspects that are applicable across multiple industries or entities.

EXAMPLE

Example of vertical standards: Standards about social alarm systems and telecare, which are ICT-mediated services aiming to provide safety and wellbeing to citizens, especially to the elderly and disabled. The EN 50134 family of standards about social alarm systems, published by CENELEC, deal with different aspects of social alarms, such as the vocabulary and terms, the technical requirements for their devices (sensors, panic buttons, home units, etc.), their interconnections, etc.

Example of horizontal standards: Standards about electromagnetic compatibility (EM), the IEC EN 61000 family of standards about EM addresses aspects that include terminology, descriptions of electromagnetic phenomena and the EM environment, measurement and testing techniques, and guidelines on installation and mitigation.

Given their nature, vertical standards normally reference horizontal standards. For instance, electromagnetic compatibility (EM) standards apply to many different pieces of electrical equipment of all kinds, such as mobile phones and social care alarm devices.

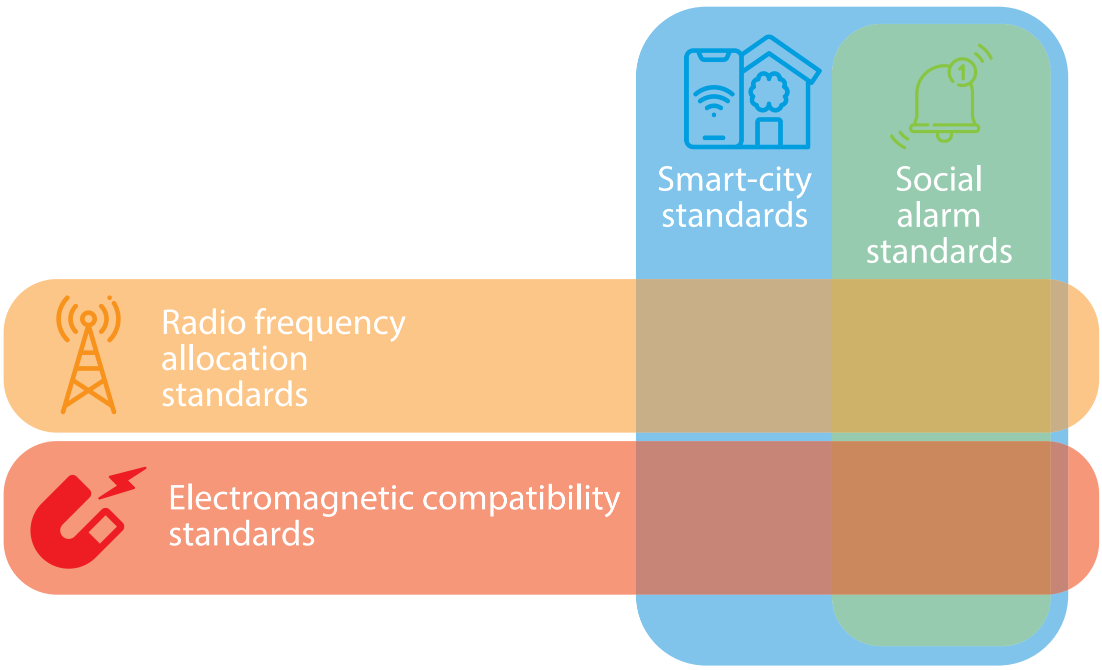

***Figure 3.2**: Illustration with examples of horizontal vs. vertical standards*

3.2 NATIONAL, REGIONAL AND INTERNATIONAL STANDARDIZATION: COOPERATION AND COORDINATION

This section introduces three major regional scopes of recognized SDOs (international, regional and national) as well as the existing mechanisms that support coordination and cooperation within their standardization activities and deliverables. Among these mechanisms, this section addresses the national and regional adoption of standards published by SDOs with a wider scope.

3.2.1 NATIONAL, REGIONAL AND INTERNATIONAL SDOS AND STANDARDS

Recognized SDOs have a national, regional or international scope, as do the standards they produce:

- ISO, IEC and ITU are international standard organizations, with a worldwide scope.
- CEN, CENELEC and ETSI are officially recognized as European bodies for standardization, although ETSI has an international membership base and produces globally applicable standards.
- PASC is a regional SDO in the Pacific area.
- DIN is the national SDO in Germany, UNE in Spain, ANSI in USA, and BIS in India.

National SDOs represent their own countries in organizations with a regional or international scope. At the same time, regional SDOs may be represented in international SDOs. Article 2 of the EU Regulation 1025/2012 on European standardization provides the following definitions for formal standards in the EU:

- "International standard" means a standard adopted by an international standardization organization.
- "European standard" means a standard adopted by a European standardization organization.
- "Harmonized standard" is a special case for a European standard. Harmonized standards are adopted on the basis of a request made by the Commission, with the objective of supporting the harmonization of EU legislation.
- "National standard" means a standard adopted by a national standardization body.

Sometimes, SDOs produce standards with a scope that goes beyond their alleged geographical coverage. For instance, ETSI is an official SDO within the European Union. However, it also publishes standards that are adopted globally, such as the GSM family of standards for mobile communications.

3.2.2 COOPERATION AND COORDINATION AMONG DIFFERENT LEVELS OF STANDARDIZATION

The need for coordination among different levels is inherent to the spirit of standardization. The objective is to ensure that organizations make the best use of their resources, to help them to exchange information, increase the transparency of procedures and reduce the possibility of duplicating work unnecessarily at a national, regional or international level.

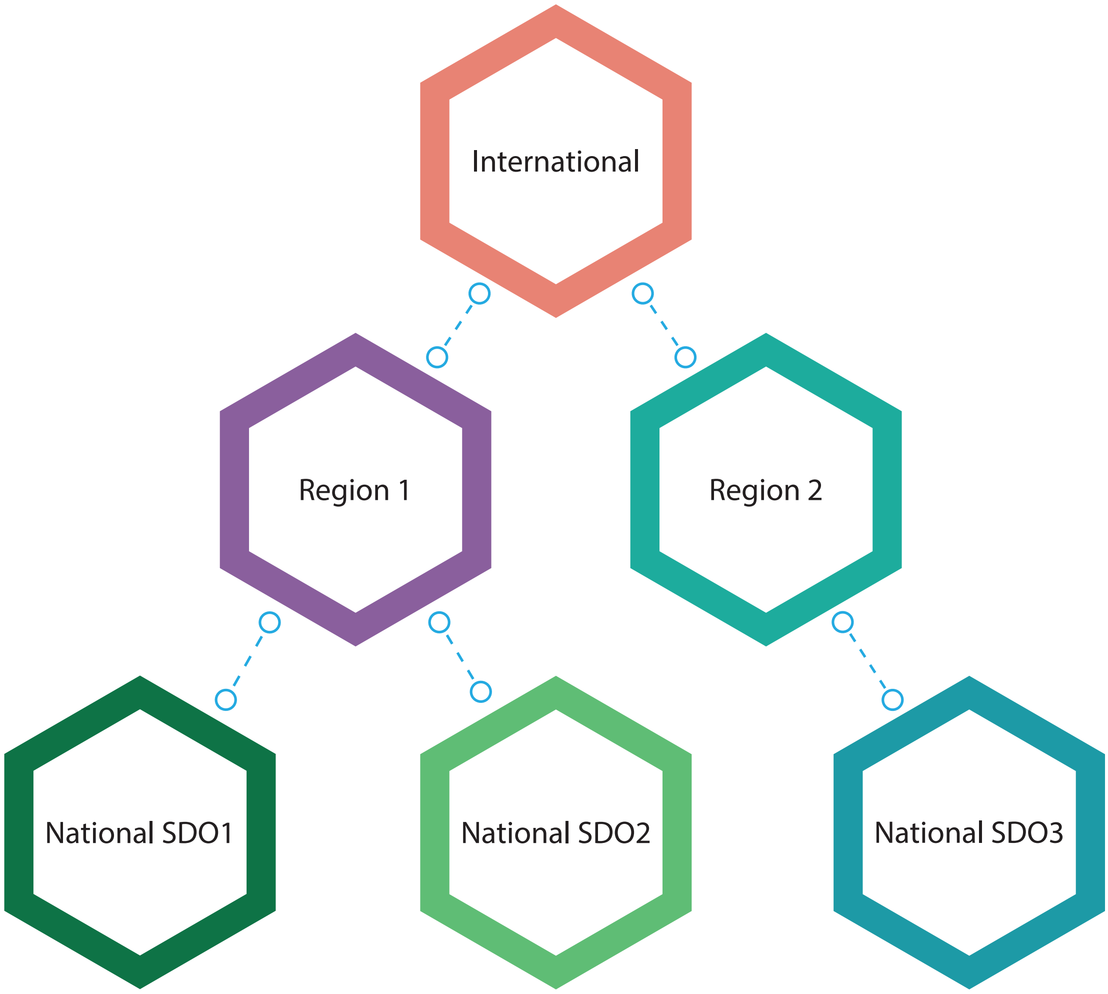

Figure 3.3: *Hierarchy of SDOs according to their geographical scope*

The typical stance when seeking coordination among different levels of standardization is that international standardization takes precedence over regional standardization, which in turn takes precedence over national standardization. One of the objectives of standardization carried out at higher levels (i.e. international and regional) is to harmonize standardization coming out from lower levels (i.e. regional and national, respectively). The ideal process is for approved international standards to be simultaneously adopted as regional standards, and then as national standards in the countries in that region. However, that requires a previous agreement among the SDOs at the different levels (national, regional and international). SDO agreements also tend to recognize standardization with a narrower scope (regional, national), which may have particular needs to be considered when adopting standards with a wider scope. Furthermore, membership of SDOs in organizations with a wider geographical scope is also relevant to coordination: it is commonplace for national SDOs to be members of their corresponding regional SDOs; and for national and regional SDOs to be members of their corresponding international SDOs.

When national standards organizations adopt European and International standards, they have the advantage of a wider geographical scope, covering in principle the whole world in the case of international standards. Purely national standards may exist. However, they are only a small part—often less than 10%—of the national SDO portfolio of standards.

COORDINATION AMONG EUROPEAN AND NATIONAL STANDARDIZATION ACTIVITIES

According to the BSI "European standards and the UK" report (BSI 2017), the single-standard model pursued by the European Union supports the European single market, as it means that there is only one standard in use across all the countries of the single market on any given issue. This model is favoured by industry because it reduces the number of standards that a company may have to consider in order to trade across borders. It also reduces costs and increases choice for consumers by making it easier for goods and services to be traded. Businesses gain the benefits of market-driven good practice developed by broad communities of experts through robust and open standardization processes.

In this respect, the "standstill" is a relevant concept in European coordination of standards. It entails an obligation for the national SDOs to not take any action, neither during the preparation of a European Standard (EN), nor after its approval, that could prejudice the intended harmonization and, in particular, not to publish a new or revised national standard that is not identical to an existing EN. For the sake of transparency and the achievement of good coordination, both European and their national member SDOs periodically (at least annually) publish their work programmes and the list of approved/adopted standards.

Once a European SDO has approved a standardization project where a standard is to be developed, the generic process of coordination with a national SDO can be summarized as follows:

- Drafting: a standardization group within a technical committee of a European SDO drafts the document.
- Voting and commenting: national SDOs that are represented in the technical committee voice their corresponding national perspectives in the draft and submit their votes and comments about the draft.
- Publication and national adoption: approved European standards are transposed and announced by each national SDO. Where national legislation exists, it should be mentioned in an annex to the standard. Importantly, national standards that conflict with the new European Standard are withdrawn. The adoption of an EN can be done either by mere endorsement, by publishing a national standard with identical text, by translating the standard into the national language, by publishing an endorsement sheet, or by an announcement in the national member's official journal. The default national adoption dates for an EN vary between three to six months after publication by the ESO. There are guidelines for the naming and numbering of European Standards that are adopted nationally. In addition, there may be applicable requirements for distributing and selling adopted European standards nationally. For instance, when EN 50134-3:2012 "Alarm systems—Social alarm systems—Part 3: Local unit and controller" was approved by CENELEC, it automatically became a national standard in each of the CENELEC member countries (e.g. BS EN 50134–3 in the United Kingdom).

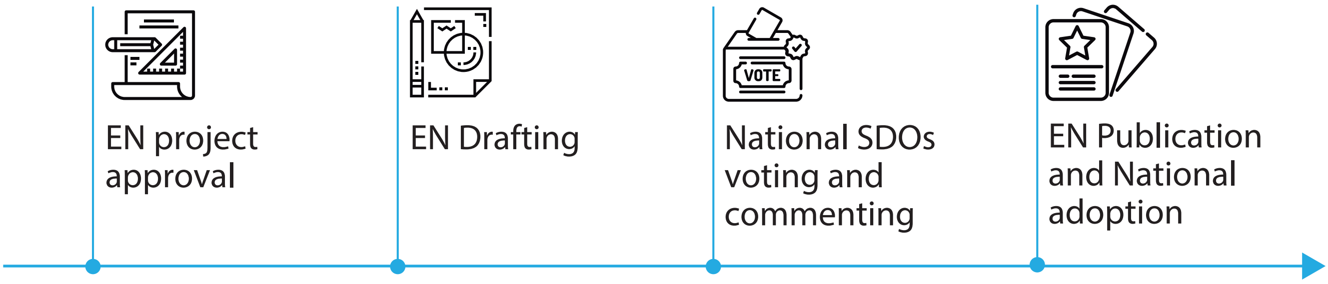

Figure 3.4: *The process of coordination of an EN project with national standardization*

In those cases where the European SDO decides to exclude certain aspects from the scope and application field of the future EN that are relevant to the national SDO, the latter is free to publish the additional aspects as national standards. In any case, the national SDO has to ensure that this national standard is not in conflict with the aims of European standardization and will not create barriers to trade.

Details about the obligations, rights and processes of national SDOs in relation to European Standards are provided in the following documents:

- (ETSI 2015)
- (CEN, CENELEC 2008)
- (CEN 2016)

EXAMPLE

Each national SDO member of CEN, CENELEC and ETSI has adopted the European Standard EN 301 549, which was published in response to Mandate 376 of the European Commission.

In parallel, each member state of the European Union should transpose the Directive (EU) 2016/2102 (which references the EN) into its national law within two years of the Directive being approved. This mechanism ensures that each transposed law references the corresponding standard resulting from the adoption of EN 301 549.

COORDINATION AMONG EUROPEAN AND INTERNATIONAL SDOS

As described in Figure 3.5, there are cooperation and coordination agreements between international and European SDOs.

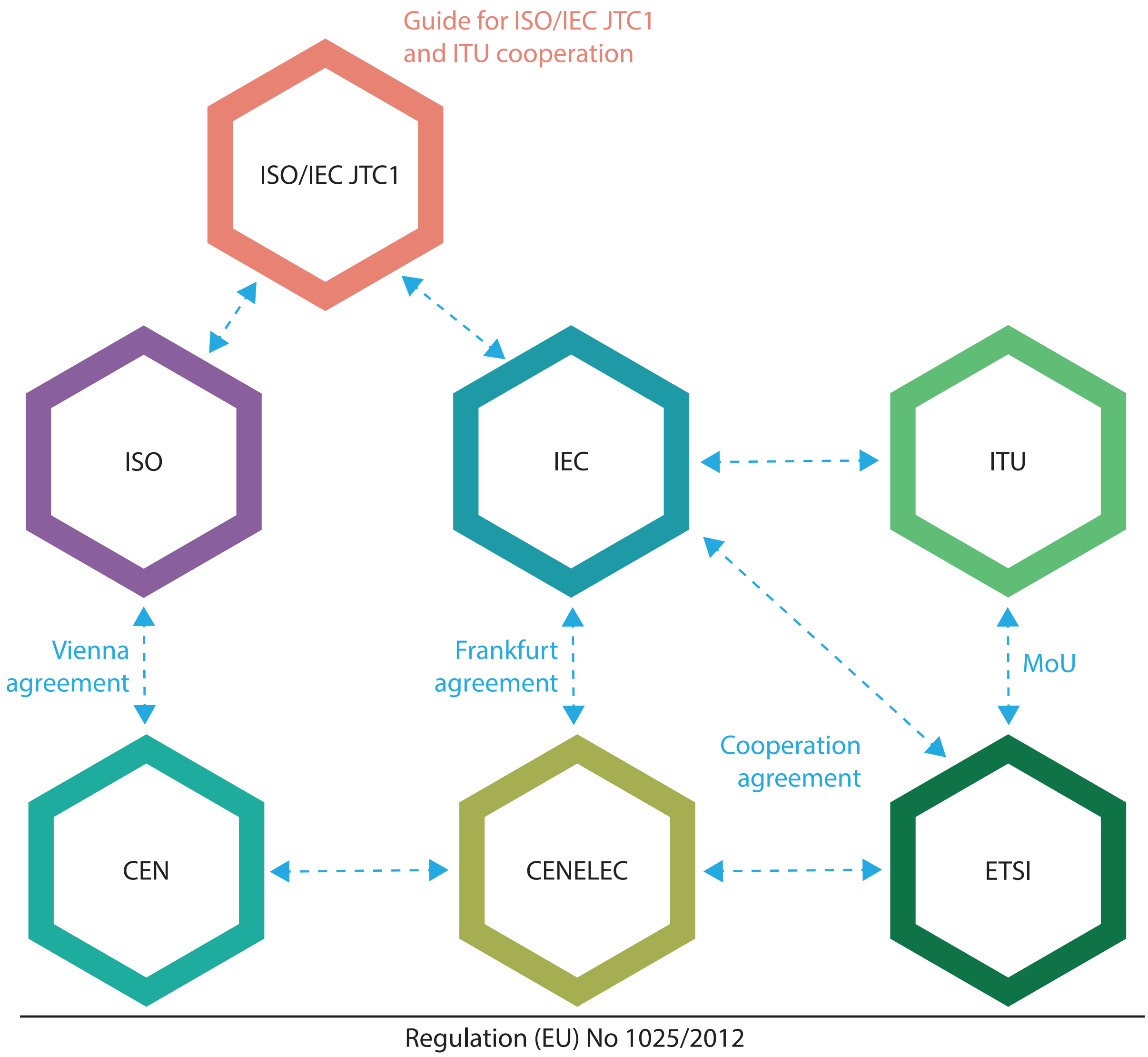

***Figure 3.5**: Cooperation and coordination agreements between European and international SDOs; modified from Jakobs (2008)*

COORDINATION BETWEEN ISO AND CEN (VIENNA AGREEMENT)

The agreement on technical cooperation between ISO and CEN (ISO and CEN 2001) is an agreement on technical cooperation between these two SDOs. The latest version of the Vienna Agreement came into effect in 2001, superseding both the 1991 version of the Vienna Agreement and the earlier 1989 Lisbon Agreement.

In further detail, the agreement underlines that international standardization takes precedence over national standardization (ISO and CEN 2016). ISO standards are simultaneously approved as a European Standards, and they are adopted by each CEN member. In addition, CEN members must withdraw any pre- existing conflicting national standards. For instance, ISO 9001:2015 Quality management systems—Requirements was automatically adopted as a European Standard (EN ISO 9001:2015) and nationally by member states such as Spain as a Spanish standard (UNE-EN 9001:2015).

The agreement also recognizes that the single European market may have particular needs, for example in the case of standards for which there is no international need currently recognized, or standards that are urgently required in the European Union, but which have a lower priority at international level (ISO and CEN 2016). In these cases, the agreement permits European standards to be made available for voting and commenting by all ISO member bodies at the enquiry and formal approval stages. This allows non-European ISO members to influence the content of European Standards and, where appropriate, to approve those standards as International Standards.

Furthermore, the Vienna Agreement provides three main modes of cooperation between ISO and CEN:

- By correspondence/exchange of information;
- By mutual representation at meetings;
- By parallel approval of standards at international and European levels.

Approximately 30% of CEN standards are developed under the Vienna agreement.

COORDINATION BETWEEN IEC AND CENELEC (FRANKFURT AGREEMENT)

In 2016, IEC and CENELEC signed the Frankfurt Agreement (IEC and CENELEC 2016), which confirms their "agreement on common planning of new work and parallel voting" that started in 1996 with the Dresden Agreement. The agreement has had a significant impact on the activities of these organizations, as around 80% of all European electrotechnical standards are identical to or based on IEC International Standards. Moreover, new electrical standards projects are jointly planned between CENELEC and IEC and, where possible, most are carried out at international level. For instance, the international standard IEC 62236-3-2:2008 "Railway applications – Electromagnetic compatibility – Part 3-2: Rolling stock – Apparatus" constitutes a technical revision and is based on the European standard EN 50121-3-2:2006.

The latest version of the agreement includes several updates that aim to simplify the voting processes carried out in parallel and to increase the traceability of international standards adopted in Europe thanks to a new referencing system.

GUIDANCE FOR THE REGIONAL OR NATIONAL ADOPTION OF INTERNATIONAL STANDARDS

ISO/IEC Guide 21 provides guidance on regional or national adoption of international standards and other international deliverables. It has two parts:

- Part 1: Adoption of international standards, and
- Part 2: Adoption of international deliverables other than international standards (i.e., Technical Specifications and Technical Reports).

This guide provides methods for the adoption of international standards (and other international deliverables) as regional or national standards. Furthermore, it defines a system for indicating the degree of correspondence between international standards and their national or regional adoptions. It also gives the rules for the adoption of international deliverables other than international standards, and provides indications for numbering regional or national standards that are identical adoptions of international standards (and other international deliverables).

ITU and ETSI have established a Memorandum of Understanding (ITU and ETSI 2016) where both SDOs have agreed to strengthen information exchange and cooperation, including:

- An iterative process where ETSI submits input documents to ITU study groups and other groups.
- The exchange of information on areas of mutual interest.

COORDINATION BETWEEN ISO AND IEC

ISO/IEC JTC 1 was formed in 1987 as a merger between ISO/TC 97 (Information Technology) and IEC/TC 83, with IEC/SC 47B joining later. The intention was to bring together in a single committee the IT standardization activities of the two parent organizations, in order to avoid duplicative or possibly incompatible standards. The mandate of JTC 1 was to develop base standards in information technology, upon which other technical committees could build. This would allow for the development of domain- and application-specific standards that could be applicable to specific business domains, while also ensuring the interoperation and function of the standards on a consistent base (ISO and IEC n.d.). ISO/IEC Joint Technical Committee 2 (JTC 2) was created in 2009 for the purpose of "standardization in the field of energy efficiency and renewable energy sources".

The guide for ITU-T and ISO/IEC JTC1 cooperation (ITU and ISO/IEC 2014) contains a set of procedures for cooperation between ITU-T and ISO/IEC JTC 1. It is written in an informal style, much like a tutorial, to be a practical, educational and insightful reference for both leaders and participants in cooperative work.

3GPP AS AN EXAMPLE OF INTERNATIONAL COORDINATION (3RD GENERATION PARTNERSHIP PROJECT)

3GPP is composed of ICT SDOs (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC), known as organizational partners, and provides its members with a stable environment to produce reports and specifications about mobile communication technologies, a field in constant evolution.

Once these deliverables are approved by 3GPP, each organizational partner adopts and publishes these deliverables with identical text. Furthermore, organizational partners take decisions on the creation or discontinuation of Technical Specification Groups, as well as the approval of their scope and terms of reference.

***Figure 3.6**: SDOs that are partners of 3GPP*

EXAMPLE

In the case of ETSI, 3GPP deliverables are adopted correspondingly as ETSI Reports or ETSI specifications through the following process. First, a new document is created by inserting the text of the 3GPP specification into the ETSI deliverable template. Second, the ETSI title page is added, including the specification title and code. Third, the administrative page, the ETSI Intellectual Property (IPR) information, the Foreword and the final history pages are added. Finally, the document is made available for free download from the ETSI website. When so requested by the European Commission, the document may be adopted as a European Standard (EN).

The organizational partners may invite other organizations as market representation partners in 3GPP. These market representation partners do not take part in the definition of specifications, but offer market advice to 3GPP to give 3GPP a consensus view of market requirements.

3.3 ADOPTION/TRANSPOSITION OF STANDARDS

3.3.1 INTRODUCTION

There are situations in which a standard may be transposed or adopted by a committee different to the one that produced it in the first place. There are cases when a de facto standard or a standard written by a consortium / industrial forum is published and endorsed with the same content by a recognized SDO. This may also happen when a marketing organization writes a testing specification to promote the market adoption of a standard. Furthermore, a standard may be referenced as technical content of a regulation. This section describes the cases that may occur and what type of documents may be concerned in this regard.

3.3.2 ADOPTION OF A DE FACTO OR INDUSTRIAL CONSORTIUM STANDARD

Industrial consortia are alliances of companies operating in the same domain that come together to prepare specifications for products that must be brought to market very quickly. They usually benefit from a lighter process and a lower level of consensus of document approval than the processes that traditional SDOs go through. In response to the rapid development of ICT systems, a large number of consortia has been created in this sector. Major industry players often consider consortia to be more efficient and more oriented towards the needs of the industry than the formal standards-setting process, which—according to them—depends on a cumbersome and time consuming wide consensus process. The time-to-market of their specifications is expected to be much shorter than those of the recognized SDOs.

Consortia specifications are different from other documents owned by a single company (for example, Windows as a Microsoft standard) in the sense that they are written by a community. In some cases, a consortium may ultimately prefer to have its specifications become formal standards, as this provides more confidence and ensures wider adoption by the market. It may bring a whole set of benefits to the developed technology, because it ensures that the specifications comply with quality rules, which are often tighter than what a private group may deliver.

Recognized SDOs have procedures for referencing and incorporating industrial technical specifications or collaborating in the development of standards with these consortia. These procedures guarantee that the fundamental principles set out in Section 3.1.5 are respected. After publication of the standards, it is possible to develop further versions as necessary due to technological evolution, which will be discussed within a larger group of stakeholders, thus fostering wider market adoption.

DEFINITION

THE PAS PROCESS

The Publicly Available Specification (PAS) procedure is a means to transpose a specification more rapidly into an international standard published by a recognized SDO. This mechanism has primarily been designed to enable JTC 1 to transpose specifications that originated from consortia into international standards.

The PAS procedure takes into consideration the fact that the publication is already developed at an almost final stage and approved by consensus at consortium level. The approval of the document by a technical committee is then set up at the recognized SDO. PASs are published by the SDO for immediate use. The standard benefits from the SDO's reputation as a provider of standards for global use and receives increased visibility. A PAS published as a standard is subsequently maintained and possibly evolved by the SDO that applied the procedure. The PAS process allows the document to be available to the market faster and in a lighter way than with the full, regular SDO process.

EXAMPLE

ETSI defines Publicly Available Specifications (PAS) for technical specifications developed by Standards Development Organizations outside ETSI. The ETSI PAS process (ETSI 2017) defines the procedures to adopt specifications written by industrial alliances as ETSI documents, namely ETSI Technical Specifications (TS) or ETSI Technical Reports (TR). It has already been applied to specifications from two different consortia, the Home Gateway Initiative (HGI) and the Car Connectivity Consortium (CCC), presented below.

Based upon the "Home Gateway" as a modular application platform, HGI developed a smart home architecture that enables applications to connect with devices on any home network interface. Following the closure of HGI in June 2016, TC SmartM2M handled the conversion of the three HGI specifications (HGI 2016) into ETSI TSs using the PAS procedure and published the three TSs in November 2016.

"HGI consulted closely with ETSI SmartM2M during the development of these key documents. This work complements our own work on smart appliances very well, and we are happy to integrate these HGI requirements into our family of specifications." (ETSI 2016c)

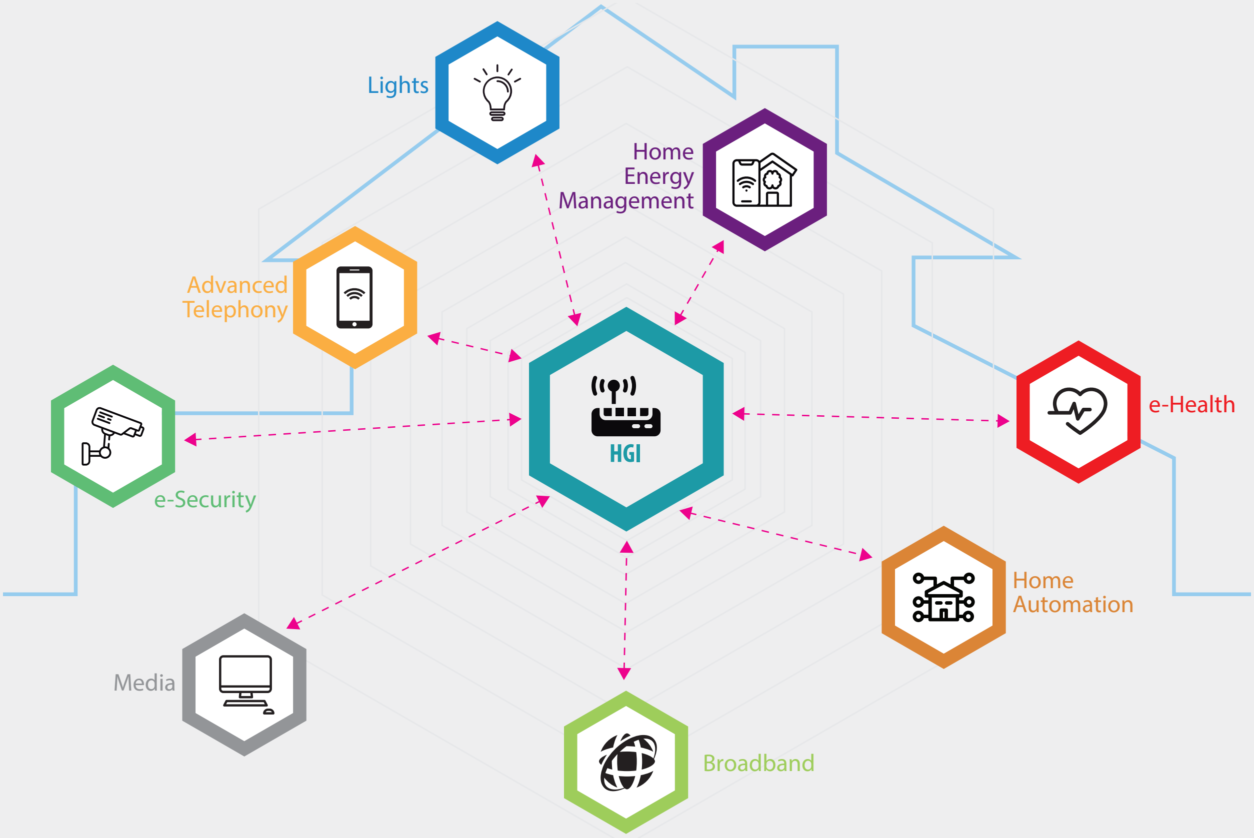

***Figure 3.7**: Overview of HGI use cases*

The CCC (CCC 2016) is a cross-industry collaboration including car OEMs, tier-1 suppliers, phone manufacturers and application developers, who create global solutions for smartphone and in-vehicle connectivity. Developed by the CCC, MirrorLink® is an open standard for smartphone-car connectivity that allows smartphone apps to be displayed on the In-Vehicle Infotainment (IVI) system.

MirrorLink® specifications were released through the ETSI PAS process and published as ETSI TS in October 2017. The addition of MirrorLink® to the list of ETSI standards is expected to facilitate implementation of the technology by manufacturers.

The PAS procedure is offered by ISO as well. The EnOcean Alliance (EnOcean 2017) created a wireless standard to develop self-powered wireless monitoring and control systems for sustainable buildings as well as energy harvesting solutions. The specifications of the Wireless Short-Packet protocol (WSP) for the IoT were later ratified as an ISO/IEC standard.

According to EnOcean, the international standardization is expected to accelerate the development and implementation of energy-optimized wireless sensors and wireless sensor networks, and to open up new markets and areas of application. Moreover, the EnOcean Alliance complemented the standard with dedicated equipment and generic profiles, which describe the data communication of products using the WSP protocol. Developers and manufacturers can therefore benefit from the Alliance's practical experience and years of user education. This has been documented by ETSI (2016).

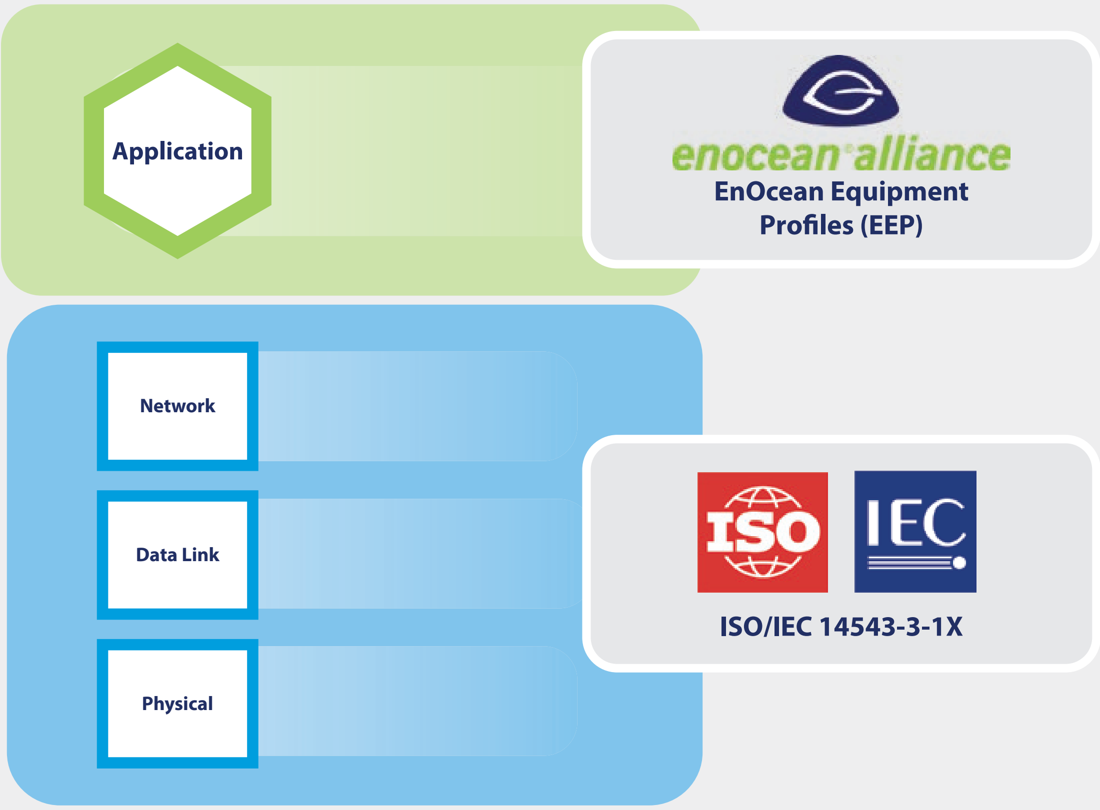

***Figure 3.8**: EnOcean Alliance standards*

Another case occurs when specifications from SDOs partnership projects are adopted as standards at regional level. This is the "mirror process". The partnership project produces Technical Specifications, which are transposed by relevant standardization bodies into appropriate deliverables and standards.

EXAMPLE

For example, the 3rd Generation Partnership Project (3GPP) and oneM2M are partnership projects including regional organizations, such as ATIS (USA), ETSI (Europe) and ARIB (Japan), as well as other related bodies. Both projects bring together telecommunications SDOs and regional organizations, which have signed a partnership agreement.

The mirror process means that, for example, 3GPP TS 23.401 version 14.7.0 Release 14 was published by ETSI as ETSI TS 123 401 V14.7.0 and oneM2M TS-0001 version 2.10.0 Release 2 was transposed as ETSI TS 118 101 V2.10.0.

3GPP is presented in more detail as a case study in Section 4.5.

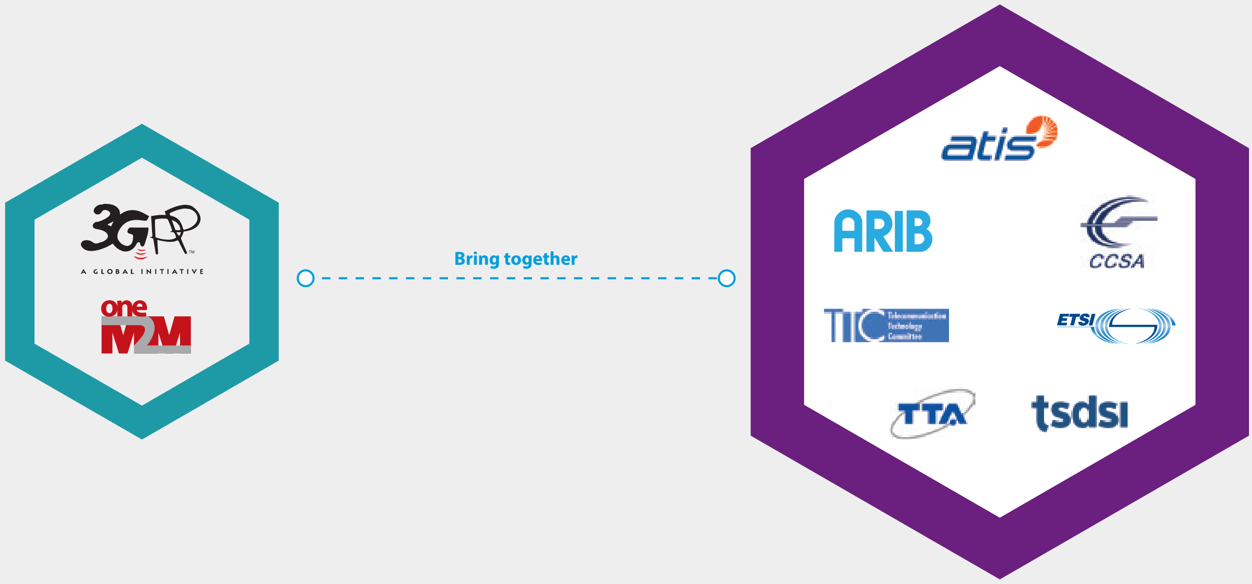

***Figure 3.9**: Link between 3GPP and its organizational partners. OneM2M has a similar model*

ISO/ IEC JTC 1 is another example of partnership between ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission). ISO and IEC technical committees collaborate in fields of mutual interest. ISO/IEC JTC 1 is a joint technical committee for the development of worldwide Information and Communication Technologies (ICT) standards for business and consumer applications. The standards produced are identified with both SDO names and can be obtained from either ISO or IEC catalogues.

3.3.3 EXTENSION OF STANDARDS BY MARKETING ORGANIZATIONS

In the reverse direction, standards are referenced by industrial alliances to build test suite specifications and promote the technology. Their objective is to provide specifications for testing, certification and other related elements of conformity assessment, and ensure that the products, services or systems implemented according to the initial standards meet the standards' requirements.

Conformity assessment activities act as an essential intermediary between standards and the products themselves. The produced test specifications describe the testing methodology used to assess the conformity as well as the conformity assessment process itself. Conformity assessment plays an important role in various areas, including safety control, government procurement, business transactions and product selection by consumers.

Different types of organizations operate third-party certification programmes, for example competent laboratories, trade associations, organizations composed of producers, and testing facilities. For critical products, they may need an accreditation from the regional or national authorities to be allowed to operate.

EXAMPLE

For example, the IEEE 802.11 standard was adopted by the Wi-Fi Alliance to develop the requirements and profiles for certification of WLAN products. The Wi-Fi Test Suite (Wi-Fi 2017) is a software platform designed to support the certification programme development and the certification of the devices themselves.

As another example, the Global System for Mobile Communications Association (GSMA) writes guidelines and specifications to help implementers use the ETSI standards developed by 3GPP. For example, the latest guidelines published address topics such as "Service Provider Device Configuration" (RCC 14 v5.0, published in June 2017), "Device Field and Lab Test Guidelines" (TS.11 v19.0, published in April 2017) and "Smarter Traffic Management" (IG.16, published in March 2017).

3.3.4 ADOPTION INTO/FROM REGULATIONS

A strong link exists between regulations, legislation and policies defined by local authorities at regional level, and standards. The authorities are regularly required to draft regulatory texts, in which they must define technical specifications to be complied with. They have the choice of developing their own specifications or using already existing standards. In the ICT domain, referencing standards avoids having to describe technical attributes such as requirements on performance indicator, on testing limits, etc.

Standards can be referenced in regulations to simplify their content, facilitate or reduce certain controls, and better enact laws. It helps to focus the regulations on public policy goals and requirements. Regulations can reference standards in several ways: by mentioning them implicitly or explicitly, with the title and with/without the date, and with an optional, privileged or binding reference. A standard that has been made compulsory becomes part of the regulation.

Moreover, standards may be subject to copyrights held by the SDO. It is thus better practice for regulations to only refer to the relevant standard and avoid citing parts of it.

REGULATIONS REFERRING TO STANDARDS

Regulations may refer to, use or impose standards and specifications.

The reference to standards and specifications concerns either the mandatory adherence to technical requirements, including the required implementation of standards and specifications, or these standards and specifications serve as references for mandatory essential requirements. In the latter case, the implementation of the referenced standards and specifications is optional, but the contained mandatory essential requirements must be met.

With respect to the corresponding legislation, regulations may then add further details and references to standards and specifications. Enforcement of specific regulations may be entrusted to and exercised by specific entities appointed for that purpose. Furthermore, a regulation may allow penalties and sanctions to be imposed with immediate effect if the regulation is not observed.

CATEGORIES OF STANDARDS SUITABLE FOR REFERENCES

Legislation and regulations may include references to the following types of standards:

- Harmonized standards, developed for this purpose, which are voluntary and carry with them the presumption of conformity: compliance with these standards is the recommended but not exclusive method to meet essential requirements, e.g. for CE marking.
- Other standards or specifications that may be recommended or imposed.

USE OF HARMONIZED STANDARDS

DEFINITION

A harmonized standard is a European standard developed by a recognized European Standards Organization: CEN, CENELEC, or ETSI, created following a request from the European Commission to one of these organizations.

Adherence to harmonized standards carries with it the presumption of conformity with essential requirements. Conformity to harmonized standards can be used to demonstrate that products, services or processes comply with relevant EU legislation: the use and correct implementation of these standards is assumed to be sufficient indication that the relevant essential requirements have been met.

However, implementation of these harmonized standards remains voluntary: manufacturers, other economic operators and conformity assessment bodies are free to choose other technical solutions, but then need to demonstrate compliance with the mandatory essential requirements.

The references of harmonized standards are published in the Official Journal of the European Union (OJEU); it is a precondition for legal validity of the harmonized standards and references to them, including the presumption of conformity. (EC 2018).

EXAMPLE

Radio Spectrum Regulatory Framework

Figure 3.10 illustrates the European Radio spectrum regulatory environment (ETSI-ECC 2016).

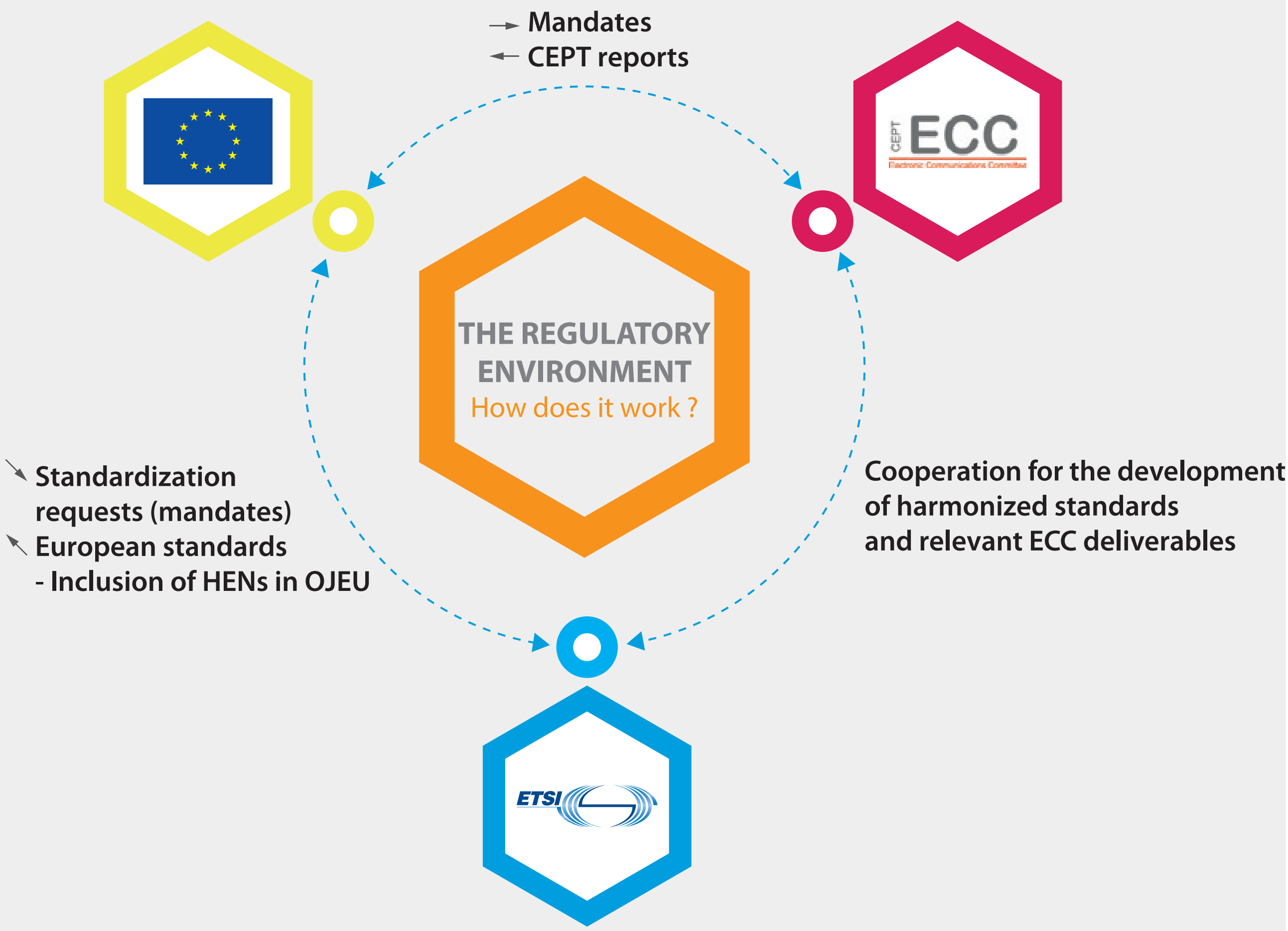

***Figure 3.10**: European radio spectrum regulatory environment*

The radio spectrum regulation framework is a typical example of this collaboration between authorities and SDOs. It associates three entities: the European Commission (EC), the Electronic Communications Committee (ECC) of the European Conference of Postal and Telecommunications Administrations (CEPT), and the ESOs: ETSI and CENELEC. The CEPT and the ECC bring together radio spectrum experts delegated by 48 countries, including the EU member states. One of the ECC's main objectives is to harmonize the efficient use of the radio spectrum across Europe.

- The EC, via its Radio Spectrum Committee (RSC), mandates the CEPT to conduct technical studies in order to develop technical measures related to the radio spectrum to be implemented at the European community level. Such measures may be specifications or other documentation on specific technologies and their application. For example, System Reference Documents advise on the need for an allocation of spectrum, in particular when either a change in the current frequency usage, or a change in the regulatory framework for the proposed band, is needed to accommodate a new radio system or service.
- ETSI, as an SDO, receives standardization requests from the EC. The appropriate ETSI working groups prepare standards to be approved as harmonized standards in collaboration with the ECC and specify how products can comply with the requirements of the EC and EFTA (European Free Trade Association, a regional trade organization and free trade area consisting of four European states: Iceland, Liechtenstein, Norway and Switzerland).
- The ECC/CEPT prepares CEPT reports in response to the mandates received from the EC.
- The application of harmonized standards referenced in the Official Journal of the European Union (OJEU) enables manufacturers and service providers to benefit from a presumption of conformity with the requirements of the EC Directives, and thus to be able to market their radio devices within the EU.

The Radio Equipment Directive (RED) (EU 2014) is a typical application of the regulatory environment described above. Its provisions have been applicable since 13 June 2016.

Any provider that wants to place transmitting or receiving radio equipment on the European market and operate it using the radio spectrum must meet the requirements of the relevant directives and regulations. In the EU, the manufacturer or distributor of a device bears full responsibility for placing it on the market. The RED specifies the requirements to be met by products with radio equipment in order to be sold and put into service.

Radio equipment covered by the RED is not subject to the Low-Voltage Directive (LVD) or the Electromagnetic Compatibility Directive (EMCD): the essential requirements of those Directives are comprehensively covered by the RED itself, with certain modifications with respect to the LVD and the EMCD. RED also applies to radiodetermination equipment: equipment that uses the propagation qualities of radio waves to determine its position; this includes systems that receive GPS signals.

The RED places additional emphasis on efficient and effective use of the spectrum: radio equipment needs to demonstrate its receiver and transmitter performance, as both are considered to affect the efficient and effective use of the spectrum. As a consequence, broadcast TV & radio receivers are now specifically included in the scope of the RED to ensure efficient operation.

Harmonized standards developed after the RED allow manufacturers to enter the market with a presumption of conformity.

EXAMPLE

CE Marking

"CE" is the abbreviation of "Conformité Européenne", or "European Conformity". The official term now used for labelling is "CE Marking" and is included in all EU official documents (EC 2018).

CE Marking is a requirement for products covered by this regulation entering the European Economic Area (EEA) and European Free Trade Association (EFTA) markets. It is not intended for use with products not covered by this regulation. It is forbidden to affix CE Marking to such products.

CE Marking identifies a product as complying with the health and safety requirements contained in European legislation (Directives). Once CE marked, a product or equipment can enter the EEA and EFTA markets.

The requirements of the CE Marking process are as follows:

- Identify applicable directive(s)
- Identify the harmonized standards concerned
- Verify the product's specific requirements
- Identify whether a conformity assessment by a notified body is necessary
- Test the product's conformity with the relevant requirements and, if necessary, have tests performed by a notified body
- Establish the required technical documentation
- Affix the CE marking and complete the Declaration of Conformity.

CE marking does not indicate that a product has been approved as safe by the EU or by another authority, neither does it indicate the origin of a product. Furthermore, CE marking does not automatically guarantee the parameters of individual product characteristics: manufactured products might deviate and not conform to the relevant requirements due to changes in the requirements, changes to the product or poor-quality production.

Due to the size of the combined EU and EFTA markets, CE marking has an influence that goes well beyond the market: for example, it is not uncommon to find CE marking on products (also) sold on the American market.

3.4 TYPES OF DOCUMENTS PRODUCED BY SDOS

This section explains the differences between types of standardization documents in terms of their scope and addressed stakeholders, whether they contain requirements (normative documents) or they simply provide information, as well as the process leading to their approval/publication. These types of documents are produced by most of the official SDOs. However, they may also be published by non-recognized SDOs. This section also deals with the organizations that are suitable for producing each type of document, and describes the definition/purpose of each type of document, which may differ across organizations. Finally, this section illustrates the main characteristics of each type of standardization document.

There are different types of standardization documents, which may differ in certain aspects, including:

- Their scope and addressed stakeholders.
- The absence or presence of requirements that could lead to certification.
- The process leading to their approval/publication.

In addition, the type of organization needs to be considered, as: 1) not all organizations are suitable for producing every type of document; 2) the definition/purpose of each type of document may differ across organizations.

Regarding their applicability to compliance processes, standards fall into two general categories: normative and informative (Hatto 2013). Normative documents contain requirements, which must be met in order to claim compliance with the standard. Requirements in a standard are usually worded with the term "shall", while recommendations are worded with "should". Informative documents do not contain requirements. Normative documents may include informative elements, but these must be clearly presented as such and may not contain requirements.

3.4.1 NORMATIVE DOCUMENTS

A standard is a document that contains requirements or recommendations that have reached wide consensus. Normally, for standards to be approved, they must first go through the comprehensive and rigorous procedures of the organizations publishing them.

- EN 301 893 5 GHz RLAN; Harmonized Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU

A specification is a document needed by industry in the short term concerning a technical aspect that is still under technical development, or where it is believed that there will be a future, but not immediate, possibility of agreement on a standard.

- Example: ISO/IEC TS 19841:2015 Technical Specification for C++ Extensions for Transactional Memory

3.4.2 INFORMATIVE DOCUMENTS

A technical report is a document with explanatory material about a topic.

- Example: ETSI TR 103 234 Power Line Telecommunications; Power line recommendations for very high bitrate services. This document investigates the capacity of several technologies to distribute streaming services from residential home gateways to set-top box and media servers.

A guide is a document used by standards organizations for guidance regarding how to handle specific technical standardization activities.

- Example: ISO/IEC Guide 71 Guide for addressing accessibility in standards
  - Guides standardizers on how to address accessibility when either producing new standards or revising existing ones
- Example: CEN-CENELEC and ISO-IEC Guide 17 for writing standards, by taking into account the needs of micro, small and medium-sized enterprises
  - This document guides standardizers on how to take SME needs into account, for instance by making standards "simple and understandable".

3.4.3 DOCUMENTS SPECIFIC TO CERTAIN ORGANIZATIONS

Some document types are specific to certain organizations, e.g.:

- ETSI Standard (ES): ETSI uses this kind of document for a standard that is submitted to the whole ETSI membership for its approval. (ETSI n.d.).
- CEN Workshop Agreement (CWA) is an agreement developed and approved in a CEN Workshop (CEN n.d.).
- ISO Workshop Agreement (IWA) is a document developed outside the normal ISO committee system to enable market players to negotiate in an "open workshop" environment (ISO n.d.).
- ISO Publicly Available Specifications (PAS) are published to respond to an urgent market need. They do not call for wide consensus involving all stakeholder groups, but only the consensus of the experts within a working group, or a consensus in an organization outside ISO. PAS are published for immediate use and serve as a means to get feedback for an eventual transformation into an International Standard (ISO n.d.).

3.5 NAMING CONVENTIONS FOR STANDARDIZATION DOCUMENTS

This section deals with the naming conventions of different SDOs, and shows how to extract and identify several characteristics of a document from its name, including the title, the SDO that published/adopted the document, the type of standardization document, whether or not the document belongs to a family of standards, whether it is a harmonized standard, the version of the standard, as well as the date/year the document was published.

The name of a standardization document may contain information about:

- The SDO (or SDOs, in the case of a joint publication) that published it.
- Other SDOs that might have adopted the standard after it was originally published.
- The type of document, for instance if it is an international, European or national standard, a specification, technical report, etc.
- Whether the document belongs to a family of standards.
- Whether it is a harmonized standard.
- The version number of the standard that indicates whether it is a draft or final version and informs whether the document adds major, technical or editorial changes to the previous version.
- The year of publication of the document.
- The title of the standard.

Some issues concerning naming conventions are significant. First, different SDOs have different naming conventions. Furthermore, different countries or regions may use different naming conventions, either for the formal standards published by the SDOs operating in that geographical context or for the standards adopted from SDOs with a wider scope, such as international standards. Finally, the names of standards may differ slightly depending on whether they are given directly by the publishing SDO (e.g. the standard itself or the institutional database) or by external sources, such as the standard's citations by a report or journal, which may have specific citation guidelines or restrictions.

EXAMPLE

EN 45502-2-3:2010 Active implantable medical devices—Part 2-3: Particular requirements for cochlear and auditory brainstem implant systems

What information can we obtain from this name?

- The "EN" prefix indicates that it is a European Standard.
- The code of the standard "45502-2-3" indicates that it includes the 2nd and the 3rd documents of a standard family ("45502").
- It was published in 2010.
- The family name is "Active implantable medical devices".
- The title of the standard itself is "Part 2-3: Particular requirements for cochlear and auditory brainstem implant systems".

The name of the standard does not tell us whether it was developed and published by CENELEC. Each European Standard is identified by a unique reference code that contains the letters "EN", without stating which of the three recognized European SDOs (CEN, CENELEC or ETSI) published it. Furthermore, the name does not provide any indication as to whether previous versions of this standard exist.

EXAMPLE

ETSI TS 102 412 V12.0.0 (2015-02) "Smart Cards; Smart Card Platform Requirements Stage 1" (Release 12)

What information can be obtained from this name?

- The "ETSI" prefix indicates that this standard was published by ETSI.
- The "TS" prefix indicates that it is a technical specification.
- The code of the standard is 102 412.
- This is version 12.0.0 of the standard (which is confirmed by the "Release 12" in the title). ETSI uses three numbers (x.y.z) to indicate its document versions. The first final version of a document will be Version 1.1.1. Subsequent final documents will increase the first number "1.x.x" of the version number (1.x.x, 2.x.x, etc.). While the document is under review, subsequent draft versions will increase "x.1.1", e.g., 1.2.0, 1.3.0, etc.
- It was published in February 2015.
- The document is part of the "Smart Cards" family of standards.

Nevertheless, it is not clear whether there is a unique code for this family of standards. In fact, ETSI allocates consecutive numbers to their individual standards, irrespective of whether they are part of a family or not.

EXAMPLE

ISO/IEC 27002:2013 Information technology—Security techniques—Code of practice for information security controls

What information can be obtained from this name?

- The "ISO/IEC" prefix indicates that this standard was published jointly by ISO and IEC, as part of the JTC 1 agreement.
- The code of the standard is 27002.
- This document belongs to a family of standards named "Information technology—Security techniques", the 27000 series. Another example of a document in this family is ISO/IEC 27005—Information technology—Security techniques—Information security risk management.

This is an international standard (IS), but this information is not explicitly stated in the title of ISO documents. Should the document belong to any other category (e.g. Guide, Specification, etc.), this would be made explicit in the document name (e.g. ISO Guide 82:2014 Guidelines for addressing sustainability in standards, ISO/IEC TR 14143-5:2004 Information technology—Software measurement—Functional size measurement—Part 5: Determination of functional domains for use with functional size measurement).

EXAMPLE

BS EN ISO/IEC 27002:2005 Information technology. Security techniques. Code of practice for information security management

What information can be obtained from this name?

- The "BS EN ISO/IEC" prefix indicates that this standard was first published by ISO/IEC, then adopted as a European Standard (EN), and then as a British standard (BS)

EXAMPLE

ETSI has produced several different versions of the ETSI EN 302 054 standard. Let's have a look at a subset of them:

- ETSI EN 302 054 V2.2.1 (2018-02) Meteorological Aids (Met Aids); Radiosondes to be used in the 400,15 MHz to 406 MHz frequency range with power levels ranging up to 200 mW; Harmonized Standard for access to radio spectrum
- ETSI EN 302 054 V2.1.1 (2017-10) Meteorological Aids (Met Aids); Radiosondes to be used in the 400,15 MHz to 406 MHz frequency range with power levels ranging up to 200 mW; Harmonized Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU
- Draft ETSI EN 302 054 V2.1.0 (2017-05) Meteorological Aids (Met Aids); Radiosondes to be used in the 400,15 MHz to 406 MHz frequency range with power levels ranging up to 200 mW; Harmonized Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU
- ETSI EN 302 054-2 V1.2.1 (2015-10) Meteorological Aids (Met Aids); Radiosondes to be used in the 400,15 MHz to 406 MHz frequency range with power levels ranging up to 200 mW; Part 2: Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU
- ETSI EN 302 054-1 V1.1.1 (2003-03) European Standard (Telecommunications series)

Electromagnetic compatibility and Radio spectrum Matters (ERM); Meteorological Aids (Met Aids); Radiosondes to be used in the 400,15 MHz to 406 MHz frequency range with power levels ranging up to 200 mW; Part 1: Technical characteristics and test methods

What information can be obtained from the names in the above list?

The standard was a European Standard (EN), and therefore a formal standard, since its first version was published. Version 2 of the document was approved as a harmonized standard, as it reads in the document title. Furthermore, the deliverable was originally a two-part standard, but in version 2 it became a single-part standard.

Regarding the different versions of the standard, and based on the version numbering system used by ETSI (ETSI 2016), we can say the following:

- There has been one major revision of the standard (from version 1.x.x to version 2.x.x). After an analysis of the document titles, we can conclude that this major revision included the transformation of the originally multi-part standard into a single-part standard.
- The first approved document for version 2 of the document was version V2.1.1, which has editorial differences to V2.1.0. According to its name, version V2.1.0 was only published as a draft, but it was not finally approved as an ETSI deliverable.
- After V2.1.1, V2.2.1 was published. There are technical differences between them.

3.6 CASE STUDY: THE REVISION OF A NATIONAL STANDARD ABOUT TELECARE, FROM THE ICT ACCESSIBILITY PERSPECTIVE

The UNE 158401 standard was approved in 2007 by UNE, the Spanish official SDO. The objective and scope section of the document reads as follows: "This standard specifies the minimum requirements and the level of service that the telecare service must meet, both in its domiciliary and mobile versions. This standard does not cover the requirements for the applied technology".

Public administration agencies in the country, usually local authorities, or regional government in the case of telecare provision, hire private companies through calls for tenders. These companies provide the telecare services and equipment to eligible end users. In the calls for tenders, the professional and technical standing of the companies are assessed against the telecare standard. There are several hundreds of thousands of citizens from that country who benefit from telecare to enhance their safety and wellbeing. Hence, the economic and social impact of this standard is significant.

In early 2016, nine years after the first version of the standard was published, the telecare committee decided to revise the document. By that time, the committee was composed of social representatives of the telecare arena, including public administration, service providers and manufacturers of telecare equipment.

The document was in need of an update, as both the service model and the technology had evolved quite a lot in recent years. At the time the revision began, telecare was much more advanced than it used to be; a single panic button now allowed the end user to make a hands-free phone call to request help from an operator. Existing technology and services can detect and alert users in case of fire, extreme temperatures, and user falls. It is also possible to identify and pick up on behavioural patterns that might indicate a deterioration of users' physical or cognitive abilities to live on their own. Furthermore, telecare is increasingly using IP and web technologies as a complement to traditional phone communications.

According to its scope section, the original version of the standard did not cover technology aspects of telecare. Stakeholders agreed that the standard should be revised to include requirements about technology aspects such us minimum battery life and the minimum set of events that should be detected and transmitted by telecare sensors, etc.

However, in this case study we focus on one single aspect of technology: the accessibility of telecare devices to citizens with and without disabilities. Considering that a significant percentage of potential beneficiaries of telecare have a disability, lack of accessibility requirements within the standard stood as a major barrier for the impact and quality of telecare services in the country.

Shortly before the revision of the telecare standard was agreed, standards and regulation on ICT accessibility were changing fast in the EU. The standard EN 301 549 V1.1.2 (2015-04) "Accessibility requirements suitable for public procurement of ICT products and services in Europe" had been approved in April 2015, following Mandate 376 issued by the European Commission. M376 asked the three ESOs (CEN, CENELEC and ETSI) to deliver "a European Standard specifying for all ICT products and services within each of the technical areas the corresponding requirements for accessibility". One year later, the European Parliament and the Council approved Directive 2016/2102 on the accessibility of the websites and mobile applications of public sector bodies. The Directive explicitly states that the content of websites that fulfils the relevant requirements of European standard EN 301 549 V1.1.2 (2015-04) shall be presumed to be in conformity with the Directive's accessibility requirements.

In parallel to what was going on in the telecare committee, the members of another standards committee on "ICT accessibility" learnt that the telecare standard was being revised. In fact, this was a combination of coincidence and informal communications among standardizers working in different committees. The two committees had not previously established formal contact, and therefore were not automatically notified by the SDO information system about each other's activities.

This committee on ICT accessibility was composed of accessibility advocates who were up to date on standardization and regulatory news on the subject of ICT accessibility in the EU. They realized that the revision process was a good opportunity to include requirements about ICT accessibility.

Regarding the accessibility inputs to the standard revision, the process can be summarized as follows:

- The ICT accessibility committee conducted desk research that revealed that there were not any European or International standards published specifically on telecare accessibility, except an ETSI Guide on human factors of telecare services (ETSI EG 202 487). Hence, EN 301 549 and ETSI EG 202 487 were used as the primary references to prompt comments for the revision of the telecare standard.
- The convener of the ICT accessibility committee was designated as the delegate in the telecare committee. Being a delegate means attending telecare committee meetings, introducing and negotiating the comments submitted, receiving automatic notifications on meeting schedules and minutes, as well as on updates to committee documents.
- The negotiations about accessibility requirements were long and complex. Especially in the beginning, the proposals to include accessibility requirements in the telecare standard: a) were not fully understood by the telecare professionals within the committee, b) entailed real challenges for the telecare manufacturers and providers participating in calls for tenders, as the services and devices would have to comply with the accessibility requirements, c) might imply higher costs for the public administrations funding the services.
- At the beginning of the revision process, a training session was held on the application of EN 301 549 accessibility requirements to telecare. The session was structured around real case studies submitted by telecare stakeholders (either public administrations or providers). The aim was to train delegates on the rationale of user-accessibility needs as well as on the technical solutions required to address them.
- The negotiations had to reach a consensus: Not all of the accessibility contributions were ultimately included in the telecare standard as requirements (i.e., with the term "should"). Those that were not achievable in practice for the industry at that time were included as recommendations (i.e., with the term "shall"). A further revision of the standard would transform recommendations into requirements when feasible.

In the end, the telecare committee considered that the accessibility contributions added value to the revised standard:

- More citizens with disabilities will benefit from telecare services, leading to a growing telecare market.
- By integrating ICT accessibility solutions into their products, telecare providers and manufacturers are innovating their service portfolio.

Relationship of the case study with the learning objectives of our materials (guidance information for teachers):

- Standards published by recognized SDOs are used as technical references in public procurement processes
- Standards need to be revised from time to time because of changes in technology and/or societal needs
- The relevance of the information contained in the "objectives and scope" section of standards
- Pros of open standardization:
  - Committees that are open to all stakeholders reflect the real needs of society in the standards they produce
  - Committees from different standardization areas may cooperate, provided that their activities are openly and publicly disseminated
  - Liaisons between different standardization committees and the use of information systems for notifications ensure effective communication among committees
- Cons of open standardization:
  - Reaching consensus takes time, especially when different stakeholders are represented in the committee
  - Different knowledge domains and backgrounds across committees may imply different "languages and cultures"
- Standardizers should be up to date on the most recent standards and regulations in their area
- Negotiation and communication are soft skills that standardizers should possess.

3.7 SUMMARY

This chapter provides readers with key concepts and examples to orientate themselves in the complex landscape of standardization.

First, it describes the main types of Standards Development Organizations (SDOs), as well as several classifications for the standards they produce.

Then, it describes the three major geographical scopes of SDOs (international, regional and national), as well as the need for coordination among these organizations, and the main agreements supporting that coordination. The case of coordination between European and national SDOs is described in detail. Finally, the naming conventions of the different organizations are analysed.

Furthermore, this chapter defines the main types of documents published by official SDOs. Normative and informative documents are defined, as well as the main types of documents within each of these two categories. Then, the chapter introduces some examples of document types that are specific to particular SDOs.

Regarding naming conventions, the typical information contained in a standard's name is described, and several examples are provided.

Finally, the chapter has shown how standards may be reused by other standards and official documents. Regional standards are transposed at national level, industrial specifications become formal standards, or they may serve as references for test and certification platform specifications, or for regulatory texts.

Key messages which should be retained from this chapter include:

- The standardization landscape is rich and complex, because of the variety of standards and the organizations producing them.
- From a geographical perspective, there are three major SDO scopes (international, regional and national). There is a justified need for coordination among these organizations and the treaties, which is supported through agreements supporting that coordination. The case of coordination between European and national SDOs, and with international SDOs, is especially relevant.
- In addition to geographical coordination, interoperability among industrial consortia and recognized SDOs is relevant.
- The names and codes of standardization documents provide readers with useful information, including the SDO that published/adopted the document, the type of standardization document, its topic, its code and family, its version and the publication date.
- There are a number of types of standardization deliverables. The most important classification is normative vs. informative documents. Then, each of these categories has other subcategories; some of them are particular to specific SDOs.

3.8 QUIZ

1 - RECOGNIZED SDOS ARE:

(See Section 3.1 for hints)

a) *Organizations with a sole mission to publish standards that are referenced by regulation.*

b) *Organizations that have been elected by the corresponding Parliament (e.g., National Parliament, European Parliament, etc.)*

c) *Public organizations that have been created by treaties.*

d) *Officially recognized by regulation systems as providers of standards.*

2 - FORMAL STANDARDS:

(See Section 3.1 for hints)

a) *Are also known as de facto standards.*

b) *Are produced by SDOs.*

c) *Are only published by officially recognized SDOs.*

d) *Are documents that companies and public organizations must comply with.*

3 - STANDARDIZATION REQUESTS FROM THE EUROPEAN COMMISSION:

(See Section 3.1 for hints)

a) *Are drafted by the European Commission after consulting social representatives.*

b) *Can be refused by the European SDOs, but this situation is quite rare.*

c) *Must be previously approved by each Member State.*

d) *Need to be ratified by the European Parliament.*

4 - STANDARDIZATION REQUESTS FROM THE EUROPEAN COMMISSION:

(See Section 3.1 for hints)

a) *Are translated into all the official languages of the European Union, and then approved as directives.*

b) *Are requests to the European Standardization Organizations to develop standards.*

c) *Are transformed into de facto standards by non-official SDOs.*

d) *Are transformed into de facto standards once their adoption is universal.*

5 - NON-OFFICIALLY RECOGNIZED SDOS:

(See Section 3.1 for hints)

a) *May have well-established procedures to ensure the quality of their standards.*

b) *Only produce private standardization documents.*

c) *Produce standards that may later be published by recognized SDOs.*

d) *Approve regulatory documents.*

6 - DE FACTO STANDARDS:

(See Section 3.1 for hints)

a) *Cannot ever become formal standards.*

b) *Have been previously approved by a public SDO.*

c) *Are conventions that have achieved a dominant position.*

d) *Usually have the characteristic of having been validated by the market.*

7 - THE CONCEPT OF DOMINANT DESIGN:

(See Section 3.1 for hints)

a) *Is the main topic of an ISO Guide that addresses the coordination of SDOs.*

b) *Is related to the key technological features that transform a document into a de jure standard.*

c) *Is always based on the best user experience of technology.*

d) *Is related to the key technological features that become a de facto standard.*

8 - EXAMPLES OF DE FACTO STANDARDS ARE:

(See Section 3.1 for hints)

a) *PDF.*

b) *Asynchronous communication.*

c) *ISO 9001.*

d) *HTML.*

9 - REGARDING PUBLIC AND PRIVATE SDOS:

(See Section 3.1 for hints)

a) *Only public SDOs may adopt de facto standards as formal standards.*

b) *Public SDOs are usually created by treaties.*

c) *Generally speaking, private SDOs are commercial companies that publish private standards.*

d) *Only public SDOs are eligible as recognized SDOs.*

10 - THE FOLLOWING ASPECTS REFLECT GOOD PRACTICES IN STANDARDIZATION OPENNESS:

(See Section 3.1 for hints)

a) *Consensus.*

b) *Mandatory compliance with standards.*

c) *Respect for the intellectual property of other SDOs.*

d) *Transparent, well-documented standardization processes.*

11 - THE FOLLOWING ARE PROS OF OPENNESS IN STANDARDIZATION:

(See Section 3.1 for hints)

a) *Institutions putting open standardization into practice never need to involve proprietary technologies when developing standards.*

b) *Civil society will participate in the development of standards more effectively.*

c) *More interoperability.*

d) *It is an effective tool for public administrations to tackle ICT lock-in.*

12 - THE FOLLOWING ARE CONS OF OPENNESS IN STANDARDIZATION:

(See Section 3.1 for hints)

a) *It may be harder to reach consensus.*

b) *At a certain point in time, SDOs developing open standards may need to involve proprietary technology, which implies complex debates on how to do so.*

c) *It increases the ICT lock-in effect in public administrations.*

d) *Privacy issues are not duly considered.*

13 - INDICATE WHICH OF THE FOLLOWING STATEMENTS ARE TRUE, REGARDING THE CLASSIFICATION OF ICT STANDARDS:

(See Section 3.1 for hints)

a) *The ITU-T Recommendation I.112. Vocabulary of terms for ISDNs belongs to the "terminology standards" category.*

b) *The standard ISO/IEC 24800-4 File format for metadata embedded in image data (JPEG and JPEG 2000) belongs to the "System management standards" category.*

c) *The UML specification belongs to the "Communication reference models" category.*

d) *The 802.3 IEEE Standard for Ethernet belongs to the "software and networking" category.*

14 - REGARDING VERTICAL AND HORIZONTAL STANDARDS:

(See Section 3.1 for hints)

a) *The ISO/IEC 27001 standards on information security management are vertical standards.*

b) *The ETSI GSM family of standards are an example of horizontal standards.*

c) *The smart grid standards belong to the category of vertical standards.*

d) *The standards applicable to the food and drink industry are horizontal standards.*

15 - REGARDING INTERNATIONAL, REGIONAL AND NATIONAL SDOS:

(See Section 3.2 for hints)

a) *Regional organizations may be represented in international SDOs.*

b) *National SDOs may not be represented in international SDOs.*

c) *Standards published by an official regional SDO cannot ever be adopted beyond the scope of the region where that SDO is officially recognized.*

d) *ISO and ITU are international organizations with a worldwide scope.*

16 - REGARDING COORDINATION AMONG DIFFERENT LEVELS OF STANDARDIZATION:

(See Section 3.2 for hints)

a) *International standardization takes precedence over regional standardization.*

b) *National standardization takes precedence over regional standardization.*

c) *Regional standardization takes precedence over national standardization.*

d) *Regional standardization takes precedence over international standardization.*

17 - REGARDING COORDINATION AMONG DIFFERENT LEVELS OF STANDARDIZATION:

(See Section 3.2 for hints)

a) *Agreements among the corresponding SDOs make it possible for approved international standards to be adopted as regional standards, and then as national standards.*

b) *Agreements tend to recognize that standardization at a narrower scope may have particular needs that need to be considered when adopting standards with a wider scope.*

c) *Approved international standards are usually adopted as regional standards, and then as national standards.*

d) *Approved national standards are simultaneously adopted as regional standards, and then as international standards.*

18 - ABOUT THE STANDSTILL CONCEPT:

(See Section 3.2 for hints)

a) *It is a process through which national standards are approved as international standards.*

b) *It is the process through which SDOs are officially recognized by the European Commission.*

c) *It entails an obligation for national SDOs not to take any action that could prejudice European standard harmonization.*

d) *It is a tool to support coordination between European and national standardization activities.*

19 - REGARDING THE PROCESS OF COORDINATION AMONG EUROPEAN AND NATIONAL SDOS:

(See Section 3.2 for hints)

a) *Once a European standard is approved, conflicting national standards are withdrawn.*

b) *First, national SDOs submit their contributions or national perspectives on the standard's topic and scope; these contributions inform the drafting of the first version of the European standard, which is undertaken by the European SDO.*

c) *European SDOs translate the approved EN into the languages of all of the nations where the standard is adopted.*

d) *First, a standardization group within a technical committee of a European SDO drafts the document, then national SDOs submit their votes and comments about the draft.*

20 - THE VIENNA AGREEMENT:

(See Section 3.2 for hints)

a) *Establishes that international standards are simultaneously approved as European standards.*

b) *Establishes that any pre-existing conflicting national standards must be withdrawn.*

c) *Recognizes that the European Single Market may have particular needs.*

d) *Was signed between ITU and ETSI, and underlines the fact that international standardization takes precedence over national standardization.*

21 - AS A RESULT OF THE FRANKFURT AGREEMENT:

(See Section 3.2 for hints)

a) *Around 80% of all European electrotechnical standards are identical to or based on IEC International Standards.*

b) *New electrical standards projects are jointly planned between CENELEC and IEC.*

c) *All European electrotechnical standards are identical to or based on IEC International Standards.*

d) *All European electrotechnical standards are identical to or based on ISO International Standards*

22 - WHAT IS THE PROCEDURE USED TO RELEASE AN INDUSTRIAL SPECIFICATION AS A FORMAL STANDARD?

(See Section 3.3 for hints)

a) *Adoption*

b) *Transposition*

c) *Publicly available specification*

d) *Regulation*

23 - WHAT IS THE AVERAGE PROPORTION OF EUROPEAN STANDARDS IN AN EU COUNTRY?

(See Section 3.3 for hints)

a) *Less than 10%*

b) *Between 10% and 50%*

c) *Between 50% and 90%*

d) *More than 90%*

24 - REGARDING NORMATIVE AND INFORMATIVE STANDARDIZATION DOCUMENTS:

(See Section 3.4 for hints)

a) *Normative documents contain requirements, which must be met in order to claim compliance with the standard.*

b) *Requirements in a standard are usually worded with the term "must".*

c) *Informative documents contain information and requirements.*

d) *The term "should" is used to include recommendations*

25 - THE NAME ETSI ES 201 873-11 V4.7.1 (2017-06) GIVES THE READER THE FOLLOWING INFORMATION ABOUT THE STANDARDIZATION DOCUMENT:

(See Section 3.5 for hints)

a) *It is part of a family of standards.*

b) *It is a European Standard.*

c) *It needs to be revised before June 2019.*

d) *It has been approved by ETSI.*

26 - THE NAME NF EN ISO/IEC 15416 AUGUST 2003 GIVES THE READER THE FOLLOWING INFORMATION ABOUT THE STANDARDIZATION DOCUMENT:

(See Section 3.5 for hints)

a) *It has been previously approved by ISO/IEC.*

b) *The document was originally approved as an International Standard, then as a European Standard, and then as a National Standard.*

c) *It is document 416 within the 15000 family of standards.*

d) *It was published in 2003.*

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3.9 GLOSSARY

- Alliance: Organization gathering companies operating in the same domain, which gather to achieve a common objective, e.g. the production of specifications for a specific technology.
- Directive (European Union): A directive is a legal act of the European Union that requires member states to achieve a particular result without dictating the means of achieving that result.
- Drafting: Iterative writing of the different clauses of a draft standard.
- Guide: Documents used by standards organizations for guidance on how to handle specific technical standardization activities.
- Specification: Set of rules that competing products must comply with to enable their interoperability.
- Standardization stakeholder: Parties impacted by the publication of standards, e.g., corporate organizations, user groups or national authorities.
- Technical body: Generic term designating technical committees, sub-committees and working groups that bring together delegates to produce standards.

3.10 LIST OF ABBREVIATIONS

- 3GPP: Third Generation Partnership Project
- AFNOR: Association Française de Normalisation (French Standards Association)
- ANSI: American National Standards Institute
- API: Application Programming Interface
- ARIB: Association of Radio Industries and Businesses
- ATIS: Alliance for Telecommunications Industry Solutions
- BIS: Bureau of Indian Standards
- BS: British Standard
- BSI: British Standards Institution
- C2C-CC: Car to Car—Communication Consortium
- CA: Conseil d'Administration (Administrative Board)
- CCC: Car Connectivity Consortium
- CE (Marking): Conformité Européenne (European Conformity)
- CEN: Comité Européen de Normalisation (European Committee for Standardization)
- CENELEC: European Committee for Electrotechnical Standardization
- CSC: Council Standing Committee
- CEPT: Conférence Européenne des Postes et des Télécommunications
- CWA: CEN Workshop Agreement
- DIN: German Institute for Standardization
- EC: European Commission
- ECC: Electronic Communications Committee
- EEA: European Economic Area
- ETFA: European Free Trade Association
- EM: Electromagnetic Compatibility
- EMCD: Electromagnetic Compatibility Directive
- EN: European Standard
- EPC: Evolved Packet Core
- ES: ETSI Standard
- ESO: European Standards Organization
- ETSI: European Telecommunication Standards Institute
- EU: European Union
- FIN: Finance
- FTC: Federal Trade Commission
- FTP: File Transfer Protocol
- GA: General Assembly
- GSC: Global Standards Collaboration
- GSMA: Global System for Mobile Communications (GSM) Association
- HEN: Harmonized European Standard
- HGI: Home Gateway Initiative
- HL7: Health Level Seven
- HTML: HyperText Markup Language
- IAB: Internet Architecture Board
- IANA: Internet Assigned Numbers Authority
- IASA: IETF Administrative Support Activity
- ICT: Information and Communication Technology
- I-D: Internet-Draft
- IEC: International Electrotechnical Commission
- IEEE: Institute of Electrical and Electronics Engineers
- IESG: Internet Engineering Steering Group
- IETF: Internet Engineering Task Force
- IM: Instant Messaging
- IPR: Intellectual Property Rights
- IRTF: Internet Research Task Force
- IRSG: Internet Research Steering Group
- IS: International Standard
- ISO: International Organization for Standardization

- ISO/IEC JTC 1: Joint technical committee 1 of ISO/IEC
- ISOC: Internet Society
- ISO/CS: ISO Central Secretariat
- IT: Information Technology
- ITS: Intelligent Transport System
- ITU: International Telecommunication Union
- ITU-T: International Telecommunication Union—Telecommunication Sector
- IVI: In-Vehicle Infotainment
- IWA: ISO Workshop Agreement.
- JTC: Joint Technical Committee
- LTE: Long Term Evolution
- LVD: Low-Voltage Directive
- M2M: Machine-to-Machine
- MoU: Memorandum of Understanding
- NIST: National Institute of Standards and Technology
- NSO: National Standards Organization
- OASIS: Not-for-profit consortium, the acronym stands for Advancing Open Standards for the Information Society
- OEM: Original Equipment Manufacturer
- OJEU: Official Journal of the European Union
- OMG: Object Management Group
- PAS: Publicly Available Specifications
- PAS (ISO): ISO Publicly Available Specification
- PASC: Pacific Area Standardization Conference
- PDF: Portable Document Format
- PT: Project Team
- RED: Radio Equipment Directive
- RFC: Request for Comments
- RSC: Radio Spectrum Committee
- SC: Sub-Committee
- SDO: Standards Development Organization
- SE: Standardization Expert
- SME: Small or Medium-sized Enterprise
- SPC: Strategy and Policy Committee
- Std: Standard
- TBT: Technical Barriers to Trade
- TC: Technical Committee
- TR: Technical Report
- TS: Technical Specification
- TSG: Technical Specification Group
- TV: Television
- UML: Unified Modelling Language
- UNE: Spanish Association for Standardization
- US: United States
- W3C: World Wide Web Consortium
- WCAG: Web Content Accessibility Guidelines
- WG: Working Group
- WI: Work Item
- WLAN: Wireless Local Area Network
- WS-Security: Microsoft Web Services Security specification
- WSP: Wireless Short-Packet (protocol)
- WTO: World Trade Organization

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4 THE PRODUCTION OF STANDARDS

LEARNING OBJECTIVES

Regarding the standardization scene, students should understand the development process and methodology for producing high-quality standards. Important concepts, such as consensus, and guiding principles, such as fairness, which are applied during the different phases of standard writing, are presented in this section. Students should be able to identify the most important management and administration bodies and roles in SDOs, such as the technical management board, chief executive officer, and the most important parties in the project organization, as well as in technical committees, for instance the chairman of a committee. By the end of the section, they should know how to initiate a new standard and how to become a member of an SDO.

As for the roles and competencies of a standardization expert, students should know and understand the most relevant skills that make an efficient delegate of a technical body (in the context of active participation in standardization). This section should serve as a basis for students to develop the necessary skills of a delegate.

When addressing the activities of a standardization expert, students should learn the main tasks that a standardization expert has to perform during standardization meetings, between standardization meetings and inside his company. They should know how to cooperate with different company departments (e.g. marketing, sales) to achieve the most out of standardization. Furthermore, students should understand the additional duties of a national SDO delegate.

The standardization scene

An example of a standardization process (e.g. CEN/CENELEC) will be provided, and all of the key stages, events and outcomes will be described by means of a timeline. The students will gain knowledge about the structure and organization of an SDO as well as all of the key internal players, together with their tasks and responsibilities. Concerning the standardization process, the composition of the working group (e.g. companies, academics, users and further external stakeholders) will be discussed. Further concepts such as consensus and other important guiding principles and rules in the standardization process are explained. In addition, other areas/concepts surrounding the standards development process (e.g. implementation, adoption, usage, technology and standard updates) will be explained.

Roles and competencies of a standardization expert

The notion of "standardization expert" is introduced as the general concept of an individual active in standardization tasks. The relevant technical competencies, experience and soft skills are discussed and linked to the tasks of a member of an organization actively participating in standardization. The tools used to execute these tasks are also introduced.

Activities of a standardization expert

The main tasks of a standardization expert are explained. These include e.g., coordination of internal and external standardization activities, preparation of draft documents and requests for national and international standardization together with subject matter experts (inside an organization), tracking and monitoring of external standardization deadlines, ensuring the approval of new standards, managing the internal repository of standards and the communication of the standardization work inside the company, quality management tasks, and improvement of all the processes in this area. These tasks are also discussed for representatives of organization types other than industry, such as academia researchers or national organization delegates.

4.1 INTRODUCTION

This chapter addresses several topics related to the development and methodology used to produce formal standards of high quality. It first sets the standardization scene by introducing the underlying code of good practice of formal standardization and the different criteria that should be satisfied to ensure the high quality of a standard. The process of producing standards is described in detail and illustrated with several examples of different methodologies, as well as the organization of SDOs that are responsible for providing a suitable environment. As standards are written by standardization experts, this chapter describes their roles in the standardization process as well as the technical and personal skills that enable them to carry out their daily tasks. Finally, this chapter presents the main activities and duties of standardization experts and how they interact with their peers, both inside the standardization group and within their own organization.

4.2 THE STANDARDIZATION SCENE

4.2.1 INTRODUCTION

A standard describes technical solutions, and its preparation strongly depends on organizational aspects and social ramifications. To prepare a good and fair standard, some fundamental principles and quality requirements should be respected. Some of them have already been described in Section2.4.2, "Main characteristics of a standard", for example clarity of the content. Nevertheless, other criteria should be fulfilled as well: openness, transparency, impartiality, consensus, relevance to market needs, and avoiding duplication and competition among SDOs. These criteria are presented in the first part of this section. Indeed, the implementation of standards is voluntary and all the above characteristics can help increase their level of adoption.

Different steps allow the comprehensive standardization of a technology, a function or a system. These steps are usually documented in either dedicated or more integrated documents. Such documents range from feasibility study reports to testing specifications. The production of a standard follows a well-defined procedure that may vary, depending on SDO policies. Generally, the procedure covers activities starting from inception and ending in the publication and maintenance of a document. These activities are described in the second part of this section.

SDOs are organizations with a well-defined structure designed to manage and administer the activities of their members. Becoming a member of an SDO requires a set of rules to be followed, which vary depending on the organization. The way SDOs are governed, including the internal organization of a technical committee, is described in the last part of this section. Knowledge of governance is essential for success in standardization.

4.2.2 CODE OF GOOD PRACTICE FOR THE DEVELOPMENT OF INTERNATIONAL STANDARDS

Standardization is based on a set of fundamental principles and mechanisms to foster the production of fair standards. These principles have been identified by the World Trade Organization's (WTO) Committee of Technical Barriers to Trade (TBT) (WTO 2000) and are fulfilled by the recognized SDOs. Other SDOs tend to apply these principles in their methodology as well. The principles cover notions such as openness, transparency, impartiality, consensus, efficiency, relevance, development, and coherence. Respecting these principles is especially important for standards to be referenced by regulations. This explains why authorities often prefer to mandate and use standards published by recognized SDOs, which fully adhere to these principles. Indeed, industrial alliances have their own set of rules and usually prefer the faster adoption of their specifications, as compared to SDO standards. Membership and participation of experts are restricted to a specific industry group (Jakobs 2008), which results in a lower level of enforcement of fundamental principles such as openness and transparency.

In the following sections, we describe these principles, policies and best practices. Furthermore, we give a broader view of how these principles may be circumvented to serve specific interests.

OPENNESS

As previously mentioned, open standards are made available to the general public and are developed (or approved) and maintained via a collaborative and consensus-driven process (ITU-T 2017b). Open standards facilitate interoperability and data exchange among different products or services and are intended for widespread adoption.

Openness also means that the standardization process is easily accessible to any interested stakeholder at all stages, from policy development and draft submission, to adoption and dissemination of the standards. The SDO work programme is published, together with the list of standards under development, and kept updated. New standard proposals announce their precise scope and objectives.

Industry fora/consortia may disregard this principle and have closed meetings and membership restricted only to companies with a specific industry interest. Access to the standards, whether under development or even approved, is then limited to paying members only. In contrast, recognized SDOs often offer access to their approved standards for a small fee or even for free.

TRANSPARENCY

Transparency is achieved if the draft standard is made available to all of the working group members throughout its development steps with sufficient time to give them the opportunity to submit comments.

Transparency implies that these comments will be collected, taken into account and discussed. Transparency also means that notification of standard proposals is given at an early stage, that approved standards are published in a timely manner after their adoption and that a monitoring system is set up to periodically verify the status of the different standards. The policies adopted for the governance and activities of the organization, as well as the rules of the standards development process should be easily available to all the members and users of the standard.

However, in real life, a standard may well be put forward for approval at very short notice, with little notification given to peer working group members, who are deprived of the opportunity to read and carefully analyse the document prior to its approval.

IMPARTIALITY

An impartial process is managed by a group of diverse stakeholders with varied interests so that the group avoids being influenced, for instance by funding or by an interest group.

SDO rules grant identical basic rights to all participants of standardization work, although special additional rights may be granted in specific cases. Any interested party directly or indirectly affected by the activity is able to propose a new standard, submit comments and contributions at any stage of the development process, and express its views or ask for the revision of an outdated document.

On this matter, Intellectual Property Rights (IPR), such as patents, are a very sensitive topic and recognized SDOs often require that known IPRs be declared as early as possible, in order to be able to take appropriate action, such as selecting another technology or ensuring fair and reasonable terms and licensing conditions for all implementers/users.

However, it might be possible for a standard is proposed purely to satisfy the interests of a particular supplier or governmental entity. Alternatively, a major player who dominates the market might be reluctant to have any standard at all and might try to slow down the process by adopting a difficult and demanding attitude.

EQUITY

A balanced standardization process is achieved if all representatives are allowed to express their positions and comments, and every representative's opinion is considered.

The development process does not favour the interests of a specific provider, country or region. The platform used for standards development is neutral and equally accessible to all parties. All interests are taken into account, whether they are private or public, economical, societal or environmental. Committee officials are required to adopt a neutral position in their tasks.

It might happen, however, that the valid opinion of a participant is noted and not further considered because it hampers the objectives of a specific interest group.

CONSENSUS

Consensus is obtained if a standard is approved by a large majority of the group of stakeholders. Every effort is made to reach unanimity. The views of all stakeholders are taken into account, even when they are diverging, and they generally agree to the resulting publication; no sustained opposition is expressed on a substantial issue. SDO development rules aim to reconcile conflicting opinions, including a fair mechanism for raising objections and enabling discussions until a large majority of the participants can achieve an acceptable compromise. Tough negotiations often occur in parallel and outside of official SDO meetings. In any case, consensus does not necessarily mean unanimity. Consensus may be achieved, for example, through a voting process. This depends on the SDO's established procedures.

In practice, actions might be taken to silence the objections of one or a group of stakeholders, for example by providing the final version at very short notice, which facilitates the adoption of a disputed standard. Groups of members might block approval by unexpectedly bringing many "rarely participating" members into a voting situation.

EFFECTIVENESS

Standards should be developed only when it has been proven that implementation is feasible and appropriate, based on existing technological capabilities. Standards requiring performance indicators from the technology or specifying interfaces between entities are considered more efficient than descriptive or design standards. Moreover, the high quality of standards ready to be published is checked by independent reviewers. Standards are revised when they become obsolete or have been identified as ineffective. In the worst case, they are marked as deactivated.

Some standards are, however, developed to describe an emergent technology, which is not yet mature, but whose supporters want to reach the market early and prevent the development of other competing technologies. Because the future market and market positions are still unclear, economic interests may favour ambiguities in that standard. It is thus good practice, when drafting a standard, to validate it with experience from a few implementations and testing events.

RELEVANCE

Relevance means that the standard responds to regulatory and market needs. Fair standards enable implementation by different providers and enable competition in the market. They do not try to distort the global market and do not prevent innovation and future evolutions of technologies. Impact risk assessment studies may help determine whether adverse effects can be expected. At the SDOs, IPR policies ensure transparent procedures and strategy plans are periodically revised to analyse and follow the market evolution and their stakeholders' needs.

Nevertheless, it might happen that a stakeholder tries to develop a standard to consolidate its position in the market. Furthermore, so-called "patent hold-up" may occur when the owner of a patented technology, necessary to implement a standard, starts claiming ownership and fees after the approval and publication phases are completed. In a published case, two sub-committee officers provided a misinterpretation of the standards, which weakened the competitiveness of one of the providers. In the US, the Federal Trade Commission (FTC) has identified examples of standards and certification documents that had the effect of restraining trade or deceiving customers (Breitenberg 2009).

DEVELOPMENT

According to the development principle, the standardization process is open to all interested parties and encourages the participation of developing countries. For example, the SDO Secretariat provides additional technical assistance and capacity to contribute to the concerned delegates. The standards are neutral and do not favour characteristics of specific countries or regions when different needs exist in other parts of the world. Another important point is that the process remains market driven rather than regulatory driven and does not fulfil the needs of a specific national authority.

However, it might happen in practice that, as recognized by the "Technical Barriers to Trade" (TBT) agreement (WTO 2000), technical regulations and standards are published to protect domestic industries.

COHERENCE

When respecting the coherence principle, the work programme of an SDO and its committees avoids duplicating the work of another SDO. The standardization contributes to the coherence of the market and prevents the introduction of a solution that conflicts or overlaps with the standards developed in another SDO.

In this regard, collaboration and cooperation rather than competition with other SDOs is essential. Coherence also means that national SDOs do not develop their local standards in parallel to a regional organization. In Europe for example, this process is called the "standstill" (CEN 2017). Cooperation can be established at different levels, such as liaison or exchange of information between committees and/or sub-committees (see Section 4.2.5), or creating a collaborative team shared by the two SDOs or coordination groups where work programmes are exchanged and discussed. Partnership projects are yet another instance of such cooperation. The projects coordinate the activities of regional SDOs and industry consortia. The best-known example is 3GPP, which produces standards for mobile communications (see Section 4.5).

However, it might happen in the practice of standardization that SDOs or consortia are requested by competing interest groups to work in parallel towards standards for technologies targeting the same market. They claim to rely on the market to select the "winning" one, but in reality, they fragment it and hinder its development. Furthermore, a large number of industrial consortia have been or are being created in the ICT domain, which is evolving at a fast pace. Coordinating their work, in parallel to the activities of the recognized SDOs, represents a huge challenge.

EXAMPLE

For example, the Global Standards Collaboration (GSC) group annually brings together the world's leading telecommunications and radio standards organizations to share work programmes and other information in a number of technical areas.

EXAMPLE

In the US, many private and public SDOs are active in all types of ICT domains. NIST is a federal agency, of which one of the missions is to promote innovation and competitiveness. On the other hand, ANSI serves as the coordinator of the private sector standardization system. Both organizations have signed a MoU, which defines their respective roles and their cooperation objective to strengthen US standards.

Finally, recognized SDOs must guarantee the viability and stability of the standardization process and of their IT infrastructure in the long run, even at times of budget restrictions. They have to handle large volumes of data, documents, delegates and communications. They have to ensure proper funding, while enforcing fundamental principles such as openness and impartiality through balanced governance rules.

4.2.3 CRITERIA FOR PRODUCING GOOD STANDARDS

A standard specification is made up of a set of requirements, which guarantee compliance of the products that implement the standard. Adhering to the main principles of standard development presented in the previous section directly impacts the requirements introduced in the standard specification. Poorly written standards can cause additional transaction costs, reduce product safety and quality, and create barriers to trade (Breitenberg 2009). They can also constrain innovation, entrench inferior technologies, and prevent the development of interoperable products and systems. Accordingly, high-quality standards should fulfil the following set of criteria for the requirements they contain:

- The requirements are necessary. They specify only what is required to implement and meet the standard's objectives, rather than how to achieve them. They do not impose a particular approach to implementation and rather permit the development of a variety of competing implementations of interoperable products or services.
- The requirements are unambiguous. They are technically credible and it is impossible to interpret the normative parts of the standard in more than one way. Rationale statements may be associated with the requirements to explain the criteria used in their development and provide relevant information to the developers.
- The requirements are comprehensive and accurate. This is also called inclusiveness. The requirements are of high quality. They contain all the information necessary to understand their meaning, either directly or by reference to other documents.
- The requirements are precise. They are expressed clearly and concisely, written in plain language, without unnecessary details that might confuse readers and hinder implementation.
- The requirements are well structured. The individual elements of the requirement are all included in an appropriate manner and are easy to read and understand. Normative (i.e. prescriptive) parts are clearly differentiated from informative (i.e. descriptive) parts of the standard. Designated keywords indicate the different requirement levels.
- The requirements are consistent. There is no contradiction among the different requirements within the standard, nor with any other related standards.
- The requirements are validated by prototype implementations and are testable. There are clear and obvious means of devising a test to demonstrate that an implementation complies with the requirements.
- The requirements are open. The standard is available to the general public and is developed, approved and maintained via a collaborative and consensus-driven process. Policies should ensure that patented technology or copyrighted material has been declared and is accessible in a fair manner.
- The requirements are up to date. The standard is well-maintained and supported by the responsible committee. Maintenance, evolution or withdrawal needs are regularly assessed.

4.2.4 THE PROCESS OF PRODUCING STANDARDS

This section first presents the different steps for the standardization of an ICT system. A system made of several entities typically requires the publication of several standards, including technical reports, functional specifications, interface specifications and testing specifications. The section later focuses on the different steps involved for the production of one standard.

The exhaustive standardization of an ICT system usually follows a well-proven methodology that includes several stages, first described in ITU Recommendation I.130 (ITU-T 1988) and shown in Figure 4.1 below.

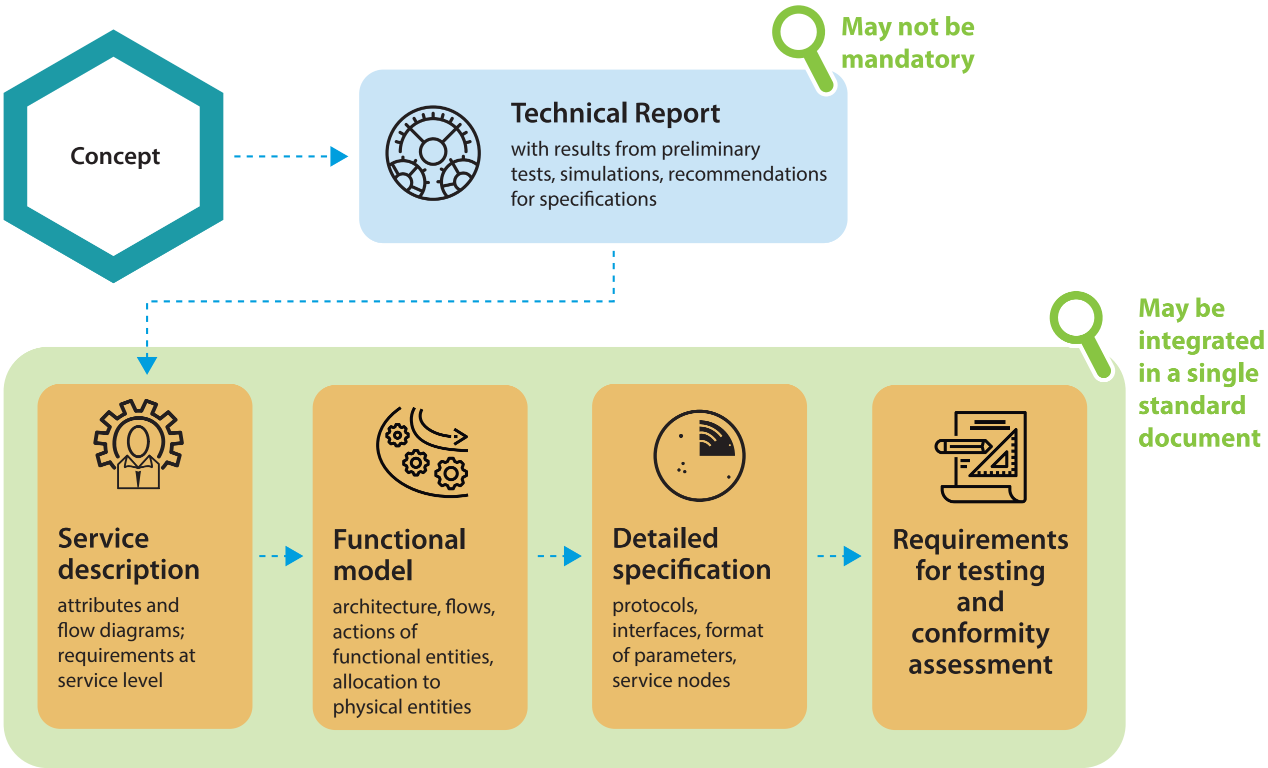

***Figure 4.1**: Typical methodology for the standardization of an ICT system*

The purpose of the ITU Recommendation is to provide a method for the development of protocol and service standards as well as to define the network capabilities needed. It promotes a systematic development process. Its main objectives are to give a common framework and tools to be adopted for the service description and to show how protocols and network resources for providing such services can be defined. The design process is divided into three stages of activity, typically resulting in a corresponding series of specifications.

Stage 1 is a general description of the service and objectives from the user's perspective but does not go into detail about the human-machine interface itself. It includes a description of the service in terms of the perceptions of users receiving or involved in the service, a static description of the service using its attributes, and a dynamic description of the service using flow charts, e.g., presenting all the information that is sent to and received by the user, from activation to completion of the service.

Stage 2 develops a functional model to meet those objectives. It identifies the architecture and functional capabilities as well as the information flows needed to support the service as described in stage 1. A functional model is derived for each service element. The functions required to provide the service are grouped into functional entities. Information flow diagrams are created for successful operation and may be drawn as appropriate for other cases. The semantic meaning and information content of each information flow is determined. The actions performed within a functional entity are represented as a list or as a sequence of functional entity actions. The functional entities and information flows identified in previous steps are allocated to physical entities.

Stage 3 develops a specification of the detailed implementation requirements. The information flows obtained from stage 2 form the basis for producing detailed specifications, including the messages needed to support these information flows as well as their detailed message elements and procedures. Stage 3 clearly lists the requirements applied to each specific function (functional entity actions).

Moreover, it is common practice to publish test specifications or conformance test suites for each of the standards developed in stage 3, directly derived from the requirements in the standard. They are particularly helpful for the specification developers and need to be available by the time the standard is implemented in commercial products.

Later groups have added a preliminary stage to the ITU Recommendation, consisting of a technical study to evaluate the different options for and feasibility of the features to be developed, using results from the preliminary proof of concept and simulations, and to provide recommendations for the system to be standardized. The ITU Recommendation has been taken as a reference by many groups developing ICT systems.

STANDARDIZATION PROCESS, FROM INCEPTION TO PUBLICATION

The development of a standard follows a well-defined procedure that can be more or less formal depending on the type of organization. For instance, a standard developed by an industrial alliance is often written and published faster than a standard produced by a recognized SDO. Some SDOs (e.g. ISO) distinguish the phases in the standards development process by attributing tags to documents to indicate their degree of maturity.

The main phases of this procedure were introduced in Section 2.4, which provided an overview of the standardization process. There are five phases: inception, conception, drafting, approval and maintenance. These phases are presented again in Figure 4.2 below, which is reproduced from Chapter 2. The following section explains the top-down approach for the standards development phases. The bottom-up approach is presented in the IETF example, followed by a description of other possible models, based on an object-oriented approach or on implementation.

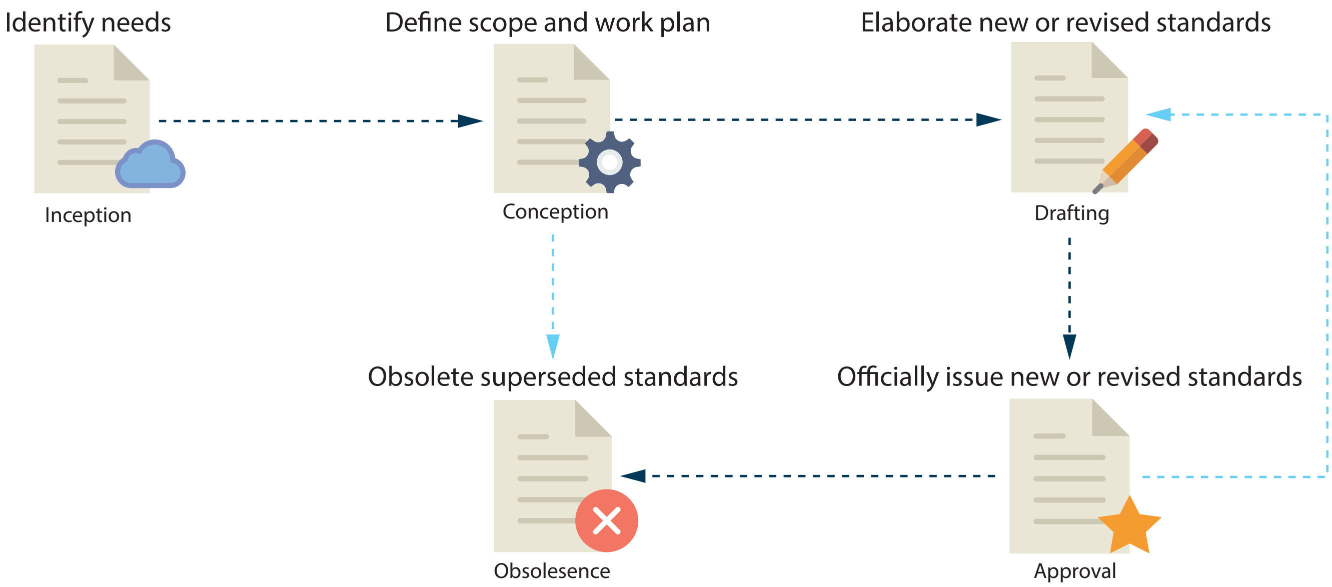

***Figure 4.2**: Overview of the standardization process*

PHASE 1: INCEPTION TO IDENTIFY NEEDS

The process starts when a group of SDO members identifies the need for a concept or process to be standardized, or for a standard to be updated. They find other interested delegates who can help focus the scope and convince the committee that the project is worthwhile. In effect, a standard is a result of the collaboration and consensus of a group. The tasks related to the proposed standard need to be identified and submitted to the relevant committee. The state of maturity of the technology to be specified has to be verified. A standard produced too early for an emergent technology may quickly become out of date because there is little certainty about how the technology will develop, and the scope cannot be precise enough, whereas a standard that is published too late risks being ignored in favour of earlier, competing standards or proprietary solutions.

PHASE 2: CONCEPTION TO DEFINE THE SCOPE AND WORK PLAN

The group of initiators submits the proposal for new standardization work to the best-suited technical body, using the appropriate form, and tries to trigger its interest. It prepares a document with a proposal including a clear scope describing the purpose of the target document, an estimated schedule with realistic milestones to track its progress, a named Standardization Expert (SE) who is knowledgeable about the topic and put forward as document editor or rapporteur, as well as a sufficiently complete list of committed supporting members. The presentation of the project includes insights on the proposed work and its technical content.

The committee endorses the proposal as a work objective if it considers that the standard is really valuable, or objects to the continuation of the process if certain criteria are not met. Once approved, it carefully considers how to pursue the work, particularly which sub-committee or project team will be in charge and what type of standard to create, based on the relevant information received. A new Work Item (WI) is then included in the committee and in the SDO work programme.

PHASE 3: DRAFTING TO PREPARE THE NEW OR REVISED STANDARD.

The rapporteur prepares an outline of the document, describing all of the sections, i.e. the structure of the final document. S/he distributes the work among contributors, who volunteer to write the clauses of the outline, and later collects the contributions from interested organizations. The different contributions are gathered in a draft standard, which should reflect the group's decisions.

Specific drafting meetings may be needed to review and discuss details of the content. An early review of the outline and of the draft document may be used to identify and solve potential conflicts at an early stage. Successive versions are circulated until the delegates agree on the content. IPRs should also be declared at an early stage to ensure that the standard is developed with a technology that is fairly accessible to all implementers.

Test development, implementations, prototypes and field tests of the standard should be run in parallel to its drafting. Implementers can then provide useful feedback about the standard to its developers, including extensions, guidelines and best practices to avoid inconsistencies and ambiguities. Some SDOs organize interoperability events, where providers interconnect prototypes and check for inconsistencies as well as conformance to requirements. The more stable the standards are, the more valuable they are and the more suited they are to repeated use.

At this stage, the draft usually remains internal to the sub-committee or project group and is not distributed or published externally, but this depends on the SDO. Milestones are periodically and carefully screened to ensure that deadlines are respected, in order to meet the market needs and keep the resources spent at a reasonable level.

PHASE 4: APPROVAL TO ACHIEVE CONSENSUS ON THE DRAFT STANDARD.

When the draft is ready in a stable form, it is circulated within the sub-committee for comments. Raised issues may be tracked separately to monitor their resolution. Change requests and comments are analysed and evaluated, and their follow-up is integrated into the document. Resolution meetings and an iterative process may be needed to achieve agreement on the content of the draft.

The final version of the draft is submitted for approval to the sub-committee and, if applicable, shared with the parent committee. A period of time (often called ballot) is allocated to the committee members to review the latest version of the document and make their decision: approve, comment, oppose or abstain. The final approval decision can be obtained during a meeting or using electronic tools. The objective is to reach a unanimous agreement or, if not possible, at least consensus. If this cannot be achieved either, a vote is organized, while the sustained opposition from some of the committee members is recorded for later referral.

Once approved, the draft is sent for final editing and quality check procedures. The final editor ensures correct formulation and presentation of the text in accordance with the SDO rules, including linguistic quality. Only editorial corrections are made at this stage, in collaboration with the rapporteur and selected members of the drafting group. No technical updates can be made. Once this is achieved, the document is sent for publication as a standard.

PHASE 5: STANDARD MAINTENANCE TO UPDATE, EVOLVE OR WITHDRAW STANDARD CONTENT.

Standards have to be kept updated in order to ensure that they remain relevant in the context of changing market or regulatory needs, and new scientific and technological developments. This is an important part of the viability of a working standard. Some SDOs trigger an automatic review of the validity of the standard after a pre-defined period, for instance every five or ten years. Corrections may be needed at different levels. Such corrections may include technical or editorial corrections of inconsistences, issues in the concept or content of the standard, extension of the standard's domain of use, and evolution of the technology and/or of other standards in the committee or in peer technical bodies.

If the need for corrections or maintenance of the standard is identified during the review or because flaws are discovered, the whole process is restarted to publish an amendment, update the standard, create a new standard, withdraw an obsolete standard, or downgrade the current standard to an inactive status. If the standard is referenced in a regulatory text, the procedure takes into account the transition period required to amend the reference.

EXAMPLES

Example of the CEN/CENELEC Standardization process

The standardization process at CEN/CENELEC is a typical application of the top-down standards development approach described in the previous paragraphs. The different phases are identified as: proposal from relevant national members, technical bodies, the EC or the EFTA secretariat; drafting and consensus building; public enquiry from national members and partner organizations, followed by a formal vote; consideration of comments; approval and final ratification; and finally, publication of the standard and announcement for national endorsement (see Figure 4.3 below).

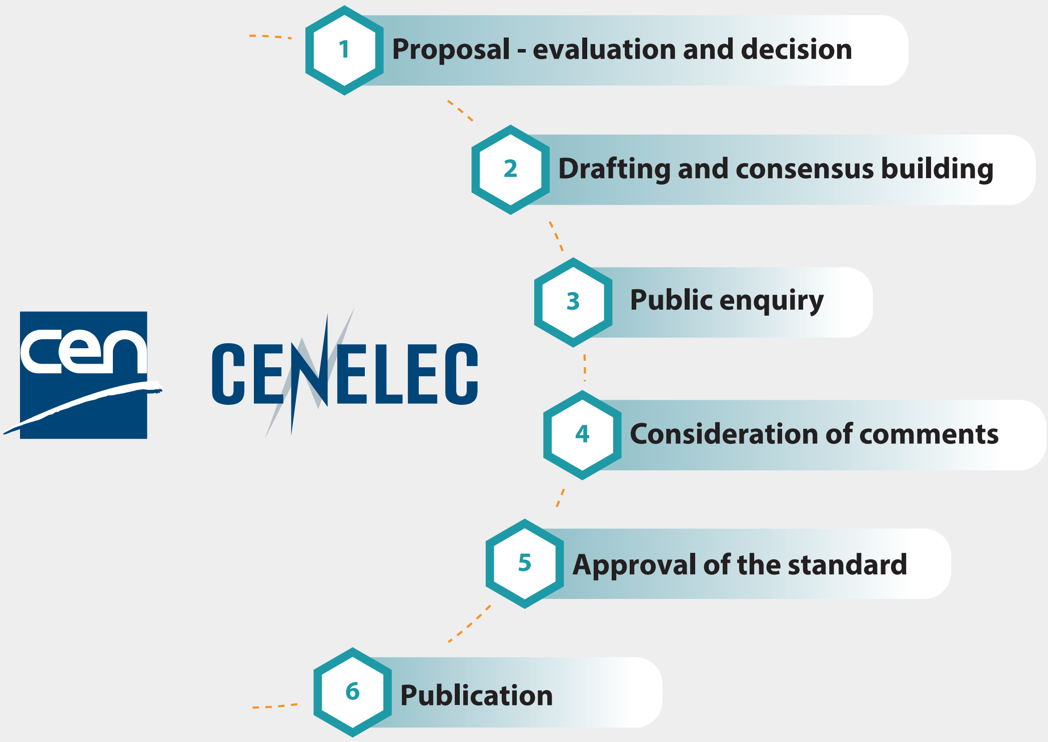

***Figure 4.3**: Standardization process at CEN/CENELEC (CEN 2016)*

Example of the ETSI standards development process

The key phases of the ETSI standards development process are described in ETSI (2013) and consist of the following steps: a) create a Work Item; b) develop the draft standard; c) validate the draft; d) submit the draft for editorial checking; e) approve and publish the standard; f) maintain and evolve the standard.

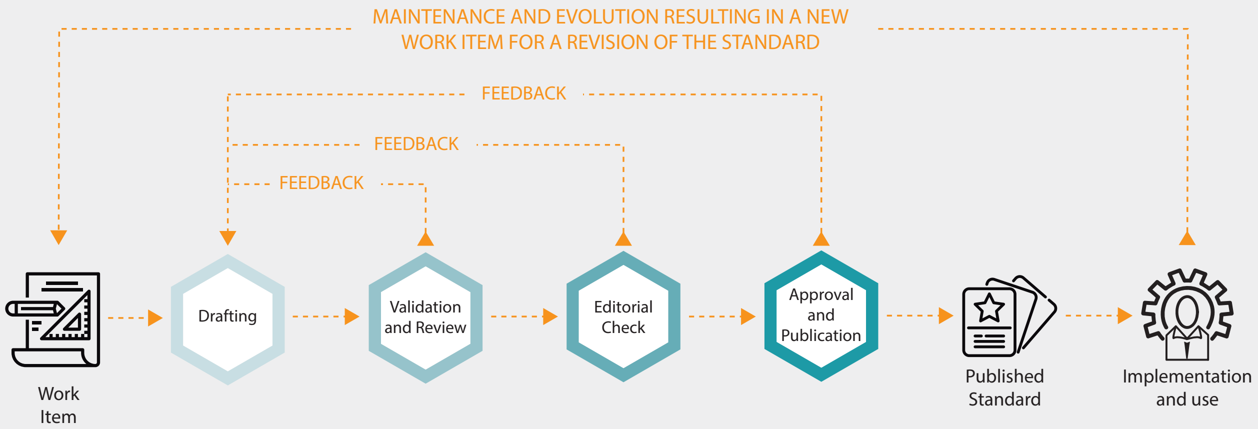

Figure 4.4: *Standardization process at ETSI (ETSI 2013)*

Example of the IETF development process: getting an RFC published

The IETF adopts a bottom-up process (IETF 2012; IETF 2015) where new proposals are submitted as drafts by individuals. An Internet Draft (I-D) can be either a WG draft or an individual submission. WG drafts are usually reviewed by the WG before being accepted as a WG item, although the chairs have the final decision. When agreed after the "WG Last Call", the draft is sent to the Internet Engineering Steering Group (IESG) for further updates. It is submitted for review to the entire IETF community, which triggers discussions on remaining issues and their solutions. After approval, it is published as an RFC by an organization named RFC Editor.

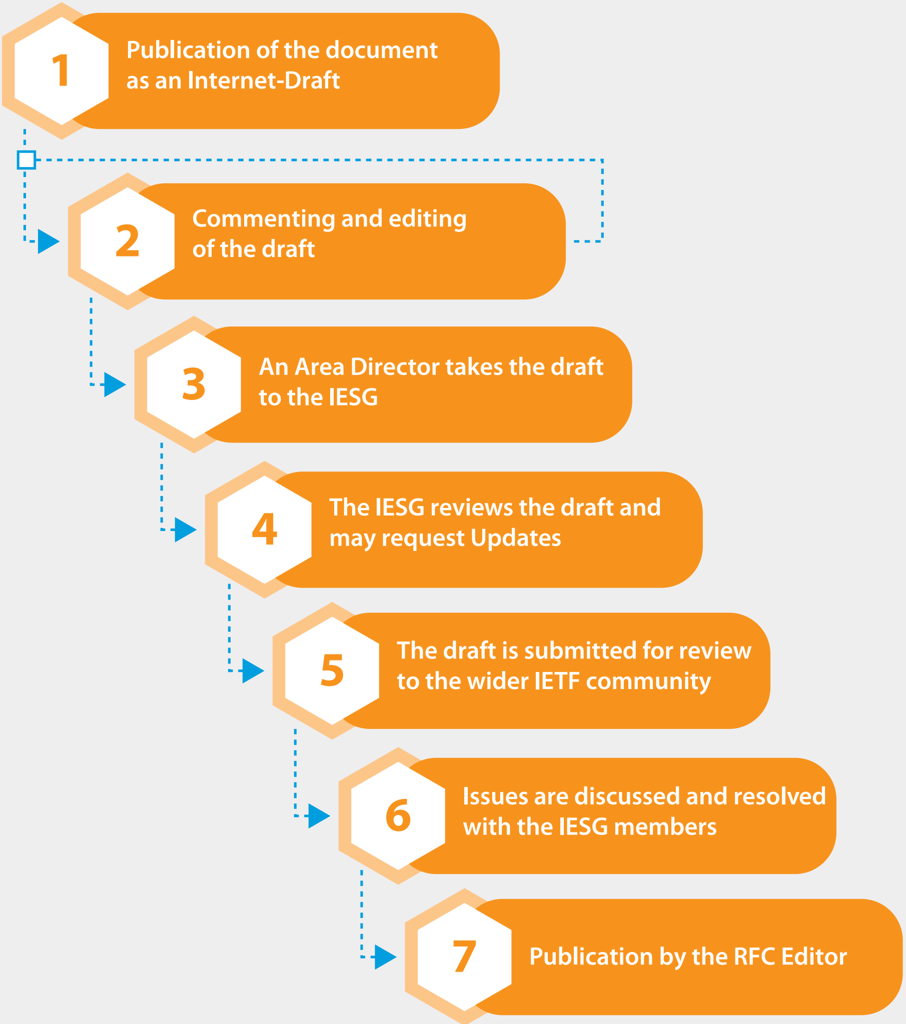

Figure 4.5*: Standardization process at the IETF*

Example of Health Level Seven (HL7)

HL7 is an international community of experts in healthcare subject matter and information scientists collaborating to create standards for the exchange, management and integration of electronic healthcare information. It was established to develop a protocol for the exchange of healthcare information in clinical settings. HL7 adopts a different process based on the object-oriented development of information models. Figure 4.6 below shows the diagram of the primary models and development steps specified by the HL7 Version 3 Message Development Framework (Beeler 1998).

The first model developed is the Use Case Model, which identifies actors and events as well as how they behave in specific use cases. It enables the identification of the key concepts, subject classes and relevant states, which are described in the information model. This is a critical element of the process, as it is based on a single reference model shared by all the HL7 standards. The information model is used to create an Interaction Model, which specifies the sub-systems that communicate using HL7 messages and how they interact. Finally, the Message Design Model specifies the message format needed to meet the interaction requirements. The development process is cyclical, as different models developed are refined and new features are introduced.

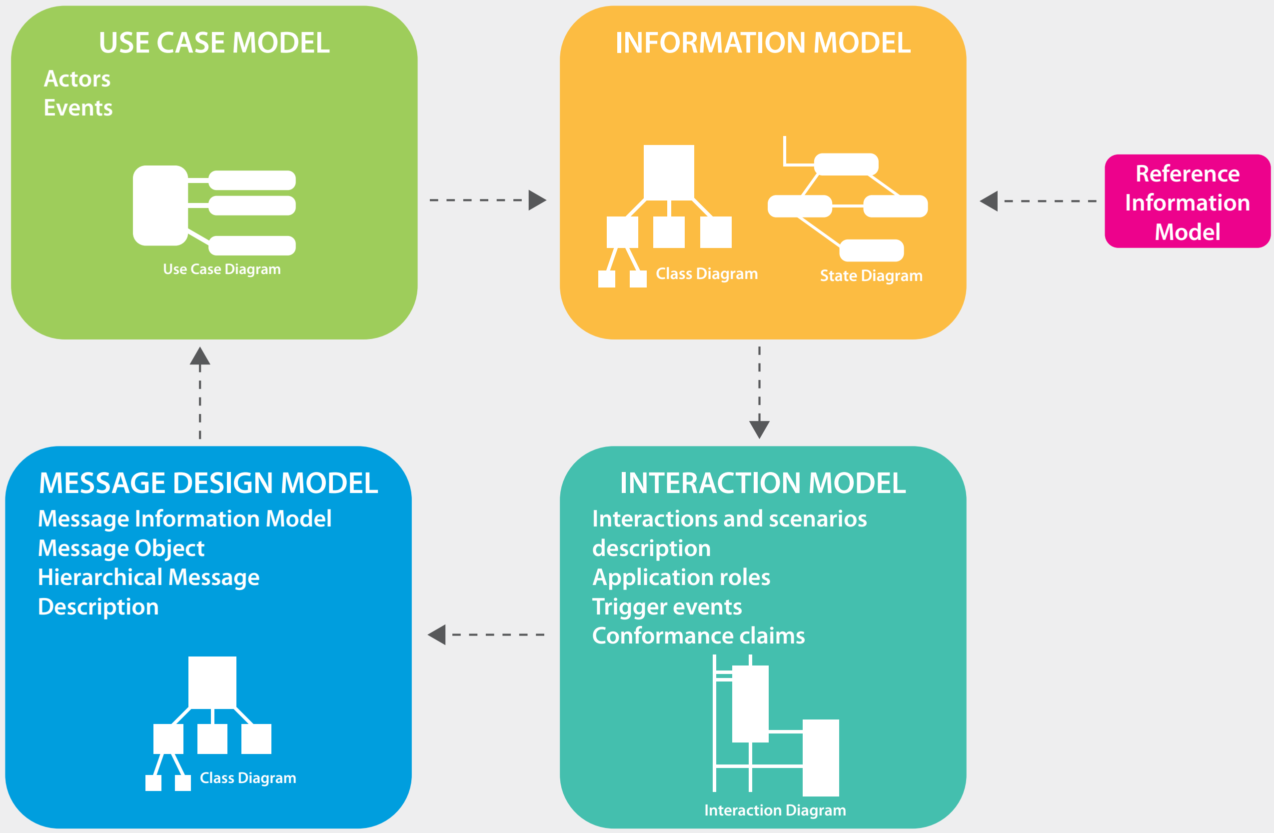

Figure 4.6: *Standardization process based on models and an object-oriented methodology*

Example of the Integrative Design Model

The Integrative Design Model defines another standardization process based on the experience of implementation and user-developer relations. The standards development cycle is shown as a three-phase model that includes development, deployment and local enactment, where design activities occur throughout all three phases (Millerand & Baker 2010).

Millerand & Baker (2010) analyse the complexity of the standards development process, summarized in their development models and inspired by a case study. User involvement and user-developer relations step in throughout the whole standards development life cycle.

They describe a development model together with an associated local implementation model, which provides feedback throughout the implementation phase. The Integrative Design Model serves as an alternative to the traditional iterative four-phase implementation process (design, development, deployment, enactment). In the Integrative Design Model, (re)design activities occur continuously in each of the three phases. The model also highlights that resources—and negotiation processes for their allocation—are a critical enabling factor for successful collaborative work.

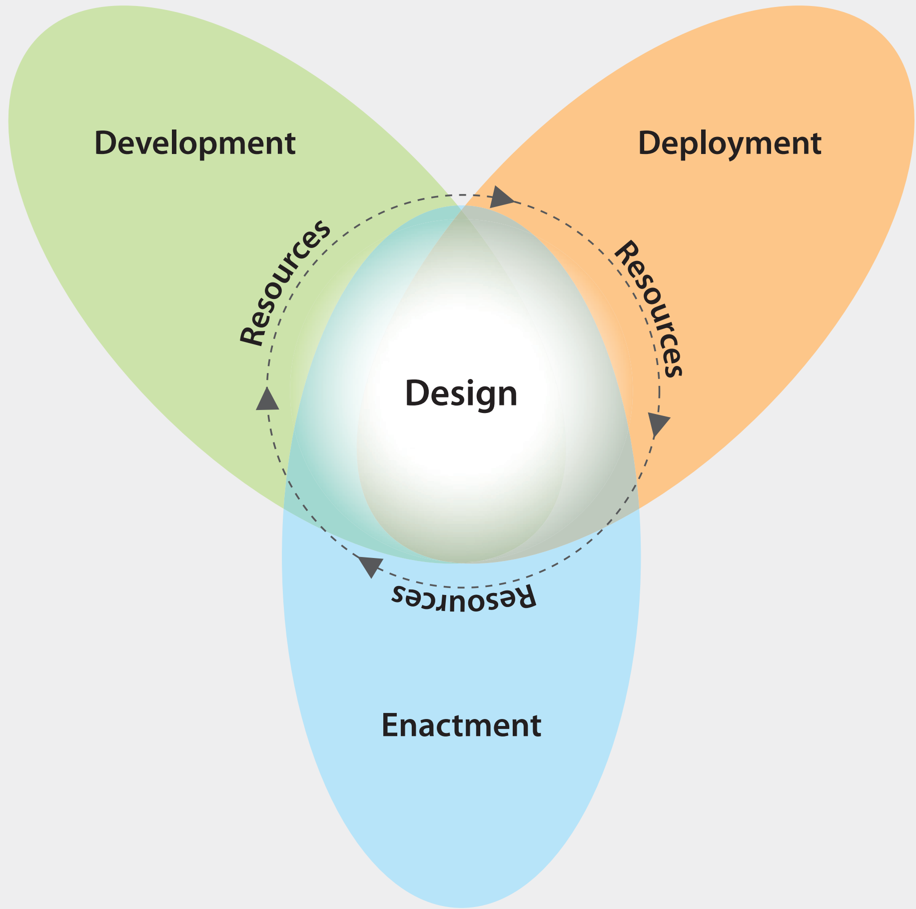

***Figure 4.7**: Standardization process based on the integrative design model*

4.2.5 ORGANIZATION OF AN SDO

This section explains how an SDO is typically organized, from the level of its governing entities down to its committees and WGs. It includes a presentation of how its members are recruited. In practice, each technical body (SDO, consortium or industry forum) has its own membership, works within its own environment, and defines its own set of governing policies.

The governance of an SDO is usually organized as a hierarchical structure, as shown in Figure 4.8 below. This ensures clear and assigned responsibilities for accountability within the system and for the consistency of the different activities. The figure and text below are explained using terms inspired from some recognized SDOs to give meaningful examples, but equivalent terminology exists in all organizations.

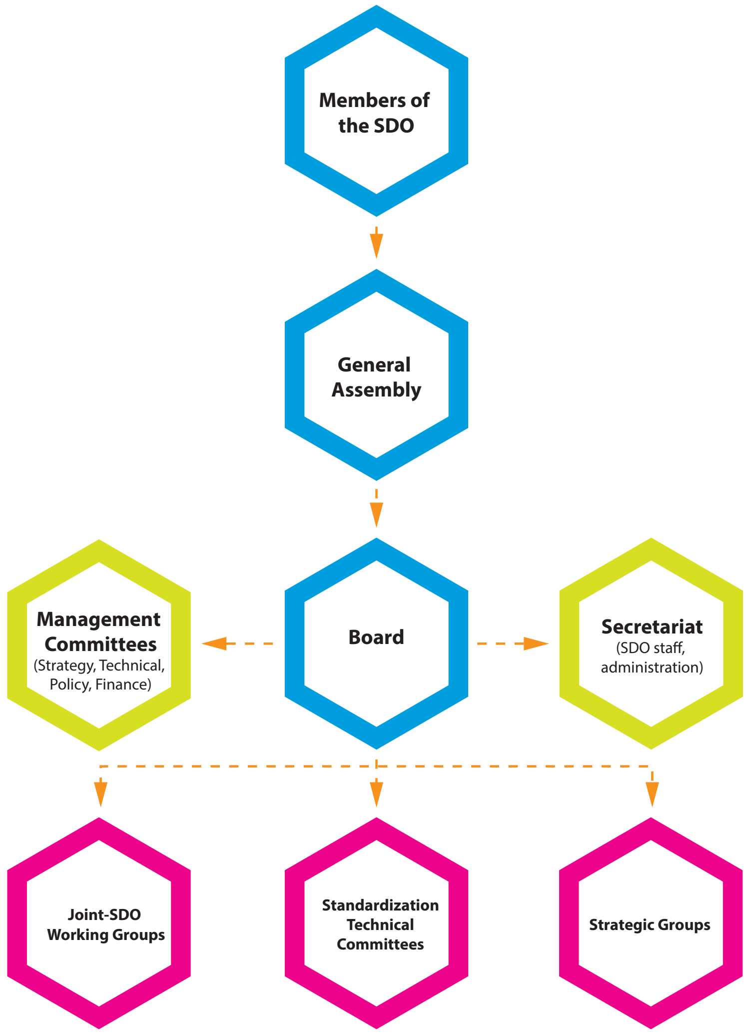

***Figure 4.8**: Typical organization of an SDO*

The main entity of an SDO is the association of its members. The types of members vary according to its internal organization and recruiting rules. The members are represented by the General Assembly (GA), which meets periodically to make the governance decisions. The GA delegates the daily governance to a Board, which manages and coordinates the SDO's focus and strategy. The Board works in collaboration with Management Committees for finance, strategy, etc. It is supported by the SDO Secretariat made of SDO permanent staff. The Secretariat enables the coordination of the committees as well as the technical and operational cooperation with other SDOs. It promotes the SDO's activities in the external environment and makes IT tools, platforms and solutions available. It ensures that the established process and procedures are respected and that legal requirements are fulfilled.

The Board controls the standards programme and supervises the implementation work of the different technical bodies such as committees, strategic groups or joint-SDO working groups. The committees are usually quite autonomous. They create sub-committees to address specific tasks or topics. They are responsible for preparing and disseminating the draft documents for comment, voting, appeals and delivering the approved standardization documents. They maintain a work programme, which is reviewed periodically. When a WG inside a committee has fulfilled all its tasks, it may cease its operations. Committees and WGs are mainly responsible for the quality of their output. The Secretariat provides administrative and logistical support to committees and WGs for standardization activities. It also provides capacity for the editing, printing, publishing, sale and distribution of standards

FUNDING OF SDOS AND STANDARDIZATION

Financial options related to the development of standards, including both financial support for SDOs and the self-funded participation of the industry sector, are important to guarantee the impartiality of the standards development process. The financing of standardization activities should be capable of covering all activities related to the production of standardization deliverables for products and services. It may also cover the administrative expenses incurred by the preparation, monitoring, inspection, auditing and evaluation necessary for the purposes of implementation.

Funding may come from different sources, such as direct funding from governing authorities, membership fees, income from the sales of standards, and income from certification activities and their operations.

EXAMPLES

Example: ISO Structure and governance (ISO 2016; ISO 2016b)

The ISO General Assembly is attended by ISO's Principal Officers and delegates nominated by the member bodies or national representatives. Correspondent members and subscriber members may attend as observers. The ISO Council governs the operations of ISO. The President's Committee is composed of the Principal Officers. It advises the Council on the implementation of its decisions. It also ensures effective communication and coordination among the ISO Council, the Technical Management Board and the two Council Standing Committees: the Strategy and Policy Committee (CSC/SPC) and the Committee on Finance (CSC/FIN). The Technical Management Board reports to the Council and is responsible for the overall management of the technical work. It decides on the establishment of technical committees and appoints their secretariats and Chairs.

The ISO Central Secretariat (ISO/CS) is responsible for supporting the governance and policy, advisory structure, and the operations of ISO. It assists the development process and publishes the standards.

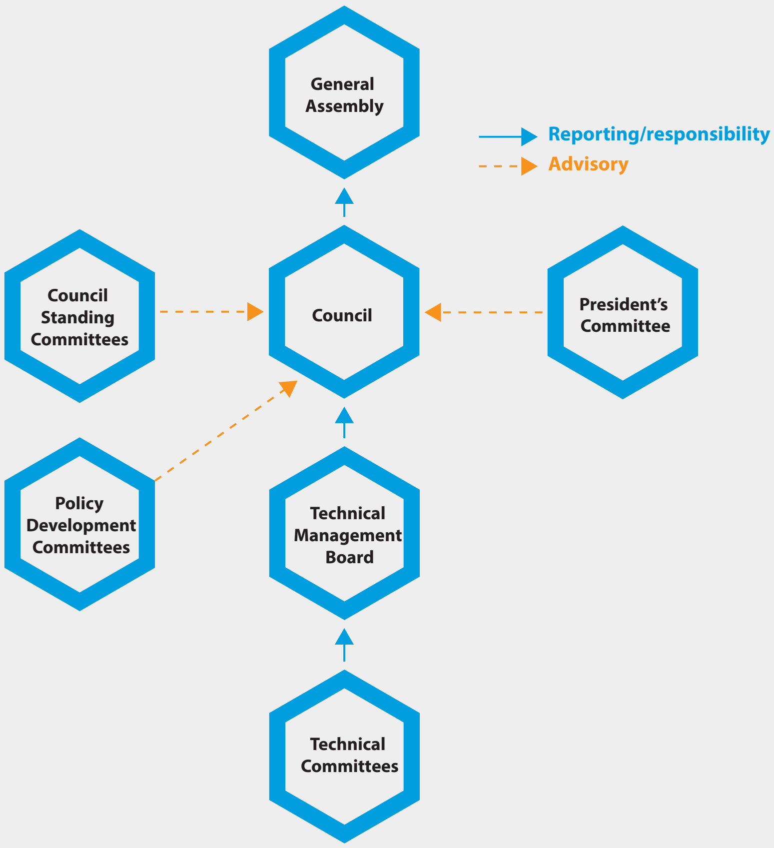

***Figure 4.9**: ISO governance structure (ISO 2016)*

The IEC is a not-for-profit organization that develops International Standards and operates conformity assessment systems in the field of electrotechnology (IEC 2017). The IEC comprises one member National Committee per country, they each pay membership fees and in exchange can participate fully in IEC work. The IEC works closely with ISO and adopts a similar hierarchical governance.

Example: CEN-CENELEC cooperation model

The case of the CEN and CENELEC ESOs shows how the two SDOs cooperate to avoid duplication of standards and the correlated issues. CEN and CENELEC are two ESOs that complement each other. They have implemented a close cooperation agreement to clearly distribute the tasks between the two organizations: electrical and electronic engineering fields for CENELEC, all other subjects for CEN. In parallel, each organization remains independent, with its own governance structure built according to the hierarchical model. Figure 4.10 shows how the two structures collaborate for membership evaluation, with one common committee reporting to the governance structure of each of the SDOs.

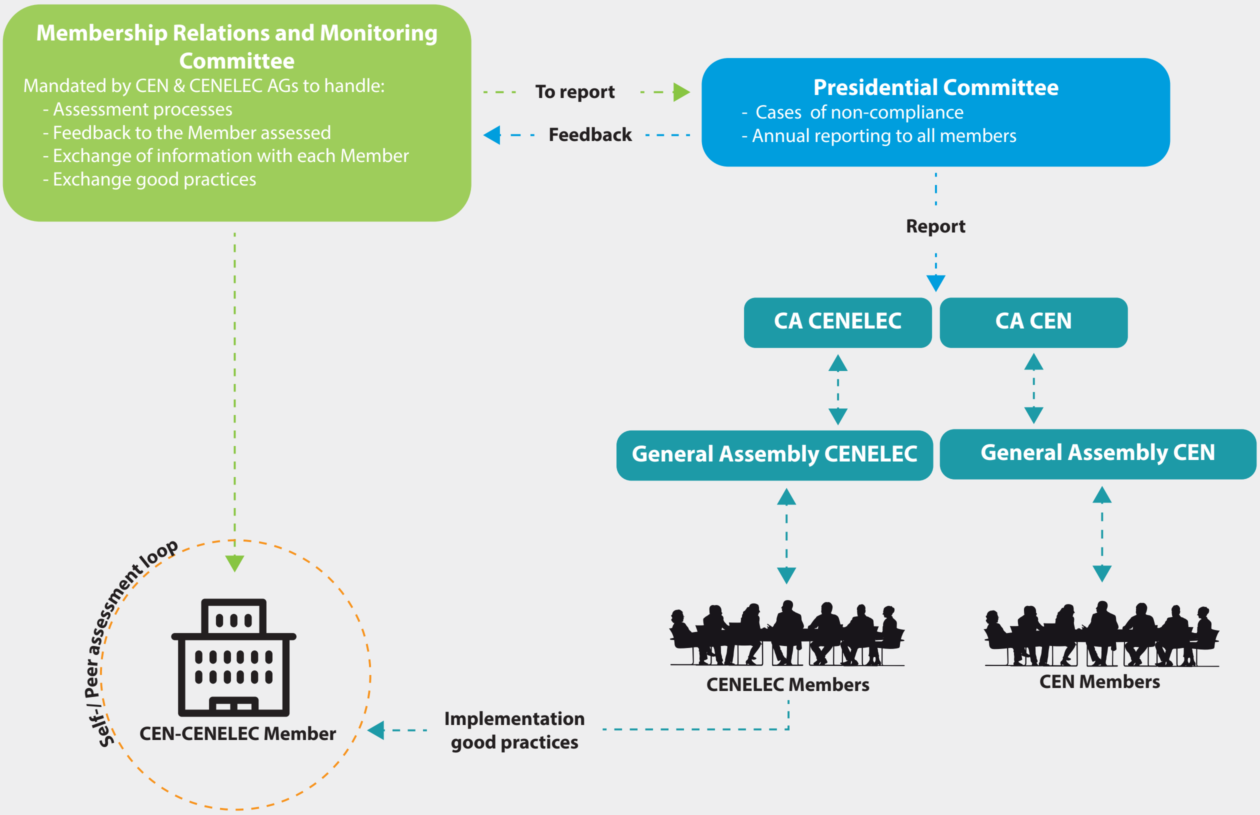

***Figure 4.10**: CEN-CENELEC governance and collaboration*

Example: IETF Structure and governance (IETF 2012)

The IETF is not a traditional standards organization, although many specifications that are produced do become recognized standards. It is not a corporation and has no board of directors, no members, and no fees. The ISOC (Internet Society) is an international membership organization that fosters the expansion of the Internet. The ISOC supports the administrative staff directly employed by the IETF Administrative Support Activity (IASA). The IESG (Internet Engineering Steering Group) is responsible for the technical management of IETF activities and the Internet standards process. An important task of the IESG is to monitor the output of all the WGs to help prevent the specification of IETF protocols that are inconsistent with one another. The IAB (Internet Architecture Board) focuses on long-range planning and coordination among the various areas of IETF activity. It stays informed about important long-term issues in the Internet, through the IRSG (Internet Research Steering Group). The core registrar for the IETF's activities is the IANA (Internet Assigned Numbers Authority). The IETF depends on a volunteer group of active participants.

***Figure 4.11**: IETF governance structure*

The members of an SDO are all stakeholders interested in the development of standards. Experts from interested parties can participate in the development of standards that affect them. The members of the standardization commissions are a diverse selection of qualified individuals.

The typical employers of attendees in ICT standardization are corporate organizations such as industrial companies and SMEs, ICT equipment manufacturers, service providers, and network operators. Another important group of contributors comes from research centres, academia and university staff, such as faculty and students from engineering, business, public policy, and law departments. Consultancy companies, testing laboratories and certification bodies are involved as well. Standards are also created by people who will use and be impacted by them: user groups, pressure groups, societal organizations (consumer, environmental and social), trade unions, civil society, and non-governmental organizations. Finally, administrations and public authorities, national organizations and government agencies are recommended to follow the standardization work. It allows them to stay informed of technological developments in the field and evolutions around the standards relevant for them, especially those referenced by regulations, or to give their input during the development of a standard to ensure its consistency with the regulatory objectives pursued.

User groups hardly ever participate in standards development, even if they are the final consumers and beneficiaries of the products and processes standardized. In addition to funding issues, they suffer from a lack of technical background, as well as a lack of sufficient interest due to the complexity of the process. They are often unlikely to provide meaningful input in the process. So, most often, they are represented by corporate users or societal organizations. Recognized SDOs now develop policies to promote their participation in standardization activities and dissemination of knowledge of standardization. Inter-disciplinary collaboration (verticals associated with IT specialists) is important at this time of digitalization of society and industry.

Membership also varies depending on the region. In Europe, membership in a national SDO requires the member to be European or to have a business interest or manufacturing presence in Europe. According to the organization, joining an SDO and becoming a member may be driven by national representations or business interest. In India, it is based on the Public-Private Partnership mode (PPP). In the US, membership is usually unrestricted and very often has an international scope.

***Figure 4.12**: Stakeholders involved in the activities of an SDO*

Similar to the SDO governance, committees adopt a hierarchical structure when they are responsible for a large work programme requiring expertise in different topics. A committee gathers the appointed officials, the member representatives and potentially the representatives of external organizations, which have established a liaison with the committee/WG because they share a similar interest in the topic.

Sufficiently large committees establish sub-committees to focus on specific tasks. WGs and SCs work to create, write and make technical decisions in the process of developing standards. The number of WGs depends on the size of the committee. It often happens that small committees do not have sufficient matters to create WGs. In this case, the committee adopts a flat structure, which means that there is no sub-group created, and the entirety of the work is performed by the committee as a whole. Each committee or sub-group is managed by a chair elected by the group members or appointed by the SDO board. When established, the WG chair is responsible for reporting WG activity to the parent committee.

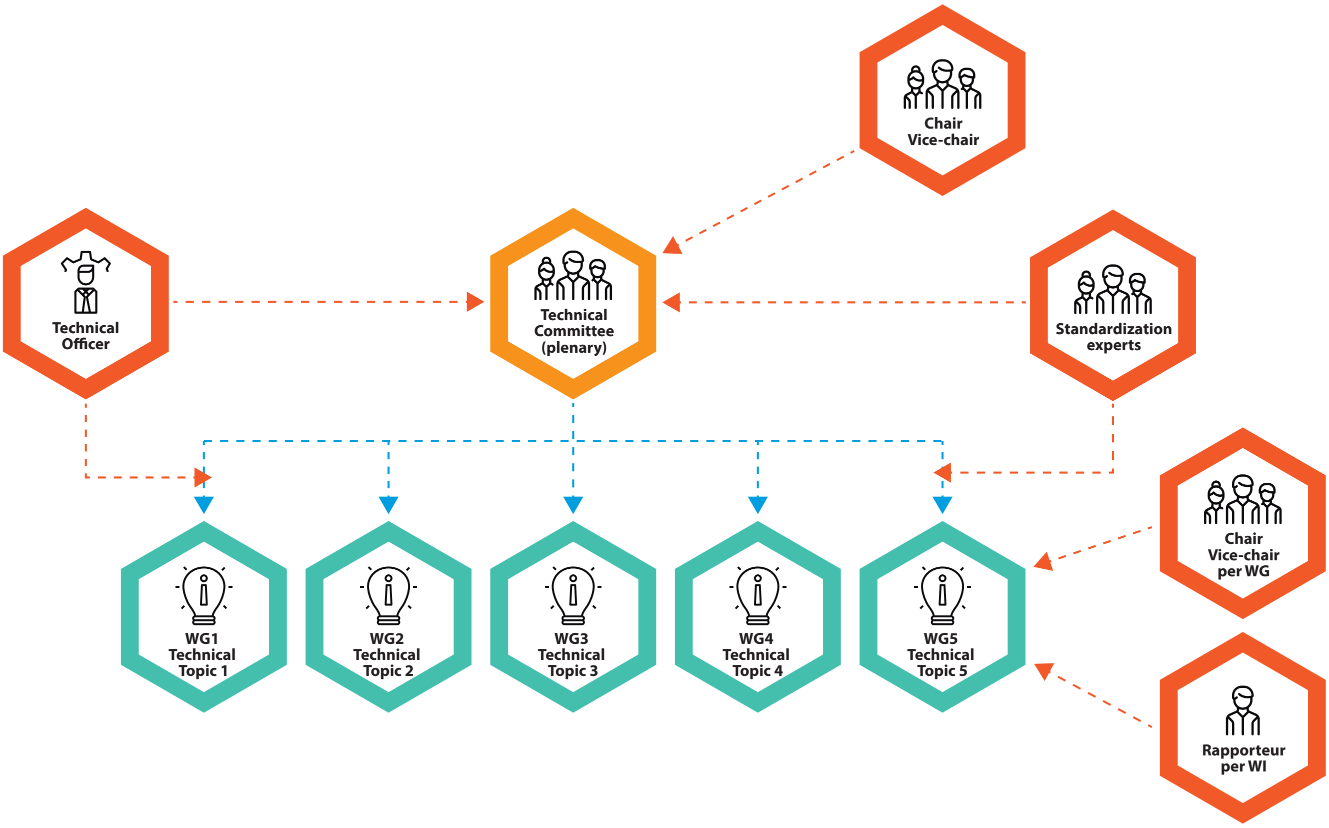

***Figure 4.13**: Typical organization of a Technical Committee*

EXAMPLE

Example: Organization of an IEC Committee (IEC 2017b)

The chair of an IEC technical committee (TC) is responsible for the overall management of that technical committee, including any sub-committees and working groups. The secretary is responsible for preparing the committee working documents and assisting with project management. In each working group, a convenor is named who is responsible for arranging and organizing the meetings and activities of the working group. For the development of each project, a project leader (the WG/PT convenor, a designated expert or, if appropriate, the secretary) is appointed by the TC or SC. In the case of a project team, the project leader reports to the parent committee. Experts in relevant technical fields for each committee are individuals appointed by their National Committees, via an Expert Management System, and designated to one or more working groups, maintenance teams or project teams. Experts take part in the drafting of working documents. They are capable of advising on technical issues in the field of the committee to which they have been appointed.

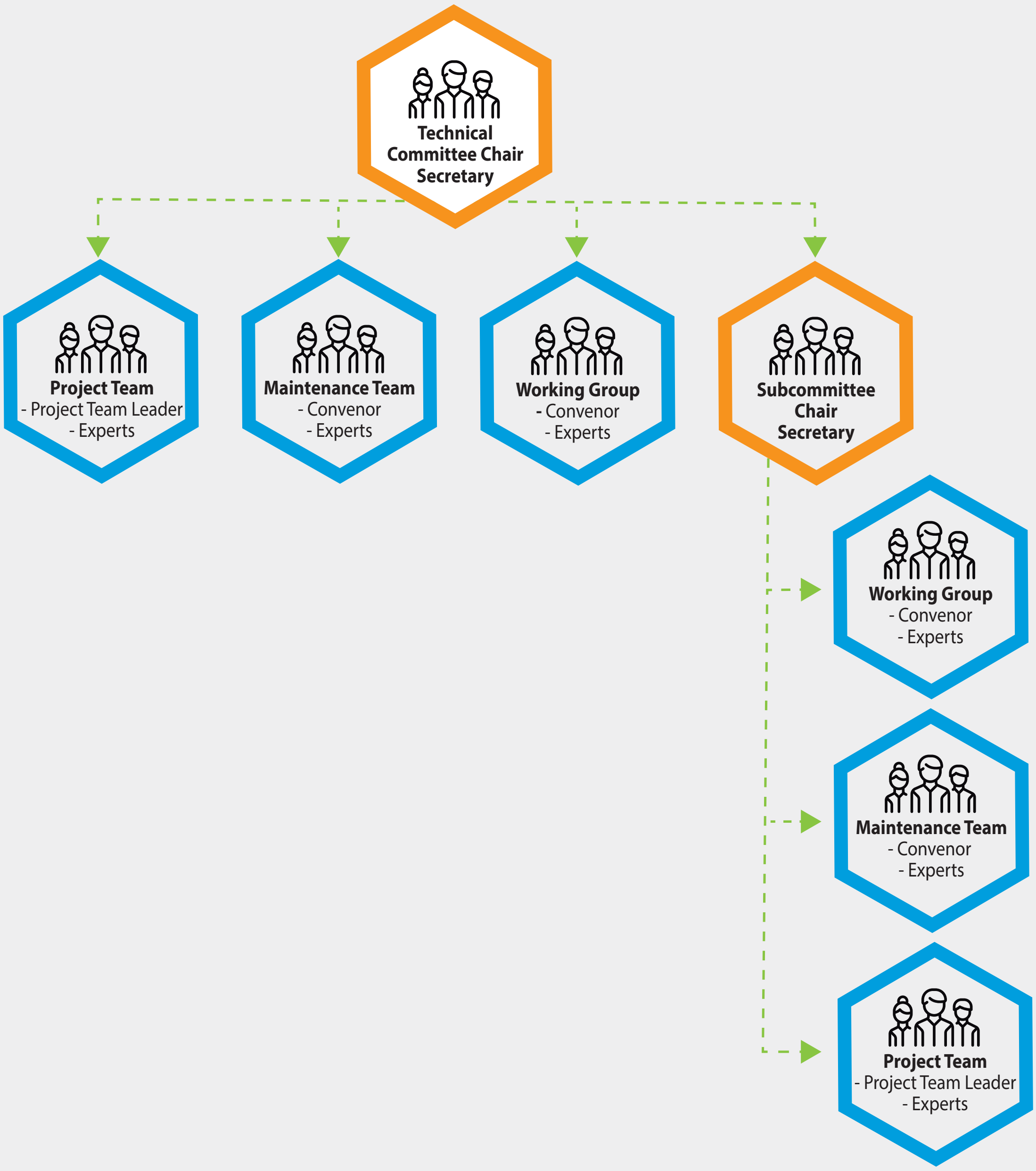

***Figure 4.14**: Typical organization of an IEC Technical Committee (IEC 2017b)*

Another example of a committee structure can be found in ISO documentation (ISO 2016).

4.3 ROLES AND COMPETENCIES OF A STANDARDIZATION EXPERT

4.3.1 INTRODUCTION

This section explains the roles and competencies of a standardization expert.

DEFINITION

A standardization expert is a professional who works in a corporate organization, often in industry, national administration, research or an academic organization, consumer or professional association, or as a staff member of an SDO. S/he is nominated to represent her/his organization in an SDO committee. S/he does not need to have an engineering degree but does need to be knowledgeable about the technical matters to be standardized. S/he carries out, but also often coordinates, most of the tasks and activities to be performed in the standardization process with the help of the other experts and her/his company's staff.

Usually, the production of a standard involves different types of professionals and functions. These functions can be classified in two groups, depending on whether the expert is active: a) in the standardization committees or b) in the SDO's permanent staff. The expert's main responsibilities are described in the first part of this section. Furthermore, two types of competences serve the standardization expert in her/his daily activities. A standardization expert has to demonstrate a mix of hard, or technical, skills and soft, or personal, competences. Indeed, the skills actually required depend on the role of the expert in the standardization process. The standardization expert should possess some of these technical and personal competences. The more of these skills the standardization expert has, the more likely s/he is to succeed in the standardization activities.

4.3.2 ROLES OF PROFESSIONALS INVOLVED IN THE STANDARDS DEVELOPMENT PROCESS

The individuals that participate in the standardization process perform different types of activities or roles. A committee or Working Group (WG) consists of standardization experts appointed by their respective organizations. They all play specific roles by acting as chairman (or vice-chairman) of the group, standardization expert, standards proposer, rapporteur, or liaison representative. The work of a committee also depends on the permanent staff of the SDO—often named the Secretariat—who take care of the administrative and technical organization of the SDO. In the Secretariat, technical officers and final editors are directly involved in the development of the standards.

The tasks and responsibilities of the experts in the working groups depend on the role they play in the committee.

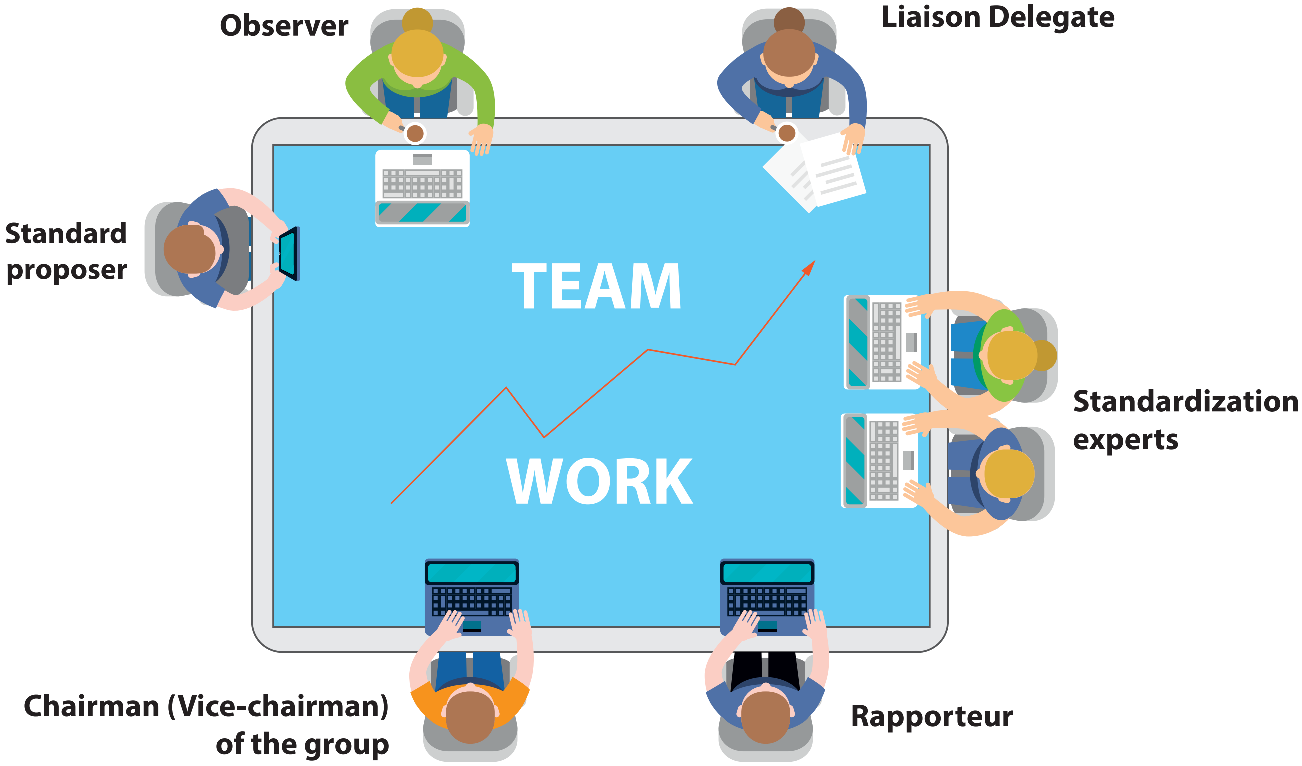

Figure 4.15*: Roles of standardization experts involved in a technical committee*

The chairman and the vice-chairman lead the activities of the Standardization Experts in the Working Groups (WG). Together, they manage WG meetings by taking appropriate actions and decisions. They steer the discussions towards consensus, while trying to avoid sustained opposition to a standard. They ensure that the work programme is completed in due time, that milestones are achieved, and that the strategy of the SDO is followed. They provide guidance to the SDO secretariat and validate the start of the approval process for the draft standards, which are nearing publication. They are responsible for the technical and non-technical outputs from the WG, for example sending liaison statements to peer WGs and keeping them informed of the activities of the WG. Sometimes, they represent the WG at external meetings to provide activity reports to the council, present the work programme in workshops, or give technical advice on topics addressed by the WG to other groups and committees.

The experts participate in WGs, where they provide technical expertise, knowledge, and a dedicated interest in the technology that is being standardized. They write the standards by submitting contributions and change requests, while sticking to the planned schedule.

They are often divided into two circles: the inner circle active in the drafting of a standard and the wider group that conducts monitoring activities due to its interest in the development of the standard (de Vries 2006). Their work must be useful for three types of stakeholders: a) the standards developers, who write the specifications and ensure their quality; b) the implementers, who use the standard to develop their products and are dependent on its content; and c) the customers, who buy the derived products and expect them to work successfully. The experts discuss the content of the drafts and make technical decisions. They accept or reject the approval of final drafts during ballots. They base their decisions on the position of the party they are representing. When attending as observers, they follow the activities of the WG, but do not take an active part and are not allowed to participate in the decision-making process.

Among the standardization experts, a standard proposer may detect a market need for a new standard, usually based on information received from her/his own organization. Each standard is organized as a specific short-term task with a clear scope and schedule. If interest can be raised for a specific development, the standard proposer submits a proposal to the members of the committee and triggers discussion of it during a committee meeting. S/he must receive support and interest from other members, as obtaining approval is often a criterion to start a new standard in recognized SDOs.

The rapporteur takes responsibility for a standard under development. S/he serves as editor of the standardization document, following the guidance of the WG in accordance with the work specifications, guidelines, delivery schedule, and the SDO internal rules that steer its technical quality. S/he leads drafting and comment resolution meetings, collects contributions from other experts and organizations involved in the WG, and maintains the draft versions of the standard. S/he provides input for the assessment and resolution of comments during the approval process and, when necessary, updates the draft. S/he provides technical advice to the technical body on the subject/topic. Her/his objective is to obtain the largest consensus possible on the content of the standard and resolve potential conflicts. S/he delivers the final draft to the final editor and contributes to its editorial clean-up. Additionally, s/he may serve as a focal point for technical questions related to the topic under standardization.

The liaison delegates serve as a link between two committees or WGs. They are appointed by both groups after a liaison has been established. They attend WG meetings as observers. Their role is to report to each WG on the activities and standards of the other group. Documents may also be exchanged in the liaison process if deemed necessary by the liaison delegate.

EXAMPLE

Figure 4.16 below gives an example of the roles held by standardization experts in an ISO committee (ISO 2016). More specifically, it shows the roles of chairs, secretaries, committee members and liaison officers.

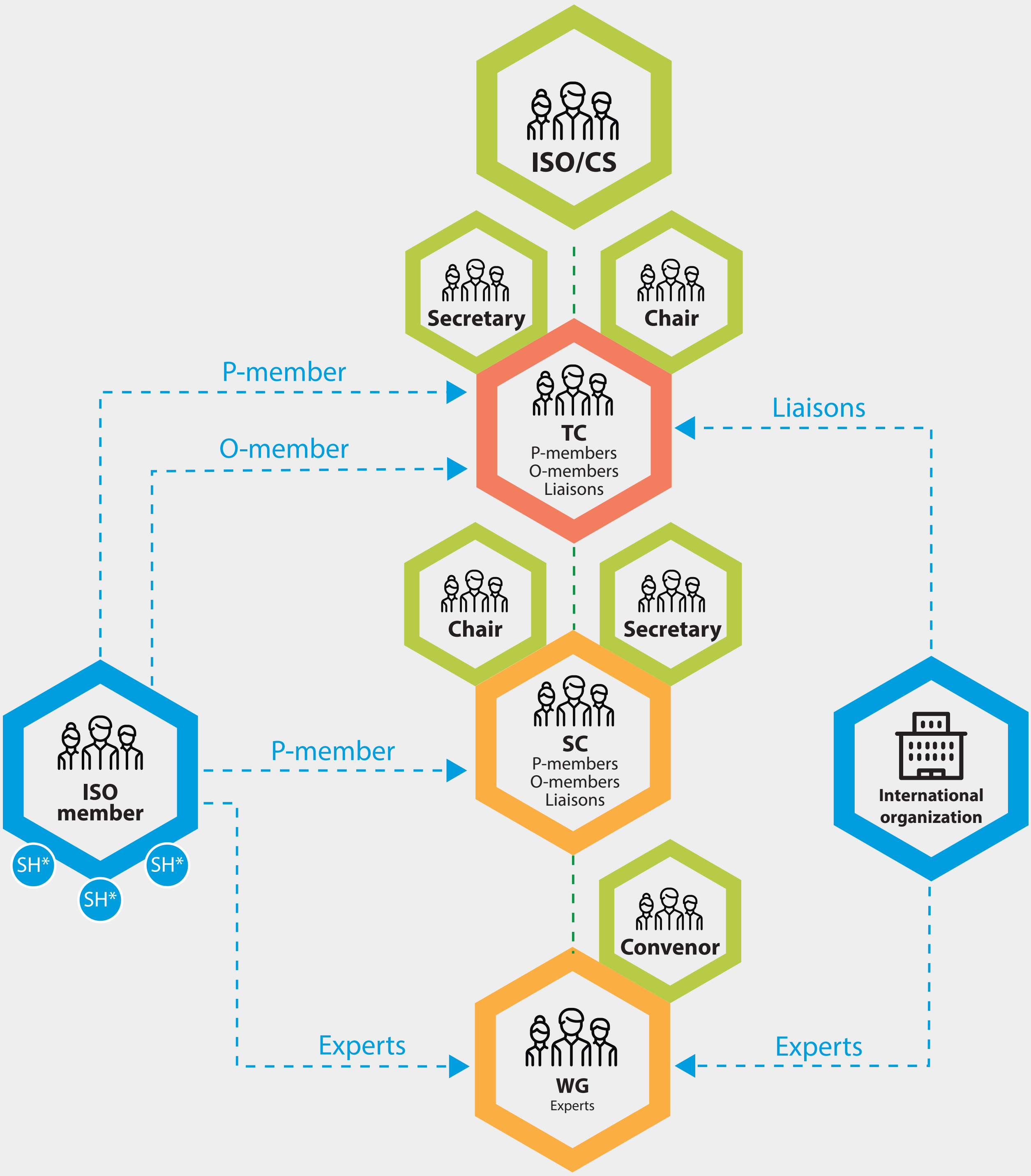

***Figure 4.16**: Professionals involved in the standardization process (ISO 2016)*

The tasks and responsibilities of the permanent staff of the SDO secretariat are to facilitate the work of experts in the WG. From a general perspective, SDO staff monitor the standardization work, from incubation to delivery to SDO members. They coordinate the standardization process and publish the standard. Where relevant, they provide guidance on the testability of the requirements and the production of test specifications. They promote the SDO's activities by participating in workshops, seminars and conferences, while maintaining collaboration relationships with external organizations, including governing authorities where applicable. They support the referencing of standards in regulations and the correct application of SDO governing policies. Within SDO staff, the technical officer and the final editor are more closely involved in standard production and publication.

More specifically, the technical officer provides administrative support to the WG chairman, rapporteur and experts concerning the standardization technical process, its procedure, and the work programme schedule. S/he responds to technical queries from the group's officials and delegates, or from third parties relating to the group's sphere of activity. S/he organizes the approval of the standard and enforces compliance with SDO standardization policies. S/he performs an ongoing check of the standard on matters such as editorial quality and project consistency during its drafting. S/he is aware of the technology being standardized but works in strict impartiality and has no decision-making rights.

Once the standard has been approved, the final editor performs a final check of the text, including editorial, language and terms validation and conformity with the SDO's drafting rules. If required, the text is corrected in collaboration with the authors/rapporteurs. The final editor is responsible for the publication of the standard.

4.3.3 COMPETENCIES OF A STANDARDIZATION EXPERT

To explore and promote standardization as an element of formal, academic as well as vocational training, an EC report (Blind and Drechsler 2017) dressed a comprehensive assessment of what market demand is needed. The approach was to identify "Job profiles" for which the present European employment market requests standardization-related competences. This section approaches the matter from an ICT professional's perspective. It describes which skills the ICT professional should develop and demonstrate to be more comfortable and efficient as a standardization expert. The different skills are presented in tables, which are organized according to the findings of the EC report (Blind and Drechsler 2017).

From a technical perspective, a standardization expert provides knowledge and technical expertise in the ICT technologies related to the standardization topic (e.g. radio systems, short-range communication protocols, etc.) and to the market. The reader is also referred to Table 26 "Overview about necessary knowledge and skills (companies' perspective)" of the EC report (Blind and Drechsler 2017) for a list of skills applicable to the job market perspective.

GROUP OF SKILLS	SPECIFIC SKILLS
UNDERSTANDING AND MANAGEMENT OF TECHNICAL CONTENT	skills in mathematics, sciences and engineering (technical team professionals)
	learning skills to follow the rapid evolution of the technology
	focus on architecture, influence the conception, development and implementation of technical innovations
	understand its impact, with professional and ethical responsibility
	understand and structure complex systems, respecting all sorts of technical and non-technical constraints
	manage the relationships and interactions between the designed systems
	problem-solving skills, identify and formulate technical problems, generalize across problems
	able to find innovative approaches to resolve an issue
	design and conduct experimental proofs of concept
	able to analyse and interpret the resulting data
UNDERSTANDING AND MANAGEMENT OF ICT STANDARDIZATION	experience in the field of ICT standardization
	understand the interactions and relationships between the different SDOs and their standards
	understand the international standardization strategy
	understand the process, rules and good practices applied at the SDO regarding the approval of a standard
	understand the context of committee activities
	able to identify gaps and visualize innovative trends and solutions
	able to keep up with the pace of the work and not slow down the progress of standardization work
UNDERSTANDING AND MANAGEMENT OF ORGANIZATION STRATEGY	experience of her/his organization and its technologies, products, business fields
	apply the organization's process management
	work towards achieving strategic and operational goals by taking critical success factors into account
	understand customer/user needs
	able to commit to the organization goals

***Table 4.1**: Hard/Technical skills*

Technical skills are of high importance, but standardization also requires personal skills often not taught in Higher Education curricula. A standardization expert will be more efficient, if s/he possesses certain soft/ personal skills.

GROUP OF SKILLS	SPECIFIC CAPABILITIES
COMMUNICATION COMPETENCES	communicate, listen, articulate and clearly express her/his views
	write clear, concise and user-friendly standards and technical documents
	raise issues on drafts and suggest changes
	design appropriate visual aids to prepare presentations and reports
	understand and work in the language used by the SDO, i.e. the national official languages for national bodies, which are usually English, French or German in European and International organizations
SOCIAL COMPETENCES	cooperate easily with her/his organization teams and fellow standardization experts
	persuade others with her/his own opinions and views, but at the same time, is able to listen to peer delegates and respect others' opinions
	manage negotiation and cooperation, in other words how to influence people and organizations
	re-evaluate her/his own standpoint if required, in response to external conditions and internal needs
	leadership skills to steer the group towards a satisfactory technical solution and consensus
	inspire trust in her/his decisions
	coordinate the many skillsets in her/his business organization
PERSONAL COMPETENCES	willing to keep learning and transfer her/his skills to peer experts
	firm when necessary and confident in conflict management
	flexible and able to decide whether a compromise is acceptable
	remain open-minded when receiving criticism
	network and collaborate easily with peer delegates
METHODOLOGY COMPETENCES	read a large number of documents, essentially the WG documents and draft standards
	organize and prioritize her/his work, project management capabilities
	deliver tasks and documents within the planned deadlines
	take initiative and work autonomously
	use recent electronic and collaborative tools such as mailing lists, word processors, web and FTP services, wikis, phone and web conferencing
	willing to travel to attend meetings to discuss specific matters more directly with WG participants

Table 4.2*: Soft/Personal competences*

4.4 ACTIVITIES OF A STANDARDIZATION EXPERT

4.4.1 INTRODUCTION

This section explains the main activities of a standardization expert. The expert's tasks are split over three periods of activities. The main activities related to standardization take place during standardization meetings on SDO premises when participating in the meeting, but also during interim periods such as networking breaks. Between meetings, the standardization expert writes or reviews standardization documents.

The section also explains how the standardization expert has impact and collaborates inside her/his corporate organization. S/he interacts with her/his colleagues on company premises to discuss the standards with relevant technical teams, as well as with marketing and management teams. The activities to be performed by the standardization experts from consulting companies or academia may be similar to the activities performed by industry experts.

Finally, the last part of this section introduces the specific duties of the standardization expert when s/he representing her/his country's interests as a national delegate.

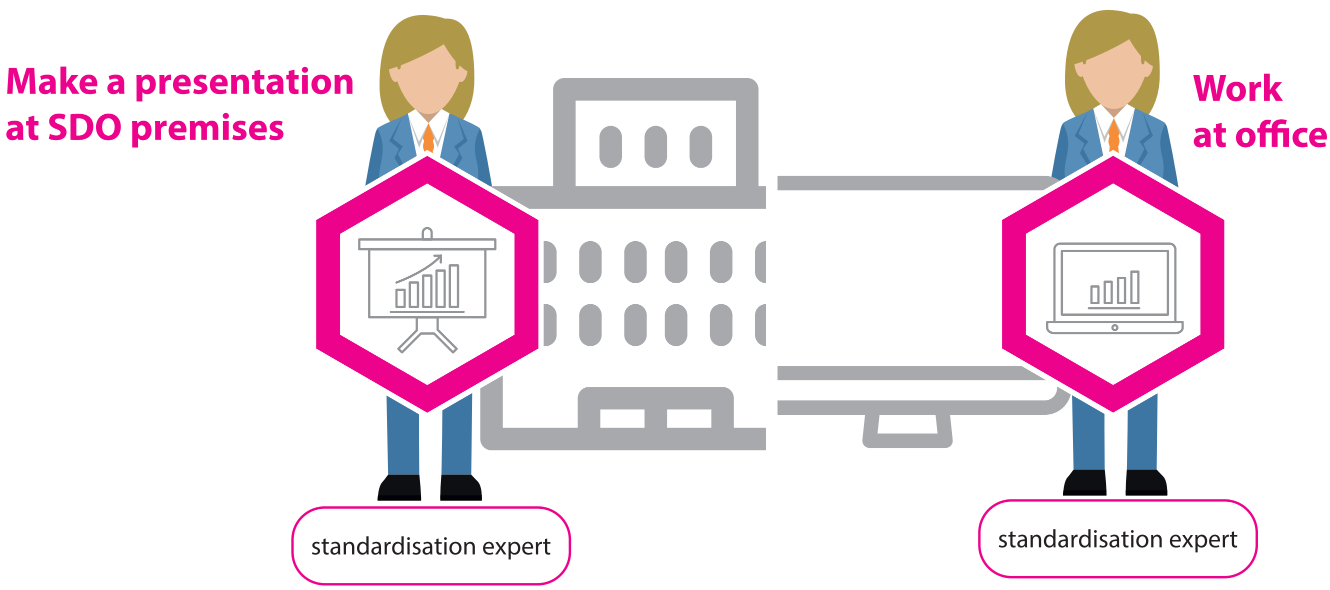

__Figure 4.17__: Standardization expert working at the SDO and then at the office

4.4.2 DURING WORKING GROUP MEETINGS

Standardization meetings involve the appointed experts and, where relevant, external observers and liaison officers. This is the place where ideas are discussed and the Working Group (WG) can cooperate and progress on the work programme, which is carefully reviewed against deadlines. Before leaving for the meeting, the standardization expert has to read the draft documents and contributions in her/his area of expertise.

The majority of the meeting is spent reviewing the status of the WG documents: draft standards, contributions, and proposals for new standards. When s/he attends standardization or WG meetings and attends as a Working Group member, the standardization expert gets involved in the discussions, while bringing in her/his own knowledge on the topics discussed, and trying to find compromise solutions where necessary. If a draft standard is ready for approval, the standardization expert participates in the decision-making process. If the standardization expert has been selected as liaison officer between two WGs or two SDOs, s/he presents the activities that are taking place at the other WGs/SDOs. Learning from these reports enables cooperation between SDOs and the coherence of the standardization as a whole for a given market.

As a rapporteur, the standardization expert presents the latest version of the draft standard to enable the progress and tracking of the Work Item (WI). The rapporteur explains what changes have been made since the previous version. A few slides can be helpful to present a status report and the main ideas to be discussed.

Depending on the WG, meetings may include drafting sessions, where draft standards are updated, or only reviewing sessions, where changes and open issues are discussed. The rapporteur collects questions, while triggering discussions and trying to provide answers to clarify the topic. When competing ideas block the progression of the work, the standardization expert suggests compromises to obtain consensus on a possible solution that will be recorded in a status report and integrated in the revision of the draft standard.

***Figure 4.18**: Rapporteur presenting the draft standard to the Working Group members*

A large part of the work is also performed by people talking to one another during the standardization meetings or during breaks or networking time such as lunches and dinners. Unofficial get-together sessions can also be organized on the fly between peers to progress on a draft, try to resolve blocking issues, set up multilateral agreements, or agree political deals between competing interests. Working in smaller groups allows faster progress on issues. Networking time is also a good opportunity for the standardization expert to raise awareness about new concepts or processes to be standardized and to find supporters for triggering a new standard.

4.4.3 BETWEEN STANDARDIZATION MEETINGS

When in her/his office, the standardization expert acting as rapporteur updates the current draft to prepare the next version of the standard. S/he organizes drafting meetings where standardization experts discuss the content of the draft. Drafting meetings can be organized as virtual interim meetings, where interested parties discuss the document in more detail, or simply get involved in the process at a lower cost than if they meet face to face. Drafting sessions can also be launched as an email discussion or an informal phone call among a few experts.

As the main editor of a draft standard, the rapporteur collects contributions and uses the interim meetings to obtain input from other experts, and to trigger and distribute writing tasks among the participants that are willing to contribute. At her/his office, the rapporteur has more time to identify the IPRs related to the topic under standardization and ensure that the SDO rules on the matter are respected in the document. Furthermore, before the next WG meeting, the rapporteur prepares a status report of the WIs under her/his responsibility.

If s/he is not the rapporteur, the standardization expert prepares contributions and change requests to draft standards. S/he uses traditional and digital working tools: word processor, Instant Messaging (IM), phone, collaborative/shared workspace and conference tools to get access to WG documents or attend interim drafting meetings. The standardization expert can also use this period to implement the standard in collaboration with in-house technical teams and prepare a report of inconsistencies that were found during implementation and testing. An important part of the work related to standardization activities is done before each WG meeting. The standardization expert reads the latest versions of the drafts and other documents that have been submitted, while making sure that s/he understands their contents. The standardization expert also tries to identify open points and issues to be discussed at the meeting.

4.4.4 INSIDE THE EXPERT'S CORPORATE COMPANY

Developing and standardizing a new or an evolved technology usually requires the collaborative work of technical, marketing and managerial teams. Back at the office, the standardization expert is asked to exchange with these teams.

Inside the company, the standardization expert exchanges with the relevant technical teams and reports on recent standardization activities and trends, especially with respect to the latest standards approved, and the liaison reports from other SDOs. Usually, s/he provides it as a complete meeting report. The report also gives feedback on the interest received from other delegates about the proposed developments and about copyright or IPR issues that may be associated with the information included in the report.

When collaborating with the development teams, the standardization expert explains the standards and how to use them to accelerate the product-to-market process, ensuring that changes to protocols, entities or interfaces decided by the WG on proposed technologies are retro-fitted into local prototypes and products. In this way, the standardization expert tries to prevent the technical teams from creating proprietary solutions. If needed, the terminology for a common understanding of the in-house projects is defined or updated according to the terms used in the standards.

The standardization expert leads or participates in the activity of building prototypes that demonstrate the effectiveness of the new technologies to be standardized and the correctness of the standards requirements, while showing how existing systems must be tweaked. Implementing standards is an important activity that helps potential problems be discovered early.

The standardization expert uses office time to extend her/his knowledge about existing and future technologies, concepts and developments, such as ongoing research or expertise handled by other organizations. Contributing to knowledge management and dissemination is an essential activity to achieve innovation in the company.

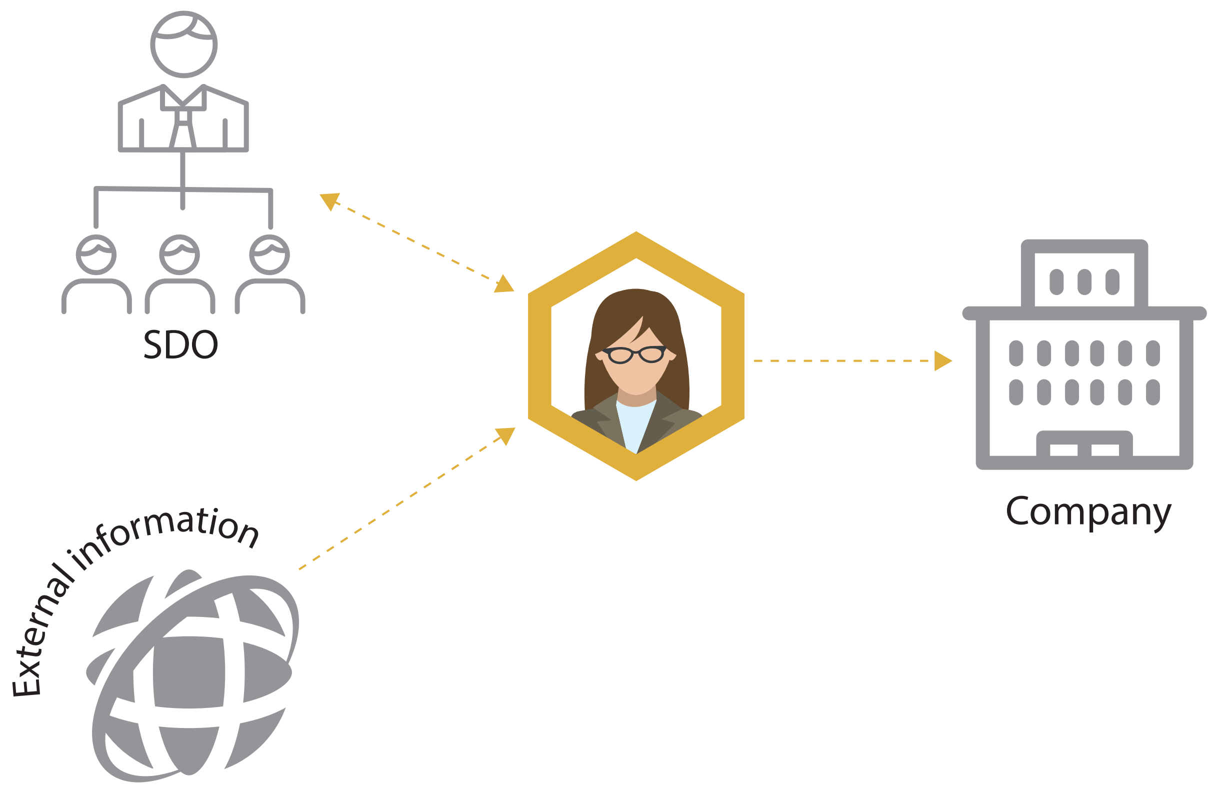

***Figure 4.19**: Standardization expert involved in the technical activities of a corporate company*

Inside the company, the standardization expert exchanges with the marketing team. As the ICT market is evolving at a fast pace, it is important to evaluate how companies can enhance existing products or introduce new ones. Standards play an important role here, as they can foster the company's innovation or, on the contrary, exclude it from the market.

The standardization expert is the link between the marketing teams and the standardization committee. S/he is able to grasp the strategy of the business units and secure it through standards.

The standardization expert understands and analyses with the marketing team the customer's feedback and expectations and identifies potential standardization gaps. S/he identifies the new standards required by customers' needs and prepares proposals to start their development. Thus, it is crucial for corporate organizations to actively participate in the standardization process related to their market.

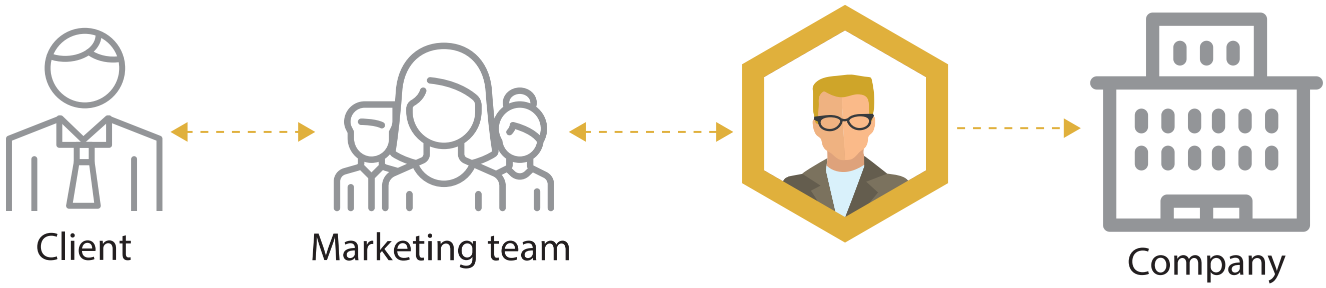

Figure 4.20*: Standardization expert involved in the marketing activities of the company*

Inside the company, the standardization expert exchanges with the management team, together with the technical and marketing teams, to understand the company's strategy with respect to its standards portfolio. It is important for ICT companies to maintain internal coordination efforts and develop and implement a standards strategy. Except for very large companies, the high number of consortia and SDOs working in the various ICT domains would need too many resources if standardization experts had to attend all of them. A careful selection needs to be made by ICT manufacturers and vendors to ensure that the company is active at the relevant standardization groups that can help develop its own innovation.

The standardization expert together with the management team should analyse which SDO memberships are of interest and how to organize and maintain the contributions to the company's standard portfolio. It may happen that the motives for this strategy are not technical, thus requiring additional effort to gain the expert's support.

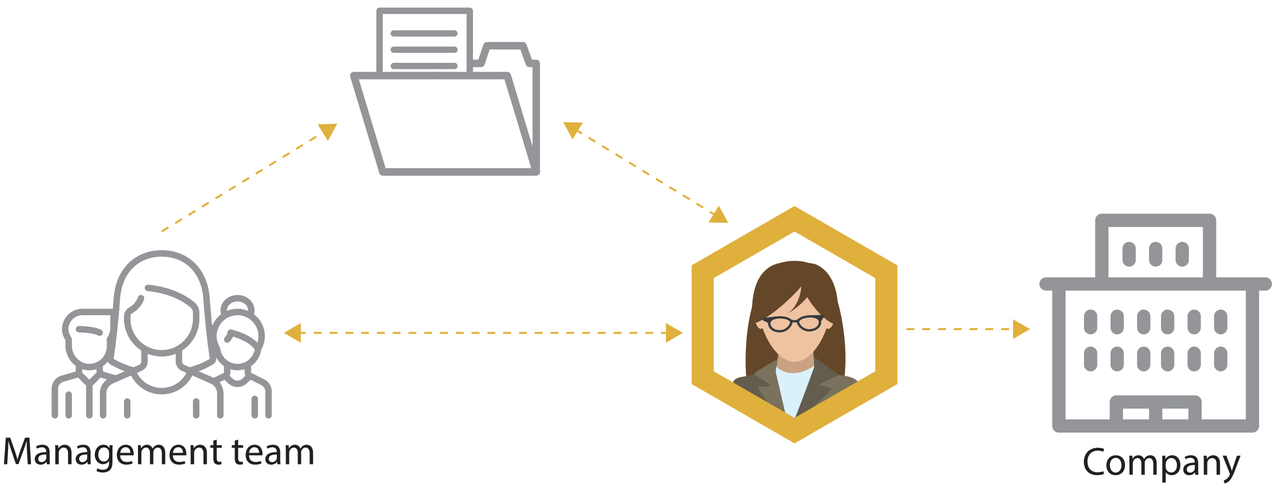

Figure 4.21*: Standardization expert involved in the management activities of the company*

4.4.5 AS A NATIONAL DELEGATE

As has been stated before, SDO governance defines rules for membership application. Standardization experts can contribute to the SDO in their own capacity, for example at the IETF and IEEE, even if their activities are actually funded by their own organizations. In other cases, membership is obtained directly by the expert's organization and s/he is appointed by the organization to represent it. This is the case at ETSI and ANSI for example, and in the majority of industrial alliances. SDO governance may require members to be representatives of an organization recognized as the official standards body in the country, or as an organization competent in the domain of the SDO in its country. CEN, CENELEC, ITU and ISO belong to this category. In this case, a national delegate is an individual expert appointed by the national member of an SDO where membership is attributed on a per-country basis.

A standardization expert that serves as a national delegate represents the point of view of her/his country in the standardization group. In addition to the activities described in the previous sections, the standardization expert has the following duties. S/he triggers at national level the adoption, promotion and dissemination of international or regional (for example, European) standards, and the withdrawal of conflicting national standards. S/he organizes meetings of national stakeholders, for instance in national technical mirror committees, to collect their positions, thus acting as a facilitator and coordinator of local involvement in the standards by all types of national players: providers, academia, societal stakeholders and national authorities.

4.5 CASE STUDY: THE 3RD GENERATION PARTNERSHIP PROJECT (3GPP)

The 3rd Generation Partnership Project (3GPP) covers cellular telecommunications network technologies. 3GPP began its activities in 1998, when several ICT SDOs, including ETSI and ARIB, came together to develop a single standard for "third-generation" mobile telecommunications, in application of the fundamental coherence principle (3GPP 1998). A similar organization, the 3GPP2, was founded in parallel in the US to develop a competitive technology. Both converged when the evolution of the market required an evolution for faster Internet, as well as a global solution. It was named the Long-Term Evolution (LTE) cellular system, also known as 4G.

The 3GPP brings together telecommunications SDOs, known as "Organizational Partners" (3GPP 1998). An Organizational Partner is an SDO that has signed the Partnership Project Agreement and that has an officially recognized status with the capability and authority to publish standards nationally or regionally. The 3GPP makes all approved versions of its specifications available as soon as possible after their approval on a file server (3GPP 2017), while the Organizational Partners transpose and adopt the relevant Technical Specifications (TS) as their own deliverables through their normal procedures.

The 3GPP committee structure is made up of three Technical Specification Groups (TSGs), each addressing a sub-system of the cellular communications system (System and Services, Radio, Core Network). Each TSG has established WGs to address dedicated working topics. Meetings are organized periodically to measure the progress of the work and make decisions. They take place in locations where partners are active, which means that delegates travel all over the world. The size of the different WGs vary, and sometimes prevent the discussion of technical topics during meetings. The large number of documents to be reviewed requires that delegates discuss the technical issues during offline discussions, leaving room only for approval or rejection of decisions during the meetings. 3GPP specifications and studies are contribution-driven by member companies in WGs and at the Technical Specification Group level.

3GPP follows a three-stage methodology similar to ITU Recommendation I.130 (ITU-T 1988). Its own methodology is defined in 3GPP TR 21.900 (3GPP 2017) clause 4.1.

At 3GPP, stage 1 (Service requirements) consists in describing the aim of the system, as seen by those for which the service is provided, such as end users, operators, service providers, etc. Stage 2 is an overall architectural description of the organization of the network functions to map service requirements onto network capabilities. In stage 3, the technical implementation covers the detailed interface specifications that are needed to support the services defined in stage 1. The architectural implications and requirements need to be identified at a very early stage in the process.

In 3GPP, it is often seen as appropriate to first produce a feasibility report prior to the specification work. A feasibility study may include commercial as well as technical considerations. This analysis leads to the definition of candidate new features to be added to the existing system. This is sometimes referred to as "stage 0". Furthermore, it is also appropriate to follow stage 3 with the production of test and certification specifications. This is referred to as stage 4.

Delegates thus represent a very wide variety of technical skills, from system architects to specialists such as radio or security experts. Decisions may have a very real impact on business, given the wide range of interests involved in standardization work; as such, delegates often have well-proven negotiation skills.

The progress of 3GPP standards is measured by the milestones set when the Work Item (WI) is approved (3GPP 2017). The progress of the entire collection of 3GPP specifications is also measured as a whole, in releases. New features are "functionality frozen" and are ready for implementation when a release is completed. 3GPP works on a number of releases in parallel, starting future work well in advance of the completion of the current release.

4.6 SUMMARY

Standards production is a complex process that involves technical resources, but also a strong organization and social aspects. Fair standards enabling fair competition and fair trade implies compliance with a set of fundamental principles. A systematic development methodology for ICT systems as well as for individual standards has been described. SDOs and technical committees generally adopt a hierarchical structure for their governance.

The roles of standardization experts in SDOs and committees are clearly defined, even if they vary slightly among the different SDOs. Technical skills are of prime importance, but a variety of soft/personal competences, often not taught during Higher Education, also help make a successful standardization expert.

Finally, the chapter addresses the fact that standardization experts work for the production of standards not only during committee meetings, but also during breaks and between meetings when the experts are in their offices, and that they closely collaborate with their colleagues from development, marketing and management in their own organizations.

4.7 QUIZ

1 - WHICH PRINCIPLE BELOW IS NOT A FUNDAMENTAL PRINCIPLE OF THE STANDARDIZATION PROCESS?

(See Section 4.2 for hints)

a) *Openness*
b) *Abstraction*
c) *Transparency*
d) *Impartiality*

2 - WHAT IS THE NAME OF THE DEVELOPMENT PHASE TAKING PLACE AFTER INCEPTION?

(See Section 4.2 for hints)

a) *Conception*
b) *Approval*
c) *Drafting*
d) *Maintenance*

3 - WHICH GROUP OF STAKEHOLDERS DOES NOT TAKE PART IN THE PROCESS OF DEVELOPING ICT STANDARDS?

(See Section 4.2 for hints)

a) *Biology faculty members*
b) *Consulting company staff*
c) *Certification laboratory engineers*
d) *Users involved in environmental organizations*

4 - DOES THE CHAIRMAN OF A TECHNICAL COMMITTEE BELONG TO THE SECRETARIAT OF THE SDO?

(See Section 4.3 for hints)

a) *Yes*
b) *No*

5 - WHICH OF THE FOLLOWING IS NOT A SOFT SKILL?

(See Section 4.3 for hints)

a) *Active listening*
b) *Fluency in English*
c) *Problem solving*
d) *Word processing proficiency*

6 - IS MATHEMATICAL EXPERTISE REQUIRED TO BECOME A STANDARDIZATION EXPERT?

(See Section 4.3 for hints)

a) *Yes*
b) *No*

7 - THE STANDARDIZATION EXPERT ESTABLISHES THE COMPANY STANDARDS STRATEGY WITH:

(See Section 4.4 for hints)

a) *the marketing team*

b) *management*

c) *the product development leader*

8 - THE STANDARDIZATION EXPERT HAS TO TRAVEL TO ATTEND ALL HIS MEETINGS

(See Section 4.4 for hints)

a) *True*

b) *False*

9 - NATIONAL DELEGATES REPRESENT THE POINTS OF VIEW OF THEIR COUNTRIES AS PRESCRIBED BY:

(See Section 4.4 for hints)

a) *the company CEO*

b) *the network operators*

c) *the national administration*

d) *the national mirror committee*

10 - THE IETF RFC PROCESS IS:

(See Section 4.2 for hints)

a) *a top-down process*

b) *a bottom-up process*

c) *an integrative design process*

d) *a standardization technical committee*

11 - A TYPICAL SDO IS GOVERNED ACCORDING TO:

(See Section 4.2 for hints)

a) *a cooperation agreement*

b) *a hierarchical structure*

c) *a horizontal model*

12 - 3GPP IS:

(See Section 4.5 for hints)

a) *a national SDO*

b) *a European SDO*

c) *an international SDO*

d) *a partnership project among telecommunications SDOs*

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4.8 GLOSSARY

- Drafting: Iterative writing of the different clauses of a draft standard.
- Specification: Set of rules that competing products must comply with to enable their interoperability.
- Standardization expert: Professional working in a corporate organization, often industry, in a national organization, in a research or academic organization, or in a consumer or professional association and involved in standardization.
- Standardization stakeholder: Party impacted by the publication of standards, e.g., corporate organizations, user groups, or national authorities.
- Standards strategy: Plan of action designed to obtain a standards portfolio in line with corporate business goals.
- Technical body: Generic term designating technical committees, sub-committees and working groups that bring together delegates to produce standards.

4.9 LIST OF ABBREVIATIONS

- 3GPP: Third Generation Partnership Project
- ANSI: American National Standards Institute
- ARIB: Association of Radio Industries and Businesses
- ATIS: Alliance for Telecommunications Industry Solutions
- CA: Conseil d'Administration (Administrative Board)
- CEN: Comité Européen de Normalisation (European Committee for Standardization)
- CENELEC: European Committee for Electrotechnical Standardization
- CSC: Council Standing Committee
- EC: European Commission
- ETFA: European Free Trade Association
- EN: European Standard
- EPC: Evolved Packet Core
- ESO: European Standards Organization
- ETSI: European Telecommunication Standards Institute
- EU: European Union
- FIN: Finance
- FTC: Federal Trade Commission
- FTP: File Transfer Protocol
- GA: General Assembly
- GSC: Global Standards Collaboration
- GSMA: Global System for Mobile Communications (GSM) Association
- HEN: Harmonized European Standard
- HL7: Health Level Seven
- IAB: Internet Architecture Board
- IANA: Internet Assigned Numbers Authority
- IASA: IETF Administrative Support Activity
- ICT: Information and Communication Technology
- I-D: Internet-Draft
- IEC: International Electrotechnical Commission

- IEEE: Institute of Electrical and Electronics Engineers
- IESG: Internet Engineering Steering Group
- IETF: Internet Engineering Task Force
- IM: Instant Messaging
- IPR: Intellectual Property Rights
- IRTF: Internet Research Task Force
- IRSG: Internet Research Steering Group
- ISO: International Organization for Standardization
- ISOC: Internet Society
- ISO/CS: ISO Central Secretariat
- IT: Information Technology
- ITU: International Telecommunication Union
- ITU-T: International Telecommunication Union—Telecommunication Sector
- LTE: Long Term Evolution
- MoU: Memorandum of Understanding
- NIST: National Institute of Standards and Technology
- NSO: National Standards Organization
- PT: Project Team
- RFC: Request for Comments
- SC: Sub-Committee
- SDO: Standards Development Organization
- SE: Standardization Expert
- SME: Small or Medium-sized Enterprise
- SPC: Strategy and Policy Committee
- TBT: Technical Barriers to Trade
- TC: Technical Committee
- TR: Technical Report
- TS: Technical Specification
- TSG: Technical Specification Group
- US: United States
- WG: Working Group
- WI: Work Item
- WSP: Wireless Short-Packet (protocol)
- WTO: World Trade Organization

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5 STANDARDIZATION AND INNOVATION

LEARNING OBJECTIVES

This chapter provides students with the required knowledge on the interdependencies between innovation and standards/standardization. Some people believe that standardization and innovation are opposites and cannot be reconciled. We demonstrate that this claim is not true, as standardization and standards can actually boost innovation. First, we provide a short introduction on how standardization can foster innovation. Then, we show how technology development and standardization are linked. An example from ICT demonstrates how standardization could contribute to the development of next-generation Ethernet networks. Finally, we relate different types of innovation to standardization. Readers should be able to understand the ways in which innovation and standardization are related, and how standardization can support innovation.

In addition, we discuss the relationships between research and standardization. The research process is explained and linked to the use of standards and/or participation in the standardization processes. In this way, it will be clear how standardization can benefit research. This gives an insight into how standards and standardization can be leveraged during the research process.

At the end of the chapter, based on Abdelkafi and Makhotin (2014), we show how standards and participation in the standardization process can support invention and exploitation in companies. Exploitation is understood in the sense of identifying market applications for inventions. Readers will learn the ways in which standards and standardization can support innovation, both as a process and as an output in the sense of a technology or product. In particular, readers will gain in-depth knowledge of so-called innovation potential in standardization according to Abdelkafi and Makhotin (2014):

- Efficient target-oriented innovation
- Differentiation
- Exceeding the requirements of standards
- Business model innovation
- Innovation impulses
- Innovation communication
- Absorption of innovation

5.1 INTRODUCTION

To succeed in a competitive marketplace, companies need to be innovative. They have to constantly look for new opportunities for innovation. So far, scientific literature has identified many innovation drivers, such as innovation teams (e.g. interdisciplinary teams that work on a specific innovation task), innovation cultures (e.g. company cultures that do not sanction failures and encourage learning), creative techniques (e.g. bionics and TRIZ), and innovation competitions (also called innovation contests that give individuals from inside or outside the organization the opportunity to work on an innovative task). Whereas innovation is understood as the result of a creative process, standards represent stability and identification of common grounds. Both aspects are—at least at first glance—not necessarily conducive to innovation. In the literature, innovation has been mainly described as the output of out-of-the-box thinking, which is rather unstructured and out of the ordinary. As such, the interactions between innovation and standards are by no means self-explanatory.

Standards are the result of many years of knowledge gathering and structuring. As such, standards are an important source of codified knowledge. Although they are crucial to the company's success, many companies do not perceive the relationships between standards/standardization and innovation.

More in-depth consideration can reveal how the two processes are, or at least should be, strictly and effectively correlated. First, as standards are a relevant source of codified knowledge, we could think of them as a "box" that delimits and consolidates state-of-the-art approaches. In this respect, innovative companies (to really be innovative) would need to understand the contents of the box and then deliberately place themselves outside of this box. Second, modern standards are flexible by design and do not have to be solution oriented; i.e. describing a particular solution to be implemented. Standards can be requirements oriented, thus only defining a general framework, but still allowing freedom of design and interpretation. Third, current research, especially in the information and communications technology industry, suggests that standardization plays a crucial role in the emergence and diffusion of innovation.

The next section provides an in-depth analysis of the interdependencies among standards, standardization and innovation. Section 5.3 deals with the relationship between standardization and research, as research can be a fundamental component in the quest for innovation. We will demonstrate how standards and standardization can support the research process in an effective way. Section 5.4 shows that formal standardization can be a useful aid to innovation. In particular, it describes the so-called innovation potential in standardization. Finally, section 5.5 summarizes the contents of the chapter as well as the key insights.

5.2 INTERDEPENDENCIES BETWEEN STANDARDIZATION AND INNOVATION

5.2.1 INTRODUCTION TO INNOVATION

Innovation is defined by Schumpeter (1934) as the "commercialization of all new combinations based upon the application of new materials and components, the introduction of new processes, the opening of new markets, and/or the introduction of new organizational forms". Innovation is actually more than an invention; it also includes the commercialization of the invention. In addition, innovation is not only limited to final products sold to customers. It can actually happen at different levels, such as materials, processes, services, components, markets and/or organizational forms.

The degree of novelty is an important property of innovation. Innovation can be incremental or radical. Incremental innovation (also called evolutionary) happens when the performance of an existing technology improves in small steps over time. In the case where the technology achieves a high level of performance over a very short time period, the innovation is referred to as radical or revolutionary.

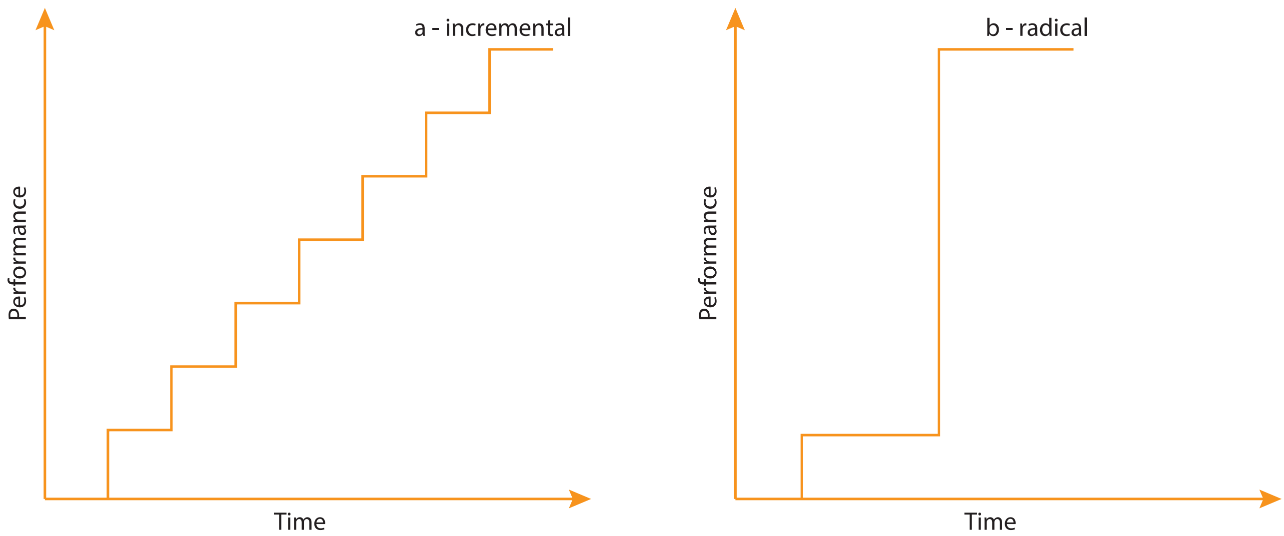

Figure 5.1 *Incremental and radical innovation*

According to OECD (2005), depending on the novelty level, there are four types of innovation: New-To-the-Firm (NTF), New-To-the-Market (NTM), New-To-the World (NTW) and disruptive innovation. NTF innovation means that a company adopts an existing technology. For instance, an Enterprise Resource Planning (ERP) system that is already used by other companies in an industry sector but is implemented for the first time by a particular company is an NTF innovation. Hence, even the adoption of an existing technology can be understood as innovation activity. The ability of companies to accommodate existing innovation is called absorption capacity (Cohen and Levinthal 1990). Absorption capacity is understood as a firm's "ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal 1990, p. 128). NTM innovation happens when known technologies are being transferred into a new market, whereas NTW innovation is ground-breaking and did not exist before. Disruptive innovation (Bower and Christensen 1996) offers less performance than an established technology with respect to a relevant feature, around which competition has taken place thus far. Because the performance of the disruptive technology is lower, it can be produced at lower costs than the established technology. As such, it addresses non-consumers who did not buy the established technology before. Also, because of its lower performance, the companies in the established market do not perceive the danger of the new technology. But the new technology can improve over time, in such a way that its performance becomes attractive to consumers, whose needs are overshot by the established technology. Now, because the new technology is lower priced and its performance is sufficiently good, the consumer in the established market switches to the new technology, leaving the companies offering the established technology in trouble. This technology is called disruptive.

5.2.2 STANDARDS AS AN ENABLER FOR INNOVATION-DRIVEN GROWTH

"Standardization and innovation give the impression of being opposites" (Perera 2010). Standardization appears to be about keeping things the same, whereas innovation is about the development of new things. According to David (1995) however, standards are "the flux between freedom and order".

There are many reasons why standards may have been perceived as innovation hampering. For instance, standards contain solutions that are intended to be used repeatedly. This is often perceived as "static", as the solution seems to be "frozen" for a certain period of time. Only when there is the necessity to develop another solution does the old one make place for the new one (de Vries 2006b).

But standards can also promote innovation. They allow critical mass to be achieved. Standards also ensure compatibility, allowing for innovation to take place based on other innovations. Furthermore, standards support the diffusion of research results, thus allowing for technology transfer (de Vries 2006b).

EXAMPLE

QWERTY vs. DVORAK keyboard

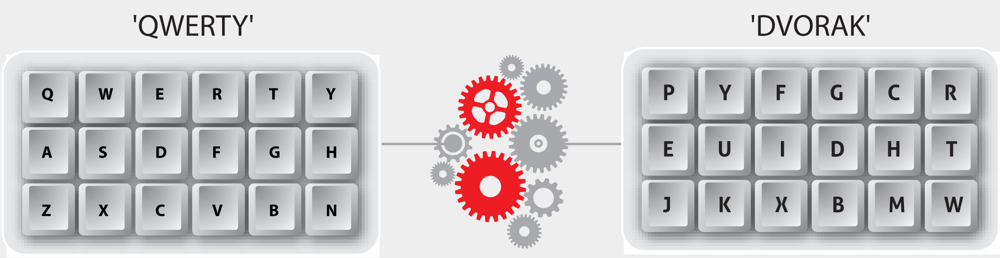

***Figure 5.2**: QWERTY vs. DVORAK*

Developed in 1879, the QWERTY keyboard was developed to slow down the typist. The layout of the keyboard is designed in a way that makes the keys less likely to jam. In the meantime, the computer has replaced the mechanical typewriting machine. As such, the QWERTY keyboard does not provide any benefit. In spite of the fact that the Dvorak layout—named after its inventor Dr August Dvorak—is superior, this design with improved ergonomics could not establish itself in the market.

Indeed, the QWERTY standard had many innovation-hampering aspects, in particular the lock-in effect. The lock-in-effect means that when users adopt and spend time, effort and money to learn a specific technology, they are less likely to switch to another technology (The Independent 2010). Hardware replacement incurs high costs for users. Learning how to use a new standard, such the DVORAK keyboard, costs users. In addition, the old standard has a network effect. The network effect is when the value of the technology increases the more users it has. As such, it would only be attractive for users to switch to the new standard if others do so. Consequently, everyone is waiting for the other to go for the new technology (penguin effect).

QWERTY, however, was somehow innovation fostering. Actually, QWERTY is only the standard for the interface between human and machine. The typewriting machine itself has been further developed, leading to the combined use of computer and text-processing software, based on the QWERTY standard. QWERTY is used worldwide and enables suppliers of hardware and software to benefit from economies of scale. An improved machine without a standardized interface would not be acceptable for customers (de Vries 2006b).

Standards support the development of new products and services, and are the foundation upon which markets can grow. The analogy between pruning a tree to maximize its fruitfulness and the design of the standards system to maximize innovation-led growth is a useful way to illustrate the potential of standards in supporting innovation and growth. So, why does a tree need pruning? Pruning is important to remove weak, dead and damaged branches and to promote healthy growth of wood. In addition, pruning is important to thin a dense canopy on a tree in order to increase air supply and sunlight absorption, resulting in healthy and increased flowering and fruitfulness. The trunk and branch structure plays a key role in determining the vigour of growth, leaves and fruit. It is dysfunctional to let all shoots grow, but through pruning, the tree has to select a shoot and concentrate its energy into the growth of this individual shoot. Finally, pruning gives the tree the desired shape (Swann 2000).

By analogy, like pruning, which eliminates dead and weak branches, standardization limits variety but helps to develop a "strong tree". The tree is analogous to technology. Innovation helps to grow the tree—in other words the technology—but standardization stops messy proliferation by holding back subsequent messy growth.

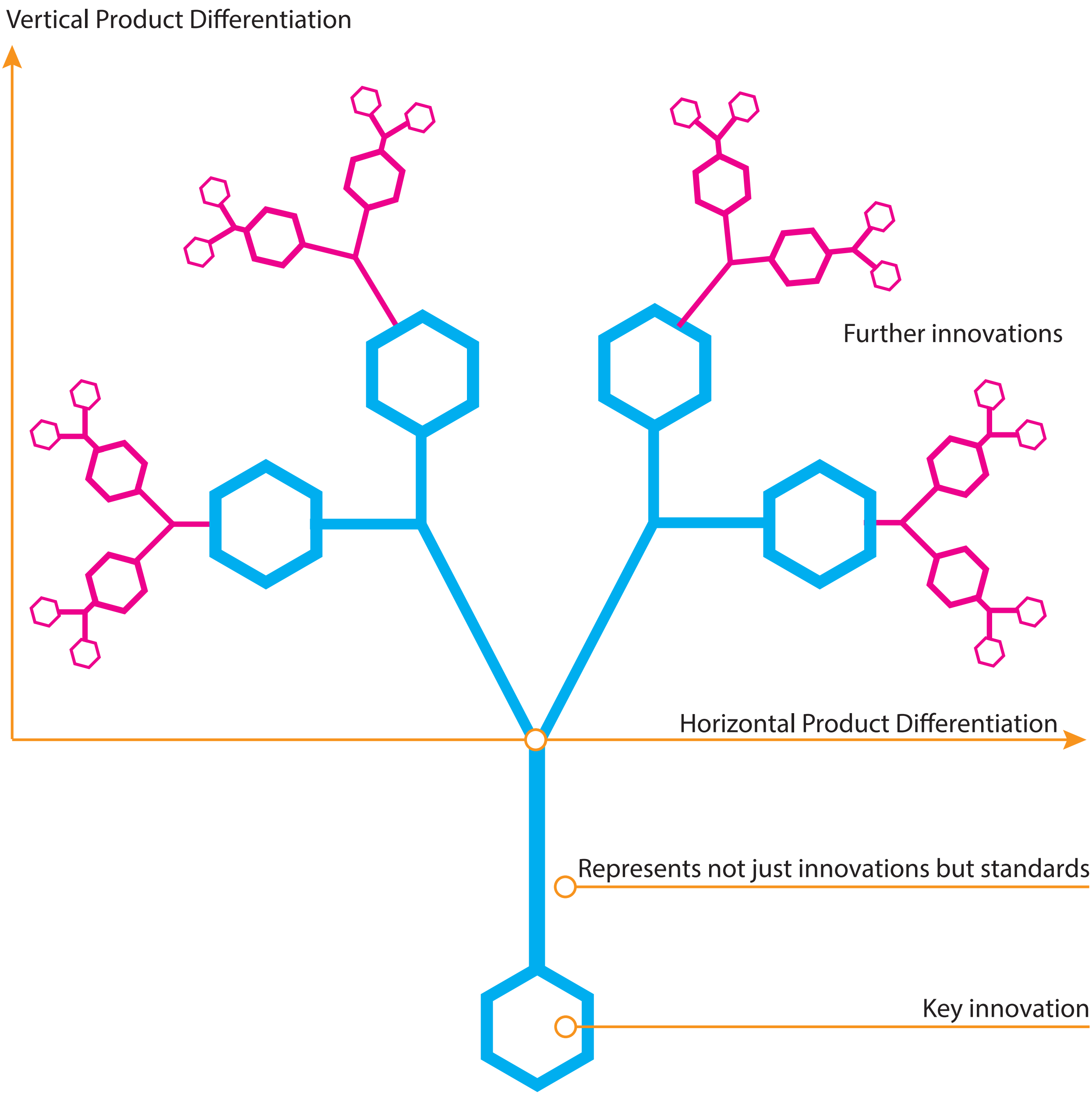

Figure 5.3 *Product innovation with standardization; adapted from Swann (2000)*

When applying this analogy to the evolution of standards and innovative products or services, the structure of the standards system can be depicted by a diagram, as shown by Figure 5.3. The diagram itself represents the technological space, and along the axes we distinguish between vertical product differentiation, which means the further up the diagram, the greater the performance or functionality, and horizontal product differentiation, which means that products of different designs and configurations have roughly comparable functionality (Abbott 1955).

Starting from the first node, for example a key innovation, standards support the development of further innovations. The usual forces of product innovation and competition continue to build a "canopy" of competing products and services of different characteristics. Standards enable and shape this pattern of innovation. The closer the innovations are to a standard, the greater the confidence of consumers and producers.

If product or service innovations are developed without standardization, the same process of innovation-led growth takes place, but a large number of slightly differentiated innovations follow different directions from the base point. Each stage shows a substantial amount of innovation and duplicated effort. Therefore, the potential for economies of scale is unused. The "canopy" is very dense, but the vertical product differentiation does not reach as far as it does with formal standardization.

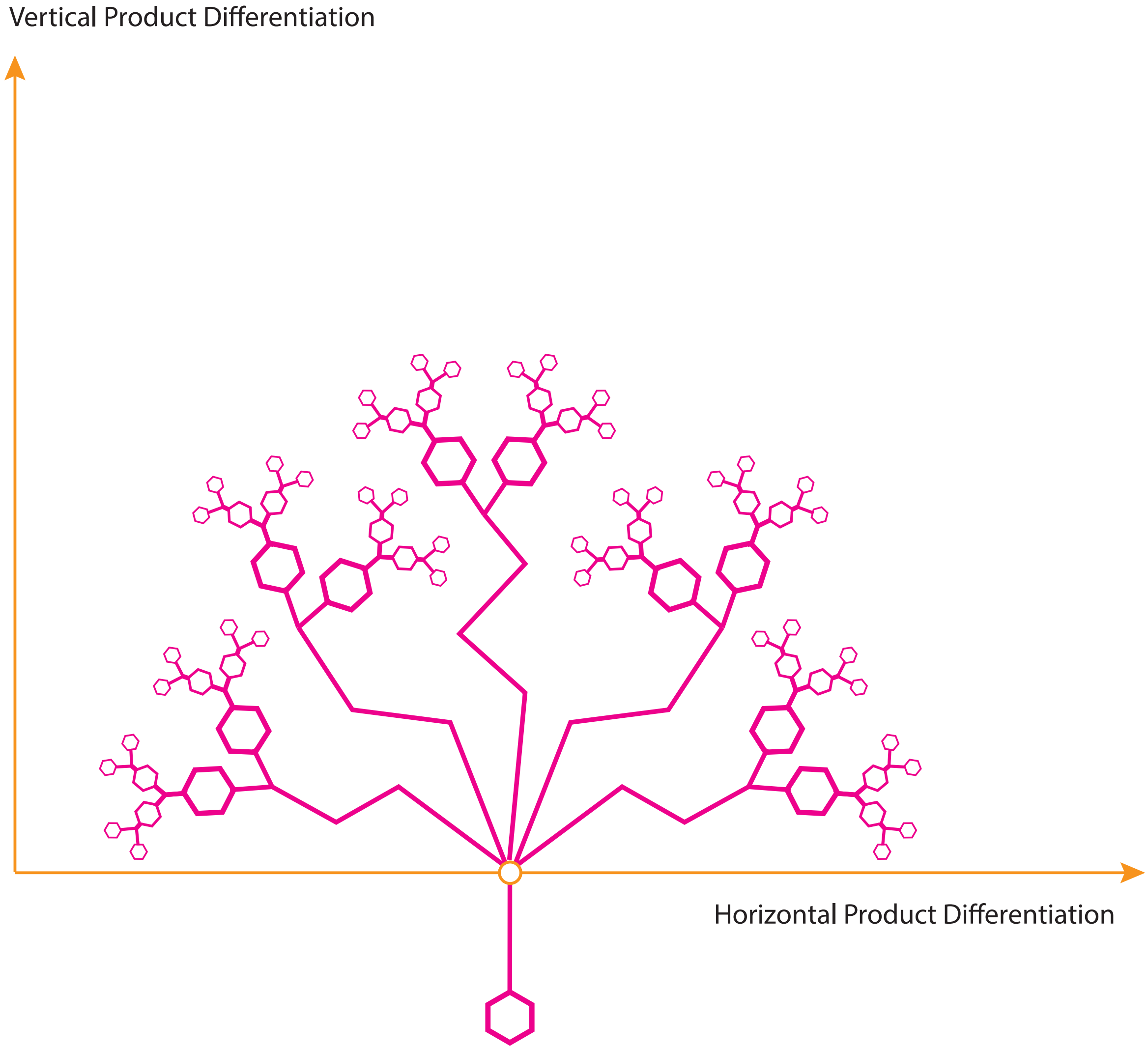

Figure 5.4 *Product innovation without standardization; adapted from Swann (2000)*

5.2.3 STANDARDIZATION AND THE TECHNOLOGY LIFE CYCLE

The moment in time in which standardization can take place can be related to the Technology Life Cycle (TLC), represented by an S-curve. The TLC describes the level of commercial return and improvement in technological performance, depending on the investments in Research and Development (R&D). At the beginning of the TLC, investments in R&D generate an increasing improvement in performance and commercial return. This level of improvement grows slowly at the beginning, then accelerates until it reaches a peak (tipping point), after which the rate of growth tends to decrease. The TLC, depicted by the S-curve, consists of four phases: introduction, growth, maturity and decline.

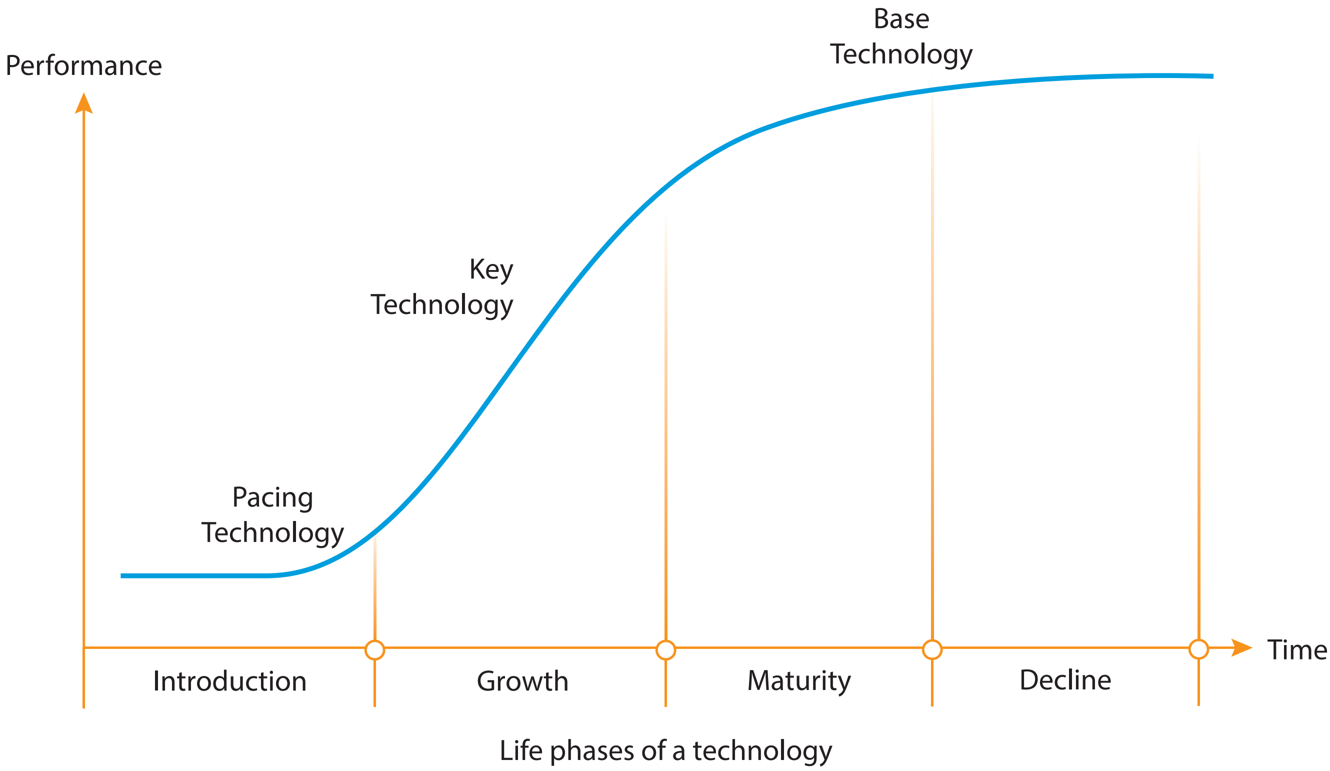

Figure 5.5 *Technology Life Cycle over time; translated from Brockhoff (1999)*

The Technology Life Cycle starts with the Introduction phase, which is characterized by a relatively slow progress of technology performance. In this phase, the technology is still new, and no dominant design has been established yet. This condition leads to higher competition on the market, as every market player aims to push through its technology to a dominant design, in other words to a de facto standard. Therefore, companies intensively invest in R&D, resulting in improved performance. In the Growth phase, the dominant design emerges, and the performance of the technology improves at a higher pace. In particular, there are great advances in production processes, thereby lowering costs due to economies of scale and learning curve effects. As the technology improves further, it approaches its physical limits that derive from the laws of nature. At this point, the technology reaches its Maturity phase. It is almost completely adopted by the market, and the strong competition causes the market players to spend their resources on improving production, and lowering costs. After reaching market saturation, the curve starts to dip in the Decline phase because of decelerated development.

At the beginning of the Technology Life Cycle, during the introduction phase, the technology is called a pacing technology. During its growth, it is a key technology, whereas during the maturity and decline phases, the technology is called a base technology.

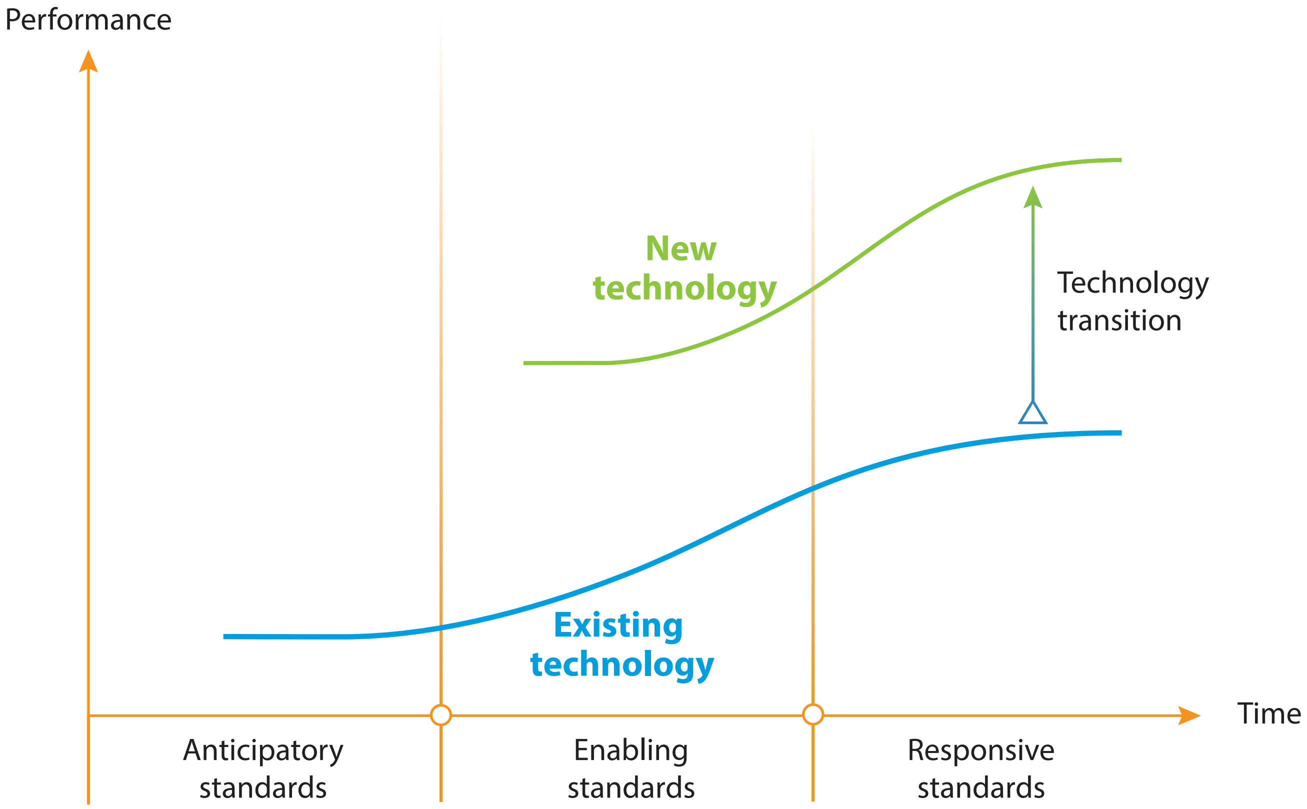

***Figure 5.6**: Standards related to the Technology Life Cycle (Sherif et al. 2005)*

Standards can be related to the Technology Life Cycle. There are three types of standards that are worth introducing in this regard: anticipatory standards, enabling standards and responsive standards. Note, however, that while this classification of the types of standards is useful, it does not rely on terminology that is used during the standardization making process.

Anticipatory standards are "forward-looking" answers to expected technological problems. They are essential for successful network systems. The specification of anticipatory standards runs in parallel to the development of prototypes, pilots and field trials to condense available theoretical and practical knowledge. Anticipatory standards also provide a way of sharing ideas. This is crucial when the risks of not collaborating with other competitors are high. Examples of anticipatory standards are: X.25, Integrated Services Digital Network (ISDN), Secure Sockets Layer (SSL), Bluetooth, Universal Mobile Telecommunications System

(UMTS), etc. (Egyedi and Sherif 2008). Anticipatory standards are used during the introduction phase of the Technology Life Cycle and can lead to the acceleration of technology development as well as the reduction of redundant development.

Enabling standards proceed in parallel with market growth and the improvement of technology and products to enhance the agreed-upon design by extending robustness and scale. In general, competitive forces and the need to reduce production costs influence the direction in which the standard develops. Enabling standards support the diffusion of technical knowledge and prevent market fragmentation. Enabling standards support the growth phase in the Technology Life Cycle. One example of enabling standards is the V.90 Recommendation from ITU-T for modems at 56Kbit/s, used for digital communication on traditional analogue telephone networks. Some proprietary designs of modems operating at that rate already existed. To avoid market fragmentation and to increase the total market size, chip manufacturers were forced to collaborate in the standardization process at ITU to develop an implementation that would work independently of the chipset used. Some technologies rely on a mixture of anticipatory and enabling standards. For instance, some areas of GSM (Groupe Spécial Mobile—Global System for Mobile communications) specifications were anticipatory to define a platform for future growth both for service operators and manufacturers, and others were enabling, defined after getting feedback from the market (Egyedi and Sherif 2008).

Responsive standards are created at the end of technology development, in other words during the maturity or decline phases. Internal responsive standards are defined after the dominant design has stabilized. The main objective is to codify best practices. The advantage of external responsive standards is that they improve efficiency or reduce market uncertainty for auxiliary product and services. Responsive standards may also be called "business standards", as they contribute to achieving maximum return associated with an already established technology. For instance, Transport Layer Security (TLS) is a responsive standard following the establishment of Secure Sockets Layer (SSL). TLS/SSL are cryptographic protocols to secure communication over a TCP/IP computer network at transport layer (Egyedi and Sherif 2008).

5.3 RESEARCH AND STANDARDIZATION

Innovation and research are related. Research is the transformation of money into knowledge, whereas innovation is the transformation of that created knowledge into money. A successful transfer of research results into innovative products and processes is crucial for the economy. So far, many technology transfer instruments have been developed and implemented. Still, standardization has not been widely recognized as an instrument that enables the transfer of knowledge from research to a practical context. Germany, for example, at some point achieved a leading position in nanotechnology research globally, but was not able to leverage this advantage and occupy a leading position in European and international markets due to a delay in national standardization activities (Blind 2009).

There are actually many reasons why research results should be integrated in standards. First, companies that build upon these standards absorb the latest knowledge. Second, standardization constitutes an excellent mechanism to support the transfer of research results into innovative products/services. In contrast to patents, standards are more likely to be broadly implemented because all interested stakeholders that participated in the standardization process reached consensus. Third, publicly funded R&D results become public goods through standards, thus increasing the economic efficiency and the economic objectives of research subsidies (Perera 2010).

5.3.1 TRADITIONAL VS. RECURSIVE RESEARCH EXPLOITATION

Standardization and research can be closely related. Research produces knowledge that flows into standards (traditional technology transfer), and standards can also serve as a knowledge source for further/new R&D projects. Consequently, there is a recursive knowledge flow from standardization back to research. This prevents the reinvention of the wheel and stimulates ideas for new research projects (Blind 2013).

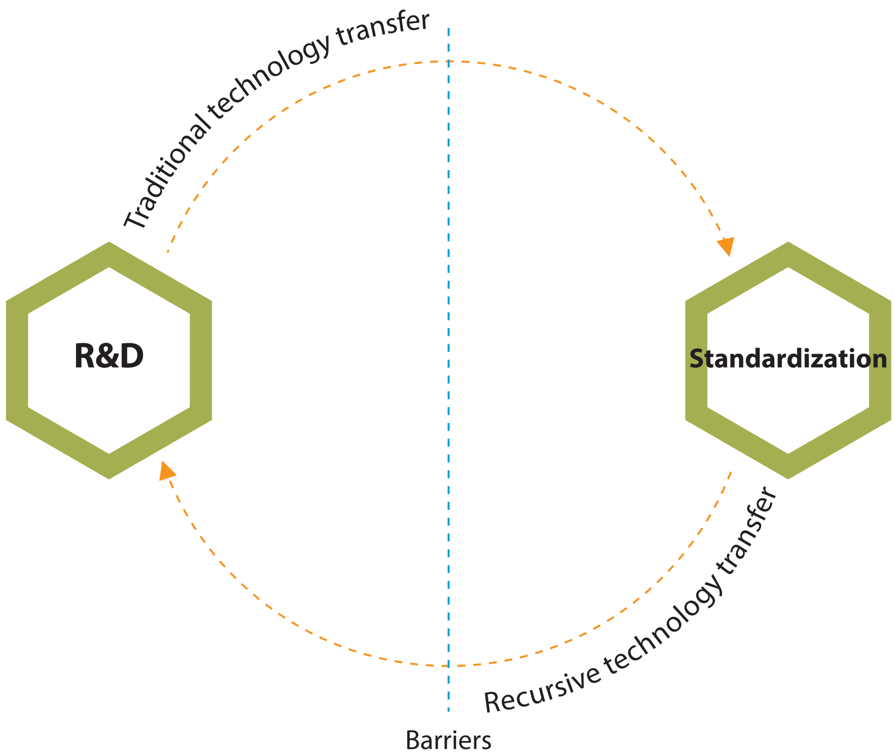

Figure 5.7: *Research and standardization; adapted from Blind (2009)*

5.3.2 STANDARDIZATION AS A COOPERATIVE PROCESS TO SUPPORT THE EXPLOITATION OF RESEARCH RESULTS

Standardization enables not only the transfer process of knowledge, but also cooperation. Standardization can provide a common platform for players from heterogeneous backgrounds such as research, industry, government, Non-Profit Organizations (NPOs), and consumers to cooperate. For example, the standardization process not only leads to the standard, which is the final output, but also supports the exchange of tacit knowledge among the members of the standardization committees. The standard combines the different perspectives of many companies and other players, as the standardization process leads to the integration of inputs from heterogeneous sources (e.g. knowledge from producers and consumers) (Blind 2013).

Figure 5.8 displays how research and standardization can interact in a simple technology transfer model. Research and development activities produce knowledge, which can be codified in publications and patents. These publications and patents combined with knowledge from experts can feed the standardization process. The process of standardization as well as the coordination work (e.g. facilitated by an SDO) generate standards, and these standards are then implemented in practice. The implementation of the standards feeds back to standardization (e.g. to update the standard) and research (e.g. new research areas or insights emerge after standards have been implemented in practice).

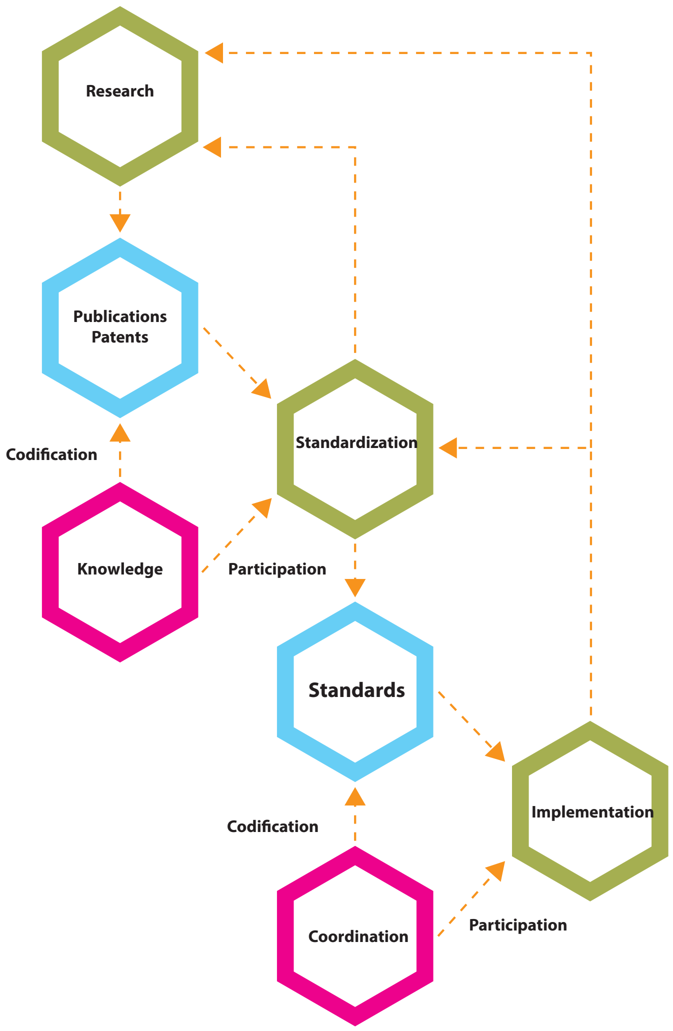

***Figure 5.8**: Research and standardization in a simple technology transfer model (Blind and Gauch 2009)*

5.3.3 A MODEL FOR THE INTEGRATION OF STANDARDIZATION IN RESEARCH

The research and innovation process consists of different phases. Blind (2013) identifies five phases: pure basic research, oriented basic research, applied research, experimental development, and diffusion. The objective of pure basic research is to conduct theoretical or experimental work to generate new knowledge of the underlying foundations. Oriented basic research aims to produce a base of knowledge that is likely to form the background to the solution of current or future problems. Applied research constitutes an original investigation towards an aim or objective. It involves the practical application of science. Experimental development represents systematic work that leverages knowledge gained from research and practical experience, while producing additional knowledge directed at producing new products. The diffusion process deals with spreading innovation from the first implementation to wide implementation for different consumers, countries, regions, sectors, markets and firms (OECD 2005, 2015).

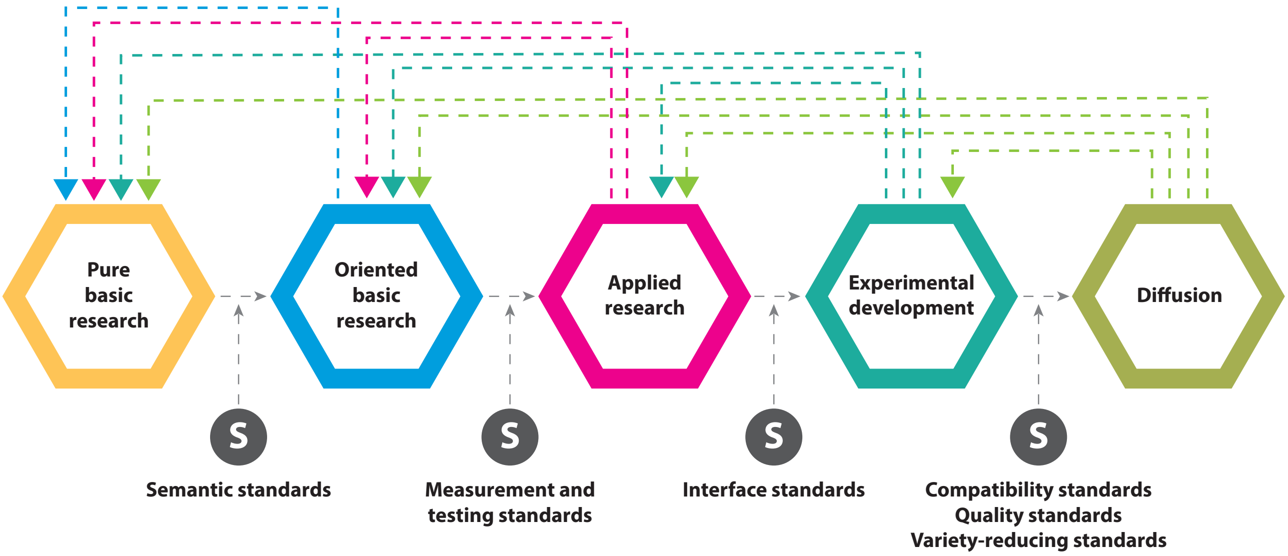

***Figure 5.9**: Various roles of different types of standards in the innovation process (Blind and Gauch 2009)*

Standardization and research are highly interlinked. Different standards can play different roles at several stages of the research and innovation process. Terminology or semantic standards facilitate efficient communication. They are required in basic research as well as in the transfer of knowledge to oriented basic research and all subsequent research activities. Measurement and testing standards allow the first moves to be made towards product-related developments. They can be used to check whether specific requirements have been met (e.g. performance criteria). Furthermore, they ensure the comparability of the results through agreed-upon test methods. Interface standards allow for the interoperability of components integrated into products or process technology, whereas compatibility, quality and variety-reducing standards support the transition of products into mass markets (Blind and Gauch 2009).

These types of standards will be dealt with in greater detail in Chapter 8. Semantic standards and measurement and testing standards can reduce information and transaction costs. Interface standards drive the interoperability among components and save adaption costs. Compatibility standards, quality standards and variety-reducing standards lead to increased quality as well as reduced health, privacy, and safety risks, while supporting the building of critical mass. In addition, these standards support interoperability among products, economies of scale, and the creation of network externalities.

EXAMPLE

MP3 is an excellent example that illustrates how standardization and research can support each other. The MP3 patent is actually included in an ISO (formal) standard. Research within the Digital Audio Broadcast (DAB) project was conducted at the University of Erlangen-Nuremberg, Germany. The first patent applications, based on the results of the project, were filed in 1987. Also in 1987, Fraunhofer Institute for Integrated Circuits (Fraunhofer IIS), also based in Nuremberg, Germany, started audio encoding research as part of the DAB project. In 1989, the Moving Picture Expert Group (MPEG) standardization committee was founded. This committee included leading companies from the industry such as Sony, Phillips and EMI. In 1992, MPEG released MPEG-1-Layer3, known as MP3, as a standard MP3-player format. The MP3 standard was very successful. It led to the sale of more than 100 million MP3 players and to more than €100 million in licensing revenue for the Fraunhofer society (Blind 2009).

In spite of the importance of standardization and standards for research, there is currently limited awareness of the benefits of standards and standardization among researchers. The broad accessibility of standards (in contrast to scientific publications and patents) drives free-riding, and this has resulted in too few incentives for researchers to engage in standardization. Furthermore, as standards are often driven by strongly business-oriented industries, there may be some scepticism against researchers and research in general and a tendency to not acknowledge their expertise as relevant to the standardization process. Another important aspect is that standardization is a time-consuming process that may cause delay in the transfer process and discourage researchers from working in standardization committees. In this regard, however, it is worth noting that patenting processes often take longer than the average standardization process of three years (Blind 2009, 2013).

5.4 FORMAL STANDARDIZATION: A DRIVER FOR INNOVATION

"Standardization is an essential part of the microeconomic infrastructure: it enables innovation and acts as a barrier to undesirable outcomes" (Swann 2010, p. 9). Standards and standardization can support innovation, which is as a combination of invention and exploitation. Consequently, standards and standardization can have a positive effect on invention and exploitation. This section is based on research conducted by Abdelkafi and Makhotin (2014) within the scope of a project funded by the German Institute for Standardization (DIN). It investigates how German companies, in particular SMEs, can leverage committee standards to drive innovation.

Figure 5.10 below classifies the opportunities for the support of innovation according to two dimensions. The first dimension distinguishes between two aspects: invention and exploitation. That is, standards and standardization can support invention by inspiring people and triggering new ideas, or can facilitate the exploitation process by pushing commercialization and sales. The second dimension concerns whether the innovation opportunity is derived from the company's work with standards or participation in the standardization process. The quadrants in the figure show the innovation opportunities, revealing how invention and exploitation can be concretely supported. The content of these quadrants will be specifically discussed and expanded in the following sections.

	Opportunities for the support of innovation through standards and standardization	
	Invention-Support...	**Exploitation-Support...**
...through standards	• Exceeding the requirements of standards • Efficient and target-oriented innovation • Stimulating innovation through update of standards and new standards	• Business model innovation (e.g. laboratories)
...through the standardization process	• Stimulating innovation from participation in standardization process (ideas/insight from customers, competitors and other stakeholders)	• Innovation communication • Absorption of innovation during standardization process

***Figure 5.10**: Innovation potentials in standardization; adapted from Abdelkafi and Makhotin (2014, p.46)*

5.4.1 EFFICIENT AND TARGET-ORIENTED INNOVATION

Committee standards provide a useful framework for the development of new products. Standardization increases the effectiveness of R&D activities and enables the transfer of innovations from one sector to another. For instance, a security company sees the set of standards as the basic prerequisite in order to not develop products "for the trash".

Standards can provide a guideline for the innovation process. They enable efficient and target-oriented innovation. The efficiency of innovation projects depends on resource inputs such as time, material, energy and money (Spath et al. 2010). Standards can positively influence these factors, thus decreasing the cost of generating innovation. The use of standards in development projects improves productivity and supports target-oriented innovation. In highly innovative technological fields, quality standards ensure reliable documentation and traceability. Both are essential for the approval of a new product. In less-standardized fields such as nanotechnology, setting standardized testing methods supports comparability among products, making the developers of new products aware of the requirements to be fulfilled.

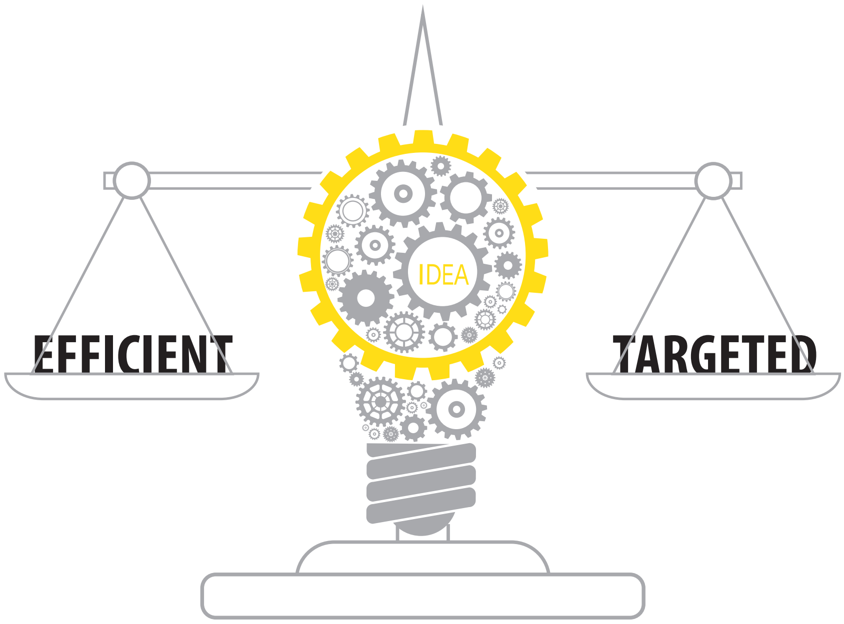

***Figure 5.11**: Efficient and target-oriented innovation*

5.4.2 DIFFERENTIATION

Companies can achieve a competitive advantage, depending on how well and how quickly they can fulfil the requirements of a new standard. Standardization creates opportunities for the development of differentiated products. This can take place when the company synchronizes its R&D process with the standards development process and when it differentiates its products and services through the development of customer-tailored (but standard-compliant) portfolios.

Standards represent state-of-the-art knowledge and define the requirements that apply equally to all stakeholders. Hence, it is paradoxical to consider standards as a means of differentiation. Nevertheless, the standard represents the foundation upon which companies can develop their unique selling points. In effect, by knowing the requirements of the standard solution, which can be fulfilled by virtually all competitors, the company can select the areas in which it can be different. In these areas, it can develop specific capabilities, particularly core competencies (Prahalad and Hamel 1990), thus differentiating itself from the competition.

Not only standards, but also the standardization process, can support differentiation. The information advantage that participants gain during the standardization committee can be exploited within the R&D process to achieve product differentiation (de Vries 2006a).

***Figure 5.12**: Synchronizing the product development and standardization activities with the objectve of differentiating own products*

5.4.3 EXCEEDING THE REQUIREMENTS OF STANDARDS

Standardization and standards can drive innovation if the company sets the standard as the minimum requirements to be achieved and then tries to do better than what the standard actually recommends. Good standards specify requirements and leave some degree of freedom. Knowing the basic requirements within the standards, companies are even able to develop new solutions. For instance, one company producing equipment for security gates at airports uses the related standards as a starting point. Let us say that the standard proposes that people traversing security gates should not be radiated with more than five radiation units. The company sets a target to produce equipment with much lower radiation units, whereas most of the competitors produce equipment with five radiation units. Thus, knowing the basic requirements, which are documented in the standards, companies are able to develop "out-of-the box" solutions. Besides the general need of increasing competitiveness, going beyond standards may be justified by other reasons like special-purpose customer requests, marketing reasons, previous experience or hedging against uncertainties.

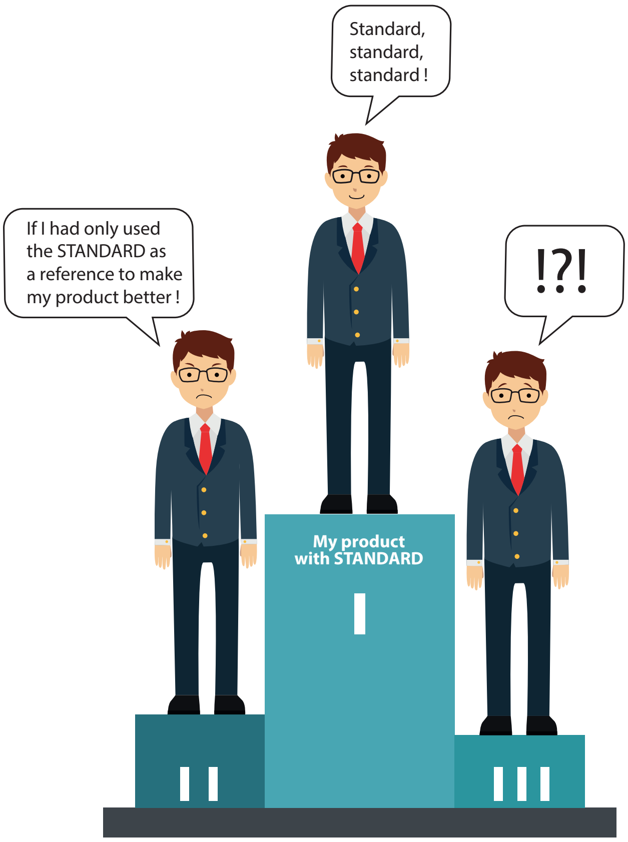

Figure 5.13: *Exceeding the requirements of standards*

5.4.4 BUSINESS MODEL INNOVATION

Standards can lead to new business models, such as test labs, consulting firms and certification organizations. Business models describe how an organization creates value (Linder and Cantrell 2000). Business model innovation refers to the process of renewal or design of business models (Wright et al. 2012), and standards can represent the backbone of this process. Test laboratories, consultancies and educational services can use standards as a core element of their business models. Test laboratories, for instance, specialize in the application of standardized procedures. By integrating new standards in the value proposition, they can address the requirements of new customers. As such, standards constitute an integral part of the business model, since the decision of which standards to include in or eliminate from the portfolio determines the cost structure (e.g. additional investments) and potential sources of revenue. Some consultancies would never be able to do business without standards, because they entirely build their business models around standards (e.g. quality standards). For instance, in technology areas where it is difficult to get a good overview of the relevant standards, entrepreneurs launch new start-up companies in the field of standards to provide advice for companies that need consultancy services in the area.

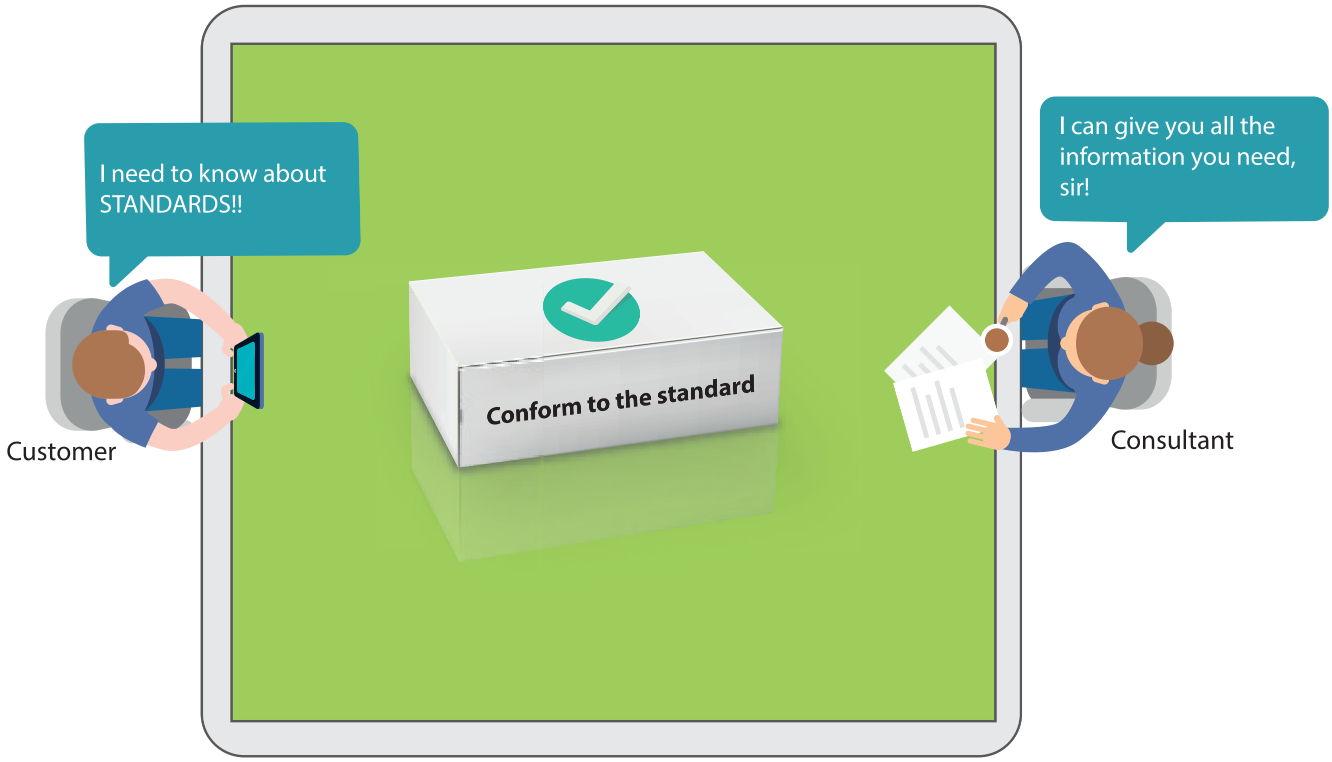

***Figure 5.14**: Business model innovation through standardization*

5.4.5 INNOVATION IMPULSES

Innovation impulses can result from the update of an existing standard or after a new one is introduced. When standards are changed over time, companies get an incentive to comply and make their products fit the new version of the standard. The development of a completely new standard can also drive companies to adapt their products. Hence, this process is likely to result in innovative solutions. Changes in standards can only be transferred to innovations if certain conditions are fulfilled. First, acceptance of the change inside the company should be high. Second, the company should be capable of integrating the standards in its innovation process. Thus, the change of standards released by national or international standardization bodies can be a source for innovation. It also provides a strong incentive to companies to actively participate in standardization processes.

However, the updates of standards can be perceived as a burden for the company because of additional development efforts. For instance, one company in the biotechnology field stated that the change of standards could put the company in a position where it needs to update already produced products (stock), and this leads to extra costs that are not welcomed by the company.

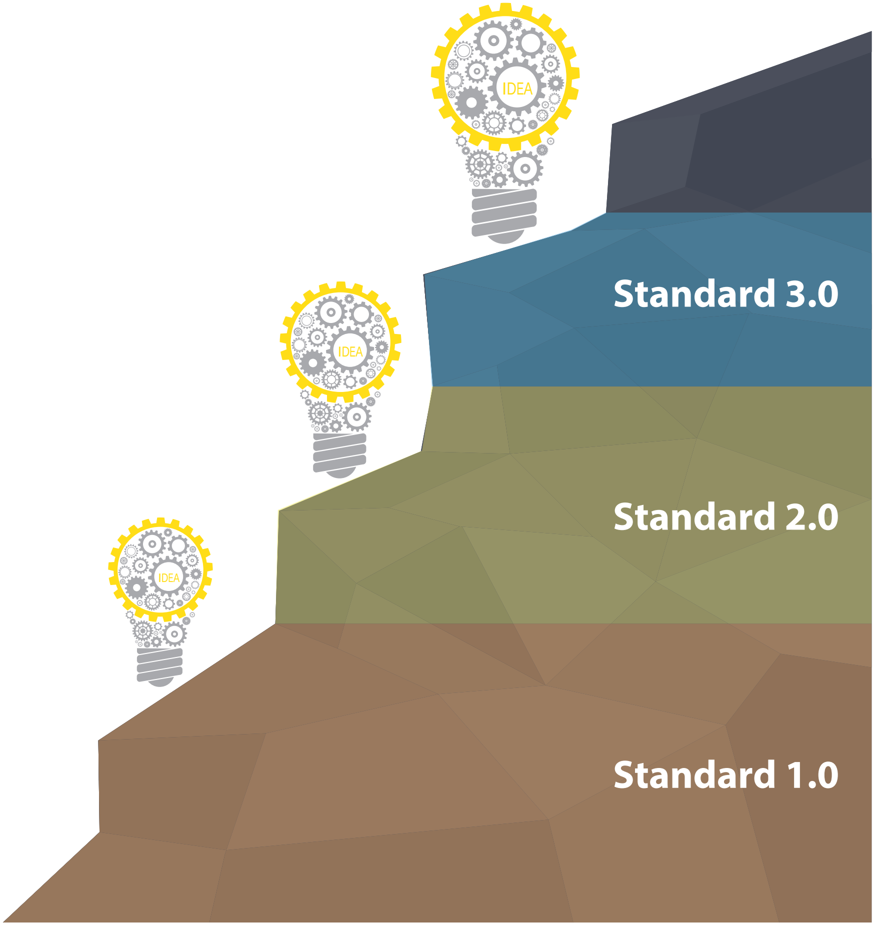

***Figure 5.15**: Innovation impulses through standardization*

5.4.6 INNOVATION COMMUNICATION

Companies should actively communicate their innovation capabilities. In general, companies that participate in standard-setting processes signal know-how and high competence to the outside, which is especially important in the Business-to-Business (B2B) field. For instance, producers that participate in the standard-setting process can achieve compatibility of their products with market requirements and make their customers more confident in the company's solutions. Customers benefit from this because they incur no risk of the product becoming obsolete after the standard has been released. In general, innovation communication with standards helps companies to build trust with their customers, especially in areas with rapid technology development. A company in the field of nanotechnology continuously informs its customers about its activities in the standard-setting process, in order for the customer to know what the company is doing. The customers, on the other hand, are quite happy to receive this up-to-date information. Consequently, innovation communication positively contributes to the diffusion of technology.

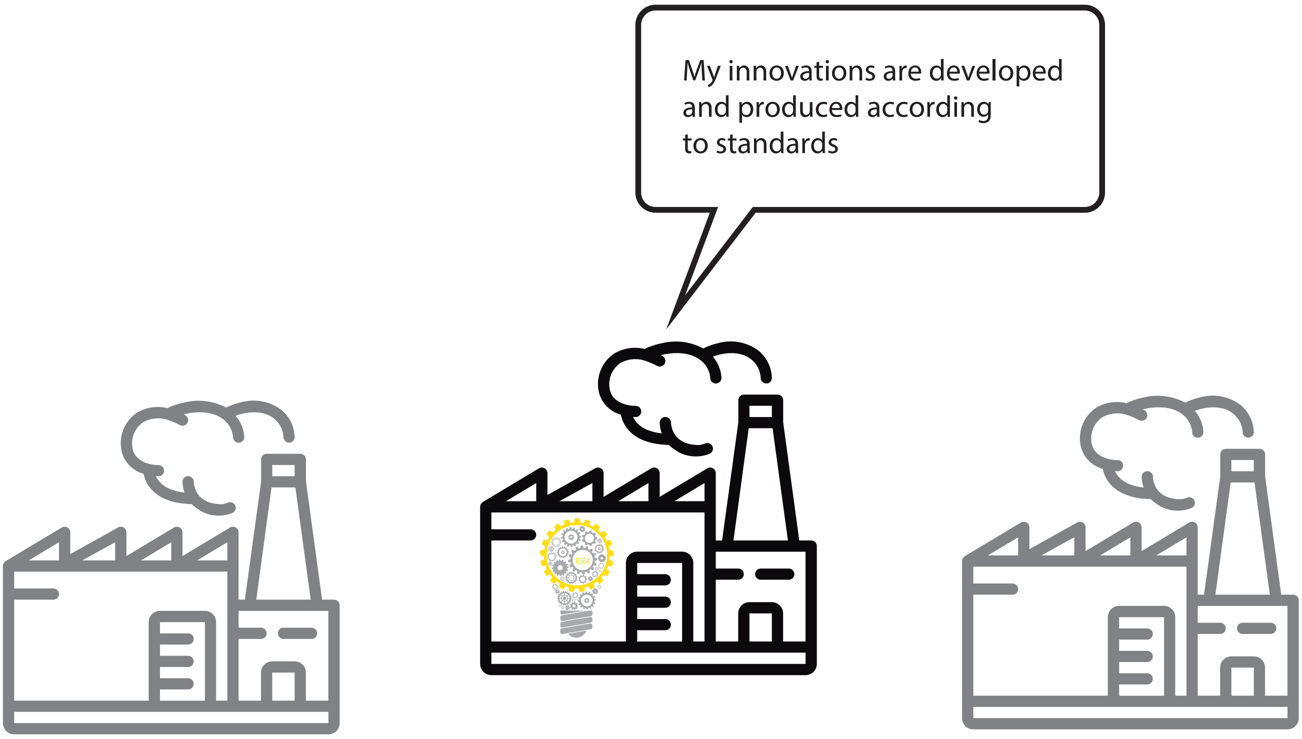

***Figure 5.16**: Innovation communication through standardization*

5.4.7 ABSORPTION OF INNOVATION

Standardization committees are an important instrument for increasing the absorptive capacity of companies. Absorptive capacity describes the ability of companies to transfer and apply novel and useful external knowledge (Teece 1998; Cohen and Levinthal 1990). Companies that are in contact with their peers during the committee meetings can absorb important technical knowledge and can even identify new markets. Thus, companies that participate regularly in standardization processes can leverage this innovation potential. These companies see the process as an important opportunity to gain relevant knowledge that supports innovation. A company that produces devices that switch off electric current to protect machines and people from electric shocks noted that not only was the development of standards important for the company, but also the discussions with committee members that led to the identification of new application areas for the company's own products. This company was able to scale up its businesses from about 20 people in the 70s to about 700 employees currently with the help of standardization.

Note that innovation diffusion and absorption are two sides of the same coin. As the knowledge is revealed within the standardization processes, diffusion occurs, if the companies that participate in the standard committee absorb and adopt the innovation. In addition, the diversity of the participants in the standard committee supports the diffusion process, as people with different backgrounds can see new areas of application of an existing technology or product.

5.5 SUMMARY

This chapter provides a comprehensive overview on the basics of standardization and innovation. First of all, it is important to observe that sometimes standards can hamper innovation if standardization is not adequately managed over time or if the standard induces a lock-in effect. For instance, the keyboard example (QWERTY vs. DVORAK) shows that people find it difficult to change an established standard and switch to a better solution. Nevertheless, we argue that the positive contribution of standards and standardization to innovation more than outweighs its negative impacts.

We define innovation as a process and as an output of that process. Standards and standardization can offer an essential contribution to innovation as both a process and an output, but they are more effective in promoting incremental and evolutionary, rather than radical and disruptive innovations. The analogy between the pruning of a tree and standardization perfectly illustrates how and why standards can support innovation and growth. In the same way that pruning increases the fruitfulness of a tree, standardization supports innovation-led growth by channelling and focusing the energy that companies spend to develop a given innovation. A business landscape without standards would lead to energy distributed over many possible evolutionary paths, resulting in large waste of resources, redundancies, and slower progress in general.

Standards and standardization activities can be effectively related to the technology life cycle, which consists of four phases: introduction, growth, maturity and decline. There are three types of standards that can be used during these phases. Anticipatory standards are forward-looking and solve expected interoperability problems. As such, they can support the introduction phase of a technology. Enabling standards are established during the growth phase and improvement of a technology or products to enhance robustness and scale of an agreed-upon or a dominant design. Responsive standards are created at the end of technology development, during the maturity and decline phase. Their aim is to pick up on and document best practices.

Standardization and standards can be very useful during the research process. The results of the research process can be used by the standardization process to draft new standards. The other way around is also possible, as standards can give input for the research process. Therefore, there is a recursive knowledge flow from standardization to research. The research and innovation process consists of five different phases: pure basic research, oriented basic research, applied research, experimental development, and diffusion. These phases are supported by different types of standards. Terminology standards facilitate efficient communication and are required in basic research as well as in the transfer of knowledge to oriented basic research. Measurement and testing standards can be used to check whether specific requirements such as performance criteria have been met, while ensuring the comparability of the results. Interface standards allow interoperability of components, whereas compatibility, quality and variety-reducing standards support diffusion.

Finally, the last section focuses on the innovation potential in formal standards and standardization. In total, standards and standardization support innovation in seven ways. Standards can promote efficient and target-oriented innovation, as products developed in compliance with available standards are more likely to be accepted by the market and have better chances of success. Companies that participate in standardization committees can communicate their involvement actively, resulting in a good reputation and positive signs to the outside that they are innovative. The update of standards can also give companies impulses for innovation, even though some companies may find such changes bothersome and annoying. During the standardization process, companies may gain valuable knowledge that they can use to differentiate their products from those not involved in standardization committees. In addition, the standard can be used as a basic requirement, and companies can deliberately decide to exceed what the standard proposes in order to generate innovations. It is also possible for some businesses to build their business models upon standards in a given sector, for example when consulting services are offered for standards to give companies advice on which standards are relevant for them and what the standards say. Finally, standardization processes enable companies to identify new knowledge that can be of high value to them. This knowledge can be used to nurture the innovation process or to identify new markets. All of these aspects clearly demonstrate how standards and standardization can boost innovation. Companies that are aware of all of these advantages can actively strengthen their innovation capabilities.

5.6 QUIZ

1 - WHAT IS INNOVATION?

(See Section 5.2.1 for hints)

a) *Innovation is a new invention.*

b) *Innovation happens only at the product and service level.*

c) *Innovation is the combination of invention and commercialization.*

d) *Innovation is incremental when there is a considerable improvement of performance within a short period of time.*

2 - AN ENTERPRISE RESOURCE PLANNING (ERP) SYSTEM THAT IS ALREADY USED BY OTHER COMPANIES IN A SECTOR, BUT ACTUALLY IMPLEMENTED FOR THE FIRST TIME BY A PARTICULAR COMPANY IS A …

(See Section 5.2.1 for hints)

a) *New-To-the-Market (NTM) innovation*

b) *New-To-the-Firm (NTF) innovation*

c) *New-To-the-World (NTW) innovation*

d) *Disruptive innovation*

3 - QWERTY IS…

(See Section 5.2.2 for hints)

a) *superior to DVORAK.*

b) *a formal standard.*

c) *a committee standard.*

d) *a de facto standard.*

4 - THE ANALOGY BETWEEN STANDARDIZATION AND TREE PRUNING ILLUSTRATES…

(See Section 5.2.2 for hints)

a) *the potential of standards in supporting innovation and growth.*

b) *how standards inhibit innovation.*

c) *that standards lead to a waste of innovation resources.*

d) *the chaotic nature of the innovation process.*

5 - AT WHICH PHASE IN THE TECHNOLOGY LIFE CYCLE DOES A DOMINANT DESIGN EMERGE?

(See Section 5.2.3 for hints)

a) *Introduction*

b) *Growth*

c) *Maturity*

d) *Decline*

6 - ANTICIPATORY STANDARDS...

(See Section 5.2.3 for hints)

a) *proceed in parallel with market growth and improvement of technology.*

b) *are "forward-looking" answers to expected interoperability problems.*

c) *are created at the end of technology development*

d) *are not conducive to innovation, as they inhibit creativity.*

7 - THE INNOVATION PROCESS CONSISTS OF...

(See Section 5.3.3 for hints)

a) *Pure basic research, oriented basic research, applied research, and experimental development*

b) *Pure basic research, oriented basic research, applied research, and diffusion*

c) *Pure basic research, oriented basic research, applied research, experimental development and diffusion*

d) *Pure basic research, applied research, experimental development, and diffusion*

8 - INNOVATION IS SUPPORTED...

(See Section 5.4 for hints)

a) *only by standards.*

b) *neither by standards nor by standardization.*

c) *only by the standardization process.*

d) *by standards and by standardization.*

9 - EXCEEDING THE REQUIREMENTS OF STANDARDS IS...

(See Section 5.4.3 for hints)

a) *an innovation potential, as it provides impulses for the improvement of products and technologies.*

b) *a cost-increasing factor.*

c) *not an innovation potential, as competitors will strive to do the same.*

d) *not allowed because of regulations.*

➜ **SOLUTIONS PAGE 253**

5.7 GLOSSARY

- Innovation: "An innovation is the implementation of a new or significantly improved product (good or service) or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" (OECD 2005, p. 46).
- Incremental innovation: When the performance of an existing technology improves in small steps over time. It is also called evolutionary.
- Radical innovation: In the case where the technology achieves a high level of performance over a very short time period, the innovation is referred to as radical or revolutionary.
- Invention: "Something that has never been made before, or the process of creating something that has never been made before" (Cambridge Dictionary n.d.).
- Innovation teams: As innovation requires multiple skills, in most cases multiple people form a team to gather a wide range of skills to keep the innovation engine running (Eckert n.d.)
- Absorption capacity: A firm's "ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal 1990, p. 128).
- Technology lock-in effect: The idea that the more a user uses and learns about a specific technology, the more unlikely it is that he switches (The Independent 2010).
- Penguin effect: "Even if users unanimously favour a switch, each user may prefer the other to switch first". This is based on the following analogy: penguins who have to enter the water to look for food often delay doing so because they fear possible predators. The penguins would prefer another penguin to test the water first. (Farrell and Saloner 1986, p. 943)
- Economies of scale: The average costs per unit of output decrease with the increase in the scale of the output being produced by a firm. (OECD 2003)
- Anticipatory standards: "Forward-looking" answers to expected interoperability problems. They are essential for successful network systems. Examples of anticipatory standards are: X.25, Integrated Services Digital Network (ISDN), Secure Sockets Layer (SSL), Bluetooth, Universal Mobile Telecommunications System (UMTS).
- Enabling standards: Standards that proceed in parallel with market growth and improvement of technology and products to enhance the agreed-upon design by extending robustness and scale. One example of enabling standards is the V.90 client modem.
- Responsive standards: Sometimes also called "business standards", as they contribute to achieving maximum returns associated with an already established technology. For instance, Transport Layer Security (TLS) is a responsive standard following the establishment of Secure Sockets Layer (SSL). TLS/SSL are cryptographic protocols to secure communication over a computer network.

5.8 LIST OF ABBREVIATIONS

- R&D: Research and Development
- TLC: Technology Life Cycle
- ISDN: Integrated Services Digital Network
- SSL: Secure Sockets Layer
- UMTS: Universal Mobile Telecommunications System
- NPO: Non-Profit-Organization
- DAB: Digital Audio Broadcast
- Fraunhofer IIS: Fraunhofer Institute for Integrated Circuits
- MPEG: Moving Picture Expert Group
- B2B: Business-to-Business

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6 A STRATEGIC PERSPECTIVE ON STANDARDIZATION

LEARNING OBJECTIVES

The objective of this chapter is to explain the motives and methods of participation in standardization activities from the perspective of an interested organization, both strategically and technically.

This includes dealing with aspects such as the choice of which standards organizations, SDOs, to participate in, and the coordination of the organization's external and internal activities, including internal specifications and rules.

Some explanation is given regarding the choice of suitable standards for a given application.

6.1 INTRODUCTION

This chapter looks at participation in standardization from the perspective of an organization interested in getting involved in standardization, looking both at strategic and technical aspects.

It looks at different strategies that organizations may have for participation, and at the choice of which SDO to join, as a function of scope of activities and of geographical location. It also looks at the more technical aspects of standardization, including implementation of standards.

Addressed is also the operation of standardization efforts and SDOs, including voting, and the impact of external influences.

Next, the communication aspects of standardization efforts are discussed, again from the perspective of a participating organization.

The chapter concludes with a section with guidance on how to select standards for a given application. It gives useful considerations for evaluating the different possibilities that should result in criteria for the selection of the most suitable set of standards.

6.2 DIFFERENT STRATEGIES FOR PARTICIPATION

This section addresses both the organizational, technology and technical aspects of participation in standardization, including motives, objectives and strategy.

6.2.1 ORGANIZATIONAL STRATEGIES

Organizations can be classified according to which role they play and intend to play in the standardization ecosystem, using here a classification according to Corporate Strategic Standardization Management (SSM).

The role that standardization plays for the organization is a function of how important standardization and/or presence in standardization is for the overall, primarily business-oriented, strategy. Active participation should be seen as a strategic tool that needs to be carefully managed, and needs to be aligned with the organization's overall, primarily business strategy. This is illustrated in Table 6.1.

LEADER	CONTRIBUTOR	FOLLOWER	SPECTATOR
■ Participation in standards-setting activity is business critical	■ Active participation in standardization process ■ Less interested in influencing the strategic direction of an SDO	■ Full membership privileges wanted ■ Not interested in influencing the strategic direction	■ Main motivation: intelligence gathering ■ No active contribution to the creation of a standard

Table 6.1: *Organizations classified by their participation strategy*

An organization may have a differentiated approach and may participate in different domains with different objectives, such as the protection of its business interests, early warning for technological and market developments, promotion of IPR and internal as well as proprietary standards, avoiding duplication between countries or continents, etc. This also means that different roles may be taken, such as a leader in one domain, spectator in another, etc. This in turn may lead to issues of perception by peers; for instance, an organization might be expected to be a leader in other domains in addition to its main priorities.

The business strategy is supported by a set of technology strategies. The standardization strategy of an organization is therefore driven by both the business strategy itself and by the derived technology strategies. To understand the standardization strategy of an organization, it is also useful to at least know and understand its supporting technology strategies.

6.2.2 TECHNICAL FOCUS

Where and how to participate will be a function of the technical needs and priorities of an organization. Priority will certainly be given to standardization topics related to the core activities of the organization.

However, the market and development of these core activities may depend on the availability and functionality of the infrastructure (telecom and non-telecom) and of related activities such as privacy and security requirements and support. Therefore, the organization may decide to also be present in domains of activity related to, but outside of its core activities. An example is given in the next section.

ORGANIZATION	TYPICAL TECHNICAL FOCUS OF ICT ACTIVITY
ITU	Interoperable telecom specifications, incl. architecture, services, protocols, addressing/numbering plans
ISO	ICT, incl. architecture, services, protocols incl. application protocols
IEC	Electrotechnical standards, incl. connectors, electrical safety, EMC and tests
JTC 1	ICT, incl. architecture, services, protocols incl. application protocols
ETSI	Interoperable telecom specifications, incl. architecture, services, protocols and tests
CEN	ICT, incl. architecture, services, protocols incl. application protocols
CENELEC	Electrotechnical standards, incl. connectors, electrical safety, EMC and tests
CEN/CENELEC	ICT architecture (OSI model) services, protocols incl. application protocols
IEEE	A wide range of technical and electrotechnical domains, incl. all LAN specifications: IEEE 802.xx, cabled LANs, Wireless LANs (WLAN), e.g. Wi-Fi
IETF	All Internet-related specifications, including protocols, generic applications, addressing rules (IP, URL)
ECMA INTERNATIONAL	Media specifications, ICT specifications fed into ETSI, ISO/IEC, IEEE, etc

***Table 6.2**: A simplified, non-exhaustive overview of the ICT standardization ecosystem*

Architecture, including networking architecture, is essential in standardization as well as in the technology strategies supporting a business strategy. In standardization, for example, at ITU and ETSI, the architecture is defined as part of the three-stage development process. And, whereas few implementations of a full Open Systems Interconnection model (OSI) stack are still in use, the OSI reference model, including the description of concatenation and overlay networks in the Internal Organization of the Network Layer (IONL), is still used as reference for networking architecture.

6.2.3 LOCATIONS AND RELATIONS AMONG SDOS

In deciding in which SDOs to participate, the interrelations among the SDOs, and the status of an SDO with respect to public authorities, may play an important role. For example, for ETSI members, the status of ETSI as a recognized EU standardization body, and its relations with ITU, CEN/CENELEC and IEEE are important, and have probably played their part in member organizations choosing to participate in ETSI activities.

The geographical location, in particular in which continent, and the locations where meetings take place also play a role in deciding in which SDO to participate.

The geographical location may create organizational complications for an organization, as this location may not coincide with its geographic organization. For example, the standardization activity may take place in a different continent to the geographic location of the entity with the corresponding technical responsibility within the organization.

It is to be noted that standards organizations typically are Non-Governmental Organizations (NGOs), with the legal status of non-profit organizations.

An exception is the ITU, which became a United Nations organization, mainly due to its long history of existence—since 1865—as an international committee.

ORGANIZATION	TYPE	HEADQUARTERS	RECOGNITION	DOMAIN OF ACTIVITY	MEMBERS	STANDARDS "FEEDING"
ITU	UN	Geneva (CH)	UN	Telecom + RF spectrum	National delegations	> JTC 1
ISO	NGO	Geneva (CH)	Multi-national	ICT	National delegations	> ITU
IEC	NGO	Geneva (CH)	Multi-national	Electrotechnical	National delegations	(> ITU)
JTC 1	NGO	Geneva (CH)	Multi-national	Joint comm. ISO + IEC	National delegations	> ITU
ETSI	NGO	Sophia Ant (FR)	Multi-nat. / EU	Telecom	Organizations	> ITU
CEN	NGO	Brussels (BE)	Multi-nat. / EU	ICT	National delegations	> ISO
CENELEC	NGO	Brussels (BE)	Multi-nat. / EU	Electrotechnical	National delegations	> IEC
CEN/CENELEC	NGO	Brussels (BE)	Multi-nat. / EU	Joint comm. CEN + CLC	National delegations	> ISO + IEC
IEEE	NGO	New York (US)	De facto	ICT + electrotechnical	Individuals	> ISO
IETF	NGO	Fremont (US)	De facto	ICT (Internet)	Individuals	(> ITU + ISO)
ECMA INTERNATIONAL	NGO	Geneva (CH)	De facto	ICT	Organizations	> ISO

***Table 6.3**: A simplified classification of SDOs by geographical scope and technical domain*

6.2.4 TECHNOLOGY STRATEGIES

Apart from showing presence, which may be rather important from a marketing or a public relations perspective, there are also key technology-related considerations for participation:

- The "radar" function: standardization gives an excellent insight into technologies and applications that may become important in the (near) future.
- The activity of other participants may be an indication of their level of R&D activity and positioning with respect to the state of the art, and/or an indication of the priority as well as importance that an organization gives to a certain development.
- The participation may be used to provide information for the formation of consortia, interest groups, fora, etc.
- The participation may help promote ideas and solutions, including IPR.
- The scale of the standards development may incite dialogue with public authorities, giving a preview of public support, measures and concerns.

As stated before, organizations may also decide to be active in standardization activities that do not correspond to their core activities. In this case, it is unlikely that these organizations will have the same level of competence in these domains, in comparison with their core activities and competencies, and therefore may have more limited possibilities to contribute.

EXAMPLE

A telecom services operator targeting involvement in Intelligent Transport Systems may need to follow standardization efforts related to telecom infrastructure, ITS infrastructure and road infrastructure. However, the technical areas in which the operator would be able to significantly contribute on road infrastructure, for example, may be limited.

An organization leading in a domain may take an active role in new developments, or it may take a defensive role. It might not look favourably on standardization activities that might result in competition for standards in which it has invested.

6.3 CONDITIONS AND EXTERNAL INFLUENCES

This section deals with factors and boundary conditions that have an impact on the standardization process, from the perspective of a participating organization. In the following section, we will look at relations within the standards ecosystem as well as the external factors and influences.

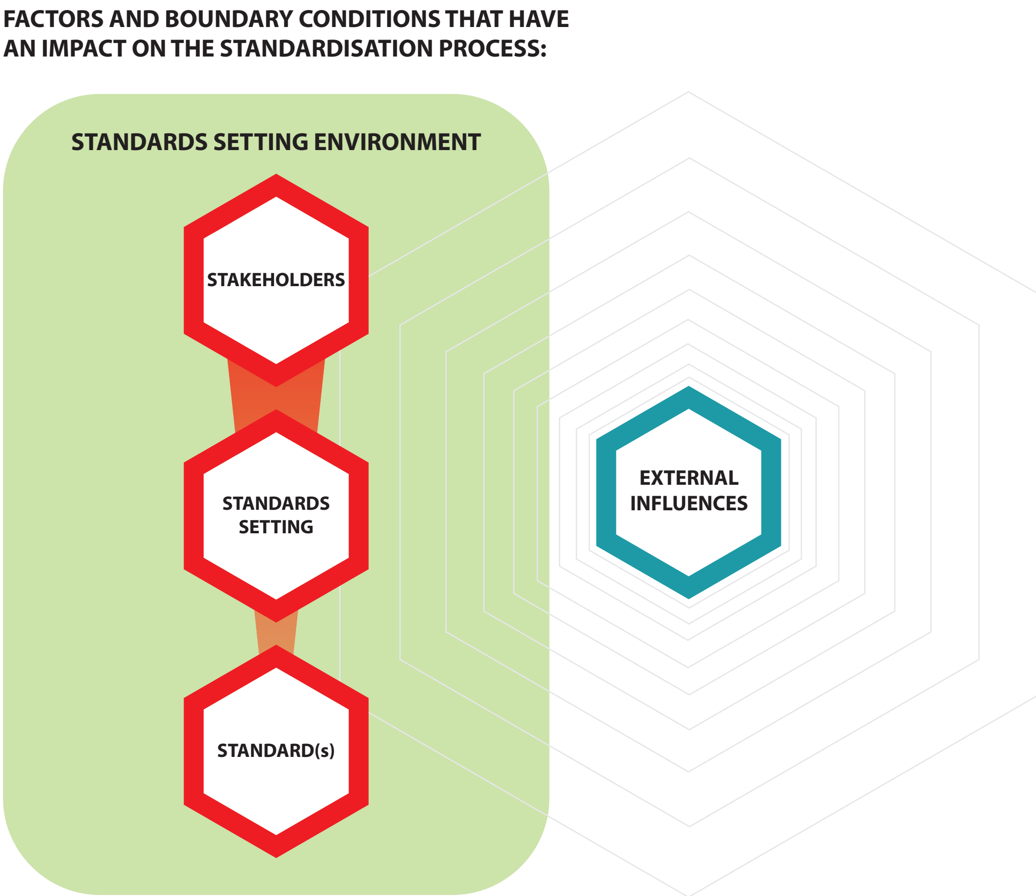

Figure 6.1: A very simple view of what influences a standard (Jakobs 2014)

6.3.1 MANAGING THE RELATIONSHIP BETWEEN STANDARDIZATION AND MARKETS

There is a strong interrelation between standardization, technical development and market development. Managing the relationship is challenging and needs to take into consideration, as far as possible, dynamic market trends, developments, and market forces, as well as technology developments and their industrial applicability and maturity.

Active participation in standardization requires good insight and knowledge about a company's or an organization's objectives, policies, market and financial position, and ongoing research and development.

This also requires deep insight and a good assessment of the technology's opportunities for development, roadmaps, and uncertainties. Uncertainties may include "unknown unknowns". Included in the latter category is unexpected competition developing among different technologies, i.e. the domain of application of one technology overlapping with the domain of application of another technology. But also the application of a given technology unexpectedly becoming more prominent in the market than was foreseen.

EXAMPLE

Here are a number of examples, cases in which most industry observers were surprised by events:

The first example is the importance of SMS and of roaming in GSM cellular wireless communications. In follow-on technologies (3G, 4G) and in regulation this has been taken fully into consideration.

A second example is the overlap in application domains between wireless communication and fixed network technology. Whereas there is still significant complementarity between fixed and wireless networks, the area of overlap is much larger than had been expected initially.

Another example is the use of generic data services on modern higher speed networks (fixed as well as wireless) to support services such as voice over IP and conferencing over IP, strongly competing with the equivalent dedicated services such as voice, audio, video conferencing, etc.

A final example is the user interface, evolving from character mode to graphic mode, to colour graphic mode, then to touch and voice recognition.

6.3.2 MANAGING COOPERATION

Standardization is a competitive domain, but one that requires cooperation to produce results. This requires competitors to work together as partners. Such cooperation can take two modes of operation: active cooperation and passive cooperation.

Active cooperation requires partners and competitors to work actively together on the development of a standard or specification, including technical details, as well as promotion outside of the SDO. This often reveals different visions, different product strategies, and interests that go well beyond the personal preferences of individuals or organizations.

As such, tensions may arise when working on technical issues, some of which may be related to diverging product strategies. For example, during the development of the specification for a carrier service, the requirements may be perceived differently by participants intending to use it for film and TV distribution and by participants targeting general "Internet" services, where the latter may accept much higher tolerances in quality-of-service parameters.

Passive cooperation may be a pragmatic and "honourable" attitude in standardization; it does not, however, give any indication of commitment for the support and adoption of the results, and therefore does not prevent less successful standards nor the proliferation of standards ("you have your standard; I have my standard").

6.3.3 MANAGING SYNCHRONIZATION

Standardization may be considered as leading, in sync or following with regard to developments, including technology developments and trends, market developments and value chain ordering, market push and pull, societal trends and developments, and last but not least, the legal and regulatory environment.

Leading, i.e. early standardization, means that not all issues and requirements are fully known or understood. This results in standards of the anticipatory type (see Chapter 4)

In sync, i.e. "just-in-time" standardization, needs the process to be agile and may need flexibility to adapt to and stay in sync with technological development. By staying in sync, standards of the enabling type are produced (see Chapter 4)

Following, i.e. "late" standardization, may mean a catch-up with a de facto situation, or with a dominant design. This leads to the generation of standards of the so-called responsive type (see Chapter 4)

EXAMPLE

An analysis of these principles can be made by taking GSM as an example. GSM consists of a rather complex system of a range of functions; for each function, one or more standards were developed. A detailed evaluation of different technical aspects of the relevant GSM standards versus market developments, including unforeseen developments in the market, gives differentiated results.

It must be stressed that this evaluation is based on what we know now, and how we look at it now, in other words, roughly 30 years after the development (hindsight).

The subjects of leading, and therefore rather anticipatory, standardization were the included data services and roaming, for which respectively limited data rates and limited usage were expected.

The subject of in sync, and therefore enabling, standardization was, and is, cellular organization, including handover, etc.

The subject of following standardization, but mainly in the sense of adopting elements of dominant design and existing standards, in particular ISDN, was the 64 kbit/s virtual circuit channel structure, while coding techniques had advanced to a level allowing for example an 8 kbit/s virtual circuit channel structure.

6.3.4 VOTING AND VOTING RULES

This section deals with the conditions and voting rules applied in different organizations. Different standards organizations have different voting rules, such as:

- weighted voting, based on category, size, etc.; for example: ETSI, CEN/CENELEC
- individual expert vote, based on regular attendance; for example: IEEE802, IETF

At ETSI, the issue of a possible imbalance between the total votes of different categories of members has been raised because of the weighted voting rights being linked to the declared size of the telecommunications-related revenues of member organizations. Large organizations represented by delegations from different countries accumulate significant amounts of weighted, revenue-linked voting rights (while at the same time paying a large accumulated fee or contribution).

Also, the interests of an SDO as an organization itself may play a role in how it handles standardization developments. The SDO's operational entities, in other words its secretariat and governance entities, likely have a role in relations with members, other SDOs and with public authorities. The organization's overall vision, roadmaps and interests may play a role in the evaluation to accept or reject proposals for new standards. This might even play a role in the voting on the acceptance or rejection of a standard, for example whether the standard fits in with the organization's views and cooperation with partner organizations.

Public authorities address their communications and requests mainly to an SDO as an organization. For example, the European Commission as a customer and as a sponsor addresses its communications first to the ETSI and CEN/CENELEC secretariats, giving them a clear role, at least in terms of communication, between the European Commission and the respective membership.

6.3.5 "BACKDOOR POLICY"

The so-called "backdoor policy" is when a group of stakeholders decide to switch to another SDO when a first-choice SDO and its members are not favourable when it comes to undertaking or accepting a new standardization activity. This brings with it opportunities and issues. While the "backdoor" circumvents blockage of new or different approaches, it carries with it the risk of duplication of efforts and the proliferation of standards.

Ecma International has played a role as an alternative standards route of this type. For example, industry standards for "private telecommunications" such as X.25 and ISDN found a more advanced and flexible alternative to the more restrictive public SDOs.

However, a "backdoor policy" together with passive cooperation may also lead to significant issues, as was demonstrated in the case of ECMA-376.

EXAMPLE

A standard for "Office Open XML File Formats" was developed at Ecma International on the basis of material submitted by Microsoft, and was adopted as ECMA-376.

ECMA-376 was then submitted to Joint Technical Committee 1 (JTC 1), using the "fast-track" procedure (a simplified voting procedure for standard proposals that have already passed an adoption procedure, considered indicative of the level of consensus).

ECMA-376 initially failed to pass, was amended, and, not without controversy, became ISO/IEC 29500.

The controversy stems from this standard being considered to overlap with ISO/IEC 26300, OASIS (Open Document Format for Office Applications), in other words, Microsoft-originating file formats versus "Open Office" / "Open Document" formats.

6.3.6 STANDARDS PORTFOLIO MANAGEMENT / TECHNOLOGY DEVELOPMENT

Ideally, standardization takes place "just in time" (or better, "in sync"), i.e. when technological development and market requirements have arrived at a complementary and supportive level of expected maturity. This is not always achieved, resulting in initial and possible "growing pains" between the evolving technological state-of-the-art and/or market requirements, and the developed standard.

It may be considered normal, however, during the lifetime of a standard, for "stress" to develop between a standard and technological advances and/or changing market requirements, resulting in standards needing updating and amending, or eventually losing importance or being withdrawn.

Today, we all consider that technology and markets are developing at a fast pace. However, this is only partially applicable to infrastructure, which has a greatly delayed connection to the fast developments of technology, as deployment and roll-out of infrastructure takes significantly more time. Therefore, equipment that interfaces with infrastructure will be developed in synchronization with the development of the underlying technology, at least for the interface and related parts.

EXAMPLE

As an example, in most Western European countries there is still work ongoing to complete the coverage of the territory with 2G/GSM. In fact, operators may be working in parallel to deploy 2G, 3G, 4G, and soon 5G, infrastructure and services. Mobile phones need still to support 2G, as it still has the widest coverage. Similarly, standardization in 3GPP needs to consider maintenance of 2G and 3G, bug fixes in 4G and requirements for 5G.

The strict adherence to (sub-)layer independence, as stipulated and promoted by, among others, the ISO model, has allowed "legacy" infrastructure to be used with protocols and coding techniques that were not known when the infrastructure was designed. A more extreme example is that of telecommunication satellites, launched decades ago, now transmitting digitally coded signals. It is indeed rather difficult to do repairs and upgrades on satellites.

6.3.7 MANAGING PHASES OF STANDARDIZATION

Standardization needs to consider the following external aspects of management.

Standards need to comply with legal, regulatory and other requirements concerning materials, safety, safe practices, security, etc.

Standards need to coexist with existing systems or those developing in parallel. The concept of coexistence is relatively new and increasingly important. In particular, coexistence is of importance for access to the frequency spectrum. In the past, radio systems were mostly allocated unique frequency bands; however, due to the sharp increase in the cumulative bandwidth required for wireless systems, frequency spectrum management now accepts reuse, overlap with and sharing of frequency bands, which introduces significant coexistence requirements.

Although this may be achieved only partially, standards need to achieve interoperability among the different implementations of equipment and services using them.

6.3.8 OTHER ACTIVITIES

SDOs may be initiated by an industry or industry groups with other related activities. They may also be enablers of platforms for related activities, and may take on other roles for the benefit of their members. An initiative at ETSI to address the concerns of the European Commission regarding the timing and conditions of the introduction of the Radio Equipment Directive (RED) is an example of what could be considered a natural consequence of the presence of the stakeholders, and therefore as a natural extension of ETSI’s role.

6.4 COMMUNICATION WITHIN STANDARDIZATION ACTIVITIES

The requirements for senior standardization experts include the right mix of leadership, technical and/or market vision, technical competence, communication skills and representativeness, diplomacy and negotiation skills.

Meeting all these requirements requires highly skilled and communicative persons with full support from top management. This requires the organization to recruit or train senior standardization experts and give them the means to communicate with all levels of the organization.

Often, however, only some of these conditions are met and, consequently, standardization experts may lack some of the critical support needed to fully perform their tasks.

One of the reasons for this is that senior standards experts would need access to top-level persons in a large part of the organization, as a "non-resident"; this requires privileges that, in an organization, may be restricted to high-level officials, e.g. vice-presidents and higher.

An alternative would be for the individual expert or for the internal standardization entity to obtain a high level of recognition from other entities in the organization. However, this may lead to incomplete access to the necessary information and to informal exchange of information.

The best solution is to have a "standardization champion" in top management to coordinate and stimulate the support and effectiveness of standardization activities.

6.5 CHOOSING YOUR STANDARD(S)

6.5.1 THE STANDARDIZATION PROCESS FROM AN IMPLEMENTATION PERSPECTIVE

The ultimate goal of standardization is the implementation of the resulting standards in products and services, for the benefit of users and industry as a whole.

Excellent examples of successful standardization are the sets of standards for 2G, 3G and 4G mobile networks (with 5G under development). These sets of standards have achieved wide acceptance in global markets. Technically, these standards excel in achieving interoperability, as is demonstrated by almost flawless international roaming capabilities.

6.5.2 WHAT TO TAKE INTO CONSIDERATION

Selecting standards and/or specifications for your application.

Since the need for compliance with numerous standards and specifications is increasing, and the perception of the distinction between committee standards and de facto standards is diminishing, this section gives some practical considerations and steps to select the most suitable set of standards and specifications to adhere to when implementing a given application.

In some cases, choosing the standards you will need to adhere to may be rather simple. For example, when the intention is to bring to the market products supporting access to 2G, 3G and 4G networks, the choice is obvious (even though in practice there are many optional features). There is a complete suite of standards and tests available.

Less clear, however, is the choice when, for example, products are aimed at the "smart anything everywhere" market, where there is a choice of many different wireless networks (including supporting access to "LPWANs" such as LoRa, Sigfox, Ingenu, in addition to 2G, 3G, 4G or the forthcoming 5G).

In the following pages, some considerations, criteria and guidance for selecting the standard(s) in such cases are provided. Note, however, that these criteria are only intended to help and provide guidance, and are not be used as, a "1-2-3 decision machine". Furthermore, to be comprehensive, a simplified overview is given.

Interest in standards in a specific case may range from the need to specify compatibility and/or interoperability in procurement, purchasing sub-systems or systems required to implement certain standards, to developing "in-house" products or services that need to comply with standards and interoperate with other implementations. The issue of "developing products that comply with standards" is particularly challenging.

In the following, we provide some important criteria by means of questions that should help organizations in the standards evaluation task.

Completeness: is this standard / set of standards all that is needed, or is it the tip of the iceberg; what other standards are needed to support or complement this/these standard(s)?

Stability: is this standard new and still developing; is it mature and widely adopted and tested; is it aging and needs to be brought up to date (legacy components, coexistence and interoperability with more recent systems); is there an installed base, and what is its influence (stability, but also inertia)?

Maintenance: is maintenance of the standards ensured; are there other mechanisms to learn about issues, workarounds, and de-facto reference implementations?

Interoperability and conformance: are good conformance tests and test facilities available; what is the required level of interoperability, does it need to be demonstrated, is it a condition sine qua non; what is the scope of the required interoperability: some functions, a subset, all functions; is interoperability required with the standard or with a dominant implementation (that itself may be only partially compliant with the standard or specification); are good interoperability tests and test facilities available; what level of interoperability is demonstrated by products on the market?

Assuming that implementation of the standard(s) is targeted, then interoperability is of key importance. Interoperability is often achieved only partially. Conformance is a prerequisite, but not a sufficient condition for interoperability. Complementary "plugtest" testing is a very useful addition, but by itself may not guarantee general interoperability either.

The next step in the evaluation process would be to attribute a weight to these parameters, which may range from less important to a condition sine qua non, in other words, a blocking factor if not met.

6.5.3 Supporting standard "X": what next?

After making a choice, you implement a specific set of standards and specifications. This choice, but equally the results of the detailed evaluation that led to this choice, may influence your position: you are now a stakeholder with an interest in a specific standard "X". And this then may be an argument to change some of your priorities in participation in standardization. This may include increased participation, or more focused participation.

For example, the interest may now be on increased involvement, supporting, improving or completing the selected standard(s) and specifications, adding or improving interoperability tests and testing, etc.

6.5.3 WHAT IF A SUITABLE SET OF STANDARDS OR SPECIFICATIONS CANNOT BE FOUND?

If, after your internal evaluation, you cannot come up with a suitable set of standards or specifications, it is recommended that you consult with your partners (suppliers, customers and competitors). If the subject appears suitable for an existing SDO, then direct your request, along with your reasons, to what you consider to be the most suitable standards organization. If the subject appears less suitable for an existing SDO, then consider pitching it to a suitable industry forum.

If the subject does not appear to fit anywhere, then consider setting up your own forum, together with partners, including competitors. An industry specification developed in this manner could later gain the status of a "publicly available specification". It could also become a committee standard if, in the meantime, interest in the subject has increased and become more widespread.

6.6 SUMMARY

In this chapter, participation in standardization is dealt with from the perspective of an organization interested in getting involved.

In addition to the different reasons that organizations may have to participate, this chapter examined how to choose a standards organization (SDO) to participate in, as a function of the domain of activities and possibly of geographical location. It also dealt with technology aspects.

This chapter also addressed the operation of standardization efforts and organizations, including voting systems and rights, and external influences. Among the important external influences are market trends and developments, which may also be considered the most difficult influences to deal with. It is also considered that standardization in general is closely linked to technological development. However, this is not a guarantee that each standard has taken all relevant technological development sufficiently into account. The relevance may evolve, or become visible only (long) after a standard has been published.

As presented, participation in standardization requires internal and external communication within an organization. It also requires in-house company rules and specifications to be linked with external standardization. To succeed in their tasks, standardization experts should have the possibility to communicate with virtually everybody anywhere in the organization.

Finally, the chapter discussed some considerations to help evaluate and choose standards for a certain application. It also dealt with the consequences of both the evaluation and the resulting choices. Effectively, a stakeholder that takes a different perspective can influence certain standards activities.

6.7 QUIZ

1 - WHEN IS AN ORGANIZATION PARTICIPATING IN STANDARDIZATION CONSIDERED A "LEADER"?

(See Section 6.2 for hints)

a) *When it develops more standards than others*

b) *When other organizations use its ideas*

c) *When standardization is business critical for the organization*

d) *When it pays the highest membership fees*

2 - WHAT IS THE FORMAL STATUS OF MOST STANDARDIZATION ORGANIZATIONS?

(See Section 6.2 for hints)

a) *They are part of the ministry of internal affairs*

b) *They are part of the ministry for trade and foreign affairs*

c) *They are, non-governmental organizations (NGOs) registered as legal entities, like non-profits*

d) *They are part of United Nations organizations, like the IMF and WHO*

3 - CAN AN ORGANIZATION BE A MEMBER OF BOTH CEN/CENELEC AND ETSI?

(See Section 6.2 for hints)

a) *No, CEN/CENELEC has national organizations as members, ETSI only accepts companies*

b) *Yes, but only national standards organizations can be a member of both CEN/CENELEC and ETSI*

c) *No, because ETSI only accepts commercial organizations that pay a membership fee*

d) *Yes, because commercial organizations can be members of both CEN/CENELEC and ETSI*

4 - WHICH STANDARDS ORGANIZATIONS HAVE A "ONE MAN, ONE VOTE" RULE?

(See Section 6.3 for hints)

a) *CEN/CENELEC, because each member organization can vote only once*

b) *ETSI, as only one person can vote from each organization*

c) *IEEE and the IETF, as votes are given to individuals with regular attendance*

d) *ITU, as only the Director is allowed to vote*

5 - IS IT EASIER TO OBTAIN A LARGE VOTING RIGHT IN ETSI THAN IN THE IETF?

(See Section 6.3 for hints)

a) *Yes, because you can "buy" votes by accumulating high membership fees*

b) *No, because in the IETF an organization can send many people to a few meetings*

c) *They are about the same, as both require resources: in the IETF an organization could send more people, in ETSI an organization would need a significant amount of revenue and fees*

d) *Yes, because in the IETF an organization gets disqualified if it sends too many people*

6 - WHAT MAKES A STANDARD PROPRIETARY?

(See Section 3.1 for hints)

a) *It is widely used*

b) *An organization holds an essential patent limiting its use by others*

c) *It is very comprehensive and comes with a complete test suite*

d) *It has been developed in isolation by a single or a closed group of organizations*

7 - WHO IS RESPONSIBLE FOR THE MAINTENANCE OF STANDARDS?

(See Section 4.2 for hints)

a) *In the EU, the European Commission*

b) *ETSI and CEN/CENELEC*

c) *Strictly speaking, nobody: there is a moral but no legal obligation for the organization that has developed and/or adopted and published a standard to maintain the standard*

d) *The users, as they represent the biggest test environment*

8 - TO TEST INTEROPERABILITY, IS ONE-TO-ONE TESTING SUCH AS "PLUGTEST" BETTER THAN CONFORMANCE AND INTEROPERABILITY TESTING?

(See Section 6.5 for hints)

a) *One-to-one testing, such as "plugtest", and interoperability testing are equivalent*

b) *One-to-one testing, such as "plugtest", and interoperability are complementary*

c) *One-to-one testing, such as "plugtest", is better because it tests two systems connected to each other*

d) *Interoperability testing is better as it tests against a reference implementation*

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6.8 GLOSSARY

- Backdoor policy: To switch to another SDO when a first-choice SDO does not want to undertake or accept a new standardization activity.
- Proprietary standard: A standard developed and controlled by a single or a small group of organizations

6.9 LIST OF ABBREVIATIONS

- SDO: Standards Development Organization
- SSM: (Corporate) Strategic Standardization Management
- ISO: International Organization for Standardization
- IEC: International Electrotechnical Commission
- JTC 1: Joint Technical Committee 1 (an ISO/IEC joint technical committee)

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7 A BUSINESS PERSPECTIVE: IPR AND STANDARDIZATION

LEARNING OBJECTIVES

This chapter provides readers with the required knowledge of the business perspective on standards, in particular the relationship between Intellectual Property Rights (IPR) and standardization. As IPR can play a crucial role in the context of standardization, readers should understand how standardization and IPR interact.

IPR issues will be discussed in general (e.g. the disclosure of IPR) and with respect to standardization. Different IPR instruments and mechanisms, such as secrecy, patents, standard-essential patents, standard types, and mere publication of contents, will be discussed and linked to a company's goals and strategy. In addition, readers will get an overview of the different protective mechanisms and instruments that are available in this context.

The chapter also compares the benefits and risks of standards and standardization to those of patenting. For example, standards and standardization may help companies open up new markets and achieve positive network effects and compatibility between products. There are also many risks associated with standards and standardization, such as knowledge spillovers, free riding, and the inability to fully control the outcome of a standardization process. Thus, readers will gain important knowledge on when a company can benefit from a specific instrument and when it cannot.

In this regard, a decision tree can guide managers in selecting an adequate instrument. The tree explains the main influencing factors that have an impact on decision making. The decision tree enables readers to make informed decisions concerning existing options. After reading this chapter, they will know when it is advantageous to go for standardization and when it makes more sense to apply for a patent, or to keep knowledge secret.

To illustrate the decision-making process, different case studies from the ICT sector will be presented. The case studies consist of general information such as a description of the company, its technologies, etc. Readers can use the decision tree to go through the decision process. In this way, they can experience the complexity of the decision process, while applying their knowledge to real company situations and technologies.

7.1 INTRODUCTION

Decisions related to Intellectual Property Rights (IPR) have a significant impact on a company's business success. Given a new technology, companies can select from a menu of possible options: patenting, standardization, mixed strategy, or keep their technology secret. When companies make the right decision, they can achieve commercial success and be competitive in the marketplace.

Protecting intellectual property through patents is an often-used instrument among companies. But setting standards through national and international standardization bodies is also a valuable option that can enable companies to achieve technology diffusion, discover new market applications, and identify new partners with whom they can cooperate. However, the benefits of standardization and patenting, or a combination of both, come at a price. The processes of patenting and standardization require high up-front costs that firms have to incur. In addition, defending against patent infringements, which leads to high litigation costs, and the relatively long time required for the development of standards, are considerable constraints that increase the cost level. To be successful in the market, companies have to make the right decisions in order to capture the value of their innovations: to patent, to standardize, or to pursue a mixed strategy?

This chapter tackles this issue. It is structured as follows. First, we present the basics of IPR, while dealing with the main instruments in this regard: committee standards, patents, and secrecy. Then, a tool is presented that helps companies make an informed decision when they have a new product or technology. Finally, case studies from the ICT sector illustrate how this tool can be used in practical contexts.

7.2 IPR AND SDO-SUPPORTED STANDARDIZATION: TWO VALUABLE INSTRUMENTS

7.2.1 BASICS OF IPR

Intellectual property (IP) refers to creations of the mind, such as inventions, literary and artistic works, designs and symbols, and names and images used in commerce. IP is protected by law to safeguard the integrity of intellectual objects. Intellectual property rights (IPR) are critical to fostering innovation, since without the protection of ideas, businesses would not be able to reap the full benefits of their inventions and would focus less on research and development (WIPO - World Intellectual Property Organization n.d.b).

As illustrated by Figure 7.1, there are five types of IPRs:

- Copyright: "The exclusive and assignable legal right, given to the originator for a fixed number of years, to print, publish, perform, film, or record literary, artistic, or musical material" (e.g. software). (Oxford Living Dictionaries n.d.a)
- Trademark: "A symbol, word, or words legally registered or established by use as representing a company or product" (e.g. "Just do itTM" by Nike). (Oxford Living Dictionaries n.d.e)
- Industrial design: "The art or process of designing manufactured products" (e.g. car design). (Oxford Living Dictionaries n.d.b)
- Patent: "A government authority or licence conferring a right or title for a set period, especially the sole right to exclude others from making, using, or selling an invention" (e.g. Dropbox, GoPro). (Oxford Living Dictionaries n.d.c)
- Trade secrets: "A secret device or technique used by a company in manufacturing its products" (e.g. R&D information, software algorithms, inventions, formulas, ingredients—for instance the Coca-Cola formula). (Oxford Living Dictionaries n.d.d)

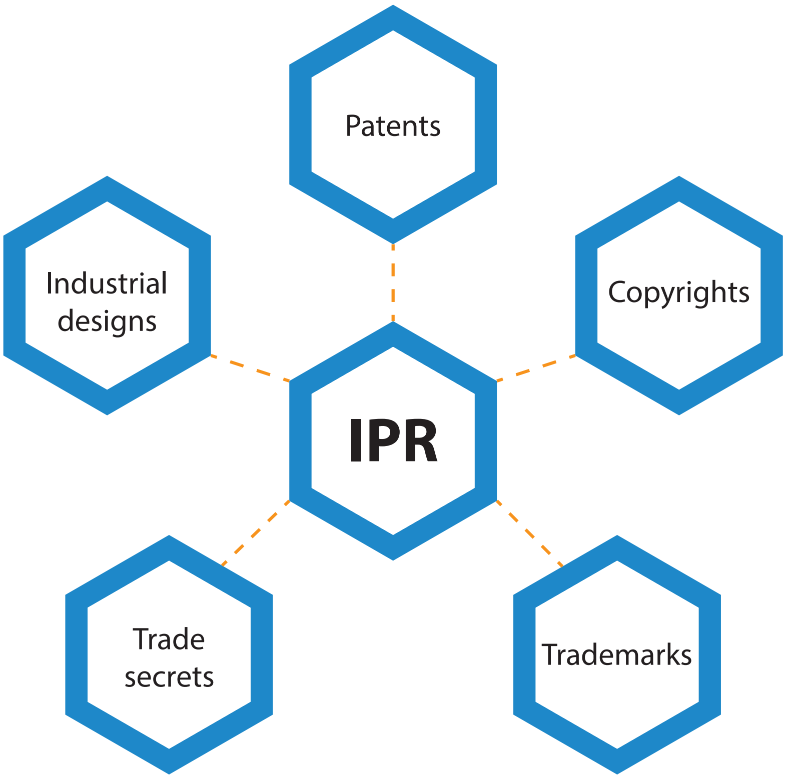

Figure 7.1: *Types of IPR*

7.2.2 COMMITTEE STANDARDS

Companies can choose from different types of standardization. They can either establish a dominant design, in other words a de facto standard in their industries, or choose to join an SDO to actively or passively participate in committee standardization. In turn, there are two types of standardization: formal standardization, facilitated by SDOs, and non-official standardization, such as standardization in consortia.

INTERNAL INFLUENCING FACTORS	EXTERNAL INFLUENCING FACTORS
COMPANY CHARACTERISTICS	**COMPANY ENVIRONMENT**
■ Available resources ■ Short-term and middle-term goals ■ Company size and growth ■ Products/services and technology ■ Marketing and impact	■ Dynamics ■ Complexity ■ Competition intensity ■ Specifics of the sector, such as regulations
DECISION MAKER(S)	**STAKEHOLDERS**
■ Previous knowledge ■ Experience ■ Perception and acceptance of the instruments	■ Standards Development Organizations (SDOs) ■ Customers ■ Competitors ■ Other business partners

Table 7.1: *Selected external and internal factors influencing decision making with respect to patenting and standardization; based on Abdelkafi et al. (2016)*

During the early stages of technology development, different solutions compete with one another until one solution prevails. Frequently, technological superiority is not a necessary requirement, as the winning technology may not be the best one. The battles that happen between companies are called standard wars, because each company intends to push through its own technology.

EXAMPLE

In the home video market, there have been two well-known standard wars: the first, with video tape cassettes, between VHS by JVC and Betamax by Sony, and the second, with laser disks for HD content, between Blu-Ray by Sony and High Definition Digital Versatile Disk (HD DVD) by Toshiba.

A dominant design is a technology that achieves market dominance; it is then a de facto standard (Narayanan and Chen 2012). Companies that succeed in establishing dominant designs in their market have the power to make a profit out of their R&D investments and also have full control over the standard's contents. Dominant designs enable companies to appropriate value from technologies, as explained by Teece (1986). In contrast to a dominant design, committee standardization can serve as a "low-cost" option to conquer a market, but committee standardization is actually much more than that. Note, however, that when it comes to consumer standards, there is a thin line (or none at all) between dominant designs and committee standards.

EXAMPLE

One example is Firewire vs. USB2. Firewire is a formal standard: IEEE 1394. USB2 has de facto standards behind it. Apple and Sony, for instance, were the big backers of Firewire. But apparently, they wanted too much in royalty payments for the IPR behind Firewire (even if it was FRAND). So the PC and peripheral industry ignored it and went with USB2, which was not quite as capable. Even Firewire 800, twice as fast as Firewire and USB2, and years ahead of USB3, also failed, probably for the same reason.

As opposed to a dominant design, committee standards call for the cooperation of many market participants to establish a standard based on consensus.

DEFINITION

A committee standard is "a document established by a consensus that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context" (Egyedi and Blind 2008).

The standardization process is facilitated by the SDO that provides (more or less) "neutral grounds" for the negotiation process. Note, however, that companies still benefit greatly from participating actively or passively in a technical committee, in spite of the fact that they do not have full control over the standardization outcome.

There are two types of committee standardization: formal and non-official standardization. Formal standardization leads to the development of standards with wide consensus or specifications such as PAS at the European level or DIN Specifications in Germany, which do not actually call for wide consensus, as the number of involved participants is limited. Formal standardization is carried out by recognized SDOs. The real distinction between formal and non-official standardization documents is the nature of recognition of the SDO. CEN, CENELEC, ETSI, ISO, IEC, ITU, DIN, AFNOR, BSI and IEEE have formal recognition as an SDO, at one level or another (national, European, international). W3C, IETF, Bluetooth SIG, etc. do not have any formal recognition. The IETF and W3C are not even legal entities. In some areas, the establishment of standards is more common (e.g. telecommunication), and in others, non-official standardization, especially through consortia, is the norm (e.g. internet technologies).

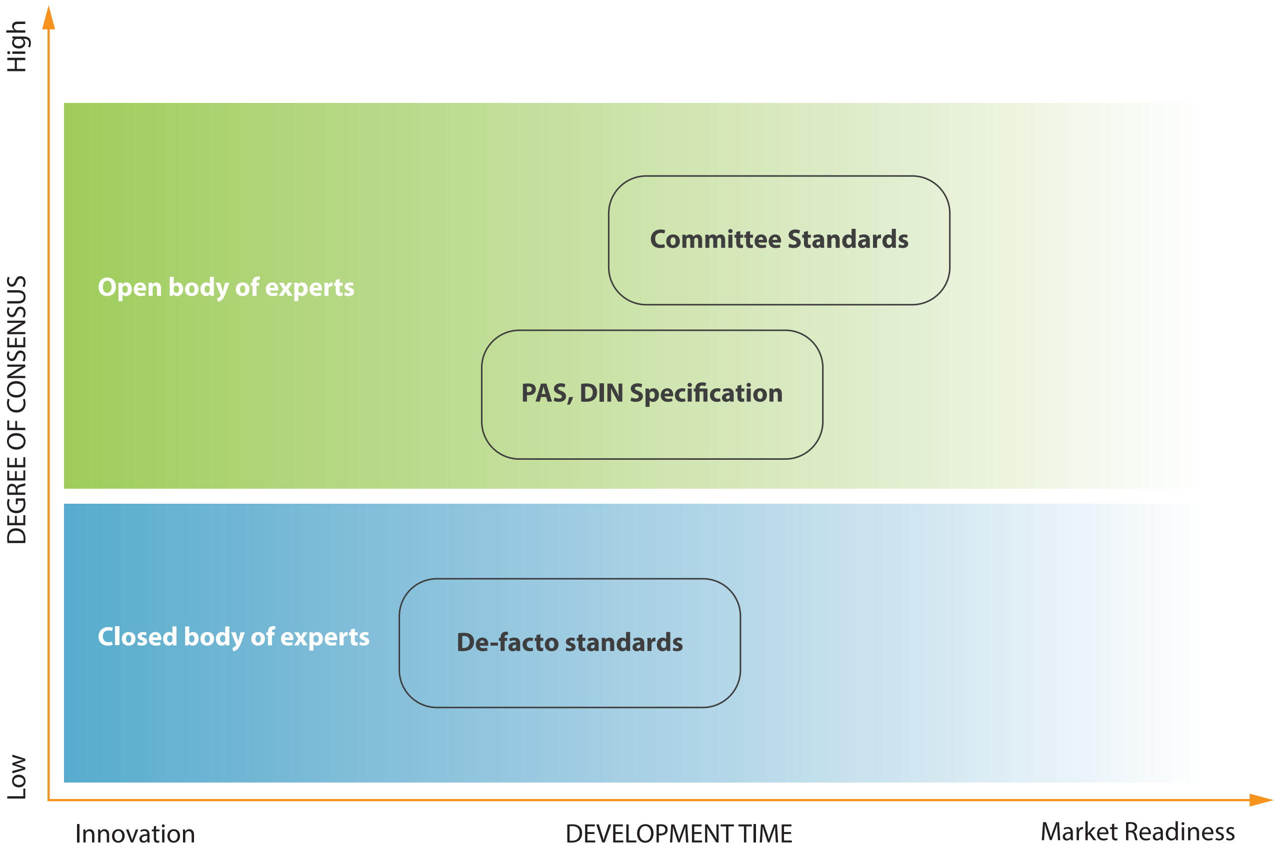

Figure 7.2: *Standard types; translated and adapted from Zeitz (2017)*

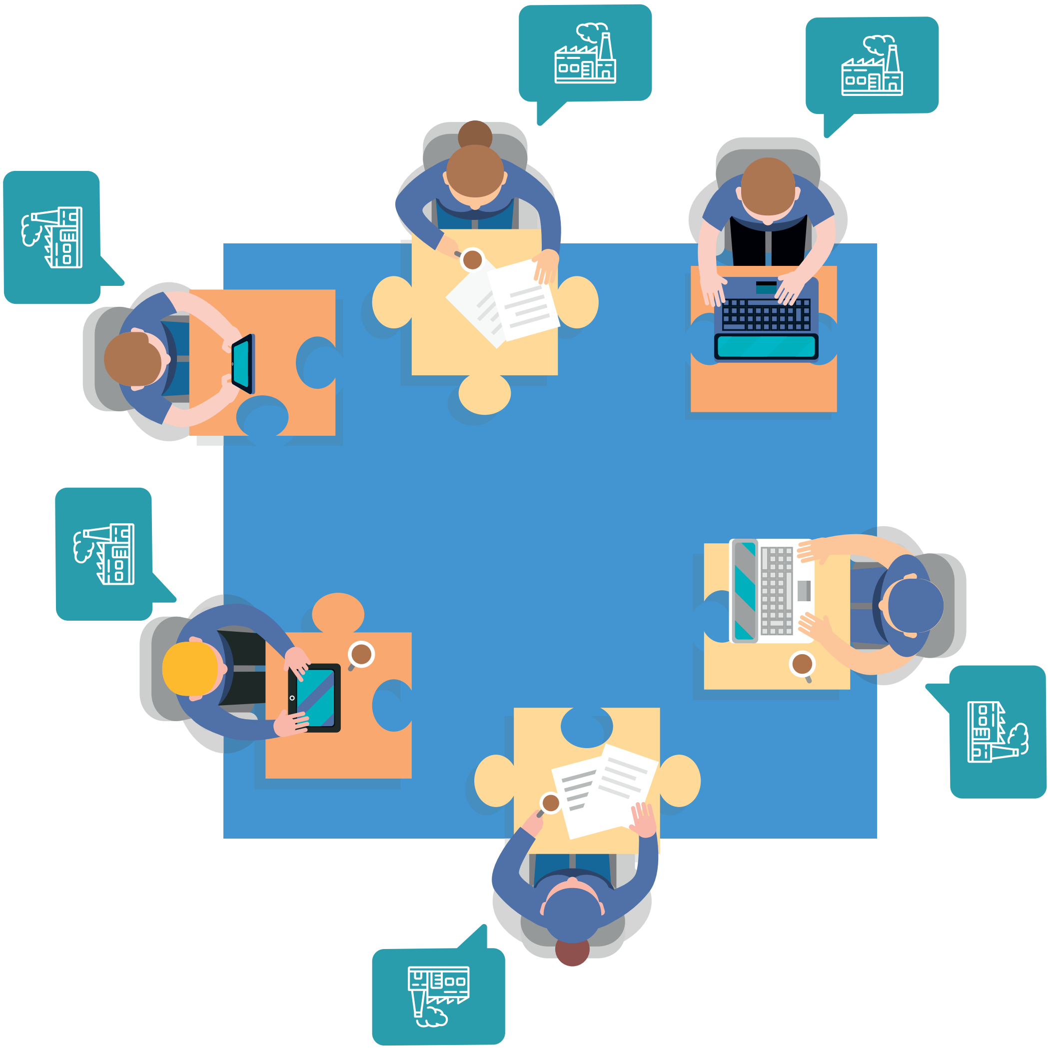

***Figure 7.3**: Standards connect market participants*

The benefits of committee standardization are manifold. Companies that participate in the development of standards gain a competitive advantage over those that do not. Technical committees provide companies with a good opportunity to scan the environment, and thus to identify new market opportunities and competitors. Companies can gain insider knowledge and early access to information, while having the chance to increase the diffusion of (own) integrated technologies/knowledge and to influence future technologies proactively. Furthermore, as seen in Chapter 5, participation in standardization committees helps companies to develop new markets and increase their market shares for products, services and technologies, as well as to strategically position themselves within those markets. On almost any given day, a working group or technical committee is meeting and making decisions that could affect "our" bottom line (Caldas 2017).

In general, the active participation of companies in committee standardization results in many benefits. It fosters social networking, alliance building and the identification of new business partners, while supporting personal trust and connections on a one-to-one-basis. According to Blind (2006), this can be seen as a special form of R&D collaboration.

Active participation in committee standardization has a positive effect on customer confidence. The endorsement of a technology by an SDO is perceived as a proof of quality, and association with the standards committee can enhance a company's reputation. In addition, committee standards are freely available to other market participants. This can reduce the dependence on specific suppliers by avoiding vendor lock-in, while enabling customers to make better comparisons between products.

Standards and standardization can support cost efficiency. As standardization reduces variety, it leads to the achievement of economies of scale. Standards can also facilitate coordination among several economic players, thus decreasing transaction costs. In particular, in the case of complex technologies, standards can ensure compatibility and interoperability between technologies and complementary devices from different producers. This can decrease bargaining costs, as standards can serve as a basis for contracts between companies. Therefore, standards have the potential to provide legal security.

Nevertheless, committee standardization bears some risks for companies. Because of IP disclosure, technologies and knowledge are integrated in the standard, leading companies to lose exclusive rights of using their own IP. It is also possible for knowledge spillovers to happen unintentionally during the standardization process. As seen in Chapter 5, companies cannot fully influence the standardization process. Consequently, they must accept compromises. Furthermore, companies may back the wrong horse, as there is no guarantee that a standard will be implemented and diffused successfully in a market (e.g. Open Systems Interconnection [OSI] standard). Although participation in standardization processes is recommended over not participating, companies that are not active in standardization can still benefit from committee standards (free riding), while saving the costs of participation.

EXAMPLE

Intergraph is a company that originally focused on the American market. Intergraph had plans to expand in Europe. Its headquarters in Europe are based in The Netherlands. Intergraph's product family consists of a wide range of software and hardware solutions, as well as computers for graphical applications.

Intergraph produced dedicated keyboards for graphical computers. These keyboards were equipped with function keys that had a status indicator for which Light Emitting Diodes (LEDs) were used. In the United States, the Underwriters Laboratories (UL) requirements applied, whereas in Europe the European Committee for Electrotechnical Standardization (CENELEC) standards were relevant. To get informed about the requirements in Europe, Intergraph Europe participated in the Dutch standardization committee. Intergraph noticed, however, that the red colour used for the LEDs in the keyboards dedicated for the American market did not meet the international standard IEC 60073 as well as its European equivalent EN-IEC 60073. The main problem was that the colour red should be used exclusively to indicate danger. To introduce the required changes, the total costs were estimated to be about €19,000. As a member of the Dutch committee, Intergraph was informed that the IEC standard was going to be modified by adding the text: "Where colours are used for functional controls or indicators, any colour, including red, is permitted provided that it is clear that safety is not involved". Just by knowing that this statement was going to be included in the standard, the company could recover the cost of its participation in the standardization committee (de Vries 2006).

EXAMPLE

Another interesting example with respect to committee standardization is Tyco Electronics. Tyco Electronics works in the field of electrical and electronic connectors. Tyco's product family is composed of fibre-optic products, switches, Integrated Circuit (IC) sockets, and application tooling. Tyco Electronics could achieve an increased market share by participating in standardization.

Published in 1991, the ANSI/EIA/TIA 568 standard was at that time the dominant standard for commercial building telecommunications wiring on the US market. In the same period, the development of a similar standard in Europe by CENELEC and an international standard was initiated. Tyco Electronics joined the standardization process and managed to get the new standards to refer to its SC connector. However, this did not mean that the company had exclusive rights to produce the technology, since the rules and regulations of CENELEC and the International Electrotechnical Commission (IEC) forbid such exclusive rights, but the company could achieve a competitive advantage and benefit in terms of knowledge, time to market, and economies of scale. In the period between 1995 and 2004, the additional profits have been estimated to amount to between US$50,000,000 and US$100,000,000, whereas costs of the company's participation were in the range of US$100,000 to US$200,000. Consequently, the attained cost-to-benefit ratio was about 1:500. (de Vries 2006)

7.2.3 PATENTS

"Patents denote an exclusive right granted for an invention (product or process) that provides a new way of doing something, or offers a new technical solution to a problem" (WIPO - World Intellectual Property Organization n.d.a). The benefits and risks of patents are summarized in Table 7.2 below.

BENEFITS	RISKS
+ Capitalizing IP through royalty fees + Temporary monopoly/ exclusive rights (20 years) + Serves as a form of signalling for potential customers and investors + Patenting protects	- Includes the disclosure of patent contents (even if the patent has not been granted yet) - In many cases, the imitation of patents can be hidden very well and is hard to detect - The easier a patent can be bypassed, the more limited its effectiveness - Often, companies—especially young companies and SMEs—do not possess the resources to pursue patent infringements - Duration of the process: 1.5–3 years, often more (disadvantageous in markets with a high pace of

***Table 7.2**: Benefits and risks of patents*

An important category of patent is the Standard-Essential Patent (SEPs). SEPs claim an invention that must be applied by all companies in order to comply with a technical standard. Most of the formal SDOs only allow the inclusion of patented technology in a standard if patent holders disclose the presence of patented technology. In addition, patent holders have to license their relevant IPR to standard implementers on Fair, Reasonable, and Non-Discriminatory (FRAND) terms. Fair is related to the licensing terms, which should not be anti-competitive or against the law. Reasonable addresses the fees that the licensor would charge the licensee, in order to use its SEP. Non-discriminatory means that all individual licensees are treated in the same manner (Teece 2013). Note, however, that while some SDOs are satisfied with a FRAND commitment, in other words that the SEP owner is willing to license his technology in return for a fee, other SDOs seek royalty-free commitments (Bekkers 2017). FRAND does not necessarily mean that licensing incomes will be lower, as standardization supports the diffusion and wide usage of the patent claims, making a higher number of licensees more likely.

EXAMPLE

The MP3 example of the Fraunhofer Society shows that FRAND licences can be very lucrative. About €100 million in royalty income has been generated for the Fraunhofer Society (Blind 2009). In the case of Qualcomm, with UMTS / Long Term Evolution (LTE), in 2013 around 3% of a smartphone's price went to the company as licence fees (Forbes 2014).

Because of the immense power that patents can have when implemented in standards, SDOs and standard implementers/developers fear monopoly and lock-in situations in the context of SEPs.

7.2.4 SECRECY

A trade secret denotes any type of confidential knowledge or business information that gives the owner of a secret an opportunity to obtain an advantage over competitors who do not know or use the secret. Thus, trade secrets protect information, knowledge and technologies that are critical to the firm. In particular, technologies that can be easily imitated can benefit from secrecy. The unauthorized use of such information by third parties is regarded as unfair practice and a violation of the trade secret. The protection of trade secrets depends on the legal system. Either it forms part of the general concept of protection against unfair competition, or it is based on specific provisions or case law.

7.2.5 THE INTERPLAY BETWEEN STANDARDIZATION AND IPR

Standards define the common characteristics and requirements of a technology. They open up new markets for innovative products that comply with these requirements, whereas patents define unique inventions and secure the exclusive rights of inventors, the protection of intellectual property, and competitive advantage. Patents play a key role in standardization. Standardization encourages widespread take-up of inventions codified by standards, and companies can incorporate patented inventions into standards (Standard-Essential Patents) or use them in parallel.

IPR should be considered in the standardization work facilitated by SDOs. The integration of technology, knowledge or other content in a standard often involves a company's IPR. Therefore, SDOs have developed policies and rules to deal with IPR issues during the standard-setting process. For instance, International Telecommunication Union (ITU) has issued IPR guidelines concerning patents, software copyrights and trademarks.

Companies that participate in standard setting, at least in the formal organizations, are obliged to disclose any existing patents that are essential to the standard. Patents should be licensed under FRAND (Fair, Reasonable and Non-Discriminatory) conditions, as standards are a form of common property. This gives a higher level of security to companies implementing the standard. FRAND should also function as an incentive for companies, as they can retain their IPR.

When companies do not disclose relevant patents when they work on a standard, this is called "patent holdup", which refers to the situation where the owner of a patent requires the payment of more than "reasonable and non-discriminatory" royalties or other fees from implementers of a standard. When the owner of the patent wants to maximize the yield, it will wait until the standard has already become widely adopted, and therefore difficult or impossible to change (to render it non-infringing) without great expense, before disclosing his patent. When this happens, this is referred to as a "submarine patent", because the hostile party takes everyone by surprise when it suddenly emerges onto the scene (Updegrove 2011).

EXAMPLE

The example of Sun Microsystems (SUNM) with respect to Java is a case in point to illustrate the interaction between intellectual property and standardization. SUNM recognized that rapid and significant investments in new technology are accompanied by the industry's desire to protect their investments. For SUNM, the best way was to move Java into a stable, experienced, formal SDO that is recognized worldwide by government, industry and other SDOs. SUNM chose to apply for a Publicly Available Specification (PAS), which it submitted to ISO/IEC JTC 1 and was granted in 1999.

DEFINITION

Note, however, that a Publicly Available Specification is different to a standard. A PAS is published in response to an urgent market need. The objective of a PAS is to speed up standardization in areas of rapidly evolving technology. A simple majority of the participating members of a Technical Committee or Subcommittee approves the document. PAS has a maximum life of six years. If, during these six years, it is not transformed into an International Standard, the PAS should be withdrawn (ISO/IEC n.d.).

SUNM wanted to retain its patents (although no fees are asked), its copyrights (joint copyright ownership was suggested, no fees asked), and trademarks (e.g. control over compatibility logo). It also wanted to stay in charge of the maintenance of the standard (Schoechle 2009). SUNM wanted to get the endorsement of a standards organization, but it was not willing to give up control over the technology, especially over the trademark and maintenance. SUNM's model of competition strongly conflicted with the cooperative standard-setting policy of ISO. As a result, SUNM declared its plans to have ISO adopt Java over and turned to other SDOs.

7.3 A DECISION-MAKING TOOL: IPR VS. STANDARDIZATION

7.3.1 THE BASIC PROCESS

Blind (2013) proposes a procedure to help decide when to standardize and when to patent. Once research findings have been made, the first question to be asked by managers or researchers is whether the results are patentable or not. If they are, then the benefits of patenting should be compared to the costs and fees incurred in filing a patent. If the benefits outweigh the costs, then patenting is an option, and subsequently the company or research institution should go for patent registration and wait for the patent to be granted. If it works, then the patent is granted to the inventors. Blind (2013) proposes that if, during the patenting process, something does not function, standardization remains an interesting and serious option. If the patent is granted, companies may still proceed with standardization by integrating their patents into standards as an SEP.

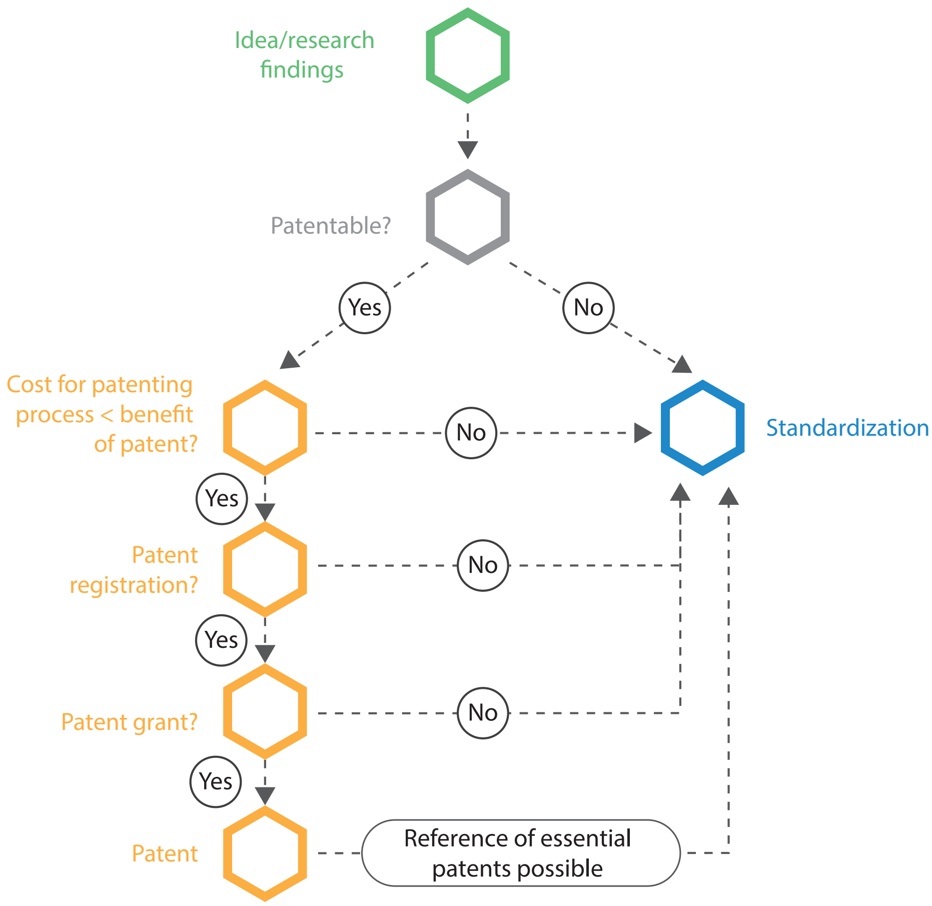

Figure 7.4: Relationship between patenting and standardization decisions; translated from Blind (2013)

7.3.2 THE DECISION TREE: AN OVERVIEW

In the following section, we present a decision tree to help companies choose between standardization and patenting. The decision-making process is highly complex, as it involves many variables and has to take into account many factors. Companies actually have many options. They can choose between secrecy, patenting, active participation in formal or non-official standardization, a combination of standardization and patents, or SEPs. The decision tree can be used by entrepreneurs or technology managers in companies; it provides them with a strategic decision-support tool to choose an adequate instrument, given a technology they have developed.

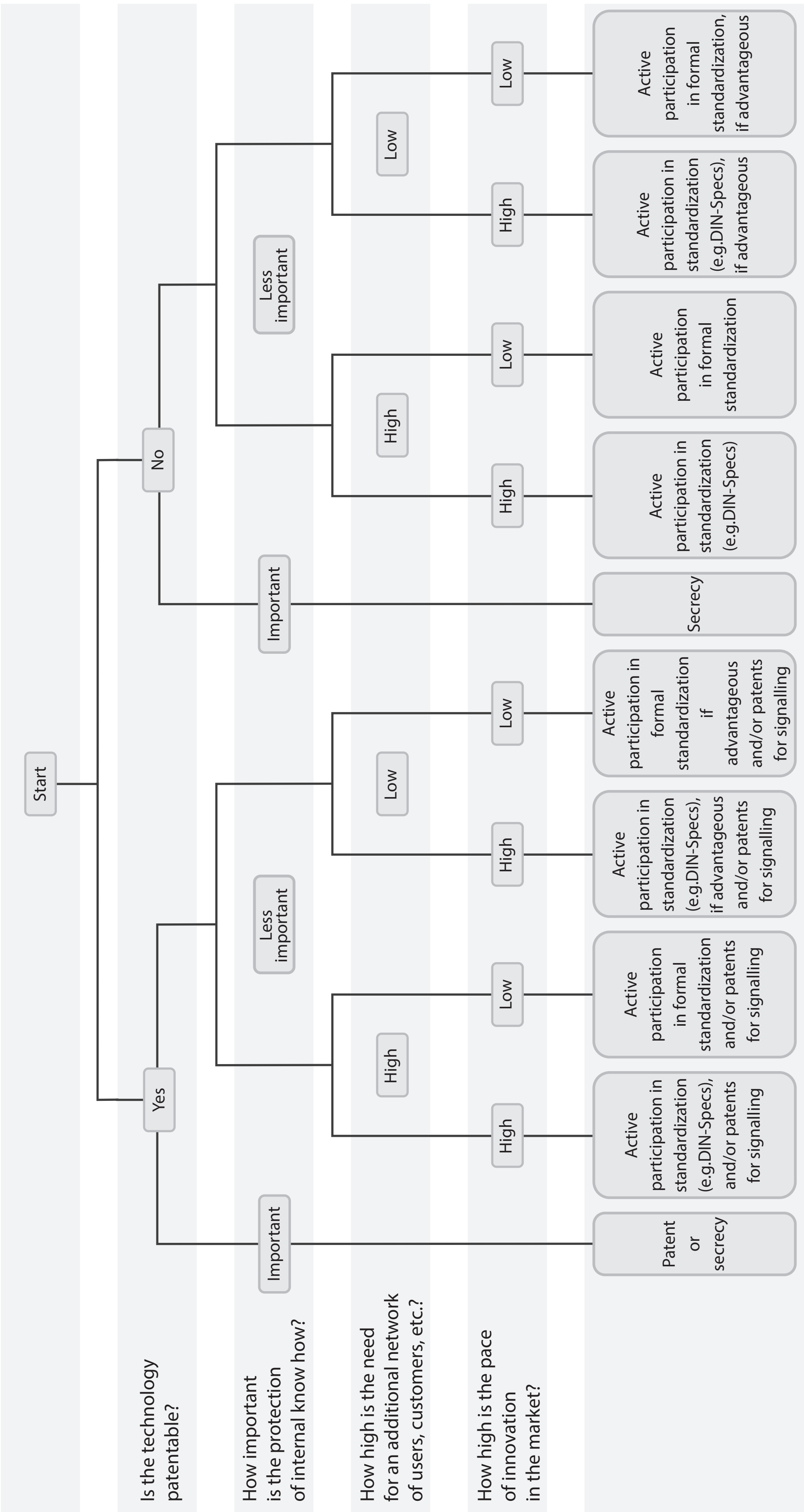

***Figure 7.5**: Decision tree (Abdelkafi et al. 2016)*

7.3.3 DECISION CRITERIA

The four levels of the decision tree refer to relevant questions that entrepreneurs have to answer in order to be guided to the right instrument to be implemented. These questions are related to four aspects: patentability of technologies, importance of protection of internal know-how, need for additional networks of users, customers and other stakeholders, as well as the pace of innovation in the market.

THE PATENTABILITY OF TECHNOLOGIES

The first question that a company has to ask is, as mentioned in the framework by Blind (2013), whether the technology is patentable or not? This is actually not an easy question. In the ICT sector, patenting concerns hardware and computer-implemented inventions, and the patent office is capable of assessing the patentability of an invention based on three necessary requirements:

- First, the invention has to be a novelty, in other words no prior use of anything similar in the market.
- Second, it should also involve an inventive step that is not readily discovered.
- Third, the invention should be suitable for industrial application.

Answering the question of patentability is not a straightforward process. It calls for extensive research and often needs the support of a professional patent attorney. Note, however, that even if patenting is possible, it is not necessarily the best option (EPO 2013).

THE IMPORTANCE OF THE PROTECTION OF INTERNAL KNOW-HOW

The level of importance of protection of internal know-how depends on the specific goals of a company, in particular its business model. A company that is not planning to implement its technology itself, but to sell it or license it for a fee, evaluates the relevance of internal know-how differently to a company that aims to implement its technology.

The effectiveness of a specific instrument (secrecy, patenting or standardization) also depends on the (geographical) context. The appropriability regime (Teece 1986), in other words the ability of a company to capture value from its innovation, depends on the region. For instance, IPR enforcement in China is weak, compared to western countries such as Germany. A company may decide to keep its technology secret in a region where the appropriability regime is weak instead of filing a patent. The competitive environment also plays an important role. For example, knowledge protection is very important if there are many competitors in the market with the ability to imitate the technology.

Further aspects, such as the type and characteristics of a technology, determine the importance of knowledge protection. For instance, a company producing measurement instruments can standardize the procedure according to which measurements take place, whereas it may patent the core technology of the device that takes the measurement. This actually requires the technology to be divided into different parts, of which some are suitable for patenting and some for standardization. In addition, when the technology in question cannot be seen by competitors, for example a new internal manufacturing process, the importance of internal protection can be evaluated as high. Patents may not help in this case, as patents are published, thus providing competitors with the required knowledge to imitate the process. Also, it would not be easy to detect patent infringement, with it being an internal process.

THE NEED FOR ADDITIONAL NETWORKS OF USERS, CUSTOMERS AND OTHER STAKEHOLDERS

To decide whether to standardize or to patent, a company should also ask to what extent it is required to integrate additional networks of relevant stakeholders. ICT technologies and systems are often too complex to develop in isolation, and therefore cooperation is required. For young, small and medium enterprises, however, the development of a business network may turn out to be challenging, and the standardization process can be especially helpful for them.

Standardization supports networking. In technical committees, competitors, suppliers, users, and other important stakeholders work together to develop standards. The participants gain insight and knowledge related to the standard during its development. In addition, the standardization process facilitates knowledge exchange among all participants, thus fostering R&D through target-oriented development of technologies, for instance by getting feedback from other stakeholders. According to Blind (2006), because standards support compatibility and the diffusion of a technology, they can be seen as a special form of R&D collaboration. Furthermore, the endorsement of a technology by an SDO is perceived as proof of quality, thus enhancing the reputation of a company associated with building the standard, and making others more willing to interact and cooperate with the company.

Thus, standardization clearly supports companies in extending their networks. Compared to standardization, the advantage of patents in this regard is rather low. Patenting is a way of signalling to the outside that the company is innovative. Investors especially see patents as an important indicator of how well a company can capture value from its innovation. Patents often play a key role in helping companies gain access to investor networks.

The following questions can help companies assess whether their need for additional networks is high or low:

- Is signalling important for the company (in the sense of reputation and visibility)?
- Is it difficult to make contact with "big players" in a given technology area?
- Is compatibility with other systems or technologies important?
- Does the technology benefit highly from positive network effects?
- Is additional knowledge needed?
- Are there SDOs active in the area of the company’s technology?
- How likely is it that potential business partners and/or competitors will participate in a specific SDO?

THE PACE OF INNOVATION IN THE MARKET

The pace of innovation of a technology can influence the decision to patent or to standardize. The development of patents as well as formal standards is tedious, time consuming and can take many years. Consequently, the technology life cycle is an important factor in the decision process.

Formal standardization is not suitable if the technology changes—perhaps many times—before the standard is released. In a fast-changing innovation environment, standardization could prove inefficient, as the standard would already be out of date when it is published. The same also applies for patenting. Patenting is also not only a time-consuming, but also a costly process, especially if the patent is filed in many regions worldwide.

If the technology life cycle is short, market uncertainties are high, and therefore the development of publicly available specifications (PAS), or consortium standards are more favourable, as these standards can be generated much faster (in approximately six months). A wide consensus is not required. In general, short product life cycles and a high number of competitors indicate a high pace of innovation in the market.

Companies may use the following questions to evaluate the pace of innovation in their industries:

- How high is the market uncertainty concerning future developments?
- How long is the life cycle of own products or products in the market?
- How many competitors exist in the market?

7.3.4 USING THE TREE FOR DECISION MAKING

Depending on the path that decision makers take through the decision tree, they can choose from different instruments. In Figure 7.6, the left part (L) describes solutions where patenting is possible, whereas the right part (R) focuses only on standardization.

On the left side of the tree, the technology is patentable. The company still has plenty of instruments that it can use. The company may deliberately decide upon secrecy, especially if it turns out that it cannot prove patent infringement in the event that a competitor illegally uses its technology.

If the protection of internal know-how is less important for the company, patenting and secrecy are no longer the first choices. Instead, standardization is a much better instrument, since the company can additionally benefit from the networking advantage that results from the standardization process. When the pace of innovation as well as the resulting market uncertainties are high, it is advisable to go for the drafting of specifications, because the process is relatively fast to complete, whereas when the pace of innovation is slow, formal standards based on a larger level of consensus turns out to be the most adequate instrument. Note, however, that since the technology is patentable, companies may still supplement their standardization endeavours through patenting. In this way, they use a combined strategy. This can make sense in situations where the company wants to signal innovative capabilities to the outside, for example when looking for external investment money.

As discussed previously, there are many possible combinations of standardization and patenting:

- Technologies could be integrated into standards in form of SEPs, while charging licensing fees.
- Including patents in the standard without charging licensing fees. In this way, companies put their IP in the public domain to achieve a wide level of diffusion.
- Companies could patent their technologies and participate independently in standardization (patents based around a standard are more likely to generate increased licensing income).
- If a company cannot fight patent infringements, it may be advisable (if the IPR rules of an SDO allow so) to not disclose relevant IPR

The difference between the left and right sides of the decision tree is that on the right side the technology is not patentable, and therefore patenting is no longer an option for the company. The decision tree shows that standardization is an important instrument that is actually as valuable as patenting and, if well used, can help companies achieve many advantages.

Finally, it is worth noting that the term "if advantageous" is found on both sides of the decision tree when the need for additional networks is evaluated as low. It indicates that active participation in standardization should be carefully evaluated, because its positive effect is actually lower than in other end nodes of the tree. In effect, when the need of an additional network is low, a company must have other good reasons to participate. This could be the case if a company intends to integrate a technology in a standard to support its diffusion.

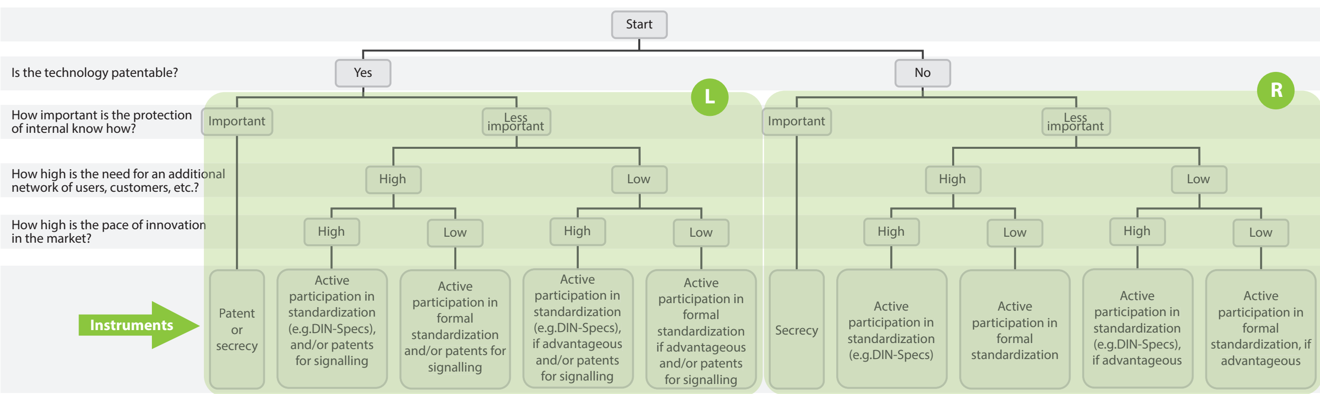

***Figure 7.6**: Decision tree (Abdelkafi et al. 2016)*

7.4 CASE STUDIES: TO STANDARDIZE OR TO PATENT?

7.4.1 CASE STUDY: SECURE DATA GMBH - IT SECURITY SOFTWARE, INFRASTRUCTURE AND CONSULTING

Secure Data is a company founded in 2008 that offers IT security software, infrastructure and consulting services to support its customers in achieving secure communication. The company currently has 25 employees and serves the German market, which is very dynamic and characterized by a high innovation potential. Secure Data drew up a DIN SPEC for a technology it developed in the area of IT network security.

DEFINITION

A DIN Specification, or DIN SPEC, is a document that specifies requirements for products, services and/or processes. However, in contrast to standards, DIN SPECs do not require full consensus and the involvement of all stakeholders. They are drawn up in temporary bodies called workshops. DIN SPECs are a trusted strategic instrument for quickly and easily establishing and disseminating innovative solutions on the market. (DIN Deutsches Institut für Normung e. V n.d.)

Why this choice? The company's reasoning was as follows: the technology is patentable and superior to available solutions. The company mentioned in this regard, "There is nothing comparable [to our product]. This had been checked extensively." Nevertheless, a patent does not make sense. Firstly, patenting is expensive (> €150,000 estimated costs) for the company, and defence against patent infringements would be costly. As a small company, it does not have the resources to deal with the cost of patenting. Secondly, the company would not be able to discover patent infringements. The newly invented process technology works in the background, so there is no way to prove that a competitor is using it. In the words of the company's owner: "Patents have as much value as you can enforce by law".

Because of this, secrecy and standardization appear to be more promising. Firstly, the company does not believe in keeping the technology secret, particularly because of the owner's personal conviction that it would not be fair to hide a technology from parties that may benefit from it. Secondly, DIN, as an SDO, was very interested in the technology. Thirdly, the company aims to offer and promote new services such as consultancy and certification around their technology in the future, as explained by the owner: "The advantage of the standard is that others might want to get certified and we can earn money from that. With the patent, we most probably would not have a chance to do so, because people would simply use it without us ever noticing it". Fourthly, standardization leads to a stronger reputation and better diffusion, as the DIN SPEC is sent to a large number of SDO partners. The owner says in this regard, "Thanks to DIN, the solution becomes more popular. […] It used to be a niche product. But because of the publication process we got some extra requests for it."

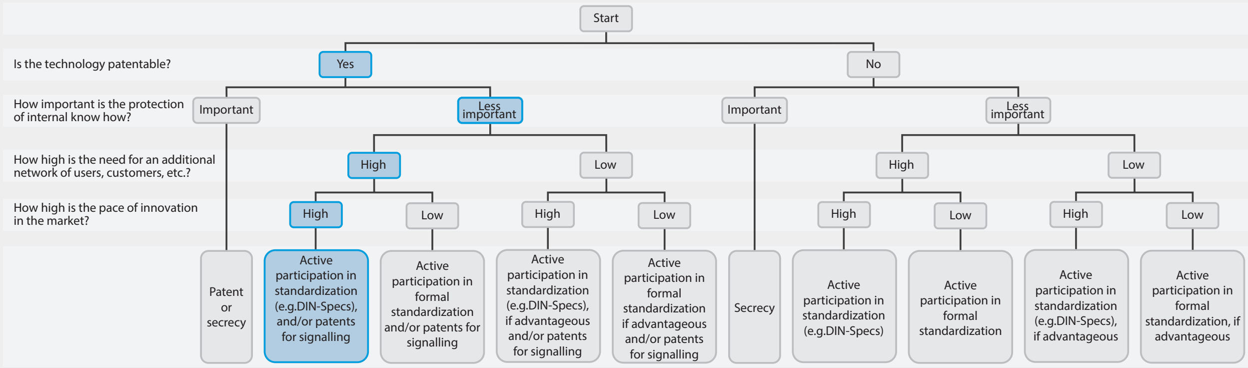

Figure 7.7: *Decisions of Secure Data GmbH (Abdelkafi et al. 2016)*

7.4.2 CASE STUDY: LOCATOR GMBH - EMBEDDED LOCATION PLATFORM SERVICES AND DEVICES

Locator GmbH offers an embedded location platform (hardware and software), which enables a robust, energy-efficient location service. The company has been operating in the ICT sector for about 25 years. Locator has about 25 employees, and the product portfolio is composed of IC wireless modules, tags, anchors, and location engine software. The market situation of the company is very dynamic and exhibits a high innovation potential. Furthermore, formal and non-official standardization documents and standards are of high importance in the industry. The company patented its embedded location platform, which is also standardized in IEC/ISO 24730-5: Real-Time Locating System (RTLS) air interface (global tracking).

The company opted for a mixed approach that combines formal standardization and patenting. Why this choice? The company made such a choice for two reasons: firstly to ensure exclusive rights, while generating licence revenues, especially from standardization activities (SEPs), and secondly to achieve wide dissemination of the company’s patented technology and to conquer new markets. The CEO of the company said in this regard, "We developed intellectual property, and we wanted to make it the standard". In addition, the objective of the company is "to not just write the patent, but also to develop the strategy around it. I ask myself, what is the overall strategy for innovation? It consists of both patents and standards".

In this case, the technology is patentable. The patent portfolio covers the inventions and constitutes an important asset of the company in order to attract investors. Because of its size, the company's resources are limited, and there is a need for external investment money. Investors needed to be convinced about the standardization activities. In the CEO's words, "Patents are generally needed when I search for investors. Until now I could not manage to make investors enthusiastic about my company, by pushing standardization."

All in all, IP protection was essential for Locator GmbH, although the company would not be able to fight against patent infringements. Standardization was used as a tool to distribute the patented technology at an international level (SEP). The essential patent was licensed under fair, reasonable, and non-discriminatory terms (FRAND). The importance of standardization in achieving international take-up of the technology is summarized by the following statement from the CEO: "I do not choose the countries because of the standardization activities, but I take standardization to approach the countries."

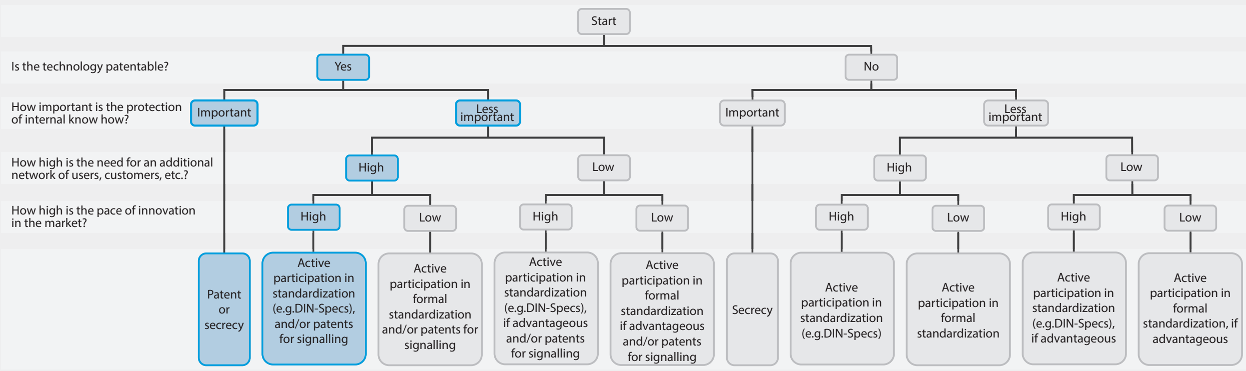

***Figure 7.8**: Decision tree branch for Locator GmbH (Abdelkafi et al. 2016)*

7.5 SUMMARY

Intellectual property (IP) refers to creations of the mind such as inventions, literary and artistic works, designs and symbols, and names and images used in commerce. In this chapter, we dealt with three main instruments by which companies can deal with their IP: committee standards, patents and secrecy. Companies can choose to join an SDO to actively or passively participate in committee standardization. There are two types of committee standardization: formal standardization, which is facilitated by recognized SDOs such as ISO or ETSI, formal standards or specifications according to the PAS process; and non-official standardization, such as standardization in consortia.

Patents grant an exclusive right for an invention (product or process) that provides a new way of doing something or offers a new technical solution to a problem. IPR should be taken into consideration in standardization. Companies participating in standard setting, at least in the formal organizations, are obliged to disclose any existing patents that are related to the standard. Patents should be licensed under FRAND (Fair, Reasonable and Non-Discriminatory) conditions, as standards are a form of common property.

A trade secret denotes any type of confidential knowledge or business information that gives the owner of a secret an opportunity to obtain an advantage over competitors that do not know or use the secret. In particular, technologies that can be easily imitated can benefit from secrecy.

Committee standards, patents and trade secrets have benefits and risks. For instance, committee standards enable companies to gain insider knowledge and early access to information, while increasing the distribution of their technologies and proactively influencing future technologies. Furthermore, participation in standardization committees helps companies to develop new markets. But committee standards can take a long time to complete. Patents are also advantageous for companies, as they generate licensing fees, allocate temporary monopoly/exclusive rights for a specific period of time and serve as a way of signalling innovation to potential customers and investors. There are some inherent risks in patenting for the company, as the patent contents need to be disclosed, even if the patent has not been granted yet. In many cases, imitation of patents can be very well hidden and is hard to detect. Furthermore, the process to register a patent can be long and costly. The process of defending against patent infringement can also cost the company a lot of time and money. A trade secret is beneficial when the IP in question is related to an internal process that is not visible from the outside. However, secrecy in itself cannot grant any rights to the company if a technology is imitated.

A decision tree was introduced that helps companies make an informed and systematic decision whether to patent, to standardize, to combine both, or to keep a technology secret. The decision tree consists of four levels. At the first level, companies have to ask whether the technology is patentable. Subsequently, the company should consider how important the protection of internal know-how is. The third level is about how high the need is for additional networks of users, customers, etc. The final question is about the pace of innovation in the market. When these questions are answered, the decision tree gives recommendations on which instrument to implement. Two case studies from the ICT sector have explained in detail how to use the decision tree to support decision making.

7.6 QUIZ

1 - WHICH ONE OF THE FOLLOWING INSTRUMENTS IS NOT CONSIDERED A TYPE OF IPR?

(See Section 7.2.1 for hints)

a) *Patents*

b) *Trademarks*

c) *Standards*

d) *Copyright*

2 - STANDARD ESSENTIAL PATENTS ARE…

(See Section 7.2.3 for hints)

a) *Patents that are standardized.*

b) *Patented standards.*

c) *Patents that compete with standards.*

d) *Patents that are required for the implementation of the standards.*

3 - PATENTS SHOULD BE LICENSED UNDER FRAND CONDITIONS. WHAT DOES THE ABBREVIATION FRAND STAND FOR?

(See Section 7.2.1 for hints)

a) *Free, Rational and Non-Discriminatory*

b) *Fair, Rational and Non-Discriminatory*

c) *Free, Reasonable and Non-Discriminatory*

d) *Fair, Reasonable and Non-Discriminatory*

4 - PARTICIPATION IN COMMITTEE STANDARDS…

(See Section 7.2.2 for hints)

a) *is only active.*

b) *can be active or passive.*

c) *is only passive.*

d) *is neither active nor passive.*

5 - THE STANDARD WAR BETWEEN VHS AND BETAMAX RESULTED IN…

(See Section 7.2.2 for hints)

a) *Betamax winning the battle because it had better performance.*

b) *VHS winning the battle because it was supported by an SDO.*

c) *Betamax losing the battle because VHS had the technological superiority.*

d) *VHS becoming a de facto standard.*

6 - A PUBLICLY AVAILABLE SPECIFICATION (PAS)...

(See Section 7.2.1 for hints)

a) *is a de facto standard.*

b) *is a committee standard.*

c) *has a maximum life of 10 years.*

d) *is not relevant for companies operating in areas of rapidly evolving technologies.*

7 - WHICH OF THE FOLLOWING STATEMENTS DENOTES A PATENT RISK?

(See Section 7.2.3 for hints)

a) *Patents grant their owner a temporary monopoly/exclusive rights for about 20 years.*

b) *The easier a patent can be bypassed, the more limited is its efficiency.*

c) *A patent serves as a form of signalling for potential customers and investors.*

d) *Patenting protects IP in the standardization process.*

8 - SECRECY IS A FORM OF IP PROTECTION THAT IS SUITABLE FOR...

(See Section 7.2.4 for hints)

a) *Products that can be easily imitated.*

b) *Process technologies that are not visible to competitors.*

c) *Technologies that are visible to competitors.*

d) *Most high-tech products.*

9 - THE FOLLOWING CRITERIA ARE IMPORTANT IN ORDER FOR A COMPANY TO CHOOSE WHETHER TO STANDARDIZE, PATENT, OR FOLLOW A MIXED STRATEGY.

(See Section 7.3.2 for hints)

a) *Patentability, importance of protection of internal know-how, need for an additional network of partners, and the pace of innovation*

b) *Patentability, the ownership of standards essential patents, need for an additional network of partners, and the pace of innovation*

c) *Patentability, importance of protection of internal know-how, need for additional investments, and the pace of innovation*

d) *Importance of protection of internal know-how, need for an additional network of partners, and the pace of innovation in a given industry*

10 - THE APPROPRIABILITY REGIME DENOTES...

(See Section 7.3.2 for hints)

a) *The ability of a company to acquire resources*

b) *The ability of a company to accommodate innovations from the outside and integrate new technologies*

c) *The ability of a company to capture value from its innovation*

d) *The ability of company to patent its technologies*

➜ ***SOLUTIONS PAGE 257***

7.7 GLOSSARY

- Intellectual Property Rights: "Intellectual property rights refers to the general term for the assignment of property rights through patents, copyrights and trademarks. These property rights allow the holder to exercise a monopoly on the use of the item for a specified period." (OECD 2005)
- Patent: "A government authority or licence conferring a right or title for a set period, especially the sole right to exclude others from making, using, or selling an invention" (e.g. Dropbox, GoPro). (Oxford Living Dictionaries n.d.c)
- Standard-Essential Patents (SEPs): Claim an invention that must be applied by all companies in order to comply with a technical standard (Aldrich and Auster 1986).
- Network effect (or network externality): Can be direct or indirect. A direct network effect is when the value of a given product, software or technology increases with the number of people and organizations using it. Examples are the telephone, fax, Facebook and Twitter. For instance, the value of the telephone depends of the size of the network of people that can be reached via telephone. Indirect network effects arise when the value of a good/service does not depend directly on the number of users, but rather on the availability of complementary and compatible components. For instance, the value of video game consoles depends on the availability of video games. The more games, the greater the choice, and the better for the consumer.
- Copyright: "The exclusive and assignable legal right, given to the originator for a fixed number of years, to print, publish, perform, film, or record literary, artistic, or musical material" (e.g. software). (Oxford Living Dictionaries n.d.a)
- Trademark: "A symbol, word, or words legally registered or established by use as representing a company or product" (e.g. "just do it" by Nike). (Oxford Living Dictionaries n.d.d)
- Trade secrets: A secret device or technique used by a company in manufacturing its products" (e.g. R&D information, software algorithms, inventions, formulas, ingredients). (Oxford Living Dictionaries n.d.c)
- Publicly Available Specification (PAS): Different from a standard. A PAS is published to respond to an urgent market need. The objective of a PAS is to speed up standardization in areas of rapidly evolving technology. A simple majority of the participating members of a Technical Committee or Subcommittee approves the document. PAS has a maximum life of six years. If, during these six years, it is not transformed into an International Standard, the PAS should be withdrawn. (ISO/IEC n.d.)
- Dominant design: A dominant design is a technology that achieves market dominance.
- De facto standard: When a technology achieves market dominance, it is then a de facto standard (Narayanan and Chen 2012).
- Committee standard: "A document established by a consensus that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context" (Egyedi and Blind 2008).
- DIN SPEC (DIN Specification): A document that specifies requirements for products, services and/or processes. However, in contrast to standards, DIN SPECs do not require full consensus and the involvement of all stakeholders. They are drawn up in temporary bodies called workshops. DIN SPECs are a trusted strategic instrument for quickly and easily establishing and disseminating innovative solutions on the market. (DIN Deutsches Institut für Normung e. V n.d.)

7.8 LIST OF ABBREVIATIONS

- IPR: Intellectual Property Rights
- IP: Intellectual Property
- SDO: Standards Development Organizations
- ITU: International Telecommunication Union
- FRAND: Fair, Reasonable and Non-Discriminatory
- SUNM: Sun Microsystems
- PAS: Publicly Available Specification
- SEP: Standard-Essential Patent
- VHS: Video Home System
- HD DVD: High Definition Digital Versatile Disk
- LED: Light Emitting Diode
- UL: Underwriters Laboratories
- CENELEC: European Committee for Electrotechnical Standardization
- AMP: Accelerated Mobile Pages
- IC: Integrated Circuit
- IEC: International Electrotechnical Commission
- LTE: Long Term Evolution
- RTLS: Real-Time Locating System

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8 AN ECONOMIC PERSPECTIVE ON STANDARDIZATION

LEARNING OBJECTIVES

This chapter shows the relevance of standards and standardization from a macroeconomic perspective, in particular the contribution of standards to the Gross Domestic Product (GDP). Students should understand that standards and standardization are an important basis for a functioning economic system.

This chapter also gives an answer to the question of how standards can be beneficial to the overall economy. In particular, it discusses the relationships among standardization and costs, productivity, market entry, competition, innovation, trade, outsourcing, market failure and related effects (e.g., network effects, switching costs) that are typical for IT. Some examples of successful IT standards are provided. In this way, readers can get valuable insights into the far-reaching impacts of standardization on our economy, and how different stakeholders benefit from them.

Standardization can also be an important tool for governments, for instance to achieve quality or cost objectives. Therefore, this chapter covers the governmental perspective of ICT standardization by focusing on public procurement in particular. We introduce public procurement, while providing a real example. In addition, we identify and describe key legal frameworks and policies. Subsequently, we deal with the contribution of standardization to public procurement, as an enabler of innovation and interoperability, as well as the benefits of standardization for governments and stakeholders such as citizens and companies. After reading the dedicated section, students should be able to explain the impact of standardization on public procurement. They should also be able to recall the most important policy and legal frameworks in this area and link the benefits of standardization to different stakeholders such as citizens and businesses.

8.1 INTRODUCTION

Standards are an important instrument in the diffusion of new technologies and technological know-how. Their resulting contribution to economic growth is well documented in various empirical studies. For instance, in the period between 2002 and 2006, standards and technical rules were responsible for the generation of 0.7 to 0.8% of Germany's Gross Domestic Product (GDP). In addition, the impact of standards has been studied in the context of trade. Swann (2010a, p. 2) reviewed many empirical studies in this regard and found "that there is often, but not always, a positive relationship between international standards and exports or imports". In an empirical analysis by Blind et al. (2018), the authors found that ISO 9000 certification intensity in the exporting country signals a certain quality performance to potential buyers. As such, ISO 9000 can lower information asymmetries between sellers and buyers, decrease transaction costs, and increase trade among countries.

Although our world is heavily reliant on standards, their actual effects on the economy are less obvious. Similar to patents, standards are carriers of codified knowledge and can provide companies with state-of-the-art knowledge. Especially when standards are open and not controlled by a single company, all market players can benefit from and trust the same knowledge. Thus, standards foster competition and prevent the occurrence of lock-in effects or high switching costs.

Standards also support the compatibility between different technical platforms and systems. Without interface standards, the flourishing industries based on complementary products, such as the various apps we can find in app stores or the wide range of video games for our game consoles, would not be possible. Moreover, standards help us to assess the quality of products and services that we can buy and prevent an unmanageable number of different product variants. They support companies in achieving focus in markets and building up critical mass.

Governments use standards in the context of public procurement to guarantee a high quality of public services. Companies that are willing to apply for public tenders need to comply with the indicated standards. Thus, the government can indirectly encourage the adoption of standards by companies and therefore support the innovative strength and technological progress of a nation.

This chapter provides an in-depth analysis of the economic contribution of standards and their role in public procurement. Whereas Section 8.2 focuses on the economic contribution of standards to the GDP, Section 8.3 highlights the real economic effects of standards. Subsequently, Section 8.4 addresses the topic of public procurement and explains how governments can benefit from standardization. Finally, Section 8.5 summarizes the contents of the chapter.

8.2 THE ECONOMIC CONTRIBUTION OF STANDARDS

Several studies have dealt with the contribution of standards to economic growth in different countries such as the United Kingdom (DTI 2005), Germany (Blind et al. 2011), France (Miotti 2009) and Canada (Haimowitz and Warren 2007). The effects of standards on economic growth have been calculated using regression analysis (a statistical process for estimating relationships among variables).

8.2.1 CONTRIBUTION OF STANDARDS TO THE GDP

In Germany, Blind et al. (2011) estimated the contribution of standards to GDP. They used the Cobb-Douglas production function to represent the relationship between economic input (e.g. capital and labour) and output (e.g. products and services).

Total Factor Productivity (TFP) is an essential parameter that determines the quantity of output produced in a country. TFP is a function of technical progress, which increases with the number of companies that incorporate technological knowledge. In other words, economic growth depends on the generation of knowledge and inventions as well as the wide dissemination of this knowledge among companies. The more companies can use that knowledge to improve their production output, the better (Blind et al. 2011). Consequently, TFP is dependent on three factors:

- Technological knowledge generated in a country (e.g. number of patents)
- Technological knowledge imported from abroad (e.g. number of technological licence payments abroad)
- The level of diffusion of this technological knowledge (e.g. number of standards)

Thus, it is clear that standards contribute to economic input. As opposed to codified knowledge in patents, the use of standards is accessible to all. Furthermore, in the best case, committee standards are developed in consensus with the participation of all relevant market players. Therefore, the benefits of standardization for economic growth lie in the dissemination of technological knowledge by increasing the innovative strength and technological progress of a national economy and counteracting the diminishing marginal returns in capital and labour. This is the concept of "knowledge economy": rather than in terms of production, the growth of an economy depends on the quality, quantity and accessibility of information available (Oxford Living Dictionaries n.d.). It is also worth noting that national economies are generally affected by external political factors such as oil crises and "new economy" bubbles, which should be taken into account.

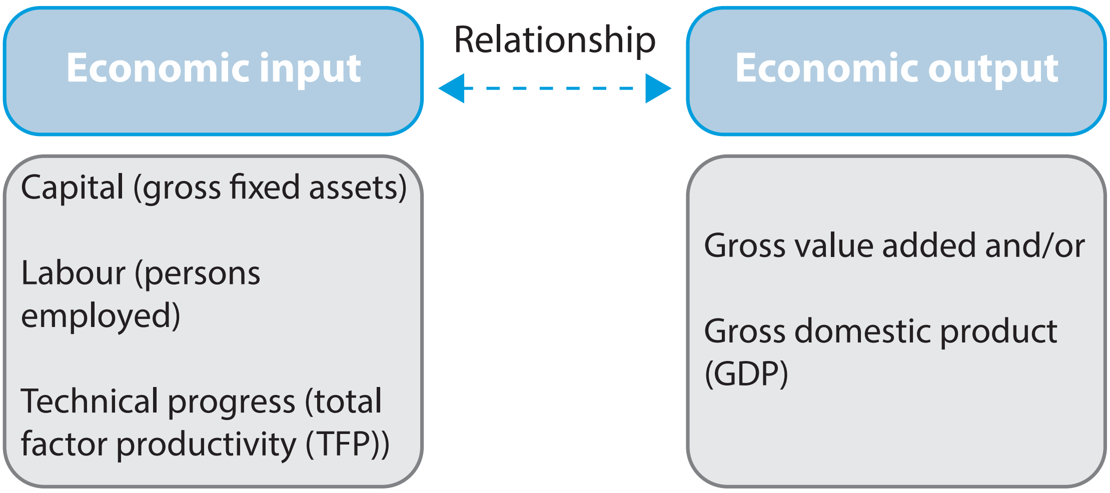

***Figure 8.1**: Correlation between economic input and output*

Blind et al. (2011) found that standards had an increasing contribution to GDP throughout the 1970s. Between 1986 and 1990, the available standard collection was adjusted, in the sense of harmonizing or updating standards. Since the German reunification, however, the contribution of standards has been estimated to have stabilized at a level of between 0.7 and 0.8%. In monetary terms, this equates to some €16.77 billion a year (from 2002 to 2006 in Germany). Table 8.1 shows the contribution to growth of various production factors, including standards, in Germany, whereas Table 8.2 summarizes data regarding the contribution of standards to GDP in other countries: France, United Kingdom, Canada, and Australia.

	1961-1965	1966-1970	1971-1975	1976-1980	1981-1985	1986-1990	1992*-1996	1997-2001	2002-2006
CAPITAL	2.30%	1.70%	1.60%	1.10%	0.90%	0.90%	0.90%	0.50%	0.30%
LABOUR	0.70%	0.10%	-0.50%	0.60%	-0.40%	1.20%	-0.70%	0.60%	-0.30%
PATENTS	0.50%	0.50%	-0.60%	0.60%	1.00%	0.00%	-0.70%	-0.60%	-0.60%
LICENCES	0.90%	0.80%	0.90%	0.30%	0.50%	2.00%	1.70%	0.10%	0.50%
STANDARDS	0.40%	0.60%	1.80%	1.20%	0.70%	-0.02%	0.70%	0.80%	0.70%
SPECIAL FACTORS	0.01%	0.01%	-0.70%	-0.20%	-1.30%	0.01%	0.01%	-1.10%	1.10%

* There is no reliable data for 1991 due to German reunification.

***Table 8.1**: Contribution to growth of various production factors, in %; based on Blind et al. (2011)*

COUNTRY	PUBLISHER	PERIOD	GROWTH RATE OF GDP	CONTRIBUTION OF STANDARDS
FRANCE	Association Française de Normalisation (AFNOR) (2009)	1950–2007	5.4%	0.8%
UNITED KINGDOM	Department of Trade and Industry (DTI) (2005)	1948–2002	2.5%	0.3%
CANADA	Standards Council of Canada (2007)	1981–2004	2.7%	0.2%
AUSTRALIA	Standards Australia (2006)	1962–2003	3.6%	0.8%
Note: The table covers different periods, as no consistent data was available.				

Table 8.2: *Contribution of standards to GDP in countries other than Germany; based on Blind et al. (2011)*

8.2.2 COSTS OF STANDARDIZATION AND STANDARDS FROM THE COMPANY'S PERSPECTIVE

This section focuses on the costs of standardization and standards from the perspective of a company. Therefore, we do not look at the costs of the development of standards as such. To calculate this, we need to evaluate the contribution of companies and other stakeholders to the drafting of the standards. From the company's perspective, the costs of standards may be divided into the cost of purchasing the standards from the SDOs and the costs of resources spent on developing standards, in other words the process of standardization. Standards can generally be bought for a small amount of money from SDOs. For instance, in Germany, DIN has Beuth Verlag, which is the publisher that releases and distributes standards documents. Standardization costs are those required to develop the standard, to achieve consensus and to maintain it. These costs are generally incurred by participants such as companies or academia, which have to finance standardization activities themselves in terms of membership fees (e.g. ETSI's €6000/year for SMEs), travel costs, and staff costs (working hours of institution representatives in the standardization committees). Sometimes, standardization costs are subsidized with public funds, e.g. WIPANO (German abbreviation for "knowledge and technology transfer via patents and standards") in Germany. This project gives financial support to SMEs to support them in safeguarding and utilizing their innovative ideas (German Federal Ministry for Economic Affairs and Energy BMWi n.d.). The SDOs themselves can financially support the generation of standards. For instance, the "DIN Connect" programme launched by DIN to promote R&D in innovative areas funds the development of DIN SPECs (DIN Deutsches Institut für Normung e. V 2016). However, the long-term benefits of standardization more than compensate for the incurred costs.

8.3 THE ECONOMIC EFFECTS OF STANDARDIZATION

The table below summarizes the positive and negative effects of four of the most important types of standards from an economic perspective. They are grouped by their main purpose, for example to ensure compatibility or distribute knowledge (information/measurement standards). The occurrence of the listed positive and negative effects is highly linked to a standard's characteristics such as open vs. proprietary or formal vs. de facto. Moreover, the market structure, in terms of the number and size of market players, as well as competitive aspects play a major role when it comes to determining the probability of occurrence of the effects.

	POSITIVE EFFECTS	NEGATIVE EFFECTS
COMPATIBILITY/INTERFACE STANDARDS	■ Network externalities ■ Avoiding lock-in in old technologies ■ Increased variety of system products ■ Efficiency in supply chains	■ Anti-competitive, leading to monopoly ■ Lock-in in old technologies in case of strong network externalities
MINIMUM QUALITY/SAFETY STANDARDS	■ Avoiding adverse selection ■ Creating trust ■ Reducing transaction costs	■ Regulatory capture ■ Raising rivals' costs
VARIETY-REDUCING STANDARDS	■ Economies of scale ■ Building focus and critical mass	■ Reduced choice ■ Leading to monopoly, market access barriers
INFORMATION/MEASUREMENT STANDARDS	■ Facilitating trade ■ Reduced transaction costs ■ Providing codified knowledge	■ Regulatory capture

***Table 8.3**: Effects of standards; based on Swann (2000); Pham (2006); Blind (2013)*

In the following sections, we deal with the four different types of standards and describe their economic benefits. These standards are compatibility/interface standards, minimum quality/safety standards, variety-reducing standards, and information measurement standards.

8.3.1 COMPATIBILITY/INTERFACE STANDARDS

A key role of standards is to ensure compatibility, which according to ISO (25010) consists of two components: coexistence and interoperability. Coexistence means that an IT service/product shares a common environment as well as resources with other independent services/products without adverse side effects, whereas interoperability is the ability of components to work constructively with one another.

In the ICT sector, compatibility/interface standards play a crucial role. Two economic phenomena that can influence customers and producers are relevant in such a sector: switching costs, and network effects. Switching costs are incurred when a user switches from one technology or product to another. Recall the example of QWERTY and DVORAK keyboards. The switching costs of learning to type quickly using the DVORAK keyboard are high for users, so most of them prefer to continue using the old standard. Producers or customers that have invested a large amount of money into the integration of particular interface standards would incur high costs if they have to switch to another standard.

Examples of switching costs (Parr et al. 2005) are:

- Acquisition costs: when new equipment has to be bought or adapted.
- Training costs: associated with learning to use a new product
- Testing costs: if there is uncertainty with respect to the suitability of alternative products/services

The second economic effect is called the network effect, which can be direct or indirect. A direct network effect is when the value of a given product, software or technology increases with the number of people and organizations using it. Examples are the telephone, fax, Facebook and Twitter. For instance, the value of the telephone depends on the size of the network of people that can be reached via telephone. Indirect network effects arise when the value of a good/service does not depend directly on the number of users, but rather on the availability of complementary and compatible components. For instance, the value of video game consoles depends on the availability of video games. The more there are, the greater the choice, and the better for the consumer.

If the switching costs and network effects are high, then there is a risk of so-called lock-in effects. Sometimes, markets get locked in with inferior products, services or technologies because producers and customers will only switch to a better design when everyone else does so too. If nobody moves on to the next standard, everybody stays with the current solution or standards. In addition, the lock-in effect will dominate if the players that operate in the market cannot afford the switching costs

There are different ways in which a standard can achieve dominance in the market. This also differs for formal and de facto standards (Table 8.4).

FORMAL STANDARD	DE FACTO STANDARD
■ Developed in SDOs ■ Open and consensus oriented with the option of opposition, which may sometimes lead to lengthy decision procedures ■ Clear and transparent participation and voting rules ■ IPR policy has to follow FRAND licensing rules	■ Dominant design through a standard war or natural selection. E.g. a company achieves a dominant position by public acceptance or market forces ■ Standardization process with restricted access; homogeneous environment may allow fast decisions ■ Direct participation of company alliances (e.g. consortia) and individual companies ■ Flexible IPR rules according to the preferences of the initiators and technological/market contexts, which may favour exploitation of IPR

***Table 8.4**: Comparison of formal and de facto standards (Blind 2008)*

Note, however, that the winners of standard races do not necessarily possess the technology with the best performance, but are those that are most effective in building a wide network and attracting suppliers of complementary products.

When a standard is proprietary, lock-in is more likely to happen, because one party has full control over the standard. For the market, lock-ins also mean high barriers to market entry. These barriers arise because of the high costs imposed by the owner of the proprietary standard or the patents in terms of licensing fees. In addition, switching to another environment would not be possible, because of the large critical mass of users that is required in order to escape the lock-in. Lock-ins can result in monopolies that are not conducive to competition (according to antitrust and competition laws) (de Vries et al. 2008).

EXAMPLE

A case in point is the Microsoft Windows operating system. The Microsoft Windows Application Programming Interface (API) supports vendor lock-in by using proprietary file formats. In terms of the Windows API, Microsoft's general manager for C++ development, Aaron Contorer, stated in an internal Microsoft memo drafted for Bill Gates: "The Windows API […] is so deeply embedded in the source code of many Windows apps that there is a huge switching cost to using a different operating system instead" (European Commission 2004, pp. 126–127). Through a Microsoft-exclusive franchise, Microsoft grants other suppliers the right to use the Windows API to produce systems according to its specifications. This allows the development of many third-party programs, which increase the Windows platform's value. The strategic role of API is to maintain the network effect and prevent competition. Thus, the use of proprietary file formats in Microsoft's application software exhibits lock-in (Deek and McHugh 2007).

EXAMPLE

Another case is Apple's iPod. Digital music files with Digital Rights Management (DRM) are purchased from Apple's iTunes store. Advanced Audio Coding (AAC) format is only compatible with Apple's iTunes media player software. Consequently, users could not play purchased music in other software environments. After the launch of the iPod in 2001 and a licence deal with major music companies, Apple controlled almost 75% of the US market for paid music downloads. However, the DRM conditions and incompatibility with other music players caused conflicts with consumer rights. Since 2009, and after several suits for "unlawful bundling", DRM has been removed from digital music files (Raustiala and Sprigman 2012).

Open standards are the opposite of proprietary standards and have several positive effects. They attract producers of complementary products as well as customers who want to avoid being dependent on one company. Furthermore, they promote competition among multiple producers using the same standards, in contrast to proprietary ones, which enhance the market power of a single producer (leading to a monopoly). In this regard, Swann (2000, p. 5) comments that "it is better to have a share of a large market than a monopoly of a tiny one". With an open standard, the risk of lock-in is reduced, because the standard is more freely available, leading to lower barriers to entry and lower switching costs for consumers. Note that companies that are seeking first-mover advantage will be more interested in closed and proprietary standards, whereas later entrants will favour open ones.

In general, compatibility standards help companies to reduce transaction costs. If buyers know that a particular piece of software is compatible with a specific operating system, the burden to verify that the software will run as expected is low. This reduction in transaction costs facilitates the division of labour, as low transaction costs support market coordination (Coase 1937; Williamson 1989; Picot et al. 2013). The computer industry is a good example of the division of labour that is supported by standardized interfaces. A computer consists of components with predefined interfaces that are outsourced to suppliers all over the world. The globalization of the industry has been possible only because of internationally accepted compatibility standards. In this way, suppliers can focus on small portions of the value chain to achieve economies of scale and, for instance, sell computer components to an international market.

Generally accepted compatibility standards reduce the barriers to entry for small-scale entrants producing "add-on" products. For example, in recent years, we have witnessed a growth of cottage industries producing iPhone "apps". Many of these companies are micro-entities that would not be able to enter the software market at all in the absence of well-established platforms with accepted compatibility standards.

In summary, the previous discussion has several implications for companies. Compatibility or interface standards support network effects, which in turn enable companies to reach a critical mass on the market. If the network effects are important to buyers, suppliers will likely produce goods or services that conform to the prevailing compatibility standard in the market. Consequently, companies that set the dominant standard have a high chance of being successful, as other market players will be interested in adopting that standard. However, if the technology or product is still in the introduction phase—in other words, at the beginning of the technology life cycle—and the market is still fragmented, standard races can occur. In the case of open standards, producers may face higher competition, since others will also use the same standard, but they equally have to deal with a much lower level of risk than in the case of proprietary closed standards.

8.3.2 MINIMUM QUALITY/SAFETY STANDARDS

Minimum quality standards refer to the minimum acceptable level of requirements. These standards can be related to the reliability, durability, or secondary effects and safety of products and services, as well as to other fields such as working conditions. They can have a welfare-improving effect on the economy, as they are also applied in the in the fields of health and natural environment. With these standards, it is possible to help reduce the level of risk felt by buyers, thus improving trust between traders. For instance, in the commodity market, traders must be in a position to buy and sell large volumes without even seeing their goods. This assumes the existence of clearly designed standards and possibly certifications that confirm that the traded commodities meet certain levels of quality or requirements. However, these kinds of standards can be misused and may have a negative effect. For instance, if they are set at an unnecessarily high level, they can function as a barrier to entry (Swinnen 2015; Locksley 1990).

Because customers face a huge variety of different products, they often find it difficult to assess which option is best suited for their purpose. Furthermore, when buyers cannot distinguish between different product variants, the quality sellers may not be able sustain a price premium, as their costs are likely to exceed those of lower quality sellers. This is called Gresham's law: "bad drives out the good". Bad sellers who only sell lower quality products drive out good-quality sellers by undercutting them. In the worst case, the market will break down, leading to market failure (Swann 2000).

***Figure 8.2**: Customer confronted with a large variety of products*

This problem is a clear example of information asymmetries between buyers and sellers. Information asymmetry is when one party has more or better information (in this case, the seller) than the other (the buyer), which makes it hard for the one with less information to make an informed decision. Leland (1979) showed that minimum quality standards could help overcome information asymmetries, as they function as a reference and define the minimum requirements a product should have. In this way, buyers can make faster and easier decisions. Some companies even trade on their reputation and can sustain a price premium for their products that are of a quality well above the minimum threshold in the relevant standard. The standard functions in this way as reference for the distinguishing feature (see Chapter 5 in the context of innovation). For instance, "ex post restitution" (e.g. a guarantee) can also work as a substitute for a certified minimum quality standard.

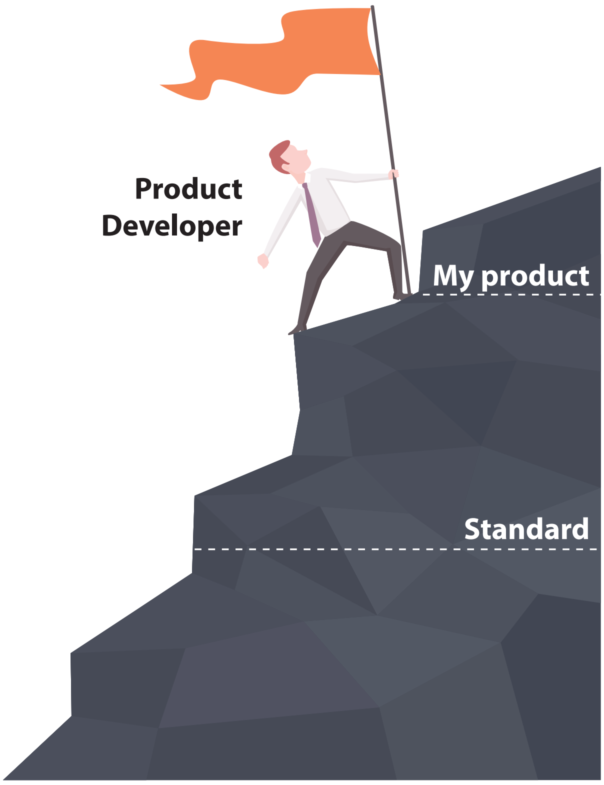

Figure 8.3*: Standards set a target level for quality*

Minimum quality standards exhibit many advantages. They reduce transaction and search costs caused by economic exchange. Furthermore, they make it possible to define products in a way that reduces buyer uncertainty. Thus, the buyer's risk is reduced, and there is less need for the buyer to spend money and time evaluating different products before a purchase. In the case of product certification, this can function as a shortcut for buyers, as certification constitutes proof of compliance with a standard (Pham 2006; Swann 2000, 2010a)

For market entry, the effects of minimum quality standards are uncertain. When the characteristics of products are documented in an open standard, the playing field between incumbent and entrant gets levelled. However, in its absence, incumbents may have an information advantage over entrants. Some quality standards can be set at an unnecessarily high level in order to deter newcomers from entering a market. Note that even though these standards may impose a cost burden on incumbents, this strategy can be very effective when the cost burden on entrants is even greater. This is an effective approach to increase barriers to market entry, referred to as "raising rivals' costs" (Salop and Scheffman 1983).

The concept of "regulatory capture" can be considered a variant of the "raising rivals' costs" concept. Some producers may lobby to persuade the regulator to define regulations in their interest rather than in the interest of the buyer/customer (original intention of standards). "Some high-cost and high-quality producers may find it in their interest to lobby for an unnecessarily high minimum quality standard, because that will in effect exclude their lower cost, lower quality rivals from the market" (Swann 2000, p. 8). Therefore, minimum quality standards should be open and defined cooperatively to ensure that all parties benefit, and to overcome Gresham's Law. Minimum quality standards can also protect third parties, such as in the area of health or environment to reduce the negative impacts that can result during production or product consumption.

8.3.3 VARIETY-REDUCING STANDARDS

Variety-reducing standards reduce the variability of key product characteristics. These standards have two main functions: to support the achievement of economies of scale and to prevent market fragmentation.

They support economies of scale by minimizing the proliferation of minimally differentiated models. For instance, standard clothing sizes also mean compromises for non-standard customer sizes and individual wishes, thus constraining choice. However, these standards have a positive effect on price and transaction costs on the customer's side, since customers do not have to choose from a large number of product variants.

Variety reduction can also prevent market fragmentation and support a joint vision. In effect, some technologies get stuck in the pre-paradigmatic stage because suppliers and users are too dispersed. A lack of focus or critical mass prevents the development of a market (Swann and Watts 2002). Therefore, standards can play an important role in achieving focus and cohesion amongst pioneers—especially in the formative stages of a market (Moore and Benbasat 1991).

In this way, standards can shape future technological trajectories, and consequently constitute an instrument for the development of new markets (Dosi 1982; Swann and Gill 1993).

For suppliers, less fragmentation also means reduced risk (even if they face more competition). Variety-reducing standards can lower the barriers to entry, as it acts against variety proliferation, which incumbents can use to limit competition from small-scale entrants who cannot provide the same degree of variety. Variety-reducing standards do not need to be defined publicly because economies of scale, which is the best-known function of this type of standard, can also be obtained with an idiosyncratic model range. Note, however, that a store selling clothes in idiosyncratic sizes may not able to succeed (Swann 2000; Pham 2006).

8.3.4 INFORMATION/MEASUREMENT STANDARDS

Information and measurement standards contain codified knowledge and product descriptions. They constitute an important instrument for technology transfer, as they codify the work and experience of generations of experts in their specific fields, and support the dissemination of best practices. As such, they have a positive effect on the market by diffusing knowledge (Temple and Williams 2002).

EXAMPLE

Digital image compression (ANSI n.d.)

With the rapid diffusion of image and video processing applications and the further advancement of multimedia technologies, compression methods became more and more important during the early 1990s. International standardization noticed this trend and released several standards describing different compression methods, such as JPEG (Joint Photographic Experts Group). These standards offered the industry new solutions for saving storage space and reducing transmission rate requirements. Thus, compression standards laid the foundation for innovative applications, services, and even markets. Many companies of all sizes have based their software products on these compression methods, which are used by millions of users worldwide today. The JPEG standard itself and its descendants are comprised in various applications, such as the sharing of digital images, remote sensing, archiving, digital cinema, and image search and retrieval.

Measurement standards describe "those devices, artefacts, procedures, instruments, systems, protocols, or processes that are used to define (or to realize) measurement units and on which all lower echelon (less accurate) measurements depend" (Sharp 1999). They can enable advances in process control, thereby supporting the achievement of economies of scale. Especially in the area of manufacturing, they foster the precision of production, and support market players producing products and services of higher quality to demonstrate their superiority. Measurement standards can lead to lower transaction costs and less risk between trading partners, as they can build on widely used and accepted standard methods that help to assess the quality of raw materials, products and services. Thus, measurement standards also support the effective division of labour (Swann 2010a).

Standards that primarily carry information or codified knowledge have various economic effects on the market. Without a doubt, they support capacity building via their main function of spreading state-of-the-art knowledge. When information standards are publicly available (open), they can foster equal competitive conditions in markets—even between incumbents and entrants. As a result, information standards prevent information asymmetries between market players, and lower the barriers to entry. In addition, companies often refer to standards in contracts or job offers by using the link as a shortcut to a specific description of products or skills. Hence, information standards support the reduction of transaction costs and the achievement of a feasible division of labour (Swann 2000, 2010a, 2010b; Blind 2013)

Although measurement and information standards are usually treated as a separate category of standards, they could also be seen as hybrids of the three aforementioned types, as all standards contain the two types of codified knowledge to at least some extent (Swann 2000).

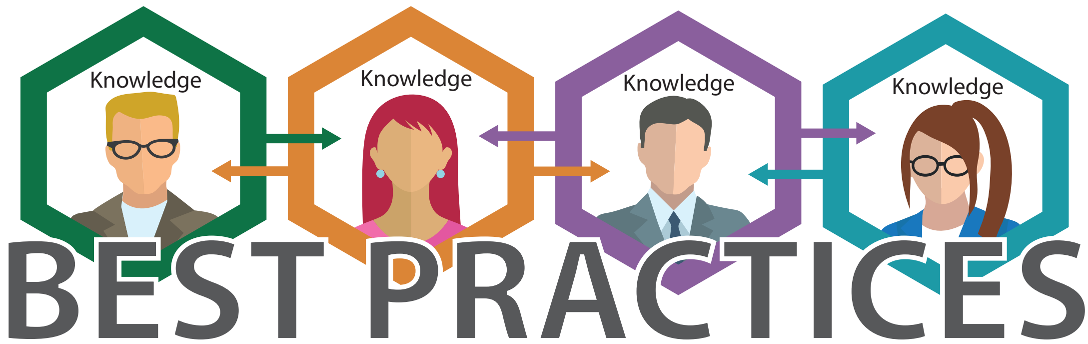

Figure 8.4: *Exchange of implicit knowledge*

8.3.5 SUMMARY

It is clear that all standards have many advantages and that they are conducive to economic growth. However, from the buyer and user's perspective, the four types of standards (compatibility/interoperability, minimum quality/safety, variety reducing, and information) do not seem to contribute equally to demand-side effects: network effects, economies of scale, reduction of information asymmetries, and lowering uncertainty and risk. Whereas compatibility and interoperability standards are particularly suited to supporting network effects, variety-reducing standards have a special positive impact on economies of scale. Minimum quality and safety standards lead to less uncertainty and risk, while information standards are particularly effective in reducing information asymmetries (Table 8.5).

	DIFFERENT TYPES OF STANDARDS AND THEIR MAJOR DEMAND-SIDE EFFECTS FOR INNOVATION			
	GENERATION OF NETWORK EFFECTS	ACHIEVEMENT OF ECONOMIES OF SCALE	REDUCTION OF INFORMATION ASYMMETRIES	LOWERING UNCERTAINTY AND RISK
COMPATIBILITY/ INTEROPERABILITY	X			
MINIMUM QUALITY/SAFETY				X
VARIETY REDUCING		X		
INFORMATION			X	

Table 8.5: *Different types of standards and their demand-side effects (Blind 2013)*

8.4 PUBLIC PROCUREMENT AND STANDARDIZATION

The public sector can use standards in the context of public procurement (e.g. in tender specifications) to foster demand-side effects. This way, governments can diffuse innovations to the private sector, as companies and other organizations applying for public tenders have to comply with specific standards.

DEFINITION

Public procurement is the process by which public authorities (e.g. government departments or local authorities) purchase work, goods or services from companies, for example, the building of a state school, purchasing of furniture for a public prosecutor's office, or contracting cleaning services for a public university (Blind 2013).

In the context of public procurement, standards yield many positive effects. They improve the quality of public services and infrastructures, leading to high customer and citizen satisfaction. The improvement of public services generates more competition among regions, and this can increase regional attractiveness. Furthermore, by integrating innovations in the public sector, cost savings can be made, such as lower maintenance and repair costs or lower energy consumption.

EXAMPLE

Disseminating accessibility standards through public procurement

Without access to ICT, persons with disabilities cannot get equal access to education, everyday services, and social and other areas of life. To achieve an inclusive society, ETSI released a new standard (EN 301 549) that is intended in particular for use in public procurement to ensure that software products, web applications and digital devices satisfy basic accessibility requirements. By referencing the standard in public tenders, governments can improve the accessibility of ICT for their own employees and the public (e.g. ticket vending machines, websites). Companies applying for these tenders need to comply with the accessibility criteria laid down in the standard, thus promoting the spread of the standard (ETSI 2014; Rice 2015).

Note that in general, industry can be strongly influenced by the rules of governments. Christy Hubbard, product marketing manager for Adobe's ePaper Solutions Group, once stressed the following in an interview:

"When government says you need to build technology a certain way, for vendors like ourselves that's a very compelling maxim. We need to build products that can be sold to the government. It's not very practical for us to build multiple versions of our products." (Marsan 2001)

Negative effects, however, can result from the fact that new features or improved functionalities trigger higher purchasing prices. Innovative technologies bear higher risks for the user but also, for instance, for the environment, and they can increase maintenance costs due to less operational experience. In addition, there may be very limited competition, since the innovation to be purchased by the public sector may only be produced by a small number of companies (or even just one).

According to Blind (2013), standards referenced in public tenders lead to the creation of innovative products that can reduce production costs, while lowering the price to be paid by public procurers. Furthermore, they secure the interoperability of the purchased innovation with already existing infrastructure and can push competition, thus increasing the innovation pressure among competitors for public tenders. In addition, they reduce the risk of lock-in to a specific supplier and trigger direct innovation effects for companies through the implementation of newly released standards. In general, this results in reduced risk related to costs, health, environment and safety, and facilitates positive spillovers through innovation supporting procurement processes in the private sector.

Standards come into play at various stages of the procurement process (Figure 8.5). Before procurement, appropriate standards should be analysed and then referenced. During procurement, they support the selection of proposals, as only those proposals that comply with the standards are retained. In addition, possible conflicts can be solved with the help of standards. After procurement, standards can reduce transaction costs by identifying possible deviations and enable easier monitoring of technology by taking newly released standards into account (Blind 2013).

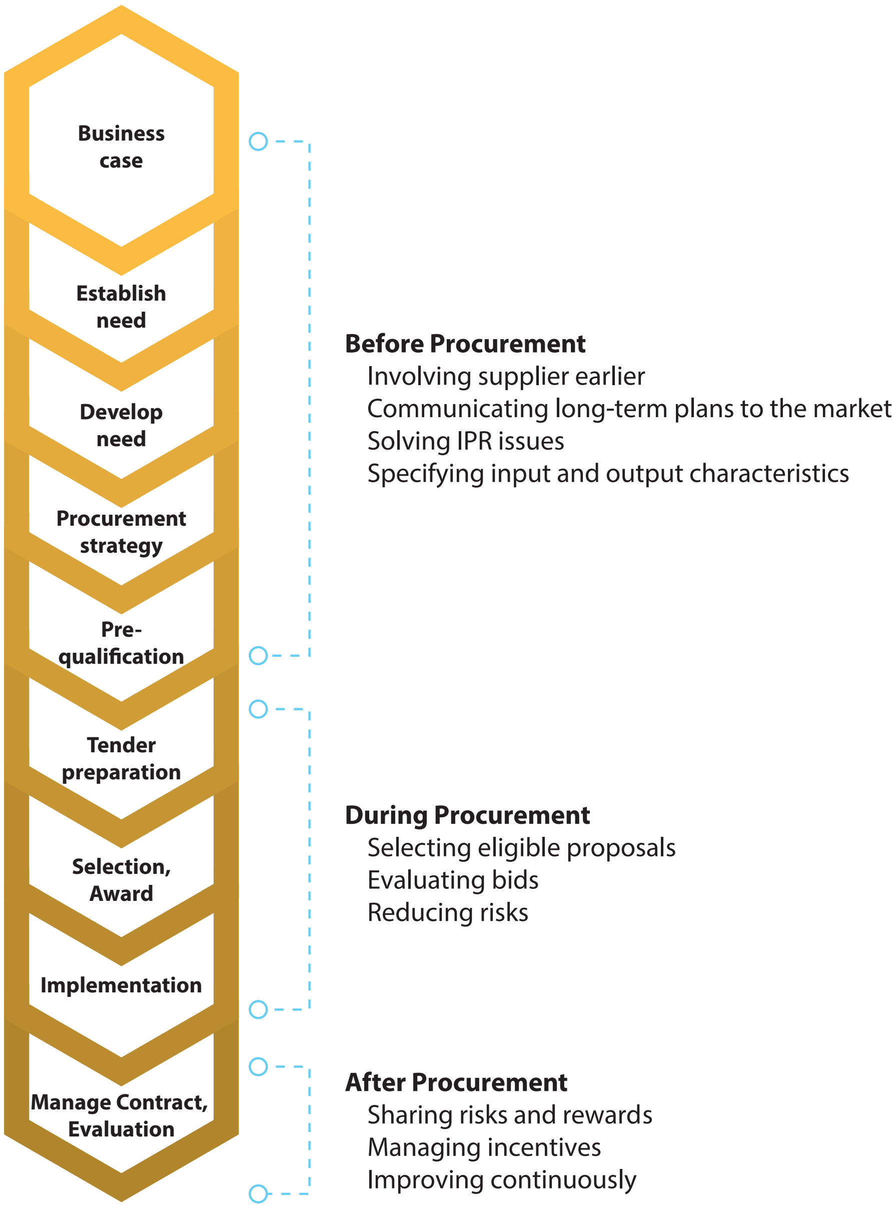

***Figure 8.5**: The procurement process (Blind 2013)*

8.5 SUMMARY

Standards play an essential role in the dissemination of technologies and know-how and, as such, contribute to a nation's GDP. In this chapter, we took a closer look at the positive and negative economic effects of standards. We dealt with the four most relevant types: compatibility/interface, minimum quality/safety, variety-reducing and information/measurement standards.

Compatibility standards in particular have a wide range of effects on the economy. They can support network externalities, avoid lock-ins and foster an increased variety of system products as well as more efficiency in supply chains. On the negative side, especially when a standard is proprietary, compatibility standards can lead to monopolies and, in the case of strong network externalities, to lock-in effects.

Minimum quality or safety standards support the avoidance of adverse selection, help increase trust between different market players and reduce transaction costs. If minimum quality criteria are set unnecessarily high, i.e. inspired by lobbyists, quality standards can also function as a market barrier.

Variety-reducing standards can lead to increased economies of scale and can support a company in building focus in markets and achieving critical mass. An obvious negative side effect is the general reduction of choice. At the same time, variety-reducing standards can lead to monopolies or market barriers if a market player misuses the standard to limit competition, e.g. incumbents against small-scale entrants who cannot provide the same degree of variety.

Information/measurement standards that provide codified knowledge can facilitate trade and reduce transaction costs when publicly available to all market players. Like minimum quality/safety standards, they are vulnerable to the effect of regulatory capture. All in all, standards have an influence on a variety of economic effects, such as prices, productivity, market entry, competition, innovation, trade, outsourcing, and market failure.

Finally, governments can use standards in the context of public procurement to foster demand-side effects. This way, governments can diffuse innovations to the private sector, as companies and other organizations that apply for public tenders have to comply with those standards. However, this procedure can lead to negative effects: new features or improved functionalities in standards can trigger higher purchasing prices. In addition, innovative technologies bear higher risks for users and also, for instance, the environment, and they can increase maintenance costs due to little operational experience.

8.6 QUIZ

1 - TO WHAT EXTENT DID STANDARDS CONTRIBUTE TO GERMANY'S GDP BETWEEN 2002 AND 2006?

(See Section 8.2.1 for hints)

a) *Between 0.07 and 0.08%*

b) *There is no evidence that standards contributed to the GDP*

c) *Between 0.7 and 0.8%*

d) *Between 7 and 8%*

2 - TOTAL FACTOR PRODUCTIVITY (TFP) IS AN ESSENTIAL PARAMETER THAT DETERMINES THE QUANTITY OF ECONOMIC OUTPUT PRODUCED IN A COUNTRY. IT PLAYS AN IMPORTANT ROLE IN ESTIMATING THE CONTRIBUTION OF STANDARDS TO THE GDP. ON WHICH FACTORS DOES THE TFP DEPEND?

(See Section 8.2.1 for hints)

a) *Technological knowledge generated in a country (number of patents),*

b) *Technological knowledge imported from abroad (number of technological licence payments abroad)*

c) *The level of diffusion of this technological knowledge (number of standards)*

d) *Technological knowledge generated in a country (number of papers)*

3 - WHO BEARS THE COSTS OF DEVELOPING, UPDATING AND DISTRIBUTING STANDARDS?

(See Section 8.2.2 for hints)

a) *Standardization is financed by governments as the resulting standards contribute to the economy as a whole*

b) *The costs are generally incurred by companies, academia and other organizations by participating in the standard-setting process, or by purchasing standards*

c) *50% of the costs are covered by the state and the remaining 50% are covered by companies participating in standard setting*

d) *SDOs cover the costs via crowdfunding initiatives and voluntary donations*

4 - VARIETY-REDUCING STANDARDS REDUCE THE VARIABILITY OF KEY PRODUCT CHARACTERISTICS. WHICH ECONOMIC EFFECTS ARE MAINLY ASSOCIATED WITH THIS TYPE OF STANDARD?

(See Section 8.3.3 for hints)

a) *They support economies of scale*

b) *They support network effects*

c) *They prevent lock-ins into old technologies*

d) *They can prevent market fragmentation*

5 - HOW DOES A FORMAL STANDARD DIFFER FROM A DE FACTO STANDARD?

(See Section 8.3.1 for hints)

a) *a) It is developed by recognized SDOs*

b) *b) The standard is proprietary and not open to the public*

c) *c) All interested parties are invited to participate in the standard-setting process*

d) *d) It is developed by a single company*

6 - WHAT ARE THE RISKS OF PROPRIETARY STANDARDS FROM A MACROECONOMIC PERSPECTIVE?

(See Section 8.3.1 for hints)

a) *They bear the risk of inferior knowledge being disseminated, as most proprietary standards are of poor quality*

b) *There might be high costs imposed by the owner of the proprietary standard, which could hinder its wide diffusion in the market*

c) *When a standard is proprietary, lock-ins are more likely to happen, which can result in monopolies that are not conducive to competition*

d) *Proprietary standards are not recognized at an international level and therefore hinder international trade*

7 - WHAT ARE THE MAIN POSITIVE EFFECTS OF VARIETY-REDUCING STANDARDS FROM A MACROECONOMIC PERSPECTIVE?

(See Section 8.3 for hints)

a) *They reduce choice*

b) *They foster economies of scale*

c) *They help achieve a critical mass*

d) *They help achieve a focus in the market*

8 - THE GLOBALIZATION OF THE COMPUTER INDUSTRY HAS ONLY BEEN POSSIBLE BECAUSE OF INTERNATIONALLY ACCEPTED COMPATIBILITY STANDARDS. HOW DO COMPATIBILITY STANDARDS SUPPORT THE DIVISION OF LABOUR IN THE COMPUTER INDUSTRY?

(See Section 8.3.1 for hints)

a) *They stipulate the exact tasks for all market players in the value chain*

b) *Through predefined interfaces, the production of computer components can be outsourced to suppliers all over the world*

c) *Suppliers can focus on small portions of the value chain to achieve economies of scale and sell computer components to an international market*

d) *They describe which activity of the value chain should be conducted in a certain geographic area for environmental protection reasons*

9 - MINIMUM QUALITY STANDARDS REFER TO THE MINIMUM ACCEPTABLE LEVEL OF REQUIREMENTS. WHAT ARE THE EFFECTS OF MINIMUM QUALITY STANDARDS FROM THE CUSTOMER/CONSUMER PERSPECTIVE?

(See Section 8.3.2 for hints)

a) *They make it easy to assess which product is best suited for their purposes*

b) *They make it harder to distinguish between different product variants*

c) *They help in assessing if a certain product is worth a certain price*

d) *They foster information asymmetries between buyers and sellers*

10 - WHICH STATEMENTS ARE TRUE?

(See Sections 8.3.1 and 8.3.2 for hints)

a) *Open standards attract producers of complementary products who want to avoid dependence on one company*

b) *Open standards are especially attractive for enterprises seeking first-mover advantage*

c) *Open standards make it more likely for the market to get locked-in in inferior technology*

d) *Open standards enhance the market power of a single producer, leading to a monopoly*

11 - HOW DO DIFFERENT TYPES OF STANDARDS POSITIVELY INFLUENCE TRADE?

(See Section 8.3 for hints)

a) *Minimum quality standards can foster trust between trading partners*

b) *Information standards that provide codified knowledge can facilitate trade*

c) *Minimum quality standards help reduce the level of risk felt by buyers*

d) *Measurement standards can lead to lower transaction costs and less risk between trading partners*

12 - WHY DO GOVERNMENTS REFER TO STANDARDS IN OPEN TENDERS?

(See Section 8.4 for hints)

a) *To limit the number of applications to a manageable number, as only companies complying with the standard can apply*

b) *To improve the quality of public services and infrastructures*

c) *So that they can diffuse innovations to the private sector*

d) *They are legally obliged to refer to standards whenever possible*

13 - WHAT IS THE MAJOR DEMAND-SIDE EFFECT ON INNOVATION OF COMPATIBILITY STANDARDS?

(See Section 8.3.5 for hints)

a) *Achievement of economies of scale*

b) *Reduction of information asymmetries*

c) *Generation of network effects*

d) *Lowering uncertainty and risk*

14 - HOW CAN A TECHNOLOGY ACHIEVE DOMINANCE IN THE MARKET?

(See Section 8.3.1 for hints)

a) *By natural selection*

b) *By winning a standard race*

c) *By being released by an SDO officially recognized by a government*

d) *Only a technology defined in a patent can achieve dominance in a market*

15 - WHAT ARE THE MAIN NEGATIVE EFFECTS OF MINIMUM QUALITY STANDARDS?

(See Section 8.3 for hints)

a) *Reduced choice*

b) *Regulatory capture*

c) *Raising rivals' costs*

d) *Avoiding adverse selection*

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8.7 GLOSSARY

- Gross Domestic Product: The OECD defines the Gross Domestic Product or GDP as "an aggregate measure of production equal to the sum of the gross values added of all resident and institutional units engaged in production (plus any taxes, and minus any subsidies, on products not included in the value of their outputs)." (OECD 2001)
- Trade: "Trade is the activity of buying, selling, or exchanging goods or services between people, firms, or countries." (Collins dictionary n.d.)
- Outsourcing: Outsourcing is the action of "delegating (part of) activities to an outside contractor" (OECD 2002).
- Switching costs: A consumer faces switching costs when changing a brand, supplier or a product (Investopedia n.d.). Examples of switching costs are:
  - Acquisition costs: when new equipment has to be bought or adapted
  - Training costs: associated with learning to use a new product
  - Testing costs: if there is uncertainty as to the suitability of alternative products/services (Parr et al. 2005)
- Public Procurement: The process by which public authorities (e.g. government departments or local authorities) purchase work, goods or services from companies, for example, the building of a state school, purchasing of furniture for a public prosecutor's office, or contracting cleaning services for a public university (Blind 2013).
- Lock-in effect: When a user of a product or service is dependent on a particular vendor because of prohibitive switching costs, therefore the effect is also called vendor lock-in. (Deek and McHugh 2007)
- Transaction costs: "The costs involved in market exchange. These include the costs of discovering market prices and the costs of writing and enforcing contracts." (OECD 2003)
- Gresham's law: The assertion that "bad drives out good". The presence of "bad" products in a market, and the inability of the buyer to distinguish bad from good from the outset, means that the supplier of good products withdraws from the market, as he cannot get a satisfactory price (Akerlof 1970; Swann 2000, p. 35).
- Division of labour: "Specialization in work, which may be effected by breaking an activity into component tasks, or by assigning specific groups of persons to certain jobs or outputs." (OECD 2013)
- Information asymmetry: When one party in an economic transaction is more or better informed than the other.
- Public tender: "A bidding process that is open to all qualified bidders and where the sealed bids are opened in public for scrutiny and are chosen on the basis of price and quality." Also called competitive tender or open tender. (Business Dictionary n.d.)
- Regulatory capture: Some producers may lobby so skilfully that they persuade the regulatory agency to define regulations in the interest of the producers rather than in the interest of the customer. (Swann 2000, p. 8)

8.8 LIST OF ABBREVIATIONS

- GDP: Gross Domestic Product
- DTI: Department of Trade and Industry (United Kingdom)
- TFP: Total Factor Productivity
- AFNOR: Association Française de Normalisation
- JPEG: Joint Photographic Experts Group
- API: Application Programming Interface
- DRM: Digital Rights Management
- AAC: Advanced Audio Coding

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9 CONCLUSION

This textbook introduces the key concepts and examples that enable readers to orientate themselves in the tricky landscape of standardization. It describes the main types of standards development organizations (SDOs), as well as several classifications for the standards they produce.

Standards production is a complex process that involves technical resources, but also a strong organization, and social elements. Fair standards enable fair competition, and fair trade implies compliance with a set of fundamental principles.

The roles of standardization experts in SDOs and committees are clearly defined, even if they vary slightly among the different SDOs. Technical competence is of prime importance, but a wide variety of soft and personal skills also help make a successful standardization expert.

Chapter 5 provides a comprehensive overview of the basics of standardization and innovation. It is important to observe that sometimes standards can hamper innovation if standardization is not adequately managed over time or if the standard induces a lock in effect. For instance, the keyboard example (QWERTY vs. DVORAK) shows that people find it difficult to change an established standard and switch to a better solution. Nevertheless, we argue that the positive contributions of standards and standardization to innovation more than outweigh their negative impacts. Furthermore, standardization and standards can be very useful during the research process. The results of the research process can be used in standardization to draw up new standards. The other way around is also possible, as standards can give input for the research process. In addition, it is demonstrated that standards and standardization are conducive to innovation. Hence, contrary to popular belief, standards and standardization do support companies in improving their innovation capabilities.

In Chapter 6, participation in standardization was dealt with from the perspective of an organization interested in getting involved. In addition to the different interests that organizations may have in participating, the chapter provides essential knowledge on how to choose a standards organization to participate in, as a function of the domain of activities and of geographical location. It also dealt with the close links to technology and market developments, requiring a high level of internal communication for successful participation in standardization. Furthermore, it dealt with the operation of SDOs. Finally, the chapter discussed some considerations to help evaluate and choose standards for a certain application.

Intellectual property (IP) refers to creations of the mind, such as inventions, literary and artistic works, designs and symbols, and names and images used in commerce. In Chapter 7, we focused on three main instruments by which companies can deal with their IP: committee standards, patents, and secrecy. Committee standards, patents and trade secrets have benefits and risks. For instance, committee standards enable companies to gain insider knowledge and early access to information, and sometimes even to discover new applications for their technologies and to develop new markets. A decision tree was introduced that helps companies make an informed decision on whether to patent, to standardize, to combine both, or to keep a technology secret. Two case studies from the ICT sector explained in detail how to use the decision tree to support decision making.

Standards play an essential role in the dissemination of technologies and know-how and, as such, contribute to a nation's GDP. In Chapter 8, we took a closer look at the positive and negative economic effects of standards. We dealt with the four most relevant types of standards: compatibility/interface, minimum quality/safety, variety-reducing, and information/measurement standards. Furthermore, governments can use standards in the context of public procurement to foster demand-side effects. This way, governments can diffuse innovations to the private sector, as companies and other organizations applying for public tenders have to comply with those standards.

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ACKNOWLEDGEMENTS

The authors would like to acknowledge the assistance they received from Theresa Stein, of Fraunhofer IMW, and Ultan Mulligan and Hermann Brand, of ETSI.

The development of this book and accompanying teaching material was funded by the European Commission and the EFTA Secretariat.

ANSWERS TO QUIZ QUESTIONS

CHAPTER 2 - INTRODUCTION TO STANDARDS - *P. 46*

1 - WHICH OF THE FOLLOWING STATEMENTS APPLY TO A "DE FACTO" STANDARD?

(See Section 2.1 for hints)

a) *it usually has very little impact, as it is recognized only within a restricted community of users; (wrong)*

b) *it is based on a winning technologic solution, which is widely and independently adopted by different producers/providers within a market segment and products developed on such basis are widely accepted by users/customers; (right)*

c) *it has been agreed through a formal process by members of an established organization. (wrong)*

2 - WHICH OF THE FOLLOWING STATEMENTS APPLY TO A "FORMAL" STANDARD?

(See Section 2.1 for hints)

a) *it has been developed through a fair process and by consensus by members of an established organization; (right)*

b) *it establishes mandatory characteristics of a product to be put on the market; (wrong)*

c) *it strictly and fully rules the design of an item. (wrong)*

3 - WHAT IS THE DIFFERENCE BETWEEN "REGULATIONS" AND "STANDARDS"?

(See Section 2.1 for hints)

a) *none, as standards "regulate" the characteristics of products; (wrong)*

b) *regulations define a set of characteristics an item needs to have to access a regulated market, while compliance with standards is on voluntary basis; (right)*

c) *standards only provide a set of best practices to design/develop a specific item and cannot cover critical issues (such as safety or security) that are governed by regulatory bodies. (wrong)*

4 - HOW ARE REGULATIONS AND STANDARDS RELATED?

(See Section 2.1 for hints)

a) *standards and regulations are the same thing; (wrong)*

b) *standards are sometimes turned into regulations; (wrong)*

c) *standards are often referenced by regulations. (right)*

5 - WHAT DO STANDARDS PROVIDE TO PRODUCT DEVELOPERS/DESIGNERS?

(See Section 2.1 for hints)

a) *a thorough set of design rules they are forced to comply with; (wrong)*

b) *references for a high-quality design; (wrong)*

c) *a minimum set of requirements in order to make the product meet certain well-defined objectives. (right)*

6 - HOW DO STANDARDS BENEFIT INNOVATION?

(See Section 2.2 for hints)

a) *by defining the products' characteristics related to the most critical aspects, so as to reduce design risks and time; (right)*

b) *by inspiring designers with innovative ideas; (wrong)*

c) *by constraining designers' choices, so as to speed up the design phase. (wrong)*

7 - HOW DO STANDARDS BENEFIT THE ENVIRONMENT?

(See Section 2.2 for hints)

a) *by enforcing mandatory safety and sustainability characteristics for marketable products; (wrong)*

b) *by defining widely shared safety and sustainability requirements for products, often publicized to customers through proper product labelling; (right)*

c) *by forcing designers to follow detailed design rules that ensure products meet determined safety and sustainability requirements. (wrong)*

8 - HOW DO STANDARDS BENEFIT THE ECONOMY?

(See Section 2.2 for hints)

a) *by restricting market access to only standard-compliant, high-quality products; (wrong)*

b) *by enabling economies of scale, encouraging wider and fairer competition and facilitating trade thanks to the definition of widely shared practices; (right)*

c) *by freezing technological evolution, so as to allow producers and customers to get the best return from their past investments in established products. (wrong)*

9 - HOW DO STANDARDS BENEFIT INDUSTRIES?

(See Section 2.2 for hints)

a) *by facilitating the development of new technologies, by ensuring fair competition among industries and by enlarging products' market penetration opportunities; (right)*

b) *by ruling market access of new products, as they define a mandatory minimum set of requirements that new products must comply with; (wrong)*

c) *by pacing the technological evolution, so as to consolidate market positions of established industries. (wrong)*

10 - HOW DO STANDARDS BENEFIT SOCIETY AND INDIVIDUALS?

(See Section 2.2 for hints)

a) *by ruling the market introduction of innovative products, so as to guarantee safety and environmental sustainability; (wrong)*

b) *by establishing a minimum level of performances for any new product entering the market; (wrong)*

c) *by promoting innovation, a safer environment and a more competitive market. (right)*

11 - COMPLETE THE TABLE BELOW BY DEFINING THE CHARACTERISTICS OF THE LISTED SDOS ACCORDING TO THE CLASSIFICATION CRITERIA DEFINED IN THE FIRST ROW:

(See Section 2.3 for hints)

SDO	GEOGRAPHICAL COVERAGE	TYPE OF AFFILIATES	MAIN TECHNICAL SCOPE
ISO	International	National SDOs	ICT
ITU	International	National and regional SDOs, Industries, Academia, Government bodies	Telecoms, ICT
ETSI	International	National SDOs, Industries, Research institutes, Government bodies	Telecoms, ICT
3GPP	International	SDOs, Industries, Research institutes, Government bodies	Mobile Telecommunications
IETF	International	Professionals	ICT
ECMA	International	Industries	ICT

12 - LIST THE MAIN PHASES OF THE GENERIC STANDARD LIFE CYCLE AND SUMMARIZE WHAT THEY ARE FOR:

(See Section 2.4 for hints)

PHASE NUMBER	PHASE NAME	WHAT IT IS FOR (SCOPE, MAIN ACTIVITIES INCLUDED IN THE PHASE)
1	Inception	Identification of needs for new standards
2	Conception	Start of standardization action; - Official submission to a SDO of the proposal for a new standardization work - Definition of objectives - Definition of action plan - Assignment of SDO's resources
3	Drafting	Standard development: • Document writing and internal reviewing • Request for the formal approval of stable documents
4	Approval	Stamp of approval for the new standards
5	Obsolescence	Standard withdrawn

13 - IDENTIFY THE TWO CHARACTERISTICS, FROM THOSE LISTED BELOW, THAT DO NOT DESCRIBE A NORMATIVE REQUIREMENT PART OF A STANDARD:

(See Section 2.4 for hints)

a) *clear, concise and unambiguous; (wrong)*

b) *widely explained by means of extended examples; (right)*

c) *expressed by means of specialized notations; (wrong)*

d) *defined by means of references to other standards; (wrong)*

e) *well justified by means of an extended technical dissertation; (right)*

f) *testable: the description has to be worded so as to provide all needed information to implement (possible) relevant tests. (wrong)*

14 - DESCRIBE THE TYPICAL CONTENT OF THE VARIOUS BELOW-LISTED SECTIONS OF A GENERIC STANDARD

(See Section 2.3 and 2.5 for hints)

SECTION	CONTENT
SCOPE / ABSTRACT	Brief description of the standard's content and objectives.
REFERENCES	List of reference documentation.
DEFINITIONS	List of definitions that are necessary for the understanding of certain terms used in the recommendation.
BODY OF THE DOCUMENT	It is the normative part of the standard.
ANNEXES	They detail some specific matters; they may be either informative or normative.

CHAPTER 3 - THE STANDARDS ECOSYSTEM - *P. 88*

1 - RECOGNIZED SDOS ARE:

(See Section 3.1 for hints)

a) *Organizations with a sole mission to publish standards that are referenced by regulation. (wrong)*

b) *Organizations that have been elected by the corresponding Parliament (e.g., National Parliament, European Parliament, etc.). (wrong)*

c) *Public organizations that have been created by treaties. (wrong)*

d) *Officially recognized by regulation systems as providers of standards. (right)*

2 - FORMAL STANDARDS:

(See Section 3.1 for hints)

a) *Are also known as de facto standards. (wrong)*

b) *Are produced by SDOs. (right)*

c) *Are only published by officially recognized SDOs. (wrong)*

d) *Are documents that companies and public organizations must comply with. (wrong)*

3 - STANDARDIZATION REQUESTS FROM THE EUROPEAN COMMISSION:

(See Section 3.1 for hints)

a) *Are drafted by the European Commission after consulting social representatives. (right)*

b) *Can be refused by the European SDOs, but this situation is quite rare. (right)*

c) *Must be previously approved by each Member State. (wrong)*

d) *Need to be ratified by the European Parliament. (wrong)*

4 - STANDARDIZATION REQUESTS FROM THE EUROPEAN COMMISSION:

(See Section 3.1 for hints)

a) *Are translated into all the official languages of the European Union, and then approved as directives. (wrong)*

b) *Are requests to the European Standardization Organizations to develop standards. (right)*

c) *Are transformed into de facto standards by non-official SDOs. (wrong)*

d) *Are transformed into de facto standards once their adoption is universal. (wrong)*

5 - NON-OFFICIALLY RECOGNIZED SDOS:

(See Section 3.1 for hints)

a) *May have well-established procedures to ensure the quality of their standards. (right)*

b) *Only produce private standardization documents. (wrong)*

c) *Produce standards that may later be published by recognized SDOs. (right)*

d) *Approve regulatory documents. (wrong)*

6 - DE FACTO STANDARDS:

(See Section 3.1 for hints)

a) *Cannot ever become formal standards. (wrong)*

b) *Have been previously approved by a public SDO. (wrong)*

c) *Are conventions that have achieved a dominant position. (right)*

d) *Usually have the characteristic of having been validated by the market. (right)*

7 - THE CONCEPT OF DOMINANT DESIGN:

(See Section 3.1 for hints)

a) *Is the main topic of an ISO Guide that addresses the coordination of SDOs. (wrong)*

b) *Is related to the key technological features that transform a document into a de jure standard. (wrong)*

c) *Is always based on the best user experience of technology. (wrong)*

d) *Is related to the key technological features that become a de facto standard. (right)*

8 - EXAMPLES OF DE FACTO STANDARDS ARE:

(See Section 3.1 for hints)

a) *PDF. (right)*

b) *Asynchronous communication. (wrong)*

c) *ISO 9001. (wrong)*

d) *HTML. (right)*

9 - REGARDING PUBLIC AND PRIVATE SDOS:

(See Section 3.1 for hints)

a) *Only public SDOs may adopt de facto standards as formal standards. (wrong)*

b) *Public SDOs are usually created by treaties. (right)*

c) *Generally speaking, private SDOs are commercial companies that publish private standards. (wrong)*

d) *Only public SDOs are eligible as recognized SDOs. (wrong)*

10 - THE FOLLOWING ASPECTS REFLECT GOOD PRACTICES IN STANDARDIZATION OPENNESS:

(See Section 3.1 for hints)

a) *Consensus. (right)*

b) *Mandatory compliance with standards. (wrong)*

c) *Respect for the intellectual property of other SDOs. (right)*

d) *Transparent, well-documented standardization processes. (right)*

11 - THE FOLLOWING ARE PROS OF OPENNESS IN STANDARDIZATION:

(See Section 3.1 for hints)

a) *Institutions putting open standardization into practice never need to involve proprietary technologies when developing standards. (wrong)*

b) *Civil society will participate in the development of standards more effectively. (right)*

c) *More interoperability. (right)*

d) *It is an effective tool for public administrations to tackle ICT lock-in. (right)*

12 - THE FOLLOWING ARE CONS OF OPENNESS IN STANDARDIZATION:

(See Section 3.1 for hints)

a) *It may be harder to reach consensus. (right)*

b) *At a certain point in time, SDOs developing open standards may need to involve proprietary technology, which implies complex debates on how to do so. (right)*

c) *It increases the ICT lock-in effect in public administrations. (wrong)*

d) *Privacy issues are not duly considered. (wrong)*

13 - INDICATE WHICH OF THE FOLLOWING STATEMENTS ARE TRUE, REGARDING THE CLASSIFICATION OF ICT STANDARDS:

(See Section 3.1 for hints)

a) *The ITU-T Recommendation I.112. Vocabulary of terms for ISDNs belongs to the "terminology standards" category. (right)*

b) *The standard ISO/IEC 24800-4 File format for metadata embedded in image data (JPEG and JPEG 2000) belongs to the "System management standards" category. (wrong)*

c) *The UML specification belongs to the "Communication reference models" category. (wrong)*

d) *The 802.3 IEEE Standard for Ethernet belongs to the "software and networking" category. (right)*

14 - REGARDING VERTICAL AND HORIZONTAL STANDARDS:

(See Section 3.1 for hints)

a) *The ISO/IEC 27001 standards on information security management are vertical standards. (wrong)*

b) *The ETSI GSM family of standards are an example of horizontal standards. (right)*

c) *The smart grid standards belong to the category of vertical standards. (wrong)*

d) *The standards applicable to the food and drink industry are horizontal standards. (wrong)*

15 - REGARDING INTERNATIONAL, REGIONAL AND NATIONAL SDOS:

(See Section 3.2 for hints)

a) *Regional organizations may be represented in international SDOs. (right)*

b) *National SDOs may not be represented in international SDOs. (wrong)*

c) *Standards published by an official regional SDO cannot ever be adopted beyond the scope of the region where that SDO is officially recognized. (wrong)*

d) *ISO and ITU are international organizations with a worldwide scope. (right)*

16 - REGARDING COORDINATION AMONG DIFFERENT LEVELS OF STANDARDIZATION:

(See Section 3.2 for hints)

a) *International standardization takes precedence over regional standardization. (right)*

b) *National standardization takes precedence over regional standardization. (wrong)*

c) *Regional standardization takes precedence over national standardization. (right)*

d) *Regional standardization takes precedence over international standardization. (wrong)*

17 - REGARDING COORDINATION AMONG DIFFERENT LEVELS OF STANDARDIZATION:

(See Section 3.2 for hints)

a) *Agreements among the corresponding SDOs make it possible for approved international standards to be adopted as regional standards, and then as national standards. (right)*

b) *Agreements tend to recognize that standardization at a narrower scope may have particular needs that need to be considered when adopting standards with a wider scope. (right)*

c) *Approved international standards are usually adopted as regional standards, and then as national standards. (right)*

d) *Approved national standards are simultaneously adopted as regional standards, and then as international standards. (wrong)*

18 - ABOUT THE STANDSTILL CONCEPT:

(See Section 3.2 for hints)

a) *It is a process through which national standards are approved as international standards. (wrong)*

b) *It is the process through which SDOs are officially recognized by the European Commission. (wrong)*

c) *It entails an obligation for national SDOs not to take any action that could prejudice European standard harmonization. (right)*

d) *It is a tool to support coordination between European and national standardization activities. (right)*

19 - REGARDING THE PROCESS OF COORDINATION AMONG EUROPEAN AND NATIONAL SDOS:

(See Section 3.2 for hints)

a) *Once a European standard is approved, conflicting national standards are withdrawn. (right)*

b) *First, national SDOs submit their contributions or national perspectives on the standard's topic and scope; these contributions inform the drafting of the first version of the European standard, which is undertaken by the European SDO. (wrong)*

c) *European SDOs translate the approved EN into the languages of all of the nations where the standard is adopted. (wrong)*

d) *First, a standardization group within a technical committee of a European SDO drafts the document, then national SDOs submit their votes and comments about the draft. (right)*

20 - THE VIENNA AGREEMENT:

(See Section 3.2 for hints)

a) *Establishes that international standards are simultaneously approved as European standards. (right)*

b) *Establishes that any pre-existing conflicting national standards must be withdrawn. (right)*

c) *Recognizes that the European Single Market may have particular needs. (right)*

d) *Was signed between ITU and ETSI, and underlines the fact that international standardization takes precedence over national standardization. (wrong)*

21 - AS A RESULT OF THE FRANKFURT AGREEMENT:

(See Section 3.2 for hints)

a) *Around 80% of all European electrotechnical standards are identical to or based on IEC International Standards. (right)*

b) *New electrical standards projects are jointly planned between CENELEC and IEC. (right)*

c) *All European electrotechnical standards are identical to or based on IEC International Standards. (wrong)*

d) *All European electrotechnical standards are identical to or based on ISO International Standards. (wrong)*

22 - WHAT IS THE PROCEDURE USED TO RELEASE AN INDUSTRIAL SPECIFICATION AS A FORMAL STANDARD?

(See Section 3.3 for hints)

a) *Adoption. (wrong)*

b) *Transposition. (wrong)*

c) *Publicly available specification. (right)*

d) *Regulation. (wrong)*

23 - WHAT IS THE AVERAGE PROPORTION OF EUROPEAN STANDARDS IN AN EU COUNTRY?

(See Section 3.3 for hints)

a) *Less than 10%. (wrong)*

b) *Between 10% and 50%. (wrong)*

c) *Between 50% and 90%. (wrong)*

d) *More than 90%. (right)*

24 - REGARDING NORMATIVE AND INFORMATIVE STANDARDIZATION DOCUMENTS:

(See Section 3.4 for hints)

a) *Normative documents contain requirements, which must be met in order to claim compliance with the standard. (right)*

b) *Requirements in a standard are usually worded with the term "must". (wrong)*

c) *Informative documents contain information and requirements. (wrong)*

d) *The term "should" is used to include recommendations. (right)*

25 - THE NAME ETSI ES 201 873-11 V4.7.1 (2017-06) GIVES THE READER THE FOLLOWING INFORMATION ABOUT THE STANDARDIZATION DOCUMENT:

(See Section 3.5 for hints)

a) *It is part of a family of standards. (right)*

b) *It is a European Standard. (wrong)*

c) *It needs to be revised before June 2019. (wrong)*

d) *It has been approved by ETSI. (right)*

26 - THE NAME NF EN ISO/IEC 15416 AUGUST 2003 GIVES THE READER THE FOLLOWING INFORMATION ABOUT THE STANDARDIZATION DOCUMENT:

(See Section 3.5 for hints)

a) *It has been previously approved by ISO/IEC. (right)*

b) *The document was originally approved as an International Standard, then as a European Standard, and then as a National Standard. (right)*

c) *It is document 416 within the 15000 family of standards. (wrong)*

d) *It was published in 2003. (right)*

CHAPTER 4 - THE PRODUCTION OF STANDARDS - *P. 139*

1 - WHICH PRINCIPLE BELOW IS NOT A FUNDAMENTAL PRINCIPLE OF THE STANDARDIZATION PROCESS?

(See Section 4.2 for hints)

a) *Openness (wrong)*

b) *Abstraction (right)*

c) *Transparency (wrong)*

d) *Impartiality (wrong)*

2 - WHAT IS THE NAME OF THE DEVELOPMENT PHASE TAKING PLACE AFTER INCEPTION?

(See Section 4.2 for hints)

a) *Conception (wrong)*

b) *Approval (wrong)*

c) *Drafting (right)*

d) *Maintenance (wrong)*

3 - WHICH GROUP OF STAKEHOLDERS DOES NOT TAKE PART IN THE PROCESS OF DEVELOPING ICT STANDARDS?

(See Section 4.2 for hints)

a) *Biology faculty members (right)*

b) *Consulting company staff (wrong)*

c) *Certification laboratory engineers (wrong)*

d) *Users involved in environmental organizations (wrong)*

4 - DOES THE CHAIRMAN OF A TECHNICAL COMMITTEE BELONG TO THE SECRETARIAT OF THE SDO?

(See Section 4.3 for hints)

a) *Yes (wrong)*

b) *No (right)*

5 - WHICH OF THE FOLLOWING IS NOT A SOFT SKILL?

(See Section 4.3 for hints)

a) *Active listening (wrong)*

b) *Fluency in English (wrong)*

c) *Problem solving (right)*

d) *Word processing proficiency (wrong)*

6 - IS MATHEMATICAL EXPERTISE REQUIRED TO BECOME A STANDARDIZATION EXPERT?

(See Section 4.3 for hints)

a) *Yes (wrong)*

b) *No (right)*

7 - THE STANDARDIZATION EXPERT ESTABLISHES THE COMPANY STANDARDS STRATEGY WITH:

(See Section 4.4 for hints)

a) *the marketing team (wrong)*

b) *management (right)*

c) *the product development leader (wrong)*

8 - THE STANDARDIZATION EXPERT HAS TO TRAVEL TO ATTEND ALL HIS MEETINGS

(See Section 4.4 for hints)

a) *True (wrong)*

b) *False (right)*

9 - NATIONAL DELEGATES REPRESENT THE POINTS OF VIEW OF THEIR COUNTRIES AS PRESCRIBED BY:

(See Section 4.4 for hints)

a) *the company CEO (wrong)*

b) *the network operators (wrong)*

c) *the national administration (wrong)*

d) *the national mirror committee (right)*

10 - THE IETF RFC PROCESS IS:

(See Section 4.2 for hints)

a) *a top-down process (wrong)*

b) *a bottom-up process (right)*

c) *an integrative design process (wrong)*

d) *a standardization technical committee (wrong)*

11 - A TYPICAL SDO IS GOVERNED ACCORDING TO:

(See Section 4.2 for hints)

a) *a cooperation agreement (wrong)*

b) *a hierarchical structure (right)*

c) *a horizontal model (wrong)*

12 - 3GPP IS:

(See Section 4.5 for hints)

a) *a national SDO (wrong)*

b) *a European SDO (wrong)*

c) *an international SDO (wrong)*

d) *a partnership project among telecommunications SDOs (right)*

CHAPTER - 5 STANDARDIZATION AND INNOVATION - *P. 169*

1 - WHAT IS INNOVATION?

(See Section 5.2.1 for hints)

a) *Innovation is a new invention. (wrong)*

b) *Innovation happens only at the product and service level. (wrong)*

c) *Innovation is the combination of invention and commercialization. (right)*

d) *Innovation is incremental when there is a considerable improvement of performance within a short period of time. (wrong)*

2 - AN ENTERPRISE RESOURCE PLANNING (ERP) SYSTEM THAT IS ALREADY USED BY OTHER COMPANIES IN A SECTOR, BUT ACTUALLY IMPLEMENTED FOR THE FIRST TIME BY A PARTICULAR COMPANY IS A …

(See Section 5.2.1 for hints)

a) *New-To-the-Market (NTM) innovation (wrong)*

b) *New-To-the-Firm (NTF) innovation (right)*

c) *New-To-the-World (NTW) innovation (wrong)*

d) *Disruptive innovation (wrong)*

3 - QWERTY IS…

(See Section 5.2.2 for hints)

a) *superior to DVORAK. (wrong)*

b) *a formal standard. (wrong)*

c) *a committee standard. (wrong)*

d) *a de facto standard. (right)*

4 - THE ANALOGY BETWEEN STANDARDIZATION AND TREE PRUNING ILLUSTRATES…

(See Section 5.2.2 for hints)

a) *the potential of standards in supporting innovation and growth. (right)*

b) *how standards inhibit innovation. (wrong)*

c) *that standards lead to a waste of innovation resources. (wrong)*

d) *the chaotic nature of the innovation process. (wrong)*

5 - AT WHICH PHASE IN THE TECHNOLOGY LIFE CYCLE DOES A DOMINANT DESIGN EMERGE?

(See Section 5.2.3 for hints)

a) *Introduction (wrong)*

b) *Growth (wrong)*

c) *Maturity (right)*

d) *Decline (wrong)*

6 - ANTICIPATORY STANDARDS…

(See Section 5.2.3 for hints)

a) *proceed in parallel with market growth and improvement of technology. (wrong)*

b) *are "forward-looking" answers to expected interoperability problems. (right)*

c) *are created at the end of technology development (wrong)*

d) *are not conducive to innovation, as they inhibit creativity. (wrong)*

7 - THE INNOVATION PROCESS CONSISTS OF…

(See Section 5.3.3 for hints)

a) *Pure basic research, oriented basic research, applied research, and experimental development (wrong)*

b) *Pure basic research, oriented basic research, applied research, and diffusion (wrong)*

c) *Pure basic research, oriented basic research, applied research, experimental development and diffusion (right)*

d) *Pure basic research, applied research, experimental development, and diffusion (wrong)*

8 - INNOVATION IS SUPPORTED…

(See Section 5.4 for hints)

a) *only by standards. (wrong)*

b) *neither by standards nor by standardization. (wrong)*

c) *only by the standardization process. (wrong)*

d) *by standards and by standardization. (right)*

9 - EXCEEDING THE REQUIREMENTS OF STANDARDS IS…

(See Section 5.4.3 for hints)

a) *an innovation potential, as it provides impulses for the improvement of products and technologies. (right)*

b) *a cost-increasing factor. (wrong)*

c) *not an innovation potential, as competitors will strive to do the same. (wrong)*

d) *not allowed because of regulations. (wrong)*

CHAPTER 6 - A STRATEGIC PERSPECTIVE ON STANDARDIZATION - *P. 187*

1 - WHEN IS AN ORGANIZATION PARTICIPATING IN STANDARDIZATION CONSIDERED A "LEADER"?

(See Section 6.2 for hints)

a) *When it develops more standards than others (wrong)*

b) *When other organizations use its ideas (wrong)*

c) *When standardization is business critical for the organization (right)*

d) *When it pays the highest membership fees (wrong)*

2 - WHAT IS THE FORMAL STATUS OF MOST STANDARDIZATION ORGANIZATIONS?

(See Section 6.2 for hints)

a) *They are part of the ministry of internal affairs (wrong)*

b) *They are part of the ministry for trade and foreign affairs (wrong)*

c) *They are, non-governmental organizations (NGOs) registered as legal entities, like non-profits (right)*

d) *They are part of United Nations organizations, like the IMF and WHO (wrong)*

3 - CAN AN ORGANIZATION BE A MEMBER OF BOTH CEN/CENELEC AND ETSI?

(See Section 6.2 for hints)

a) *No, CEN/CENELEC has national organizations as members, ETSI only accepts companies (wrong)*

b) *Yes, but only national standards organizations can be a member of both CEN/CENELEC and ETSI (right)*

c) *No, because ETSI only accepts commercial organizations that pay a membership fee (wrong)*

d) *Yes, because commercial organizations can be members of both CEN/CENELEC and ETSI (wrong)*

4 - WHICH STANDARDS ORGANIZATIONS HAVE A "ONE MAN, ONE VOTE" RULE?

(See Section 6.3 for hints)

a) *CEN/CENELEC, because each member organization can vote only once (wrong)*

b) *ETSI, as only one person can vote from each organization (wrong)*

c) *IEEE and the IETF, as votes are given to individuals with regular attendance (right)*

d) *ITU, as only the Director is allowed to vote (wrong)*

5 - IS IT EASIER TO OBTAIN A LARGE VOTING RIGHT IN ETSI THAN IN THE IETF?

(See Section 6.3 for hints)

a) *Yes, because you can "buy" votes by accumulating high membership fees (wrong)*

b) *No, because in the IETF an organization can send many people to a few meetings (wrong)*

c) *They are about the same, as both require resources: in the IETF an organization could send more people, in ETSI an organization would need a significant amount of revenue and fees (right)*

d) *Yes, because in the IETF an organization gets disqualified if it sends too many people (wrong)*

6 - WHAT MAKES A STANDARD PROPRIETARY?

(See Section 3.1 for hints)

a) *It is widely used (wrong)*

b) *An organization holds an essential patent limiting its use by others (wrong)*

c) *It is very comprehensive and comes with a complete test suite (wrong)*

d) *It has been developed in isolation by a single or a closed group of organizations (right)*

7 - WHO IS RESPONSIBLE FOR THE MAINTENANCE OF STANDARDS?

(See Section 4.2 for hints)

a) *In the EU, the European Commission (wrong)*

b) *ETSI and CEN/CENELEC (wrong)*

c) *Strictly speaking, nobody: there is a moral but no legal obligation for the organization that has developed and/or adopted and published a standard to maintain the standard (right)*

d) *The users, as they represent the biggest test environment (wrong)*

8 - TO TEST INTEROPERABILITY, IS ONE-TO-ONE TESTING SUCH AS "PLUGTEST" BETTER THAN CONFORMANCE AND INTEROPERABILITY TESTING?

(See Section 6.5 for hints)

a) *One-to-one testing, such as "plugtest", and interoperability testing are equivalent (wrong)*

b) *One-to-one testing, such as "plugtest", and interoperability are complementary (right)*

c) *One-to-one testing, such as "plugtest", is better because it tests two systems connected to each other (wrong)*

d) *Interoperability testing is better as it tests against a reference implementation (wrong)*

CHAPTER 7 - A BUSINESS PERSPECTIVE: IPR AND STANDARDIZATION - *P. 209*

1 - WHICH ONE OF THE FOLLOWING INSTRUMENTS IS NOT CONSIDERED A TYPE OF IPR?

(See Section 7.2.1 for hints)

a) *Patents (wrong)*

b) *Trademarks (wrong)*

c) *Standards (right)*

d) *Copyright (wrong)*

2 - STANDARD ESSENTIAL PATENTS ARE…

(See Section 7.2.3 for hints)

a) *Patents that are standardized. (wrong)*

b) *Patented standards. (wrong)*

c) *Patents that compete with standards. (wrong)*

d) *Patents that are required for the implementation of the standards. (right)*

3 - PATENTS SHOULD BE LICENSED UNDER FRAND CONDITIONS. WHAT DOES THE ABBREVIATION FRAND STAND FOR?

(See Section 7.2.1 for hints)

a) *Free, Rational and Non-Discriminatory (wrong)*

b) *Fair, Rational and Non-Discriminatory (wrong)*

c) *Free, Reasonable and Non-Discriminatory (wrong)*

d) *Fair, Reasonable and Non-Discriminatory (right)*

4 - PARTICIPATION IN COMMITTEE STANDARDS…

(See Section 7.2.2 for hints)

a) *is only active. (wrong)*

b) *can be active or passive. (right)*

c) *is only passive. (wrong)*

d) *is neither active nor passive. (wrong)*

5 - THE STANDARD WAR BETWEEN VHS AND BETAMAX RESULTED IN…

(See Section 7.2.2 for hints)

a) *Betamax winning the battle because it had better performance. (wrong)*

b) *VHS winning the battle because it was supported by an SDO. (wrong)*

c) *Betamax losing the battle because VHS had the technological superiority. (wrong)*

d) *VHS becoming a de facto standard. (right)*

6 - A PUBLICLY AVAILABLE SPECIFICATION (PAS)…

(See Section 7.2.1 for hints)

a) *is a de facto standard. (wrong)*

b) *is a committee standard. (right)*

c) *has a maximum life of 10 years. (wrong)*

d) *is not relevant for companies operating in areas of rapidly evolving technologies. (wrong)*

7 - WHICH OF THE FOLLOWING STATEMENTS DENOTES A PATENT RISK?

(See Section 7.2.3 for hints)

a) *Patents grant their owner a temporary monopoly/exclusive rights for about 20 years. (wrong)*

b) *The easier a patent can be bypassed, the more limited is its efficiency. (right)*

c) *A patent serves as a form of signalling for potential customers and investors. (wrong)*

d) *Patenting protects IP in the standardization process. (wrong)*

8 - SECRECY IS A FORM OF IP PROTECTION THAT IS SUITABLE FOR…

(See Section 7.2.4 for hints)7

a) *Products that can be easily imitated. (wrong)*

b) *Process technologies that are not visible to competitors. (right)*

c) *Technologies that are visible to competitors. (wrong)*

d) *Most high-tech products. (wrong)*

9 - THE FOLLOWING CRITERIA ARE IMPORTANT IN ORDER FOR A COMPANY TO CHOOSE WHETHER TO STANDARDIZE, PATENT, OR FOLLOW A MIXED STRATEGY.

(See Section 7.3.2 for hints)

a) *Patentability, importance of protection of internal know-how, need for an additional network of partners, and the pace of innovation (right)*

b) *Patentability, the ownership of standards essential patents, need for an additional network of partners, and the pace of innovation (wrong)*

c) *Patentability, importance of protection of internal know-how, need for additional investments, and the pace of innovation (wrong)*

d) *Importance of protection of internal know-how, need for an additional network of partners, and the pace of innovation in a given industry (wrong)*

10 - THE APPROPRIABILITY REGIME DENOTES…

(See Section 7.3.2 for hints)

a) *The ability of a company to acquire resources (wrong)*

b) *The ability of a company to accommodate innovations from the outside and integrate new technologies (wrong)*

c) *The ability of a company to capture value from its innovation (right)*

d) *The ability of company to patent its technologies (wrong)*

CHAPTER 8 - AN ECONOMIC PERSPECTIVE ON STANDARDIZATION - *P. 230*

1 - TO WHAT EXTENT DID STANDARDS CONTRIBUTE TO GERMANY'S GDP BETWEEN 2002 AND 2006?

(See Section 8.2.1 for hints)

a) *Between 0.07 and 0.08% (wrong)*

b) *There is no evidence that standards contributed to the GDP (wrong)*

c) *Between 0.7 and 0.8% (right)*

d) *Between 7 and 8% (wrong)*

2 - TOTAL FACTOR PRODUCTIVITY (TFP) IS AN ESSENTIAL PARAMETER THAT DETERMINES THE QUANTITY OF ECONOMIC OUTPUT PRODUCED IN A COUNTRY. IT PLAYS AN IMPORTANT ROLE IN ESTIMATING THE CONTRIBUTION OF STANDARDS TO THE GDP. ON WHICH FACTORS DOES THE TFP DEPEND?

(See Section 8.2.1 for hints)

a) *Technological knowledge generated in a country (number of patents), (right)*

b) *Technological knowledge imported from abroad (number of technological licence payments abroad) (right)*

c) *The level of diffusion of this technological knowledge (number of standards) (right)*

d) *Technological knowledge generated in a country (number of papers) (wrong)*

3 - WHO BEARS THE COSTS OF DEVELOPING, UPDATING AND DISTRIBUTING STANDARDS?

(See Section 8.2.2 for hints)

a) *Standardization is financed by governments as the resulting standards contribute to the economy as a whole (wrong)*

b) *The costs are generally incurred by companies, academia and other organizations by participating in the standard-setting process, or by purchasing standards (right)*

c) *50% of the costs are covered by the state and the remaining 50% are covered by companies participating in standard setting (wrong)*

d) *SDOs cover the costs via crowdfunding initiatives and voluntary donations (wrong)*

4 - VARIETY-REDUCING STANDARDS REDUCE THE VARIABILITY OF KEY PRODUCT CHARACTERISTICS. WHICH ECONOMIC EFFECTS ARE MAINLY ASSOCIATED WITH THIS TYPE OF STANDARD?

(See Section 8.3.3 for hints)

a) *They support economies of scale (right)*

b) *They support network effects (wrong)*

c) *They prevent lock-ins into old technologies (wrong)*

d) *They can prevent market fragmentation (right)*

5 - HOW DOES A FORMAL STANDARD DIFFER FROM A DE FACTO STANDARD?

(See Section 8.3.1 for hints)

a) *It is developed by recognized SDOs (right)*

b) *The standard is proprietary and not open to the public (wrong)*

c) *All interested parties are invited to participate in the standard-setting process (right)*

d) *It is developed by a single company (wrong)*

6 - WHAT ARE THE RISKS OF PROPRIETARY STANDARDS FROM A MACROECONOMIC PERSPECTIVE?

(See Section 8.3.1 for hints)

a) *They bear the risk of inferior knowledge being disseminated, as most proprietary standards are of poor quality (wrong)*

b) *There might be high costs imposed by the owner of the proprietary standard, which could hinder its wide diffusion in the market (right)*

c) *When a standard is proprietary, lock-ins are more likely to happen, which can result in monopolies that are not conducive to competition (right)*

d) *Proprietary standards are not recognized at an international level and therefore hinder international trade (wrong)*

7 - WHAT ARE THE MAIN POSITIVE EFFECTS OF VARIETY-REDUCING STANDARDS FROM A MACROECONOMIC PERSPECTIVE?

(See Section 8.3 for hints)

a) *They reduce choice (wrong)*

b) *They foster economies of scale (right)*

c) *They help achieve a critical mass (right)*

d) *They help achieve a focus in the market (right)*

8 - THE GLOBALIZATION OF THE COMPUTER INDUSTRY HAS ONLY BEEN POSSIBLE BECAUSE OF INTERNATIONALLY ACCEPTED COMPATIBILITY STANDARDS. HOW DO COMPATIBILITY STANDARDS SUPPORT THE DIVISION OF LABOUR IN THE COMPUTER INDUSTRY?

(See Section 8.3.1 for hints)

a) *They stipulate the exact tasks for all market players in the value chain (wrong)*

b) *Through predefined interfaces, the production of computer components can be outsourced to suppliers all over the world (right)*

c) *Suppliers can focus on small portions of the value chain to achieve economies of scale and sell computer components to an international market (right)*

d) *They describe which activity of the value chain should be conducted in a certain geographic area for environmental protection reasons (wrong)*

9 - MINIMUM QUALITY STANDARDS REFER TO THE MINIMUM ACCEPTABLE LEVEL OF REQUIREMENTS. WHAT ARE THE EFFECTS OF MINIMUM QUALITY STANDARDS FROM THE CUSTOMER/CONSUMER PERSPECTIVE?

(See Section 8.3.2 for hints)

a) *They make it easy to assess which product is best suited for their purposes (right)*

b) *They make it harder to distinguish between different product variants (wrong)*

c) *They help in assessing if a certain product is worth a certain price (right)*

d) *They foster information asymmetries between buyers and sellers (wrong)*

10 - WHICH STATEMENTS ARE TRUE?

(See Sections 8.3.1 and 8.3.2 for hints)

a) *Open standards attract producers of complementary products who want to avoid dependence on one company (right)*

b) *Open standards are especially attractive for enterprises seeking first-mover advantage (wrong)*

c) *Open standards make it more likely for the market to get locked-in in inferior technology (wrong)*

d) *Open standards enhance the market power of a single producer, leading to a monopoly (wrong)*

11 - HOW DO DIFFERENT TYPES OF STANDARDS POSITIVELY INFLUENCE TRADE?

(See Section 8.3 for hints)

a) *Minimum quality standards can foster trust between trading partners (right)*

b) *Information standards that provide codified knowledge can facilitate trade (right)*

c) *Minimum quality standards help reduce the level of risk felt by buyers (right)*

d) *Measurement standards can lead to lower transaction costs and less risk between trading partners (right)*

12 - WHY DO GOVERNMENTS REFER TO STANDARDS IN OPEN TENDERS?

(See Section 8.4 for hints)

a) *To limit the number of applications to a manageable number, as only companies complying with the standard can apply (wrong)*

b) *To improve the quality of public services and infrastructures (right)*

c) *So that they can diffuse innovations to the private sector (right)*

d) *They are legally obliged to refer to standards whenever possible (wrong)*

13 - WHAT IS THE MAJOR DEMAND-SIDE EFFECT ON INNOVATION OF COMPATIBILITY STANDARDS?

(See Section 8.3.5 for hints)

a) *Achievement of economies of scale (wrong)*

b) *Reduction of information asymmetries (wrong)*

c) *Generation of network effects (right)*

d) *Lowering uncertainty and risk (wrong)*

14 - HOW CAN A TECHNOLOGY ACHIEVE DOMINANCE IN THE MARKET?

(See Section 8.3.1 for hints)

a) *By natural selection (right)*

b) *By winning a standard race (right)*

c) *By being released by an SDO officially recognized by a government (wrong)*

d) *Only a technology defined in a patent can achieve dominance in a market (wrong)*

15 - WHAT ARE THE MAIN NEGATIVE EFFECTS OF MINIMUM QUALITY STANDARDS?

(See Section 8.3 for hints)

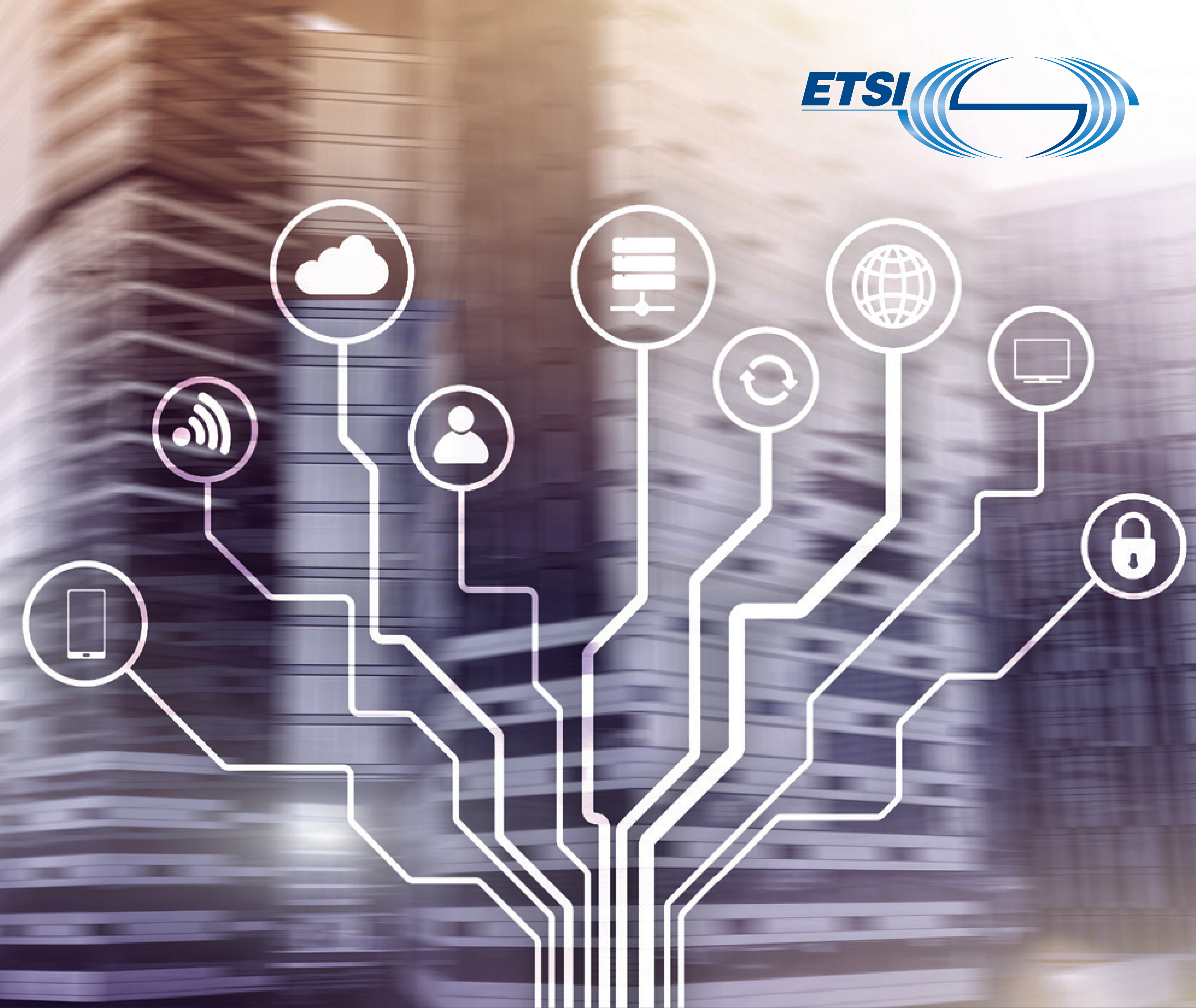
a) *Reduced choice (wrong)*

b) *Regulatory capture (right)*

c) *Raising rivals' costs (right)*

d) *Avoiding adverse selection (wrong)*

NOTES



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This textbook was written with the support of the European Commission and the EFTA Secretariat.

European Commission

EFTA

ISBN: 978-2-7437-3602-6