COMMUNICATE AND COLLABORATE BY USING BUILDING INFORMATION MODELING

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ABSTRACT

Building Information Modeling (BIM) represents a new approach within the Architecture, Engineering, and Construction (AEC) industry, one that encourages collaboration and engagement of all stakeholders on a project. This study discusses the potential of adopting BIM as a communication and collaboration platform. The discussion is based on: (1) a review of the latest BIM literature, (2) a qualitative survey of professionals within the industry, and (3) mapping of available BIM standards. This study presents the potential benefits, risks, and the overarching challenges of adopting BIM, and makes recommendations for its use, particularly as a tool for collaboration. Specifically, this study focuses on the issue of implementing standardized BIM guidelines across national borders (in this study Denmark and Sweden), and discusses the challenge of developing a common standard applicable and acceptable at both national and company level.

Keywords: BIM, communication, collaboration, standardization, socio-technical system

1. INTRODUCTION

1.1 Interregional Framework

The framework of this study is directed toward the Interreg IV A Öresund Programme "Integration of Sustainable Construction Processes – by the use of Information and Communication Technology" (Karlshoej 2009). The purpose of the Interreg IV A Öresund Programme is to enhance the market and the collaboration in the construction sector across the Öresund Region (transnational region centered on the cities of Copenhagen and Malmö), and also to enhance digital collaboration and implementation of Building Information Modeling (BIM). In principle, the Danish and Swedish construction sectors have many similarities. However, if actors are to collaborate across the Öresund Region, regional network and common *translators* of national systems are needed.

1.2 Background to Study

BIM affects all stakeholders supporting the Architecture, Engineering, and Construction (AEC) project life cycle (NIBS 2007). BIM is by its nature multidisciplinary (Kennerley 2012). Furthermore, construction processes and buildings in general are considered to be unique on every project (Hartmann et al. 2009). Consequently, the BIM process requires a high level of communication and understood workflows to support its fullest capabilities.

1.3 Multifaceted Study

This study has two goals. The first is to explore the benefits and possible risks connected to BIM adoption in the Öresund Region. The second is to develop recommendations and associated guidelines for facilitating communication and sustainable collaboration through the use of BIM. Recommendations and guidelines will be generated based on the discussion of current trends, industry work practice, and factors affecting the uptake of BIM in the Öresund Region. Using a variety of research methods, this study includes the following: (1) a review of relevant BIM literature to understand the background, (2) a survey of Danish and Swedish industry professionals to gain an understanding of their knowledge and expectations from the BIM approach, and (3) mapping of Danish and Swedish BIM standards to get an overview of existing guidelines.

2. METHODOLOGY

2.1 Literature Review

Extensive literature review of BIM has been conducted. The literature review includes research conducted by academic institutes, guidelines generated by government institutions, and articles on the practice of BIM. The literature review was chosen to develop an understanding of the current BIM status in the AEC industry. For the purpose of this study, the review focuses on BIM as a communication and collaboration tool, and also discusses the issue of BIM as a *socio-technical system* (Harty et al. 2010).

2.2 Survey of Industry Professionals

Semi-structured interviews of industry professionals have been conducted. Interviews were conducted to gain industry inputs, primarily on BIM being a platform for collaboration. The interviews were structured around a clear list of questions, with, however, sufficient flexibility to allow questions to be modified depending on the situation. All interviews were carried out in the offices of the selected participants, placing the interviewee in a comfortable environment. The selection of participants was based on *purposive sampling* (Denscombe 2007). More specifically, the participants were *hand-picked* with a purpose in mind. In this study, the participant selection was based around the participant's organization's knowledge and use of BIM. The survey sample consisted of one consulting architect, two consulting engineers, four construction contractors, one BIM consultant, and one software vendor. The diverse backgrounds of the participants provided a rich context for their inputs. For the purpose of the interregional study framework, the participants represented organizations from both Denmark and Sweden. The interviews were conducted by an interviewer fluent in both Danish and Swedish.

2.3 Mapping of BIM standards

Mapping of Danish and Swedish BIM standards has been conducted. The mapping aims to highlight similarities and differences that exist, and to identify potential deficiencies. By mapping existing BIM standards, improved approaches for developing common BIM guidelines can be realized. The mapping involved data collection from Danish bips (bips 2012) and Swedish Bygghandlingar 90 (SI 2008). The mapping was structured around a qualitative research methodology, the Grounded Theory approach, using *constant comparisons* for analyzing the data (Denscombe 2007).

3. REVIEW

3.1 BIM Communication

BIM "describes the process of designing a building collaboratively using one coherent system of computer models" (Kennerley 2012). More precisely, BIM is a marriage of both technology and work processes. BIM can be viewed as a digital process that includes all aspects, disciplines, and systems of a

building (from design development to operation and maintenance), in this way allowing all project team members to communicate and collaborate more accurately. Furthermore, BIM is a multidisciplinary process, which brings the project team together. Any modification one team member makes affects the entire BIM-process, as well as the entire BIM-model, creating constant communication (Caramona et al. 2007).

3.2 BIM is a Socio-technical System

The idea of BIM being an integrated process is the subject of increasing interest within the AEC industry. The BIM Handbook defines BIM as "a modeling technology and associated set of processes to produce, communicate and analyze building models" (Eastman et al. 2011). More specifically, BIM is as much about people and processes, as it is about technology. Therefore, BIM is a *socio-technical system* (Harty et al. 2010). In Figure 1 below, BIM is illustrated as a multilayered system with a technical core (technical parts) and layers of social practices (social parts).

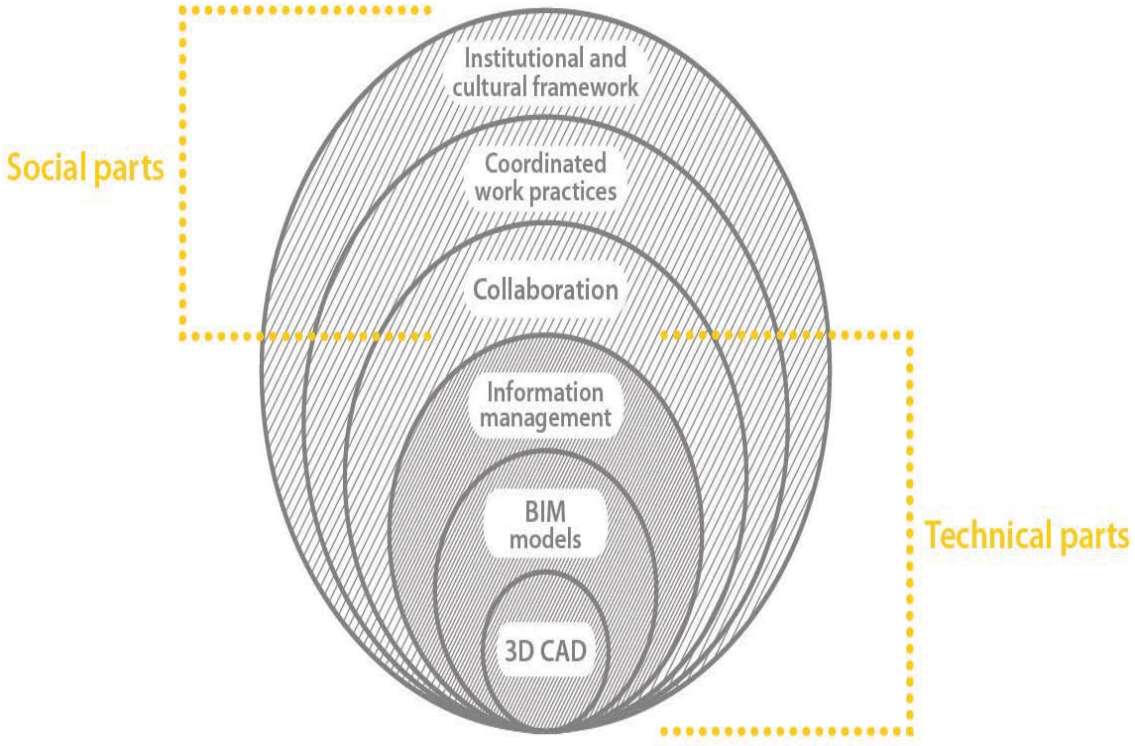

Figure 1: BIM as a socio-technical system [Inspired by (Kennerley 2012)]

3.3 BIM adoption

Despite some progress, the rate of adoption of BIM has been relatively slow (Ning et al. 2008). Key reasons include lack of initiative and education, inability to change existing work practices, and lack of clarity on the roles and benefits of using a BIM approach. In other words, BIM adoption takes time, creating an unavoidable learning curve (Oakley 2012). This process is illustrated in Figure 2 below, presenting the expected, actual, optimal, and inexpedient path.

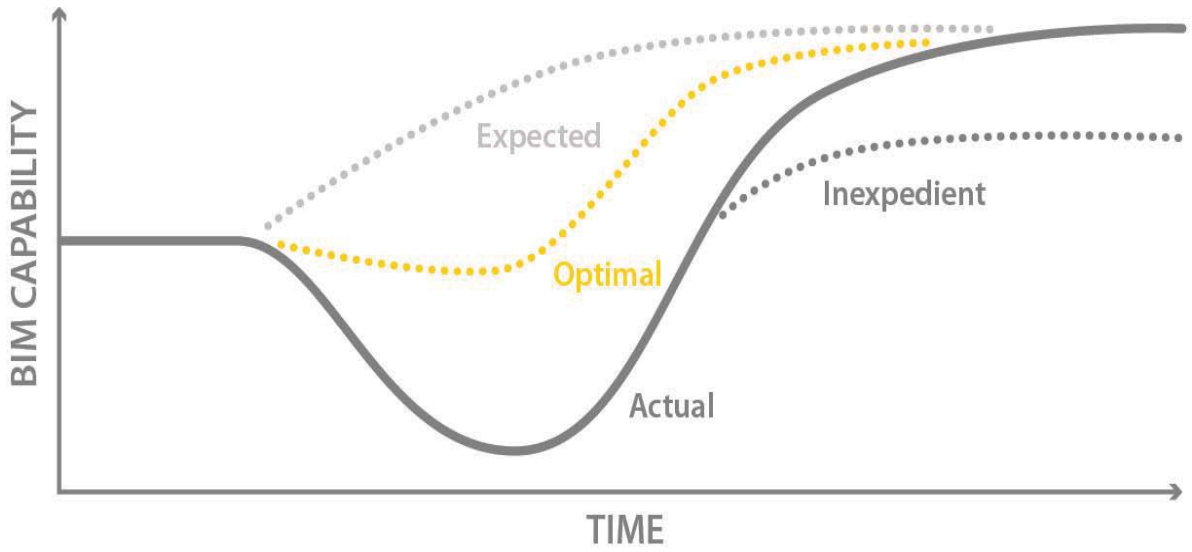

Figure 2: BIM learning curve [Inspired by (Oakley 2012)]

The learning curve is the picture of what many organizations experience when implementing BIM. As illustrated, the learning curve can be described through four phases:

- Expected Path: Many organizations rush into BIM adoption, expecting great benefits immediately.
- Actual Path: BIM adoption comes with a learning curve, imposing additional stress on employees.
- Optimal Path: Sustainable BIM adoption requires extensive preparation, training, and guidance.
- Inexpedient Path: Unsuccessful BIM adoption may occur, downgrading the expected BIM level.

4. SURVEY

4.1 Interview Analysis

Interviews were analyzed using a thematic approach, dividing the data into identified key issues. In the analysis we clearly demonstrated that utilizing BIM as a communication and collaboration tool, and BIM adoption in general, involves functions of both social and technical matter. Therefore, main themes can be summarized into social and technical issues. Based on the study framework, both issues were discussed in an interregional perspective.

4.1.1 Social Issues

The social issues identified are summarized in the following:

- All survey participants, irrespective of professional background, highlighted the potential of adopting BIM approach as a communication and collaboration tool. In particular, the participants highlighted improved in-house communication.
- Most of the participants used BIM as a tool for producing visualizations (3D, 4D, and 5D), thereby communicating the entire building.
- However, BIM collaboration across organizations appeared problematic, creating misunderstandings and communication malfunctions. Therefore, BIM collaboration requires extraordinary focus on adapting common methods and work practices.

- Another issue that was highlighted was that of collaboration between organizations with different BIM profiles. All participants described this as a common issue, often resulting in misunderstandings. This process is illustrated in Figure 3 below. Therefore, sustainable BIM collaboration requires that everyone involved possesses the BIM capabilities needed.

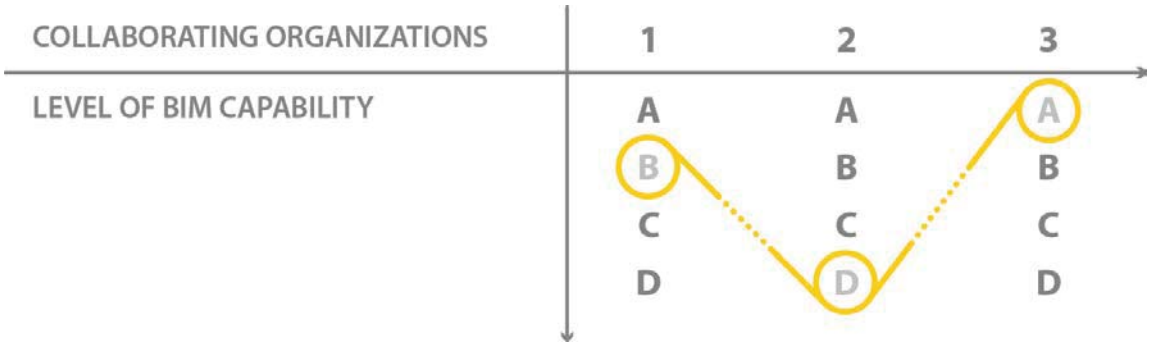

Figure 3: Various levels of BIM capability

- Although participants in the survey were generally interested in and enthusiastic about implementing BIM, they stressed that adopting BIM takes time and resources, creating an unavoidable learning curve. The process of BIM implementation places particular demands on employee training.
- Due to differences in language, culture, and work environment, interregional project collaboration often fails. For this reason, all survey participants highlighted the need for common BIM standards and coordination of Danish and Swedish work practices in general.
- How organizations implement BIM depends upon the type of organization and the type of individual projects, as well as the individual employee. Consequently, BIM guidelines should be flexible, with the possibility of being adapted to the given project, especially, when implementing BIM across national borders.

4.1.2 Technical Issues

The technical issues identified are summarized in the following:

- Based on survey responses, BIM adoption and digital collaboration leads to a number of technical challenges, for example, getting BIM tools to communicate properly. The development of shared IT regulations and standardized exchange formats here appears valuable, allowing information to flow freely, particularly, when collaborating across national borders.
- In addition, all participants highlighted the issue of using open source formats such as the Industry Foundation Class (IFC) data model standard (ISO 2010).
- The BIM-model can be used as a database throughout the life of the building, communicating digital information to all project members involved. From this perspective, several participants highlighted the potential an interregional BIM-model server as a shared collaboration platform.

5. MAPPING

5.1 Danish and Swedish BIM Standards

Based on the interregional study framework, we compared BIM standards issued by Danish bips (multiple documents) and Swedish Bygghandlingar 90 (single document). The bips association is a member-driven association, representing organizations within the Danish AEC industry. The association focuses on developing digital standards and guidelines for implementing BIM in connection with construction projects (bips 2012). Bygghandlingar 90 represents Sweden's most important guidelines for delivering

digital information within construction projects. Bygghandlingar 90 provides recommendations for managing building information but, requires some development in a number of areas including that of BIM (SI 2008).

5.2 Patterns of Mapping

Two kinds of correlations have been mapped. *Mapping via a direct link:* indicates BIM subjects directly present in both bips and Bygghandlingar 90. *Mapping via a missing link:* indicates BIM subjects only present in either bips or Bygghandlingar 90. This relationship is illustrated in Figure 4 below. By mapping these correlations, similarities and differences were demonstrated, and deficiencies were identified. The mapping process compared various BIM subjects such as 3D Working Methods, ICT Agreements, Object Structures, Exchange Formats, Information Level (LOD), Classification Systems, and further.

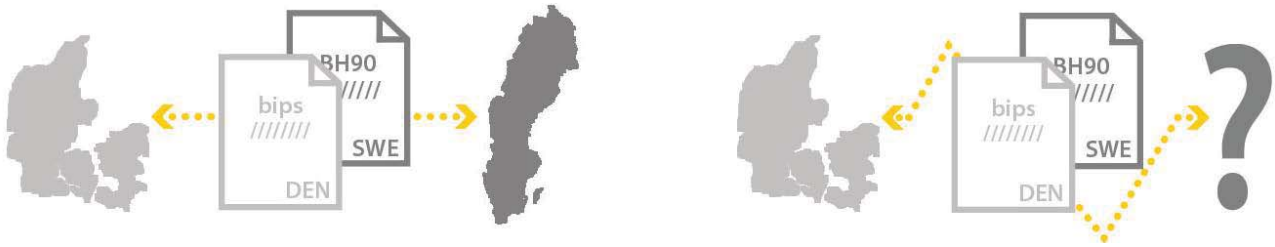

Figure 4: Mapping via a direct or a missing link

5.2.1 Similarities

The similarities identified in the mapping are summarized in the following:

- In the mapping process, we found that bips and Bygghandlingar 90 in general include guidance on more of the same subjects. For example, both bips and Bygghandlingar 90 cover the subject of implementing object-based BIM-models. From this perspective, shared building object model libraries are a potential part of an interregional BIM environment.
- In addition, both bips and Bygghandlingar 90 highlight the issue of linking BIM-models together with national classification systems (Danish DBK and Swedish BSAB). For the purpose of improving interregional communication, a common classification system appears beneficial.
- Another issue that was identified was the use of neutral BIM formats. Both bips and Bygghandlingar 90 highlight the issue of using Industry Foundation Classes (IFC) data model standard, providing the basis for achieving full interoperability between BIM tools.

5.2.2 Differences

The differences identified in mapping are summarized in the following:

- Whilst bips includes a comprehensive package of multiple BIM documents, Bygghandlingar 90's BIM guidance is represented in a single document.
- In addition, bips covers all audience levels, providing all-inclusive guidelines, applicable templates, and real practice examples, whereas Bygghandlingar 90 covers subjects for administrative purpose only.

5.2.3 Deficiencies

The deficiencies identified in mapping are summarized in the following:

- In mapping, we demonstrated that Bygghandlingar 90 lacks strategic insight and concrete examples. Here bips may be able to bridge the gaps.
- During mapping, bips at times appeared incalculable. The likely reason being that bips involves multiple documents (possibly too many), suggesting the importance of simple, and clearly articulated BIM standards.

- Both bips and Bygghandlingar 90 lack digitalization of guidelines. Most guidelines are communicated as printed publications. The absence of digitalization encourages the development of online guidance, in this way supporting digital approach and automated workflows.

6. SUMMARY

6.1 Literature Review

Technology and processes were the most prominent points in the literature review. Here, we demonstrated that BIM is a socio-technical system, combining man-made technology with associated behaviors, social norms and work processes. In other words, BIM is far more than a suite of software. This becomes clear as the technical issues begin to shape social practices by expanding possibilities. However, BIM adoption comes with a learning curve. Therefore, sustainable BIM adoption requires extensive preparation and training of employees. If done well, expanding BIM across the organization will become an organic process. Eventually this leads to improved communication, allowing different disciplines to collaborate effectively.

6.2 Interview Survey

Though many issues discussed echo the key points from the literature review, the survey gave greater insight into the practicalities of BIM adoption. Here, survey participants highlighted the potential of implementing BIM as a communication and collaboration platform. In particular, all participants highlighted the potential of improving in-house communication. BIM collaboration across organizations, however, appeared problematic; in particular, in collaborations between organizations representing different approaches and varying levels of BIM capabilities. In other words, when organizations do not speak the same language, misunderstandings and difficulty in communications occur. Therefore, BIM collaboration requires focus on adapting skills, methods, and work practices. Another issue that was highlighted was getting BIM tools to communicate properly. Here, model data export and import presented difficulties and frustration. This brings focus to the development of shared IT regulations and standardized exchange formats. Following this, all participants highlighted the issue of using open source formats and BIM-model servers as collaboration platforms.

Note: The survey is presented on the website www.bygbygg.org with the purpose of functioning as an online *translator* of Danish and Swedish BIM approaches. This may appear beneficial, when collaborating across the Öresund Region.

6.3 Mapping of BIM Standards

In the mapping process, we demonstrated that bips and Bygghandlingar 90 in general include guidance on more of the same subjects (e.g. guidance on object-based BIM-models, classification systems, open source format IFC). However, while bips covers all audience levels, containing comprehensive guidelines, templates, and concrete examples, Bygghandlingar 90 contains guidance on the administrative aspects only. This encourages Swedish organizations to build up individualized in-house BIM standards, resulting in conflicting approaches within the industry. In contrast, Danish organizations tend to simplify bips standards. The likely reason behind this may be that bips involves multiple documents. Therefore, there is a need for simple and clearly articulated BIM standards. It is worth noting that bips, and Danish BIM adoption in general, is supported by the Danish government, whereas Swedish BIM adoption is developed within private organizations.

Note: The mapping we conducted is presented on the website www.bygbygg.org with the aim of functioning as an online *translator* of Danish and Swedish BIM standards. This may appear beneficial, when collaborating across the Öresund Region.

7. CONCLUSIONS

7.1 Conclusions

BIM and interoperability of software have emerged with substantial improvements in recent years, permitting development of digital collaboration. However, to achieve potential benefits, one has to get through the many difficulties of BIM adoption. In this study, we presented benefits and challenges of adopting BIM as a communication and collaboration platform. In addition, interregional perspectives were presented, discussing the issue of implementing BIM across national borders.

7.1.1 Key Benefits

The key benefits of BIM adoption are summarized in the following:

- Sustainable BIM adoption will improve project communication, allowing stakeholders to collaborate more effectively and more accurately.
- BIM is by nature multidisciplinary. Therefore, BIM brings project members together, creating constant communication.
- BIM-model servers can be used as online databases throughout the life of the building, communicating information to all project members involved.

7.1.2 Key Challenges

The key challenges of BIM adoption are summarized in the following:

- BIM is a socio-technical system. Therefore, sustainable BIM adoption requires an integrated approach, combining technical structures and social practices.
- Adoption of BIM comes with a learning curve. Consequently, sustainable BIM adoption requires extensive preparation and training of employees.
- BIM collaboration between organizations (and across national borders) appears problematic. Therefore, there is a need for common standards and documented procedures.
- Interoperability between BIM tools appears problematic. Consequently, shared IT regulations and standardized exchange formats are needed.
- BIM adoption leads to organizational change. For example, changes in work practices and interpersonal dynamics. For changes to be adopted, managers and leaders must engage.

8. RECOMMENDATIONS

8.1 Recommendations

Although solutions in the market are continuing to evolve, BIM is still in its formative stage. To make full use of BIM, a more integrated and collaborative approach must be adopted. The recommendation is to develop common BIM standards that: (1) cover all audience levels and communicate with all disciplines, (2) provide guidance on both social behaviors and technical issues, (3) consist of concrete examples and adaptable templates, (4) are simple and clearly articulated, and (5) available online. Such standards represent a tool for collaborative improvement. However, the potential benefits do not lie in simply setting common BIM standards. Rather, the benefits lie in the implementation and continuous development of the standards by project members. To develop common interregional BIM standards, it is recommended that European or International standards be used as a foundation. The concept is illustrated in Figure 5 below. Furthermore, BIM standards should be flexible enough to allow adaption at both company and national level.

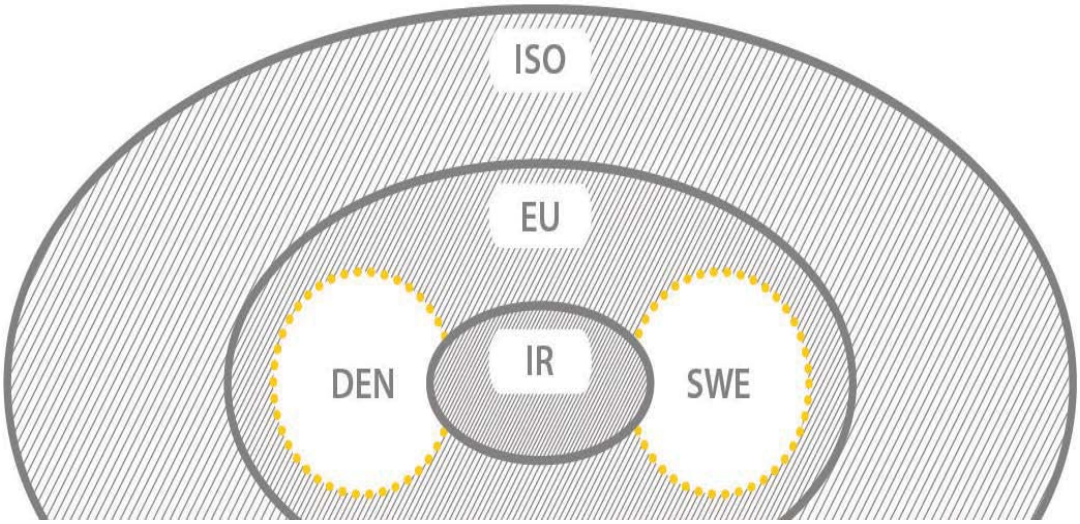

Figure 5: Interregional (IR) standards with European (EU) or International (ISO) foundation

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