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Digital Revolution in Construction: Transitioning from BSAB to CoClass Classification

Exploring the Challenges, Benefits, and Implications for Consultants and Clients in Enhancing Collaboration and Efficiency in Swedish Infrastructure Projects

Master's thesis in Design and Construction Project Management

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Abstract

This research aims to study the role of digitalization and BIM technology (Building Information Modeling) in construction and infrastructure projects, focusing on the transformation from the old standards like BSAB to the new standard CoClass in Sweden. This research explores the communication challenges in the construction industry and the importance of standardization to enhance effective collaboration between stakeholders. The study will use qualitative research methodology including interviews and literature review, to identify potential benefits and challenges of this transformation, especially to meet the Swedish Transport Administration's requirements.

The research question examines understanding consultants' insights of these changes and their effects on the implementation of the new standard, CoClass. The scope of this study is limited to communication challenges linked to BIM implementation and focusing on one client, the Swedish Transport Administration. As well as the project aims to provide insights into improving communication efficiency in construction projects.

This study takes great care of the ethical considerations, reliability, and validity issues at each stage of the whole research process.

The interviews results highlight different perspectives from consultants and clients and highlight the complexity of BIM classification systems and communication processes within projects. The literature review provides a comprehensive overview of BIM processes and classification systems like BSAB and CoClass, which helps to understand their importance in the construction industry and opportunities, providing valuable insights for industry stakeholders.

Keywords: digitalization, Building Information Modeling (BIM), Standardization, BSAB, CoClass, Swedish Transport Administration, Qualitative methodology.

Foreword

This master's thesis represents the final work within our master's program in design and construction project management at the Department of Architecture and Civil Engineering at Chalmers University of Technology. This work was carried out in the spring of 2024 with guidance of our dedicated university supervisor Mikael Viklund Tallgren.

We would like to express our deep gratitude to everyone who contributed to this project. Special gratitude goes to our supervisor and examiner Mikael Viklund Tallgren. We are also grateful for the cooperation from all interviewees from different organizations and the Swedish Transport Administration for generously sharing their insights and experiences. We would also like to thank everyone who contributed with feedback at Chalmers and our friends and families which helped with endless support.

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Asem Alkawamleh and Andreas Vindevall

Sammanfattning

Detta projekt undersöker digitaliseringens och Building Information Modeling (BIM) roll i bygg- och infrastrukturprojekt, med fokus på övergången från de gamla standarderna som BSAB till den nya standarden CoClass i Sverige. Studien utforskar kommunikationsutmaningarna inom byggbranschen och vikten av standardisering för att förbättra samarbete mellan intressenter. Genom den kvalitativa forskningsmetodiken inklusive intervjuer och litteraturöversikt syftar studien till att identifiera de potentiella fördelarna och utmaningarna med denna omvandling, särskilt för att möta Trafikverkets krav.

Forskningsfrågan fördjupar sig i att förstå konsulters uppfattning om dessa förändringar och deras inverkan på implementeringen av den nya standarden, CoClass. Genom att avgränsa studien till kommunikationsutmaningarna som är kopplad till BIM-implementering och fokusera på en uppdragsgivare, Trafikverket. Projektet syftar till att ge insikter i att förbättra kommunikationseffektiviteten i byggprojekt.

Denna studie tar stor hänsyn till de etiska övervägandena, tillförlitligheten och validitetsfrågorna i varje skede av hela forskningsprocessen.

Resultaten av intervjuerna lyfter fram olika perspektiv från konsulter och kunder, och belyser komplexiteten kring BIM-klassificeringssystem och kommunikationsprocesser inom projekt. Medan litteraturöversikten ger en omfattande översikt över BIM-processer och klassificeringssystem som BSAB och CoClass, vilket hjälper till att förstå deras betydelse i byggbranschen och möjligheter, vilket ger värdefulla insikter för branschens intressenter.

Nyckelord: digitalisering, Building Information Modeling (BIM), Standardisering, BSAB, CoClass, Trafikverket, kvalitativ metodik.

List of Acronyms

AMA	General Material and Work Description
BIM	Building Information Modelling
BSAB	Byggandets Samordning AB
CAD	Computer-aided design
CoClass	A new classification system for the built environment in Sweden
ISO	International Organization for Standardization
NVDB	Via National Road database
PLM	Product Lifecycle Management
SB11	A classification system issued by the Swedish Construction Service
STA	Swedish Transport Administration
TTL	Taxonomic Trace Link

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1. Introduction

The following is a brief introduction about digitalization and Building Information Modeling (BIM) and their role in construction/Infrastructure projects. It will also explore BIM's status in Sweden and identify the potential benefits and challenges that manifest from the transition from old standards such as BSAB to the new standard CoClass, and how these affect the communication flow within the construction industry. Next, the purpose of the study, Research question, and the delimitations that have been established for the study are presented.

1.1 Background

In In today's construction industry, there are challenges with communication between different actors, which requires measures to promote cooperation towards common goals. The use of different internal designations and classification systems such as BSAB and CoClass can be a starting point to achieve mutual understanding. Therefore, the focus will be on the transformation in the move from traditional classification systems like BSAB to more modern frameworks like CoClass , which represents a significant step in confronting these challenges. CoClass is a comprehensive classification system for the built environment designed to standardize the way information is structured and exchanged among project stakeholders. The transition aims to enhance collaboration, communication, and efficiency in the industry, especially in large-scale infrastructure projects managed by entities such as the Swedish Transport Administration (STA). Currently, STA is the largest client for infrastructure projects. They are responsible for defining various requirements, including the utilization of CoClass. On the consulting side, it is important to emphasize the importance of understanding and following these standards in order to effectively collaborate with STA and other stakeholders in the industry.

When it comes to digitalization, Building Information Modeling (BIM) plays a crucial function inside the digitalization process inside the construction industry (Azhar, 2011). BIM's number one objective is to visualize and facilitate making plans, designing, and construction strategies, incorporating constructing factors, geographical geometry, and related prices and time considerations at every step. BIM extends beyond 3D models and includes complete information control throughout a building's life cycle, encompassing work methods, procedures, and the handling of both records and geometric data (Boverket, 2023). This method permits for the creation of digital models with associated information, assisting decision-making at some point of the constructing's lifestyles cycle, from design and construction to management.

The implementation of BIM can be described in 4 levels from 0 to 3, where these levels represent the level of maturity and development that BIM implementation has reached (Boverket, 2023). Level 0 represents traditional 2D CAD without special format and level 3 represents full interoperability data sharing through standards and Common Data Environments and for the whole life cycle of the building. Through the application of BIM, the construction industry is enabled to streamline processes, reduce errors, conserve resources, and promote sustainability over the building's existence. Azhar emphasizes that a key advantage of BIM lies in its ability to create a common space where stakeholders can actively participate, enabling them to observe and comprehend the contributions of all involved parties throughout the project (Azhar, 2011).

In Sweden, the use of Building Information Modeling (BIM) has increased significantly across all types of projects compared to before, a successful example of a project that has succeeded in fully digital work is the Celsius project, which started in April 2018 and was successfully completed in November 2021 (Boverket, 2023). Standardization issues are relevant and crucial due to their direct impact on the effectiveness of implementing and utilizing BIM in construction projects. Where the work to improve BIM goes ahead both at national level and within organizations. The goal is to make it easier for other projects to get the right start, formulate requirements and find the effective work processes for dealing with information and models. Despite the good knowledge of BIM in Sweden, there is a reluctance to share the knowledge. It is possible due to the lock-in effects and fear of losing competitive advantage between companies, where the lock-in effects arise from the companies' investments in specific BIM programs, tools, or workflows. That is, when companies have committed to a particular technology or approach, they can become dependent on it, which make it difficult to switch to alternative solutions. This creates a barrier to sharing knowledge and adopting new practices, as companies fear potential losses of investment and competitive advantage associated with their current systems. This has resulted in a lack of feedback between projects. In addition, the information gap between designers and contractors is large in many areas, complicating the implementation of BIM projects. The implementation of BIM varies between different actors, as there are no national requirements. The lower knowledge of BIM amongst clients compared to design consultants have resulted in a lack of client requirements that can drive the industry's development.

In Sweden, one main challenge in the planning of BIM is establishing similar names for object properties (BIM Alliance Sweden, 2014; Svensk Byggtjänst, 2005). The concept of object classification is a solution to these challenges, where it means that many objects or elements can have common names or codes. Classifications system is a central part of the BIM process because it gives common information about each object or elements in the model. Within object classification, there are many national standards to classifies and simplify communication between the different actors in the construction process, among these standards BSAB and CoClass. They facilitate the transfer and interpretation/understanding of information between different actors, disciplines, and stages in BIM design, which increases efficiency and minimizes misunderstanding. Although BSAB is widely used, it faces limitations in meeting the current digital requirements for information exchange and collaboration. As projects become more complex, the need for a unified and strong classification system becomes more important.

1.2 Purpose

The purpose of the study is to analyze the role played by digitalization and Building Information Modelling (BIM) in infrastructure projects. The primary focus is on the identification of potential benefits and challenges that manifest from the transition from old classification system such as BSAB to the new standard CoClass. By comparing the consultant side with the client side, the study aims to contribute significant insights to the research domain and provide practical benefits to industry stakeholders. This includes a comprehensive understanding of the challenges faced by the industry, with the intent to propose viable solutions aimed at enhancing overall efficiency in the construction process.

1.3 Research question

In order to achieve the overall objective of the study, the purpose has been structured into sub-goals. These sub-goals serve as the guiding framework, facilitating the process of the transition from the old classification system to CoClass and its implications for infrastructure projects.

- Identify challenges in the transition from the current classification system to CoClass.
- Analyze the overall benefits the Swedish Transport Administration sees in requiring CoClass in their projects.
- Assess the impact of CoClass implementation on consultants.

1.4 Delimitations

The decision to limit the study to consultants and clients is due to the fact that they are mainly involved in the early stages of projects and interact with the classification systems more often than contractors. The time constraints of the study also contributed to this decision. The Swedish Transport Administration has a central role as the largest commissioner of infrastructure projects in Sweden and oversees the planning and management of projects, making their perspective significant. Similarly, consultants play an important role in the design of the early stages of the project, which is a central part within CoClass.

2. Method

For this master thesis, a qualitative methodology was employed to interpret and analyze data obtained from interviews, utilizing an inductive approach. The reason for using a qualitative methodology is based on the preference for using the assembled data to formulate theories and generate insights. Another reason is attributed to the method of data collection, as described by Bryman (2018), wherein the data collected relies on words rather than quantitative measurements.

Given the complexity of the study, employing a qualitative method facilitated a deeper understanding of the subject by utilizing interviews as the primary method of data collection. The objective is according to Bryman (2018) to recognize individuals' social realities and an exploration of how they interpret these realities by seeing it from their eyes.

Qualitative research is commonly associated with the inductive approach, where the theoretical framework emerges from the outcomes of the research effort (Bryman, 2018). Throughout the process, data were collected and examined in order to identify patterns between the empirical data and the theoretical framework. As the study progressed, the theoretical framework was continuously analyzed and reflected upon. Establishing the theoretical framework is according to Bryman (2019 an iterative process, and researchers will continue to collect data if the theory is not sustainable.

2.1 Literature review

The literature review is based on a theoretical framework developed through a comprehensive analysis of relevant literature. This framework served as a foundation for the interview process, providing guidance and structure to the interview guide. The literature review also played a role in understanding the complexity of the subject, as it was used to navigate the empirical findings from the interviews. According to Dysthe et.al (2021) the literature review aims to analyze previous knowledge and identify potential gaps in the current knowledge landscape. It also provides an overview of sources of information connected to a specific theme, research area, or theory. By acquiring a deeper understanding of the subject, the literature review played an important role in formulating the research question. Bryman (2018) further emphasizes this point, arguing that a literature review helps to establish the significance of the research question and the need for the study.

The sources used in the study include books, websites, scientific articles, and research reports. These sources are primarily digital, having been accessed through reputable platforms such as Chalmers Library, ResearchGate, Google Scholar, and Scopus. To ensure the credibility of the information, a critical evaluation considers several factors, including how well the sources reflect the research topic, the currency of the content, author qualifications, and the alignment of the source with other relevant sources. By considering these factors, this critical approach contributes to a thorough assessment of the sources' relevance and reliability in the theoretical framework.

2.2 Interviews

For the interviews, a semi-structured approach was employed to systematically gather data following an interview guide. It was structured around three main sections: introduction questions, core questions focused on the research topic, and concluding questions. The main objective of the interview was to use pre-determined questions allowing open and unrestricted responses from the respondent, avoiding closed-ended questions with subsequent follow-up questions and requests for illustrative examples. This is also highlighted by Bryman (2018) as semi-structured interviews allow researchers to maintain openness throughout the process while still providing guidance to ensure qualitative data collection aligns with the research objectives. This method yielded valuable insights that led to a more profound understanding of the research topic by balancing flexibility with structure.

For the initial interview, questions were formulated based on the existing knowledge of the subject matter, in line with the objective of the study. Based on the results from the initial interview, new questions were developed for the next interview for a more precise and detailed answer. According to Bryman (2019), this is an iterative process where questions for the interviews are formulated, and further revised based on the previous interview answers. This process continued until the questionnaire framework yielded accurate and precise answers for both the consultants and the clients. For the client interviews, which were done after the consultants, some questions were adapted to ensure their relevance to each perspective, while maintaining consistency with the core research objective.

Interview sessions featured either one or two interviewers actively engaged, one asking questions while the other observed actively. Each interview lasted for a duration of 60 to 90 minutes and was conducted using methods like video communication tools such as Zoom/Teams and in-person sessions. The respondents where consent for recording and assurances of anonymity were sought. Additionally, all interviews were conducted in Swedish to avoid any language barriers.

Following the interviews, the recordings were transcribed and summarized to identify patterns and themes, enabling comparisons across participants. This process of pattern identification involved coding, where colors were assigned to matching text segments and labels or phrases were used to categorize and summarize similar answers. The data was later categorized into themes in order to identify recurring themes and refine the research questions. According to Bryman (2019), coding involves assigning labels either words or phrases to segments of data that share similar characteristics. This process helps researchers identify recurring patterns and organize the data into meaningful themes or categories.

2.3 Reliability and validity

Both reliability and validity were central considerations throughout the qualitative research process. To achieve reliability, interviews followed a structured format using an interview guide. This approach promotes consistency across interviews, facilitating the comparison of responses and potentially enabling replication of the study across different occasions (Lind, 2019).

Given the niche and complexity of the topic, the interview guide was provided to the respondents beforehand. This allowed them time to reflect on the questions, potentially leading to more in-depth and thoughtful responses during the interviews. However, it's acknowledged that pre-exposure to questions can introduce bias, as participants might adapt their answers or rehearse responses.

The interview guide, located in appendix and served as guidelines for the interviews, started with introductory questions about the respondents' roles and backgrounds, gradually moving into the main questions. This procedure was to make participants feel at ease and encourage them to provide thoughtful and truthful responses without feeling judged. The interview guide also incorporated a variety of question formats, including open-ended questions, follow-up prompts, and probes. This approach helps to secure comprehensive and high-quality answers, thereby allowing researchers to critically examine participant responses, as suggested by Kvale and Brinkmann (2017). Questioning assumptions and potential misunderstandings in the answers is important for ensuring the validity of the study's interpretations (Kvale and Brinkmann, 2017). Anonymization was also implemented to further protect participant confidentiality.

After the interview, to ensure the reliability of the thematic analysis, both researchers independently coded the data and then compared their coding to identify any inconsistency. This process helps to minimize the influence of individual bias in interpreting the data (Kvale and Brinkmann, 2017). According to Mason (1996, as cited in Bryman, 2018, p. 465), both reliability and validity serve as benchmarks for assessing the quality of the study.

2.4 Selection of participants

Eight semi-structured interviews were conducted to gather empirical findings: five with the consultants and three with the clients, with a total of nine respondents. The consultants' responses converged, indicating no need for further interviews. Regarding the client-side interviews with the Swedish Transport Administration, those interviewed were already prominent figures in the field, and similar responses were obtained. Therefore, additional interviews were deemed not necessary.

Consultants were selected based on their roles and prior exposure to the subject of BIM and classification systems to ensure varied perspectives, although the level of experience and knowledge varied among respondents. For the clients, the respondents directly involved in the subject matter were limited, and the interviewed were individuals with great experience and knowledge. As Lind (2019) suggests, careful participant selection is crucial due to the limited number of individuals involved. Since the information gathered is verbal and not standardized, it is the researcher's responsibility to analyze the data, identify common themes, and pinpoint key findings.

2.5 Ethical considerations

Ethical considerations were considered throughout the research process, adhering to the four key principles outlined by Lind (2019): voluntariness, privacy, confidentiality, and anonymity.

- Participants were informed of their voluntary participation, meaning they were provided with an explaining about the study's purpose and procedures. They also had the right to withdraw at any time.
- Interviews were conducted in a private setting, ensuring *privacy*, and unnecessary personal details were avoided during questioning.
- To maintain *confidentiality*, participants were assured that their identities would not be revealed in the research report or publications.
- *Anonymity* was additionally ensured by employing pseudonyms, such as "Respondent X", during both data analysis and reporting."

3. Literature review

The literature study is based on a comprehensive search which was performed to collect all relevant information related to the topic/subject. In this search, the BIM (Building Information Modeling) process and the well-known object classification programs such as BSAB and CoClass, including their background for example ISO system will be reviewed. This will be achieved by giving a comprehensive overview of these aspects to provide in-depth understanding of their role and importance in the building and construction industry.

3.1 What is BIM - Building Information Modelling

Building Information Modelling (BIM) is a complete and collaborative process that uses technology to create a virtual representation of a construction project (Azhar, 2011). It includes creating a digital building information model, which is an accurate and detailed virtual model of a building. This model includes geometry, spatial relationships, geographic information, quantities, properties of building elements, cost estimates, material inventories, and project schedules. The applications of BIM span the whole project life cycle, including design, procurement, manufacturing, construction, operations, and maintenance.

BIM isn't limited to a just 3D model, it is a technique that includes work methods, processes, and the management of both information and geometries (Boverket, 2023). In the design section, BIM is often used to create a 3D model to gather information about the building or facility (Azhar, 2011). However, it does more than just the preliminary model and is employed in various ways throughout different project stages. BIM helps collaboration among all stakeholders, including owners, architects, engineers, contractors, subcontractors, and suppliers. It is more than just software, it represents a shift in workflow and project delivery processes, fostering a new paradigm inside the Architecture, Engineering, and Construction (AEC) industry.

BIM involves three basic aspects:

- BIM as a Process (Building Information Modeling): It is the process of making a digital constructing information model by using BIM tools (Nordic BIM Group, n.d.). It consists of consistent refinement and adjustment of the model by team members throughout the project, ensuring accuracy before physical construction.

- BIM as a Product (Building Information Model): It is the completed digital product model of the planned constructing, containing a geometric 3D model and essential information about time, budget range, energy consumption and material properties (Nordic BIM Group, n.d.).

- BIM as Management (Building Information Management): It is the overarching process that creates and manages information about a building throughout its lifecycle, giving importance to the transfer of information between different phases and disciplines (Nordic BIM Group, n.d.). BIM promotes the reuse and recyclability of data, structured according to national and international standards. This differs from

BIM as process, where BIM as process creates a digital information model by using BIM tools and adjusting the model during the project.

The implementation of BIM can be defined in different levels, usually using a 4-level system (Boverket, 2023). It ranges from Level 0, representing traditional 2D CAD without special coordination, to Level 3, representing fully interoperable data sharing via standards and Common Data Environments (CDE) for the entire constructing life cycle. Figure 2 shows the progression through four levels: Drawings, Models, Objects, and Collaboration, leading to Transactable Interoperable Data. BIM has developed over time, transitioning from traditional paper-based methods to the current stage of integration with web services through platforms like “BIM Hub”.

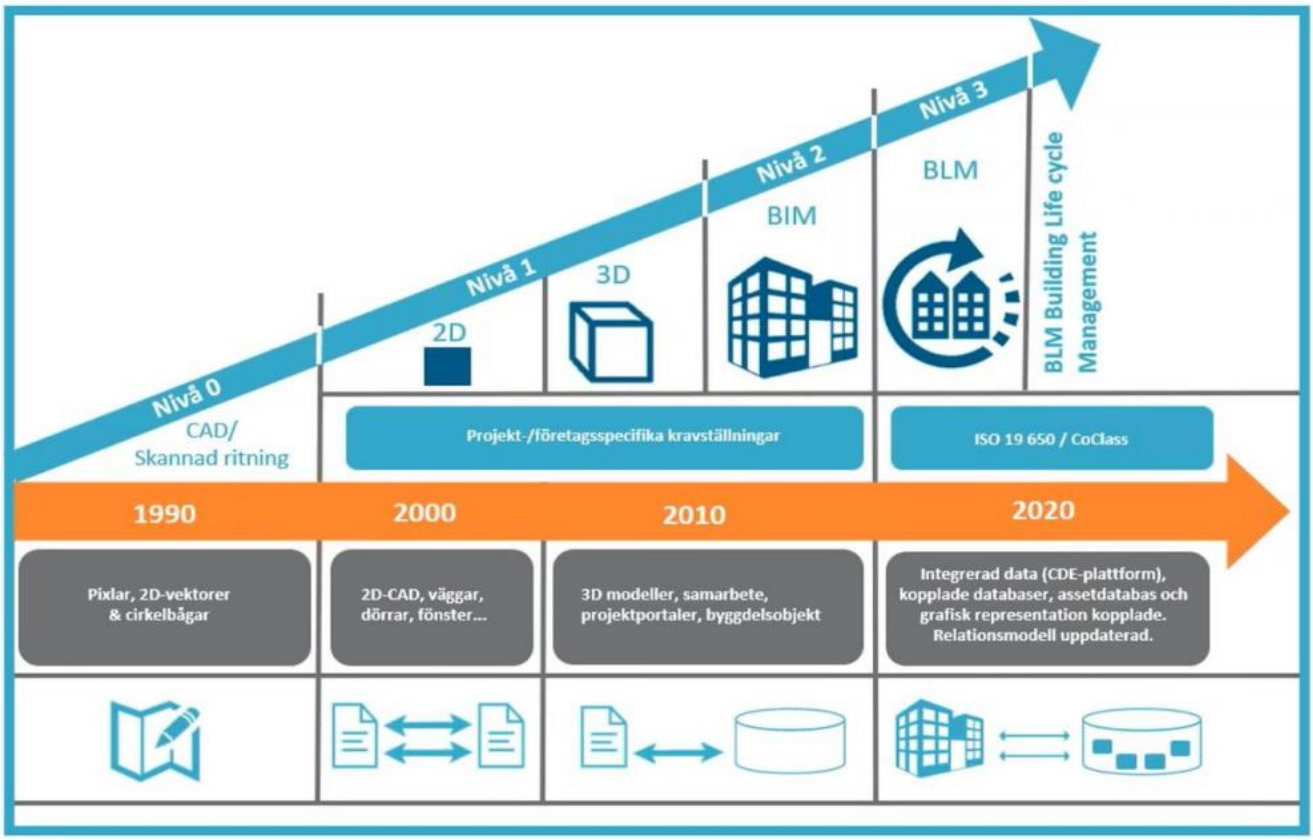

Figure 1. BIM maturity Levels (Service Works Global, 2020).

3.2 What is a classification system?

A classification system in the context of the construction industry is a way of sharing and organizing information between different actors involved in different aspects of construction projects (Lou and Goulding, 2008). These systems are of the utmost importance in our era in which the way of sharing information about buildings is done by digitalization, starting from design and construction issues up to the contractual matters that involve the parties from different sectors.

Classification systems serve as a standardized framework for organizing information flow within the construction industry's processes and structures (Royano et al., 2023). The standard aims to cover the

whole life cycle of construction works, which includes product identification, product production and product use. By organizing data systematically into standardized groups, it simplifies complex information, which allows effective communication between stakeholders such as architects, engineers, and contractors. This "common language" that the classification system creates between stakeholders reduces complexity and ensures uniformity in communication, which allows effective information exchange. While the development and adoption of such systems can be challenging, their use between professionals will allow to make the benefits of standardization and efficiency widespread. Although they provide a common language for communication and streamline information exchange throughout the building's life cycle, challenges such as achieving widespread adoption and addressing the complexity of classification systems must be navigated. In addition to this, the integration of these systems with advancing technologies such as Building Information Modelling (BIM) are expected to bring more challenges and opportunities for standardization and efficiency in the construction industry.

Classifications within the construction sector in the past have been formed by the pragmatic traditions and national needs (Lou and Goulding, 2008). However, with the growing internationalization of the construction market and the computer-aided processes integration such as product data modelling, there is a need for neutral conceptual frameworks that would facilitate international application of classification standards. There are many different classification systems, which can be arranged in the hierarchical type. Among these classification systems, the ISO system is the most well-known classification system in construction. It consists of two types, ISO 12006-2 and ISO 81346-12 and meets the requirements of modern construction practices.

Overall, the aim of classification systems is to standardize the description of data, information, and knowledge in construction (Lou and Goulding, 2008). That way communication, structuring documents, and calculating costs within the construction industry are facilitating, regardless of geographical or organizational limitations.

3.2.1 ISO standardization

This section will introduce two ISO systems used for classification in construction: ISO 12006-2, offering a framework for comprehensive classification, and ISO 81346-12, enhancing classification uniformity.

3.2.1.1 ISO 12006-2 as a building classification system

ISO 12006-2 is an international standard, specified as a specific type of ISO standard that provides a framework for classification in the construction sector (Trafikverket, 2014). It establishes terms and recommended tables for use both by the companies that develop the classification systems at national or regional level. The standard aims to cover the whole life cycle of construction works, which includes product identification, product production and product use. ISO 12006-2 emphasizes the importance of creating a common view of the classification so that information exchange between different information processes such as CAD modelling and costing is supported. The classes in the standard are organized

according to the different perspectives towards buildings, such as functional, spatial, and process-related views. Assigning specific classes to each object allows separate calculations for different aspects of the construction work, facilitating various functions, such as estimating the cost. ISO 12006-2 also includes diagrams illustrating the relationships between the different classes and emphasizes the need to define relationships between building objects for model-based information systems.

Figure 2 illustrates a flowchart providing an overview of the ISO standard, showcasing the relationships between main components, such as results, processes, resources, and their sub-components (Trafikverket, 2014). These connections are represented by links such as "type of," "result of," and "have one or many," providing a comprehensive representation of how the framework operates and the complexity of standardization.

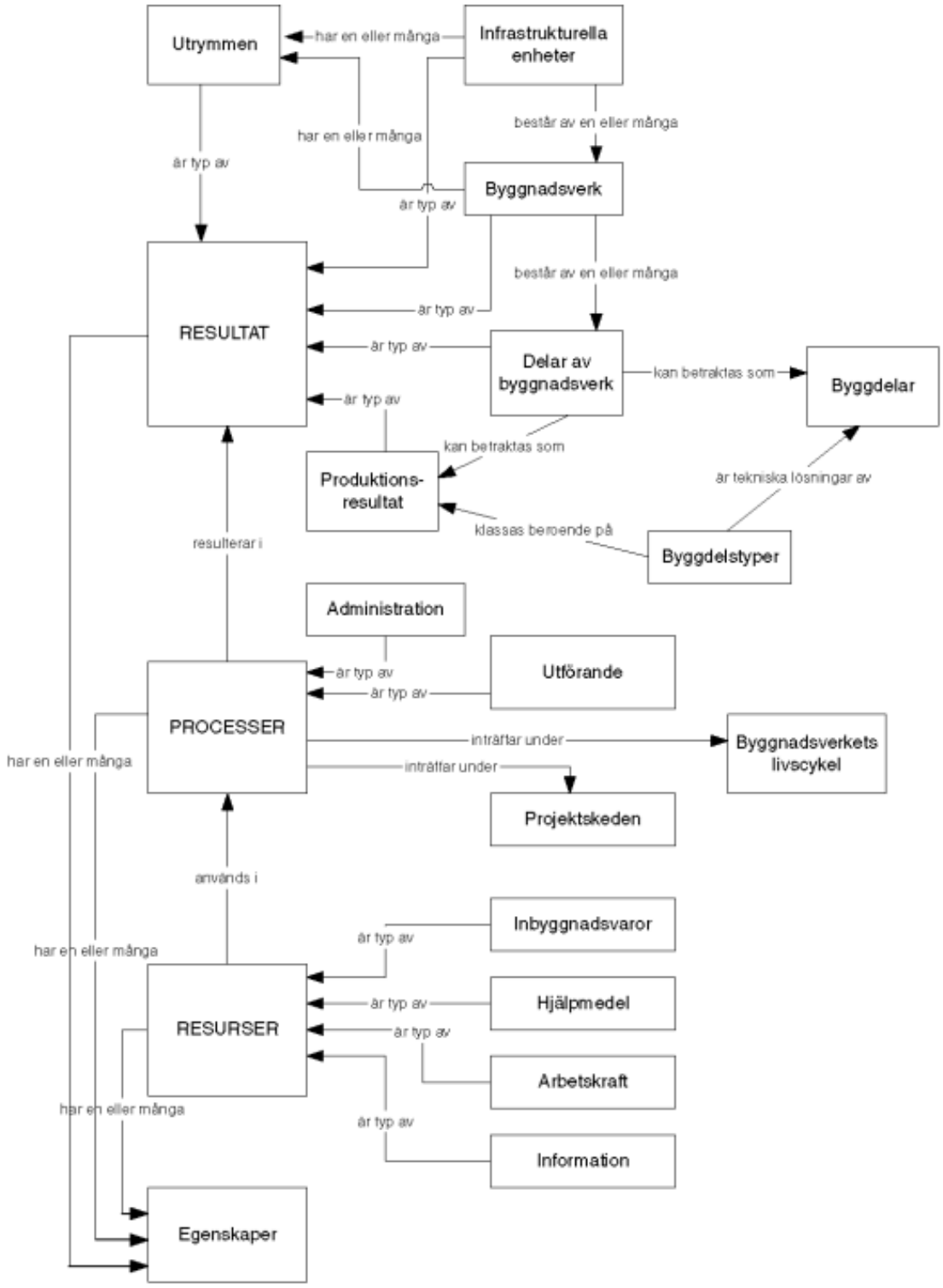

Figure 2. Relationships between results, processes, and resources in ISO 12006–2. (Trafikverket, 2014).

3.2.1.2 ISO 81346-12 as a new generation of building classification system

ISO 81346-12 is a new international standard that will standardize the classification of building systems (Svensk Byggtjänst, 2016). This standard is based on ISO 12006-2, which serves basic guidelines for

the classification of the built environment and the division of objects into different classes. ISO 81346-12 is currently under development and aims to embodies the classification process according to ISO 12006-2 by providing proposals and guidelines for how this can be implemented in practice. This standard enhances uniformity and understanding in the construction sector by using clear classification methods, which in turn helps in facilitating communication and cooperation between different actors in the construction process.

3.3 BSAB and CoClass

This section will provide an in-depth overview of both BSAB and CoClass, explaining the structure of their respective classification systems. At the same time, going into their comprehensive frameworks, project planning methodologies, and the distinct phases of production and management stages, highlighting the nuances that set them apart.

3.3.1 BSAB: Overview

BSAB is a Swedish classification system that has been the industry standard in Sweden for many years, it was introduced in 1972 by the construction company Byggandets Samordning AB (OPENBIM, 2013). BSAB is a classification system based on ISO 12006-2, the development of installation systems and the creation of new AMA publications led to its formation, which was initiated by Byggandets Samordning AB (Trafikverket, 2014). It is mainly used for the technical descriptions, lists of quantities and drawing numbering in the construction industry (Svensk Byggtjänst, 2020). It aims to uniformly identify, divide, and organize information for construction and property operations, regardless of the user or party responsible for handling the information.

In 1983, Svensk Byggtjänst released the first updated version of BSAB which was called BSAB 83 (Trafikverket, 2014). In 1996, the demand for IT and property management called for the development of the latest version of BSAB, known as BSAB 96.

BSAB has many properties and recipes to describe the components of the building by creating recipe structures that can describe the different components by using codes (OPENBIM, 2013). This created a connection between the CAD program (Revit) and a Product Lifecycle Management (PLM) system by "Fokus I – BIM med BSAB" development project, which was facilitated by using the Enovia program. This integration aims to make the process easier for designers, enabling them to access quality-assured information more efficiently during the early stages of the project.

The basic concepts of BSAB are Class and Property, where a class is a group of objects with common properties and defined with attributes (Ekholm, 2001). Classification divides objects into classes based on purpose, taking into account particular characteristics such as color or material. The classification table structures these categories hierarchically, from general to specific, and each object belongs to one class. Figure 4 shows an example of the structure of a classification table, where the circles represent classes in different degrees of fineness and rectangles represent classified objects. Whereas Properties

refer to the different properties of a system or an object. These can be either internal, relating to their parts and relationships, or mutual, arising through the interaction with the environment. An important part of properties are functions, which affect the state of other objects and can depend on the environment, while attributes characterize classes in the system. Classification of properties is critical to organizing information and understanding products and their attributes in the construction industry.

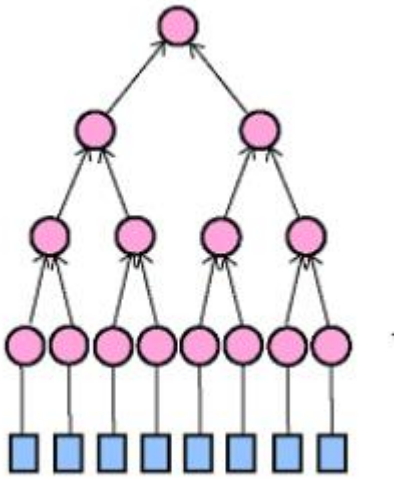

Figure 3. Structure of a classification table consisting of circles and rectangles (Ekholm, 2001).

BSAB can be used as an information structure to create a new generation of BIM (Svensk Byggtjänst, 2020). By integrating BSAB into the BIM process, the requirements management could be improved and the actors in the construction sector can get access to uniform and standardized information from the design stage to the production stage. There are also areas where the BSAB system needs to be completed and changed to maximize its value within BIM. While the BSAB system currently works as before, the Svensk Byggtjänst company is considering the possibility of making changes to better meet the needs of the fast-developing BIM industry by introducing a new system called CoClass.

Figure 4 illustrates the fundamental concepts of BSAB 96 and their connections, where infrastructural units and buildings are classified based on various aspects (Trafikverket, 2014). The project is segmented into several parts, starting from larger entities down to an individual building. It further demonstrates how the building object is subdivided into the necessary resources and activities for creating the subcomponents that come together to form a unified unit.

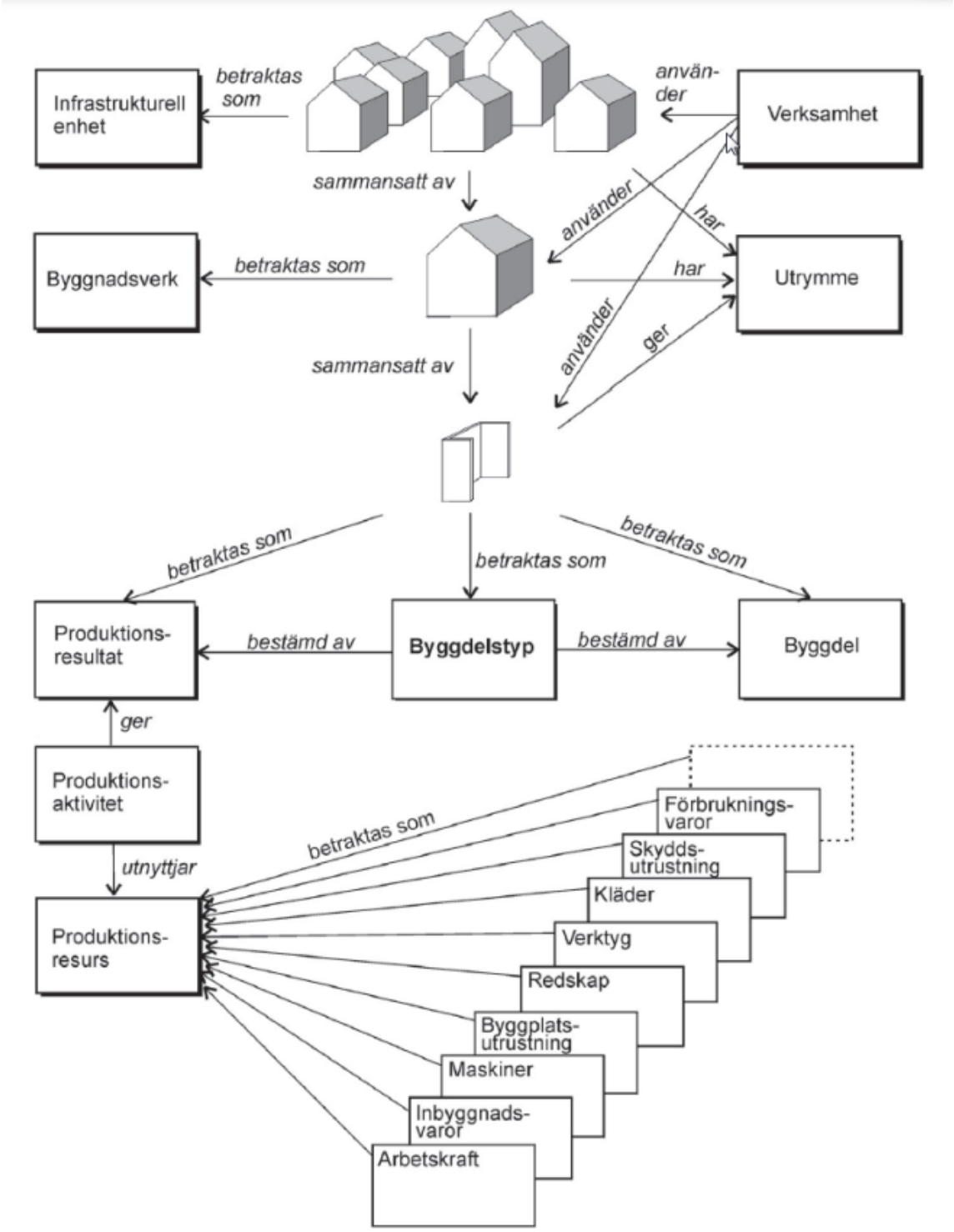

Figure 4. Relationships between concepts in BSAB 96 (Trafikverket, 2014).

Along with BSAB system, there is another system which is SB11 system (Abdeen and Unterkalmsteiner, n.d.). It is a classification system used in the construction industry in Sweden. SB11 serves as a fundamental framework for classifying different elements, including requirements and design models. SB11 integrates ISO 13567 with BSAB 96 to divide layers in CAD. This offers layer tables and detailed instructions and enhancing classification consistency (Van et al., 2013). BSAB 96 helps in classification, while SB11 gives priority to BSAB's building parts tables represent CAD drawings.

Within software development projects, the Taxonomic Trace Link (TTL) approach works to enhance SB11's capabilities by establishing trace links between different artifacts (Abdeen and Unterkalmsteiner, n.d.). This improvement facilitates seamless requirements traceability throughout the project life cycle. The TTL approach is about creating connections between requirements and classes within the SB11 classification system, thereby facilitating the process of following tracing these requirements to design models. To simplify the process of requirements classification process, a recommendation system has been developed. This system analyzes requirements and proposes appropriate classes from SB11. The recommendation system aims to help the domain experts classify requirements accurately and efficiently.

3.3.2 BSAB: Structure and Framework

The structure and framework of the BSAB system consists of a hierarchical classification of buildings and their parts (Ekholm, 2001). The classes within the BSAB system are defined with inherited and distinguishing attributes according to applicable terminology. In addition to the definitions, there are lists of attributes, conceptual diagrams and the explanatory images and texts.

The central part of the BSAB system is the concept of "construction part", which refers to the physical part of the specific construction work identified based on its main function (Ekholm, 2001). Building parts are identified using a "top-down" approach, where the three main functions of physical parts of buildings include load bearing, spatial delineation and distribution functions. These main functions are defined based on properties in relation to other parts of the building, soil factors, climate, and use.

In BSAB 96, a part must be classified as a construction part if it has at least one main function (Ekholm, 2001). If the part has several main functions, one of them must be chosen as the starting point for the classification. The load-bearing function is prioritized in relation to non-load-bearing functions. The building parts are defined regardless of the technical solution, material content or production method, See Figure 6. Where the term also includes components for installations which are called installation systems defined in BSAB 96 as components whose main function is to provide media.

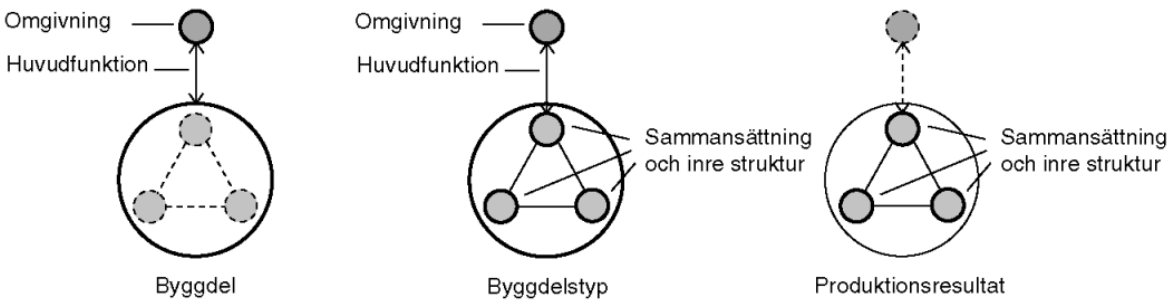

Figure 5. Component, component type and production result (Ekholm, 2001).

The BSAB system also includes the concepts of "Activity and Resources", where the production activity refers to activities on the construction site for the production of parts of or the whole construction work (Ekholm, 2001). The production activities aim to achieve production results that meet the requirements

for the different building components and their types. Resources in BSAB 96 include many objects used in the implementation of the activity, including manpower, machines, tools, materials, and documentation.

An important part of the BSAB system is the classification of "Production Results", which are physical parts of the construction work which are distinguished on the basis of material and production method (Ekholm, 2001). The production results are defined regardless of the main function of the part in the construction work. The classification of production results is based on the type of activity, such as construction or the sheet metal.

Table 1 shows two examples from the Production results table in BSAB 96 (Ekholm, 2001). While these examples are from the construction phase, similar scenarios can also happen within infrastructure projects. These examples refer to classes for chimneys, either made of brick or metal. The tables show BSAB's code and name, and for each step in the list more details are added. The BSAB system is like a list, where each level has more information. The specialization is not about differentiating between metal or steel chimneys, but about the production method.

Table 1. Examples of specialization of production results (Ekholm, 2001).

F	Construction
FS	Construction in houses
FSG	Brickwork in houses
FSG.3	Chimneys, fireplaces etc. of brick
FSG.31	Brick chimneys for combustion gases
P	Appliances, lines etc. in pipe systems and wiring networks
PL	Smoke ducts and exhaust ducts
PLB	Smoke ducts and exhaust ducts of metal
PLB.1	Smoke ducts and exhaust ducts of steel or cast iron

The BSAB system uses a hierarchical structure where each level is characterized by an additional attribute (Ekholm, 2001). The specialization not only refers to the distinction between different functions, but also different production methods. In addition, the BSAB system includes the concept of "Building Part Type", which describes the technical solution for the function of the building part. The component types are used to gradually define the technical solutions and support the needs of production planning.

3.3.3 BSAB: Project planning and Production stage

During the design and production phases, there are different needs for classification and information about materials and construction products, as these phases aim for different purposes (Ekholm, 2001). In the design phase, programs and proposals are developed to provide an overview of the building and its use to the buyer. It is not necessary here to do an in-depth analysis of the building components. When main and system documents are then produced, and then the construction documents are presented, a

more detailed and informative picture of the building is given to facilitate production. These documents go into details such as climate separators and supporting structures.

The main purpose of BSAB is to transfer information from planning to production (Ekholm, 2001). For example, it is used to produce cost estimates based on quantity calculations during the procurement stage using the construction parts table. In addition, descriptions, documents, and drawings are structured using this classification to prepare for production.

Today, a large part of the manufacturing and construction industry uses computer-aided programs for planning and management, which has led BSAB to be developed to integrate with different CAD systems such as Revit, AutoCAD, and others (Ekholm, 2001). By integrating these programs, the exchange of information between the design and management phases is significantly improved.

3.3.4 BSAB: Management stage

The scope of use and the need for classification in the management process is extensive and plays a crucial role for the manager (Trafikverket, 2014). By applying classification, the planning of maintenance and operational efforts is greatly facilitated, as well as the handling of maintenance and operational information and the feedback of technical experience.

A central component of this process is the building component classification table, which is a basic management tool (Trafikverket, 2014). Even though its importance, this table often lacks the level of detail required to cover all aspects of management needs. To meet this need, it is proposed to supplement the table with functional units, which would enable a more comprehensive and detailed division of the functional systems.

By incorporating functional units, the manager can get a more comprehensive and accurate picture of the components and systems that make up the property or facility, which in turn would contribute to more effective and targeted management decisions (Trafikverket, 2014).

3.3.5 CoClass: Overview

CoClass is the newest classification system in Sweden that is based on international standards (ISO) and is developed within the BSAB 2.0 project, which was published in 2016 (Svensk Byggtjänst, 2016). The aim of the project is to create a classification system that not only meets today's information needs, but also takes into consideration the future requirements/needs and technological progress. This system is known as the new generation of BSAB and aims to change and improve work processes within the industry by facilitating unified information management and a common understanding. CoClass for infrastructure projects is not commonly used in Sweden but is slowly implemented through road and railway projects.

CoClass can be used in many ways along the spectrum. Svensk Byggtjänst (2024) describes it as following:

- **Digital:** gives you placeholders for digital information.
- **Common:** Same language and same structure - at all stages - with all partners - in all software - in all information deliveries.
- **All built environment:** Covers all parts of the built environment.
- **Full life cycle:** Covers the needs for planning, program, design, production, management and demolition.
- **International:** Bilingual and based on international standards.
- **Future-proof:** Open and combine structures based on function.

Utilizing a CoClass for infrastructure facilitates the process by enabling structured handling of information (Svensk Byggtjänst 2022a). It can be applied to specific project components or throughout the entire lifecycle. CoClass is built on a flexible framework, allowing easy adjustments based on project requirements, facilitating the transition from production to management. The information used will change and may evolve across different project stages. This requires the user to ensure proper formatting and structure for the specific project, along with the necessary information to be included. Given the unique needs and requirements of each project, finding a one-size-fits-all standardization is challenging. Therefore, much of the work depends on the user to adjust the approach to their specific project needs.

CoClass can be utilized throughout the entire lifecycle of a project (Svensk Byggtjänst, 2024). This process is illustrated in the flowchart presented in Figure 6, where the foundation of CoClass is based on ISO 12006-2 and 81346-12. This visual representation outlines the interconnections between the foundational components and the sub-components. The components can also be described in a hierarchical order, starting from the top with the Building Complex, followed by Building Works, Spaces, Functional Systems, Constructive Systems, and Components. This will be elaborated in more detail in the following chapter.

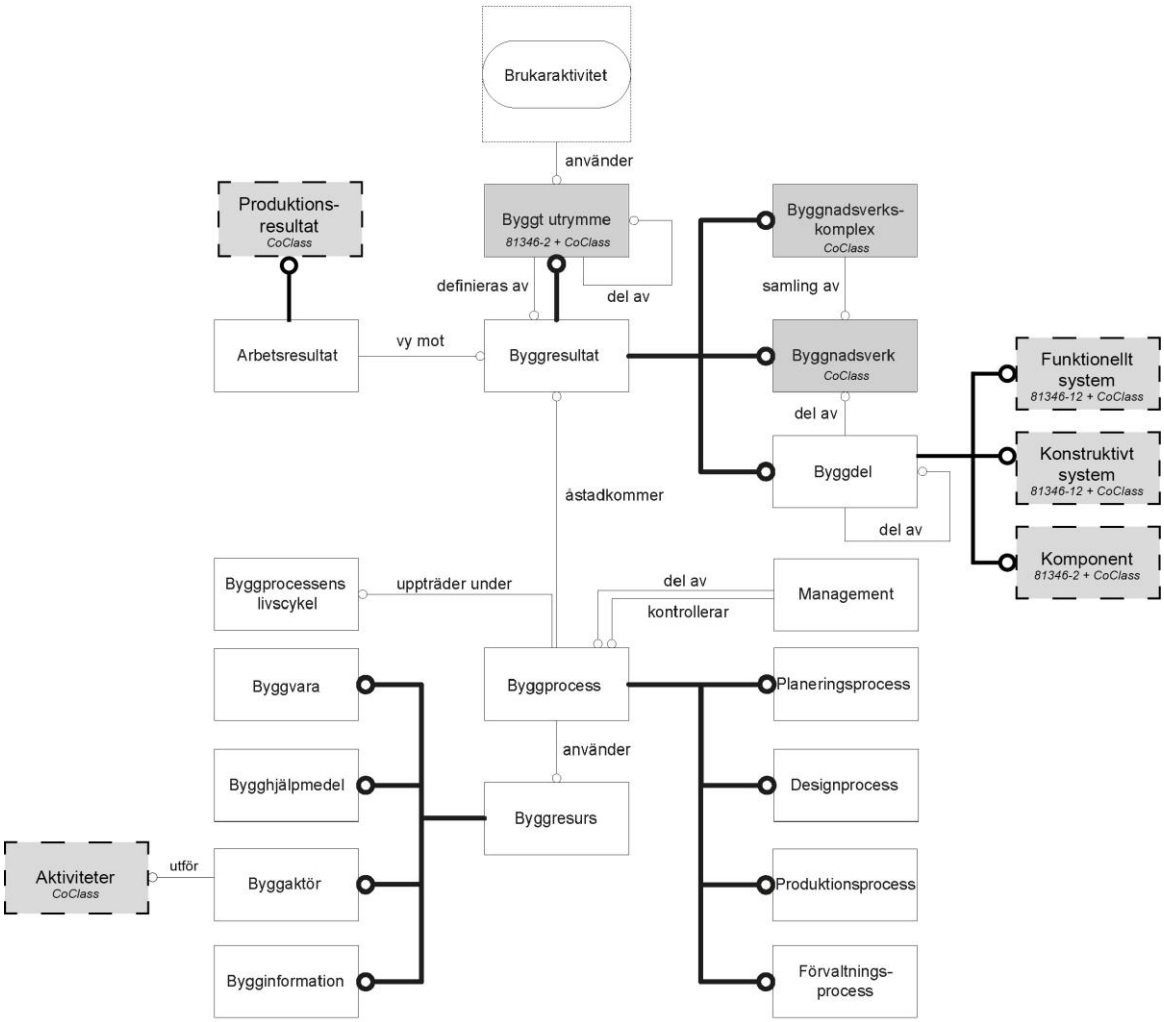

Figure 6: Flowchart illustrating the connections between the foundational components and subcomponents of ISO 12006-2 (Svensk Byggtjänst, 2024).

3.3.6 CoClass: Structure and Framework

For infrastructure projects, CoClass follows a similar approach to the housing sector, standing on the same foundation (Svensk Byggtjänst, 2022b). The basis of CoClass is established upon the following international ISO standardizations:

- **EN ISO 12006–2:2020**: General structure.
- **EN 81346-1:2010** Rules of structuring of systems and reference designations of objects.
- **EN IEC 81346-2:2019** Classes for building parts (components) and spaces.

- **SS-ISO 81346-12:2018** Classes for building elements (functional systems and constructive systems.

CoClass is made up of tables according to the international standardization of ISO 12006 and ISO 81346 (Svensk Byggtjänst, 2022a). This serves as a complement for the ISO standardization as it also includes a diverse set of classes to provide further specification.

Each table contains information and objectives in accordance with the building environment (Svensk Byggtjänst, 2022a). For the table, the application uses the following hierarchical structure: Building complexes, Building works, Spaces, Functional systems, Constructive systems, and Components. The hierarchical structure is an international standard and a framework for how things should look like, but the objectives can be tailored to their unique needs and requirements, and Svensk Byggtjänst will provide structured templates accordingly. This will also define how the relationship between the tables will look like and the kind of definitions and codes which should be included. This aligns with one of the principles of CoClass. The users have to form their objectives, establish a foundational definition of the environment, and set a clear goal for the structure and purpose. The range of information will vary across the cycle, so it is important for the users to determine the specific information they want to include.

The classification of objectives using CoClass involves the use of 1-3 letters. The numerical sequence indicates the hierarchical structure of the objective (Svensk Byggtjänst, 2022a). For instance, AA, AB signifies that the second letter represents a component related to the first one. While the second letter can vary, the first one remains fixed. Each class contains various types, identified by two numbers, which explain their function or construction. These types within each class are further organized into different groups, facilitating the overall classification of an object. This approach provides users with significant flexibility.

The following table illustrates how the basics of classification can appear following a hierarchical structure, with examples sourced from Svensk Byggtjänst (2022b).

Table 2. Example of the application and types.

Application	**Types**	**Example**
Building Complexes:	Function, Technical solutions	Examples of function: CAA Cable Networks, CAA10 Power Networks, CAA11 Low-Voltage Networks.
Buildings Works	Function, Form	Examples of form: AAA Single-family Houses, AAA10 Detached Single-family Houses, AAA11 Supplementary Houses, AAA20 Townhouses, AAA30 Row Houses.
Spaces	Function, Position, Technical solution	Examples of location: CBA Furniture Storage, CBA10 Attic Storage, CBA20 Basement Storage.
		Examples of technical solutions: ABF Sauna, ABF10 Dry Sauna, ABF20 Wet Sauna, ABF30 Steam Sauna, ABF40 Infrared Sauna.
Functional systems	Function, Position	B10 Exterior Wall System, B20 Interior Wall System, B21 Excavation Wall, B22 Elevator Shaft Wall; B60 Tunnel Wall System; B80 Bridge Structure.
Constructive systems	Function, Position, Technical solution	Example of location: CE Railway substructure, CE10 Railway substructure on embankment, CE20 Railway substructure in street, CE30
		Example of technical solution: CB Superstructure for road and plan, CB10 Flexible superstructure for road and plan road and level, CB20 Rigid road and level superstructure
Components		Examples of position: FQD Guardrail, FQD10 Fall protection railing, FQD11 Balcony railing, FQD12

	Function, Position, Technical solution, Material	Example of technical solution: EGA Heat pump/refrigerator, EGA10 Heat pump, EGA11
		Examples of materials: NCA Ground cover, NCA10 Unbound ground cover, NCA11 Gravel wearing course gravel wearing course,

Table 2 illustrates the division and summarization of types based on the data presented in table 3. This provides a simplified structure for organizing the application and its various types, facilitating in the identification of included components.

Table 3. Basic of classification for *types:* FO = form, FU = Function, L = Elevation, M = Material, T = Technical solution (Svensk Byggtjänst, 2022b)

Application	**FU**	**FO**	**T**	**L**	**M**
Building Complex	x		x		
Building Structure	x	x			
Spaces	x		x	x	
Functional system	x			x	
Constructive system	x		x	x	
Components	x		x	x	x

3.3.7 CoClass: Project planning and Production stage

In project planning and production phases, CoClass can improve efficiency and collaboration (Svensk Byggtjänst, 2016a). During the project plannings phase, CoClass is used to organize requirements systematically and hierarchically. This ensures that all project specifications are clearly defined and communicated. The standardized terminology helps create accurate CAD models, technical descriptions and cost estimates. This reduces misunderstandings and errors, as all parties have a common understanding of the project's components and requirements.

While in the productions phase, CoClass facilitates coordination and management by enabling consistent classification of objects within CAD models and other project documents (Svensk Byggtjänst, 2016a). This is crucial for effective collaboration between all stakeholders. The system supports integration with deffirent software tools, including CAD, purchasing and cost management systems, ensuring that data is transferred consistently and accurately between different platforms.

3.3.8 CoClass: Management stage

Management with CoClass can be conducted through an entire project or by parts linked to a project (Svensk Byggtjänst, 2022a). CoClass is utilized to ease the transition from production to management. It is also possible to follow up on values and verify if the outcome aligns with the specified request (Smart Built Environment, 2017). It facilitates the processes in operation, maintenance, and care. CoClass aims to enhance the efficiency of communication and asset management by unifying language, definitions, and terminology, thereby saving resources for companies in the industry. By implementing CoClass, the organization will have a better overview of management, this includes both the economical and practical aspects.

The openness and flexibility of CoClass are grounded in the specific requirements articulated by the manager regarding the desired information and structural framework (Svensk Byggtjänst, 2022a). It is important for the manager to have a clear understanding of their needs, given that each project has its own characteristics and requirements.

3.3.3 Differences between BSAB and CoClass

Both BSAB and CoClass are classification systems that aim to facilitate communication and structuring of information in the construction and real estate industry. Despite their similarities, there are big differences between them.

Level of Detail and Width: CoClass has a very high level of detail and wide coverage, making it ideal for handling complex property structures and extensive data (Planima, 2021). Where it aims to improve information exchange and address the previous deficiencies by offering a common information structure (Svensk Byggtjänst, 2016). On the other hand, BSAB also has a high level of detail and wide coverage, but it does not quite reach the same level of richness and scope of detail as CoClass (Planima, 2021).

International use and BIM compatibility: CoClass is internationally usable and BIM compatible, which makes it suitable for organizations that work internationally and use BIM technology (Planima, 2021). Where its digital nature and adaptation to the ISO standard make it possible to connect with other classification systems internationally. CoClass aims to adapt construction classification systems to digital models taking into account the perspective of whole life cycle. It includes all stages from development to management (Svensk Byggtjänst, 2016). On the other hand, BSAB does not have the same international usage or BIM compatibility as CoClass (Planima, 2021). BSAB 96 is designed for the Swedish construction environment and mainly supports the stages from development/design to production. It has been actively established and is used for example in reference works such as AMA (Svensk Byggtjänst, 2016).

Pricing: CoClass has a yearly cost (as for now) of SEK 7,900 and offers different subscription levels with different advantages, including a free basic option (Svensk Byggtjänst, n.d.1). Extra costs for the education are also added because CoClass is still a new system and education are needed to be able to implement this system (Svensk Byggtjänst, n.d.2). Svenska Byggtjänst organizes a training course on CoClass that focuses on explaining the system and its areas of use, including how it facilitates documentation and the basis of calculation. The cost is 2,900 SEK per person plus VAT, and no previous

knowledge is required. Registration is mandatory. On the other hand, BSAB is free to use online, but if the person wants to integrate it with internal or external applications, a license agreement is required for that (Planima, 2021). The price of this agreement varies according to use.

Advantages and disadvantages: CoClass offers a high degree of flexibility, detail and complete coverage, which make it ideal for users who need to manage complex property structures and want BIM compatibility (Planima, 2021). At the same time, its high level of detail can be too much for some maintenance needs, and sometimes it lacks specific examples and best practices for maintenance work. On the other hand, BSAB is well suitable for the users who are already work with BSAB and familiar with the system. It has no need for international use or BIM compatibility. Its use is also free, which makes it a financially beneficial option for some organizations.

CoClass important goals:

- Digitalisation and BIM: It is about using digital platforms to easily organize information about objects (Svensk Byggtjänst, 2016a). It makes it possible to connect properties and activities to different parts of the information, and it is also compatible with the international IFC standard.

- Unified communication: By using a common information structure, it will be easy to create uniform communication between all parties in the construction process (Svensk Byggtjänst, 2016a). It reduces the risk of errors and misunderstandings.

- Covering everything in the construction process: CoClass includes not only buildings but also land, landscape, technical installations, and other aspects of the construction environment (Svensk Byggtjänst, 2016a). It is useful for planning, design, and development.

- The whole life cycle: Unlike BSAB, which focuses mainly on design to production, CoClass considers the whole life cycle of a project, from the concept stage to completion (Svensk Byggtjänst, 2016a).

- International adaptation: CoClass is available in both Swedish and English and follows ISO standards for data management, which make it useful and internationally recognized (Svensk Byggtjänst, 2016a).

- Future-oriented: The CoClass structure is designed to be flexible and to be able to adapt to new technologies and solutions over time without big problems (Svensk Byggtjänst, 2016a).

The figure below illustrates the evolution in transitioning from BSAB 96 to CoClass. CoClass offers a more detailed and comprehensive approach compared to BSAB 96.

Figure 7. A comparison between BSAB 96 and CoClass (Svensk Byggtjänst, 2016a).

4. Interviews

The following chapter presents summarized results from the conducted interviews, themed into sections. The content is selective, including only information involving responses linked to the research questions.

4.1 Results from interviews

The interviews contained a total of nine interviews from both client and consultant side. All with various experience and knowledge in BIM. The following table will divide them into groups based on their perspective, role, current position, and company.

Table 4. Presenting the interviewees: Perspective, role, information, and company.

Perspective	Role	Information	Company
Consultant 1	BIM-Coordinator	Driving digitalization in the transport sector, including recruiting, and managing of BIM specialists and coordinators to define working methods, as well as global digital design initiatives.	A
Consultant 2	Strategic Data Coordinator	Quality ensuring of BIM-models and actively engaged with a team working close to BIM	A
Consultant 3	BIM-Coordinator	BIM designer for railway in certain technical aspects, primarily responsible for producing 3D models and coordinating various elements such as assembling models and setting requirements.	B
Consultant 4	BIM-Manager/Strategist	Responsible for IT, including CAD software and process development, as well as working as a BIM strategist and technical lead for infrastructure projects.	C
Consultant 5	BIM- Manager/Data coordinator	Part-time team leader with staff oversight manages data coordination for infrastructure projects and oversees BIM disciplines	D
Client 1	Assistant Project Manager	Assisting the project manager with system documentation for railway expansion projects	STA
Client 2	BIM-Specialist	Work actively with BIM as a data coordinator	STA
Client 3	BIM-Strategist	Strategist in information management and information governance in the implementation of BIM systems	STA
Client 4	BIM-Strategist	Strategic responsibility for information governance and business development, where BIM is incorporated	STA

The results will include perspectives from consultants and clients to comprehensively understand their views on the classification of systems in BIM. This approach focuses on gaining insights into diverse perspectives on BIM and how communication is conducted within projects. Furthermore, the results emphasize identifying common themes among these perspectives to uncover opportunities and challenges associated with classification systems and the varied designations.

4.1.1 Finances and Resources

The Strategic Data Coordinator from company A suggests that the adoption of a new classification system, such as CoClass, may be driven by economic considerations. Transitioning to a different system

incurs costs associated with consulting services, resource allocation for integrating additional information, and training personnel. There are also expenses related to acquiring software and the requisite tools. As the STA does not include a template or system, it is up to each company to figure out the new system.

The BIM Manager from company C highlights the financial pressures within the industry. With everyone striving to outbid competitors during procurement, there's a tendency to deliver products meeting only the bare minimum standards, thereby compromising quality. The interviewee stresses the importance for entities like STA and other clients to prioritize not just cost but also ensure adherence to requirements and uphold quality standards.

The BIM Manager from company C emphasizes that due to the financial constraints prevalent in the industry, it's a common practice for companies to outsource work to countries where labor costs are lower, such as India, Bulgaria, Estonia, and Lithuania. However, this often leads to compromised quality and results in inferior products. To address this issue, STA requires that consultants receive reduced hourly rates for work done at cheaper overseas locations. It's typical for companies to allocate a percentage of their work to be completed abroad, leading to a tendency to seek shortcuts.

“The industry as a whole can get higher compensation because otherwise, we will not get higher compensation then everyone will try to find all the loopholes and stuff to go around financially. “

- BIM Manager from company C

The BIM Specialist from STA had a similar view, noting that companies outside of STA are capable of exploiting loopholes and shortcuts when assessing digitalization possibilities, leading to time and cost savings. The interviewee suggests that CoClass could serve as a valuable tool in economizing and standardizing the classification of infrastructure projects.

The BIM Strategist from company C continues to elaborate that it's prevalent for the majority of projects to have variable pricing rather than fixed rates. This discourages automation and efficiency efforts, as the focus tends to shift towards billing more hours. The interviewee suggests that transitioning towards a fixed pricing model, particularly if implemented by STA, could enhance product quality. Tt would also free up resources to invest in areas like employee salaries, training, and innovating new processes.

"As long as the STA runs on a budget, there is no incentive to automate and become more efficient. "

- BIM Strategist from company C

The assisting Project Manager from STA acknowledges the challenge of establishing project requirements, particularly regarding the appropriate allocation of hours and information, especially under a fixed pricing model. They emphasize that the quality of the final model is contingent on the range of input hours.

“*Because it is difficult to define what it really wants. It is completely impossible. And then, how long is a string. what should you put a price on. It is difficult. Do the minimum possible on a fixed price. On a variable price, they want to project as many models as possible.”* - Assisting Project Manager from STA

The assisting Project Manager from STA remarks on the substantial resources allocated to modeling for management and planning purposes. However, they express concern regarding the lack of careful handling and management of these models. Similar to the response shared by the BIM Manager from company C, the Project Manager from STA observes that due to resource pressures, individuals tend to focus solely on what's necessary. If management isn't explicitly required and there's no additional compensation, it often gets overlooked, and the bare minimum is being done.

The BIM Strategist from STA (Client 3) emphasizes the importance of maintaining quality throughout the process. While ensuring the presence of necessary information for maintenance and operation incurs costs, carelessly pursuing it isn't effective. The interviewee underscores the significance for STA to prioritize quality information, even if it isn't the most sustainable approach.

4.1.2 Regulation and Adaptation

The Strategic Data Coordinator from company A notes that CoClass isn't widely adopted presently, attributing this partly to the lack of industry demand and the absence of a requirement from the STA. Although the STA indicated in 2019 that all projects would incorporate class, this transition hasn't occurred yet. The project methodologies still adhere to a standardization process with strict requirements, although this varies between projects.

The Strategic Data Coordinator from company A continues to say that existing standards lack the necessary detail, posing challenges. CoClass, on the other hand, offers an additional layer of information beyond older frameworks. Transitioning to CoClass would necessitate changes in software practices, information management, education, and internal procedures. The current standards like BSAB are still commonly employed in current practices. BIM-Manager from company D also agrees on this and says the implementation of CoClass would bring about significant changes, considering the well-established routines and processes under BSAB.

"If you are experienced and confident in a certain way, it may not be easy to leave it and move on to something else. "- Strategic Data Coordinator from company A

BIM-Coordinator at company B highlights that the railway industry still relies on old practices, shaped by the contributions of various individuals over time. Project managers and leading disciplines typically favor what they perceive as secure options and avoiding risk, often leaning towards BSAB or SB11. The BIM-Coordinator at company B continuously emphasizes the industry's tendency to cling to established routines, with much of the process dictated by strict requirements documents and oversight from the STA, as also mentioned by The Strategic Data Coordinator from company A.

"So given the way it is structured, it is difficult to make major changes. So that's probably the reason why it looks the way it does within railway projects." -BIM-Coordinator from company B

BIM-Manager from company C says that BSAB remains the standard across all projects, noting that CoClass hasn't been brought up in their entire career or among their colleagues. While they possess knowledge of these standards through their involvement in verification processes, CoClass isn't yet

required or emphasized by the STA. Similar to the view expressed by the Strategic Data Coordinator from company A, the BIM-Manager from Company C indicates an unwillingness to advocate for additional standardization if the STA's requirements remain unchanged.

The BIM-Manager from company C continues saying the absence of any mention of CoClass or new systems in recent STA documents suggests that its implementation isn't likely anytime soon. The BIM Manager from company C mentions the high level of rotation within the industry, with professionals gaining diverse experiences across different roles. Any significant development in standards should ideally originate from external sources rather than within the industry itself.

"If there would be any good new thinking, then it is from people like you (students) where you are not tied to economic pieces you can think a little more freely. You can see the big picture in a different way than those of us who are pretty much wrapped up in all the problems that arise of various kinds. So, I think a dialogue between the various universities and the STA is what could get new thinking in a positive way." -BIM-Manager from company C

The Assistant Project Manager from STA says that although BIM has been integrated into the STA since 2015, its full implementation is still pending due to the need for processing digital maturity. The BIM-Specialist from the STA further adds to this that many projects have lengthy durations, and currently, the STA lacks the maturity to effectively manage all 3D models. It is suggested that perhaps in a decade's time, the STA may be better equipped for this task. This is further emphasized by the BIM-Strategist (Client 3) from STA.

The Assistant Project Manager from the STA further explains that the current lack of requirement for 3D models or extensive information is due to the ongoing digital development within the maintenance department. The BIM-Specialist from the STA adds that currently, the STA primarily utilizes 3D models for oversight, while the bulk of the management work falls on consultants and suppliers, indicating that comprehensive management of these files is still in progress. The Assistant Project Manager from STA continues to say that while the STA has been involved in the development of CoClass, it's uncertain if they will require its use in the near future, at least not fully implemented in projects. This was also said by the BIM-Strategist (Client 3) from STA and the BIM-Strategist (Client 4) from STA. BIM is not yet fully developed in the organization, and there is a process going on with the hierarchical structure of information and the accessibility of roads and railways, which is of importance. BIM-Strategist (Client 3) from STA continues to say that CoClass is necessary to live up to today's standard to meet the requirements of digitalization, which BSAB 96 is not.

"*BSAB 96 is not adapted to BIM models or object-oriented information management and does not meet the requirements of digitalization. Therefore, the BSAB 2.0 project was launched, resulting in CoClass to meet these needs. CoClass aims to provide a more detailed classification to handle the increasing amount of data and understanding of system components."* -BIM-Strategist (Client 3) from STA

The BIM-Strategist (Client 3) from STA underscores the necessity for the industry to embrace change, identifying CoClass adoption as a key aspect. While the STA recognizes the merits of a new system, they acknowledge the numerous challenges it presents. Moving from conceptualization to management necessitates significant adaptations, especially in aligning with the system's objectives, and requires

meticulous precision for seamless integration. Similar to the BIM-Coordinator from company B, the BIM Strategist (Client 3) from STA asserts that the industry requires a significant change to advance.

"The conservative attitude of the industry, probably due to long-standing positions and cultural factors, hinders development. Despite the challenges, CoClass has helped us learn and put theory into practice, with Svensk Byggtjänst as a key partner" -BIM-Strategist (Client 3) from STA.

The BIM-Strategist (Client 4) from STA notes that as of today, there are many variations of BSAB used simultaneously, reflecting the industry's slow progress in digital maturity. They emphasize the complexity of the industry's digital heritage, which poses challenges for adaptation. However, there is a willingness from the STA to explore new modern approaches despite this difficulty.

The BIM-Strategist (Client 4) continues to highlight the industry's struggle to grasp the connection between requirements and the utilization of BIM models, which occasionally leads to misunderstandings. They stress the importance of driving organizational progress in maintenance and operations, although they caution against overly aggressive pursuit. While traditional methods may provide a sense of security, they acknowledge that they can often be more expensive in the long run

"Experienced project managers dare to take risks again to find the drive. We need to change how we distribute risks in the organization and between parties such as the STA and suppliers. Daring to move forward, as in the case of (project xx), requires anchoring and intensive investigations. Many see the benefits of working digitally, which can facilitate investments. -BIM-Strategist (Client 4) from STA

The BIM-Strategist (Client 4) from STA further explains that digital maturity progresses more slowly within the private sector compared to the public sector, primarily due to a greater emphasis on resilience and risk mitigation. They note that the STA, in particular, lags behind other units in terms of digital advancement. This trend appears consistent across major cities in Sweden. Digitization initiatives are often driven by enthusiasts rather than in a structured way.

"We are faced with the challenge of being robust and acting quickly when needed, even if this means prioritizing immediate action over long-term development. The balance between risk and performance is crucial to manage, especially with high expectations of quick returns. It is a challenge to focus on long-term goals when there is pressure to deliver results quickly." -BIM-Strategist (Client 4) from STA

4.1.3 Communication and Transparency

The Strategic Data Coordinator from company A suggests that the STA should be clearer and more detailed in terms of the information they request, and the requirements set for their projects. The importance of clear specifications to maintain the quality of projects, as insufficient guidance can impact the project's outcome. The Strategic Data Coordinator from company A also believes that establishing higher standards would facilitate budgeting for consultants. Despite these suggestions, they acknowledge that projects from the STA generally maintain a high standard.

The BIM-Coordinator from company B emphasizes the importance of early communication in the project and the need to identify requirements that align with the project goals, which are then discussed and confirmed by the client. They stress the importance of having a clear dialogue where all parties openly discuss what should be included in the project scope. The BIM-Coordinator from company B says that there is often a shortage of data and information, so including more details is preferable. Furthermore, they mention that the requirements have remained relatively consistent over the years, at least in the railway sector, but there is ongoing progression from the STA which has become better over time. Similar to the Strategic Data Coordinator from company A, The BIM-Coordinator from Company B believes that there is still sometimes an unclear understanding of what the requirements mean and what should be included in the finalized product.

The BIM-Manager from company C highlights that while clients often provide numerous requirements, it's common for consultants to exploit loopholes to ensure product approval. They stress the importance of clients conducting thorough reception control to mitigate the risk of models containing shortcuts or loopholes. The BIM-Manager from Company C emphasizes that it's irrelevant whether clients have specific requirements for standardization if they fail to follow up on them. Additionally, they note that while the STA outlines clear project expectations during procurement, many individuals fail to fully comprehend or absorb the information due to insufficient resources for a thorough review.

"It clearly states that you should do this. But we haven't read that... we don't have time for that, we don't have money for that... there aren't hours for that etc. It is very difficult to get people to understand and read and absorb the requirements that are actually written in black and white. "

-BIM-Manager from company C

The BIM-Manager from company D says that the STA hasn't prioritized precision details in infrastructure projects yet focusing instead on foundational aspects like baselines and soil surveys. Consequently, there's less precision modeled in these projects. However, there's an ongoing discussion about revising the information requirements for infrastructure projects. The BIM-Manager from Company D advocates for stricter requirements, suggesting that employing CoClass could standardize object classification across all projects, thereby enhancing understanding and uniformity. They further elaborate on the distinctions between BSAB and CoClass.

"CoClass is more flexible than BSAB. To manage information effectively, you need a clear structure and a clear understanding of how to classify and manage objects. By creating your own profiles on CoClass, you can apply the same standardization to all projects, simplifying management and providing consistent coding. This facilitates the identification of objects in buildings or facilities and allows their functions to be understood quickly and accurately" -BIM-Manager from company D.

BIM-Manager from company D continues by emphasizing that strict requirements from clients are crucial; without them, the transition to a new standardization process won't occur. They assert that the STA hasn't fully achieved its goal yet, and inconsistent requirements could result in uneven outcomes.

"The client side needs to make it more demanding, also in their procurements on designers and contractors what they require at the information level and modeling and production level" -BIM-Manager from company D.

BIM Specialist (Client 2) from STA points out that the STA doesn't specify all the information required in the models; some of it is left to the suppliers. The requirements provided are typically comprehensive but lack detailed specifications, focusing more on format and structure. The Assistant Project Manager from STA agrees with the BIM-Specialist from STA, adding that it's challenging for the STA to determine the scope of requirements. The BIM-Specialist from STA elaborates by mentioning that while there are requirements for management data in maintenance, they are often referenced against drawings and CAD layers. There are also requirements for object-oriented information in BIM models, focusing on format and structure. However, determining end product requirements poses difficulties as there's more to consider beyond just the end product. The BIM-specialist from STA further explains that SB11 is a common requirement from the STA, serving as an extension of BSAB and is commonly used in all projects.

The BIM-Strategist (Client 3) from STA explains that the STA is actively involved in developing CoClass to standardize classification structures and foundational classifications for different project scenarios. These classifications can be utilized to adapt to various facilities with different construction systems. Furthermore, they note that because CoClass is based on international standards, it will also enhance communication with various actors, this also includes other Nordic countries.

The BIM-Strategist (Client 4) from STA emphasizes that the foundation of the industry revolves around prioritizing quality and effectiveness. Despite the integration of new technologies in BIM, there's a noticeable absence of structure and intelligence in the processes. Therefore, reverting to drawings and documentation still remains important to prevent miscommunication and uphold high-quality standards throughout the project. The BIM-Strategist (Client 4) from STA highlights that the classification system isn't determined by the project manager; instead, it originates from the documentation. The project manager's role primarily involves making operational decisions regarding the application of controls within the project.

"Classification is usually not a decision for the project manager but is used when applying requirements templates and organizing requirements databases and maintenance requirements. This can cause problems for the project manager. However, the project manager can take the initiative and suggest sorting tools such as CoClass, but this can be costly and is therefore often avoided." -BIM-Strategist (Client 4) from STA

BIM-Strategist (Client 4) from STA further explains that the STA is engaged in collaborative efforts across various levels to develop CoClass. However, there is uncertainty regarding its limitations. The development of CoClass aims to streamline requirements, particularly for the benefit of users, to enhance efficiency, and effectiveness in project management.

4.1.4 Education and Innovation

The Strategic Data Coordinator from Company A notes that if the STA implements new standardization requirements, consultants will need to adapt, requiring education for personnel. This includes internal development and software upgrades, constituting investments in both equipment and human resources. The Strategic Data Coordinator from Company A further emphasizes the importance of self-learning,

often through informal channels such as communicating with managers, interacting with colleagues, and learning during projects. Education is a gradual process, and companies typically do not send all employees for courses simultaneously. The Strategic Data Coordinator from company A highlights the challenge of improving software proficiency within each discipline, as implementing CoClass will involve incorporating more information.

The BIM-Coordinator from company B highlights a knowledge gap regarding CoClass in railway projects, suggesting that significant effort lies ahead to address this gap. They also mention the slower pace of digital progression in railways compared to other disciplines and foresee challenges in project management, particularly with the integration of CoClass

The BIM-Strategist from company C observes that due to high staff turnover in the industry, investing in new knowledge and education presents challenges. They further remark that individuals often struggle to absorb new information and stay updated. Simply communicating new information is ineffective if individuals are not actively engaging with it, as they tend to maintain familiar approaches rather than adopting new practices.

"You can spend as much time on it as you like, so you improve things now and then, but then we have a turnover of staff in the industry of between 10 and 20 percent, there was a period when we were up to 20-25 percent. This means that over a period of 4-5 years, you have replaced hypothetically 70-80 percent of the designers. So further training of knowledge etc. is difficult. When you have had good cooperation with a number of people but three years later everyone is gone" -BIM-Strategist from company C

BIM-Manager from company D notes that continuity in working with the same client facilitates progression, and the implementation of CoClass is an ongoing process. While some individuals are educated and certified in this area, there remains a need for clear definitions regarding how CoClass should be utilized in projects. The BIM-Manager from company D further adds that efforts are being made within the industry to enhance the number of individuals certified in CoClass, aiming to elevate the classification standard and identify areas for improvement.

"It is important to use and practice the system in real projects to achieve this. Despite significant progress in some projects and with some stakeholders, it is still far from being universally embraced" - BIM-Manager from Company D

The BIM-Strategist (Client 3) from STA emphasizes the significance of STA's inclusion of education for all stakeholders in the digital transformation process, both internally and externally. They stress the necessity for a substantial training initiative to address the forthcoming challenges in digital advancement.

Like The BIM-Strategist (Client 3) from STA, BIM-Strategist (Client 4) from STA also underscores the importance of education as a critical element for navigating the digital journey effectively. They highlight the need for project organizers to grasp the system comprehensively, spanning from planning

to management. The BIM-Strategist (Client 4) from STA believes that such education will be advantageous for the entire industry.

"Those working on the requirements need to understand their role and the importance of their work. This is a bit of a challenge." -BIM-Strategist (Client 4) from STA

5. Discussion and Analysis

This section will describe and discuss the findings from the interviews, focusing on the implementation of a new classification system. How will the integration of a new classification system will look like, and how each side will have to adapt to the potential challenges which comes with it.

5.1 Consultant and Client

This section delves into the different important aspects of understanding the implications of implementation a new classification system like CoClass. It will explore the challenges in finances and resources, regulatory adaptations, communication transparency, and the imperative role of education and innovation.

5.1.1 Finances and Resources

The challenges of today are heavily dependent on financial and resource management, and introducing a new classification system, like CoClass, is costly and resource demanding. The STA is responsible for implementing the new standardization since they determine the requirements and desired outcomes for their projects. Consultants must adapt their approach to project requirements. While a standard classification system like BSAB or SB11 is usually required, it can be customized for individual projects. As The BIM Manager from Company C, the consultant, said, the consultants won't suggest implementing a new classification system unless the client demands it. The BIM Manager from Company C further explains the industry's resource constraints for exploring new systems. It has to be done by outside researchers who are not tied up to resource management in the same manner. The industry is working with slim margins, where research and development is resource and financial demanding for companies. This was further elaborated by the Strategic Data Coordinator from Company A. Implementing a new classification system adds complexity and requires additional effort for the consultants to learn and master it. Companies typically do not send a large portion of their employees for education, as it requires significant resources.

According to the Assistant Project Manager from STA, STA uses both fixed and variable pricing models for their projects, with variable pricing being the more common approach. They highlight the difficulty of setting prices for infrastructure projects. At the same time, the BIM Manager from Company C highlights the prevalence of variable pricing models and the potential benefits of transitioning to a fixed pricing model to enhance product quality. The Assistant Project Manager from STA also emphasizes that the complexity inherent in such projects makes it challenging to accurately estimate the exact number of hours and required information during budgeting. As project details became clearer, it was also common to request additional information throughout the process. By being unable to define the

amount of information included in the models, and the number of hours it's going to take will also be reflected on the quality outcome. Moreover, the BIM Manager from Company C highlights the financial pressures within the industry, highlighting on tendencies to compromise quality to meet minimum standards. This confirms the importance of maintaining quality standards despite economic pressures. This was mentioned by respondents and clients, and something both sides mention as a challenge. As seen from the comments from the consultants and the clients that the consultant aims to maximize billable hours, while the client strives to minimize costs.

According to the BIM Manager from Company C, the STA needs to set higher requirements on the use of CoClass for their projects in order to get higher quality models, but this also incurs extra costs and requires more work from the consultant. At the same time, they confirmed that the industry is a competition, and everyone tries to find loopholes in order to save money, this occurs throughout the process. The BIM Manager from Company C mentioned that the industry as a whole need improved the financial compensation. Otherwise, if compensation remains low, companies will continue to seek loopholes in the requirements to meet their financial needs. Companies in the industry try doing the bare minimum for the project to be passed. As they also mentioned that because of the financial constraints prevalent in the industry, it's a common practice for companies to outsourcing work to countries with lower labor costs and the associated compromises in quality, along with measures taken by STA to address this issue. This reflects the industry's struggle to balance cost-saving measures with quality assurance protocols. The BIM Manager from Company C further emphasized that without a comprehensive and detailed "reception check" conducted by the STA, the overall quality of the project will not improve.

During the process, the STA dedicates considerable time and resources to developing models, as mentioned by the Assistant Project Manager from STA. The models have requirements for both structure and format included, but for management there is still a gap. As it is costly to manage the 3d models, and there is not enough attention for management nor requirement for it. The STA also does not get paid for management of the 3d models. However, there has recently been a change to open up to include the 3d models with the 2d drawings and other documents. The Assistant Project Manager from STA continues saying once the STA is mature enough, more 3d models will be included and managed.

Integrating CoClass into projects can enhance the breakdown of project structures, spanning from investment to management. According to Svensk Byggtjänst (2016), the commonly used BSAB system lacks the detailed level provided by CoClass. This highlights CoClass's significant role in facilitating project understanding, particularly in estimating hours and offering a hierarchical breakdown for enhanced information. Such clarity aids clients in planning both the required hours and the necessary information, potentially elevating project quality through more comprehensive requirements. Consequently, consultants must adapt to this approach, as noted by the BIM-Specialist from STA, who emphasized CoClass's implementation streamlining processes and ensuring requisite information quality. The BIM- Technology Manager from Company D further emphasized CoClass's ability to enhance understanding at more granular levels, thereby enabling deeper comprehension of project structure and format.

5.1.2 Regulation and Adaptation

BSAB and SB11 are two well established industry standards that are incorporated into nearly every project. Integrating a new system like CoClass will inevitably change the operational environment, given that its foundation lies in BSAB and adheres to international standardization protocols (Svensk Byggtjänst, 2016). However, the digital maturity in the industry to adopt a new classification standard needs to be processed. The Assistant Project Manager from STA indicates that the STA is still in the process of integrating BIM and digitalization into its organization, and as of now, CoClass hasn't yet been prioritized by industry stakeholders. This is highlighted by the BIM Manager from Company C, who notes that the latest requirements from the STA make no mention of CoClass. It's anticipated that once the STA reaches a sufficient level of maturity, CoClass will be tried and integrated into projects either in part or in its entirety, spanning from planning to management. CoClass aims to provide a standardized foundation for all project stakeholders, streamlining the entire lifecycle (Svensk Byggtjänst, 2016).

Both consultants and clients are accustomed to incorporating project standardizations into their workflows, as the BIM Specialist (Client 2) from STA describes. Despite the STA's efforts to introduce CoClass since 2019, its implementation has not met expectations. This is what the Assistant Project Manager from STA confirms when they say that although the efforts by STA to integrate BIM and digitalization, there's a slow progress due to factors like lack of maturity in handling 3D-models and a conservative approach towards adopting new systems. This is further emphasized by the BIM Strategist (Client 3) from STA. Therefore, the industry continues to rely on existing systems, admitting with a desire for a modern, comprehensive solution like CoClass to address future digitalization needs. As outlined by Svensk Byggtjänst (2016), CoClass is forward-looking and adaptable to emerging technologies and solutions. This is also confirmed by the BIM Strategist (Client 3) from STA.

The challenge of integrating a new classification system can be linked to the industry's conservative nature, as highlighted by the BIM Coordinator from Company B. With individuals in senior positions with years of experience, there's a tendency to use what's familiar and proven effective. Given that decision-makers are accustomed to specific approaches, they are inclined to maintain the status-quo, preferring structured current methods and familiar systems such as the BSAB system. The wealth of knowledge and experience possessed by the older generation further contributes to this conservatism, as testing new methods may be perceived as risky. The BIM Coordinator from Company B mentions that while project managers may be open for discussions about classification standards, they ultimately go for the one they feel most secure with, given their accountability for project outcomes. This was also confirmed by the Strategic Data Coordinator from Company A and the BIM Manager from Company C as they highlight the industry's resistance to adopting new standards because of established routines, perceived security in existing standards like BSAB, and reluctance to embrace change.

Additionally, the Assistant Project Manager from STA discusses the adherence to standardize protocols, which may vary slightly for individual projects. However, any modifications typically relate to specific details within the classification system rather than the system itself. This is usually linked to requirements from the STA. As the BIM Coordinator from Company B points out, the railway industry's

adherence to requirements from the STA presents a barrier to implementing major changes. Consequently, any external changes face resistance, and it falls upon the STA to initiate any significant shifts within the industry.

5.1.3 Communication and Transparency

According to STA, the main challenge is the lack of understanding what kind of information which should be included into the documents during procurement. The STA does not fully understand what kind of information they need themself during the early stages of the projects, this creates a communication barrier. This is confirmed by the BIM Coordinator from company B, who highlights the issue of the unclear information requirements from the client, which leads to confusion and extra work for consultants. They further emphasize that without clear requirements from the clients, there are great difficulties in adopting new classification standards due to lack of clarity, which in turn leads to a lack of understanding.

The consultants only adapt to what the client wants, and if the information is not there, it won't be done. The requirements are not strict enough, meaning there are always ways to find loopholes and will affect the quality of the project. It seems like a lot of people are aware of the problem, but there is not enough power of action. This was further elaborated by the BIM Manager from company C, where they say that without strict requirements and clear follow up from the clients, there is a tendency to take shortcuts, which creates loopholes in project management. This respondent emphasizes the importance of clients conducting thorough reception control to mitigate risks of models containing shortcuts or loopholes. They also stress the importance of clear requirements from the client and follow up to prevent these problems and ensure quality. As the BIM Specialist (Client 2) from STA said that it was not always clear what information needed themself, as they could ask afterwards for more information. It appears that the client has to be clearer and more transparent, but this is a difficult task since each part of the organization has their own needs. The Assistant Project Manager from STA confirms this and adds that it's challenging for the STA to determine the scope of requirements. This makes communication important as the STA is both planning and managing the project. On the other hand, the Strategic Data Coordinator from Company A confirms this by suggesting that the STA should be clearer and more detailed in terms of the information they request, and the requirements set for their projects. They emphasize the importance of clear specifications to maintain project quality. At the same time, the BIM-Coordinator from Company B highlights the significance of early communication, clear dialogue, and detailed information inclusion in projects.

Specifying more information creates a better understanding of their components and parts of their facilities, but this is easier said than done. Being clear from the start makes it easier for the consultants as well and will benefit the STA once the project is finished. As the BIM Technology Manager from

company D mentioned, including CoClass can help overcome these barriers, as it is implemented throughout the whole process, as it improves communication and collaboration.

On the other hand, the literature also highlights the importance of CoClass to improve communication and increase transparency in the work processes (Planima, 2021). As also outlined by Svensk Byggtjänst (2016), CoClass is considered a potential solution to improve information exchange and the management of complex projects. By offering a common information structure, CoClass can reduce the risk of errors and misunderstandings and facilitate communication between different parties throughout the whole construction process. In addition, according to Svensk Byggtjänst, CoClass covers all stages of the project, from development to management, and its international usability and compatibility with BIM technology facilitates communication between different stakeholders (Svensk Byggtjänst, 2016). By integrating CoClass into the projects, organizations and STAs can improve their ability to manage information exchange and ensure uniform and clear communication over the whole project's life cycle.

In short, it can be said that all respondents from organizations and STA as well as the literature review highlight the need for effective information management and clear communication to improve quality and the success of construction projects. And by implementing standards such as CoClass, they can meet these challenges and enhance better collaboration and results in their projects.

5.1.4 Education and Innovation

The effective implementation of classification systems like CoClass requires significant and enough educational support. This was confirmed by several respondents, including the BIM Technology Manager from Company D, as well as the BIM Specialists (Client2 and Client3) from STA. However, insights from interviews indicate that the infrastructure sector of the construction industry is still not adequately prepared to accommodate such advancements. This is what the BIM-Strategist from company C discussed that these advancements create challenges such as the challenge of high staff turnover in the industry, making it difficult to maintain consistent knowledge. Additionally, turnover can complicate the idea of further training. Therefore, with the rise of digitalization, both sides have to confront these challenges and educate themselves to keep pace with the wheel of development.

To educate also has close ties to the financial part, where educating the personnel and implementing new processes is both resource and financially demanding. As the BIM Coordinator from Company B mentions, it is not common for companies to send all employees to education, where the person learns from his colleagues instead or by himself along the process, and this is a step-by-step process. The same respondent confirms that the disciplines have to become better at using their software in a way which has not been happening before, and this will be visible once CoClass is set as a requirement by the STA. The Strategic Data Coordinator from Company A talkies about that when the industry is controlled, it is difficult to make any major changes. Therefore, if there is a change to a new classification system like

CoClass, these adjustments have to be taken into consideration. Because there is no one educated about CoClass. The BIM Technology Manager from Company D says that they have already started to adapt for the change and had some people which were educated on the CoClass, but this was mainly on the house side, as CoClass was more implemented there. But once CoClass is implemented fully on the housing side, there could be parallels drawn. From the responses of the respondents, it seemed like the companies had has come in various length in their progress of education of the personnel and changing of their processes. CoClass could be implemented in various parts of the projects, but this requires continued efforts from all participants, as mentioned by the BIM Specialist (Client3) from STA.

On the other hand, the respondents from STA also highlighted the challenges of lack of training and knowledge in implementing CoClass. They focused on enhancing a culture of adaptation and continuous improvement within STA. Furthermore, they highlighted the necessity of training personnel to be able to understand and exploit the potential of CoClass system in infrastructure projects. They thought that the implementation of CoClass requires great training efforts and commitment from all stakeholders, both within and outside the STA. This was confirmed by both BIM-Strategists from STA (Client 3 and Client 4), where they emphasized the significance of education for stakeholders in the digital transformation process. They stressed the necessity for the substantial training initiatives to drive development forward.

Based on both the consultant's and the client's insights, the lack of training seems to be a significant challenge in the implementation of CoClass, and this challenge is closely linked to the financial aspect of the project. Furthermore, given the information in the literature review that the company (Svensk Byggtjänst) organizes paid trainings about CoClass, this indicates that the lack of training and knowledge is a central challenge and that these trainings are necessary to deal with this lack. But at the same time, both consultant and client try to avoid the extra costs that can arise by investing in such training measures. This confirms the importance of providing enough training and resources to support a successful implementation of CoClass.

6. Conclusion

The research aimed to explore the potential challenges associated with transitioning from the current classification system to a new one, like CoClass, and to assess the advantages perceived by the STA in this process. The study also sought to investigate the implications for consultants once the STA is ready to implement the new system, whether partially or throughout the entire project lifecycle, for upcoming infrastructure projects

The study concluded that the industry still faces challenges before transitioning from the current classification system to the new implementation of CoClass. The barriers that need to be overcome include financial and resource constraints, regulatory adaptation, communication and transparency, as well as education and innovation. The current standard, BSAB, and its extension, SB11, are insufficient to meet the digital demands for information, communication, and collaboration, as highlighted by both client and consultants.

The challenges are closely interlinked and require a joint effort to solve. Implementing a new classification system like CoClass seemed costly and resource-intensive, with consultants struggling to adapt due to limited margins and existing commitments to well-established standards like BSAB and SB11. Communication issues arise from unclear information requirements, leading to project quality compromises. Additionally, the industry's conservative nature and resistance to change further complicated these difficulties. The industry's high staff turnover and reluctance to invest in comprehensive training also hinder the effective adoption of CoClass, necessitating substantial efforts and commitment from all stakeholders to overcome these obstacles and enhance project quality.

Finally, we can conclude that the implementation of CoClass provides a standardized framework that improves understanding among project stakeholders and facilitates clearer communication of information requirements. Despite the shared willingness of both clients and consultants, challenges within the industry still persist, necessitating a shared commitment to address them effectively. However, as the classification system becomes more developed and integrated into practice, there is a potential for CoClass to serve as the foundation for future infrastructure projects.

6.1 Recommendations for further research:

Regarding future research, it would be valuable to conduct longitudinal studies of projects where CoClass is fully implemented. This would allow for monitoring the implementation process, either partially or fully, throughout the project. The goal is to provide insights into the long-term benefits and challenges of CoClass. Implementing CoClass in practice can help understand its evolution and adaptation to industry needs over time, as well as its impact on project efficiency and stakeholder collaboration

It would also be interesting to conduct a similar study analyzing the entrepreneur's perspective to identify the challenges and benefits they face. Since CoClass can be used from planning to management, entrepreneurs will be able to see its potential advantages.

Lastly, since no solutions were provided for the challenges mentioned in the study, it would be beneficial to expand the research to explore potential solutions. This can help further understand the barriers the industry is facing from a solution perspective and therefore identify appropriate strategies to alleviate these obstacles when implementing CoClass.

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Appendix

Consultant interview questions

Do you want to be anonymous?

Can we record this interview?

Interview Questions

- Introductory Questions

What is BIM, could you give us your definition of it?

What is your main area of responsibility regarding BIM in your work?

What does a typical working day look like for you?

What types of projects have you worked on and how long has this usually lasted?

- BIM-related questions

What type of collection platform of data and information is usually standard within the projects you have been involved in?

Which classification systems do you use, and what is most common in the construction industry?

What type of protocol do you usually use to classify data within the model?

How do you experience the difference between BSAB and CoClass within the projects you have worked on?

How do you think the transition from BSAB to CoClass has worked?

How has your work changed as the client requesteds more data to be integrated into the model?

Is it common for companies to create their own versions of classification systems?

If it is project-based, does this mean you need to do again names and definitions on every new project?

How do you work internally to to stay updated on new systems?

Which classification system do you think works optimally?

Why do you think it differs in the construction industry and people do not choose to be consistent around a common system?

What does the communication look like in order to find the lowest common denominator in the requirements to the client and consultant?

What trainings or preparations have you and your team undergone to stay updated on the latest updates regarding the classification system?

Are there any concrete examples of situations where the variation in terms has complicated communication between disciplines?

Have you noticed any changes over time in how disciplines exchange information and data during the coordination meetings?

- Continued development and future research

How do you think classification systems can continue to develop and change the ways we implement construction projects?

How do you think the amount of data implemented in the BIM model will change over time?

Client interview questions

Do you want to be anonymous?

Can we record this interview?

Interview Questions

- Introductory Questions

What is BIM, could you give us your definition of it?

What is your main area of responsibility regarding BIM in your work?

What does a typical working day look like for you?

What types of projects have you worked on and how long has this usually lasted?

- BIM-related questions

What type of collection platform of data and information is usually standard within the projects you have been involved in?

Which classification systems do you use, and what is most common in the construction industry?

What type of protocol do you usually use to classify data within the model?

How do you experience the difference between BSAB and CoClass within the projects you have worked on?

What does the process look like when the Swedish Transport Administration establishes its requirements for new projects regarding to classification?

Who decides what type of classification should be included in the projects?

How does the transition to CoClass been within projects you/your team have worked on in relation to the industry? But also, at the Swedish Transport Administration in general?

How do you think the transition from BSAB to CoClass has worked?

Which classification system do you think works optimally?

Why do you think it differs in the construction industry and people do not choose to be consistent around a common system?

What does the communication look like in order to find the lowest common denominator in the requirements to the client and consultant?

What trainings or preparations have you and your team undergone to stay updated on the latest updates regarding the classification system?

Are there any concrete examples of situations where the variation in terms has complicated communication between disciplines?

Have you noticed any changes over time in how disciplines exchange information and data during the coordination meetings?

- Continued development and future research

How do you think classification systems can continue to develop and change the ways we implement construction projects?

When do you think CoClass will be implemented and reach its full potential in infrastructure?

How do you think the amount of data implemented in the BIM model will change over time?