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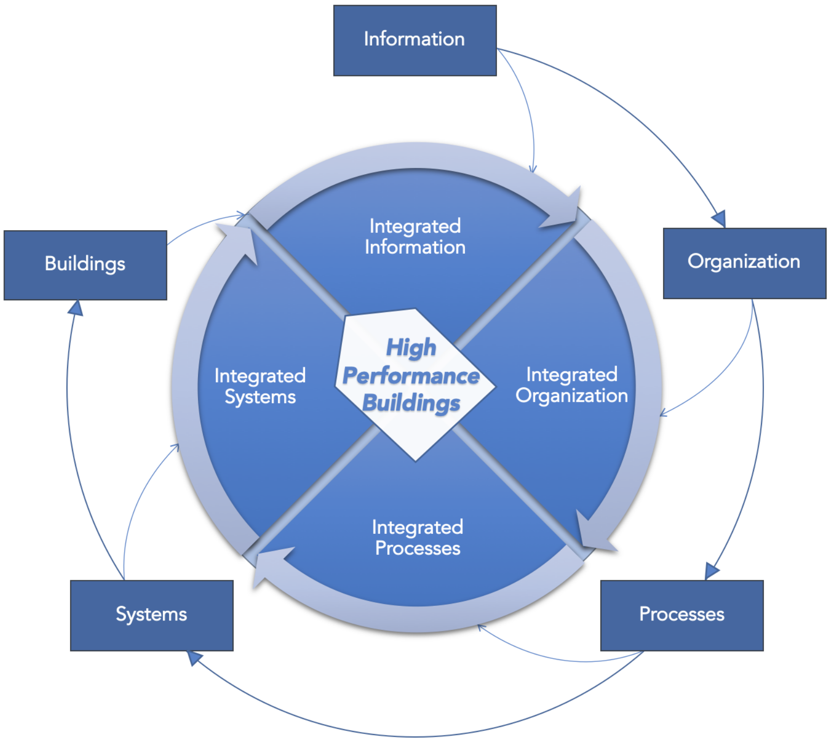


# Project Integration Strategies to Achieve High Performance Buildings

## An interview study concerning Integrated Delivery Methods in the AEC industry

Master's thesis in Master Programmes International Project Management, Design and Construction Project Management

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Gothenburg, Sweden 2019

Master's thesis ACEX30-19-32

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Cover: New Integration Model created by the authors to illustrate the lifecycle aspect of an integrated approach. It further visualizes the IPD aspects required to achieve a transition towards integrated delivery and high performance buildings.

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## Abstract

Construction projects normally include many key participants that are required to cooperate throughout the project to finish on time, within budget and with the accurate level of quality and functionality that the owner requires. However, traditional project approaches within the industry contain a significant degree of fragmentation, which means that the participants tend to work separately and focus on individual work instead of the joint progress of the project. As a result, to deal with problems of the traditional approach, new integrated delivery methods have been developed in order to support coordination, collaboration and innovation within construction projects. An integrated delivery approach allows team collaboration while increasing the value they provide throughout the project lifecycle, while focusing on delivering a high performing building.

The purpose of this thesis is therefore, to examine how the implementation of integration strategies can support the achievement of high performance buildings. Building on the concept of IPD, the purpose is to examine how clients can make the transition from a traditional delivery approach towards an integrated delivery approach. The thesis provides a visual model of how to make the transition, with the aim to find a way to determine the level of integration for organizations to make comparisons between actors of the AEC industry.

The findings of this thesis entail that both formal and informal integration aspects need to be considered in order to carry out projects in an integrated fashion. Suitable tools and methods for each project is dependent on the circumstance around the project, which complicates the aim of giving specific recommendations to clients. Construction projects need to adopt appropriate contractual agreements, that specifically includes incentives that motivates all project participants to collaborate and deliver a well-performed project. The transition towards an integrated approach also requires good leadership, clear communication and extensive follow-up procedures to ensure that proper functions are provided.

Keywords: High performance buildings, Integrated Project Delivery, PLM, ICE, ECI, BIM, Lean.

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Mattias Rundberg, Isak Vendelstrand

Gothenburg, June 2019

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# List of Abbreviations

AEC: Architectural, Engineering and Construction

CAD: Computer Aided Design

DB: Design-build

DBB: Design-bid-build

BIM: Building Information Modelling

CIFE: Center of Integrated Facility

ECI: Early Contractor Involvement

ICE: Integrated Concurrent Engineering

IoT: Internet of Things

IPD: Integrated Project Delivery

PLM: Product Lifecycle Management

POP: Product Organization Process

VDC: Virtual Design and Construction

# 1 Introduction

This chapter starts by introducing background and problem definition of this thesis, followed by the purpose and objective of the study. Delimitations are also presented in this chapter to clearly show what has been studied. Lastly, the contribution of the study concludes the introduction.

## 1.1 Background and problem definition

A large degree of fragmentation exists and characterize the architecture, engineering and construction industry (AEC industry). Property development processes are described as fragmented in all phases of the project lifecycle. The fragmentation of the AEC industry is a consequence of two substantial factors. First, the complexity of buildings can be perceived as considerably high. Secondly, a high degree of specialization in design and construction characterize the industry. Specialization allows organizations to use their specific knowledge and foster new understanding as an advantage against competitors. The AEC sector is specialized because of the division of labour between organizations and organizational positions. Specialization of knowledge can be harmful to the industry since goals and a general understanding of systems and processes are shattered between organizations. It further requires a high degree of coordination and collaboration between participants, that sometimes can be complicated to overcome. Mitropoulos and Tatum (2000) argue that the complexity and specialization lead to less favourable decisions, changes and conflicts during the projects design and implementation phases. Consequently, increased integration of the property development process is an opportunity for improvement of organizational operations (Mitropoulos and Tatum, 2000).

Construction projects involve many key participants that need to collaborate throughout the project to complete the project on time, on budget with the correct level of quality and functionality that the owner requires. However, there is a tendency for participants to work separately and focus on individual work instead of the joint progress of the project. Standard industry contracts and a legacy of litigation is often the causes accountable for selfish patterns in the industry (Harper et al., 2016). The standard construction contracts of today are developed on the basis for Transactional contract law by Williston (1920). The contract structure encourages each party to function within its own goals and procedures rather than aiming to achieve the project objectives (Ghassemi and Becerik-Gerber, 2011). As a result, finger pointing and disputes arise during the projects instead of promoting conflict solving and collaboration (Matthews and Howell, 2005).

Traditional project delivery methods like Design-build (DB) and Design-bid-build (DBB) have been found inefficient and inflexible (Azhar et al., 2014). The relationship between clients and contractors are often adversarial in construction projects governed by traditional contracts. Opportunistic behaviour is less apparent when there is an incentive to cooperatively overcome risks and finalize projects on time between participants. Therefore, it is often assumed that more cooperation between client and contractor will improve the performance of construction projects (Laan et al., 2011). Azhar et al. (2014) argue that the AEC industry would benefit from an alternative delivery method based on integration and trust in construction projects. Large parts of the AEC industry spend a substantial amount of time gathering and analyzing information during project activities. The flow of related information is generally more common than the actual workflow itself. Therefore, collaboration and easy access to information is a fundamental factor to achieve project success (Othman and Al-Maatouk, 2018). To deal with problems of traditional approaches, new integrated delivery methods have been developed (Azhar et al., 2014).

The concept of Integrated Project Delivery (IPD) emerged to maximize value and minimize waste for projects as a cure to the common deficiencies of traditional project delivery approaches. The traditional contractual structure rewards contractors to withhold valuable ideas and improve their performance at the expense of other parties of the project (Matthews and Howell, 2005). The structure is further identified to restrain coordination, cooperation and innovation. The integrated delivery approach contributes to reducing the costs of design changes since the ability to impact cost and functional value is cheaper during the early stages of the project. Design changes that normally occur during the implementation phase in traditional delivery methods become more expensive since most of the design work is already set (MacLeamy, 2008).

The first scholars to write about IPD was published early in the 21st century and has since then been accompanied by a large amount of literature that tries to understand the concept and investigates its impact on trust, innovation and supply chain collaboration (Hall and Scott, 2016). AIA (2007) claims that IPD leverages early contributions of expertise and knowledge through the use of new technologies. It further allows all team members to better realize their highest potentials while increasing the value they provide throughout the project lifecycle. Early collaboration and use of Building Information Modeling (BIM) technology, will provide an approach that is more integrated, interactive and virtually shaped in regard to building design, construction and operation (AIA, 2007).

Nowadays, BIM is acknowledged as an information technology within information management with the possibility to distinctly change the AEC industry. Even though BIM is used for many projects today, the full potential has not yet been reached (Liu et al., 2015). In times where the demand for sustainable buildings has increased, the high performance building concept has gotten a lot more attention. Today, high performance buildings involve not only strategies for low energy consumption but also products incorporated in buildings to prioritize maximum energy conservation and the wellbeing of the occupants. Sustainable high performing buildings further apprehend the quality of the indoor environment, user satisfaction, health and productivity. It is argued that high performance buildings and sustainable buildings are closely connected and interchangeable in this thesis. The level of complexity of projects increases when targeting sustainable goals to achieve high performance buildings. Therefore, interdisciplinary interaction becomes vital for optimized systems in terms of, for instance, mechanical, electrical, lighting, building design and material selection. Complex systems and interdisciplinary interaction propose concepts of early involvement of key participants, more integrated levels of communication and compatibility within project teams to achieve better outcomes. Thus, the level of integration realized in high performance building projects has been suggested to be highly influential the for successful completion of project goals (Mollaoglu-Korkmaz et al., 2013).

## 1.2 Purpose

In consideration of a fragmented AEC industry, the purpose of this thesis is to examine how the implementation of integration strategies can support the achievement of high performance buildings. Building on the concept of IPD, the purpose is to examine how clients can benefit from and make the transition from a traditional delivery approach towards an integrated delivery approach. Regarding the current fragmented and unintegrated working processes of the industry, the purpose is to further study integrated collaboration arrangements in order to facilitate coordination of sustainable facilities.

## 1.3 Objective

The objective of this thesis is to examine how an integrated delivery approach can be established to achieve sustainable high performance buildings. Originating from a traditional delivery approach, the aim is to study how new methods or tools can be applied to elevate traditional ways of working to a more integrated approach. Therefore, the first research question for the study considers the following:

- **RQ1:** What are the benefits of working more integrated compared to a traditional delivery approach?

The thesis provides a visual model of how to make a transition from traditional delivery to integrated delivery, supported by the integration strategies presented in this thesis. The aim is to find a way to determine the level of integration for organizations, in order to make a comparison between actors of the industry. Consequently, the second research question becomes:

- **RQ2:** How can the level of integration for actors of the industry be measured and how are the aspects interconnected?

By identifying the level of integration for different organizations, this thesis intends to investigate the underlying factors that constrain the conditions for collaboration within the AEC industry. Thus, the third research question is distinguished as:

- **RQ3:** How can incentives and compensation models support collaboration and integrated ways of working?

The relationship between project integration strategies and high performance buildings is also addressed and emphasized. As a result, the final objective is to give appropriate recommendations to clients that want to integrate the processes of their construction projects and therefore realizing a better performing final product. Which is why the fourth research question is recognized as:

- **RQ4:** Which project integration strategies could clients benefit from and how can they manage the aspects of integration?

## 1.4 Delimitations

The thesis concerns the formal and informal project integration strategies, but there will be not as much focus on formal issues such as contractual arrangements. The thesis mainly focuses on the informal integration strategies but also discusses the formal strategies briefly since they interrelate in terms of implementing integrated delivery approaches. Another delimitation of the thesis concerns the search words.

Only English search words have been used when searching for IPD literature during the literature review, which may have limited the thesis from Swedish literature. The reason for the delimitation is that the IPD concept originates from the US and has not yet been applied to Swedish projects.

The term "building" in high performance buildings should be interpreted as a method and final product of construction projects, not only house projects. Furthermore, the tools and methods for project integration are recognized for each aspect but not in-depth. The tools and techniques mentioned in this thesis are limited to qualified examples of specific ways to integrate construction projects since it, naturally, exist other methods and technologies of integrating work processes.

## 1.5 Contribution

With the intention of giving the AEC industry a broader understanding of the subject, the study aims to contribute with the knowledge and advantages of making a transition towards an integrated delivery approach. This thesis contributes to research with an assessment tool to determine how far companies have come with their work of integrating processes. The thesis also examines its applicability throughout the different construction phases. Ultimately, this thesis intends to contribute clients with awareness as well as strategies of how they can sustainably integrate their projects.

# 2
# Theory

In the following sections, the relevant theory according to the topic of this thesis is presented. The theoretical framework is based on literature in the shape of both articles and books. First, the theory regarding high performance building is provided, followed by the theory of traditional and integrated delivery approaches. Further, the implementation of IPD and integrated delivery methods are discussed. Lastly, the various aspects according to the model for project integration is addressed, namely integrated information, integrated organizations, integrated processes and integrated systems.

## 2.1 High Performance Buildings

As a general term, high performance building is planned to describe buildings that are designed, or modified, to a higher and more advanced standard of performance. This performance standard reaches a percentage benchmark above the average of current requirements (Robinson, 2014). Robinson (2014) defines high performance building as: ‘’an integrated systems approach to design, engineering, construction and operations which cuts waste, optimizes resource efficiency, improves cost, reduces environmental impact and maximizes occupant comfort” (Robinson, 2014). Therefore, the term ‘’high performance building” signifies a building that is integrated and produced to optimize the most important high performance building characteristics. These characteristics concerns, for instance, durability, energy efficiency, occupant productivity and lifecycle performance (United States Congress, 2005). It further means that it is necessary to calculate and analyze the energy performance of the building in order to validate forecasted performance objectives for both new and reconstructed buildings. However, the definition of the term has been continuously developed over the past years, and what might be defined as high-performance a couple of years ago may not be high-performance regarding today’s standards. The reason for this is that the reference point for minimum performance objectives is increasing when the building codes are modified and improved (Robinson, 2014). Figure 2.1 illustrates requirements and measurability of a high performance building.

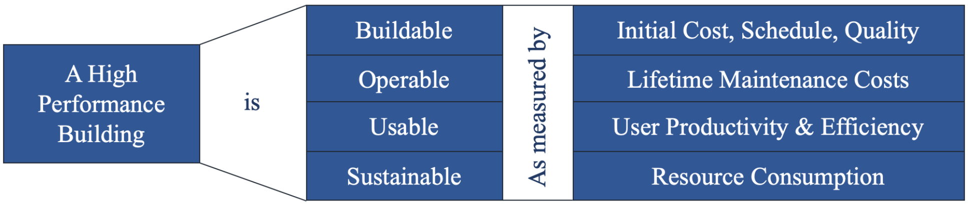


**Figure 2.1:** Requirements and measurability of a High Performance Building (Hall and Levitt, 2018).

According to Figure 2.1, which is also emphasized by the Center of Integrated Facility (CIFE), it is a necessity for high performance buildings to meet all of the requirements regarding the four focus areas – buildability, operability, usability and sustainability (Hall and Levitt, 2018). The project has to be buildable in terms of cost, time and quality, and it needs to be operable in terms of maintenance costs of the facility throughout its lifecycle. Additionally, the project needs to be usable, allowing efficiency, productivity and comfort for residents in the building. Ultimately, the project has to be sustainable, with focus on minimizing the usage of resources such as water and energy. By fulfilling these four areas, the building can be classified as a high performance building (Hall and Levitt, 2018).

## 2.2 Traditional approach

Design-bid-build (DBB) contracts are the most frequently used type of project delivery approach for the majority of construction projects in general. It is considered to be the "traditional" delivery method. Other types of traditional delivery methods are Design-build (DB) projects. DB projects are focused on accelerating the delivery through parallel design and construction activities. As for many types of projects and delivery methods, DB projects are conceptualized by the owner. The owner set the objectives to be met and the planning is carried out aligning the economic and technical feasibility of the project (Forbes and Ahmed, 2010).

### 2.2.1 Traditional process

The traditional delivery methods of construction projects cannot always meet the requirements for high performance buildings (Hall and Levitt, 2018). The reason behind this is an AEC industry that is distinguished by an extensive fragmentation among project stakeholders, as well as a significant inclination towards focusing on primarily minimizing costs in opposition to maximizing value throughout the project lifecycle. The aforementioned fragmentation is frequently mentioned as the reason behind poor project outcomes (Hall and Levitt, 2018). As a result, clients tend to show a greater interest in project integration strategies to achieve high performance buildings.

Fischer et al. (2014) challenge traditional delivery by introducing a new perspective on IPD where strategies of the organization, work methods, work processes and information management are derived from the value created through design and construction of a building. The new perspective is called "A simple framework" and it aims at describing areas that needs to perform at a desired level of performance when delivering a high performing building. It builds on two major perspectives, American Institute of Architects (AIA, 2007) guide to IPD and Virtual Design and Construction (VDC). The simple framework is presented in Figure 2.2.

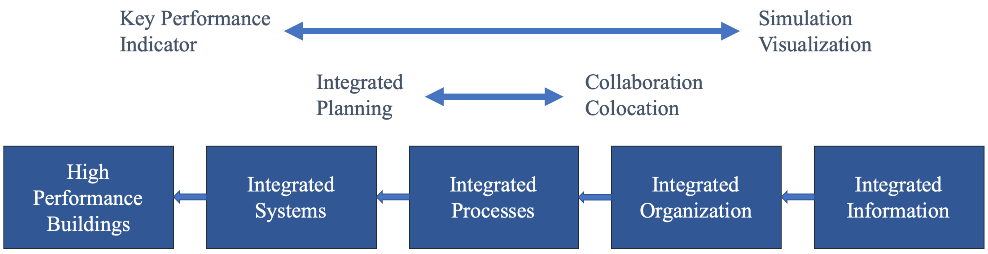


**Figure 2.2:** A simple framework (Fischer et al., 2014).

The different aspects of information, organization, processes and systems are methods based on VDC implementation that support and compliment the aspects of integration. The methods described in Figure 2.2 are simulation and visualization, collaboration and colocation, integrated planning and key performance indicators (Fischer et al., 2014).

Project integration strategies could be recognized as specific tools and methods to integrate the information, organization, processes or systems of project teams (Hall and Levitt, 2018). The project integration strategies can be identified as formal or informal. Formal project integration strategies concern, for instance, contractual arrangements whilst informal project integration strategies relates to the project culture and team behaviour. The project integration strategies are illustrated by the vertical arrows in Figure 2.3, and consist of tools and methods such as BIM, ICE, ECI in the context of lean philosophy. These strategies can be implemented in order to make traditional processes more integrated. Figure 2.3 is created by the consultancy company Plan B AB to illustrate aspects that need to achieve an elevation of integrated processes towards a high performance building. The model originates from the simple framework of IPD made by Fischer et al. (2014) and compliments the previous version by focusing on the elevation of different processes required with the purpose of motivating organizations to make the transition.

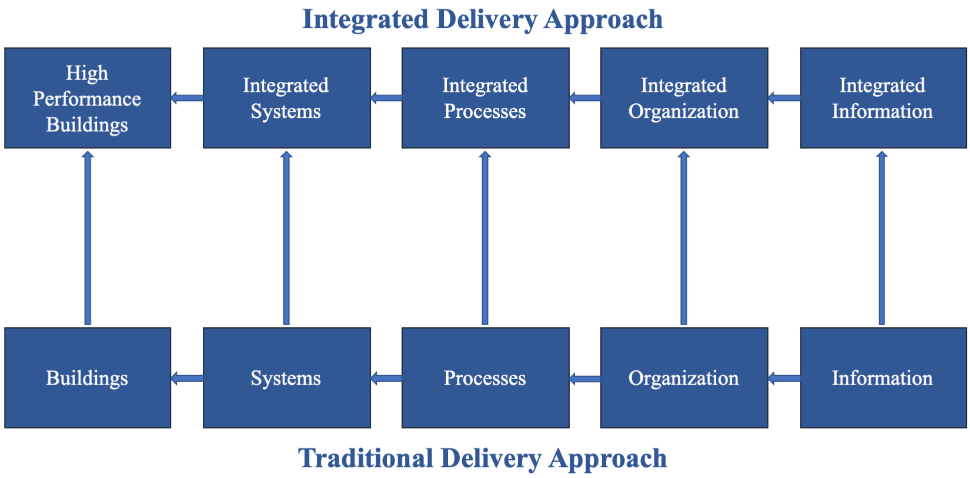


**Figure 2.3:** Model for project integration, used to visualize aspects required to elevate processes of project integration. Created by Plan B AB, 2018.

The various parts of the model, as well as the integration strategies, will be addressed and further explained in the sections from 2.5 to 2.8 in the theory chapter. It should be noted that this model represents aspects of integration and should not be mixed with the process of designing and building a facility itself. The model for project integration with its including aspects can be applied to the entire process of building a facility but also to each step of the building process. Hence, these aspects should be considered as components to a successful project integration.

Full project collaboration is generally opposed or discouraged in the traditional AEC industry (The Construction Users Roundtable, 2004). This is due to a long-lasting industry culture in conjunction with the fragmented supply chain that describes the majority of construction projects. For instance, in traditional building projects, the design and construction actors align and execute a single project, then after the handover, they dissolve and will most likely never work together in the same formation again. Therefore, not only every building is unique but also every project team. This means that the gained knowledge and important learnings from a project only proceed in a fragmented manner towards future projects. By constantly submitting to a traditional approach, with the roles and characteristics that are included, owners usually assign responsibility to other parties in order to coordinate and to drive the project process forward. Which means that the owners are not assertive in commanding and not able to implement new enhanced processes in order to reach improved results (The Construction Users Roundtable, 2004).

### 2.2.2 Limitations of traditional contract approach

In traditional contracts, subcontractors and consultants are usually summoned to the project by the general contractor during the design development stage of the design phase when competitive prices are of importance for the general contractor. Before the design development stage takes place, a couple of subcontractors and consultants are consulted regarding configurations and ideas about the project. Although many actors are consulted and asked to give input to the design process, there is no real commitment for them to provide the best solutions at this stage. Information, ideas and solutions to potential problems in the project become a competitive edge during the bidding process. Opportunity for innovation and time is lost since the best ideas arrive too late and the design team needs to change and accommodate the new changes (Matthews and Howell, 2005).

Another problem regarding traditional trades is the system of subcontractors that form the framework for the relationship of the project. Normally, the prime contractor holds the contract for all subcontractors and consultants which makes communication between participants more complicated. The contractual agreements for subcontractors involve a great deal of detail of what is to be delivered and expected from each party. It includes rules for compensation and when the work is to be performed. These extensive contracts mostly deal with remedies and penalties for noncompliance. Too complex contracts hamper innovation across boundaries as well as for tasks outlined in the contract. Managers experience it difficult to coordinate several actors simultaneously, especially when the actors lack proper commitment. Some projects have partnering-like sessions where all actors meet and the work is planned out together, but unfortunately many projects lack formal efforts to link the planning systems for subcontractors or any form of mutual commitments and expectations for involved parties. Furthermore, the result of uncoordinated planning creates conflicts of interests when different work tasks intersect (Matthews and Howell, 2005).

Participants and subcontractors strive to optimize their own performance instead of fostering collaborative efforts since the subcontract agreement and the difficulties to coordinate, motivates subcontractors to defend their own interests (Ghassemi and Becerik-Gerber, 2011). Egocentric approaches stifle the construction sector at the expense of other parties. To conclude, subcontracting agreement acts as a moral compass for all parties since participants often take legalistic and litigious stances (Matthews and Howell, 2005).

## 2.3 Integrated delivery approach

Integrated delivery could be perceived and recognized as a project team of clients, contractors, consultants, fabricators and users cooperating with each other in an environment of enhanced collaboration and information sharing, where the most recent BIM technology is leveraged. However, an integrated delivery approach reaches beyond individual projects and involves the entire lifecycle of the built facility. It concerns the relationship between clients that extend over time, multi-project portfolios and programs that profit from the knowledge growth and acquired information as new strategies are implemented, different solutions tested, and performance measured and analyzed.

Therefore, the essential basis of integrated delivery is to improve project value, quality and sustainability while at the same time reducing potential risks. The aim for an integrated delivery approach is to exploit these opportunities and to extend these outcomes throughout the whole company, and not just for individual projects.

MacLeamy (2008) argues that the implementation of BIM should improve the design efforts to the phases of schematic design and design development. The researcher further states that additional efforts at early design phases will lead to improved execution and solve many deep-rooted problems associated with traditional DBB procurement systems. The time-efforts distribution curves can be used to measure implications of overall costs or benefits for the BIM implementation (Lu et al., 2014). An integrated approach transfers the required workload that is traditionally related to construction documents, so it transpires earlier in the design phase. As a result, opportunities arise by taking advantage of the fact that decisions being made earlier in the design process are less expensive (The Construction Users Roundtable, 2004). In Figure 2.4, an adapted MacLeamy's time-effort distribution curve can be found.

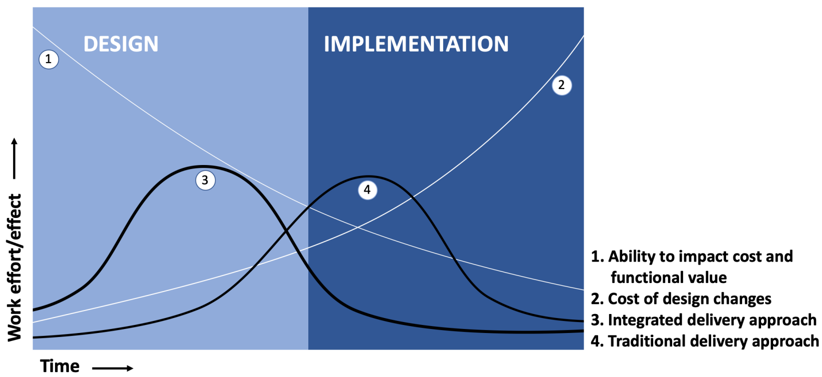


**Figure 2.4:** Adapted MacLeamy curve illustrating the benefits of pushing design work forward through time-effort distribution curves (MacLeamy, 2008).

Figure 2.4 contains four curves. The first curve that is numbered one, indicates the ability to impact cost and functional value as a project advance. The second curve indicates the cost of design changes in relation to time progressed. The third curve shows design effort distribution in integrated delivery approaches and the last curve, referred to as number four, express traditional delivery approaches of AEC processes. Normal traditional delivery efforts include separate efforts from participants. DBB procurement systems comprise a large separation between designers and contractors. Integrated efforts (curve three) encourage, for example, early collaboration and open information sharing from all participants during design development phases (Lu et al., 2014).

The saved efforts as a result of a successful implementation of BIM can be measured by subtracting the two enclosed areas generated by the horizontal and vertical axis and each curve numbered three or four. Curve four represents traditional delivery methods without BIM implementation and curve three represent integrated methods with BIM implementation. The difference equals saved efforts using BIM combined with other integrated methods (Lu et al., 2014). Table 2.1 briefly explains the main differences between traditional project delivery and integrated project delivery.

**Table 2.1:** Comparison between traditional project delivery and integrated project delivery.

| | **Traditional Project Delivery** | **Integrated Project Delivery** |
|---|---|---|
| Phases | Design, Implementation | Design, Implementation |
| Team | Hierarchical; consultants engaged on an only-as-needed basis | Collaborative; consultants engaged earlier in the design process |
| Work effort | Surge of work effort occurs late in the process | Surge of work effort occurs early in the process |
| Decision making | Late | Early |
| Team knowledge | Surge of work effort results in knowledge drop-off | Surge of work effort results in earlier knowledge drop-off |
| Collaboration | Limited collaboration between silos of expertise | Increased collaboration; mutual respect between parties |
| Decision sharing | Avoided | Encouraged |
| Technology | 2D/3D CAD | 3D/4D BIM |
| Agreements | Standard agreements; goals and objectives are misaligned | Goals and objectives aligned through multi-party agreements |
| Risk | Higher | Lower |
| Performance metrics | Schedule/Cost/Quality | Schedule/Cost/Quality, Sustainability |

### 2.3.1 Integrated Project Delivery

Integrated project delivery (IPD) is an approach to deliver projects that focuses on bringing all participants together and utilize the knowledge, talent and insights of the project team members to optimize the project collaboratively. The approach is a process that emphasizes the integration of people, systems, business structures and practices to increase the value to the owner, waste reduction and efficiency of all phases of the project (AIA, 2007). Unlike other alternatives, IPD focuses on the overall progress and integrates processes, tools and people in a system. The previous alternative delivery systems focused on specific areas of project delivery and lacked the overall view of improvement for project delivery (Azhar et al., 2014).

IPD is an approach that deals with how organizations handle and execute construction projects. To implement IPD in its purest form, there are a few characteristics that differentiate traditional delivery methods from IPD projects. The characteristics of an IPD project are as follows:

- A multi-party contract
- Early involvement of key participants
- Collaborative decision making and control
- Shared risks and rewards
- Liability waivers among key participants
- Jointly developed project goals

There are different levels of IPD implementation and not all projects employ all of the different characteristics. Some projects sample a few of the characteristics to accomplish a higher efficiency while other projects need to adopt more of these characteristics. In summary, the most fundamental differences between traditional delivery methods and the IPD approach are categorized in terms of contracts, team relationship and compensation structures (Ghassemi and Becerik-Gerber, 2011). IPD principles can be applied to a variety of contractual arrangements and IPD teams will usually include participants well beyond the basic triad of owner, architect, and contractor. It therefore requires the use of relational contracts or a single agreement that all the key participants' signs. Subcontractors and suppliers are sometimes also added to the contract if needed. The approach of IPD is a change of business that integrates participants and aligns all interest towards a successful project outcome. It requires leadership from owners and full commitment from all team members. It further requires a mind shift from the traditional way of working towards its foundation based on trust and willingness to collaborate. BIM and lean design and construction concepts can be used as tools to ease and compliment the facilitation of IPD.

BIM and IPD are two separate and independent concepts, however, synergies have been known to appear between the two (Azhar et al., 2014). The correlation between BIM and IPD is sometimes rather direct and uncomplicated, whilst in some occasions, the connection could be more problematic. Efficient use of BIM has the potential to facilitate the high-level of collaboration that is required in IPD projects. The type of data that is being exploited with BIM has a direct effect over the IPD execution. By ensuring data accuracy and reliability by successfully managing the building information, decision-making will be facilitated, and more reasonable goals could be achieved for the construction projects. BIM creates the possibility to visualize the design before the construction phase, which has a certain effect on IPD projects by making them more integrated through multi-user collaboration with a design of higher quality and improved control over the projects. Besides, quantity takeoffs are more easily performed and precise by applying BIM to IPD projects, allowing more accurate estimations of project costs which in turn could lead to an improved and more beneficial risk and reward arrangement between the partners in IPD projects. Further, it could be benefited in order to establish and validate cost-related goals for the construction projects (Azhar et al., 2014). Ultimately, even though there are many advantages of using IPD, the implementation can be challenging (Azhar et al., 2014).

### 2.3.2 Partnering

The partnering business model and marketing strategy was first introduced and established in the USA in the middle of 1980s. Since then, it has been widely adopted and used in several countries as an attempt to be more innovative and to overcome adversarial relationships resulting in industry performance problems (Crespin-Mazet et al., 2015). The concept got introduced in Sweden around 1990s and it is still evolving (Bjerle, 2014). Partnering is an alternative coordination mode to a standard project development process with separate sequences. The focus lies on promoting collaboration, more open and less hierarchical relationships between project stakeholders to reach better integration and supply chain management. However, incorporating the partnering business model and strategies does not come without difficulties. Nevertheless, the potential benefits associated with the model are increased productivity and quality, reduced transaction costs and projects times, improved customer satisfaction and stability, facilitation of joint risk management and allocation, reduced disputes and enhanced learning (Crespin-Mazet et al., 2015). Hence, a number of critical success factors need to be met for a successful partnering agreement, Cheng et al. (2000) underline the following factors for a successful implementation to be: effective communication, conflict resolution, adequate resources, management support, mutual trust, long-term commitment, coordination and creativity.

### 2.3.3 Product Lifecycle Management

Product Lifecycle Management (PLM) is the system or method of managing an organization's products throughout their entire lifecycles in the most efficient manner (Stark, 2015). The product lifecycles extend all the way from the initial idea to the retirement and disposal of the product. Therefore, PLM is considered as a management system for a company's products, signifying that it manages every part of the product as well as the product portfolio. This means that PLM includes the complete span of the products, from individual part to individual product and, finally, to the full portfolio of products (Stark, 2015). In this case, the projects are handled as products. The PLM platform could be used as one source of data where facilities are displayed as digital objects with digital defined processes, to be able to manage and compare information between different construction projects. The various actors involved in the projects can also communicate with each other through the PLM platform which enables the value of the project to be maximized over its lifecycle. By exploiting the full potential of PLM systems, the purpose and aim is to decrease project related costs and increase project revenues, and maximize the value of the project portfolio, concerning both current and future projects for customers and stakeholders.

## 2.4 Implementation of IPD

Few projects have been reported to be delivered under IPD systems today and its implementation is limited due to many reasons. The factors influencing the implementation of IPD and management-driven integration as a foundation for an integrated delivery approach can be broadly classified under legal, organizational and technological issues (Azhar et al., 2014; Mitropoulos and Tatum, 2000).

### 2.4.1 Legal factors

There are two different criteria for procuring design and construction services of present law that impedes utilization of the IPD concept. Public architect and engineering consultant services are procured through negotiated contracts based on competence and qualification for the required service at a reasonable and fair price. In public procurement law of construction services, the selection of contractors is based on the lowest responsible bid through an open completion. Additionally, the design documents need to be completely finished to be able to select the winning contractor. Thus, it does not acknowledge the involvement of key participants at the early stages of design. It further constrains multi-party agreements, shared risks and reward which all are key characteristics of IPD. Traditional public procurement is therefore not very compliant with the IPD concept since many of the features are prevented by the procurement laws. Private clients do not have to follow public client procurement directives and do not have to follow the same rules in the tendering process (Azhar et al., 2014).

Azhar et al. (2014) argue that risk allocation of traditional delivery methods is unfavourable for implementation of IPD. The risk allocation mechanism hinders the sharing of risks and rewards. Due to the fragmented construction industry of today, parties try to transfer the blame to other participants in case of delays, cost overruns or conflicts that arise at the construction site.

### 2.4.2 Organizational factors

Applying many key characteristics of IPD and implementing pure IPD is a challenge for most public organizations. At the same time, IPD is becoming more common for private sector organizations in many countries. The IPD approach can be used to all kinds of projects and organizations even though the general perception of IPD is that it mainly should be used for more extensive and complex projects because it implicates substantial initial cost investments, efforts of design and involvement of the owner (Azhar et al., 2014). Azhar et al. (2014) further argue that IPD is an excellent match for repetitive designs as well as unique projects since it allows participants to re-use and develop the projects based on previous designs. Previous projects function as lessons learned and become a source of knowledge for future projects. The project teams can at this point implement standard agreements, effective business models and conceptual designs when starting up new similar projects.

The culture of the organization has an essential role in a proper implementation of IPD. Willingness and knowledge of the owner is another important feature for IPD implementation because it requires active owners and good leadership. IPD confronts the cultural norms and requires more productive collaboration between project members and profound changes in the workplace, atmosphere and relationships in an organization. Organizations that are looking to make a transition towards more collaborative delivery methods need to accommodate a change of the organizational structure. The owners, in particular, need to recognize this paradigm shift and take suitable actions. The resistance to change imposed by the IPD concept will occur naturally but can be reduced if appropriate information and communication is transferred about its positive effects on work processes (Azhar et al., 2014).

### 2.4.3 Technological issues

Legal ownership, liability issues and concerns about interoperability are the most apparent challenges to the implementation of IPD in terms of digitalization. The integration of technology is a great tool to improve collaboration, communication and information management but it is also a challenge to maintain and harvest its full potential. The IPD concept is built on having efficient communication and collaboration which demands suitable support from the project IT infrastructure. Good and efficient IT infrastructure should be able to receive, store, retrieve and code information to support the requirements of the internal and external informational management. It could also support real and virtual settings for better visualization and other positive benefits of new technology. However, it is not compulsory to have IT infrastructure for implementation of IPD (Azhar et al., 2014).

## 2.5 Integrated building systems

To reach a high performance building, systems and components of the building cannot be drawn and assembled in isolation. Neither of the systems can further be designed according to the purpose and specifications made initially without clear communication and collaboration between actors. A building component itself require certain amount of space that will interfere with the usable volume of space for the end user but also with other components in the building, which is why the integration of building systems and actors is a necessity to achieve a high performance building. The final product as a whole need to function together instead of a mixture of many disparate systems. Even simple buildings involve components or parts that need to be integrated, a waterproof facade, for example, need to be integrated seamlessly with all other functions, sub-systems, fabricators, and contractor who construct the building etc. (Fischer et al., 2014).

Integrated building systems provide certain connectivity, which is observed as a crucial benefit over the existing disconnected and more separated systems (Maile et al., 2007). It facilitates information and system management for facility operators due to the reason that the integration offers the essential and required connectivity. Gathering synchronized information from different non-connected systems could be difficult because of the fact that the systems do not communicate with each other and that they most likely have very separate and dissimilar graphical interfaces (Maile et al., 2007). There is a significant monetary award, and time advantage, by connecting these systems in the early phases of the building design.

### 2.5.1 Internet of Things

Internet of Things (IoT) can be leveraged to provide complete connectivity to further integrate the building systems. At the moment, a large number of applications have been established, and are advancing, in the building environment (Ahuja, 2016). As the internet proceeds to nourish the attainment of integration, it is positive that a more accessible and connected building is equivalent to a more efficient and intelligent building. Several organizations are leveraging this by connecting integration protocols to more prominent internet-enabled services that offer a more modernized and efficient exchange as well as an analytical data source for the building. The services function in a way that simplifies and support the interaction of the building management systems. IoT is a way of providing the possibility to control the building environment for the end user, without the necessity of comprehending the complexities of it (Ahuja, 2016). Therefore, IoT facilitates system management for both facility operators and end users through total integration of the building systems.

## 2.6 Integrated processes

To achieve high performing buildings, it is learnt from experience that all systems need to be highly integrated. To create an excellent final product, there is a lot of building-related aspects to consider. Processes integration is all about bringing inputs and preferences of design together to utilize the full potential. It can be explained as all choices and inputs to be made during the projects as separate processes. Inputs of lighting in a building will be used to conceptualize and exemplify process integration. Lighting is dependent on inputs like daylight, space and volume of a room, exterior and interior aesthetics, open or private offices, are there any corridors, electrical wiring, energy consumption, feature control and intensity modulation devices etc. All inputs to lighting need to be integrated and formulated to an output that is valuable to its users that can be built and operated smoothly in a sustainable way (Fischer et al., 2014). Figure 2.5 illustrates the five main types of process integration as to establish a high performing buildings.

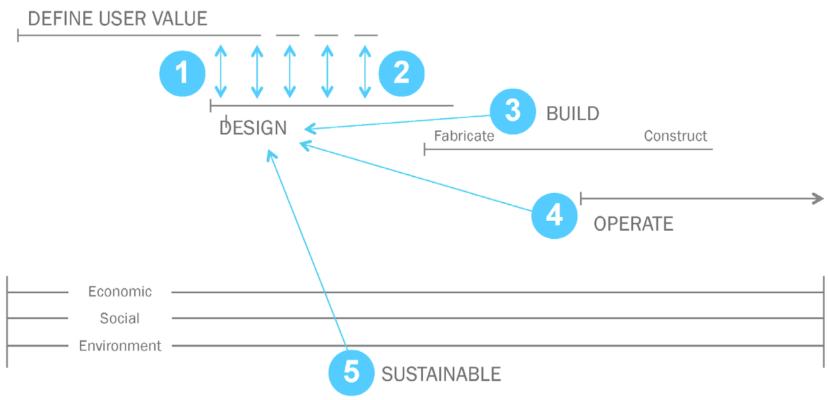


**Figure 2.5:** Five main types of process integration to achieve high-performing buildings (Fischer et al., 2014).

The first type of process integration is referred to, in Figure 2.5, to the overlap that is required for the owner and users to articulate their wishes and values, to frame the possible design and its costs. The second process required for a successful process implementation is to validate the design with the user values, as the design work progresses. The third step is to bring the construction perspective to the design process since the documentation and creation of buildable design is a very significant factor. Without all inputs made during previous steps as well as inputs from participants who will carry out the construction, a buildable output is hard to produce. The fourth step is to bring operational knowledge to the design phase to ensure appropriate operational maintenance. Utilizing knowledge of how to manage and operate the building is essential in order to have an operable facility. Lastly, the fifth process is for the integrated project team to consider sustainability during the whole lifecycle of the building in regards of economic, social, and environmental contexts (Fischer et al., 2014).

To conclude, these five integration processes emphasis design since that is what shapes the building and creates a facility that articulate ideas, needs, and wishes of the facility owner and users. The probability of succeeding with a facility that is valuable to the end user is much higher with a clear strategy adopting the five processes (Fischer et al., 2014).

### 2.6.1 Lean philosophy

Lean philosophy forms a basis for new project delivery processes where objectives, principles and techniques of lean are brought together. Unlike efforts of DB and other traditional contracts, a lean philosophy provides a foundation for new operations-based project delivery system (Forbes and Ahmed, 2010, p.45). Forbes and Ahmed

(2010) describe lean philosophy as a continuous process of minimizing and eliminating waste, meeting or exceeding customer requirements, concentrating on the whole value stream, and pursuing perfection in the implementation of a constructed project. With generally increased focus towards reducing the carbon footprint and reducing operating costs of construction project within the AEC sector. It is argued by Forbes and Ahmed (2010) that having a multi-skilled team working in close collaboration from the project definition, design, and eventually construction is the best way to have a facility that not only meets the owner's requirements but also improves both initial costs and operating costs. Utilizing e.g. BIM technology and other integration methods of IPD finds support in the lean philosophy (Forbes and Ahmed, 2010).

Lean design production system in construction originates from and uses concepts and ideas created in manufacturing. Construction processes are seen as fragmented which leads to less efficient processes. To date, practitioners from downstream phases are not involved in the early phases of the project and do not participate in making key decisions that positively impact efficiency. (Kemmer et al., 2011). Lean philosophy relates to process improvements in order to build facilities that meet the client's needs while using minimal amount of resources. A lean philosophy requires contemplation over the workflows within construction projects, with emphasis on recognizing and eliminating obstacles. Hence, lean construction focuses on workflow steadiness (Eastman et al., 2011).

## 2.7 Integrated organization

To perform work that adds value, leadership, coordination and decision making are necessary tasks that all integrated teams and sub-teams need to consider in order to achieve an integrated facility. What differs traditional organizational work from integrated organizational work is that team members need to prioritize the product and scope of the project to evaluate whether alternatives of design meet the owner's goals and objectives before executing a decision. It is done by describing and explaining design alternatives currently under consideration from the perspective of their discipline to the other project participants. It further involves a prediction of the expected performance and how it will affect the project scope and final product. Alternatives will create conflicts of interests and needs to be negotiated and adjusted to find the best optimal solution with user performance in mind (Fischer et al., 2014).

The best way to make the organization integrated is to derive the work from the product. It can be done by applying design thinking by asking the questions of what is the function, structure/form and behaviour required from the three domains the project team need to control. The domains are the product, the organization and processes (Fischer et al., 2014). The project manager is able to regulate and control the design of the product, how the organizational chart is arranged for the designing and constructing project teams and all the design-construction processes that the organization needs to follow (Kunz and Fischer, 2012). Kunz and Fischer (2012) further combine these design domains in a three by three matrix, called the POP-model, where the meaning of the features of Product, Organization and Process are defined from a stakeholder perspective. The POP model is a generic model that is used to define conceptual elements from the industry to help stakeholders assure that appropriate specifications are made in terms of the product, organization and processes. The matrix of the POP-model can be found in Table 2.2.

**Table 2.2:** POP matrix for a High-performance Building (Fischer et al., 2014).

| Question/ Lever | Product | Organization | Process |
|---|---|---|---|
| **Function** | A high-performing building supporting the value desired by the owner. | Integrate builders' and operators' knowledge in design with user needs to create sustainable value. Engage everyone in a meaningful way. | Lead.<br>Coordinate.<br>Work (learn, predict, decide, commit, act).<br>Decide. |
| **Structure/ Form** | Appropriate high-performing building made of healthy building materials that enhances, not displaces the environment. All of the features and elements (the scope) promised are built (no compromises for cost). | Engaged Leadership<br>Multi-disciplinary/ Cross-functional Teams. Direction and Coordination.<br>Information-Infrastructure.<br>Workplace. | Target Value Design.<br>Integrated Concurrent Engineering.<br>Virtual Design and Construction.<br>Plan Do Study Act.<br>Lean/ Pull Production. |
| **Behavior** | The building helps rather than hinders people doing their work. Very little grid energy is required.<br>Indoor air quality is excellent.<br>Inhabitants are always comfortable.<br>Little water is used. | Good (useable, buildable, operable, sustainable) decisions are made that advance the project. Aligned action produces value. More alternatives are thoroughly evaluated. Design disciplines develop solutions interdependently, in the same levels of detail. Ways of learning and testing are consistent across cluster teams. No one recreates available information because it's not in a form they need. High frequency and quality interactions to share knowledge | What is needed is clear and achievable Response and decision latency dramatically reduced Possible solutions can be tested and outcomes predicted with confidence. Continuous improvement to produce quality products. Waste is eliminated to deliver greater value |

### 2.7.1 Early involvement of key participants

Early contractor involvement (ECI) is a procurement management concept and strategy for project integration. ECI provides an opportunity to use contractors' specialist knowledge in the design stage to mitigate common problems that would appear later at the construction phase. To avoid issues of separation between buildability for design and constructability for the construction, ECI is a promising strategy that integrates design and construction at early stages. Plenty of benefits of ECI have been found by researchers and the three most important features are the opportunity for better relationships, better risk management and contractors input to design. These factors indicate that relationship-related features are prioritized over other benefits. Studies show that implementation of ECI can be challenging because it requires a large amount of effort and willingness from participants to change behaviour and routines. Alterations can be perceived as threatening and therefore troublesome to handle. Conflicts of interest might arise between designers and construction representatives during the design phase (Pheng et al., 2015).

### 2.7.2 Integrated Concurrent Engineering

To improve the performance and productivity in construction projects, practitioners and researchers took inspiration from the manufacturing industry and imported Concurrent engineering (CE) as an attempt to improve the work processes in the construction industry. Concurrent engineering is a design process where all stages of the product lifecycle are considered. All stages from the early conceptual stage of design to more detailed design stages are brought together and overseen in this application. The purpose is to increase the quality of the product and to decrease costs and time spent on development through the integration of diverse specialized knowledge to a unified process. It further seeks continued improvements regarding increased organizational effectiveness and efficiency, elimination of non-value adding activities known as waste, optimization of the entire system. By optimizing the entire system, CE refers to the product and its lifecycle. Including design, manufacturing, production, marketing, improved productivity and quality (Love and Gunasekaran, 1997).

The Integrated Project Delivery concept and Integrated Whole Building Design are examples of the integrated design methods that were introduced and developed based on CE principles. These new methods represent the Integrated part of the CE concept, known as Integrated Concurrent Engineering (ICE). ICE was created based on NASA's concurrent engineering approach to drastically reduce time spent on development where the focus is put on response latency of communication between participants as a significant limitation for rapid processes. It further focused on developing project management tools to reduce lead times and increase of reliability (Kovacic and Müller, 2014). ICE meetings are normally are held during a full working day once a week during early phases of design, referred to as colocation. It focuses on gathering knowledge and the most suitable project participants to discuss design issues collaboratively to shorten response latency and find optimal solutions.

## 2.8 Integrated information

Integrated information allows an integrated team to consolidate fragmented information. It further involves appropriate decision making considering all available information, extensive use of 3D models and a robust IT infrastructure that ensures access to the latest information in real-time. Information sharing is the cornerstone of all IPD organizations and the information itself need to be handled with consistency for all actors as well as giving all participants real-time access to the project information. Fragmented information has been found to be a substantial factor for project delay since much of the information need to be located, recreated and transferred in fragmented processes (Fischer et al., 2014).

### 2.8.1 Virtual Design and Construction

Over the past two decades, Virtual Design and Construction (VDC) have been established and exploited through research at CIFE and they define VDC as ‘’the use of multi-disciplinary performance models of design- construction projects, including the product (i.e., facilities), work processes and organization of the design – construction – operation team in order to support business objectives.” (Rischmoller et al., 2018). Therefore, VDC is a method of working with projects supported by Building Information Modeling.

Building information modeling, or building information model, is a method for information management in construction projects. BIM is based, and dependent on, constant use of digital models throughout the entire lifecycle of the construction projects (Borrmann et al., 2018). Building information models allow and grant access to a high-level digital representation of the physical building with an enormous informational depth. The models usually consist of a three-dimensional geometry of the various building elements at a predefined level of detail. Moreover, it could also include particular non-physical objects, for instance, schedules, spaces and zones or a hierarchical project structure (Borrmann et al., 2018). The implementation of BIM in the construction and civil engineering industry and the development towards a more integrated information management could be described by four different maturity levels, which is illustrated in Figure 2.6.

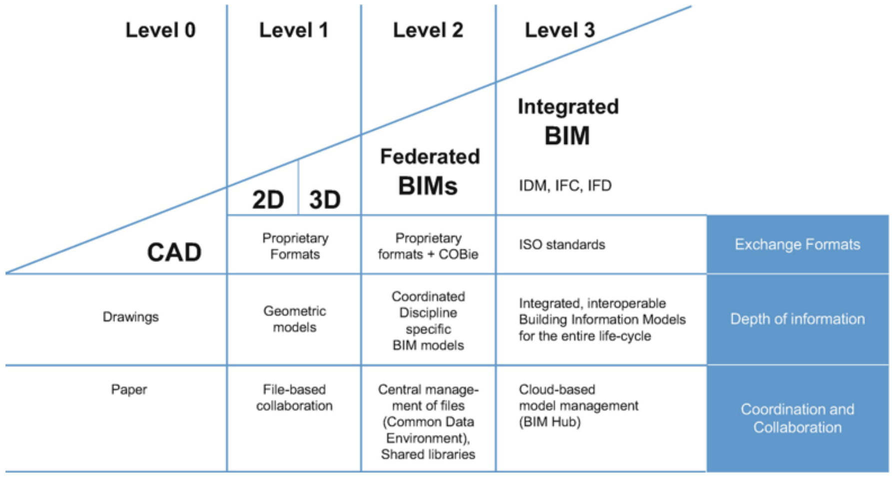


**Figure 2.6:** The BIM Maturity Ramp describes four discrete levels of BIM maturity (Bew and Richards, 2011).

The BIM Maturity Ramp, which is originally a British initiative of the UK BIM Task Group, has been adopted and translated by the Swedish Transport Administration. It describes four separate levels of BIM maturity:

- *Level 0*: Is a conventional working practice with paper-based drawings and unmanaged CAD information in 2D. Printed documents comprising the basic information carrier which are considered as the original document.

- *Level 1*: Managed CAD in 2D or 3D with a certain measure of an information standard and a collaboration tool providing a common data environment. Partially 3D modeling occurs, however, most of the design is still realized through 2D drawings. There is also visual coordination in the common data environment. In the administration, drawings and documents are stored in file-based systems. Which means that a central project platform is not established, and data exchange is achieved through sending and receiving individual files.

- *Level 2*: The work is model-oriented and defined through the use of BIM software. Managed 3D environment held in separate disciplines, where each discipline involved in the project produce its own model where the properties are linked to the different objects. The disciplines mutual interest is certified by organizing periodic coordination assemblies, where the separate sub-models are combined and examined for clashes or other discrepancies. The layout of the facility is then presented in 3D.

- *Level 3*: Fully open process which is centred around the concept of totally integrated BIM. The facility, or model object, is completely described and integrated, and they are used throughout the project's entire lifecycle, including management and maintenance. ISO standards are applied to enable data exchange and process descriptions. Cloud services are provided to manage project data with the purpose of constantly updating and maintaining data over the project lifecycle. With the collaborative model service, it is possible to search for building-related information and administrative data. Level 3 is mainly targeted for future use.

The Swedish Transport Administration's suppliers are currently working with level 0 and 1 (Trafikverket, 2015). From 2015, the Swedish Transport Administration has formulated requirements mandating a higher maturity of BIM from their suppliers, where they are reaching for level 2. Subsequently, the Swedish Transport Administration plans to gradually introduce new requirements concerning level 3 at the rate that is possible in practice.

However, the utilization of BIM in construction projects is not a first-time occurrence, it has been applied to construction projects increasingly over the last 10-15 years (BIM Alliance, 2019). Today, BIM is used as a source of efficiency as to improve the project performance through the enhancement of communication of the design between the different stakeholders in construction projects (Deshpande et al., 2014). The models are characterized as parametric objects filled with information that embodies the facility that is being designed. The design information provided through the BIM process creates a context-rich platform that can be used to store, capture and distribute knowledge that is acquired through the development of the design and construction. Compared with traditional drawing-based design methods, BIM provides considerable benefits regarding more efficient processes, reduced number of mistakes and collisions in the design phase and a higher level of transparency throughout the construction project. When put together, these benefits could lead to reduced risks and costs regarding budget and time overruns (Borrmann et al., 2018).

Therefore, the concept of BIM, which is illustrated in Figure 2.7, includes both the process of establishing and developing such a digital building model and the process of handling, maintaining and updating them during not only the construction phase but the entire lifespan of the structure.

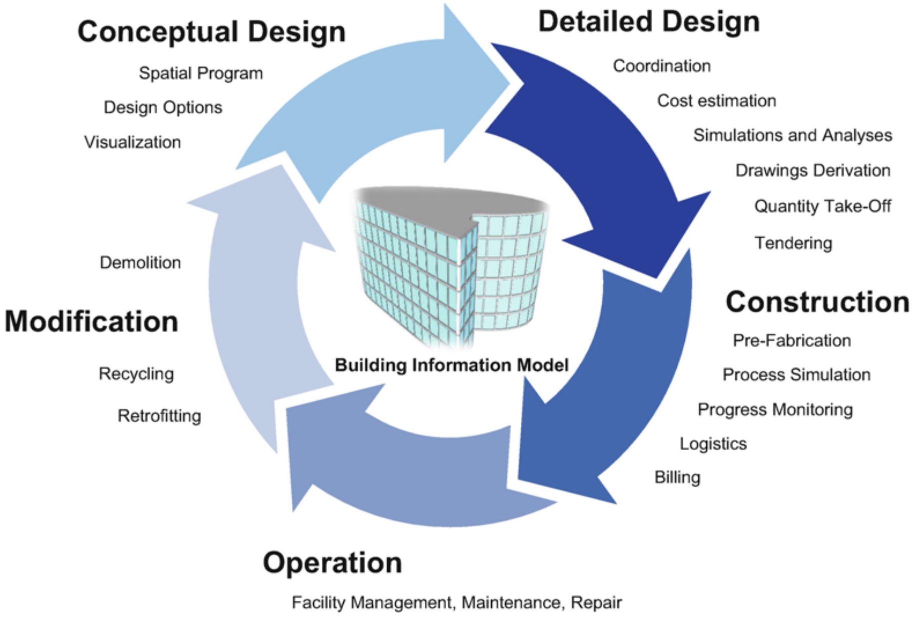


**Figure 2.7:** The concept of BIM depends on constant use management of digital information and assuring minimal loss between the project phases throughout the total lifetime of the built facility (Borrmann et al., 2018).

BIM allows testing to enable discussions of plenty of design options in less time spent compared to traditional project delivery approaches. It is also easier to quickly investigate the impact on performance targets for certain alternatives. Visualization and simulation help teams realize the impacts of certain scenarios, which in turn could be used to mitigate risks through preventive strategies (Fischer et al., 2014).

# 3
# Methods

This chapter includes the methodology used for the study. The choice of methodology is justified and presented to give the reader an understanding of how the study was carried out, to be able to do a similar study. The study involves a research approach described below, the choice of interview method and a framework to support the result from the interviews. It also highlights ethical and moral concerns regarding the implementation of the study.

## 3.1 Research approach

In the early stages of the study, the creation of the project aim and description took place followed by an extensive literature review for the selected subject. The review mainly consisted of research articles but also review articles, conference proceedings, book chapters, handbooks and legal documents to comprehend the research area. Research material was mostly accessed through Chalmers library system and google scholar online services. Literature has been selected and relevant theories have been prioritized and presented in chapter 2 Theory. Relevant research was also chosen based on the research questions shaped during the creation of the study.

The next step of the process was to formulate interview questions based on the themes from chapter 2 Theory. The questions were then verified to match the purpose and research questions of the paper. How the interviews were conducted is described further in section 3.2 Interviews. The questions themselves are based on the literature review to strengthen the validity of the research. Empirical data from the interviews were later assembled and presented in chapter 4 Results.

A framework and a new model were created for this study to strengthen the analysis and to give a clearer picture of the current situation of the industry. The framework rates the current level of integration for the companies participating in this study and the model illustrate the required prerequisites to make a transition from traditional delivery to integrated delivery. The results from the framework were then matched and compared with similar and other types of actors to find further interesting analyzes. More information about the framework and new model can be found in section 3.3 Framework.

To answer the research questions, an analysis of the results was made in section 5 Analysis, discussing the topic for each of the four research questions. The companies were also rated and compared based on the framework to give an extra layer of analysis to the study. The analysis is written with a theoretical lens when processing the empirical data from the result section. The data is then linked together with theory and findings are discussed. Conclusions are gathered and presented in section 6 Conclusion together with recommendations resulting from this study.

## 3.2 Interviews

This thesis has been accomplished through a qualitative research approach for identifying the different research questions, presented in section 1.3 Objective. Semi-structured interviews have been conducted with industry professionals with the purpose of giving a picture of the current situation of the industry complementing the theory. The reason of applying this interviewing method is because it includes some degree of predetermined order, however, it still ensures flexibility in which certain topics are addressed by the interviewee, which is considered to be the most suitable approach for the subject for this thesis. The moderately unstructured characteristics of the semi-structured interviews, as well as its capability to deliver insights and understandings on how the interviewees interpret the surroundings, is especially valuable for conducting this research (Bryman, 2012). Subsequently, theory and interviews were compared and analyzed in order to come to a conclusion.

This thesis applied an interview approach with the intention of collecting data to further investigate and understand all aspects of integrated delivery and the subject's possible connection with the aim of the thesis. The purpose of conducting interviews was to acquire extensive and revealing data of experiences and knowledge from industry professionals regarding construction projects that have applied an integrated approach. Based on the interviewee's knowledge, they were requested to answer questions and make comments on for instance the company's organizational structure and culture, current project approach and execution, and how the company utilizes digital implements to manage information within the projects.

The interviews have been conducted with 7 different professionals in the AEC sector, which are presented in Table 3.1. To get a wide perspective of the current situation in the industry, a range of project participants were asked to participate in the interviews. Since there are plenty of different organizations involved in a project, the interviews was carried out with a range of different actors to obtain a holistic view of the industry. Interviews were carried out with two contractors, two clients, one subcontractor, one consultancy firm and one architectural firm. The reason for choosing to interview two clients and two contractors was because these two actors possess a lot of power and ability to influence integration strategies for other organizations involved in the project. It further helps to mitigate the risk of getting improper or irregular answers from important actors of the industry. An interview request was sent out to employees with different roles from different organizations to get a broad perspective from the industry. The authors chose to interview professionals with experiences from both working at the project site as well as designing buildings. The organizations could at this point be perceived to have advanced differently in terms of incorporating integration strategies.

**Table 3.1:** Interviews conducted for the collection of empirical data for this thesis.

| **Title** | **Company** | **Date** |
|---|---|---|
| Project Manager/VDC Engineer | Contractor A | 10.00-11.00 2019-03-07 |
| Project Director | Client A | 14.00-15.00 2019-03-12 |
| Project Director/Design Manager | Contractor B | 13.00-14.00 2019-03-18 |
| Founder and former CEO | Consultant | 09.00-10.00 2019-03-27 |
| Partner/Project Manager | Subcontractor | 13.00-14.00 2019-04-12 |
| Region Manager | Client B | 09.00-10.00 2019-04-15 |
| BIM strategist/BIM Coordinator | Architect | 13.00-14.00 2019-05-17 |

The interviews were held within a time frame of approximately 1 hour where both interviewers asked questions and took notes. Interviews were recorded with permission and then transcribed in order to be able to revisit and summarize the shared information. The translated version of the questionnaire can be found in Appendix B since the interviews were held in Swedish. However, due to the nature of semi-structure interviews, alterations occurred regarding the questioning between the separate interviews. The obtained information from asking comprehensive and diverse questions contributed with a better overview of the companies, which in the end increased the quality of the thesis. The interviewees, and their associated companies, will remain anonymous throughout the thesis.

An issue that appeared in the interviews was that certain questions were challenging for the interviewee to comprehend. This could be a result from the way the questions were formulated or that the interviewee lacked a sufficient amount of knowledge on the addressed subject. Therefore, the interview questions were sent to the interviewees several days before as an attempt to give them time to prepare for the interviews. In retrospect, more interviews with industry professionals would have made the assessment more accurate of the organizations. Projects are often secluded in the AEC sector which means that it would have been preferable to conduct more interviews with different employees within the companies to understand how they work in all their projects, and not just in the specific project that the interviewee participates in. By increasing the number of interviews and the range of interviewees, the study could have obtained a more holistic view of the companies.

## 3.3 New Integration Model and Framework

The framework was created to support or question the data gathered from the interviews as an extra layer of analysis. It was further conducted to make the quantitative study a bit more qualitative to find possible patterns or connections that could elevate the analysis and reasoning for this thesis. During the study, the authors found a way of tying the new model of integration together with the framework to make the rating more illustrative but also to highlight areas where efforts of integration need to be concentrated. Aligning the score on top of the New Integration Model through a spider chart provides an opportunity to illustrate certain problem areas but also derive differences in integration between the same kind of actors but also differences for different types of actors.

The rating is based on the theoretical concepts of integration presented in chapter 2 Theory. Three points represent a well-integrated process while one point represents poor integration processes. A more detailed explanation of the framework can be found in Appendix A. Although, the reliability and validity of the assessment should be taken under consideration because it is highly subjective and based on the authors' perception of the interviewed companies. Therefore, the scoring of the companies may vary depending on the circumstances that affected the interviews. It is clear that the assessment of the companies would be more accurate if more interviews would have been conducted with the various organizations.

## 3.4 Ethical aspects

Plenty of actors within the AEC industry will get affected by new ways of collaborating and having to work more closely together, but there are no direct moral or ethical concerns resulting from the purpose and implementation of this study. The study aims at presenting a fair picture of the industry, where the companies and interviewees are anonymized to not damage the reputation or describe any of the involved parties in a bad light. The intention of the study is to raise awareness of the subject to hopefully cause a discussion about how to work more integrated which could cause differences of opinions, but should not create any further morally problematic concerns.

This thesis proposes that industry actors need to collaborate on a more integrated level that might cause frustration and tensions between organizations since actors are used to working in certain and imprinted ways. When implementing integrated work processes there is no room for personal grudges or being stubborn regarding collaborating with other organizations. In a larger context, it might be problematic introducing new fundamental changes of how projects are dealt with since it could harm the competition and create separations between those who utilize new technologies to complement strategies of integration and those who stick to old fashioned ways of working. In other words, smaller businesses might not have the same amount of resources to educate employees and introduce new technology, if integrated delivery methods were to be implemented as an industry standard. It is argued by the authors that the benefits involved in embracing integrated delivery still surmount the implications followed by traditional delivery. The community and industry benefits from projects with more value for money, sustainable solutions and better quality meanwhile project participants benefit from cheaper processes and faster decision making.

# 4
# Results

In this chapter, data from the interviews is presented in sections for each of the four aspects of project integration. First, the aspect of integrated systems is presented. Followed by the aspects of integrated processes, organization and information. The chapter also highlights the information regarding collaboration agreements. Table 4.1 shows a quick reminder of the companies interviewed to support the reading of this chapter.

**Table 4.1:** Companies interviewed for collection of data.

| **Company** | **Area of business** |
|---|---|
| Contractor A | Large-sized contractor |
| Contractor B | Medium-sized contractor |
| Client A | Large-sized public client |
| Client B | Large-sized public client |
| Architect | Large-sized architect and consultancy firm |
| Consultant | Consultants within virtual construction |
| Subcontractor | Subcontractor within electrical installation |

## 4.1 Aspects of integrated systems

Interviews from the study could tell that knowledge and efforts to battle traditional fragmented ways to coordinate and manage building systems in the industry exist today. All interviewees except Client A claimed to some extent comprehend the importance of integrating building systems to get a good and usable final product, where systems are designed to communicate and function in harmony. However, according to Contractor B, few projects are integrated in terms of building systems today because the implementation of the systems is perceived to be expensive. According to the Architect, clients need to provide and improve their requirements in order to have a better performing building. To date, generally speaking, there are very few attempts to create a better performing building. Contractor B argued that it is all about bringing participants together in a room to collaborate because knowledge and technical solutions exist or can be generated together. The Architect argues that there is a general lack of motivated clients to perform high performing buildings, even though many projects are complex and could benefit from integrated systems. If not the project requires integrated systems, there will not be any further attempts to integrate the building systems since it is not creating value for either the client or the participants. Contractor B concludes that as long as all the major project participants are motivated to conduct an integrated project, there are no other "real" excuses to make it work. Client B usually run a couple of research projects within larger construction projects to test new technology. One research project involves ways of integrating building systems to reach a building with high performance. The architect concludes that most clients today need to learn how information and new technology can be utilized to make the facility management processes more efficient.

Contractor A and B normally assign the coordination of systems to one project manager responsible to manage the design meetings and make sure that all requirements are met. The Architect is using design meetings on a regular basis to ensure that the project progresses and that all building systems are coordinated correctly. Client A and B, on the other hand, have technical guidelines for their systems because they are in a position to demand certain requirements when they buy construction services. In order to have a well built and good final product, Client A explains that it is vital to procure companies that are dedicated to manage and provide proper documentation. The Consultant mentions that the specifications made by clients should involve a closer look at what requirements each room or technical system should have and how to achieve appropriate room functions. According to Client A, there is a lack of integrated verification methods to ensure that the systems are appropriate for its use and aligns the overall holistic approach of a high performing building. The Consultant mentions that there is a need to change the mentality of how customer requirements and satisfaction are dealt with. The interviewee from the consultancy firm said in an interview that *"A customer is not buying a single ventilation system, they are buying a well functioning conference room that you can work in".* According to the Subcontractor, the aim is to provide the best possible integrated systems to the extent where they get paid for their work.

## 4.2 Aspects of integrated processes

ICE meetings have become an important method for Contractor A and it is now incorporated as a strategy process for many projects in order to work more integrated. It got clear from the interviews that Contractor A have come further in their implementation of ICE-meeting-processes compared to the other companies of the study. Client B implements reoccurring weekly meetings for the design team to meet and discuss the design, but it could not be distinguished whether these meetings were carried out in a collaborative or integrated manner to produce a better performing building. Contractor B mentioned that there had been successful personal attempts within the organization to manage design meetings in a more collaborative way to create a better building but there are still no decisions taken on introducing new concepts or any other organizational change.

Contractor A aims at improving their processes by sending out questionnaires to project participants when a project is finished, but getting good feedback is troublesome since parties are bought under traditional contracts, leading to biases and less interest in how the meeting could be enhanced in terms of efficient collaboration and processes. When asked about the challenges of working collaboratively in today processes, Contractor A mentioned that the hardest part is to create commitment to the task. Client B navigates through the fragmented industry by setting clear specifications, in the shape of a handbook, early during projects to ensure what product is provided. To promote innovation and creative ideas, the Architect is using inputs from project participants to define the project scope and required functions of the building during the early program phase of the projects. The essential functions of a building are established together with the client to ensure that correct functions are communicated properly. The required functions are then distributed to the project team through cloud-based software, presentations, meetings and other documentation.

Interviews could tell that the most common way of handling processes of a construction project today is in a traditional manner where Gantt-charts still are emphasized. Contractor B argues that the process in a traditional delivery approach could be described as linear, where each individual discipline performs in a silo before it delivers their part to the following discipline, whilst an integrated delivery approach necessitates the complete opposite. According to the Consultant, there is a need to approach traditional processes from another perspective in order to create engagement through agile working processes, where different phases of the construction project are performed in sprints. The Consultant further concludes, instead of having a workshop at the beginning of the project followed by months of individual work, it is necessary to gather the most suited project participants in the same room during certain weeks in order to pick each other's brains over specific tasks. The Consultant states that the working processes in the construction industry need to become more integrated in comparison with other industries, for instance the car industry, where the requirements from the suppliers are completely different when they are entering a project.

The quality of the documentation produced by Contractor A is examined and verified by many self-examinations and audits before proceeding to construct the buildings. To ensure few mistakes during the implementation phase, the projects are very seldom initiated before the documentation is finalized. The project managers at Contractor A carry a lot of the responsibility of bringing knowledge from the building site to the design table. Even though a lot of responsibility is put on the project manager, it is still perceived as an advantage to have a manager that can follow the processes and carry information from early design to implementation at site. In regards to working with processes of collaboration, two to three times a week Contractor A hold meetings at site about the progress of the work and what is expected from upcoming work. The idea of having those meetings is to ensure that all participants at site understand that everyone is responsible for coordination and the collaboration of the work.

## 4.3 Aspects of integrated organization

Since a few years back, the VDC managers at Contractor A are now educated on the principles of ICE from professionals at CIFE, Stanford University. During the following 8-10 months after the first seminar, there is a VDC certification process carried out in both design process management and how VDC can be used in the production. The project manager from Contractor A mentions that even though educations are offered about ICE, there is no standard or manual for how to lead an ICE meeting. The manager elaborates when asked about challenges about ICE, that it creates confusion among managers since the company are compelled to interpret the concept and create their own strategy of how to coordinate an ICE-meeting. Therefore, routines of ICE-meetings could shift depending on who is responsible. Other challenges of ICE are outlined as a lack of commitment from participants, lack of knowledge of the approach and resistance to change old habits. Commonly, key participants are invited on a regular basis for ICE meetings. The key participants are the client, architect, structural engineers and the contractor. Subcontractors are invited to the meetings when matters that affect their area of expertise are addressed and needs to be discussed. For Contractor A, a normal meeting usually lasts during four to eight hours and are held once every week depending on the current status and stage of the project.

According to Contractor A, there are times when difficult questions arise that cannot be solved during the meeting, participants might need to discuss with experts of their own organization before getting back with a proper solution. However, Contractor A experiences a general lack of BIM knowledge which is problematic for ICE meetings since BIM is an essential component for visualization. According to the Architect, cloud-based software is an important part of integrating a project team since it allows project participants to work separately between the weekly delivery of drawings and BIM-models. Weekly delivery of documentation together with recurring coordination sessions ensures that all participants get updated BIM-objects and information.

The manager at Contractor A could see that collaboration has become more efficient since the implementation of ICE meetings because it allows very little room for miscommunication. To increase commitment towards ICE, the manager mentioned that partnerships between participants could be established for better long-term collaboration and more efficient ICE sessions. According to Contractor A, having educated project managers of ICE principles that follow the work throughout the project lifecycle is an advantage in order to implement ICE and have someone responsible for its implementation. Another advantage for efficient implementation of ICE is to invite participants with the authority to make decisions.

On the other hand, Client B assembles a project team with the purpose of collaborating in different forums, with consecutive meetings throughout the project. Additionally, for complex projects, Client B puts together a special team with suitable experience to ensure proper knowledge sharing. According to Client B, the most important part of aligning the organization is to have clear requirements as a client. In order to achieve a high performing building, the client needs to be clear and distinct in their necessities towards the contractor. According to Contractor B, in order to reach an integrated organization then awareness needs to be raised among the project participants and the understanding increased about every step of the construction process. Contractor B therefore choose to communicate and address the time schedule to clarify, in weekly meetings, what needs to be done during the project.

According to Client A, by providing every project participant with accurate information in every step of the process, then the whole organization around the project will be aligned. Client A claims that there is a need for working more integrated between the different project actors. Moreover, Client A tries to bring in the right disciplines and participants as early as possible in their projects in order to increase the knowledge base. However, the project manager at Client A argues that there is room for improvement within the company regarding early involvement of key participants.

In contrast, the Consultant recognizes two parts needed to integrate organizations. First, colocation is a very important factor regarding integrating the organization. The second aspect concerns acknowledgement, which involves how to acknowledge other organization's performance. The Consultant, therefore, works towards creating incentives to integrate the working processes by implementing performance-based contracts with a set target price. The Consultant identifies that management aspect concerns how to manage and create the prerequisite for the project participants to be independent and solve issues when they are separated.

The Subcontractor usually conducts business under the wings of the contractor, which means that the cooperation between the subcontractor and contractor normally works well. When discussions or disputes arise between the contractor and the client, then the subcontractor usually stands beside the contractor. The project manager at Contractor A mentioned that they usually buy subcontractors on a DB-contract to avoid being responsible for their work with technical solutions in case something goes wrong. When procured under a DB-contract, the Subcontractor participates in workshops or other colocation meetings organized by the contractor or the client, but only to the point of what is necessary. Long-term subcontractor relationships are something that both Contractor A and B desires since subcontractors know from previous projects what is expected and how they operate.

However, another downside of buying a main subcontractor on a DB-contract is that they are unable to control what subcontractors they in turn are buying to execute the work. The Subcontractor has few incentives towards working more integrated in their projects to prioritize the client wishes over their own personal gain. This can be problematic for a smooth implementation of ICE since the ICE-concept is built on collaboration and mutual understanding.

It could be recognized from the interviews that colocation brings numerous advantages for construction projects. However, for a more effective implementation, there need to be clear standards and set of rules of how the meetings will transpire and whom that will attend, as well as personal motivation from the employees.

## 4.4 Aspects of integrated information

All of the companies interviewed in this study has been utilizing some level of BIM, however, how well the companies are taking advantage of the full potential of BIM is another question.

Client A claims of having high ambitions regarding the utilization of BIM within their projects. However, the company questions whether they can benefit from implementing a higher level of BIM or how they can take advantage of the existing information. Due to recent company growth, it has been a challenge for the information department at Client A to keep up with the growing amount of information. Therefore, BIM has been neglected to a certain extent within the company. Client A further admits that they have fallen behind concerning finding an efficient way of managing their information. On the other hand, Contractor B advocates the utilization of BIM and states that nearly all the companies within the AEC sector are designing in 3D today and that only a few actors have fallen behind and are still doing design work in 2D. However, Contractor B argues that it is challenging to introduce the next level with 3D-modeling and BIM to add intelligence into the modeling. Contractor B can see the benefits of efficiently managing information by connecting data to the object in the models because their biggest concern is that it circulates drawings and documents that are not updated. According to the Architect, how the information is handled and delivered within construction projects is challenging for the industry. The Architects concludes that there is a need of predetermined guidelines describing how the information should be managed.

The Subcontractor is working with BIM and 3D models to the extent that is possible and efficient for them, which means that a considerable part of the design is still completed in 2D. The level of detail when the Subcontractor is working with BIM varies because it is perceived as unnecessary to always include all components in the models, such as electrical sockets and switchers, due to the large amount of those components. This is because if a change will occur in the contractor's model, e.g. a wall transfer, then all those electrical components will be out of place which leads to a lot of rework. This is a consequence of the subcontractor's models rarely being integrated with the contractor's model. Concerning the Consultant, they have come a long way regarding information management, and they argue for a BIM level 2,5 where the work is not totally concentrated around the object model but also concerning descriptive databases. According to the Consultant, the advancement does not end at BIM level 3 and it involves a shift to another way of working with clear connections to the working processes in the car industry.

From the interviews it is clear that all companies are using some sort of online cloud service to save and store documents generated from projects during the design phase. The documents are stored locally on computers during the work and when the work is finished, documents are uploaded to the online cloud library in different folder structures accessible to all participants in the project. The Architect communicates detailed information about the project characteristics and its functions through cloud-based platforms to all project participants to ensure that actors get the same updated information, which allows for quicker and more reliable communication within projects. Regarding Client B, they have developed their own project-specific databases to handle the information, which includes certain areas for collaboration within the projects. This database follows every phase of the construction project in order to facilitate the localization of specific information in the different phases.

For Contractor A, to support knowledge sharing between projects, when projects are finished there is always a meeting to share knowledge and experiences that have been gathered during the project. The purpose of the meeting is to share knowledge between the employees but also to write down and keep records of the experiences learnt during the project. The records are then uploaded to a larger folder where project documents are accessible to employees in all offices in the region. The project manager at Contractor A mentioned that it is hard knowing what problems other project have solved and what methods they have chosen, therefore it is hard knowing what to do with the information in the cloud service. Currently, there is a need to actively search or know where the knowledge exists in order to get an answer, which appears to be an issue for the other companies of the study. For Client A, the systems that support the exchange of experience are not long-lasting and the systems are eventually deprecated because they are rarely used. Instead, Client A has created forums to exchange experiences verbally in order to get the necessary information before starting new projects. In contrast, Contractor B has constant verbal knowledge sharing at the construction site, however, they emphasize the issue of the knowledge being isolated to that specific forum and not shared to the rest of the organization. Both Contractor B and Client A claim that they have issues regarding how they handle knowledge sharing between their projects.

When asked about future improvements of the construction industry, the project manager at Contractor A and B mentions that there are plenty of improvements to be made in regards to collaboration and contracts. According to Contractor A, industry standards have to be developed to deal with digitalization. Contractor B agrees and states that there is a paradigm shift in progress regarding the utilization of BIM and they predict that BIM will be the only given design standard within five years due to increasing demands from clients.

The Consultant claimed that information is strongly connected to the requirements that come from the user or even from the facility management organization. Additionally, the integrated information has a very clear connection to how that information should flow towards the environment in which will be used when the project is over. When striving to produce high performing buildings, the information environment should be more integrated towards the customer requirements and that it is constantly connected with e.g. control systems and facility management systems. The Architect mentioned that the documentation and BIM become a tangible asset for clients when the projects are finished which in turn require a strategy of handling and maintaining the information throughout the project lifecycle.

## 4.5 Collaboration agreements

All interviewed companies participate in partnering agreements to some extent. Most partnering agreements from the companies in this study were held between a client and one main contractor. It is advised by Client A and B as clients that the main contractor in turn should strive to procure their subcontractors on a partnering agreement as well. Contractor A and B mentioned that they could benefit from having a partnering agreement with the subcontractors on a large percentual size of the total contract sum. According to Contractor B, a partnering agreement is unnecessary when the work of a subcontractor is simple and straight forward like painting a wall. According to the Consultant, partnering agreements need to involve more actors and create appropriate incentives for different parties. As of today, the Consultant does not have any incentive to work faster or more efficient while participating in a partnering project which is something that needs to be changed. The Consultant states that the industry needs more performance-based contracts for larger contractors and subcontractors with much influence, while smaller simpler work of subcontractors and consultant should have more fixed price contracts.

Client A recognizes partnering as a way for the organizations to collaborate and motivate project participants to work for the good of the project. In that term, sustainable solutions that support the project in the long-term are always prioritized and accurate information is always shared between the partners.

The Architect was in some projects procured by the contractor and other projects procured by the client. Being procured by the contractor within a DB contract did not prove to give the Architect a better position to negotiate over building design since the contractor had to cut costs to improve the financial result. Consequently, partnering agreements should preferably involve the architect to get a more integrated design.

# 5
# Analysis

This chapter includes the analysis of theory and results as well as discussions of the research questions. Section 5.1 addresses and discusses research question number one. Regarding research question two, a new model for project integration is presented as well as the framework created for this study. The framework and new model will be analyzed simultaneously to illustrate and discuss the level of integration for the interviewed companies. Research question number two is addressed in section 5.2 - 5.5, while discussing the new model for project integration. Section 5.6 addresses research question three to discuss how appropriate incentives and compensation models can support integration strategies. Lastly, section 5.7 addresses research question four to distinguish appropriate integration strategies for clients.

- **RQ1:** What are the benefits of working more integrated compared to a traditional delivery approach?
- **RQ2:** How can the level of integration for actors of the industry be measured and how are the aspects interconnected?
- **RQ3:** How can incentives and compensation models support collaboration and integrated ways of working?
- **RQ4:** Which project integration strategies could clients benefit from and how can they manage the aspects of integration?

## 5.1 Benefits of an integrated delivery approach

According to MacLeamy (2008), conducting extensive design work and leveraging both technology and collaboration will lead to fewer design changes during the implementation phase, which implicates cheaper projects since design changes are more expensive during the implementation phase than during early stages of design. Azhar et al. (2014) argues that the transfer from a traditional delivery approach to an integrated delivery approach involves several benefits, however, companies from the study struggle with the transition and do not at this point realize the full potential. Interviewed companies lack proper commitment to make a larger organizational change and do not exploit the potential by devoting too little resources.

According to Laan et al. (2011), better cooperation between client and contractor will improve the performance of construction projects, generate less fragmentation and develop better relationships. Azhar et al. (2014) further argue that construction projects are complex by its nature and it is therefore favourable to break traditional structures of fragmentation to increase the level of communication between participants. However, despite the benefits of long-term relationships between participants, neither or few of the companies from the interviews tried to actively establish any longer relationships even though previous collaborations were successful. Consequently, the authors argue that, in general, healthy contractor-client and contractor-subcontractor relationships exist to the point until tension arises and companies choose to prioritize their own gain over the wellbeing of the relationship or when contractors no longer can compete with the lowest price.

Mitropoulos and Tatum (2000) highlights the issues of fragmentation and specialization connected to traditional delivery methods and stresses the importance of solving complex issues together by utilizing the expertise and specialized knowledge to reduce the amount of time spent finding the accurate information, which is often the case for a fragmented process. On the other hand, the interviews show that many actors experience a lack of incentive to collaboratively enhance the specifications of the final product without any further funding or other long-term relationship as motivation. The companies from the study further claimed to favour partnering as one reasonable approach towards integration. Even though few of their ongoing projects were procured on a partnering agreement, it got clear that a majority of the total amount of projects were procured through traditional contracts.

According to Harper et al. (2016), standard industry contracts and a legacy of litigation is often the causes accountable for selfish patterns in the AEC industry. Ghassemi and Becerik-Gerber (2011) further argue that the traditional contract structure encourages each party to function within its own goals and procedures rather than aiming to achieve the project objectives. Contractor B could verify from previous experience in partnering projects that participants intentionally withheld information and knowledge because they were afraid of sharing too much company-specific information. This could partly be explained by inexperienced partnering actors, but it also shows that organizations are unfamiliar with collaborating and contributing to improve performance of the building. Moreover, Laan et al. (2011) argue that opportunistic behaviour is also less apparent when there is an incentive to cooperatively overcome risks and finalize projects on time. The Consultant could contend that these old habits need to be washed away from the mindset of actors of the AEC industry to achieve integrated delivery.

Mollaoglu-Korkmaz et al. (2013) argue that systems incorporated in the buildings need to communicate and function together to optimize the reduction of environmental impact to achieve the highest level of environmental standard, however, not many actors from the interviews do use interdisciplinary interaction to reach fully integrated and optimized sustainable systems. It could therefore be argued that very few projects actually strive to reach the highest level of environmental standards, since there are few attempts to fully integrate building systems. The authors of this thesis argue that there is a lack of proper commitment to invest in organizational change, new processes of integration and to build fully integrated buildings. The authors further conclude that there is not enough support for the argument of not knowing how to conduct a building with the highest possible environmental standard since technology and knowledge exist within the industry.

In the research made by Matthews and Howell (2005), it is argued that traditional contracts reward actors for withholding innovative and valuable ideas to improve their own performance at the expense of other parties of the project. The interviews showed that most subcontractors were procured with traditional contracts which would be in direct conflict with strategies of integration. Furthermore, larger subcontractors could sometimes be procured with partnering contracts by the main contractor that in turn could delegate the task of coordinating the work of building systems, which consequently would be a more appropriate contractual approach for integration strategies.

### 5.1.1 Summary of benefits of an integrated approach

To summarize this section, there are plenty of preferable characteristics and benefits brought by integrated project delivery. Most benefits of the IPD approach can be derived from traditional contracts and traditional project delivery since it by nature contradicts collaboration and accounts for selfish patterns. In response, the IPD approach has emerged in to solve problems associated with traditional delivery in construction and to emphasize collaboration for the sake of better building.

Based on collaborative methods, IPD methods provide appropriate prerequisites to deliver a sustainable building through the integration of building systems by conducting extensive collaborative design work where the client requirements are in focus. Client requirements could be argued to be equated with user value or sustainable functions of the building, which is decided separately for each project. As argued by MacLeamy (2008), leveraging both technology and collaboration through extensive design work would lead to fewer design changes during the implementation phase, which in turn would be profitable.

## 5.2 New Integration Model

Along with the progress of this thesis, the authors have interpreted and developed the model for project integration, showed in Figure 2.3, that is used to illustrate the IPD aspects that are required in order to achieve a transition towards integrated delivery and high performance buildings. The authors of this thesis present a new model called the *New Integration Model*, presented in Figure 5.1. The purpose of this new enhancement is to illustrate the lifecycle aspect of the integrated approach more clearly. It further builds on and compliments the simple framework created by Fischer et al. (2014), to make the applicability of these aspects easier to grasp. Borrmann et al. (2018) argue that benefits can be gained in terms of reducing risks, time and cost overruns when a digital building model and processes of handling, maintaining and updating the model during the entire lifespan of the facility is exploited. However, interviews showed that most actors perceive the project to be finished when the facility is finalized, instead of using the information during the full product lifecycle. The authors therefore present the circle shaped New Integration Model to show stakeholders that VDC technology, knowledge, integrated organizational methods and integrated systems should be utilized to its fullest potential throughout its product lifecycle.

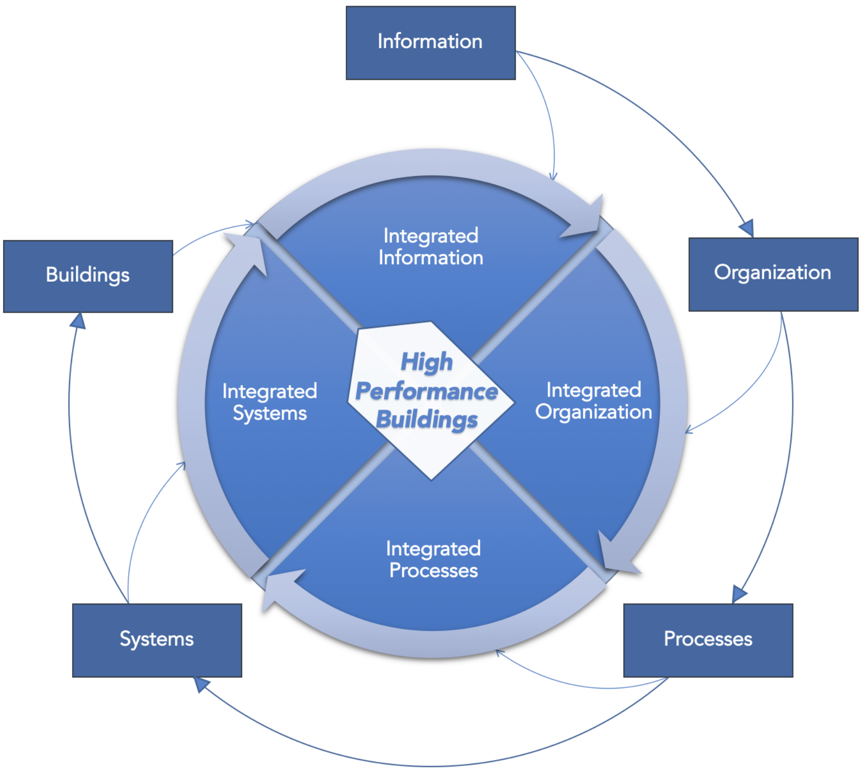


**Figure 5.1:** New Integration Model created by the authors.

According to The Construction Users Roundtable (2004), full project collaboration is generally opposed in traditional delivery methods since gained knowledge and important learnings from a project only proceed in a fragmented manner towards future projects. Working integrated is therefore a way to tackle the traditional approach where effort end after the product (facility) has been delivered. The outer non-connected circle represents the traditional approach consisting of separated and fragmented processes where the information and effort ends with the building, while the core symbolizes the lifecycle conduct of the integrated approach. Furthermore, the arrows going from the traditional outer circle towards the inner circle are representing the tools and methods for project integration. It should further be noted that the tools and methods for project integration are not only applicable for just leveraging one aspect, for instance information, to become more integrated. Project integration strategies are distinguished as efforts to come closer to the centre and to integrate the entire project.

The purpose of the new integration model is to illustrate the cyclical nature of the integrated approach where the obtained information during the project is kept for each step of the building process and ultimately saved for the next project undertaking. The former model for project integration, Figure 2.3, was perceived as hard to understand because it is difficult to interpret its applicability to project integration since the model is described in a straight-line manner. Regarding the straight-line manner, in the previous model arrows tie the aspects together starting by information on the right side, moving to high performance building to the left. In reality, the integration aspects are not consecutive, the aspects can be addressed simultaneously or by adding efforts independently. Therefore, a high performance building is a product of adding each aspect together and not a final and separated step in a process sequence, which could be interpreted from Figure 2.3. In response, the authors present a model where the integrated processes are tightly connected and visualized as a pie chart consisting of four pieces with the high performance building concept as the core of the model. Therefore, a project team that strives to make the transition towards becoming more integrated should aim at working together with close collaboration with the aim of reaching the centre of the model, hence the analogy of the integrated pie core. Integration strategies will help moving project teams closer toward the centre.

The authors attempt to make the connections to the lifecycle perspective regarding knowledge sharing, BIM-information and processes more clear by introducing the New Integration Model, presented in Figure 5.1. The new integration model will be further analyzed, in section 5.4, in combination with the framework that is presented in the following section 5.3.

## 5.3 Framework to rate the level of integration

A framework was created for this thesis to evaluate and rate the level of integration of the different companies that have been interviewed. The framework is based on common theory, presented in chapter 2 Theory, and conventional methods from the industry. The purpose of the framework is to give an extra layer to the analysis and to be able to compare interviewed companies with each other. The rating of the companies is based on a qualitative interview study which could entail that a subjective interpretation might have disrupted a fair judgment of the companies. The idea to evaluate and rate the interviewed companies emerged to improve the analysis of the study by analyzing the empirical data. The objective of the framework was originally to find a new tool to show what level of integration companies from the study currently have or what level they are working towards achieving.

What became apparent during the study was that the framework could also be used to give further comparisons and support the analysis in plenty of other ways. Since the scoring from the framework is based on qualitative interviews, the authors chose to rate companies with a scale of 1 to 3 points in order to be able to distinguish that some organizations have come further than others regarding their work towards integration. The scale is also applied to recognize which integration aspects that separate the organizations apart. Regarding the aspect of information, the scoring follows according to the BIM maturity ramp that is presented in Figure 2.6. However, it could be argued that the boundaries between the levels are not that distinctive and that it, in fact, exist areas between the maturity levels, which is the reason why the framework includes BIM maturity level 1,5 and 2,5 as an attempt to cover those areas. A more detailed scaling of the framework can be developed in another study and the authors recommend other researchers to go in further into defining the scoring of the different aspects.

Since the thesis includes interviews with different types of actors on the market, connections and relations between different actors are drawn from the framework. The comparison gives clarification of where the companies are located at the moment regarding their level of integration and it also provides an indication of what type of actor that needs to take more responsibility for integrating their delivery methods. The framework is further used to illustrate certain zones of the framework that the industry needs to improve or adapt to reach a better integration of the delivery procedures. The companies are evaluated based on the conducted interviews and the process of rating the companies has been carried out by the authors of this thesis.

Table 5.1 presents the rating of the companies from this thesis. A score of three means in general terms that the company is currently being highly integrated or seriously working towards integrating processes of the different delivery methods. A low score of one represents a company that is working according to traditional delivery methods and not familiarized with the concept of integrating delivery methods. Hence, the score of two is given to a company in between the description of one and three that participates on the initiative by other organizations but not actively drive the introduction of integrated delivery methods. In table 5.1, II is an abbreviation for Integrated Information, IO is an abbreviation for Integrated Organization, IP stands for Integrated Processes and IS stands for Integrated Systems. Finally, Agreements is a shortening for contractual collaboration agreements. The full explanation of the different sub-criteria and parameters that cause the score can be found in Appendix A. Further analysis and discussions of the framework will be conducted in section 5.4.

**Table 5.1:** Scoring based on the framework of how well companies are integrated.

| | **II** | **IO** | **IP** | **IS** | **Agreements** |
|---|---|---|---|---|---|
| Contractor A | 2 | 3 | 2 | 1 | 2 |
| Contractor B | 2 | 2 | 2 | 1 | 2 |
| Client A | 2 | 1 | 1 | 1 | 1 |
| Client B | 2 | 2 | 2 | 1 | 2 |
| Architect | 3 | 3 | 2 | 1 | 2 |
| Consultant | 3 | 3 | 3 | 2 | 2 |
| Subcontractor | 2 | 1 | 1 | 2 | 2 |

## 5.4 Analysis of the New Integration Model

Section 5.4 includes the analysis of the New Integration Model together with the scoring from the framework as an overlay on top of the New Integration model. The score is transferred from Table 5.1 for each company and matched with a similar type of organizations in the following sections to be able to differentiate between various types of actors. The framework consists of five prerequisites that are all included in the New Integration Model. Agreements were added as an additional prerequisite to give an insight into collaboration agreements. Like a spider chart, the score for each aspect is drawn from the centre of the model towards the edge to illustrate the level of integration for each of the five aspects. The chart is presented in Figure 5.2.

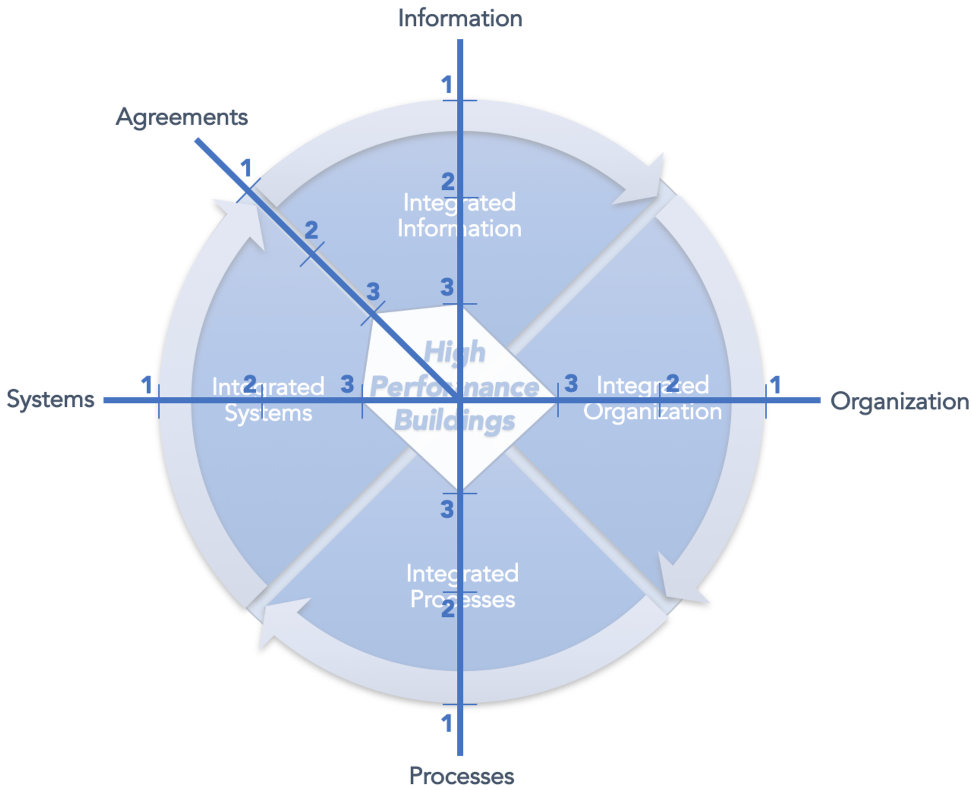


**Figure 5.2:** Framework on top of the New Integration Model, made by the authors.

The centre and core of the model is referred to as the concept of a high performance building which corresponds to a high level of integrated delivery, whilst the outer circle represent the unintegrated traditional delivery. The framework gives the highest score of three for companies that are seriously trying to implement integrated processes or currently using integrated delivery methods. Low scores are given to companies that are unaware of, or not working towards, implementing integrated delivery methods. The company's integration strategies for the different aspects therefore determines where on the axis they will end up. Excellent integration strategies lead to a higher score located closer towards the centre along the axis for each aspect. Hence, less good integration strategies will result in a low rating, situated at the edge of the model along the axis.

To entirely possess all the prerequisites needed for a successful implementation of a high performing building, all integration aspects need to be fully met, including agreements. Therefore, the highest possible score generates the smallest total area enclosed by the score from all aspects, which equals the perfect foundation to conduct a high performance building.

### 5.4.1 Contractors

The rating from the two contractors interviewed is gathered and presented in Figure 5.3 as an overlay on top of the new integration model. Findings from the interviews related to the new integration model are also analyzed. Looking at the new integration model, the interviewed contractors follow roughly the same pattern in terms of framework score. Based on the interviews, one contractor has come further in their work integrating their organization than the other contractor. In terms of organizational integration, the interviews showed that Contractor A has managed to integrate some of their organizational processes by introducing ICE-meetings during the design phase. The interviews could further indicate that Contractor A has a willingness to progress towards integrated organizational processes by actively educating their own employees of ICE-meeting principles, thus leading to a higher score in organizational integration. Contractor B, on the other hand, showed great interest in developing integration strategies, but still awaits the appropriate timing to make a more substantial organizational change. Understandably, the companies are being careful about investing resources in organizational change or any larger fundamental transitions of work processes, since it is a very complex and time-consuming procedure. According to Azhar et al. (2014), organizations need to accommodate an organizational change to emphasize the transition. The interviews showed that personal commitment from a few employees is not enough to make an organizational transition, top management need to be unified and settle clear organizational strategies. It could also be argued that some companies let other businesses or institutions drive innovation forward. Several argue that there is a paradigm shift occurring in terms of digitalization which could be why the organizations are being extra careful awaiting accurate timing and appropriate organizational strategies.

It got clear that both contractors use BIM in their daily work and claims to understand the benefits of using the information provided by 3D models throughout the project lifecycle. Yet, it could be argued that few actors of the industry actually use the full potential of BIM-information which could be interpreted as lost potential. The authors argue that integrating all processes during a construction project could be the solution to utilize the full potential of BIM-information. The New Integration Model for is presented in Figure 5.3.

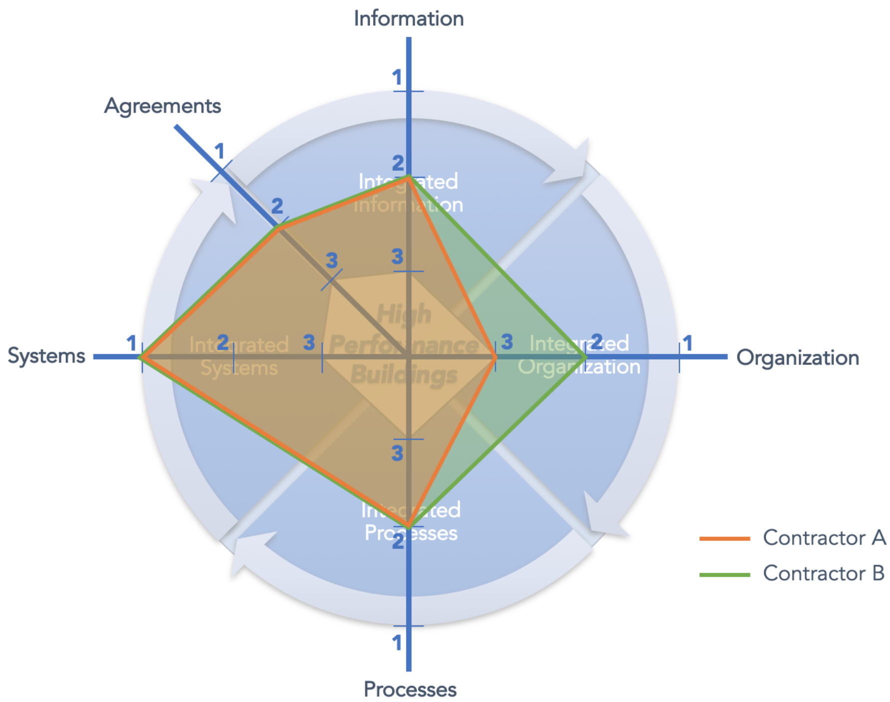


**Figure 5.3:** Analysis of the New Integration Model for Contractor, made by the authors.

According to Azhar et al. (2014), it can be concluded that traditional delivery methods are the first choice to most contractors since it is a well-proven way of doing business even though it encounters a lot of fragmentation. The contractors could see benefits of collaborating in partnering contract but neither of the companies was willing to make a complete change towards collaborative multi-party contracts or partnering contracts since the traditional delivery method is a more secure way to realize the profit. Looking at Figure 5.3, the interviewed contractors have taken one or two steps closer to the centre trying to achieve integrated delivery through integration strategies and position themselves around an average score of two consider all aspects. This entail that more can be done to achieve fully integrated delivery and that organizations need to address integration strategies. The authors argue that collaborative partnering or multi-party contracts need to be established to a greater extent in order to avoid fragmentation and work more cooperatively.

The interviews indicate that contractors provide small efforts to develop integrated systems since there is a lack of incentive for contractors to provide a better product than what is being requested by the client. Hence, the low score of one regarding the aspect of integrated systems. It can be argued that the final product needs to be addressed and prioritized above selfish actions together in a collaborative manner to integrate systems further.

### 5.4.2 Clients

The score from the two interviewed clients is gathered and presented in Figure 5.4 as an overlay on top of the new integration model in a similar way as the previous section. Findings from the interviews related to the new integration model with a client perspective are also highlighted. According to Matthews and Howell (2005), scope changes in traditional contracts resulting in additional work is something that the contractor will demand extra funding for since it is not included in the original documents. The contractors from the interviews could both verify that this is the case for traditional project delivery and that a lot of time is spent on getting that extra payment. Currently, Contractor B strive to deliver high-quality projects to maintain their good reputation and to maintain long term relationships but, only to the point where Contractor B is profitable. To conclude, additional improvements to the final product will only occur if the changes are profitable for the contractor. For tasks that the contractor is responsible for and manage themselves, the incentive to streamline processes increases. Figure 5.4 illustrates the area enclosed by the integration aspects for the clients.

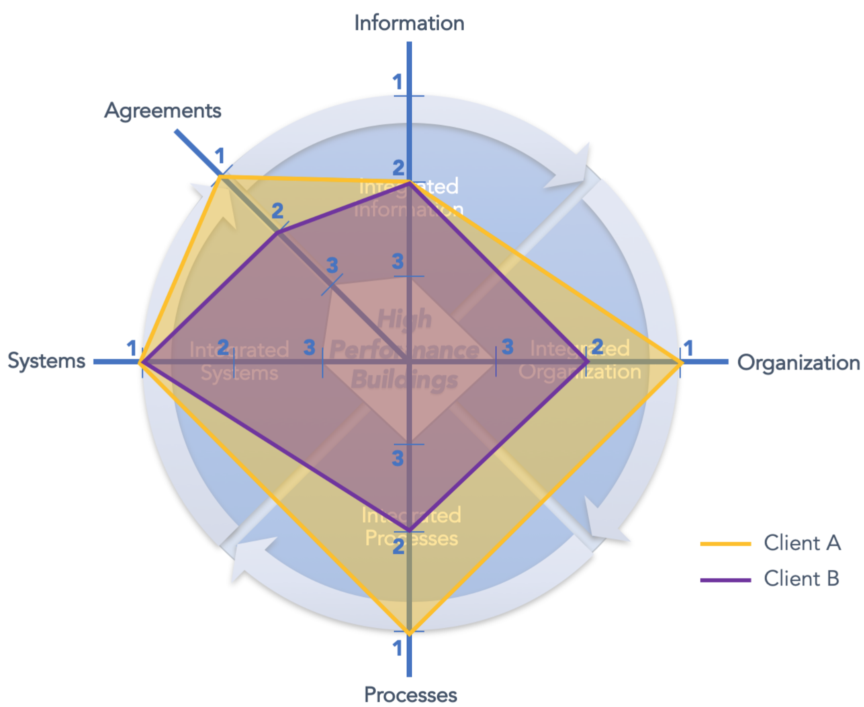


**Figure 5.4:** Analysis of the New Integration Model for clients, made by the authors.

Comparing the area generated by clients with the area of contractors, it can be argued that clients perform worse regarding integrating projects and integration strategies. The difference in score can be derived from the fact that clients are perceived to lack insights into the overall building process, lack efforts to integrate projects and lack knowledge about the integrated project delivery. To have a well performing integrated project team, the authors argue that all actors will benefit from an equal level of integration. The integrated relationship between the client and contractor might be hampered if the companies have different opinions in terms of integrating the project and how to deliver a high performance building. It could therefore be concluded that companies should be equally integrated for successful project integration. In other words, the companies should have similar or equivalent score and total area generated from the new integration model. Looking at the score and area from Contractor B and Client B, the authors argue that establishing a relationship between the organizations could be a great match since neither of the companies would have to compromise regarding work processes.

According to Matthews and Howell (2005), mutual understanding and client-contractor relationships could easily be ruined in case of a dispute due to the nature of adversarial relationships involved in the construction industry. The empirical data could confirm that without no long-term relationships there is a tendency to stick to traditional approaches and self-preservation. The interviews indicate that even partnering project could be stained by adversarial relationships if actions are not taken to maintain transparency and collaboration.

The difference in score and total area for the clients are based on the fact that Client B, in general terms, strives towards integrating processes while Client A has not yet realized the benefits of working integrated and are currently not striving towards implementing integration strategies. The reason for the clients to score low on integrated systems can be derived from the fact that neither of the clients are ensuring appropriate prerequisites to integrate building systems needed. It can be argued that, in general terms for both integrated systems and agreements, clients lack dedication towards implementing integration strategies, which would be required from a client that wants to make a transition.

### 5.4.3 Architect, consultant and subcontractor

Figure 5.5 is comparing the level of integration between the perhaps less influential, but equally important, subcontractors, consultants and architects. When comparing the graphs, it becomes apparent that the various actors might have different incentives to integrate their delivery methods.

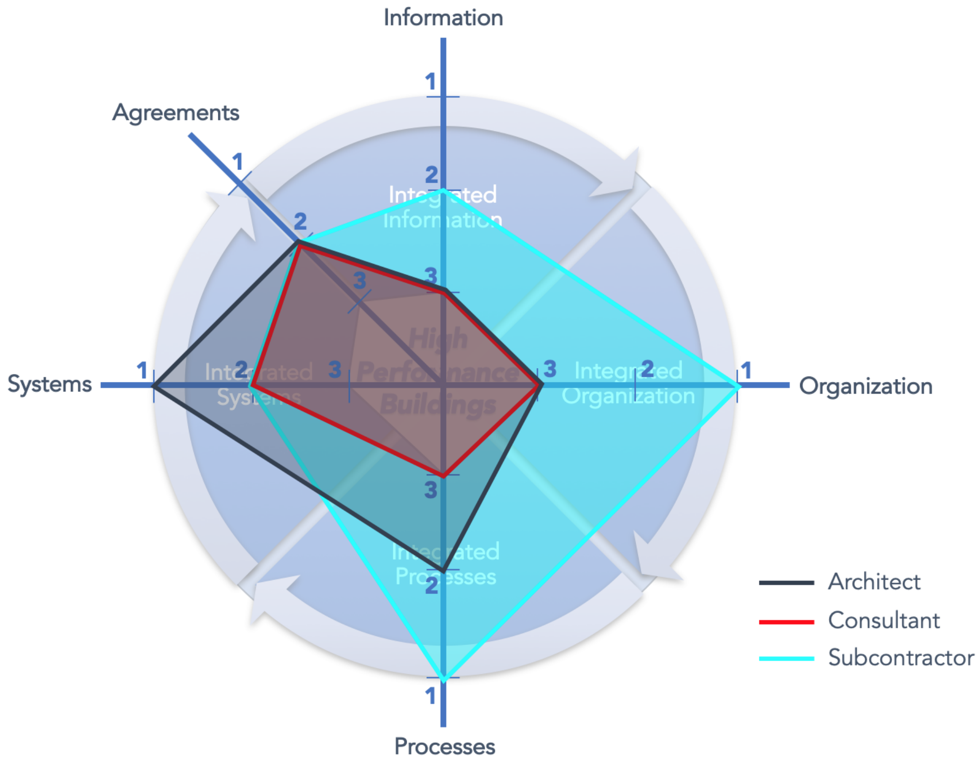


**Figure 5.5:** Analysis of the New Integration Model for the Architect, Consultant and Subcontractor, made by the authors.

When interpreting the graphs, it becomes clear that the Architect and the Consultant are at the forefront regarding information management. The Architect is usually the driving actor in the projects concerning the development of BIM as to enable visualization of the design, which is why they have managed to integrate their information and how they handle it within the organization. However, the Architect is more concerned about the design than what type of building systems that are being utilized, which explains that their graph stretches towards the left side.

The Consultant, which is a consultancy firm within virtual construction, could be recognized to be exceptionally aware of and focused towards integrating their delivery methods. The reason why the Consultant is not reaching the highest scores on the aspects of systems and agreements could be because they are, as the role of a consultant, limited in their reach to dramatically change processes within the project. However, the Consultant is still trying to achieve integrated aspects and they are working towards achieving high performance buildings. Being a consultant within virtual construction, their role is partly to support actors that want to make a transition towards digitalization.

The Subcontractor, on the other hand, is a large-scale subcontractor within electrical installation that are highly encouraged to integrate their building systems together with other subcontractors, aiming at reaching the best possible solutions. However, the Subcontractor lack incentive to integrate their own organization and processes because their own reach and impact is perceived insufficient to make any larger change of processes. The Subcontractor is only participating in integration strategies on the initiative of other actors, which is why their graph stretches towards organization and processes on the right side of the model. The Subcontractor participates in ICE-meetings and develops BIM-models to handle their information, but only because it is as a requirement from the contractor. The Subcontractor have incentives to make their own processes more efficient, but at this point subcontractors do not see any monetary award of investing in integration strategies without any larger collective efforts involving all participants of a project.

If the Consultant and the Subcontractor would have carried out a project together, tensions could arise due to their different approaches concerning project integration, particularly the aspect of organization and processes. When comparing the Architect and Subcontractor, it can be concluded that the Architect focuses on the early phases of the project when the overall design and functions are settled, meanwhile the Subcontractors focuses on providing detailed drawings of systems later during the design phase. To overcome this separation, the interviews showed that there are efforts to involve the Subcontractor earlier in the design phase which not only leads to better knowledge sharing between the disciplines but also contributes to a better understanding regarding the building systems for the Architect.

## 5.5 Applying New Integration Model for construction projects

The New Integration Model is developed through the lens of IPD and is therefore applicable to evaluate any organization of the project. However, the purpose of the New Integration Model is not to differentiate the level of integration in the different construction phases. Nonetheless, the New Integration Model can be utilized to evaluate the level of integration for all phases of the construction project. As a result, the authors have developed a model that describes the connection that is tying the various phases of a construction project together with the New Integration Model. The model for evaluating integration along the various construction phases is presented in Figure 5.6.

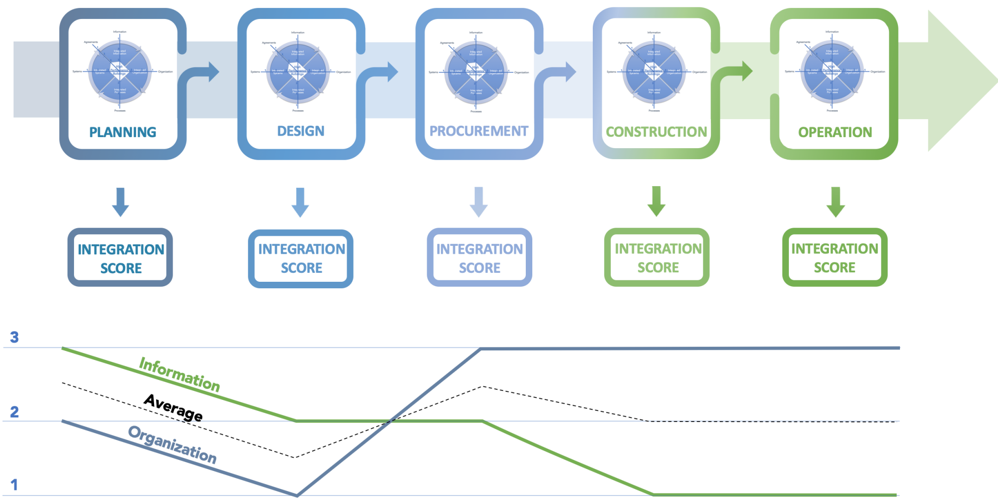


**Figure 5.6:** Possible evaluation regarding level of integration along various construction phases, created by the authors.

By applying the integration model analysis on every construction phase, it is possible to distinguish how the transition towards integration is progressing within every specific phase. Further, it provides an understanding of how the level of integration varies throughout the construction project and it gives an indication of in what phase appropriate actions needs to be taken in order to further integrate the project. Figure 5.6 illustrates possible graphs of the aspects of information and organization. The graph for information shows a closer integration during the early stages of the project and less integrated strategies during the construction and operation phase, while the graph for organization indicates the opposite. It would also be possible to produce a graph based on the average score for each phase in order to get a perception of the general level of integration throughout the project.

### 5.5.1 Summary of the New Integration Model and Framework

In sections 5.2 to 5.5, a discussion can be found concerning research question number two. Hence, the level of integration for actors of the industry can be measured using the presented framework and the New Integration Model created by the authors. Even though both the framework and New Integration Model is based on a subjective evaluation, it could still be used to broadly classify companies. Regarding the aspect interconnectedness, the New Integration Model presents the aspects of integration as pieces of a pie centred around the high performance building concept in the centre. The analogy presented in this model refers to the fact that all aspects are needed to assure that appropriate conditions are met for a project team to produce a high performance building.

## 5.6 Incentives and compensation models

This section addresses the axis named arrangements in Figure 5.2 and research question number three. The axis is an important factor because it sets the basis of collaboration between the parties. If the incentives to collaborate are not included in the contractual arrangements, then the conditions are not optimal for organizations to be integrated and work together. The agreement between the actors should include responsibilities, financial factors and governance in order to establish a foundation of trust and willingness to collaborate among the parties, so that they always work for the good of the project. It is therefore argued that incentive and compensation models should apply to all actors within the project, including the minor subcontractors.

The study can confirm that contractors and subcontractors are not making any real efforts of improving the value of their products without any incentives from external partners. Contractors and subcontractors do not seem to consider the value in producing a better building if the clients are not willing to pay for it, which is rather contradictory due to the fact that the contractors are also interested in establishing long-term relationships with their partners. One answer to why not produce a product that brings more value to the client, and the user, while simultaneously improve the opportunity of establishing a long-term relationship, could be derived from traditional contracts. Interviews could tell that contractors prefer long-term relationships but since most work is procured based on the lowest price, contractors know that they are interchangeable which result in short-term thinking.

Interviews show that many projects still involve traditional contract compensation. It is argued that new models for compensation and new incentives need to be implemented. The authors further conclude that partnering agreements need to involve other actors than just the client and contractor in order to increase the incentive to produce a better building. Speaking in general terms for the industry, compensation models need to change towards incentives that facilitate collaboration. Performance-based contracts align the change of mindset in buying a function instead of disparate systems and should be used for actors that have the ability to affect the outcome of the function. The contracts, in general, should include some kind of pain and gain-share part for all actors that could contribute to more efficient work to a lower cost for the client. To ensure incentives for consultants to work faster and more efficient and shift focus towards the clients' wishes, consultants should be bought with a contract similar to a fixed price contract that specifically specifies that required functions of a room or building to be delivered.

Partnering contracts is the closest alternative that exists in Sweden similar to an IPD multi-party contract. Partnering contracts ensure appropriate incentives for participants to collaborate without fundamental opposing logic. In that sense, participants are forced to collaborate, which would entail that partnering promotes long-term relationships. DB contracts can be argued as a suitable delivery method to work integrated since most responsibility is put on one single contractor, but if there is no pain and gain share incentives involved in the compensation structures for both the main contractor and its subcontractors, there will be no further or deeper collaboration within the project.

### 5.6.1 Summary of incentives and compensation models

To be able to change the mindset of actors from traditional contractual thinking towards collaborative delivery thinking, incentives to collaborate need to be included in the contractual arrangements. To date, the conditions are not optimal for organizations to be integrated and work together since incentives and contractual structures associated with traditional contracts are insufficient for integrated collaboration. It is therefore argued that incentive and compensation models should apply to all actors within the project, including the minor subcontractors, so that all actors work for the sake of the project.

The authors further conclude that partnering agreements need to involve more actors to increase the commitment to produce a better building. Partnering contracts ensure appropriate incentives for participants to collaborate and to establish long-term relationships, without fundamental opposing logic. IPD multi-party contracts have not yet been fully introduced in Sweden, which is why the authors promote partnering arrangements as the most similar well-known Swedish version to promote collaboration.

## 5.7 Project integration strategies

Construction projects are often characterized as long and complex which demands a certain extent of collaboration between many actors. There might exist benchmarks in order to assist clients to effectively execute construction projects, however, the traditional delivery approach still allows a large number of efficiencies to be requested.

### 5.7.1 System strategies

Due to the high-reaching goals for high performance buildings, which is presented in Figure 2.1, high performing buildings necessitate performance that is challenging to accomplish with the existing more traditional and disparate systems, methods and processes. In order to become more integrated, mindsets and behaviours need to shift towards a more collaborative way of executing projects while focusing on and engaging in each and every aspect of the integration model. The Consultant mentioned in an interview that customers (clients) should shift towards buying a well-functioning room instead of buying plenty of different disparate systems. Therefore, the mindset and contractual work of clients need to change towards buying functions by making the contractors take more responsibility for what functions they actually produce. As a result of new technology, constant connectivity and internet of things, the client can now more easily check the status or control building systems without having to comprehend all complexities and detailed knowledge involved in the systems.

### 5.7.2 Process strategies

The process in a traditional delivery approach could be described as linear, where each individual discipline performs in a silo before it delivers their part to the following discipline, whilst an integrated delivery approach necessitates the complete opposite. From the interviews, it can be concluded that traditional processes need to be approached from another perspective in order to create engagement through agile working processes, where different phases of the construction project are performed in sprints. It is argued that it is necessary to gather the most suited project participants in the same room during certain weeks in order to pick each other's brains over specific tasks instead of working separately for longer periods of time between meetings.

From the interviews, it can be concluded that there is a demand for other forms of process models that specify which decisions need to be taken along the project and what type of information being required, and what status that information should have, in order to take formal decisions. The Consultant states that the working processes in the construction industry need to become more integrated in comparison with other industries, for instance the car industry, where the supplier requirements are completely different.

### 5.7.3 Organizational strategies

Rischmoller et al. (2018) propose an integration strategy enabled by VDC and that VDC should be perceived as a lean strategy, in the same way that supply-chain integration was initially within the production systems for Toyota. In this regard, Lean and VDC interconnect on their shared basis of delivering the best achievable value. From the interviews, it is understood that VDC can only occur when its components relate to an integrated delivery approach rather than solely being applied in isolation. For instance, it is not unusual to find integrated Lean and BIM areas in specific projects or departments when in fact it might not be applicable for the entire organization, or even the entire project for that matter.

Interviews state that for a more effective organizational implementation, there need to be clear standards and set of rules of how the meetings should transpire and whom that will attend, as well as personal motivation from the employees. It is argued that clients should be engaged and make sure their products are delivered and that people are working collaboratively, aligning the theory of IPD implementation. It is argued by both Client and Architect that cloud-based software is a useful tool to integrating project teams since it allows project participants to work separately between the weekly coordination sessions with updated BIM-models, so that all participants get the same information. Further, all participants need to comprehend the user value and be engaged to deliver a good product.

Implementing ICE-meetings, ECI and other organizational processes that support organizational integration are valuable informal tools to assist the project team reaching decisions and finding design solutions faster. Colocation is an important factor in the integration of the organization.

### 5.7.4 Information strategies

It is argued that when striving to produce high performing buildings, the information environment needs to be more integrated towards the customer requirements meanwhile constantly connected with e.g. control systems and facility management systems. PLM-systems brings a lot of benefits regarding the treatment of information within and between projects but also for the entire lifecycle of the building. According to the Architect, how the information is handled and delivered within construction projects is challenging for the industry. There is further a need for predetermined guidelines describing how the information should be managed and delivered. The models provided in projects have enormous potential which today is not fully utilized. Being an active employee of the AEC industry, the amount of projects that an employee can participate in is limited during a professional career.

Gathered knowledge from previous projects can through PLM-systems be passed on to future generations and shared to the upcoming project without having to rely on human resources and knowledge. Clients that order new projects a few times every decade or less might struggle with the purpose, knowledge and experience of implementing a PLM-system. Clients that find integrated delivery tough can team up with a consultant to get support.

In order to achieve integrated information, VDC technologies and its information should be used throughout the project and building lifecycle. The information should not be secluded and isolated as often the case for traditional information management.

### 5.7.5 Summary of integration strategies

Section 5.7 consider plenty of different integration strategies for the different aspects discussed during this thesis, that could be useful for clients to reflect upon. In general terms, giving correct recommendations to all clients is indeed challenging since all clients are different. Recommendations and strategies would need to be shaped differently depending on what type of client and what type of project the client is conducting. In line with the findings of the thesis, all integration aspects need to be considered in order to give suitable tools and methods to the project team to conduct projects in an integrated manner. It is further argued that both formal and informal integration strategies need to be addressed.

# 6
# Conclusion

This thesis has been striving to raise awareness of integrated project delivery and through the new prototype for project integration, the authors have found a way to measure and compare organizations in terms of how integrated companies and projects are. Even though the assessment of the companies is something that could be developed further, in its current shape, it still contributes to a greater understanding that could lead to a more integrated industry. It is argued that the model can motivate and trigger companies to develop further in terms of integrated delivery approaches, since the possibility to visualize the integration aspects and their interrelation is provided by the model.

In the implementation and transition to integrated project delivery, both formal and informal integration strategies need to be addressed. Informal strategies concerns aspects of integration discussed in this thesis. Depending on the project and circumstances surrounding it, different sets of informal strategies need to be implemented for different clients. The findings of this thesis entail that all integration aspects need to be considered in order to recommend suitable tools and methods for each project in order for the project team to carry out projects in an integrated manner. Even though this thesis provides plenty of strategies for clients, it only scratches the surface of what is needed to fully implement integrated delivery methods.

Concerning formal integration strategies, construction projects need to adopt appropriate contractual agreements, that specifically includes incentives that motivates all project participants to collaborate and deliver a well-performed project according to the requirements of the project, namely, user value and owner requirements. The authors conclude that, incentive and compensation models should apply to all actors within the project, including the minor subcontractors, so that all actors work for the sake of the project. Consequently, partnering agreements need to involve more actors to increase the commitment to produce a better building since it ensures suitable incentives for participants to collaborate and to establish long-term relationships, without fundamental opposing logic.

Driving a transition from traditional delivery approaches towards an integrated delivery approach require active participation from the client since the requirements of the client constitutes a central part of the integrated work. The transition also requires good leadership, clear communication and extensive follow-up procedures to ensure that appropriate functions are delivered. Making the transition is not like investing in a temporary machine, it is a long-term investment in relationships, organizational change, technology and cost-effective buildings. Clients that need support strategizing the work of making the transition could benefit from teaming up with a consultant with such knowledge.

To reach new heights in terms of sustainability in the AEC sector, building systems need to be able to communicate and be synchronized to optimize energy efficiency, cut waste, reduce environmental impact and maximize occupants wellbeing. Therefore, allowing appropriate prerequisites of integration is a necessity for projects to integrate building systems that in turn leads to improved results in terms of reaching higher levels of environmental standards.

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# A

# Appendix

Appendix A is written to evaluate companies of a project. It could also be used to evaluate a construction project itself by translating companies to "the project" with all of its actors combined. The project could further be evaluated based on the different phases of a construction project.

## Integrated Information

***How integrated are companies regarding the information? From 1-3p.***

- 1p: Reaching level 1/1,5 in BIM-maturity ramp and no established information sharing platform (sending individual files between participants).
- 2p: Reaching level 2 in BIM-maturity ramp and cloud-based communication system used poorly.
- 3p: Reaching level 2,5/3 in BIM-maturity ramp and external cloud-based information sharing platform used throughout the project life-cycle and stored for future projects.

## Integrated Organization

***How integrated are companies regarding organization? From 1-3p.***

- 1p: Working in silos, not working towards integration (hierarchical organization).
- 2p: Involved in ICE-meetings and ECI-approach on other parties initiative
- 3p: Trying to implement characteristics of ICE and ECI to its fullest potential (flat organization).

## Integrated Processes

***How integrated are companies regarding processes? From 1-3p.***

- 1p: Not working towards reducing waste and improving the value of the product (no lean thinking or further collaboration).

- 2p: Claims to use Lean thinking and reduce waste and value of the product (no actual efforts to improve the value of the product).
- 3p: Using Lean thinking - reducing waste and improving the value of the product (having good processes for better collaboration and a better understanding of user value for participants).

## Integrated Systems

***Are companies working integrated to achieve integrated systems? From 1-3p.***

- 1p: Not trying to have building systems integrated.
- 2p: Trying to implement integrated systems but not yet achieving it.
- 3p: Achieving integrated building systems through collaboration.

## Agreements

***Are companies having appropriate collaboration agreements and are companies working towards achieving High Performance Buildings? From 1-3p.***

- 1p: Inadequate collaboration agreements with less productive incentives to collaborate. Not actively trying to reach a high performance building by barely meeting client project scope and requirements.
- 2p: Partly integrated collaboration agreements with productive incentives to collaborate. Attempts made towards reaching a high performance building by meeting client project scope and requirements.
- 3p: Fully integrated collaboration agreements with effective incentives to collaborate. Reaching the goals and requirements of a high performance building by meeting client project scope and requirements.

# B
# Appendix

**Interview questions**
The following questions are translated from the Swedish original copy of the interview questions conducted for this thesis.

**Introductory questions:**

- What is your position at the company you are working for?
- What are your main tasks?

**Partnering/multi-party agreements/IPD:**

- Are you using partnering or other multi-party agreements today and if yes, how does it manifest?
  - What are the biggest challenges in working with Partnering?
  - What actors are involved in partnering agreements?
    - Are subcontractors included?

**Integrated Information:**

- How do you share knowledge and information within your projects?
  - How do you share knowledge between projects?
- How do you ensure that the right actors receive the appropriate information and are updated about changes?
- How available is the information for employees and other organizations involved in projects?
- Do you use some sort of information platform to store and collect information that could be used to compare with other projects?
- Is there any shortcoming or potential improvements in how you handle information today?

**Integrated Organization:**

- How do you promote cooperation within the organization during the design process?
  - How do you promote cooperation with <u>other organizations</u> during the design process?
- How are the different projects linked together?
- How do you encourage employees to promote innovation and new ideas?
- • Are there any shortcomings or flaws with today's ways of working in your organization?

**Integrated Processes:**

- How do you work to increase the value of your finished products?
- How do you avoid late changes in the production phase?
- How do you work to make your processes more efficient?
- In what way are you trying to minimize waste of resources?

**Integrated Building Systems:**

- Are you trying to achieve smart houses or high performing buildings? (buildability, maintenance, user satisfaction and sustainability).
- Is anyone responsible for coordinating the building systems in your projects? (HVAC, ventilation).
  - Is there a holistic view of how to handle building systems in your projects?
- Are there any potential improvements to be made to achieve interconnected building systems?

**Other Questions:**

- How do you experience today's construction processes? (Are there any potential improvements?)
- How do you think future construction projects will be shape regards digitization and processes of cooperation.
- What do you think is the future of the construction industry?
- Do you participate in any development work/research work?