Benefits and challenges to applying IPD: experiences from a Norwegian mega-project

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Abstract

Purpose – The traditional construction delivery method is challenged by low trust and collaboration issues, resulting in increased project costs. The integrated project delivery (IPD) method is developed, through a contractual agreement, to overcome these challenges by creating a common set of terms, expectations and project goals.

Design/methodology/approach – A singular construction case was followed during a four-month period. Data collection consisted of contract documents and a series of semi-structured interviews with representatives from the owner, design-group and contractors.

Findings – The IPD contract was found to have a number of positive effects; it improved project behavior (e.g. trust, collaboration and communication), increased ownership among project participants and improved buildability of the design, leading to fewer surprises and interruptions in the construction phase. The study also revealed a number of challenges including contractual and legal challenges and involving too many participants in the early phases. Moreover, co-location was identified as a particular important supporting element, to build relations and improve collaboration.

Originality/value – This research identified lessons learned from the application, as well as initial barriers and persistent barriers for implementing IPD. To improve IPD application the top three lessons were as follows: 1) the contractual documents should be adapted and signed at an early stage as this increases financial transparency, 2) cost estimates should be carried as an iterative process and project main concept be freezed at an early stage to increase understanding and minimize risks, 3) only the most important project developers should be involved in the early phases, to avoid going into detailed design issues before the main concept is completed.

Keywords IPD, Case study, Lean construction, Co-location, BIM, Collaboration, Communication, Trust, Integrated project delivery

Paper type Case study

Introduction

On-site construction has for years been challenged by issues regarding time, quality and budget overruns (Larsen *et al.*, 2016). Trust and communication is found to have a huge impact on project performance (Cheung *et al.*, 2013). The more integrated collaboration the more important is trust and open communication to success (Morledge and Adnan, 2005). Integrated project delivery (IPD) aims to address the trust issues in the industry by

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attempting to foster a positive collaboration based on mutual respect and trust (Pishdad-Bozorgi and Beliveau, 2016). It is hard to find any direct critics of IPD and its benefits. Ilozor and Kelly (2012) found existing literature overwhelmingly positive and suggested future studies to include a certain lack of skepticism.

Application and current challenges

IPD has only rarely been applied in construction, especially when looking outside the USA (Whang *et al.*, 2019). Due to a number of barriers, the implementation of IPD has proven difficult (Durdyev *et al.*, 2020; Teng *et al.*, 2019). These barriers cover all aspects of IPD, thus both financial, legal, technological and behavioral aspects (Kent and Becerik-Gerber, 2010).

The early involvement of key participants can be a challenge because the traditional Design-Bid-Build approach entails that the design or at least most of the design is completed before the tendering phase, and thus the involvement of contractors (Cohen, 2010). For public construction projects IPD contracts and multiparty agreements will require a change in the laws and regulations (Cohen, 2010; Ghassemi and Becerik-Gerber, 2011).

Familiarity and knowledge of IPD within the industry is also a huge challenge. IPD is an entirely new delivery method which works very differently from the traditional Design-Bid-Build. Risk, rewards and liability are changed, as well as the entire way of collaborating. The project participants need knowledge and experience to IPD to understand each other's, as well as their own new roles (Hellmund *et al.*, 2008).

IPD requires a new way of collaboration if the owner, the designer or the contractor is not ready to work in accordance with these new guidelines it will create trouble. IPD requires the active involvement of the owner and requires that the owner is ready to accept joint project control (Cleves and Dal Gallo, 2012; Fischer *et al.*, 2017). Moreover, IPD can be a challenge for designers used to working alone, as it has increased requirements for collaboration. Finally, the elements of sharing risks and rewards and financial transparency can be a handful to establish. It can be very intimidating to open the books and it comes with a risk of padded estimates (Thomsen *et al.*, 2009). By padding the estimates, the contractors will distort the risk and rewards elements in the contract.

Because of the many barriers for adapting IPD, many of the few projects using the IPD method are given special permissions (Cohen, 2010). The many barriers and the high upfront investments in the early project phase in IPD have brought the project size and complexity into the debate. Cohen (2010) states that a project without an adequate size and complexity will not be able to return the upfront investments. Cleves and Dal Gallo (2012) disagrees by referring to a number of successful IPD projects.

The low application level is also apparent in the conducted research. In general, very limited research is conducted in the area of IPD (Bilbo *et al.*, 2015; Durdyev *et al.*, 2020). Moreover, most of the published research focuses on identifying success criteria's or how to improve project performance (Sommer *et al.*, 2014).

Only a few case studies have been conducted (Whang *et al.*, 2019), and of these only a few have been focusing on challenges, barriers or possible improvements to IPD and its implementation. The identified studies and the key findings are shown in Table 1.

Only a few of the previous studies have looked into the general application challenges to IPD. Only Simonsen *et al.* (2019) have made a short description regarding the application of the different elements of IPD and includes identification of challenges and benefits. The study is by coincidence based on the same construction case as this study, but the study is conducted two years ahead of the present one. The fact that the same case is studied in multiple phases illustrates the limited application level of IPD, and thus the limited number

Study	Focus area	Key findings
(Tillmann *et al.*, 2012)	Value creation	By integrating customers and suppliers IPD is found to facilitate an environment where value can be co-created. Integration is found to align customer requirements and supplier expectations, but on the other hand is the increased interactions found to increase the managerial challenges
(Zhang *et al.*, 2013)	Behavior	The study found a relationship between the sharing of tacit knowledge and the flexibility of the integrated project team. They concluded that promoting tacit knowledge sharing will help the integrated project team to perform in a dynamic environment such as a construction project
(Kraatz *et al.*, 2014)	General	Four overall topics were identified as important. Barriers and challenges and benefits: Important aspects include risk, value for money, industrialization and standardization. Multi-actor engagement: Important aspects include behavioral, management and economic issues. Organizational lead agents: important aspects include client drivers, mandates, standards, pilots and metrics. Knowledge intermediaries: Important aspects include diffusion and uptake, skills, productivity and asset management
(Bilbo *et al.*, 2015)	Financial/ performance	Based on a comparative study, IPD is found to give an improved cost and time performance compared to traditional construction. Moreover, the number of requests for information is substantially reduced when applying IPD. Causes were identified as team structure and a collaborative mentality. Moreover, a better application of BIM helped the project team in identifying conflicts before occurring on site
(Pishdad-Bozorgi, 2017)	Behavior	IPD requires trust. The study identified six different attributes in IPD that promote trust. Definition of interim goals to ensure early wins, Having a self-formed integrated team, Team mindset focused on project success, Sustained owner enthusiasm and involvement, Awareness of project complexity, Recognition of the uniqueness of IPD method
(Simonsen *et al.*, 2019)	General	The study revealed that because of the many differences to traditional construction, IPD should be implemented stepwise. The study revealed a tendency to fall back on traditional methods when problems occurred, they identified the main cause to be implementing too many elements at once
(Elghaish and Abrishami, 2020)	Technological	The study linked IPD to four-dimensional BIM. The study revealed an increased collaboration and trust among core team members. Moreover, they found that cost performance was improved with 22.86%

Table 1.
Case studies focusing on IPD

of cases to study cf. (Whang *et al.*, 2019). Despite of this, more studies and more depth are needed to identify all relevant challenges and barriers for implementing and applying IPD. This is highly relevant to owners or other construction professionals considering using the IPD method. Therefore, this research tries to fill this gap. Moreover, because the same construction case is studied in multiple phases, the findings from Simonsen *et al.* (2019) can be used as supplementing information to increase the understanding to the IPD application. The study's main research question is presented below:

RQ1. How does the Tønsberg project make use of IPD and how can the experience acquired be used in future IPD projects? This to identify lessons learned and barriers to overcome.

The focus has been on identified benefits and challenges related to both implementation and application. Moreover, a number of suggestions have been made to how some of these challenges can be overcome.

Integrated project delivery and its core elements

IPD emerged in 2005 as a new form of relational contracting, evolving from other methods such as partnering and project alliance (Thomsen *et al.*, 2009; Lahdenperä, 2012). The foundation of IPD is the development of collaborative, integrated and productive project teams, where all parties involved in the project jointly agree on objectives and commit in taking decisions that are best for the project outcomes rather than focusing on individual goals. This integration is promoted by the alignment of business interests through the adoption of a series of contractual, operational and behavioral elements (Fischer *et al.*, 2017; AIA, 2014; Thomsen *et al.*, 2009).

The existing literature defines elements projects must comply with to be considered IPD in its pure form. These definitions are, however, mismatched, typically differing by either considering elements as fundamental requirements or just as desirable characteristics in IPD applications. Table 2 shows a summary of recent definitions found on the literature.

In all but two studies, the behavioral elements "respect and trust," willingness to collaborate and "open communication" is found to be required elements in IPD. On the contrary, there is a great disagreement about whether lean construction, co-location or building information modeling (BIM) is a requirement or just a desirable part of IPD.

Some of the differences can be explained by simple differences in point of view. For instance; in Lean Construction IPD is viewed as the preferable delivery method and it fits well with the Lean Project Delivery methods such as Target Value Design (TVD) and Last

Table 2.
IPD Elements. "R" indicates the element is considered by the author as a requirement for IPD; "D" indicates it is considered as desirable; and "0" indicates the element is not mentioned in the respective literature

Elements of IPD	(Cohen, 2010)	(Kenig *et al.*, 2010)	(Ghassemi and Becerik-Gerber, 2011)	(Ashcraft, 2012)	(AIA, 2014)	(Lee *et al.*, 2014)	(Mesa *et al.*, 2019)
Contract							
A Early involvement of key participants	R	R	R	R	R	R	R
B Shared risk and reward	R	R	R	R	R	R	R
C Joint project control	R	R	R	R	R	R	R
D Reduced liability exposure	R	R	R	R	R	R	R
E Multiparty agreements	R	R	R	D	R	R	R
F Jointly developed and validated targets	R	R	R	R	D	0	R
G Fiscal transparency	D	D	0	D	D	0	R
H Intensified design and planning	D	D	0	D	D	R	R
Behavior							
A Respect and trust	D	D	R	R	R	R	R
B Willingness to collaborate	D	D	R	R	R	R	R
C Open communication	D	D	R	R	R	R	R
Co-location	D	D	0	R	D	0	D
Lean construction	D	D	0	R	D	R	D
BIM	D	D	0	R	D	R	D

Planner System (LPS) (Lichtig, 2006). In this context, the application of Lean Construction methods will of course be a requirement, but to organizations from outside the Lean Construction world, like AIA (2014) the primary focus is on the delivery method itself where the lean elements then are regarded as desirable.

Nevertheless, due to the similarities, the lean thinking and Lean Construction principles fit well with IPD. Lean and IPD both focus on improving collaboration, communication and trust while stimulatingly improving performance (Cheng and Johnson, 2016; Lee *et al.*, 2014). BIM and Co-location fit into this context because they support collaboration and communication (Latiffi, 2013; Andary *et al.*, 2020). Co-location supports collaboration and communication by bringing the key project participants together while BIM supports it by enabling real-time sharing of information and models (Latiffi, 2013).

IPD serves as an optimal framework for the employment of Lean Construction and BIM. Where, Lean Construction, Co-location and BIM are important enablers that combined with the behavioral elements and the contractual framework proposed by IPD, can contribute to better project outcomes. In the following are the contractual and behavioral elements in IPD, Co-location, Lean Construction and BIM explained. The explanation of the IPD elements follow the same structure as used in Table 2.

Contractual elements: theoretical concept

The contractual elements in IPD include as follows: early involvement of key participants, shared risk and reward, joint project control, reduced liability exposure, multiparty agreements, jointly developed and validated targets, fiscal transparency and intensified planning and design (AIA, 2014).

A. *Early involvement of key participants*. At a minimum, IPD requires early collaboration between owner, designer and contractor, but it can also include other parties depending on the specificity of the project (Fischer *et al.*, 2017; AIA, 2014). Identifying the right participants and determining the appropriate timing for their involvement is crucial, as participants should be engaged when their participation can, in fact, contribute to the project outcomes (Fischer *et al.*, 2017). The different viewpoints and early contributions from different knowledge areas can benefit projects by improving the constructability of the design, enhancing productivity, as well as leading to better price control and fewer surprises (Fischer *et al.*, 2017). Team members must, however, be open for a big amount of ambiguity and different interpretations (Cohen, 2010). IPD additionally requires more participation and leadership from the owner, demanding more time for management, consequently turning the process more costly (Fischer *et al.*, 2017).

B. *Shared risk and reward*. In IPD, individual profit is put at risk and is proportionate to the overall project performance, as compensations are tied to the achievement of project objectives (AIA, 2014). While the payment of direct costs is guaranteed by the owner, profit is adjusted by comparing the total project direct costs with an agreed target. If direct costs exceed the target, the amount exceeded is discounted from the profit of the whole team until, potentially, exhausted. If costs are under the target, savings are split to the benefit of the owner and the IPD team (Fischer *et al.*, 2017). By tying individual success to the success of other team members, shared risk and reward can induce parties to act more cooperatively to ensure project success (Pishdad-Bozorgi and Beliveau, 2016; AIA, 2014). The compensation model, however, must be defined in a way that earning profit is neither too difficult nor as the fear of not making a profit would possibly reduce creativity, transparency and collaboration, but neither too easy, so that project members remain challenged to think creatively, adding value to the project (Cleves and Dal Gallo, 2012).

C. *Joint project control*. Project control in IPD is shared between owner, designer and contractor, with the aim of balancing the interests of the different parties, strengthening the collaborative

nature of the project (AIA, 2014). IPD projects typically adopt a decision flow system that focuses on reaching decisions unanimously or by the majority of the vote, so all parties have a voice in decisions, with the owner holding slightly more authority through the owner's directives (Fischer *et al.*, 2017). Joint project control demands a shift of paradigm, and therefore choosing the right people when building the project team is crucial, as project success strongly depends on the commitment of participants for reaching consensus (Fischer *et al.*, 2017).

D. *Reduced liability exposure*. Liability concerns hinder creativity in the design and increase project costs, as organizations tend to create contingency allocations to protect themselves from claims (Fischer *et al.*, 2017). By reducing the ability of the parties to sue each other, IPD aims to inhibit the blaming culture in construction projects, improving collaboration and trust between participants and fomenting innovation (Fischer *et al.*, 2017; AIA, 2014).

E. *Multiparty agreement*. A contract that binds, at least, owner, designer and contractor, into a single agreement, allowing the multiple parties to agree to a common set of terms and expectations and to share risk and reward, guaranteeing the operationalization of the contractual elements of IPD (Kenig *et al.*, 2010).

F. *Jointly developed and validated targets*. The targets define the project's key goal regarding project performance. It is important that the owner, designer and contractor develop the target in collaboration to ensure everyone supports and attempts to meet the targets (Kenig *et al.*, 2010). Jointly developed targets serve to unify the key participants and to in collaboration work toward the same goals (Ahmad *et al.*, 2019).

G. *Fiscal transparency*. Is referring to that the key players, which includes the owner, designer and contractor, keep an open book (Kenig *et al.*, 2010). By sharing information about revenues and expenses, contingencies are made visible. Financial transparency serves as a component fostering collaboration and trust among project participants (Pal and Nassarudin, 2020; Ahmad *et al.*, 2019).

H. *Intensified planning and design*. In IPD there is an increased focus on increasing the quality of the design and plans (Kenig *et al.*, 2010). By improving the early design and plans, errors are caught at an early and less costly stage than during the construction process, where errors, omissions and changes in scope or in design have a direct effect on project duration and project cost (Hanif *et al.*, 2016). In general, by intensifying the project's planning and design, the project's cost-, time-, and quality-performance are improved, as well as the likelihood of meeting the project jointly developed targets (Larsen *et al.*, 2018; Kenig *et al.*, 2010).

Behavioral elements: theoretical concept

The behavioral elements of IPD include Respect and trust, willingness to collaborate and open communication (AIA, 2014). The IPD contract is made to create a context wherein these three behaviors can thrive (Hamzeh *et al.*, 2019).

A. *Respect and trust*. These elements affect how people interact and are essential to ensure a positive interpersonal working relationship in any project (Lewis and Weigert, 1985; Gabarro, 1978). Improving respect and trust leads to improved collaboration and communication (Cheung *et al.*, 2013; Chow *et al.*, 2015). Therefore, Lee *et al.* (2014), find respect and trust to be the most important behavioral element in IPD. In IPD, trust is established in the early phases where key participants are involved early and mutual agreements are made.

B. *Willingness to collaborate*. The success of any construction project is depending on the level of collaboration, where an improved collaboration will improve project performance (Cheung

et al., 2013). In IPD, collaboration is improved through the contractual document, ensuring that all parties work toward the same goals. Without achieving overall project success, the individual parties would neither succeed (Fischer *et al.*, 2017). Shared risk and reward can motivate the participants to collaborate, as it is connecting profit and performance while ensuring that optimizing the whole instead of sub-optimization is not a choice but an obligation (Ashcraft, 2012).

C. *Open communication*. Mutual conflict solving, sharing of information and a no-blame culture are important "elements" of open communication. The parties aim to jointly discuss and solve identified problems quickly within the project team, instead of finding someone to blame. Joint project control requires project participants to explain issues from their point of view and listening to the perspective of others. Thus, communication is important to enhance understanding of identified problems within the team. Limited liability enhances creativity and open communication, as well as obligating project participants to take responsibility (Fischer *et al.*, 2017; AIA, 2014).

Co-location: theoretical concept

In IPD, it is recommended to co-locate primary project participants (Kenig *et al.*, 2010). By locating the primary project participants in the same area, the behavioral elements of trust, communication and collaboration is improved and the likelihood of reaching the jointly developed project goals (Pishdad-Bozorgi, 2017; Andary *et al.*, 2020; Kenig *et al.*, 2010). Moreover, communication is easier and faster, Andary *et al.* (2020) found that the response time to request for information was reduced substantially.

Lean construction: theoretical concept

Lean Construction is an attempt to improve performance in the construction industry. In lean the key focus is on: identifying and delivering value to the customer, eliminate waste, focus on the flows and seek for perfection. TVD and LPS are two of the lean methods that are most often associated to IPD (Mesa *et al.*, 2019).

TVD is a management approach based on target costing where cost and value are the primary drives during the design process (Zimina *et al.*, 2012; Nicolini *et al.*, 2000). In TVD, the main focus is on client value and removing non-value adding parts to reach the clients expectations (Zimina *et al.*, 2012). Moreover, like IPD, TVD recommends to co-locate key players (de Melo *et al.*, 2016).

LPS is a production control system, developed to improve the production flow (Ballard, 2000). The key focus is on reducing inflow variation by making sure that scheduled activities are ready to be completed. Because readiness depends on a number of preconditions, which are within managerial control, activities can be made ready before entering the schedule (Koskela, 1999; Lindhard *et al.*, 2020). The effects of reducing inflow variation are increased scheduled reliability, reduced delay and improved production performance (Tommelein, 1998; Lindhard *et al.*, 2019).

Building information modeling: theoretical concept

Even though integrated projects may exist without the use of BIM, nearly all IPD projects rely on BIM during design, construction and operation (Ashcraft, 2012), as the full range of benefits proposed by IPD are only reached when BIM is adopted (Kenig *et al.*, 2010). BIM offers highly collaborative tools that allow IPD teams to work together, store and share intellectual capital (Thomsen *et al.*, 2009), resulting on better common understanding, less

errors and optimized evaluation of alternatives (Becerik-Gerber and Kent, 2010), allowing for better decision-making (Kenig *et al.*, 2010).

Research methodology

The present research is a single case study, where the application of IPD is viewed in its real-world context. The purpose is to conduct a comprehensive investigation and analysis of the particular case, to create an increased understanding to IPD while still considering the complexity and nature of the case in question (Yin, 2012). The aim of this article is to investigate the use of IPD as a project delivery method at a construction project in Norway. The case in the research is an exemplifying case where the intention is to capture specific circumstances regarding the situation and is chosen since it provides unique information for answering the specific research questions in the article (Bryman, 2012).

The results from the research were collected during the spring of 2020 and the project was followed for a four-month period, during the construction of the somatic building. Data collection consisted of contract documents and interviews.

The interviews were designed by following four steps of a predefined framework based on (Kvale and Brinkmann, 2009).

Step 1: Thematizing. In this step the purpose and theme of the research is defined. The importance of clear research scope is supported by Yin (2012), who advises narrowing down the focus to be able to identify the relevant information. The research scope was identified as the benefits and challenges of applying IPD.

Step 2: Designing. In this stage the form of the interview type is selected, the overall design is created and the choice of interviewees is made. The interviews were chosen to be carried out as semi-structured with representatives of both owner, design-group and contractor organizations. These members have been chosen due to their leading roles in the project and their high involvement in decisions regarding the IPD implementation. The interviewees kept the same roles during the construction of the psychiatry and somatic buildings, and therefore, the collected data is relevant for the whole duration of the project and the IPD agreement and are not solely specific for the somatic building.

The interview was designed to focus on five key elements regarding IPD. The main elements were as follows: contractual elements; behavioral elements, co-location, lean construction; BIM. Based on this framework, the following issues were addressed during the interviews:

- Which and how IPD elements were implemented.
- Benefits related to each element.
- Challenges related to each element.
- Measures to be considered in future IPD projects to overcome challenges.

Step 3: Interviewing. Four interviews were carried out with project representatives of the owner, designer and contractor. They were carried out digitally through video calls and were conducted in the participant's native language to avoid language barriers.

Step 4: Analyzing: The collected interviews were analyzed by categorizing the statements into the following four key categories: contractual elements, behavioral elements, Lean and BIM. Afterwards, the statements were compared to findings in the literature review.

Finally, the revealed findings were examined by the interviewees to avoid misunderstandings.

In addition to the interviews, the IPD agreement from the Tønsberg project also served as a source of data for this research.

Case description

The investigated project is the Tønsberg project, a hospital project in Norway. The Tønsberg project is the seventh, and final, construction stage of the hospital in Vestfold, Norway, which has gradually been upgraded and expanded between 1990 and 2005. The Tønsberg project consists of two buildings, a psychiatry building and somatic building, with a total area of 44.000 m^2.

The pre-project began in 2015, and the design-group and contractor were engaged in 2016. The design-group and contractor were engaged with an intention and plan that the project should be carried out as an IPD project, as the first construction project in Norway. The parties were engaged from an early phase to contribute with expertise and development of solutions, where several elements of IPD were decided to be implemented. The specific elements defined as part of the IPD agreement at the project are a relational contract, common project goals, early identification of joint risk, early involvement of key participants, joint project control, transparency around finances, use of lean construction methods and BIM and co-location.

The IPD agreement was signed in March 2017 when the construction of the psychiatry building started. The Tønsberg project has an expected duration of four years, with the scheduled completion of the somatic building in March 2021. The psychiatry building was completed in March 2019. The budget for the project is approximately NOK 2.7bn.

Results and discussion

The case study investigated the implementation of IPD at the Tønsberg project. In Table 3, is it indicated whether or not the different sub-elements of IPD or supporting elements were implemented. The following sections contain an elaboration of the application level, obstacles and lessons learned regarding each of the sub-element, as presented in the introduction and follow the same structure. Some of the learnings are

Implemented elements of IPD	Tønsberg project
Contract	
A Early involvement of key participants	Implemented
B Shared risk and reward	Implemented
C Joint project control	Implemented
D Reduced liability exposure	Partly implemented
E Multiparty agreements	Implemented
F Jointly developed and validated targets	Implemented
G Fiscal transparency	Partly implemented
H Intensified design and planning	Implemented
Behavior	
A Respect and trust	Implemented
B Willingness to collaborate	Implemented
C Open communication	Implemented
Co-location	Implemented
Lean construction	Implemented
BIM	Implemented

Table 3. IPD Contractual, behavioral and supporting elements implemented at the Tønsberg project

useful experiences based on the specific case, some regard barriers which relate to the initial national implementation of IPD and finally some learnings regard persistent barriers which are difficult to overcome despite repeated implementation. A categorization and summary of the findings can be found in Table 4.

Case specific learnings	Initial barriers to overcome	Persistent barriers
I. Allocate enough time for carefully selecting a small group consisting of the right people to early involve in the project	I. Lack of experience and knowledge to understand and make a fair contractual agreement and ensure that IPD and the supporting methods are applied as intended	I. Difficulties in determining realistic cost estimates in early phases which makes it difficult to create a fair sharing of risk and rewards
II. Freeze the conceptual design in an early stage and avoid going into detailed design before the main concept is defined (freezing the initial design also has a positive effect on cost estimates and risks)	II. A better understanding of IPD is needed for the project participants to fully understand their new roles and to get the full potential out of the collaboration	II. Joint project control is difficult to achieve because the owner has to be willing to give up power in decisions which influence the product he/she is purchasing
III. From the start focus should be on ensuring constructability and cost efficiency of the main concept	III. Development of national templates and adoption of national regulations and laws to fit with the IPD method	III. Opposing objectives between project participants makes it challenging to jointly develop targets that all parties find acceptable. Moreover, the owner again has to be ready to give up power
IV. Contractual documents should be adapted and signed as early as possible to increase financial transparency	IV. Development of guidelines for applying TVD to ensure the method is applied as intended	IV. It is difficult to achieve fiscal transparency through the entire project organization
V. Cost estimates should be carried as an iterative process to improve the quality of the measures		V. Ensuring that all project participants work towards the common goals (and predefined targets)
VI. Ensure a basic understanding of the contract elements to ensure a fair risk distribution		VI. A risk of opportunistic behavior of project participants which will influence the collaboration as well as the allocation of risk, rewards and liability
VII. In the pre-project and design phases, the co-location can be located where it is most practical for the project participants. Locating it closer to project participants lower travel expenses		
VIII. Make early agreements and predefined standards on level of detail in BIM. Using BIM for communication directly to craftsmen was found challenging and required extra education of the craftsmen		

Table 4.
Categorization and summary of lessons learned regarding implementation of IPD

Contractual elements: learnings from the Tønsberg project

A. *Early involvement of key participants*. The owner, design-group and contractor were involved in the pre-project and design phase of the Tønsberg project. The interviews revealed that the early involvement of key participants was crucial to optimize and scrutinize the project to guarantee the cost of the project to meet the approved cost of the investment. Additional mentioned benefits of involving the contractor in the design phase were greater ownership of solutions, reduced risks in the construction phase, more accurate cost estimates and consequently fewer surprises, in accordance with the literature from Fischer *et al.* (2017) and AIA (2014). A challenge experienced in the Tønsberg project was the involvement of too many designers too early in the project, which resulted in carrying detailed design before the main concept of the project was defined. In addition, Simonsen *et al.* (2019) found that the wrong people were included. The lesson learned is to spend more time on selecting a small group containing the right people. This team should be composed of project developers who should be engaged from the beginning to optimize solutions with a focus on constructability and cost efficiency, and freeze the main concept before initiating with detailed design. Involving less participants is in accordance with Fischer *et al.* (2017), who argues that IPD does not imply involving all project participants from the start of the project, but rather to start out with a core team to be enlarged with additional key participants as the project progresses and as their contributions are needed. This approach would have minimized changes in the drawings and thereby reduced the number of hours spent with the design. Simonsen *et al.* (2019) agree, and find that early involvement of key participants has the potential of improving project performance.

B. *Shared risk and reward*. Design-group, contractor and mechanical, electrical and plumbing (MEP) subcontractors in the Tønsberg project put 100% of their profit at risk, as profit will be fully granted only if the project meets the target cost. If the project is concluded below the target cost, the savings will be shared between the owner and the IPD team. The greatest benefit of sharing risk and reward reported in the Tønsberg project is the parties realizing they need to work toward the common goal, prioritizing the whole instead of individual performance. Consequently, unnecessary disagreements are lowered, and focus is shifted to collaborative problem-solving, leading to a positive impact in project participant's behaviors. In the long run, shared risk and reward is believed to be leading to optimal economical results, as, according to the interviews, the Tønsberg project is building with a lower square meter price than similar projects in Norway. The mentioned benefits are broadly accepted in the literature of IPD and are in line with findings from Pishdad-Bozorgi and Beliveau (2016), who identifies a mutual relationship between IPD and trust, as well as findings from multiple IPD case studies reported by Cheng and Johnson (2016), Cohen (2010) and Kenig *et al.* (2010). Nevertheless, the Tønsberg project revealed challenges with the distribution of risks in the shared risk and reward system. According to the interviews, the parties did not have a deep understanding of the contract and the project when agreeing on the target cost, and this led, according to some, to an uneven risk distribution. This is a common issue in IPD and acknowledged by Ashcraft (2011), that describes predefining all aspects of the delivered outcome as impossible, and that the parties may have different opinions whether a specific item is within the initially contemplated scope or is a justified change to the target cost. The issues of dividing risk and costs fairly in the Tønsberg project are confirmed by Simonsen *et al.* (2019). Moreover, they identified problems regarding the level of power in the decision-making process and the share of risk. The challenges observed highlight the need of having a deep understanding of the project to determine a reasonable target cost and thus minimize risks for the parties in the risk pool. Running cost estimates as an iterative process throughout the pre-project phase and freezing the main concept at an early stage would increase the understanding of what is being designed and constructed and contribute for more accurate estimates. Moreover, removing activities with a high degree of uncertainty from the composition of the target cost would also contribute to reduced risk. All in all, it is important to acknowledge that the risk of parties leaving with none or unreasonably low profit is a downside of IPD, as naturally all players want to leave the project with a profit. Thus,

carefully defining the costs and risk distribution within the compensation agreement is crucial to lead all parties to positive results. If the industry is to adopt IPD more broadly, it is, to a certain degree, dependent on companies that have tried the method and still want to defend and market the idea, which is dependent on the parties financially succeeding. This is supported by Cleves and Dal Gallo (2012), who state that proven success in delivering projects is one of the best ways to secure repeated implementations.

C. *Joint project control*. The intended outcome of joint project control in the Tønsberg project is balancing the different parties' interests. With the parties putting their profit at risk, joint project control enables them to have certain control over the project and decisions being made, which is in line with Fischer *et al.* (2017), AIA (2014) and Thomsen *et al.* (2009). The Tønsberg project adopts the decision flow process suggested by Ashcraft (2012), where a senior management team takes decisions by the majority of votes in case the project representatives cannot agree unanimously. One of the benefits pointed out in the case study is that the process allows for decisions being made as close to production as possible. According to the interviews, project participants become more engaged to find a consensus, as if they do so they can move on with their tasks. Simonsen *et al.* (2019) found that some project participants had concerns regarding equal power in the decision-making process, despite varying experiences or knowledge regarding the problem on hand. In the decision flow process adopted in the case study, the owner has the right to initiate an owner's directive and override the majority decision made by the senior management. The owner having slightly more power through these directives could lead to uneven distribution, and as Fischer *et al.* (2017) describe, delegating more authority to one party can undermine the principles of IPD. On the other hand, the owner being the one paying for the investment makes it reasonable for the owner to have the final say. Fischer *et al.* (2017) describe joint project control as challenging, as it requires change. According to the case study, the demand on unanimous decisions requires a solution-oriented attitude from the project participants, which makes the selection of the right project participants a key factor for a successful implementation. Nevertheless, taking into consideration the opinions of a broader range of participants is reported to, in some cases, slow down the decision-making process.

D. *Reduced liability exposure*. The IPD agreement used in the Tønsberg project states that the parties waive and release claims and liability between each other. The IPD team holds joint responsibility for the project during design and execution until the hand-over. In the warranty period, however, each party is reliable for their individual deliveries, as in traditional Norwegian standards. Simonsen *et al.* (2019) agrees that liability waivers have been used at the project, and reports that it has contributed to limiting the blaming culture and leading to a better work environment.

E. *Multiparty agreement*. The Tønsberg project used a multiparty agreement between the owner, the design-group and the contractor. The MEP subcontractors were also part of the IPD agreement, through mirrored IPD agreements with the contractor. The contract was developed after an American template and had to be adapted to Norwegian laws and conditions. As the Tønsberg project is the first project using this type of contract in Norway, many clauses needed to be reviewed, which represented a great deal of work in the start of the project and led some of the parties with the notion of entering a contract in which not all points had been verified and where in some areas risk had been transferred to some parties more than others. The interviews revealed, on the other hand, that project managers have the freedom to not limit themselves to exactly what is stated in the contract, if the three IPD principal members unanimously agree. Collaboration and trust among the IPD principal members were described as high. Simonsen *et al.* (2019) find that the multiparty agreement was essential for implementing other elements of IPD and for promoting desired behaviors such as trust, collaboration and open communication.

F. *Jointly developed and validated targets*. The interviewees consider that project goals and targets in the Tønsberg project were developed jointly. However, none of the three leaders from the

owner, contractor and design-group, interviewed in this study, were part of the development of these goals, as they were developed prior to their start at the project. Simonsen *et al.* (2019), however, reported a lack of inclusion of the design-group and the contractor in the development of project goals, which led to reduced affiliation and support regarding the project goals. Some of the goals have been described as obvious and standard goals, such as zero injuries and no work-related crimes. Building 10% cheaper than a project concluded nearly 15 years ago is a goal considered unreasonable by the interviewees, especially due to the different technical requirements from today. Additionally, the project has a goal of building 50% faster than comparable hospital projects, which has also been described as impossible. The construction of the project is described as fast but not necessarily faster than other building projects in Norway, as the amount of prefabrication used is similar to other construction projects. Another goal was to establish a paperless project, with extensive use of BIM. This goal is also described as challenging, especially for the contractor, as craftsmen are still demanding drawings and it is difficult to educate all crews on the use of BIM.

G. *Fiscal transparency*. The case study revealed that financial transparency is currently implemented in the Tønsberg project. Client figures, however, are not reported back to the project. The interviews also revealed that it took time to fully implement fiscal transparency in the project, as it was only late in the pre-project phase that it was decided that the contract form would, in fact, be IPD, instead of a design and build contract. Simonsen *et al.* (2019) agrees that the top level in the project organization kept open books.

H. *Intensified planning and design*. TVD is used to optimize and coordinate the design in accordance with the project objectives. The target costs is used as design criteria and contractor and subcontractors provide continuous cost projections and evaluations of different design alternatives to assist the project representatives in making the best decisions about proposed design solutions, which is in accordance with the definition from Zimina *et al.* (2012). Simonsen *et al.* (2019) reported that the Tønsberg project, due to a delayed design, faced a situation where the on-site production was initiated before the detailed design was completed. There was a number of challenges in the design phase, mainly regarding how the process should be carried out, and that there is little presented literature about how earlier projects have implemented TVD. Ashcraft (2011) also states that "concepts such as TVD are easy to express, but difficult to accomplish." Nevertheless, the project representatives are optimistic about TVD and believe that the project would not deliver within the financial constraints without the use of TVD. TVD has also been mentioned as a tool that ensures that the project meets the contractual demands and that offers the owner the possibility to participate in the selection of technical solutions, products and vendors. Scheduling at the Tønsberg project is done at multiple levels starting with the main milestone plan for the whole project, followed by a 12-week plan and a 3-week plan. The interviews revealed that the scheduling process is not differentiating much from non-IPD projects, since the process is quite common on most of the contractor's other projects. The use of digital equipment and methods for planning, however, are described to be more extensive.

Behavior: learnings from the Tønsberg project

The IPD agreement is described as one of the main reasons for the collaborative behavior experienced in the Tønsberg project. The contract is seen to contribute to good collaboration, as it enhances problem-solving and finding the best solutions jointly. Instead of blaming each other, if there is a mistake, project participants try to find the best solutions as they realize that no one wins with one-sided attitudes when risk and reward are shared and dependent on the accomplishment of common goals. The improved collaboration is also confirmed by Simonsen *et al.* (2019), they emphasize the positive effects on the working environment, and the willingness to make the best out of a specific situation. Respect and trust are described as high between the IPD representatives, according to Simonsen *et al.*

(2019), the improvement of trust and respect is evident by a reduced us versus them mindset. Finally, open communication is found to be positively affected by the implementation of co-location. Simonsen *et al.* (2019) agree on a horizontal level in the organization, but identified problems regarding vertical communication, mainly due to missing definitions of roles.

Co-location: learnings from the Tønsberg project

Co-location is mentioned as one of the contributing factors for the good collaboration in the Tønsberg project. The benefits of co-location are also confirmed by Simonsen *et al.* (2019). It allows people to get to know each other and build relations. Moreover, direct communication facilitates the decision-making process and helps avoid misunderstandings, which is in line with Fischer *et al.* (2017). Nevertheless, determining the most practical placement of the co-location can be a challenge. At the Tønsberg project, the co-location was located at the construction site in Tønsberg, which is described by Fischer *et al.* (2017) to be the most common. However, all the interviewees mentioned that the co-location is not necessary where the construction site is located, but rather closer to where the participants are resided. Co-location closer to where the participants live would have contributed to saving traveling expenses. Moreover, it was mentioned that project participants got tired of commuting, and thus the productivity decreased. This is as well in accordance with the literature from Fischer *et al.* (2017), who states that co-location at the construction site is only necessary during the execution phase. In the pre-project and design phases, the co-location can be located where it is most practical for the project participants. Fischer *et al.* (2017) also state that resistance regarding co-location can occur regarding expenses and practical matters.

Lean construction: learnings from the Tønsberg project

In general, the Tønsberg project have had a strong focus on applying lean methods. Already when the project delivery approach was chosen, the choice of applying IPD was done under consideration of the possibility of applying lean concepts. The strong emphasis on applying lean-based methods was because the lean-based methods were expected to improve project performance. Two primary methods were applied, TVD and LPS. In the design phase, TVD was applied as a management approach to control the design process. In the building phase, LPS was implemented as a production control system. The research focus has been on effects of TVD, which is elaborated in the section "Intensified planning and design".

BIM: learnings from the Tønsberg project

The building owner at the Tønsberg project has requested extensive use of BIM, which is described as higher than on other projects. The BIM model contains a high level of information, which are used both in the design and construction phases. The model also contains information regarding management, operations and maintenance to be usable for facility management. The case study revealed that a challenge with the use of BIM has been to define the level of detail, as there were different expectations. In the case study this issue was solved by establishing a type of standard defining which detail level to attain and defining how accurate the model should be. It has also been mentioned that craftsmen on-site are still demanding drawings and that it is challenging to educate all participants in the use of BIM. Simonsen *et al.* (2019) find that despite some application challenges BIM improved communication and the sharing of information.

General performance: learnings from the Tønsberg project

A huge challenge for the success of IPD is to make sure that all project participants work toward project goals. The problem relates to the prisoner's dilemma, where parties working toward their own goal benefit at the cost of the project and the other participants (Wong *et al.*, 2005). Problems with project participants working toward their own goals is a general problem Matthews (2005) and has also been a problem at the Tønsberg project, this has also been confirmed by Simonsen *et al.* (2019). The contractual elements are the core of IPD. It is through the contractual elements of the IPD contract that all parties agree to a common goal and it is due to the contract that all should be obliged to work in the project's interest. Moreover, it is due to the contractual agreement that behavioral elements such as trust is produced. According to Simonsen *et al.* (2019), the lack of jointly developed and validated targets is one reason for the lack of commitment. Unfortunately, the desire to work toward own interest is high (James, 2002), if a high level of mutual commitment from all project participants is not achieved any possibility, small error or loophole within the contract introduces the risk that one party creates a profit at the cost of the project.

Conclusion

The contract and the contractual elements are found to be the core of IPD while the behavioral elements are products fostered by the contractual elements. Because IPD is in essence the contract, co-location, lean construction and BIM is regarded as desirable and supporting elements helping to improve behavior and project performance.

At the Tønsberg project the implemented contractual elements are as follows: early involvement of key participants, shared risk and reward, joint project control, multiparty agreements, jointly developed and validated targets and intensified design and planning. Reduced liability exposure and fiscal transparency are considered partly implemented. The applied behavioral elements include respect and trust, willingness to collaborate and open communication. The implemented supporting elements include co-location, lean construction and BIM.

Future IPD projects can benefit from the experiences achieved in the Tønsberg Project. The use of IPD at the Tønsberg project revealed several positive outcomes. Overall, it led to increased ownership among project participants and fewer surprises in the construction phase due to more buildable solutions. Collaboration is also found to be improved, as the focus is shifted toward common project goals instead of individual achievements. The contractual elements create a context wherein trust, respect, communication and collaboration can thrive. Co-location, Lean and BIM can support this behavior. Especially co-locating employees is found to be an effective instrument to build relations and improve communication and collaboration while technologies such as BIM are an enabler for fast and efficient information sharing. At the Tønsberg project, the IPD approach has helped achieve a positive working atmosphere with a high degree of collaboration, trust and respect. This is among others apparent in an improved problem-solving and reduced blame culture.

The use of IPD at the Tønsberg project also posed challenges. The challenges have been divided into the following three key categories: Case specific learnings, Initial barriers and Persistent barriers.

Case specific learnings are minor missteps where the approach fairly easily can be changed in future IPD projects. In relation to the case specific learnings, the key learnings include: sign and adapt the contractual documents early in the project, avoid involving too many participants too early, avoid going into the detailed design before the main concept is defined and carry out cost estimation as an iterative process.

The initial barriers relate to the challenges which occur when IPD nationally is to be applied for the first time. The challenges include adapting national standards and laws and the need of developing national templates to fit with the IPD method, as well as developing guidelines for ensuring contractual elements and supporting methods are well understood and applied as intended.

Persistent barriers are barriers which are difficult to overcome even after revealingly applying the IPD method. The challenges include difficulties in determining realistic cost estimates in early phases, and thus creating a fair sharing of risk and rewards; achieving actual joint project control as the owner must be willing to give up power in decisions; developing common targets due to opposing objectives between project participants and finally difficulties in achieving financial transparency.

The present research focuses on implementation barriers and the application of IPD. These learnings are important for owners and other project participants considering initiating or participating in future IPD projects. More research is needed to fully understand the relationship between the contractual elements (and supporting elements) and how to maximize the desired behavior and make sure that every participant works toward project goals.

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