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Design-Build in Construction: Performance and Impact on Stakeholders

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ABSTRACT

This paper aims at synthesizing relevant findings about the Design-Build construction delivery system from previous studies. It focuses especially on cost, schedule, quality, and various sustainability aspects associated with a construction project, as they are widely used as performance indicators in this industry. The paper also investigates the impact of Design-Build on the different stakeholders involved in a construction project. This work has been done through a literature review and a content analysis, focusing on papers comparing Design-Build to the classical Design-Bid-Build delivery system. The results of the literature review show that Design-Build outperforms Design-Bid-Build in terms of cost and schedule growth as well as in terms of delivery speed, all for a similar quality. Furthermore, it may suggest that Design-Build could help in reaching highly sustainable goals. It also reveals that DB has a considerable impact on the risk distribution among the parties as it tends to reduce the risk of the owner while increasing the risk for the other project members. This study might allow owners to save time in their investigation about the performance of Design-Build, and even lead them to reconsider their project delivery system choice when planning for new project launches.

Keywords: Design-build, design-bid-build, construction delivery systems, content analysis.

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Introduction

The way construction projects are conducted and managed has evolved considerably over the years. Indeed, as technology progressed, the complexity of projects soon reached a point where it exceeded the grasp of a single expert. The increasing complexity led the stakeholders of a construction project to specialize, thereby sequencing the project's organization (Sanvido, et al., 1992). This evolution led to what is currently known as the classical delivery method, where the owner contracts a team of architects and engineers to design the building and then elects a contractor following the lowest bidder rule.

However, this classical Design-Bid-Build delivery system is still far from perfect since most of the construction projects have to face some cost increases and schedule overruns, which can be really harmful for the owner. Moreover, in some parts of the world, as is the case in the Province of Quebec, Canada, the construction industry is currently facing a drop in activity (CCQ, 2015). The lack in efficiency shown by the classical method promotes the use of alternative delivery methods such as Design-Build, characterized by a single contract with an entity dispensing both the design and the construction of the building.

Since its first definition on the early 1990s, Design-Build has been gaining market share, reaching nearly 40% in the US in 2014 (RSMeans, 2015). It makes this delivery system one of the most significant trends in design and construction (DBIA, 2016). As it becomes even more important, the Design-Build delivery system is the subject of numerous research efforts that try to determine whether this mode is more efficient than the classical method. To do so, each study focuses on specific aspects of a construction project such as cost and schedule performance, single or multiple owners, and the type of building erected. However, the literature lacks a study synthesizing all the observations and the findings found about Design-Build performance in comparison with Design-Bid-Build; which represents the goal of this study.

As a result, this paper aims at synthesizing the knowledge gathered from previous studies about the performance of Design-Build compared to the classical Design-Bid-Build delivery system. It also highlights the outcomes associated with the use of Design-Build for each of the stakeholders involved in a construction project.

The paper is divided as follows: the next section outlines some definitions for the main terms used in the study. The chosen methodology is then discussed, which mainly consists in a literature review. The results of the literature review are then exposed in two parts, the first one describing the statistics generated based on the information gathered, and the second one being composed of summaries of studies comparing Design-Build and Design-Bid-Build. A discussion highlighting the findings of the study and a conclusion addressing the limits and consequences of those findings conclude the paper.

Preliminary Concepts

As this study focuses on the comparison between Design-Build and Design-Bid-Build, these are the definitions used to characterize those project delivery methods based on the first comparative study proposed by Konchar and Sanvido (1998):

"***Design-Build*** **(DB)** is a project delivery system where the owner contracts with a single entity to perform both design and construction under a single design-build contract. Contractually, design-build offers the owner a single point of responsibility for design and construction services. Portions or all of the design and construction may be performed by a single design-build entity or by a selection of specialized workers. In some cases, all of the activities may be subcontracted to other companies (Konchar *et al.*, 1998: page IX)."

"***Design-Bid-Build*** **(DBB)** is a project delivery system where the owner contracts separately with a designer and a constructor. The owner normally contracts with a design company to provide "complete" design documents. The owner or owner-agent then usually solicits fixed price bids from construction contractors to perform the work. One contractor is usually selected and enters into an agreement with the owner to construct a facility in accordance with the plans and specifications (Konchar *et al.*, 1998: page IX)."

Even though the performance triangle time-cost-quality is not necessarily the best way to determine the success of a project (Atkinson, 1999) , it is still the tool most used by the authors to compare the two construction delivery systems. Because these criteria still remain the most representative way to synthesize results from different studies, this paper will mainly use the same indicators. A brief description of each is provided below:

Cost growth represents the growth of the final project cost compared to the initial contract cost, where the contract cost is the design contract cost plus the construction contract in a DBB project.

Schedule growth represents the growth of the final project schedule compared to the initial contract schedule, where the initial contract schedule is the sum of both design and construction contract schedules.

Unit cost represents the amount of money needed to build a representative unit of measurement depending on the type of construction being built, such as a square metre for a standard building or a kilometre for a highway.

Delivery speed represents the amount of time needed to deliver a representative unit of measurement depending again on the type of structure being built.

Quality being a subjective measurement, there is hardly a unique indicator to measure it. As a result, past research generally used surveys to collect data and then emit global conclusions about the behaviour of each delivery system concerning quality performance. The quality of constructed facilities, the compliance with construction specifications or the conformity to user expectations are some of the indicators commonly used for quality measurement.

Another aspect differentiating the two construction delivery systems and discussed later in the paper is related to the type of contract used between stakeholders. Here are the definitions of the three principal contract types used for a construction project based on Lahdenperä (2001):

"***Fixed price***, also called lump sum, is a system of payment where the party who performs a specified scope of work is paid based on a pre-established fixed price, regardless of the actual costs, the price being changed only when the scope of work changes too (Lahdenperä, 2001: page 104)."

"***Cost-plus-fee*** refers to a system of payment where the party who performs a specified scope of work is reimbursed for realized work and material costs and paid an agreed fee for services rendered without any upper limit (Lahdenperä, 2001: page 107)."

"***Guaranteed maximum price*** (GMP) refers to a system of payment where the party who performs a specified scope of work is reimbursed for realized work and material costs and paid an agreed fee for services rendered but only to a certain agreed limit (Lahdenperä, 2001: page 110)."

Research Method

All the information used to compare the two construction systems was gathered through a structured literature review (see Cooper (1998) for more details concerning this type of methodology).

The first step was to identify key articles related to the subject. In order to do so, the authors used the databases *Web of Science* and *Engineering Village* that they mined through a combination of the following keywords: "Design-Build"; "Design-Bid-Build"; "Construction Delivery Systems", "Comparative analysis". The results were sorted by citation numbers in order to identify the most popular papers so as to gain insight into their relevance for the research community right off the bat. The selected articles had to deal with both DB and DBB and compared them, or discussed the differences of implementation.

Once those "main" articles were found, the authors focused on their lists of references to identify other interesting articles related to the subject (i.e., backward snowballing, see Wohlin (2014)). It helped us to generate new keywords and refine the search, while highlighting some authors that were very active in the field. The authors took great care to ensure that validity and reliability criteria were met (Carmines & Zeller, 1979). In terms of validity, they ensured their concepts met the agreed-upon definitions in both academic and practice-related literature. Furthermore, they ensured reliability by searching with consistent keywords (see definitions above) in leading commercial databases that are well known for the quality of their curation, thus ensuring that researchers in the field could replicate this research.

Most of the articles identified in that way dealt with empirical and statistical analysis, using data from construction projects already delivered. The findings of those studies were therefore classified and analyzed to better capture the performance of each type of construction delivery system, as presented in the next section, which details the content of those comparative studies.

The readings done during the selection process as well as the information detailed in the selected papers allowed us to identify the outcomes associated to the use of the Design-Build method for the stakeholders involved in a construction project. This analysis of the impacts of DB was later confirmed and deepened thanks to additional readings.

Results

Part A

The first search on Web of Science yielded a list of 83 articles. Among all the articles found, 16 relevant papers comparing Design-Build and Design-Bid-Build were retained. From those 16 studies, 11 focused on the cost-schedule-quality performance for the two project delivery systems. Those 11 papers used data from a total of 1,609 construction projects, 636 projects concerning the DB method and 973 projects being related to the DBB approach. Moreover 98% of the project sample was located in the United States. The authors also observed that military construction projects represented 64% of the sample. The comparative study written by Konchar and Sanvido (1998) was the research most cited.

Part B

The earliest article found looking at an empirical and statistical comparison between Design-Build and Design-Bid-Build was written by James B. Pocock *et al.* in 1996. Their study compared 25 American projects divided into 4 different project delivery types: Design-Bid-Build, Design-Build, Partnering, and what is mentioned as "the rest". All these projects concerned military constructions and represented 20 different types of facility. The core of the research consisted of ranking the cost and schedule performance of a project depending on the degree of interaction between stakeholders, which was defined as "the extent of interaction among designers, builders, and project-related personnel during a project's planning, conceptual design, detailed design, procurement, construction and start-up phases (Pocock *et al*, 1996: page 2)". The study also proposed a method to measure this degree of interaction. The conclusions were that the performance of a project is likely to improve with the degree of interaction between stakeholders. However, the authors explained that even if DB performed better than DBB in terms of cost and schedule, those results were not statistically significant.

In 1997, Konchar and Sanvido published the first comparative study between different project delivery systems: Design-Bid-Build, Construction Management at Risk (CMR), and Design-Build. These systems were empirically compared through the results of numerous projects conducted in the United States, regarding their cost, schedule, and quality performances. Data concerning cost and schedule were directly extracted from project metrics while quality was evaluated based on a questionnaire sent to the project owners. In particular, the study gathered data from 351 projects, from which 44% were DB, 33% DBB, and 23% CMR. The projects concerned different building categories, namely: Light industrial, Multi-storey dwelling, Simple office, Complex office, Heavy industrial, and High-technology facilities. The researchers also proceeded to univariate analysis to compare the performance of each delivery system according to their cost, schedule, and quality. They ranked the delivery systems following the facility type and the owner type. They finally conducted a multivariate analysis to identify variables that accounted for the greatest proportion of variation concerning unit cost, construction speed, delivery speed, cost growth, and schedule growth. The authors concluded that projects administered using the Design-Build project delivery system can achieve significantly improved cost and schedule advantages while quality achieved using DB is equal or sometimes higher than the one obtained from the other delivery systems studied.

Later in 1998, Moore presented a study continuing Konchar and Sanvido's work, adding 88 federal projects from the United States, 40 of them being Design-Build projects and the other 48 being Design-Bid-Build projects. Those projects were also compared using cost, schedule, and quality performances. They were classified using the same facility type as Konchar did. The conclusions were that federal Design-Build projects performed better than federal Design-Bid-Build projects, especially in terms of schedule growth and for some quality topics such as "facility start-up quality" and "operation/maintenance cost quality".

In 2001, Allen wrote a thesis entitled *Comparison of Design-Build to Design-Bid-Build as A Project Delivery Method*. Her research compared a total of 110 projects from US military construction, based on their cost, schedule, and quality performances. Cost and schedule metrics were extracted from a financial information database, and the data concerning quality were collected through a questionnaire survey. Those 110 projects were divided into 36 DB projects and 74 DBB projects, representing a total a 12 facility types from child-care centre to airfield pavement. The conclusion of the statistical analysis conducted by the author was that DB project delivery method outperforms DBB in terms of cost growth and time growth, while leading to better quality in 2 out of the 3 areas considered.

In 2007, Shrestha published a study focusing on large highway projects. The author gathered data from 8 projects equally divided into DB and DBB. Each project selected had to be located in the US, preferably in Texas, the costs had to exceed \$100 million, and the projects had to involve construction of a considerable amount of roadways. As in most of the comparative studies, both project delivery systems were compared using cost, schedule, and quality performance indicators along with change orders and security. Data concerning those indicators were gathered with questionnaire survey and phone interviews, and then used to perform a statistical analysis. Results showed that DB performed better than DBB in terms of cost growth, cost per lane mile, and delivery speed. However, a higher schedule growth was observed for this type of project delivery system. The quality and security performance of both methods were said to be similar, but DB showed a lower cost due to change orders than DBB.

Two years later, another comparative study focusing on military construction was proposed by Hale *et al.* (2009). It compared data from 38 DB projects and 39 DBB projects which were all part of a unique facility type: U.S. Navy bachelor enlisted quarters. The performance of the two delivery systems was compared using cost and schedule performance indicators, and these data were gathered using the Naval Facilities Engineering Command database. After a statistical analysis, the authors concluded that "Design-Build projects were proven superior in performance in almost every measure". Only "Cost per bed with other costs" and "Cost per bed" did not show a significant difference.

Another study focusing on military construction was conducted the same year, by Rosner *et al.*, with data from the Air Force military construction program. This study used a large sample of projects encompassing 278 DB projects and 557 DBB projects, for a total of 835 projects. Those projects included various types of facility, from storage to more complex operational facilities or even airfield pavement. The performance was evaluated based on cost and schedule indicators, but the number of modifications per million dollars was also taken into account. A statistical analysis showed significant results in favour of Design-Build in terms of cost growth and modification per million, but the DBB achieved the advantage in terms of total project time. This study concluded that DB was most suited for 7 out of the 9 facility types studied. For the 2 other types of facility, storage and maintenance units, the statistical analysis did not show a significant difference.

Beside the statistical analysis, the large number of projects used enabled the authors to represent the evolution of the use of design-build over time, showing a notable increase around 1999/2000, when the use of DB jumped from 18% to 48%.

In 2012, Shrestha *et al.* published a second study, still focusing on large highway projects, but this time with a larger sample than the one used in 2007, totalling 22 different projects: 6 DB and 16 DBB. Every DBB project was located in Texas, and the DB projects were selected outside Texas, but still in the United States. Each project involved the construction of roadways only and was completed between 2000 and 2009 with a budget superior to $50 million. The data were once again collected via questionnaire survey and telephone interviews. In addition to the traditional cost-schedule-quality indicators (considered here as output variables of a project), the study also used some characteristics of the project as performance indicators. Specifically, a total of 21 input variables were considered, including construction work days per week, pavement type, bridge areas, and schedule performance bonus. The goal was to find links between input and output variables. Results indicated that no statistical difference in mean cost-related metrics between DB and DBB projects existed. The mean in terms of project delivery speed per lane distance and construction speed per lane distance for DB projects was significantly faster than that for DBB projects. Moreover, this study indicated that 14 input variables had associations with one or more output variables. It means that these variables could help to predict the potential cost or time frame of a project. For example, the schedule growth was significantly less in projects that have concrete pavement, few numbers of interchanges, a schedule performance bonus, a partnering process, and a greater number of construction work days per week.

In 2013, another comparative study by Minchin Jr. *et al.* dealt with bridge and highway construction projects, but from a unique agency: The Florida Department of Transportation (FDOT) in the United States. 60 projects were randomly selected in the FDOT database and compared using cost and schedule performance metrics. The results showed that Design-Build projects (involving 30 projects) slightly outperformed DBB in terms of schedule, but not in terms of cost.

Still in 2013, Shane *et al.* published a comparative study focusing on water/wastewater facilities. They gathered data from 31 Design-Build projects and 69 Design-Bid-Build projects, using a questionnaire survey distributed to a large variety of owners in the United States. The projects were conducted between 2003 and 2008 with a minimum cost of $3 million. As for the others, this study used the cost-time-quality triangle to evaluate the projects' performance. Based on a statistical analysis, the authors highlighted that DBB's mean schedule growth was twice as important as for DB. DB projects were also more likely to be completed below the contract price. No significant difference concerning quality was observed.

In 2015, a study was presented by Park *et al.*, comparing DB and DBB for large-sized public apartment housing projects in South-Korea. The project sample consists of 14 DB projects and 13 DBB projects, each building being composed of at least 20 floors. Data concerning cost and schedule were collected from the Public Urban Development Enterprises, and quality evaluation was evaluated using a questionnaire survey. The authors found that the cost growth was more important for DBB, i.e. 19% against 13% for DB. They also observed that it took 12 days less per floor to complete the construction for Design-Build projects, with a slightly better quality.

In 2016, a study was published by El Asmar *et al.*, but unlike the other studies, it did not evaluate the delivery systems using only cost, schedule, and quality metrics. Indeed, the purpose of this study was to adapt the Quarterback Rating technique to project ranking in order to compare the performance of different construction systems, which led to the "Project Quarterback Rating". The advantage of the method is that it ranks the different systems using only one output metric. The authors decided to compare 4 delivery systems: DBB, DB, CMR, and Integrated project delivery, through data from 35 projects. The project quarterback rating allowed the researchers to take a large number of indicators into account, which were divided into 7 categories: customer relations, safety, schedule, cost, quality, profit, and communication. Their method led them to emit a ranking of the four compared delivery systems: Integrated project delivery finished first, followed by Design-Build, then Construction Management at Risk, and finally Design-Bid-Build.

All the studies described above used an empirical approach to compare the different delivery systems based on cost, schedule, and quality performances. We also found other studies that rather compared the systems based on their ability to deliver sustainable projects. The level of sustainability reached by a project was generally evaluated following the LEED ranking which is recognized as the international mark of excellence for green building in 132 countries (CaGBC, 2016).

A first study was presented by Bilec in 2008. In order to compare the different construction delivery systems; the author collected data from 25 green projects through telephone interviews and questionnaires. The projects studied were divided into 3 delivery systems: 50% of them were DB, 33% were DBB and the rest involved construction management. The author combined the results of the interviews with the result of the literature to identify the best practices to put forward in order to obtain a high level of sustainability. The author concluded by saying that even though a relationship between DB and green design did not explicitly emerge, certain characteristics of green projects like complexity and flexibility are well suited with DB, and that the owner role and implication in the project is critical, regardless of the project delivery system used.

In 2009, Molenaar *et al.* published a report aiming to determine whether project delivery methods influence an owner's ability to achieve its sustainability goals. To do so, the authors gathered information about 230 projects: 53 DB, 54 DBB, and 123 CMR, using a questionnaire survey sent all over the United States. The project sample was also divided by contract type used in each delivery system. Based on the analysis of their survey responses, the researchers concluded that if the owner wants to maximize sustainability within an available budget, CMR or DB-GMP provide the greatest likelihood of success. The study also revealed that integration is necessary to seek a high level of LEED ranking.

In 2010, Korkmaz *et al.* proposed another study to determine the relationships between the level of integration in the design process, the sustainability goals, and the project delivery methods. To do so, the authors studied 12 office buildings in the US that had been awarded various levels of LEED certification. This sample contained 5 DB projects, 3 DBB, and 4 CMR. The data were collected via telephone interviews with the owner, the contractor, and the designer of each project. The authors concluded that the owner's strong commitment is a requirement to satisfy even the minimal aspects of sustainability, while an early involvement of the constructor appears to be a key factor in the success of a project. They also highlighted that both CMR and DB can provide high or medium levels of integration as they inherently facilitate early involvement of constructors. The authors finally pointed out that a low level of integration can generate more cost growth, due to the changes asked by the contractor.

Another element on which the different construction delivery systems were compared concerns the legal aspect.

Indeed, a study written by Pishdad-Bozorgi *et al.* in 2012 compared Design-Build and Design-Bid-Build from the standpoint of claims. Using a literature review and a series of interviews, the authors tried to determine the influence of DB over the number of claims between the owner and the contractor. Results showed that the number of claims emitted by the contractor decreased for DB systems, especially when it dealt with changes in contract documents. The owner's claims also tended to decrease, especially the ones dealing with cost over-run and schedule delays. Nevertheless, claims about work quality might increase for DB systems depending on the level of commitment of the owner and the design-build team expertise.

Discussion

Based on what was found in the literature, it becomes possible to highlight some aspects of the duality between Design-Build and Design-Bid-Build. First we can see that, at least in the US, Design-Bid-Build is still the main delivery system used, with 58% in 2014 against 38% for DB (RSMeans, 2015). Moreover, it seems that military construction is one of the principal users of Design-Build as it reached 48% of the MILCON use in 2009 (Rosner, et al., 2009). This may justify that 4 of the 11 empirical studies described above focused on military constructions. This goes along with the ease of access to military project data.

It is also interesting to note that most of the papers compared the different construction delivery systems using cost, schedule, and quality performance indicators. A summary of the studies using this kind of evaluation can be found in Table 1. Only the indicators included in most of the papers are presented (i.e., cost growth, unit cost, schedule growth, and delivery speed). Due to the heterogeneity of the units used to describe the unit cost and the delivery speed, no mean could be calculated for those two indicators; this heterogeneity is a consequence of the different types of building studied in each research. As quality cannot be efficiently evaluated with quantitative values, only the general conclusions of the studies which tackled this issue are represented in the table.

Table 1: Summary of the empirical studies.

Author	Project Sample		Cost		Schedule		Quality	Facility Type
			Unit Cost	Growth (%)	Delivery Speed	Growth (%)		
James B. Pocock (1996)	DB	5	--	12,9	--	41,2	--	Military
	DBB	7	--	6,7	--	48,4		
Konchar (1998)	DB	154	861 ($/m²)	2,2	636 (m²/month)	0,0	DB ≥ DBB	Industrial
	DBB	116	1291 ($/m²)	4,8	302 (m²/month)	4,4		
Moore (1998)	DB	40	124 ($/SF)	5,7	10310 (SF/month)	1,5	DB ≥ DBB	Industrial
	DBB	48	141 ($/SF)	9,0	7634 (SF/month)	11,2		
Linda N. Allen (2001)	DB	36	117.23 ($/SF)	3,0	--	-4,0	DB ≥ DBB	Military
	DBB	74	134.41 ($/SF)	21,0	--	56,0		
Pramen Prasad Shrestha (2007)	DB	4	3,52 (M$/mile)	1,5	11,4 (Days/Mile)	11,0	DB = DBB	Transport
	DBB	4	3,70 (M$/mile)	12,7	28,5 (Days/Mile)	4,3		
Darren R. Hale (2009)	DB	38	56 (K$/lit)	2,0	2,6 (Days/lit)	11,5	--	Military
	DBB	39	58 (K$/lit)	4,0	7,0 (Days/lit)	13,9		
James W. Rosner (2009)	DB	278	3,04 ($/m²)	4,5	--	17,3	--	Military
	DBB	557	2,70 ($/m²)	6,4	--	18,8		
Pramen P. Shrestha (2012)	DB	6	3,2 (M$/km)	7,8	0,3 (month/km)	20,5	DB ≥ DBB	Transport
	DBB	16	2,7 (M$/km)	6,3	1,2 (month/km)	5,1		
R. Edward Minchin Jr. (2013)	DB	30	--	45,3	--	20,2	--	Transport
	DBB	30	--	20,4	--	23,0		
Keith R. Molenaar (2013)	DB	31	--	1,6	--	4,3	DB = DBB	Water Wastewater
	DBB	69	--	3,6	--	5,0		
Hye-Sung Park (2015)	DB	14	961,6 ($/m²)	13,0	37 (Days/Floor)	--	DB ≥ DBB	Residential
	DBB	13	960,2 ($/m²)	19,0	50 (Days/Floor)	--		

Total Project Number:	**DB**	**636**	**Mean Cost Growth (%):**	**5,8**	**Mean Schedule Growth (%):**	**10,1**
	DBB	**973**		**7,8**		**18,4**

When we look at this recapitulative table, we can note that the DB system seems more reliable concerning the estimated budget and schedule. In particular, we observe a mean cost growth 2% lower and a mean schedule growth 8% lower than the ones obtained for the DBB system, even if some studies punctually showed results in disfavour of Design-Build. It is also important to note that every study providing value for the mean delivery speed tends to agree on the fact that DB is faster than the classical delivery system. The only point where Design-Build does not outperform Design-Bid-Build is the unit cost, as most of the studies found almost no differences concerning this indicator.

If we look at quality, most authors pointed out that DB quality performance was better or similar to the quality performance of DBB projects. There is however some uncertainty attributable to the subjective nature of quality, which makes it really difficult to measure without perceptual influences. But a conservative interpretation could be that DB performs at least as well as DBB in terms of quality.

The literature also highlighted the capability of Design-Build to deliver sustainable projects. Every study ridden on that subject agreed with the fact that project integration facilitates the reach of higher sustainable goals. They also confirmed that DB can achieve a greater project team integration than DBB. However, they also mentioned that the best delivery system in terms of integration, and therefore in terms of sustainability, was the Integrated Project Delivery, which is beyond the scope of this paper.

Impact on stakeholders

The information gathered from the literature also allowed us to evaluate the outcomes of DB from the perspective of each member involved in a project. In particular, we considered four main categories of stakeholder, which are: the owner, the architects, the engineers, and the contractor. We also distinguished the outcomes following three different forms of internal organization for the DB entity, which are: the architect/engineer (A/E)-led DB, the contractor-led DB, and an integrated DB. With the A/E-led DB, the owner contracts a DB agreement with the A/E company. The A/E company then subcontracts the construction part to a contractor. With the contractor-led DB, the owner contracts the DB agreement with a contractor. The contractor next subcontracts the design part to an A/E company. In an integrated DB agreement, the owner contracts with a DB entity which combines the skills of both the A/E team and the contactor.

The articles analyzed led us to conclude that the use of DB mainly impacts the way the risk is divided among the project members. As the distribution of responsibilities differs depending on the form of internal organization retained, the outcomes also change with it. The only exception to that is the owner who is barely impacted by the internal organization of the DB entity.

An A/E-led Design-Build is close to the classical delivery system in terms of structure, so the responsibilities distribution is only slightly impacted. Nevertheless, the A/E team gets an extended scope of work as it is now responsible for the scheduling and the materials procurement (Lahdenperä, 2001). It also benefits from more liberty and control over the whole process. On the other hand, the contractor may slightly decrease its risk as it has no direct contractual relationship with the owner. Moreover, the contractor is no longer responsible for supply management.

In a contractor-led agreement, the contractor is in charge and benefits from increased control over supply management and schedule. It therefore faces increased risks. As it responds to the contractor's lead, the A/E team faces decreased liberty over the design but also fewer risks. With this organization, the owner may take advantage of greater communication with the contractor to have a better overview of possible construction issues impacting the initial cost and the schedule establishment.

With an integrated DB entity, both the design and construction team are supposed to be equally represented and, as part of the same team, they necessarily share the same risk. This risk is a combination of the risk normally faced by A/E and the contractor, so it is higher than the one faced when entities work alone. The team integration gives each member a larger scope of work as the interactions with the others are favoured, which is especially true for the engineers (Siddens, 2001).

Some outcomes are not related to the internal organization of the DB entity. They mainly concern the owner who faces a unique point of responsibility, as he signs a single contract, which helps manage the risks (Haskell, 2016). As a complete design is no longer required for the initial request for proposal, the owner loses control over the details of the design (Lahdenperä, 2001) which are now the charge of the DB entity. It is also suggested that a higher level of involvement is requested for the owner to successfully keep the project on track, especially if it aims for high sustainable goals. Finally, every project member is affected by communication improvement, which is said to be a key factor for the success of a DB project.

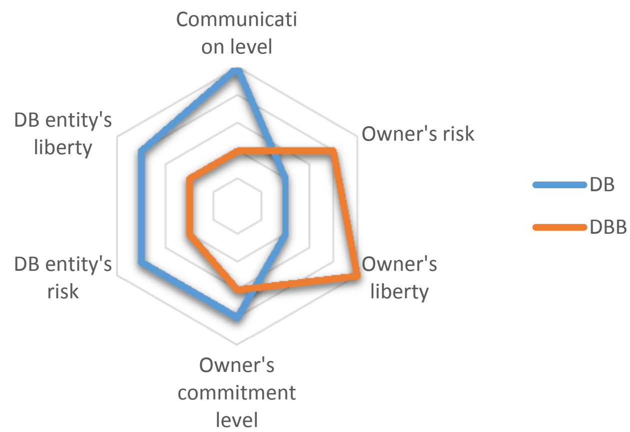
Those outcomes are summarized in Table 2 below. A comparison of the two systems in the case of an integrated DB is represented on Figure 1.

Regardless of the internal organization of the DB entity, a DB agreement can be based on different types of contract as the three ones defined previously. The main impact of the contract type selected concerns the financial risk shared between the owner and the DB entity. The most frequently-used contract seems to be the "Lump Sum" or "Fixed price" (Chen, et al., 2016) one, in which the DB entity bears the financial risk alone. In the "Cost plus fee" agreement, the entire financial risk is the responsibility of the owner. In the GMP agreement, the financial risk is shared between the two entities (Lahdenperä, 2001). GMP and cost plus fee contracts furthermore require a higher level of involvement from the owner side compared to the lump sum contract. So lump sum contracts seem to be most suited for small projects with clear understanding of the scope (Lahdenperä, 2001), while GMP contracts should be considered when competition on budget is critical (Chen, et al., 2016).

Table 2: Summary of the impact on stakeholders

Stakeholder	Outcome	Design-Build structure		
		A/E led	Contractor led	Integrated
Contractor	Higher control of design decisions		X	X
	Improved supply management		X	X
	Limited risks	X		
	Augmented risks		X	X
Architect	Higher level of communication with contractor	X	X	X
	Design liberty reduced		X	X
	Limited risks		X	
	Augmented risks	X		X
Engineer	Higher level of communication with contractor	X	X	X
	Expanded responsibilities	X	X	X
	Limited risks		X	
	Augmented risks	X		X
Owner	Decision loss over design details	X	X	X
	Higher level of implication necessary	X	X	X
	Risks centralization	X	X	X

Figure 1: Comparison of DBB and Integrated DB



Conclusion

In this article, a synthesis of previous studies comparing Design-Build and Design-Bid-Build has been proposed. We first described how the different studies have been selected. We then summarized the method and the main findings of each paper. By combining and analyzing the different results of the authors, we found a clear advantage in favour of Design-Build, as it seems to outperform the classical delivery system in each criterion typically used for measuring a construction project performance, except for the unit cost. In other words, it seems that DB is a faster and more reliable construction delivery system, leading to a slightly lower claims rate. And as even more construction projects try to achieve sustainable goals, its relative integration may represent an advantage.

However, it appears that most of the studies used in this research were based on US projects, which may not represent the situation of Design-Build elsewhere in the world. Future work could certainly involve more extensive research with more keywords and ideally more than one language to compare the findings with a larger international sample.

The analysis of the outcomes of DB for the stakeholders involved in a construction project revealed that DB has a considerable impact on the risk distribution among the parties. In fact, it tends to reduce the risk of the owner while increasing the risk for the other project members, depending on the internal organization of the DB entity. Moreover, that goes with a new repartition of the responsibilities as well, as the owner might lose control over the details of the design while the DB entity might gain some power of decision. It finally appears that the owner commitment to the project and the communication between the stakeholders are key factors of success when conducting a project based on a DB approach.

This paper represents a synthesis of the knowledge gathered around Design-Build in comparison with Design-Bid-Build, which may help further researchers in their literature reviews. This study might also allow owners to save time in their investigation about the performance of DB, and even lead them to reconsider their project delivery system choice when planning for new project launches.

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