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Shortening the execution time in projects: a state-of-the-art survey

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Project Management
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"…but I discovered at that moment that I have a fierce will to live. It's not something evident, in my experience. Some of us give up on life with only a resigned sigh. Others fight a little, then lose hope. Still others –and I am one of those– never give up."

Yann Martel, Life of Pi

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Preface

This thesis is a result of hard work and dedication during my last semester at the Norwegian University of Science and Technology. It contains insights about project schedule compression, but also it has taught me how to work independently and how to conduct a research study. I had the opportunity to organize my own time and resources in order to produce a useful guide that might serve as a reference for people within the industry and the academia.

This work is also a tangible result of an amazing learning experience as international student of Project Management. The knowledge acquired in the classrooms paved the way for me to find and analyze the right information from a critical point of view. Also, the experiences of writing my specialization project on the same topic made it easier for me to put forward and discuss the ideas in this thesis.

In spite of the efforts to match my project to a company in the Norwegian industry, my short network in this country made it difficult to find a company interested and eager to collaborate. Therefore, I decided to conduct my study by means of academic literature and articles published in engineering and project management research journals. Even though these articles were crucial for the development of my project, it made my thesis much more theoretical than I hoped.

There are three things that make this thesis really different than any other research study or text book. First, the thesis gathers many techniques and methods scattered in the literature all in a single piece of work. Second, I have tried to include examples of projects that implemented some of the techniques, in order to give a practical side to this work. And finally, it summarizes the findings in a coherent and structured manner that makes it possible for anyone to get a grasp on the topic of schedule compression.

Abstract

In the construction world, today's intense market dynamics force project owners to require faster construction times, without compromising the quality or increasing the costs. This situation has created a need for replacing the old traditional methods of construction and introducing effective tools and practices that can help to achieve a substantial reduction in the project cycle time. The subject of project schedule compression has been hovered around for some time now in the academic literature, but it is still a scattered subject in which many terms and concepts may be understood differently depending on one's point of view. The research presented in this thesis surveyed the academic literature to identify tools and practices currently used to reduce the overall project cycle time. Three important academic Project Management journals were particularly reviewed and analyzed to determine the state-of-the-art regarding techniques and methods of schedule compression. This research also identified the most common factors affecting construction projects in terms of time. This thesis concludes that the first step towards revolutionizing the construction world implies finding a common ground where all the concepts and practices are understood in the same way by everyone. Then, the subject of reducing the project cycle time should be raised as an "optimization" in which the objective is to find a balanced solution taking into consideration the particular characteristics and the context of each project. This report can be used both as preparatory work to open up new research paths on the subject and also as a guide for practitioners looking for ways to improve project performance.

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Chapter 1. Introduction

Many things have changed in today's globalized world, and the construction industry is not an exception. The intense market dynamics and its impact on the nature of competition force project owners to ask for higher quality standards, faster delivery times and reductions in project costs. These conditions represent a significant challenge for project-based organizations wanting to remain competitive, and yet the reality shows that more often than not construction projects encounter delays and unnecessary use of time.

One might think that the construction industry is fighting for a lost cause, and that achieving higher quality and efficiency levels is beyond the bounds of possibilities. However, there is evidence indicating that everything is not lost: recent (and not-so-recent) literature has suggested and proven that using specific project management techniques can help achieve reductions in project duration without increasing the costs and without compromising the quality.

Understanding the nature and the effect of these techniques and the effects of the organizations' efforts to shorten the project execution time is very useful for the industries as well as for academia. Therefore, this master thesis has dug into the efforts and initiatives made by the global construction industry in the quest for reducing project schedules effectively and efficiently.

A great deal of the work has been focused on discussing the benefits and flaws of techniques for reducing the project duration. Since the beginning, the objective consisted in studying what has been happening in the construction industry internationally and in corresponding research activities in regards of the topic of project schedule reduction.

The novelty of this thesis work lays on the fact that, even though the ideas about project schedule reduction have been around for some years, literature has been traditionally looking at this subject only from the practical point of view (Hastak et al. 2008, Khoramshahi et al. 2010, CII); many interviews, case studies and surveys have been published (Hastak et al. 2008, CII). However, it is not easy to find a coherent, structured framework, which embraces lessons learned from all these anecdotal research studies and techniques. In this light, this master thesis aims to build a solid base for understanding the subject and conduct future research.

Research Questions

Once the objective and rationale for this work has been described, the following research questions are presented:

1. What is the state-of-the-art in terms of methods and techniques for shortening the project's time in construction? What is their impact on project duration and cost?
2. What is the current state regarding schedule reduction among the formal research studies?
3. What are the major points to consider in order to effectively applying these initiatives throughout the players in the construction industry?

Report Outline

The remainder of this report is organized as follows: The report begins by giving an introduction to the construction industry and its context. In the second chapter the general idea of "productivity" is addressed. The next chapter reviews a number of initiatives of schedule compression and discusses their main benefits and challenges. Then, the report shows the results of a structured literature survey of relevant articles in the most important research data bases for project and construction management. The final section summarizes and concludes on the main points of discussion of the master thesis, and presents suggestions for further research.

Please note:

Before going any further, it is worth to mention that in this report the term "fast-tracking technique" will not be exclusive to particular technique for overlapping project phases or activities. Instead, it will refer any approaches for shortening the project life cycle time. Therefore, in this report the terms schedule compression, fast-tracking, schedule acceleration, schedule reduction make reference to the same idea.

Chapter 2. Context of the construction industry

The following chapter includes a brief description about the construction industry context. An overview about typical project characteristics is presented in order to understand the environment in which construction projects are carried out.

Construction has been one of the most significant industries for the world's development. According to the International Standard Industrial Classification (ISIC), the construction industry comprises the "economic activity directed to the creation, renovation, repair or extension of fixed assets in the form of buildings, land improvements of an engineering nature and other such engineering constructions as roads, bridges, dams and so forth."

Sexton (2007) however argues that the high number of stakeholders within the construction industry makes it much more complex than it may seem. The author argues the definition from the ISIC is rather limited and that a complete definition of the industry should include other relevant activities including:

- Upstream activities – manufacturing, mining and quarrying, architectural and technical consultancy, business services
- Parallel activities – architectural and technical consultancy
- Downstream activities – real estate activities

Construction is one of the most complex industries and it involves a great number of variables affecting any project development. Winch (1987) supports this idea arguing that construction projects are amongst the most complex types of endeavors. Dubois (2002) supports this idea suggesting that this industry is a "loosely coupled system" characterized by (1) complex elements of uncertainty and tasks interdependences, and (2) inefficiency on its operations.

The industry and its complexity

From a systems' perspective, the construction industry has a big number of factors adding complexity into the system. These elements of complexity include: the resources employed, the technical knowledge required, the project's environment and the highly interlinked workflow or supply chain. In general, Gidado (1996) divides these sources of complexity into (1) those related with the tasks as such and (2) those stemming from the interdependences between these tasks. These two sources are also highlighted by Baccarini (1996) in his studies on project complexity.

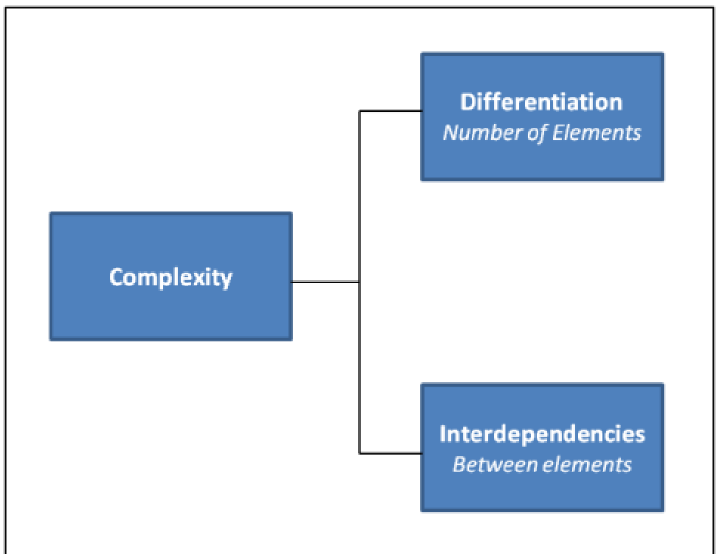

Figure1. Elements of Project Complexity. Baccarini (1996)

Gidado (1996) likewise argues that the first source of complexity (namely: differentiation) is affected by "inherent factors" and "uncertainty factors" of the specific activities of the project. On one hand, "inherent factors" are linked to the specific technological advances, physical ability, availability of skills, and so on. While "uncertainty factors" refer to aspects like: lack of clear specifications, unfamiliar environment, variability of work and unpredictability of the environment (including "unknown unknowns" (Loch et al. 2011).

The second source of complexity (interdependencies) is related with the sequencing of various operations or activities. In other words, this category refers to the coordination of factors such as: the number of technologies involved in the project, how rigid the sequence between the operations of the project is, lack of understanding and so on.

The industry and its inefficiency

Due to its high complexity, the construction industry requires improving its efficiency and has great opportunities for doing so (Dubois et. al., 2002). In this industry, the owner requires the contractor to fulfill the objectives of budget and schedule, in order to reap the benefits of the project. The contractor, on the other hand, relies on the efficiency of its suppliers and subcontractors, in order to make a good business with the project. In fact, these supply chain issues within the construction industry can be described as "how suppliers'/subcontractors' resources and activities are channeled to meet the multiple and often changing needs of the customers" (Wong, 1999). Therefore, it is comprehensible that both performance and quality might be at risk within an environment with such a high number of organizations involved.

Summing up, the construction industry can be defined as a complex environment. Therefore each one of the elements of complexity and the factors that may affect performance in projects should be addressed in order to prevent problems later on. Improving productivity and reducing the project life cycle time are two big subjects that must be embraced by all project stakeholders if they want to reap the benefits that it would bring in terms of revenue and/or social welfare. The next chapter describes the subject of productivity in construction and how the project can avoid wasting time needlessly by means of better managerial practices.

Chapter 3. Productivity in Construction

The present chapter presents a general description about the concept of productivity and its implications. The concept is evaluated from three different levels: macro-economic, project and task level.

In the previous section it was mentioned the challenge of complexity within the construction industry. Also, it was pointed out that increasing productivity represents an important challenge for the industry nowadays. Productivity is in fact the reason why some companies remain competitive and others disappear in type any business environment.

The reader should bear in mind the direct link between the concept of productivity and the topic of this thesis (schedule performance). In other words, this chapter represents a foundation that puts the reader into perspective. Productivity means working efficiently, and thus, as productivity increases, the project length can indubitably be reduced.

What is Productivity?

The concept of productivity is regarded as the ratio between outputs produced per unit of resources used. According to Forbes (2010) productivity within the construction industry refers to the rate at which a complete facility is produced, compared with how much time, work, equipment, money is needed to produce it. Productivity can be measured at different levels, ranging from a single project work package, to an entire industrial sector, or even at international macro-economic level.

Productivity benefits all players within the industry. From the project owner's point of view, a higher productivity rate is translated into higher return on investment. From the contractor's point of view, a higher productivity ratio means higher competitiveness and profits, and more satisfied customers.

The concept of productivity can also be seen from a higher industry or even country-based perspective. A higher productivity comes with higher incentives to invest in a country, more jobs and better life for the population in general.

There are many productivity measures, but the use of one or another depends on the availability of information and the purpose of the measurement. These particular productivity measures, or "partial productivity" ratios, compare the project's output to a single class of input (i.e. materials, labour, capital, time and so on) (Forbes, 2010).

On the other hand, according to the author (Forbes, 2010), "total productivity" measures a ratio of output to all inputs in the project. This is clarified with the equations below:

$$Total\ Productivity = \frac{T(s)\ (total\ output)}{Total\ Inputs}$$

or

$$Total\ Productivity = \frac{T(s)\ (total\ output)}{labor\ cost\ (M_1) + materialscost(M_2) +\ management\ cost\ (M_3) + \cdots}$$

Since, partial productivity relates the total output to only one class of input:

$$Partial\ Productivity\ (P_i) = T(s)\ /M_i$$

Then, Total Productivity can be expressed in terms of partial productivity ratios:

$$Total\ Productivity = \frac{1}{(1/P_1) + (1/P_2) + (1/P_3) + \cdots}$$

In conclusion, what these equations try to explain is that in order to increase the total productivity (TP) in any kind of enterprise, it is necessary to increase the partial productivity ratios (Pi).

More generally speaking, productivity can be improved by increasing output, decreasing input or by having a dynamic between these two that allows the productivity to increase. Gerald (1997) explains that there are five different ways for increasing productivity ratios:

- Reduced costs (input decreasing)
- Managed growth (output increasing, input increasing slower)

- Reengineering (output increasing)
- Paring down (output decreasing, inputs decreasing faster)
- Effective working (output increasing, input decreasing)

Productivity from a macro-economic level

The globalization has connected many different cultures and economic systems around the world. Thanks to the many different advances in technology, the global community is nowadays a more interrelated and dynamic arena with free-trade treats, multinational businesses, political alliances, economic growth and so on. Taking this into account, and given that the construction industry accounts for 5 – 10% of a country's GDP (Forbes 2011), it is natural to ascertain that the productivity of this sector plays an important role for the whole economy.

However, despite of the fast-paced technological development around the world, it is interesting to note how the global trends of construction productivity seem to be stagnant in comparison to other industries. In the US, for example, according to the Bureau of Labor Statistics (LBS), the productivity level of the non-agricultural sectors has grown over 100%, while the productivity in the construction industry has not risen in the same way (Forbes, 2011).

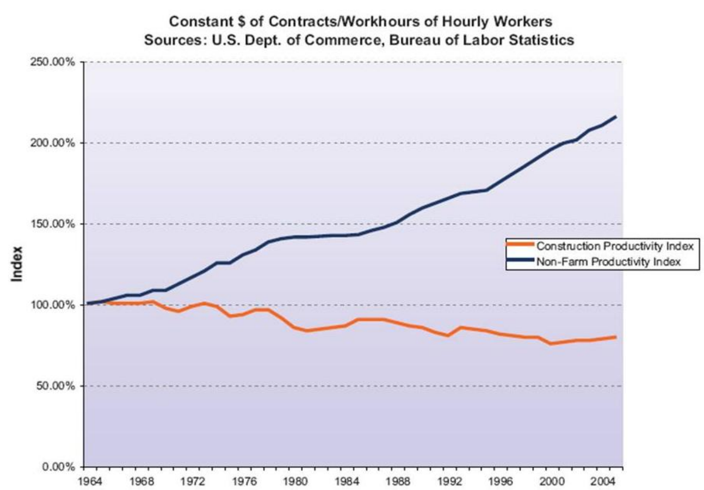

Figure 2. U.S productivity gap (1964 – 2003). Paul Teicholz, Ph. D, Professor (Research) Emeritus, Department of Civil and Environmental Engineering, Standford University.

According to the author, this trend is possibly explained by the project-based nature of the construction industry. In other words, the particularities of the construction industry make it so dynamic that these conditions at the work site can produce significant variability in terms of project output, and thus on productivity (Forbes, 2011).

Nevertheless, there is no doubt that it very important to have also a macro perspective of productivity, since this allows us to think and understand about national policies in terms of craft training, wage rates, policies of capital and labor and so on.

Productivity at project level

In order to benchmark productivity across different companies within the construction industry, the Construction Industry Institute (CII) in cooperation with practitioners developed in 2002 an Engineering Productivity Metrics System (EPMS). This system basically describes engineering productivity at a project level as the ratio between engineering direct work hours and number of equipment pieces produced (Kim, 2007). Direct work hours include activities in which the output is being produced such as: meetings, production, planning, design, rework and so on.

The EPMS is divided into six major categories or disciplines: concrete, structural steel, piping, equipment, electrical and instrumentation. These categories are classified further into subcategories and then into specific elements. Figure 3 shows a graphic representation of the EPMS. The system sets productivity indicators for each level in the pyramid and every metric is conceptualized as engineering hours per engineered quantities (Kim, 2007).

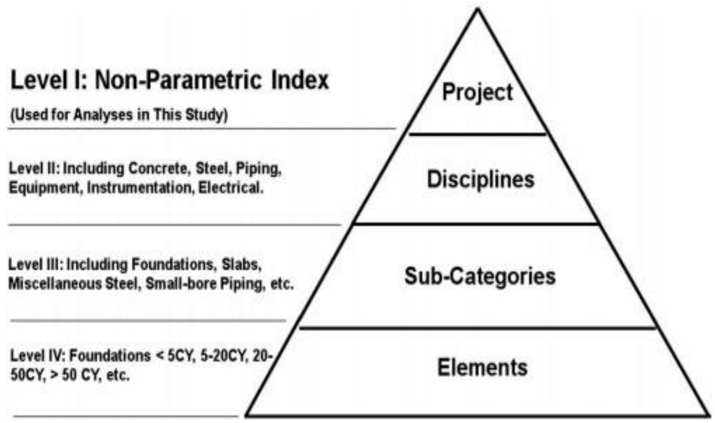

Figure 3. CII's Engineering Productivity Metrics System hierarchy (Kim, 2007)

Even though the model defines precisely what each category, sub category or element is, the fact that every project is different makes it challenging to fully compare information coming from different projects. However, it is possible to make comparisons between similar projects, in order to benchmark the different areas in construction projects (Kim, 2007).

Finally according to the author there is no doubt that there is a high interest in finding a way to collect information and data across the construction industry using this model. However, as it was mentioned before, this is not easy because of the inherent different nature and characteristics of every project work. The overall objective is therefore to find out which practices seem to have a correlation with improved performance and productivity according to the data collected from this model.

Productivity at activity level

Some writers have reported that labor represents around 30 to 50% of the total project's cost in the construction industry (Harmon and Cole 2006). Literature also points out that there is a lot of variability when comparing labor costs from site to site. Therefore, opportunities for improvement in this area are much higher than in material costs and fixed or time-related costs, which seem to be more stable. Horner (2001) and many others, argue that construction managers should focus on labor productivity due to its high impact on project profits and its potential for improvement. In fact, research shows that 20% improvement is within most people's reach (Horner, 1998).

That said, there is no doubt that improving labor productivity over the project's life cycle is critical for the industry. But at the same time, there is not much literature regarding detailed worker activities or process approaches to help management continuously improve the factors affecting productivity on site (Gouett, et. al. 2011). However, there is a method called Activity analysis that helps measuring productivity at the task level. The objective of this process is to effectively measure, analyze and eliminate elements affecting labor productivity in the project site (Gouett et al., 2011). In other words, at this level the analysis consists in looking at what sort of processes or initiatives can be done in order to improve productivity on site.

In this sense, activities are classified into different types. Particularly, Gouett (2011) categorize activities into seven groups:

1. Direct Work: Exerting physical effort directed towards an activity or physically assisting in these activities.
2. Preparatory Work: Activities related to understand assignments and determining requirements.
3. Tools and Equipment: Activity associated with obtaining, transporting, and adjusting tools or equipment.
4. Material Handling: Transporting materials from one part of the facility to another.
5. Waiting: Periods of idleness, even if attentive to ongoing work by others.
6. Travel: Travel might include walking or riding empty handed or without tools, materials, or technical information.
7. Personal Time: Time taken or idleness during normal work hours and not attentive to work.

Activity analysis is thus a continuous process for improving direct work rates (Gouett, et al., 2011). It requires a focus on continuous improvement, which is a concept introduced by W. Edwards Deming, an American quality guru. Therefore, by having a culture of continuous improvement, companies can boost its output by working more productively.

In the next section this master thesis intends to look upon different project delivery methods. These are inevitably connected to productivity since they can facilitate or hinder the application of initiatives aiming to productivity improvement, either by reducing the project schedule, reducing costs or improving quality.

Chapter 4. Project Delivery Methods

Due to their influence on the project's duration, this his chapter describes the three basic approaches used in the construction industry for delivering project work: Design/Bid/Build, Design/Build and Construction Management at Risk (CMAT)

A project delivery method describes how the entire project will be managed and in what steps it will be delivered (Gould, et al., 2009). In other words, a project delivery method encloses all the roles, the responsibilities of the stakeholders and the sequence of the project phases. The project delivery method describes the relationships between the owner, designers, contractors, during the entire length of the project.

The project owner is usually the responsible for choosing a specific type of delivery method. There is however a numerous different approaches used in the construction industry, and always the question lies on choosing between performance and price. Moreover, since every project is unique and different from others, the selection of the project delivery method should be made according to the project characteristics. This can save a lot of time and money (Gould, et al., 2009).

Project delivery methods are not contract types. The project delivery methods do not include considerations about the project price, the payment conditions and so on. Instead this information is stated and will vary depending on the contract form. According to Gould (2009), the project delivery system and the contract form shall be seen as complementary.

A very important/interesting article from Konchar & Savindo (1998), compares the three principal delivery methods in the US. Due to their relevance, it is important to describe each of them:

- Design/Bid/Build,
- Design/Build and
- Construction Management at Risk

Also, it is important to understand the different systems of project delivery and its variations, because they can lead to different construction management practices or the application of one or other construction management techniques explained in the next chapter.

Design/Bid/Build

The Design/Bid/Build method is also regarded as the traditional approach or general contracting and has been around since 1870. This method involves the separation of construction from design (Hughes et. al., 2007). Thus, the project owner is in charge of selecting a designer for the development of the whole facility. Later, when the design is complete, it is tendered so that different contractors can bid for the construction project. According to De la Garza (2006), in most of the cases the contractor who offers the lowest responsive and responsible bid is selected. The contractor is also free to employ subcontractors and is responsible for carrying out the construction according to the original design.

Under this delivery method the contractor is fully responsible for the methods, the sequencing and the coordination of subcontractors. The owner on the other hand, administers the contracts. There is no contract between the designer and the contractor, but between the owner and these two parties separately.

This project delivery method shifts most of the financial and schedule risk to the contractor. And the system also reduces the level of risk and uncertainty as it includes well-defined relationships between project participants (Gould et. al., 2009). However, the fact that the contractor does not participate during the design phase might impose problems of constructability during the execution phase of the project.

Design/Build

Under the Design/Build method, both the design and the construction execution phases of the project are the responsibility of one party or a joint venture. Typically this party is a joint venture between a design and a contractor firm, and this entity is entitled to plan, design construct, implement and control the entire project. According to De la Garza (2006), the owner has only one single point of responsibility for the project delivery. This type of delivery is every time getting more popular, as the complexity of projects increases. As a reference, this delivery method is almost always selected for building oil refineries and power plants (Gould et al., 2009).

A Design/Build delivery method is highly beneficial for increasing the level of communication between project stakeholders (particularly the design and construction team) (Gould et al., 2009). Moreover, according to Gibson (2012) the Design/Build method can reduce the total delivery time compared to the traditional approach (design/bid/build), since it allows the design and construction to overlap, in other words this delivery method allows the team to start construction before the whole building design is complete.

On the other hand, the number of change orders should be fewer than in the traditional approach, since the joint venture has all the responsibility. However, according to Gibson (2012), one of the disadvantages of selecting this type of delivery method is that the project owner loses all the control over the design and thus some misunderstandings might arise. Gould (2009) also argues that this type of delivery method can encourage less critique within the design-build firm because of the risk of losing money later on in the project.

Construction Manager at Risk (CMAR)

In this case the owner must hire a design team and a construction manager (CM) at the early phase of the project. During the pre-design and design phase, the CM collaborates with the owner and the design team providing inputs from the construction point of view. According to Gibson (2012) the owner can require a guaranteed maximum price or a fixed price for the project at any stage of the design. De la Garza (2006) mentions that usually the construction manager make an offer when the design phase has progress between 50 and 80%. Once there is an agreement over a maximum or fixed price, the CM becomes the equivalent of a general contractor during construction, and he is fully responsible to undertake the project within the established budget (De la Garza, 2006).

In this chapter we have described the three most common delivery methods. However, it also very important to mention that many variables affect the project's delivery speed and thus, these variables must be taken into account before selecting one or another project delivery method. According to Konchar and Savindo (1998) the top 5 variables affecting the variability of these three project delivery methods are:

1. Project Size
2. Contract unit cost
3. Percent design complete before construction entity joined the project team
4. Facility type
5. Project team communication

Finally the contents of this chapter, together with the previous one (productivity) adequately provide the required background information leading to the next topic of specific project techniques to reduce project's duration. However, before going into the techniques, it is important to be aware of issues that can affect the project in terms of delays. This is the topic of the next chapter and it also is relevant and builds up the description of this research work.

Chapter 5. Shortening the project's duration

In the present chapter includes a brief literature survey and discussion about the causes of delay in construction projects. Also, it summarizes previous work by the author (Rondón, 2013) which suggests, based on a survey, some preventive actions for tackling this issue.

In the modern world, the success of a company is measured most of the times by its ability for meeting its client's needs. It is also known that thanks to globalization, the market demands change at a very fast pace. Therefore, companies recognize the advantage of meeting the market's demands before its competitors. Most of the time, the first company that introduces a product in the market is the one that that results with a competitive advantage in terms of market share and profit margins. This represents a very high incentive for companies to try to reduce the overall duration of projects. Likewise, public organizations would always want their projects to be completed faster, so citizens can use the good or service in question.

This pressure for launching timely products is naturally encountered in the construction projects too. As said earlier, it is very common that the project owner requires the construction to be finished before a specific date. Therefore, all project stakeholders must work together on implementing initiatives so that the project can be delivered according to the ambitious schedule.

Why do projects fall behind schedule?

Despite the vast availability of schedule control methods and software in the market, many projects suffer from schedule overrun. The construction industry does not escape from these horrifying statistics.

Over the last two decades, there have been a number of research studies aiming to identify influencing factors leading to project schedule overruns. Most of them have been exploratory and explanatory research studies. Thus, the objective of this subsection of the report is to conduct a literature survey in order to look into these elements and to which extent their influence can affect a project schedule.

The first study of this review was conducted by Mansfield et al (1994). The author administered a survey of around 50 contractors, consultants and public clients from the Nigerian construction industry and concluded that overruns are attributed mainly to human and management problems. The most influencing elements leading to overruns were identified as: Poor contract management, financing and payment of completed works, materials shortages, changes in site conditions, imported materials and plant items, and design changes.

Kaming et al (1997) studied these factors by means of a survey undertaken by project managers of high-rise building projects in Indonesia. The study found out the main 11 causes of delay as: design changes, inadequate planning, inaccuracy of material estimates, poor labor productivity, inaccurate prediction of craftsmen production rate, materials shortages, skilled labor shortages and so on.

Yogeswaran et al (1998) surveyed a sample of 67 civil engineering projects in Hong Kong, and identified major categories for extensions of project duration. According to the authors, 15 - 20% of the time overrun was related to inclement weather.

Kumaraswamy et al (1998) also focused on the reasons for delay of construction projects in Hong Kong. The consultant's responses ranked the 10 most important factors affecting delays building projects as: delays in design information, long waiting time for approval of drawings, poor site management and supervision, unrealistic contract durations imposed by client, mistakes and discrepancies in design documents etc. The study concluded that the great degree of disagreement between clients, consultants and contractors affect project durations both directly and indirectly.

Al Momani (2000) examined 130 public building projects in Jordan. The study revealed that poor design negligence of the owner, change orders, weather conditions, site conditions, late delivery, economic conditions, and increase in qualities were the main causes of delay in such projects.

Assaf et al (2006) conducted a similar study in Saudi Arabia, in order to determine causes of delay according to owners, consultants and contractors. Seventy eight (78) variables affecting project duration were identified but only one cause was common to the three parties; "change orders by owner during construction". Other causes were common to two parties, such as delay in progress payments by owner, ineffective planning and scheduling of project by contractor, poor site management and supervision by contractor, shortage of labors and difficulties in financing project by contractor.

Even though these studies have contributed to a large extent to the clarification of issues related with project delays, some limitations have been also identified. (1) In the first place, some of these studies have been conducted more than 10 years ago. In this sense, it may be arguable that many of the conditions in the construction industry have changed. (2) Most of these studies only state the issues, but do not go further into the identification of actions to prevent projects from falling behind schedule. (3) Most of the studies have been conducted outside of Norway and, therefore, conditions such as shortage of materials or lack of labor expertise may not be valid under the Norwegian context.

This literature survey has identified a large number of the most common factors leading to schedule overrun. Some of these are related to one another and some others are overlapping. A list of the most common factors according to the literature is presented in Table 1. This table served as an important input for Rondón (2013) to develop relevant metrics for controlling the time factor in projects.

Issues	Authors
• Design Changes	• Mansfield et a. (1994) • Kaming et al (1997) • Kumaraswamy et al (1998) • Al Momani (2000) • Assaf et al (2006)
• Unrealistic project estimations	• Kaming et al (1997) • Kumaraswamy et al (1998) • Assaf et al (2006)
• Issues with suppliers, contractors	• Mansfield et al (1994) • Al Momani (2000)
• Project Management inexperience	• Kaming et al (1997) • Kumaraswamy et al (1998)
• Poor contract management	• Mansfield et al (1994) • Assaf et al (2006)

• Craftsmen inexperience	• Kaming et al (1997) • Assaf et al (2006)
• Poor Stakeholder management	• Kumaraswamy et al (1998)
• Tough weather conditions	• Mansfield et al (1994) • Yogeswran et al (1998) • Al Momani (2000)

Table 1. Identification of most common issues affecting the duration of construction projects

As a result of this literature survey and the summary presented in Table 1, Design Changes was identified as the most common issue causing delays in construction projects. This factor was highlighted in almost all the studies presented in this section. Thus, it is reasonable to take it into consideration at all times. Other issues such as unrealistic time estimations and weather conditions were very common as well.

Once the elements affecting project schedule were presented, the next logical step would be conducting a research in order to find measures for preventing the project from falling behind schedule and reducing project duration; that was the main goal of the specialization project made by Rondón (2013), which main highlights are summarized in the following section.

Avoiding schedule slippage

This section summarizes the findings of the research project conducted by Rondón (2013) during the autumn of 2013. The study prioritized the factors mentioned in the last section, according to scientific literature and practitioners' experience. The top three factors identified were: design changes, unrealistic project estimations and poor project management. It is interesting though, that the most important factors are internal elements (intrinsic characteristics of the project context). And conversely, external factors such as inflation, tough weather conditions, material shortages and so on, appear to be not as important as the internal ones (Rondón, 2013).

Rondón argues that some measures can be set in place in order to prevent or react against these factors affecting the projects ability for delivering on time. As a reference, Table 2 includes measures for dealing particularly with design changes. However, it is important to notice that these measures are not exclusive and that the author acknowledges that many other measures might be also beneficial and were not included into the study results.

Project Owner	Project Users	Project Contractor	Jointly
• Ensuring a quick resolution to decisions regarding changes	• Ensuring there is a need for the design change	• Having a design manager for reviewing information on design change process • Making sure there are enough resources for undertaking the change	• Making sure a requirement management process is in place • Ensuring the time and cost are agreed by all project stakeholders

Table 2: Measures for avoiding Design Changes (Rondón, 2013)

Another important point stemming from this study is that the majority of factors and measures identified are much more related to the so-called "project supporting processes" like project team development or communications management (Andersen, 2008), rather than to the core activities stated in the work breakdown structure (WBS). Therefore, this work highlights the importance of supporting processes in projects and functional areas dealing with the project organization. Also it focuses the attention on the importance of dealing effectively with these processes, in order to ensure an effective project delivery and efficient project execution (Rondón, 2013).

As it was mentioned before, the measures proposed by Rondón (2013) fall short, and there is a vast number of practices, techniques and methods for avoiding schedule delays accelerate the project. A description of these techniques constitutes the core of the next chapter.

Chapter 6. General Practices and Techniques for shortening the project's duration

This chapter includes a number of techniques and method that can be applied in construction projects in order to mitigate schedule slippages and reduce the overall project's lead time.

As it was mentioned at the introduction, schedule compression techniques represent an effective way to speed up projects. Both academia and practitioners within industry have attempted to develop and apply many approaches for achieving substantial results in this regards. One of the most relevant articles from the literature dealing with this subject was written by Hastak (2008). In his article, the author aimed at analyzing techniques leading to radical reduction in project cycle time. In order to do that, a preparatory literature review was done and forty-six (46) schedule reduction techniques were identified. Hastak (2008) also identified Construction Industry Intitute's (CII) best practices used in the industry. These techniques and best practices however were not fully described in the article; as the objective of the study was to prove that project cycle time reduction is achievable.

The present section is a compilation of the most effective techniques and methodologies that can be set in place in order to increase productivity in terms of project duration in construction. It includes a brief description of different strategies and techniques to effectively address today's aggressive project schedule demands.

Constructability review

In general the concept of "constructability" is linked to the efficiency with which a structure can be build. The CII also defines constructability as the optimum use of knowledge and experience in planning, design procurement and field operations, in order to achieve the project's objectives (CII, 1993).

The more constructability, the more cost efficient the building will be. This technique draws upon the importance of including the construction personnel during planning and design phases. Allowing the construction personnel to review and discuss during planning and design makes it easier to avoid problems later on. The possibilities for influencing the project are highest up front, as there cost of making amendments is lower during planning and design phases. (Samset, 2010).

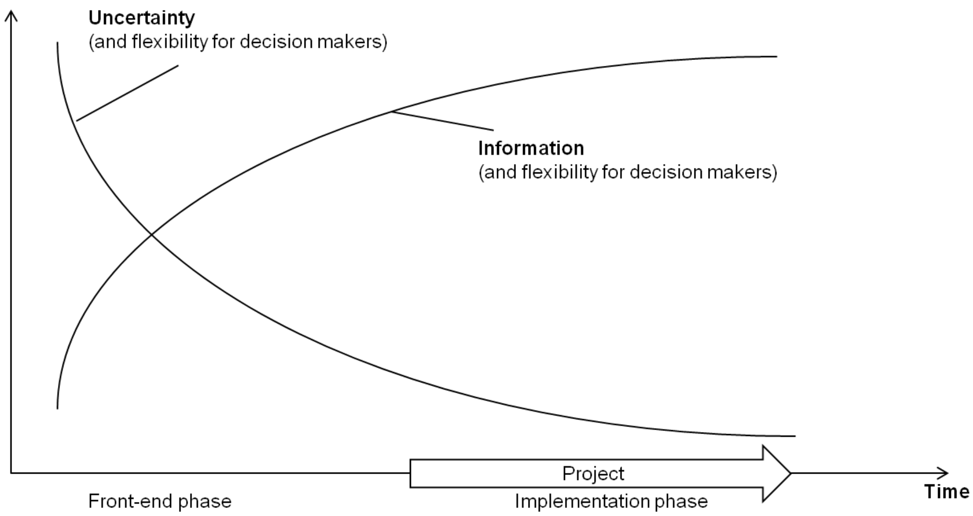

Figure 4. Possibility to influence is highest up front. (Samset, 2010)

Following the studies of De la Garza (2006), the Construction Industry Institute (CII) has developed a three-step guide to implementing this technique successfully:

1. Obtaining constructability capabilities (Step 1)

In the first phase, it is important that the whole team is aligned towards the objectives of constructability. The team sets a specific goal –for example reducing the overall project delivery time- and all people's efforts are guided towards that goal. For example, the team can develop an aggressive schedule with fixed durations for each project phase and all project stakeholders should collaborate to attain the desired delivery time. The following is a list of other possible objectives for constructability, coming from the CII's Constructability Implementation Guide:

- Use of standardized elements
- Use of modules/preassembly
- Use lift equipment
- Material laydown areas

- Ease of fabrication and erection
- Number of field welds
- Jobsite accessibility
- Develop construction-friendly specifications
- Improve constructor/engineer communications
- Minimizing construction rework
- Minimizing design rework
- Minimizing jobsite congestion
- Minimizing occurrence of labor disputes

During this phase it is also important to define a measurement system and pick up indicators in order to assess how well the project is doing in terms of constructability. The CII suggests performance measures such as: labor productivity, number of items nonconforming with owner's specifications, design rework work-hours, number of change orders, lost-time incident rate, shut-down duration (hours), personnel and material jobsite accessibility (feet/hour/unit) and so on (CII, 1993).

During this phase the team also recognizes its skills and resources at hand, in order to employ them efficiently into each project phase. The team should also decide whether or not to outsource capabilities for design, planning or construction (De la Garza, 2006).

Decisions about contracting strategy must also be made. In this case, De la Garza (2006) argues that a traditional design-bid-build contract or multi-prime strategies are not suitable for constructability, because the owner does not know who the constructor will be. On the other hand, by implementing a design-build strategy allows constructability to be more effective, because an early input from the constructor is possible.

2. Planning constructability implementation (Step 2)

This phase includes three steps. The first step consists in creating a constructability team. The team must include all project stakeholders, i.e. representatives from the owner, the designer, the constructor and suppliers. All of them should also be committed and buy the idea of constructability as important and beneficial.

The second step for planning constructability implementation is to identify and address the possible barriers of shortcoming that could jeopardize the effectiveness of constructability. These might include: lack of awareness of the concepts of constructability, lack of genuine commitment, complacency with the status quo, lack of mutual respect between designers and constructors, lack of experienced personnel and so on.

The third step is to develop the constructability procedures and integrating them into project activities. The CII suggest a number of measures that generally can be deployed during the project, especially to the engineering and procurement phases (De la Garza 2006, CII 2004, CII 1993). These include:

- Design and procurement schedules should be construction-driven
- Designs should be selected to enable efficient construction
- Standardization of design elements should be used
- Use of modularity/preassembly design which facilitate handling and installation should be investigated
- Designs should promote accessibility of all resources
- Designs should facilitate construction under adverse environments
- Specifications should not impose unnecessary complex construction methods, building materials, installation tolerances, or other requirements which hamper field operations

It is important to mention that the development of these concepts will depend on the specific project characteristics, and therefore these should be adapted to every project and its particular characteristics and context.

3. Implementing constructability (Step 3)

Lastly, this phase includes applying the constructability concepts and procedures as well as monitoring and evaluating project program effectiveness.

Finally, some of the advantages of this technique were presented in research studies and guides from the CII (CII1993, De la g, 2006). These include:

- Schedule improvements
- Early project completion

- Expenditure savings
- Better productivity
- Improvements in safety

Research in action:

Referred Content: Jergeas, G., & Put, J. V. D. (2001). Benefits of constructability on construction projects. *Journal of Construction Engineering and Management*, *127*(4), 281-290.

Case Description: In his study, Jergeas surveyed mid- to senior-level executives in the industrial construction sector responsible for the management of large construction projects in the range of $10 – 500 million. The average experience amongst practitioners was 20 years in the Canadian Construction industry. In his study the author asked the practitioners to rate CII's constructability principles in terms of its potential and actual benefit. The principles were grouped in the following areas:

- Up front involvement of construction personnel
- Use of construction-sensitive schedules
- Modularization and preassembly
- Standardization
- Designs that facilitate construction efficiency
- Use of innovative construction methods
- Use of advanced computer technology

Results:

The study concluded that the biggest efforts should be made into the areas with the largest gaps (biggest potential to achieve a higher benefit). These included:

1. Ensuring involvement of the construction personnel from the first day as these will be the people responsible for the actual construction of the facilities.

2. Building trust, respect and credibility between planners, designer and constructors. And create a common vision from the conceptual stage.

3. Being able to with a different contracting strategy than the old and traditional Design-Bid-Build.

4. Being able to try new approaches in the interest of achieving benefits in terms of cost, schedule, performance and safety.

Lean construction

Lean construction is a construction management philosophy that has its roots in the Toyota Production System (TPS). TPS's main premises include seeking perfection, aiming for zero defects, no inventories and reducing costs. Lean producers, such as Toyota, are focused on continuously adding value to a product and eliminating the so-called "muda" (waste) or non-value-adding activities. These non-value-adding activities were classified as the seven wastes by Shingeo Shingo, an industrial engineer from Toyota:

1. Overproducing
2. Idle time
3. Transporting
4. Processing waste: waste in the work itself
5. Inventory waste
6. Wasted operator motion
7. Defects in products

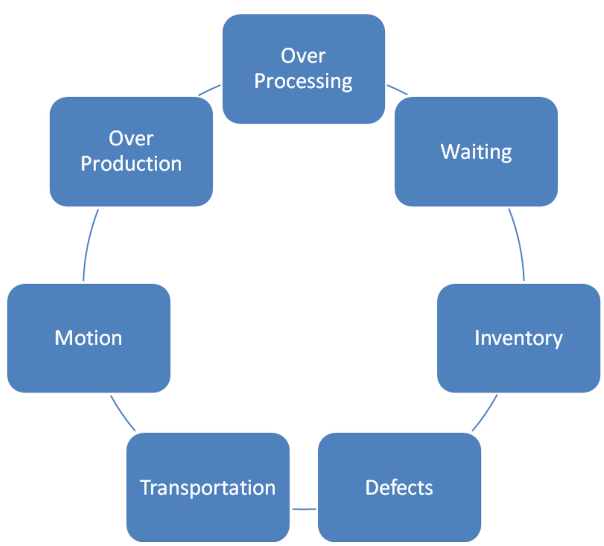

Figure 5. 7 Wastes of Lean thinking

Lean thinking can also be applied within the construction industry, making it possible to achieve significant improvements in complex projects. The CII defines lean construction as "the continuous process of eliminating waste meeting or exceeding all customer requirements, focusing on the entire value stream, and pursuing perfection in the execution of a constructed project" (CII Lean Principles in Construction Project Team, TP 191)

The CII found five lean construction principles in their study TP 191, these include:

- Customer focus
- Culture and people
- Workplace organization and standardization
- Elimination of waste
- Continuous improvement and built-in quality

There are various approaches for applying the lean construction. However, there is a commercial application of these principles called "The Last Planner" methodology; this is a methodology seeking an increase in productivity, construction performance, quality and significant reductions of time and costs through structured meetings with interdisciplinary teams looking for ways to reduce waste that can affect the construction process. The methodology was developed by Glenn Ballard and Greg Howell, who also established the Lean Construction Institute.

Finally, some Sanvido and Konchar (1999) identified several critical success factors for the implementation of lean construction. These include:

- A knowledgeable, trustworthy, and decisive facility owner/developer;
- A team with relevant experience and chemistry should be established at least before 25% of the project design is complete; and
- A contract strategy that encourages organizations for behaving as a team
- Improvements in safety

Research in action

Referred Content: Ian Johnson. (2013, July 2013). Glenn Ballard at NCC 130322 [Video file]. Retrieved from https://www.youtube.com/watch?v=XnmR5SCYoqA

Case Description: Sutter Health is a non-profit health care and hospital system in North California. They began to work with the Lean Construction Institute since 2003, and in 2005 they completed their first lean project. And as of August 2012 they had complete 22 lean projects. Some of the highlights of these projects are:

- No projects over budget or schedule
- No sacrifice of scope or quality
- Cost at completion 3,4% under budget on average
- Cost at completion approx 15% under market on average

Results:

As a reference of one project, the Eden Medical Center Replacement Hospital in Castro Valley, California. The project consisted of a 7-story hospital building with a 4-story tower on top of a 3-story podium. The design and construction cost was $230 million. The project achieved the following performance highlights:

1. Completed 6 months ahead of schedule
2. Construction rework 15 – 18% less than trade baselines
3. Productivity 5 – 20% greater than trade baselines
4. Mechanical/Plumbing installed exactly to the model 99% of the time
5. Significantly fewer requests for information (RFI), change orders and failed inspections
6. Labor productivity significantly higher than industry standards

Lean Design

As well as in lean construction, Lean Design employs the lean production principles of eliminating waste and increase efficiency within the engineering and design phase. Freire and Alarcon (2002) proposed a methodology for implementing lean design in construction projects, which resulted in benefits in terms of number of value adding activities, reduction of unit errors, decrease of waiting times. The implementation methodology includes three stages which are briefly described in the following paragraphs (Freire, 2002):

1. Diagnosis and evaluation. The main point of this stage consists in assessing the design process in term of its flow and its value generation. In this stage it is necessary to identify non-adding value activities and classify wastes. Value Stream mapping or interviews can serve as very useful tools during this stage. Also Performance indicators should be defined in order to keep track of the process and set objectives; some examples could be number of changes, errors or omissions in drawings.

2. Changes implementation. In this stage the team uses the results from the diagnosis phase in order to implement changes according to the different types of waste and problems identified. The authors also suggest five different areas of improvement including: C: client, A: administration, P: project, resources and I: information (CAPRI).

3. Control. The objective of this phase is to control and evaluate the performance indicators established at the first stage in order to determine whether or not changes or adjustments should be made.

4. Standardization. The last stage aims at introducing permanent change in order to improve the design process. The methodology however implies that there should be always a continuous improvement upon reiterating the methodology.

Some of the advantages of Lean Design is that is allows the team to identify and eliminate activities and processes that add no value within the design phase. This strategy has an important impact on the speed of delivery of the design and thus, it contributes to the reduction of the overall project's time and cost.

Freire and Alarcon (2002) also recognized some elements that play an important role in the implementation of lean design:

- Teamwork
- Flexibility
- Early implementation of changes
- Constant control
- Awareness
- Feedback

On the other hand, implementing lean design principles can be complicated. Having new procedures and tasks takes time for the team to get used to it and also causes resistance. Therefore, De la Garza (2006) explains that the efforts and investments on lean design in small projects may become too high compared with the actual benefits. Conversely, in projects of large scale, this technique can be very effective in improving design delivery in terms of time and quality (De la Garza, 2006).

Cycle time analysis

In the Operations Management Science, the cycle time indicates the length of time, on average, that it takes to complete a step or set of steps within an operation (HBS, 2000). Thus, if the concept is translated into project management terms, a Cycle Time Analysis consists in reviewing the project's time, in order to detect and eliminate non-value activities and aiming to reduce the project schedule (CII, 1995). Cycle time analysis can be applied to any phase of the project, i.e. Planning, design, materials management, construction and even project close-out.

Although there is no formal procedure for implementing cycle time analysis, the CII has developed a number of guidelines that facilitate the implementation of this technique (CII, 1995):

- Setting up a cross-functional team including key stakeholders and management. The whole team must be committed for achieving tangible benefits by applying this technique
- Selecting a process or the particular area to improve
- Conforming teams around the specific area that has been selected
- Creating a pool of performance indicators and map the process as is, and show the results that need to be improved
- Setting objectives and goals for the improvement, and communicate these to the employees at all times
- Taking advantage of technology and its benefits

Cycle time analysis can bring significant reductions of time at a relatively low cost, as the cost for implementing this technique is much lower than the total project cost. Other benefits of implementing this technique include (De la Garza, 2006): identification of bottlenecks, it boosts productivity, increases employee's sense of ownership and motivation and so on.

A key success factor for implementing the cycle time analysis is to have the top management support and guidance, in order to increase the motivation and maintain the team aligned and committed to the attainment of the results (De la Garza, 2006). It is also important to notice that without this support the employees could go back to the old, inefficient practices in their work routines. It is always hard to break the status quo.

The CII (1995) also mentions that strong communication is paramount. Without communication, there is no way that this technique can be effective, especially when finding a problem resolution. Even though cycle time analysis can be applied at any project phase, the CII strongly recommends implementing this technique during project funding approval, drawing and specification reviews, and material procurement approvals (De la Garza 2006, CII 1995).

Just-in-time delivery

Just-in- time is a system from operations management that allows the operation to reduce storage costs and general delays because materials and equipment must arrive "just in time" to the site, without having to waste time with unnecessary actions of storing and handling in general.

This technique is can directly applied during the construction phase of a project. The most important success factor for implementing this technique is to have good coordination with suppliers and subcontractors, in order to ensure precision of delivery (De la Garza, 2006). Supplier's commitment towards the attainment of specific delivery goals, communication and information sharing are also paramount for achieving a satisfactory JIT implementation.

The disadvantage however is that the risk of having disruptions in the schedule is higher when working under a JIT framework. Basically because any small failure or interruption in the delivery process will certainly result in delays and diminished of productivity (De la Garza, 2006).

Traditionally, in the construction industry the delivery of equipment in materials is executed in advance in order to avoid risks and delays. The CII mentions that one possible way to take advantage of the JIT technique within the construction industry is to execute JIT delivery only for non-critical-path activities, while materials and equipment for the critical path activities may be delivered under the traditional approach (CII, 2004).

Building Information Technology (BIM)

Construction projects involve so many different actors and disciplines working together with the same information, and for many years this information has been handled on paper (two dimensional drawings such as: plans, elevations, sections, etc.). Fortunately, nowadays the advances of technology offer another tool to improve project performance in terms of time, cost and quality. Thus, Building Information Technology (BIM) has been developed as a means to optimize construction operations by integrating all information in a single place.

According to the National BIM Standard Project Committee, BIM is defined as:

"A digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition." (National BIM Standard –US, 2014)

This technology is therefore a big data warehouse used to store large amounts of information coming from different project stakeholders. BIM allows visualizing the whole facility and its construction process beforehand and thus, it is possible to solve design or constructability issues early on, as well as analyzing potential impacts or reduce uncertainty (Smith, 2007).

BIM opens big doors for improving the construction process in terms of time. And particularly facilitates the use of prefabrication/modularization in order to make the whole process simpler and more efficient (Construction M H, 2011). BIM is definitely a powerful enabler for implementing almost all the techniques mentioned in this report, such as constructability review, project fast track, just-in-time to name a few.

Even though this technology offers huge advantages and opportunities to reduce the project schedule, its implementation might be associated with high costs, and the need of high user's knowledge and expertise. Without having the knowledge of the tool, the implementing process might be a time-consuming and cumbersome (De la Garza, 2006). This is why the implementation of this technology might be limited in small projects or in medium, small-sized organizations.

Modularization and Prefabrication

According to the European Productivity Agency, "modular coordination is a system devised to co-ordinate the sizes of factory-made building parts with the design of buildings" (Piroozfar et. al., 2013). In other words, the work is based on fundamental units or modules that share the same components and thus the whole construction process gets simplified and the risk is reduced. Modularization facilitates the coordination for design, production and construction.

On the other hand, according to Piroozfar (2013), any method of modern construction implies moving on-site activities off-site to certain degree. Prefabrication is a technique that refers to off-site construction. This means producing parts of a building in a factory and then bringing them to the site for later incorporation in the structure.

A modular system of construction is enhanced and facilitated by producing the building parts off-site. This is the reason why in some cases the combination of these two really represents a competitive advantage and a good way to improve productivity in the construction industry.

One of the early examples of prefabrication/modularization was the Crystal Royal Palace. Constructed by Joseph Paxton in 1850. The construction period lasted a few months and consisted of assembling prefabricated components.

Prefabrication/Modularization was extensively use during World War II due to the increasing need of accommodating soldiers, the reconstruction of damaged infrastructure, and also for building all-purpose lightweight military buildings that could be shipped anywhere and then assembled by non skilled labor (Construction M H, 2011).

Nowadays, thanks to the access to new technologies and innovation, there has been an enormous advance in the field of modularization/prefabrication. In this sense, processes and technologies have made it possible to deliver more complex types of facilities and also with better productivity rates that were not possible before. In fact, in one of its Smart Market Reports, Mc Graw-Hill Construction (MHC) has identified trends that prefabrication/modularization as being the next major and most important trend developing impact in the industry. One of these trends identified was the shift of an increasing number of companies involved in green construction, looking at the use of BIM (Building Information Modeling) in terms of its impact on prefabrication (Construction M H, 2011).

That said, there is no doubt that this technique has the potential to really change the construction industry and advance a great deal in terms of productivity. In fact, according to the survey study made by Mc Graw Hill (2001), modularization/prefabrication has a significant impact on decreasing project schedule. According to the study, 66% of the surveyed reported the project schedule is decreased, and among those, 35% of the respondents claimed that the benefits achieved reductions of 4 weeks or more (Figure 6).

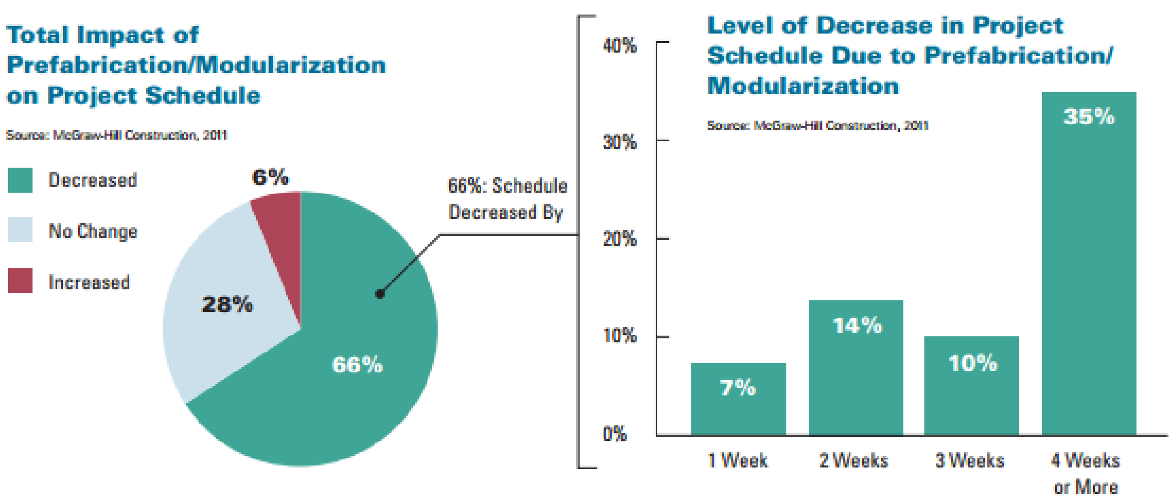

Figure 6. Total impact of Prefab/Modularization on Project Schedule. (Construction M. G, 2011)

Research in action

Referred Content: Construction, M. H. (2011). Prefabrication and Modularization: Increasing Productivity in the Construction Industry.

Case Description: The Fort Sam Houston Medical Education and Training Complex Barracks is a facility intended to house a total of 6000 soldiers. With a tight schedule of 42 months, the contractor Hensel Phelps and subcontractor Warrior Group decided to implement the project through the use of modular construction.

- Owner: Us Army Corps of Engineers
- Size: 1,6 million square feet
- Number of Buildings: 5 (roughly 320,000 square feet each)
- Height: 4 stories
- Number of Modules: 1,705 (total; 341 per building)

The modules were constructed at a facility in Belton, Texas, and approximately 2,5-hour drive north of Fort Sam. Although the transportation of modules is costly, the manufacturer can produce without any kind of restriction, and avoiding delays caused by weather conditions. Then each module is brought to the site and lifted by a 250-ton crawler crane, and the modules can then be set directly to the foundation. Then the work inside the modules is completed, i.e. painting, carpets etc.

Highlights:

The modules were very standardized and minimal errors were seen within them.

The team was able to install from 8 to 12 modules per day. And the whole building installation (341 modules) lasted about eight weeks.

General management practices

It is clear that by implementing good management practices, the project manager can achieve a substantial reduction in the project's execution time without compromising quality (Rondón, 2013). In other words, the application of these managerial techniques will indirectly translate into simplification of work and thus, the project's schedule will be positively affected. It is also worth mentioning that these practices can be successfully implemented during any of the project's phases. However, the greater opportunities for time savings are found at the early phases of the project, when the conceptualization and planning of activities are developed. The following table 3 includes a list of 32 practices recommended by the CII in order to reduce project's duration.

Practice	Pre-planning	Design	Materials Mgt.	Construction	Start-up
Start-up driven scheduling	X	X	-	X	-
Participative management	X	X	-	X	-
Invest resources in project plan	X	-	-	-	X
Pre-project planning	X	-	-	X	-
Alignment	X	X	-	X	X
Well-defined organizational structure	X	X	X	X	X
Pareto's law management	X	-	-	-	-
Employee involvement	X	X	X	-	-
Realistic scheduling	X	X	-	X	-
Construction/driven scheduling	X	-	-	X	-
Concurrent evaluation of alternatives	X	-	-	-	-
Avoid scope definition shortcuts	X	-	-	-	-
Use of electronic media	X	X	-	X	-
Constructability	-	X	-	X	-
Freezing of project scope	X	X	-	-	-
Reusable engineering	-	X	-	-	-
Non-traditional drawing release	-	X	X	-	-
Supplier/engineer early interaction	-	X	-	-	-
Materials Management	-	-	X	-	-
Material coordination	-	-	X	-	-
Prioritize procurement of material	-	-	X	-	-
Efficient packaging for transportation	-	-	X	-	-
Material I.D. on purchase documentation	-	-	X	-	-
Testing/inspection	-	-	X	-	X
Multiple suppliers	-	-	X	-	-
Supplier submittal control	-	-	X	-	-
Field management	-	-	-	X	-
Safety in workspace	-	-	-	X	-

Aggressive project close-out	-	-	-	-	X
Detailed plan	-	-	-	-	X
Determine system testing requirements	-	-	-	-	X
Zero accidents techniques	-	-	-	-	X

Table 3. Good management practices for achieving reduced delivery times. (De la Garza, et al. 2006)

As the intention of this section is to be concise, the practices are not described but only matched with the different project phases in which they can be implemented. In order to find a more exhaustive explanation of each measure, please refer to De la Garza et al. (2006). However, the author believes there is one practice in the list which is one of the most important ones, and it is worth describing it thoroughly: freezing the project scope.

Freezing the Project Scope

It is not easy to create a scope that reflects all the projects requirements, and that is accepted by all the project's stakeholders. Without scope there is no project. Having a single scope is paramount for a satisfactory project development. Therefore, the project team must work towards the attainment of the project scope and stick, before setting the first stone of the project.

Working towards freezing the project's scope pushes all the project stakeholders to pay attention into details at a very early stage and thus later problems will be avoided. Moreover, according to Eldin (2005) the application of this technique allows the project team to eliminate the uncertainties associated with design and procurement of major items so that detailed design and material procurement can proceed as soon as funding is approved.

The ultimate benefit of freezing the project scope early in time is that it prevents the project from falling under continuous reassessment and modifications. This phenomenon is called "scope creep" and it brings so much frustration for the project stakeholders. Moreover, it jeopardizes the final outcome and its ability to achieve its original purpose (Pinto, 2007).

Based on De la Garza (2006), the Construction Industry Institute (CII) advises a series of strategies for freezing the scope at the beginning of the project (CII, 2004):

- Establishing a deadline for freezing the project scope. This will increase the team motivation towards finding solutions to scope issues and coming up with a good project definition

- Determine which deliverables will be part of the "baseline" from which changes should be measured. A work break down structure will surely help on this process

- Perform reviews to ensure the scope complies with the standards of quality

- Make inspections in order to ensure that the project scope is completely align to the business strategy before freezing it

- Freeze parts of the project scope in order to keep moving forward towards freezing the whole scope

- If possible, include the whole project team, contractors and the users in checking the scope

Research conducted by the CII has also identified several factors that make the scope freezing process difficult. These are classified as employee-, management- and process-related in Table 4.

Employee Related	Management Related	Process Related
• Insufficient/lack of skills and training • Lack of continuity of project personnel	• Lack of budget	• Frequent interruptions • Disability for involving the end-used • Disability for determining cost-benefit ratio • Lack of process understanding

Table 4. Barriers to the scope freezing process. (De la Garza, et al. 2006)

Finally, it is important to take into account that the dynamics in the construction industry nowadays make it really difficult to not formulate changes after the project execution has started. However, this fact does not decrease the value of this technique, because the focus on closing the scope forces the team to address issues and details that might go unnoticed or left unsolved "for later stage". It has also been proven that the biggest savings in terms of time are usually obtained at the front end, when the project is still conceptualized and planned (De la Garza, 2006).

Research in action

Referred Paper: Eldin, N. N. (2005). The effect of early freezing of scope on project schedule.*Cost engineering*, *47*(2), 12-18.

Case Description:

A pharmaceutical R&D facility with 1.1 million sq. ft. of usable space of office, commercial, and industrial areas. The facility is built on over 200 acres site. The project contract price was $260 million and involved 150 bid packages. The project delivery time was 46 months, of which 20 months were the design phase.

Results:

1. Over 20% reduction of project delivery time. The project was completed 8 months sooner than similar ones.
2. The time savings resulted in unit prices 15% below company's historical performance.
3. Construction had fewer incidents of rework and fewer number of change orders.
4. Customers' satisfaction improved, which resulted in increased number of negotiated contracts and development of formal partnering with major customers.

Project Crashing

Also known as time-cost trade-offs, crashing is a process of accelerating a project in order to reach an early completion date. This technique implies the use of more resources in an effort to accelerate the project execution. Therefore, project crashing is based on the assessment of the cost-time trade off particularly in activities within the critical path (Pinto, 2007).

Callahan et al. (1992) mentions a number of initiatives for crashing a project, which include the following:

- Overtime
- Multiple shifts

- Increasing the number of craftmen
- Using more productive equipments
- Using equipment with faster installation methods
- Alternate construction methods or sequences

All of these initiatives translate into time reduction for the project, with a cost associated of course. Nevertheless, Pinto (2010) argues that "by far the most common method for shortening activity durations involves the decision to increase project resources", in comparison to working overtime. In fact, research has shown vastly that working overtime reduces in average 10 to 15% of working productivity (Thomas and Raynar, 1997).

The first step for crashing a project is to determine the cost associated with each activity in the project. In that sense, assuming there is a method for estimating activities' duration, it is possible to draw the following Figure 7, indicating normal length, crashed length and their associated costs.

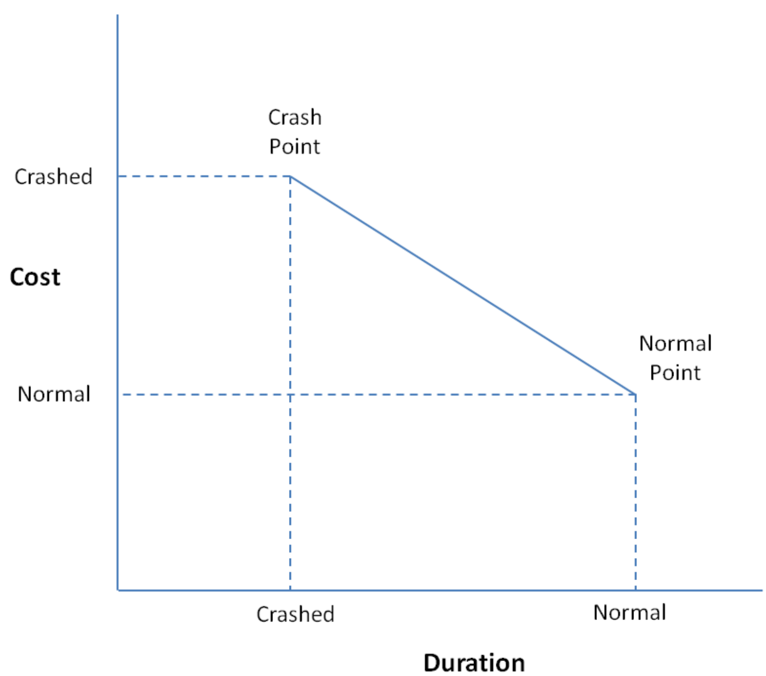

Figure 7. Time-Cost Trade-Offs for Crashing Activities (Pinto, 2010)

Figure 7 shows the relationship between cost and duration, for a particular activity. The slope of the curve between the normal and the crash point represents the rate at which an activity could be crashed. The slope is given by the following formula:

$$Slope = \frac{crash\ cost - normal\ cost}{normal\ time - crash\ time}$$

It is also important to notice that it is possible to crash activities only until certain (convenient) extent. In construction for example the project team must evaluate what the gains/losses are in accelerating an activity, and then make an optimal decision approach to accelerate the schedule, i.e. extended work days, multiple shifts, more productive equipment etc.

Determining which technique is best and to which extent an activity should be crashed requires experience in scheduling and in cost estimating too.

Location-Based Management System

There is a number of scheduling techniques in project management; all these basically compare the development of activities against a baseline. Particularly the critical path method and PERT have been the dominating methodologies in practice over the years. In recent research however, Kenley & Seppänen (2009) introduce another classification for scheduling systems known as "Location-based". Figure DD shows the division for both scheduling methodologies: the dominating "activity-based" (CPM, PERT) and "location-based" (unit production, location production).

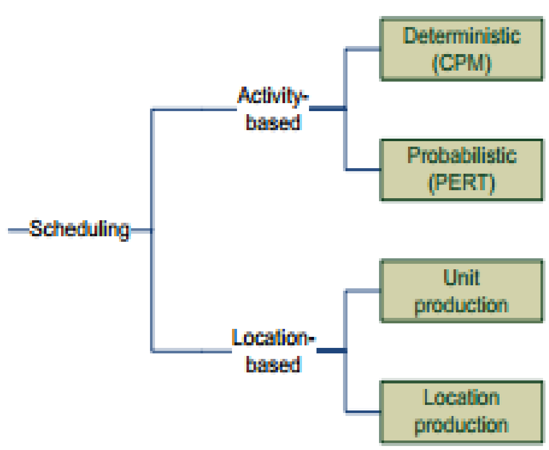

Figure 8. A typology for construction project scheduling methodologies. (Taken from Kenley& Seppanen, 2009)

The first approach "activity-based" scheduling relies on the construction of a logical network of activities and the direct relationships between them. These methodologies (CPM, PERT) are well known and therefore, will not be explained further in this master thesis.

"Location-based" scheduling however, is a family of scheduling methodologies concerned *"with the movement of resources through locations or places"*. These methods can be "*divided depending on whether the focus is on the continuous completion of repetitive units (as found in repetitive factory production, or linear projects) as typified by line of balance method, or alternatively the focus being on the completion of variable physical locations (more typical in commercial construction) as typified by the flowline method*" (Kenley& Seppanen, 2009)

Location Base Management System (LBMS) is a technical system in which the *location* is the unit of analysis, and it is provided by a Location Breakdown Structure (LBS). Also, according to Kenley& Seppanen, (2009) the system defines *task* as groups of activities of the same type which are executed on the same location. Thus, the LBMS facilitates the construction process by defining how *tasks* are going to be completed in each *location*. The system does so, by using the production information, quantities and resources available. Therefore the whole scheduling process is based on factual information rather than on assumptions or forecasts such as in CPM or PERT (Kenley & Seppanen, 2009).

There is also research that links Location Based Management System (LBMS) and the Last Planner System (LPS), in order to attain the benefits of lean (reduce waste, decrease variability, improve productivity etc) since both systems seem to be complementary (Seppanen et al. 2010).

Finally, according to Kenley & Seppanen (2009) it is time that the industry moved towards implementing alternative project planning and control methods such as LBMS and LPS, in order to reap the benefits and exploit all of its potential, particularly for finishing projects faster, within budget and without compromising quality.

The next chapter continues exploring the schedule compression techniques and it addresses the particular concept of concurrent engineering. Due to its high potential and impact over the project schedule, the author considers this concept and the techniques stemming from it are worth mentioning in a separate chapter.

Chapter 7. Concurrent Engineering

The following chapter describes the concept of Concurrent engineering and the techniques stem from it and can be applied into a project-based environment. There are mainly three applications of concurrent engineering in the project-world, namely concurrent design, concurrent construction and project fast-track. The chapter analyses advantages and risks, as well as applicability issues in relation to these techniques.

Concurrent engineering may easily be among the techniques presented in the previous chapter. In fact, the previous and the present chapter might be fused into one. However, due to its nature -which is different from the rest of the techniques- concurrent engineering can also be set apart and given a specific focus in a separate chapter. Concurrent engineering, as the reader will find out in the following lines, is based on executing task in parallel whilst the techniques presented in the previous chapter deal with managing the tasks efficiently or methods that facilitate the execution of the tasks. Therefore, without further due here we present the concept of concurrent engineering:

Concurrent Engineering or Simultaneous Engineering is a methodology originally developed for new product development. This technique is based on the parallelization of tasks in order to shorten the time to market and improve productivity. Winner, et al., (1988) defines concurrent engineering as “a systematic approach to the integrated, concurrent design of products and their related processes, including, manufacturing and support. This approach is intended to cause the developers from the very outset to consider all elements of the product life cycle, from conception to disposal, including quality, cost, schedule, and user requirements.”

Within the construction context, the implementation of this technique includes establishing a working group, evaluating the opportunities for overlapping several tasks, setting objectives and implementing the plans by having a strong and constant communication. If this technique is performed well, it can bring about significant benefits in terms of delivery time. However, the decisions of starting subsequent tasks without all the required information introduces potential risks of project changes and rework. The CII (CII, 1995) notes that concurrent engineering is of a great value especially for large, complex project in which, typically upstream information is needed in order to start subsequent activities.

As concurrent engineering implies participation of all parties involved in the tasks, the Construction Industry Institute (CII) suggests that all entities affecting or affected by the project must be included in the initiative (CII, 1996). New approaches of concurrent engineering go deeper within this theory of starting subsequent tasks before all the required information is at hand. "Fast-track" construction is one example, since it includes the overlapping between the design and construction phases. Concurrent engineering can also be implemented within the design or the construction phases separately (De la Garza, 2006). These three alternatives are explained below.

Concurrent design

Concurrent engineering can be applied during the design process, in order to reduce the time required to complete this phase of the project. In general this technique involves reducing the dependencies between activities. Prasad (1996) identifies four types of relationships between activities:

- Dependent activities. In this case the downstream activity requires information from the upstream activity in order to start
- Semi-independent activities. In this case the downstream activity only requires partial information from the upstream activity
- Independent activities. In this case there is no relationship between the two activities
- Interdependent activities. In this case both activities require information from each other in order to be complete

Moreover, Bogus (2005) explains that in order to find strategies for reducing these dependencies between activities, it is necessary to recognize the characteristics of evolution and sensitivity between the two activities in question:

- Evolution refers to the rate at which an upstream activity generates information if there is no pressure for accelerate the work.

- Sensitivity refers to how much rework would be needed within a downstream activity if there were information changes

Once the characteristics of evolution and sensitivity are defined, the next step is to develop an overlapping strategy that takes into account the particular case at hand. In this sense, Krishnan (1995) suggests that there are four different cases and strategies to follow. In the first case the evolution of the upstream activity is fast and the sensitivity downstream is low. This situation is the most convenient and therefore it is recommended to exchange preliminary information and early finalization of the upstream design. In the second case, the upstream activity has a low evolution and the downstream activity has low sensibility. Therefore, overlapping is recommended only thru exchange of information in an iterative process. The third case involves fast evolution at the upstream and fast sensitivity downstream. Therefore, only early finalization of the upstream activity is recommended. Finally, when evolution is low and sensitivity downstream is high, overlapping should be avoided as much as possible (Krishnan et al., 1995). The following Figure 9 summarizes these ideas.

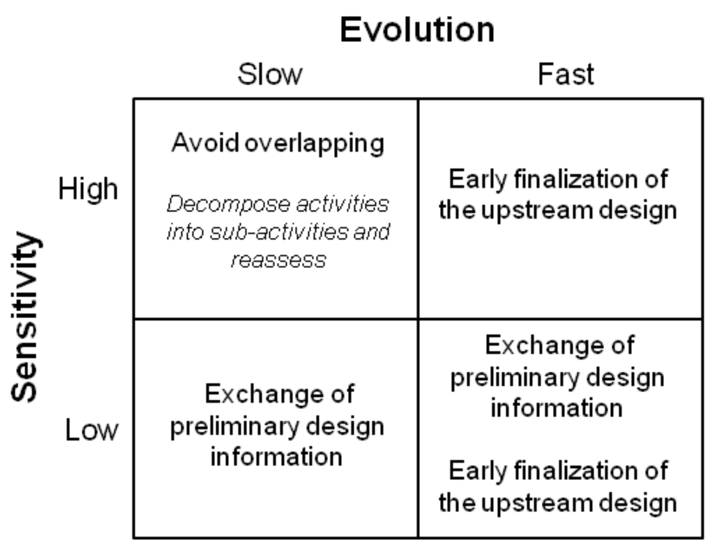

Figure 9. Overlapping strategies (Krishnan et al., 1995)

Concurrent design can really shorten the duration of the design process if it is applied in efficiently. De la Garza (2006) suggests a few steps that can be followed in order to enhance the applicability and effectiveness of this rule:

The first step includes developing an activity network and determining the critical path of the project. This would represent the baseline for assessing what benefits would overlapping bring in terms of time. Then, the activities in the critical path should be evaluated in regards of its evolution and sensitivity characteristics. The third step involves exploring the overlapping strategies for each pair of activities. Finally, for each strategy it is necessary to evaluate the tradeoffs between schedule reduction and project costs, potential consequences, rework and so on (De la Garza, 2006).

Concurrent construction

Another effective way to compress the project schedule through concurrent engineering, is by applying the technique within the construction phase of the project. In this case however, the project design must be finished and the relationships between activities (construction activities) are assumed to be only physical relationships. Bogus shows that in construction "physical relationships" are practically linked to workspace and resources availability. Thus, two activities can be overlapped only to the extent that resources and workspace are available (Bogus et al., 2005).

In this case, also the terms of evolution and sensibility presented in the previous section should be evaluated for each activity and then, an appropriate strategy for overlapping should be put in place and obviously, the risks of possible rework or delays due to overlapping should be addressed and assessed before taking any decision.

De la Garza (2006) explains that this technique particularly contributes to decreasing the idle time of resources. The author describes that the application of this technique enhances the availability of resources required to perform activities downstream. For example, when resources from the upstream activity are available, they can already start working on the downstream activity if possible, unlike the traditional, sequential schedule approach. Therefore, this technique clearly increases labor productivity in construction while at the same time decreases costs (De la Garza 2006).

One possible disadvantage of performing concurrent construction however is the need for increasing coordination in terms of the communication frequency between project members. Thus communication costs also increase (Williams, 1995).

Project Fast- Track

Project fast-track is a technique that also stems from the principles of concurrent engineering. The fast-tracking technique reduces the duration of the project by means of overlapping construction and design activities. A clear example would be starting the construction of foundations before the design drawings are completed. Project fast-tracking can dramatically reduce the time of a project, but at the same time it increases the risks of rework and schedule delays.

Overlapping principles

One of the basic concepts of project management says that any project can be divided into a finite number of activities, and thus these activities are connected and related to each other. The well known concepts of the Work Breakdown Structure (WBS) and Activity Networks may help to understand the idea of activity interrelation. Dehghan (2010) as a supporter of this idea, identifies two types of activity dependency: information dependency and resource dependency. Information dependency means one activity requires information (data, drawings, specifications etc) from the other in order to be executed. The resource dependence entails that the same resource (equipment, machine, employee and so on) is needed to complete both activities. Ultimately, the risk of overlapping two activities lies on the degree of interaction between these two types of dependencies.

The typical fast-tracking process involves dividing the design into a number of work packages. Then, as the work proceeds, early release of preliminary information from the design work packages allows construction to begin before design is fully completed (Bogus et al. 2002). According to De La Garza (2006), the implementation of this technique can begin by a phasing plan that includes how design work should be divided into packages. Once each design work package is completed, information should immediately be released for the construction work. And construction is carried out as the design packages are received (De la Garza, 2006).

According to Dehghan (2009) the degree of overlapping for two activities can be indicated by the following equation:

$$Overlapping\ \% = \frac{Duration\ of\ the\ Overlapped\ fraction}{Total\ Duration\ of\ the\ Shorter\ activity} \times 100$$

According to this equation, 0% of overlapping means no overlapping between the two activities, and 100% means full overlapping. It is important to notice that, in the equation, the shorter activity could be either the upstream or the downstream activity. As an example, Figure 10 shows activity A and B, with a 50% of overlapping (50% = (20/40) * 100).

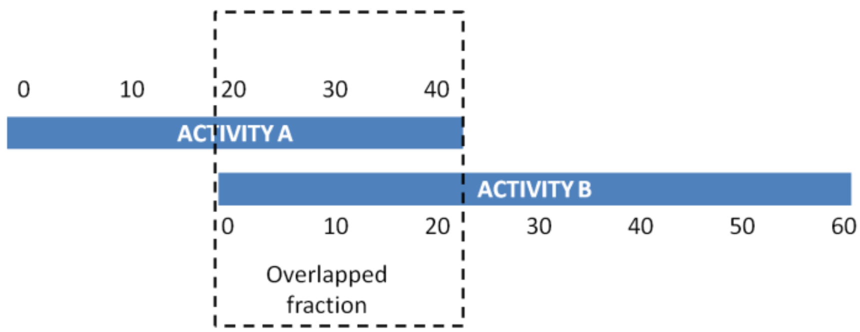

Figure 10. Degree of overlapping between two activities (Dehghan, 2009)

Challenges to overlapping design and construction

The benefits of project fast-tracking are many and cover aspects such as lower financing costs, increased prestige, time to market but the most relevant economic benefits are those derived from the earlier operation of the project. However, it is very challenging to try to overlap two (or more) dependent project phases, without compromising quality and avoiding rework.

One of de disadvantages of this technique can be that normally there is less time for revision, since information flow must occur as fast as possible from upstream to downstream activities (De la Garza et al. 2006). Engineers use less time to develop drawings and specifications as they are feel pressure for releasing the information to the designers and then defects are more likely to go unnoticed and the risk of construction rework is also higher (De la Garza, 2006).

Project fast-tracking also can lead to the team making assumptions in order to continue with the development of work. This lack of information leads to assumptions, and the risk of having to correct false assumptions would be higher and can compromise the quality, time and cost of the project (De la Garza, 2006).

It is also possible that, since the team feels pressure for come up with results, the final design might not be the optimal one. The needs for speeding up the decision making process can also reduce the probabilities of selecting the optimal design. Therefore the overall quality of the project could be also affected (De la Garza, 2006).

Implementation and applicability

As mentioned earlier, implementing overlapping may imply that upstream information requires rework in the downstream activity and thus, delays and increased costs appear. Therefore the big challenge for those trying to apply this technique consists in being able to identify the optimal point of overlapping between two activities, so that the benefits of schedule compression can be reaped without too much rework. The literature presents some models for dealing with this fact. As a reference Khoueiry (2013) suggests an optimization based model that serves as a decision support tool in scheduling fast-track construction projects. Bogus (2002) proposes a methodology for overlapping, taking into consideration the risks of delay and rework.

On the other hand, it is important to mention that overlapping construction with design is best suited for contracts in which all parties have reasons for collaborate towards the reduction of the projects life cycle. Traditionally projects were undertaken and carried out under the Design-Bid-Build (DBB) method, and this implies that each project phase must be fully completed before any subsequent phase can be started. However, a more dynamic world and an increasing need for setting tighter time schedules and deadlines, has pressured and affected the way companies execute projects nowadays. Project fast-tracking is an alternative to the DBB approach in order to face these new market demands.

In terms of enablers of project fast-tracking, the literature suggests that information is one of the most important factors for success. Khoueiry (2013) highlights the importance of information sharing between upstream and downstream activities, in order to be successful using the overlapping technique. In the same line, Williams (1995) argues that it is not the technique itself that make a fast-tracking project successful, he rather identifies success factors such as planning, communication, trust empowerment, dedication, experience, talent and good leadership.

Once the majority of techniques for reducing the project's lead time have been presented, the next logical step is to understand what the current status of the literature dealing with this subject is. The next chapter describes the methodology that was used in order to conduct the structured literature survey that allowed having a reliable picture about the trends of this topic.

Chapter 8. Research Design

This chapter describes the methods used for elaborating this report. The reader will find a detailed description on how the information was gathered and analyzed, as well as an objective assessment on the reliability and validity of this work.

Scope

The objective of this master thesis is to study the initiatives regarding schedule compression within the construction industry internationally and in corresponding research activities. In order to attain this objective, a systematic review of literature was carried out. The methodology of this research is based on similar research projects conducted by Themistocleous (2000), Betts (1995) and Baines (2006). Themistocleous (2000) undertook an analysis of the subject of project management in papers published at the International Journal of Project Management from 1984 to 1998. Betts (1995) also reviewed the public literature and documented the progress in the field of project management. And Baines (2006) determined the state-of-the art in lean design engineering by conducting a literature review.

According to Baines (2006), in order to conduct a systematic literature review, a number of variables must be defined from the outset. The review should be able to answer some basic research questions that anyone might pose when considering the topic of reducing the project's life cycle time. In this case, the author has linked these questions to the research objectives of this thesis work:

1. What is commonly meant by the term fast-track in the research world?
2. How is the concept of fast-track used effectively for reducing the project life cycle?
3. What are the main challenges for practitioners and academia in regards to reducing the project's duration?

Baines (2006) is also clear when he mentions that the point of stating some question is to guide the process of research through the literature available. However, the author points out that it is important to take into account that the literature and sources might not suffice for answering all the questions (Baines et al., 2006).

Sources, time frame and keywords

The journals selected for conducting the review were: International Journal of Project Management (IJPM), Project Management Journal (PMJ) and Journal of Construction Engineering and Management (JCEM). These three were selected because of their high relevance to the field of project management and the construction industry. The IJPM is published in collaboration with the Association for Project Management (APM) and the International Project Management Association (IPMA). The IJPM is published eight times per year and offers a wide variety of topics within project management, and its first issue was in February 1983. The JECM is one of the 34 journals of the American Society of Civil Engineers Library (ASCE Library), and its first issue goes back to 1983. Last but not least, the PMJ is the academic and research publication of the Project Management Institute (PMI). It is published by John Wiley & Sons and PMI.

Regarding the time frame investigated, only articles released within the last 10 years were analyzed (2005 – 2014). This criterion was restricted to this relatively short period of time in order to find fairly new information regarding the subject.

The search strategy also included a number of keyword combinations in order to catch relevant literature in the journals. These keywords included “schedule”, “life cycle”, “time”, “reduction”, “compression”, “fast-track” “fast-tracking”, “techniques”, “methods”.

Search strategy

In order to search through the databases, ten different search strings were created using combinations of three keywords. The search strings tried to capture as many articles as possible and then the results were registered on a matrix containing the search string and the database (see Table 5 in the next chapter).

After the results were recorded, the author proceeded to read the abstract of each article retrieved. This step of the research was very intense and time consuming as the author only relied on himself to conduct the investigation. The complete list of articles can be found on the appendixes of this work (Appendixes 1 to 4).

The classifying model was divided into three main fields. Each paper was assessed and classified according to:

- Research type
- Industry sector
- Main contribution

The author used his own analytical skills in order to organize the papers. It is important to notice that this model for classification of papers is based on the models used by Themistocleous (2000), Betts (1995) and Baines (2006). However, the author came up with his own simplified version that fulfilled the purposes of his study.

1. Research Type

The first feature or characteristic evaluated was whether or not the article included any kind of empirical research. If the article included at least following research methods, then it was classified as a qualitative research article:

- Case Studies
- Interviews
- Survey
- Analysis of secondary data

2. Industry Sector

The second point of assessment was the industry sector that contributed the most to the article. The options included the following ones:

- Agriculture
- Construction
- Facilities
- Process industries
- Manufacturing
- Information/Services

However, as the vast majority of articles were focused on the construction industry, the author decided simplify this classification into: "construction industry" and "other industries"

3. Article's contribution

Finally the papers were classified depending on the contribution achieved. These included:

- Insights: The contribution of the paper is basically stemming from the analysis of information and the discussion presented by the author. This type of paper does not include any new theory or model. It provides the information in a more general way and is normally based on empirical data or case studies.
- New Techniques/Models: The objective of this paper is developing new techniques for analyzing or managing projects. Its contents are merely theoretical, even though it could also include a practical approach for testing the model or technique introduced.

Each article was classified against these three attributes and the results can be observed in the next chapter. Also, a number of articles were marked as very relevant for this thesis and therefore were selected for a more thorough study and were included within the discussion.

Reliability, validity, generalisability, credibility

It is important to address the topic of quality or –in other words– how one can judge the quality of any study. According to Shipman (1988) there are 4 key questions about the quality of research. Each question has to do with a different aspect: reliability, validity, generalisability and credibility.

1. Reliability: If the investigation had been carried out again by different researchers using the same methods, would the same results have been obtained?

This question aims at finding out whether or not the research project can give us consistent results. In this case, since the literature survey was carried out on three specific journals, using specific keywords and a specific a time frame, the results retrieved should be the same. In this sense, this master thesis should be regarded as reliable work.

2. Validity: Does the evidence reflect the reality under investigation?. Has the researcher found out what he thinks or claims it is about?

This question clarifies whether the study is actually measuring what the author wants to measure. In this sense, this thesis might not be 100% valid since the research is limited to just three project management journals. The literature surveyed is limited and scattered, and thus the author cannot say for sure that the results are the accurate picture of the subject of schedule compression in the real world.

3. Generalisability: What relevance do the results have beyond the situation investigated?

This question explores whether or not the thesis' results fit for the whole population. And this question might be more suitable for assessing case studies or research in which specific samples or groups are tested.

Nonetheless, since the results from this literature survey were that scattered, the author thinks that generalization in this case might point at many different understandings about the terms of schedule compression, depending on the country, region, industry, culture and so on and so forth. Therefore, the results should not be easy to generalize as there are many different practices and these vary across borders.

4. Credibility: Is there sufficient detail on the way the evidence was produced for the credibility of the research to be assessed?

This question basically wants to clarify whether the research is actually credible or not. The author thinks that since the conditions and search strategy is very clear, then there should not be many issues in relation to the credibility of this work.

Research articles and other activities

Another important activity carried out during the course of this master thesis was the production of the first draft of an introductory article which will be published in September at "Prosjektledelse", a monthly magazine created by the Norwegian Association for Project Management (Norsk Forening for Prosjekledelse). The article includes a brief explanation about the motivation and the necessity for conducting research on how to increase the speed of delivery in project management. This article represents one of the first publications linked to the "Speed Up" project, a new research initiative by the Norwegian University of Science and Technology (NTNU) and SINTEF. The draft can be found in Appendix 5.

The author also made a contribution to an article presented to the European conference on Knowledge Management (ECKM) 2014 in Portugal. The name of the article is: "Speeding up projects seen from the perspective of Learning and Knowledge Sharing". Authors: Anandasivakumar Ekambaram, Agnar Johansen, Jan Alexander Langlo and Pedro Rondón.

Chapter 9. Results

The main objective of this chapter is to pinpoint the findings from a structured research survey in three important journals of engineering and project management. Note that the analysis is rather brief and to the point, as a deeper discussion can be found in the next chapter.

After implementing the search strategy, the preliminary results were gathered in Table 5, including the number of articles retrieved from each search strings. The results were organized according to journal.

The first point that calls the attention from Table 5 is the significant differences between the three journals in terms of numbers of articles retrieved after each search attempt. One can notice at first sight the predominance of the Journal of Construction Engineering and Management (JECM) over the International Journal or Project Management (IJPM) and the Project Management Journal (PMJ) . This is quite interesting since at least the JECM and the IJPM started at the same year (1983) and both journals have similar frequency of publication.

#	Søkeord	IJPM	JECM	PMJ
1	"fast-track" + Schedule + compression	0	18	1
2	"fast-tracking" + time + techniques	3	10	10
3	"life cycle" + compression + methods	5	20	3
4	"fast-track" + "life cycle" + time	40	18	29
5	Techniques + reduction + time	169	743	66
6	"life cycle" + time + reduction	110	231	48
7	Schedule + "fast-track" + methods	11	63	11
8	Time + compression + schedule	8	83	4
9	Reduction + compression + time	7	92	2
10	Methods + reduction + time	227	1014	75

Table 5. Preliminary results in terms of articles retrieved per journal

Another remarkable point is that the results from 3 of the search strings retrieved considerably many more articles than the rest: The higher number of publications was retrieved against the search string 10 ("methods + reduction + time"). Similarly the strings 5 ("techniques + reduction + time") and 6 ("life cycle" + time + reduction") retrieved a relatively high number of hits despite of the journal.

The last point to highlight is that many of the publications retrieved against search string 10 ("methods + reduction + time"), were also retrieved against the strings 5 and 6. The reason for this might be due to the fact that the combination of keywords is very similar for these three search strings. In fact, the words "time" and "reduction" were common for the three of them. However, the great amount of results is actually due to the third word in each string ("techniques", "methods" and "life cycle", respectively). There is no doubt these three terms are rather general and attracted many different articles from different industries and different branches of project or construction management.

On the other hand, search strings 1,2,3,4,7,8,9 proved to be much more effective in catching articles aligned to the topic of this master thesis. However, the number of articles was not so high and this might indicate that the topic of schedule compression or project lifecycle reduction might be underrepresented or too scattered in the important journals of project management.

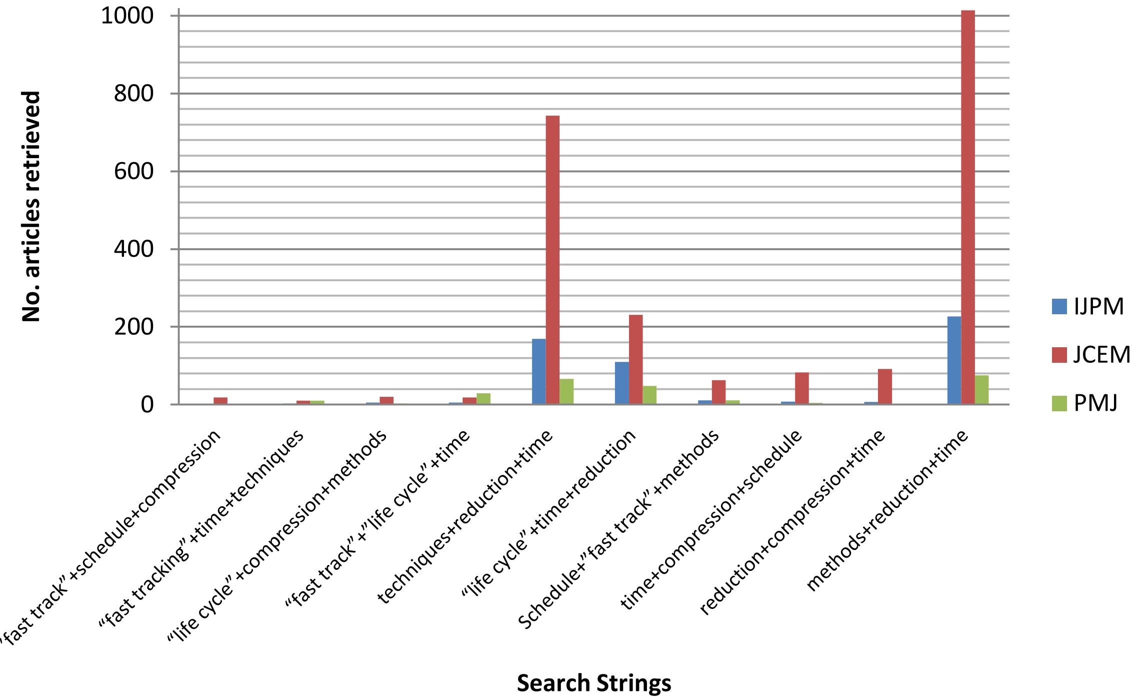

Figure 11. Number of articles retrieved per journal

Due to the limited time and resources available for this master thesis, the first four search strings were fully assessed. The assessments consisted in looking at each article and then classify it in terms of industry sector, type of research (interviews, surveys, case studies…) and type of contribution. The articles that got into the results, but were outside of the topic were marked as not relevant.

Regarding the first search string ("fast-track" + schedule + compression), the only journal that retrieved more than one article was the Journal of Engineering and Construction Management (18 hits). Table 6 presents a summary of the results. The construction industry was obviously the main contributor for the vast majority of papers retrieved from this journal, since the JECM is affiliated to the American Society of Civil Engineers and its publications are focused mainly in the construction business.

On the other hand, out of the 18 articles, 17 were considered relevant for the topic of schedule compression. All of them included at least one type of qualitative research and 10 of them aimed to developing a new model or technique for increasing the schedule efficiency directly or indirectly.

Journal of Engineering and Construction Management							
# OF ARTICLES RETRIEVED	# OF RELEVANT ARTICLES	QUALITATIVE RESEARCH INCLUDED?		INDUSTRY SECTOR		CONTRIBUTION	
18	17	YES	NO	CONSTRUCTION	OTHER	INSIGHTS	NEW MOD/TECH
		17	0	17	0	7	10
International Journal of Project Management							
# OF ARTICLES RETRIEVED	# OF RELEVANT ARTICLES	QUALITATIVE RESEARCH INCLUDED?		INDUSTRY SECTOR		CONTRIBUTION	
0	0	YES	NO	CONSTRUCTION	OTHER	INSIGHTS	NEW MOD/TECH
		N/A	N/A	N/A	N/A	N/A	N/A
Project Management Journal							
# OF ARTICLES RETRIEVED	# OF RELEVANT ARTICLES	QUALITATIVE RESEARCH INCLUDED?		INDUSTRY SECTOR		CONTRIBUTION	
1	1	YES	NO	CONSTRUCTION	OTHER	INSIGHTS	NEW MOD/TECH
		1	0	1	0	1	0

Table 6. Relative search results against the search string “fast-track” + schedule + compression)

The second search string (“fast-tracking” + time + techniques) retrieved a total of 23 results: The PMJ and the JECM retrieved 10 articles each, and the IJPM retrieved 3 articles. These results were much more balanced in comparison with the first search string. Table 7 shows the relative results.

Journal of Engineering and Construction Management (JECM)							
# OF ARTICLES RETRIEVED	# OF RELEVANT ARTICLES	QUALITATIVE RESEARCH INCLUDED?		INDUSTRY SECTOR		CONTRIBUTION	
10	10	YES	NO	CONSTRUCTION	OTHER	INSIGHTS	NEW MOD/TECH
		10	0	10	0	5	5
International Journal of Project Management (IJPM)							
# OF ARTICLES RETRIEVED	# OF RELEVANT ARTICLES	QUALITATIVE RESEARCH INCLUDED?		INDUSTRY SECTOR		CONTRIBUTION	
3	3	YES	NO	CONSTRUCTION	OTHER	INSIGHTS	NEW MOD/TECH
		0	3	1	2	3	0
Project Management Journal (PMJ)							
# OF ARTICLES RETRIEVED	# OF RELEVANT ARTICLES	QUALITATIVE RESEARCH INCLUDED?		INDUSTRY SECTOR		CONTRIBUTION	
10	10	YES	NO	CONSTRUCTION	OTHER	INSIGHTS	NEW MOD/TECH
		9	1	4	6	7	3

Table 7. Relative search results against the search string “fast-tracking” + time + techniques)

Looking at the Table 7 it is noticeable that the articles retrieved from the PMJ and IJPM were not specific only to the construction industry. Unlike the JECM, these two journals seem to include research studies addressing a wider range of industry sectors. In terms of the type of research it is clear that again the majority of articles include some sort of qualitative research method, except the IJPM which retrieved three theoretical articles. Finally, in terms of contribution, we can see that, since the quantitative research is so strong, most of the contributions constitute insights stemming from testing existing theories in a real environment.

Regarding the third search string ("life cycle" compression methods), we can observe that qualitative research is still present in the majority of articles retrieved. The construction industry represents 50% of the articles from the IJPM and PMJ. And in terms of contribution the trend continues to be mainly in favor insights, although some articles (especially from JECM) are also based on model or new techniques building. Table 8 summarizes the results.

Journal of Engineering and Construction Management (JECM)							
# OF ARTICLES RETRIEVED	# OF RELEVANT ARTICLES	QUALITATIVE RESEARCH INCLUDED?		INDUSTRY SECTOR		CONTRIBUTION	
20	10	YES	NO	CONSTRUCTION	OTHER	INSIGHTS	NEW MOD/TECH
		5	5	8	2	5	5
International Journal of Project Management (IJPM)							
# OF ARTICLES RETRIEVED	# OF RELEVANT ARTICLES	QUALITATIVE RESEARCH INCLUDED?		INDUSTRY SECTOR		CONTRIBUTION	
5	4	YES	NO	CONSTRUCTION	OTHER	INSIGHTS	NEW MOD/TECH
		2	2	2	2	3	1
Project Management Journal (PMJ)							
# OF ARTICLES RETRIEVED	# OF RELEVANT ARTICLES	QUALITATIVE RESEARCH INCLUDED?		INDUSTRY SECTOR		CONTRIBUTION	
4	4	YES	NO	CONSTRUCTION	OTHER	INSIGHTS	NEW MOD/TECH
		4	0	2	2	3	1

Table 8. Relative search results against the search string "life cycle" + compression + methods)

The fourth search string ("fast-track" "life cycle" time) retrieved a higher number of results compared with the three previous strings. It is important to notice that this search string included the words "life cycle" and time, which apparently caught a lot of non-relevant results. Nevertheless, the Journal of Engineering and Construction Management (JECM) retrieved a total of 9 relevant results and at least 6 of them touch upon new methods or models development. The results are summarized below in Table 9

Journal of Engineering and Construction Management (JECM)							
# OF ARTICLES RETRIEVED	**# OF RELEVANT ARTICLES**	**QUALITATIVE RESEARCH INCLUDED?**		**INDUSTRY SECTOR**		**CONTRIBUTION**	
18	9	**YES**	**NO**	**CONSTRUCTION**	**OTHER**	**INSIGHTS**	**NEW MOD/TECH**
		8	1	9	0	3	6
International Journal of Project Management (IJPM)							
# OF ARTICLES RETRIEVED	**# OF RELEVANT ARTICLES**	**QUALITATIVE RESEARCH INCLUDED?**		**INDUSTRY SECTOR**		**CONTRIBUTION**	
40	4	**YES**	**NO**	**CONSTRUCTION**	**OTHER**	**INSIGHTS**	**NEW MOD/TECH**
		4	0	3	1	3	1
Project Management Journal (PMJ)							
# OF ARTICLES RETRIEVED	**# OF RELEVANT ARTICLES**	**QUALITATIVE RESEARCH INCLUDED?**		**INDUSTRY SECTOR**		**CONTRIBUTION**	
29	3	**YES**	**NO**	**CONSTRUCTION**	**OTHER**	**INSIGHTS**	**NEW MOD/TECH**
		2	1	2	1	2	1

Table 9. Relative search results against the search string (“fast-track” “life cycle” time)

Following the detailed assessment of search strings and also reviewing the articles retrieved by the rest of the search strings, a total of 5 articles were identified and selected for complete analysis as they were highly aligned to the objectives of this master thesis. These are shown in Table 10 by author, title, and source, in chronological order.

Author	Title	Source
Hastak, et al. (2008)	*Analysis of techniques leading to radical reduction in project cycle time*	Journal of Engineering and Construction Management
Bayraktar, et al. (2001)	*Decision Tool for Selecting the Optimal Techniques for Cost and Schedule Reduction in Capital Projects*	Journal of Engineering and Construction Management
Dehghan, et al. (2013)	*Model of Trade-Off between Overlapping and Rework of Design Activities*	Journal of Engineering and Construction Management
Hastak, et al. (2007)	*Project Manager’s Decision Aid for a Radical*	Journal of Engineering and

	Project Cycle Reduction	Construction Management
Khoramshahi, et al. (2010)	*A Framework for Evaluating the Effect of Fast-Tracking Techniques on Project Performance*	Journal of Engineering and Construction Management

Table 10. Selection of articles for complete analysis

Once the articles were selected, these were summarized and the key concepts and ideas were highlighted. The agreements and disagreement amongst the authors were also captured. It was very important to always evaluate the contents of these articles against the research questions presented in the methodological framework.

All the key findings on this and previous the previous chapters were gathered and used to make up a solid understanding and personal view about the topic of schedule compression. These views and opinions are discussed in the next section of this work.

Chapter 10. Discussion

In this chapter the author intends to integrate the findings of this work. The chapter is divided into four sections; each section explores and offers the author's perspectives on different aspects within the topic of schedule compression.

In order to begin a discussion about the topic of reducing the project's lead time, it is necessary to comprehend the global context of the topic. The first question to ask would be: Is it really possible to reduce the lead time of projects?. In order to answer that, this master thesis has described a number of methodologies and practices, and it also has highlighted succesful case studies and examples of applications such as lean, concurrent engineering prefabrication and so on. Therefore, from the outset of this discussion the author assumes that an improvement in the project duration is possible.

After reviewing the literature, it is also possible to claim that no matter the technique, the ultimate objective of all these will always fall into one of the following two categories:

- Accelerating the project for achieving the benefits of earlier operation, or
- Recovering lost time after the project has already fallen behind schedule

These two objectives are fundamentally different. The first one suggests that the organization seeks proactively after ways to shrink the project's lead time, increasing productivity without affecting budget or scope. In the second one, the organization is already in troubles and tries to recover lost time in order to deliver on time.

One interesting question to ask is how many organizations are seeking to reduce its projects lead times because they usually struggle to deliver on time, and how many organizations are seeking to reduce its projects lead times because they actually recognize the opportunities of pushing their own limits of productivity. This is a fundamental question because, among other things, the underlying assumptions and purpose behind these questions are different. And the experience shows that unfortunately there are more organizations in the first group than in the second group; that is trying catch up the delayed time rather than proactively applying the techniques for time reduction.

My suggestion is that the underpinning characteristic that sets a company within one group or the other is simply a question of organizational culture. A culture that embraces change is very important for organizations that want to take their ideas and initiatives and actually make them happen. This requires the organization –and the whole construction industry- to have the confidence for embracing new methods and ways of work for creating synergy and achieving real, tangible results.

The following sections in this discussion address the main findings after digging into literature and information regarding the topic of project acceleration. The discussion will touch upon specific topics in relation with the current situation of the academic literature and also it will describe the global suggestions that the author considers critical in order to understand and apply the relevant practices available nowadays.

The Research: "Schedule Compression" as a research topic

The first major trend observed after performing the literature review is the fact that the articles retrieved from the Journal of Engineering and Construction Management (JECM) were consistently more aligned to the topic of schedule compression. What does that mean?: That means that the JECM seems to be the most complete journal among the three journals that were consulted regarding the topic of schedule compression. The JECM not only retrieved many more articles than the other two independently of the search string, but also the articles that were retrieved tackle the topic directly. One clear sign of this is the fact that all the articles selected for detailed review came from the JECM.

Particularly the term "fast-tracking" retrieved many more articles in the JECM, in comparison with the Project Management Journal (PMJ) and the International Journal of Project Management (IJPM). Apparently, these two journals addressed the concept of fast tracking from a broader perspective of project management techniques leading to higher productivity, while the JECM presented fast tracking as a specific technique for overlapping design and construction activities.

The Journal of Engineering and Construction Management (JECM) includes a much more practical approach to the problem of schedule compression. It was clear that the research papers retrieved from this journal were more practical than the ones retrieved from the PMJ or IJPM. Most of the articles from the JECM included case studies and applications of the theories or practices proposed. This represents an advantage in terms of the reliability of practices suggested by the articles.

Other point to mention in this section is that some of the search strings that were used for finding articles, included words that attracted too many articles and therefore, some of the results had little relevance to the topic of reducing the project's duration. This fact constituted a disadvantage in order to analyze the articles because of the limited time and resources to make this master thesis. Therefore it was not possible to summarize all the results in a comprehensible way, namely a table, graph and etc.

Keywords such as "techniques" or "methods" retrieved a big number of articles addressing the development or testing of so many different techniques within the project management field, not necessarily aiming to reduce the schedule. In the same way, the term "life cycle" managed to attract many articles related to the environmental impact of projects, which is definitely not relevant to the topic of this thesis. These three keywords made it difficult to discern between the relevant articles and the ones outside of the topic.

Last but not least, it is worth mentioning that the construction sector was unanimously the greater contributor to the research studies regarding the topic of schedule compression. This perhaps was the result of the JECM retrieving a much higher number of articles in comparison with the other two journals. Other industries appeared almost never in the results retrieved, in spite of the journal. This of course opens the doors for looking into other journals, not necessarily related with project management in order to find initiatives in relation with the topic.

The Term: Fast-track

After conducting the extensive research for this master thesis, there is no doubt that the term "fast-track" lacks consensus and it is not well structured. The term "Fast-track" can be fuzzy, and to some extent it can represent a challenge in order to find useful and correct information. The diverse uses of this term make it complicated to grasp the idea from the first moment. This can represent a challenge for anyone intending to build up a solid understanding about this subject.

It is really important mentioning that the term fast-track can be approached from at least two different points of view, and thus its meaning can vary depending on which perspective the particular author has chosen. In the following lines we will explain these two focuses:

To begin with, according to the Oxford Advanced Learner's Dictionary (2005), "Fast- track" can be used as a noun, an adjective or as a verb.

- As a noun: Refers to a quick way to achieve something, for example a high position in a company. *Example: "The fast track to promotion"*
- As an adjective: *Example: "Fast-track graduates", "A fast track route".*
- As a verb: To make somebody's progress in achieving something, for example a high position in a job, quicker than usual. *Example: "The project was fast tracked"*

In this sense, the term fast-track takes a broad perspective in which any project is a "fast-track project" as long as it incorporates at least one effort for reducing its duration. A clear example of this can be seen in the Norwegian oil and gas industry, where Statoil calls "fast track" projects those projects in which the company tries to implement a standardized oil field development (Statoil, 2014). Khoramshahi (2010) also supports this perspective and, according to him, some of the most common "fast-tracking techniques" employed by project managers include:

- Scope reduction or de-scoping (size reduction, eliminating "nice to have features", and so on)
- Design simplification (standardization, off the shelf components, over-design, concurrent engineering, and so on)
- Modularization and prefabrication

From his work, it is possible to note that Khoramshahi does not limit the term "fast-track" in any way. Instead, the author includes many different techniques and refers to all of them as "fast tracking" techniques. He even mentions concurrent engineering in the group.

On the other hand, there is a second approach towards the term "fast track" that can be found in the literature. According to the second perspective, the term is concrete and specific. "Fast track" is referred to as one specific technique for overlapping between the design and construction phases in a project. This master thesis has described the fast track technique, and this approach is clearly supported by authors such as: Bogus (2002), De la Garza (2006), Dehghan (2010). As it was explained earlier in this work, the fast-tracking technique stems from the concurrent engineering concept, and it includes the overlapping between design and construction activities in the project.

The term fast track might also be found in the literature as a "project delivery method" (Pena-Mora and Park, 2001), and even as a "replacement to the Design/Bid/Build approach" (Khoueiry, et al. 2013). Williams (1995) defines fast track as those projects completed 70% before than normal (Kasim et al. 2005). And many more descriptions, definitions and points of view can be found in the literature (please see more on Kasim et al. 2005, Khoramshahi et al. 2010, or Squires, et al. 1983). Therefore, there is a big challenge on the table for the whole construction industry; including academics and practitioners. The industry must direct efforts towards defining the terms in a clearer way that everybody can understand and make meaningful contributions. Only by doing so, the industry will reap the benefits of new advances or initiatives much faster.

The ambiguity of the term "fast track" highlighted in this section is just the tip of the iceberg since the definitional problem might be even of greater scale. There is ambiguity all around the subject of shortening the projects duration. The list of terms that can be found in the literature is overwhelming, and the same term can sometimes be referred as one thing and sometimes as another. And of course the existence of so many terms pointing at the same idea makes it difficult to collect information. The following list is just an example:

List of terms	
1. Schedule compression	9. Project’s life cycle acceleration
2. Schedule reduction	10. Shortening the Project Life Cycle
3. Project Acceleration	11. Project’s time improvement
4. Project Compression	12. Project lead time acceleration
5. Fast track projects	13. Schedule acceleration
6. Fast track techniques	14. Rapid construction
7. Fast tracking	15. Schedule efficiency
8. Project’s lead time reduction	16. Reducing project life cycle

Table 11. Some terms linked to the subject

The list is long and the industry needs to be more educated and prepared in order to really make a tangible changes. Therefore, the top institutions like construction associations, universities, research institutes, unions and organizations around the world play an important role and should work together towards unifying the concepts. It is important that only one term is selected as the big umbrella of initiatives for achieving a better performance in terms of project duration.

However, this is definitely not an easy task. And it requires really important efforts in terms of communication across the industry and academia. Everybody must be speaking the same language in order to come up with valuable solutions that can be spread internationally faster and easier. Having a clear frame, defining what is what, will definitely facilitate the search for information. Also, it will make it possible for taking the most out of the information retrieved. Well recognized institutions such as the Project Management Institute would be crucial for turn this into a reality.

The Focus: Preventing delays or Promoting time reduction

In the theoretical framework of this work, the author has described a broad range of techniques aiming at reducing the overall length of a project. It was said that the concepts and terms presented were not mutually exclusive. In other words, the application of one technique does not imply that many other are also applied into the same project.

The overlapping nature of these techniques and makes it necessary to develop a framework for classifying so many different approaches and practices. Therefore, in this section the author suggests such a framework.

To begin with, the detailed review of the scattered literature regarding schedule compression, resulted in a global understanding about the topic that made the author think of two main groups of techniques, or to main approaches to schedule compression: one preventive and one proactive.

The preventive approach includes those measures and techniques aiming to increase productivity and to make sure the project activities are executed in the best possible way; avoiding restrictions or bottlenecks and facilitating the flow of activities. In other words, the preventive approach calls for avoiding delays and working efficiently, so the project can be finished on time and (hopefully) on budget. These techniques include methodologies such as Lean, applying good managerial practices from the CII and so on. The following example clarifies the nature of the preventive approach towards schedule compression:

Let us consider project A. Project A is expected to be completed in 5 years. The project's contractor, together with the owner have included some buffer time on the forecasted schedule as a result of risk management assessment, in order to cope with any unexpected event that might affect the execution of the project's activities, leaving the project behind schedule. Figure 12 represents the total project length, including the time allocated as a result of a risk management assessment.

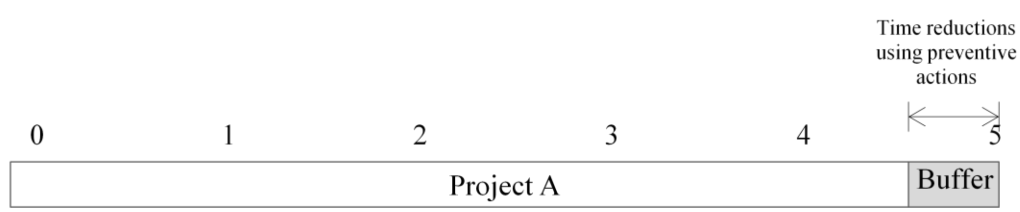

Figure 12. Opportunities for reducing project time with preventive approach

Let us assume also that all the project parties fully understand the importance and benefits of working together, aiming to complete the project on time or even before schedule. Therefore, the project parties decide to implement managerial techniques (a preventive approach) for avoiding delays and working as efficiently as possible.

However, the restriction set by resources, technology and construction methods available nowadays, imply that these efforts to reduce the project duration have (in theory) a limit point. One can assume that the project is being executed with such a highest level of coordination, that there is nothing but value added within the project activities. At this (ideal) point it is much harder to achieve substantial reductions in terms of time using techniques to avoid delays and work efficiently. In our example, project A would not need to use the buffer time at all at the ideal point where productivity is at its best.

On the other hand however, reducing the project duration can also be achieved from a more aggressive perspective; the proactive approach. This second approach includes a second group of initiatives in order to achieve project completion faster than normal. By implementing this second group of (proactive) techniques, the project duration can be reduced even more. These second group of techniques include basically concurrent engineering and project crashing. These second approach brings a whole new set of challenges, but also opens the doors for achieving even more reductions in time without changing the project scope. The next figure 13 shows this idea graphically.

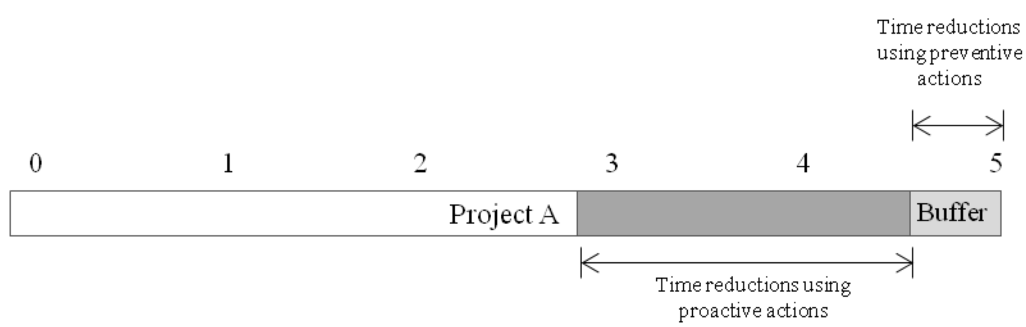

Figure 13. Opportunities for reducing project time with proactive approach

Nevertheless, as it was said before, these two approaches (preventive and proactive) are not mutually exclusive. Any project organization might include both approaches in order to become more productive in terms of schedule. Therefore, after compounding all the information of this research project, we present a framework for project schedule reduction in the following paragraphs. To begin with, figure 14 shows a visual representation of the framework that has been explained.

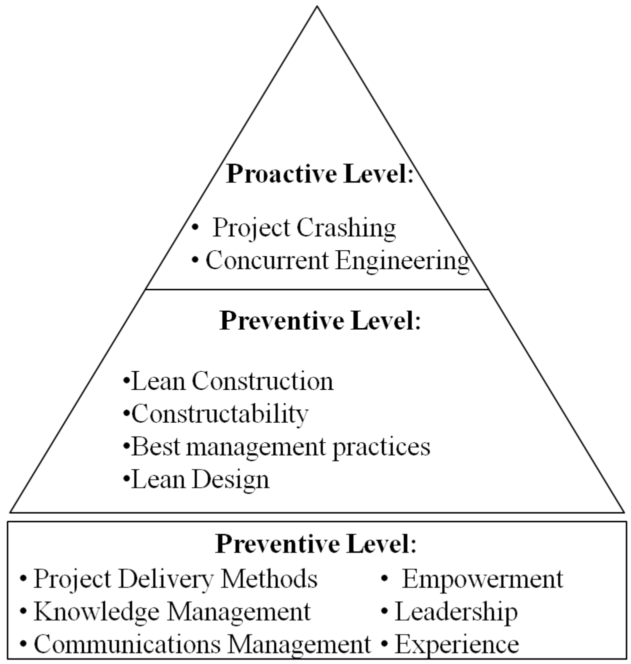

Figure 14. A model for schedule compression techniques

The figure includes a two-level triangle. The bottom of the triangle represents the preventive level. This level sets the basis for delivering excellent schedule performance both from the contractor, the designers and the project owner's point of view. This excellent performance delivers a project on time, without errors or firefighting. These practices also free up the capacity for the project organization to deliver more value from existing resources without additional costs. With the help of these techniques the organization is able to reconfigure its resources and the relationships across the whole construction industry to make a big advance in deliver a project that satisfies its original goals and purposes.

Techniques such as Lean make the whole project organization to align the project activities in such a way that the activities flow in a more productive way in comparison with projects of the same size and characteristics. The author considers that solely the application of these techniques and mentality into the company can replace the old fashion thinking within the whole construction industry where no collaboration between parties existed.

It is actually the use of these techniques what really transforms an organization and builds a culture that allows pushing the limits of productivity within the industry. This culture recognizes that the project's value is created by the actions of many different players across many different organizations. And connecting all the project stakeholders together into a seamless value stream, reveals literally hundreds of opportunities for reducing the project execution time, by eliminating non-value creating steps and without increasing the project's budget.

On the other hand, Concurrent Engineering and Project Crashing compound the upper part of the triangle. These two techniques are the two official mechanisms for compressing the project's schedule. These two represent the reactive approach of the framework we are trying to explain. However, Concurrent Engineering (Fast Tracking) and Project Crashing are fundamentally different; the first one increases the risk of rework, whilst the second one

The author thinks however, that Project Crashing is just and expensive way to accelerate the projects. It is just hiding the problems by using more resources and money. This thesis has demonstrated in one of its previous chapters the fact that usually projects falls behind schedule because of issues related with poor coordination and management and this problems can be tackled by efforts such as constructability, lean, six sigma activity analysis and so on.

Concurrent engineering as said before is all about introducing parallelism into the project schedule in order to shorten the entire project life cycle. But the big challenge for those trying to apply this technique consists in being able to identify the optimal point of overlapping between two activities, so that the benefits of schedule compression can be reaped without too much rework.

Therefore, organizations must focus its efforts firstly towards the ground level of the triangle before using project crashing or concurrent engineering as a way out to project completion. Techniques such as lean construction, lean design, cycle time analysis, constructability review and managerial measures mentioned in the previous chapters, are important to open the doors of enhanced productivity and thus facilitate the execution of the techniques at the reactive side of the pyramid.

Also, the model includes a base for the triangle. This base aims to incorporate all the supporting factors that facilitate the well development of the techniques and initiatives for reducing the project schedule time. These include aspects such as knowledge management within the organization, communication, team empowerment, leadership and perhaps the most key aspect: selecting a project delivery method that best suits for the specific project and that supports collaboration between all actors in around the project.

For example, it is not the same applying concurrent engineering under a project delivery method that where design and the execution are in hands of two companies, than applying the technique in a collaborative environment. Simply a Design Bid Build (DBB) project delivery would not allow cooperation between execution and design, simply because the design should be finished before the execution can even start. All these things must also be considered.

All in all, the overall idea behind this model is to bring about a comprehensive classification of techniques for reducing the project's duration. Also, the idea is that all project actors must work together towards the creation of a culture embraces change and improvement of practices. The more developed this collaborative culture across the industry, the more chances exist for achieving success in overlapping interrelated activities or phases in the project.

The project context

Due to many different reasons, owners, contractors and users require to complete projects faster without affecting costs or quality. The reasons for accelerating a project can relate to various sources such as: limited availability of resources, social welfare, market advantages, environmental requirements and so forth.

Nevertheless, sometimes time and costs may become two contradictory variables. For example, depending on the technique, achieving a shorter project lifecycle might require more materials and resources, resulting always in a higher project cost. On the other hand, reducing costs might imply using low-efficient equipments or inexperienced employees, which would increase the project time.

Moreover, projects have always a reason to exist; otherwise nobody would even bother to undertake any project. And the idea of starting a project is always that the project can attain its original purpose after it is completed. Therefore, project organizations must always take into account that the thirst for reducing the project duration should never jeopardize the quality of the project or its ability to attain its purpose. Also, it is true that not always applying fast-tracking techniques means a better project in terms of quality or costs.

Therefore, it is paramount to see project schedule acceleration as a means to an end, and not as an end in itself. Sometimes the owner even might accept a higher cost or project duration in order to obtain a better solution in the end. Understanding the project context and the specific project characteristics is always critical success factor for applying these techniques.

Chapter 11. Conclusions and Recommendations

The present chapter includes the conclusions and some recommendations obtained after completing the analysis and discussion of this project

Conclusions

About the results

This master thesis has included a number of techniques and considerations regarding the topic of reducing the duration of projects. Although the topic is very scattered nowadays, the author has tried to condense all the details in one work so that anyone can get a basic understanding of the subject just by reading this thesis.

It is important to mention the limitation of this thesis in the sense that –at least in connection with the literature study– this work looked mainly into journals devoted to construction projects. The author recognizes that other journals (not connected with construction) might also have some interesting or relevant articles related to this topic. However, the time-frame of the thesis work did not unfortunately allow the author to look at other journals. This can be part of future studies.

In order to provide a logical structure, this work has divided the techniques and methods that contribute to achieving a faster project execution: the preventive and the proactive approach. These two intend to improve the project's productivity and reduce its duration. However, the preventive approach does it by facilitating the work flow and the processes, and the proactive approach does it by setting actions and innovative methods of construction.

The author has stressed that none of the techniques aiming to reduce time would be effective if the project lacks a solid organizational culture and good management practices that embrace change within the project organization.

Finally, this work suggests the subject of shortening the project life cycle should be raised as an "optimization" problem. In fact, the objective is to find a balanced solution that can achieve the goals, taking into consideration the particular characteristics and context of the project. Coordination and management of all the stakeholders involved is the most important and challenging factor. The only way to achieve an "optimal solution" is when all parties are truly committed and take responsibility during the construction process. Every single person working within the project organization must understand that his contribution is important. In the end this will make the difference.

About the master thesis's process

This master thesis marks the end of two years as a student of Project Management. The learning experiences acquired during these two years have prepared me to enter into the industry with a good set of tools. However, I acknowledge that there are still so many things I have to learn in order to really become an expert in the field. I have no doubt though, that these two years and the experience of writing a master thesis in another language and in another country, will help me to undertake other challenges in the future.

If there is one thing I can conclude about this process that would be the value of setting periodic meetings with the project supervisor. These meetings can be short (around half an hour is enough). In this way, it is possible to make early amendments, as well as receiving useful suggestions and advice for making sure that the project is shaping well.

Recommendations

About the results

It is important to assess the possibility of implementing this investigation in the context of the Norwegian construction industry. In this case, another type of research strategy should be implemented in order to see the state-of the-art among practitioners and then, see whether or not it matches with the state-of-the art found in academia and the results of this master thesis.

On the other hand, the same study can be implemented in another industry (i.e. pharmaceutical, oil and gas, retail) in order to have information that can be helpful to conduct a generic benchmarking and achieve tangible benefits.

Further Research

The issue of validity that was addressed in the methodological framework, explained the inability of this master thesis to directly show the reality about the schedule compression techniques among practitioners in the industry. It only shows one side of the coin as this work relied on research articles and some academic case studies. It would be extremely interesting however, to see whether or not the techniques we have mentioned and discussed in this work are actually put in practice in the Norwegian construction industry. It would be also great to study the applicability issues that companies in Norway might have at the moment. Conducting a case study research with real life experiments or interviews is the way to go, in order to increase the validity of this master thesis.

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Squires, W. R., & Murphy, M. J. (1983). The Impact of Fast Track Construction and Construction Management on Subcontractors. *Law and Contemporary Problems*, 55-67.

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Appendix 1. Results against string 1: "fast-track" + schedule + compression

Journal of Construction Engineering Management (JCEM)

Analysis of the Higher-Order Partial Correlation between CII Best Practices and Performance of the Design Phase in Fast-Track Industrial Projects
Deshpande, A., Salem, O., and Miller, R.
Journal of Construction Engineering and Management 2012 138:6, 716-724
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

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Schedule Effectiveness of Alternative Contracting Strategies for Transportation Infrastructure Improvement Projects
Choi, K., Kwak, Y., Pyeon, J., and Son, K.
Journal of Construction Engineering and Management 2012 138:3, 323-330
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

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Reliability and Stability Buffering Approach: Focusing on the Issues of Errors and Changes in Concurrent Design and Construction Projects
Lee, S., Peña-Mora, F., and Park, M.
Journal of Construction Engineering and Management 2006 132:5, 452-464
Case Study Research: YES **Industry Sector**: Construction **Contribution**: New Techniques

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Productivity Aspects of Urban Freeway Rehabilitation with Accelerated Construction
Lee, E., Lee, H., and Ibbs, C.
Journal of Construction Engineering and Management 2007 133:10, 798-806
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

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Model of Trade-Off between Overlapping and Rework of Design Activities
Dehghan, R. and Ruwnapura, J.
Journal of Construction Engineering and Management 2014 140:2
Case Study Research: YES **Industry Sector**: Construction **Contribution**: New Techniques

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Problem-Solving Base Building under Uncertainty and Ambiguity: Multiple-Case Study on an Airport Expansion Program
Gil, N., Beckman, S., and Tommelein, I.
Journal of Construction Engineering and Management 2008 134:12, 991-1001
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

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Concurrent Engineering Approach to Reducing Design Delivery Time
Bogus, S., Molenaar, K., and Diekmann, J.
Journal of Construction Engineering and Management 2005 131:11, 1179-1185
Case Study Research: YES **Industry Sector**: Construction **Contribution**: New Techniques

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Decision Tool for Selecting the Optimal Techniques for Cost and Schedule Reduction in Capital Projects
Bayraktar, M., Hastak, M., Gokhale, S., and Safi, B.
Journal of Construction Engineering and Management 2011 137:9, 645-655
Case Study Research: YES **Industry Sector**: Construction **Contribution**: New techniques

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State-of-Practice Technologies on Accelerated Urban Highway Rehabilitation: I-15 California Experience
Lee, E. and Thomas, D.
Journal of Construction Engineering and Management 2007 133:2, 105-113
Case Study Research: YES **Industry Sector**: Construction **Contribution**: New Techniques

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Sequence Planning for Electrical Construction
Horman, M., Orosz, M., and Riley, D.
Journal of Construction Engineering and Management 2006 132:4, 363-372
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

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Analysis of Techniques Leading to Radical Reduction in Project Cycle Time
Hastak, M., Gokhale, S., Goyani, K., Hong, T., and Safi, B.
Journal of Construction Engineering and Management 2008 134:12, 915-927
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

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Embodying Product and Process Flexibility to Cope with Challenging Project Deliveries
Gil, N., Tommelein, I., Stout, A., and Garrett, T.
Journal of Construction Engineering and Management 2005 131:4, 439-448
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Model Building

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Identifying a Design Management Package to Support Concurrent Design in Building Wafer Fabrication Facilities
Dzeng, R.
Journal of Construction Engineering and Management 2006 132:6, 606-614
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Model building

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Human Factors Analysis Classification System Relating to Human Error Awareness Taxonomy in Construction Safety
Garrett, J. and Teizer, J.
Journal of Construction Engineering and Management 2009 135:8, 754-763
Case Study Research: N/A **Industry Sector**: Construction **Contribution**: N/A

Design, Development, and Deployment of a Rapid Universal Safety and Health System for Construction
Kleiner, B., Smith-Jackson, T., Mills, T., III, O'Brien, M., and Haro, E.
Journal of Construction Engineering and Management 2008 134:4, 273-279
Case Study Research: YES **Industry Sector**: Construction **Contribution**: System Building

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Application of Dependency Structure Matrix for Activity Sequencing in Concurrent Engineering Projects
Uma Maheswari, J., Varghese, K., and Sridharan, T.
Journal of Construction Engineering and Management 2006 132:5, 482-490
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insight

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Building Better: Technical Support for Construction
Tatum, C.
Journal of Construction Engineering and Management 2005 131:1, 23-32
Case Study Research: YES **Industry Sector**: Construction **Contribution**: New Techniques

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Organizing Constructability Knowledge for Design

Pulaski, M. and Horman, M.

Journal of Construction Engineering and Management 2005 131:8, 911-919

Case Study Research: YES **Industry Sector**: Construction **Contribution**: New Techniques

Appendix 2. Results against string 2: “fast-track” + time + techniques

Journal of Construction Engineering Management (JCEM)

Analysis of Techniques Leading to Radical Reduction in Project Cycle Time
Hastak, M., Gokhale, S., Goyani, K., Hong, T., and Safi, B.
Journal of Construction Engineering and Management 2008 134:12, 915-927
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

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Impact of Change’s Timing on Labor Productivity
Ibbs, W.
Journal of Construction Engineering and Management 2005 131:11, 1219-1223
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

---

Time and Cost–Optimized Decision Support Model for Fast-Track Projects
Cho, K. and Hastak, M.
Journal of Construction Engineering and Management 2013 139:1, 90-101
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Model building

---

Model of Trade-Off between Overlapping and Rework of Design Activities
Dehghan, R. and Ruwnapura, J.
Journal of Construction Engineering and Management 2014 140:2
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Model building

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Delay Mitigation in the Malaysian Construction Industry
Abdul-Rahman, H., Berawi, M., Berawi, A., Mohamed, O., Othman, M., and Yahya, I.
Journal of Construction Engineering and Management 2006 132:2, 125-133
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

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Quality and Change Management Model for Large Scale Concurrent Design and Construction Projects
Lee, S., Peña-Mora, F., and Park, M.
Journal of Construction Engineering and Management 2005 131:8, 890-902
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Model Building

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Analysis of Disruptions Caused by Construction Field Rework on Productivity in Residential Projects
Arashpour, M., Wakefield, R., Blismas, N., and Lee, E.
Journal of Construction Engineering and Management 2014 140:2
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

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Sensitivity of Construction Activities under Design Uncertainty
Blacud, N., Bogus, S., Diekmann, J., and Molenaar, K.
Journal of Construction Engineering and Management 2009 135:3, 199-206
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Model building

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Combination of Growth Model and Earned Schedule to Forecast Project Cost at Completion
Narbaev, T. and De Marco, A.
Journal of Construction Engineering and Management 2014 140:1
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Model building

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Impact of the Capital Market Collapse on Public-Private Partnership Infrastructure Projects
Regan, M., Smith, J., and Love, P.
Journal of Construction Engineering and Management 2011 137:1, 6-16
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

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International Journal of Project Management (IJPM)

Dynamic modeling of the quantitative risk allocation in construction projects
International Journal of Project Management, Volume 32, Issue 3, April 2014, Pages 442-451
Farnad Nasirzadeh, Mostafa Khanzadi, Mahdi Rezaie
Case Study Research: NO **Industry Sector**: Construction **Contribution**: Insights

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Measuring the efficiency of project control using fictitious and empirical project data
International Journal of Project Management, Volume 30, Issue 2, February 2012, Pages 252-263
Mario Vanhoucke
Case Study Research: NO **Industry Sector**: General PM **Contribution**: Insights

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An Earned Schedule-based regression model to improve cost estimate at completion
International Journal of Project Management, In Press, Corrected Proof, Available online 8 January 2014
Timur Narbaev, Alberto De Marco
Case Study Research: NO **Industry Sector**: General PM **Contribution**: Insights

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Project Management Journal (PMJ)

An Empirical Identification of Project Management Toolsets and a Comparison Among Project Types
Volume 43, Issue 5, October 2012, Pages: 24–46, Claude Besner and Brian Hobbs
Article first published online : 10 SEP 2012, DOI: 10.1002/pmj.21292
Case Study Research: YES **Industry Sector**: General PM **Contribution**: Insights

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Reconstructing Project Management Reprised: A Knowledge Perspective
Volume 44, Issue 5, October 2013, Pages: 6–23, Peter Morris
Article first published online : 3 OCT 2013, DOI: 10.1002/pmj.21369
Case Study Research: NO **Industry Sector**: General PM **Contribution**: Insights

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A Comparative Study of the Benefits of Applying Target Cost Contracts Between South Australia and Hong Kong
Volume 43, Issue 2, April 2012, Pages: 4–20, Daniel W. M. Chan, Patrick T. I. Lam, Joseph H. L. Chan, Tony Ma and Thomas Perkin
Article first published online : 28 FEB 2012, DOI: 10.1002/pmj.21255
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

---

Analysis of the front-end loading of Alberta mega oil sands projects
Volume 39, Issue 4, December 2008, Pages: 95–104, George Jergeas
Article first published online : 25 NOV 2008, DOI: 10.1002/pmj.20080
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

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Planning knowledge for phased rollout projects

Volume 38, Issue 3, September 2007, Pages: 45–60, Douglas C. Bower and Derek H. T. Walker
Article first published online : 23 AUG 2007, DOI: 10.1002/pmj.20005
Case Study Research: YES **Industry Sector**: General PM **Contribution**: Model building

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Discriminating contexts and project management best practices on innovative and noninnovative projects
Volume 39, Issue S1, 2008, Pages: S123–S134, Claude Besner and Brian Hobbs
Case Study Research: YES **Industry Sector**: General PM **Contribution**: Insights

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Aim, fire, aim—Project planning styles in dynamic environments
Volume 41, Issue 4, September 2010, Pages: 108–121, Simon Collyer, Clive Warren, Bronwyn Hemsley and Chris Stevens
Case Study Research: YES **Industry Sector**: General PM **Contribution**: Model building

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Contemporary knowledge and skill requirements in project management
Volume 40, Issue 2, June 2009, Pages: 59–69, Helgi Thor Ingason and Haukur Ingi Jónasson
Article first published online : 7 MAY 2009, DOI: 10.1002/pmj.20122
Case Study Research: YES **Industry Sector**: General PM **Contribution**: Insights

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The role of technology in the project manager performance model
Volume 39, Issue 1, March 2008, Pages: 34–48, Vittal S. Anantatmula
Article first published online : 26 FEB 2008, DOI: 10.1002/pmj.20038
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Building Model

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Knowledge acquisition using psychotherapy technique for critical factors influencing construction project layout planning
Volume 43, Issue 1, February 2012, Pages: 50–64, Hamzah Abdul-Rahman, Chen Wang and Eng Khe Siong
Article first published online : 27 DEC 2011, DOI: 10.1002/pmj.20283
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

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Appendix 3. Results against string 3: "Life cycle" + compression + methods

Journal of Construction Engineering Management (JCEM)

Life-Cycle Assessment of Concrete Dam Construction: Comparison of Environmental Impact of Rock-Filled and Conventional Concrete
Liu, C., Ahn, C., An, X., and Lee, S.
Journal of Construction Engineering and Management 2013 139:12
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Quantification of Particulate Matter from Commercial Building Excavation Activities Using Life-Cycle Approach
Ketchman, K. and Bilec, M.
Journal of Construction Engineering and Management 2013 139:12
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Modification of Advanced Programmatic Risk Analysis and Management Model for the Whole Project Life Cycle's Risks
Zeynalian, M., Trigunarsyah, B., and Ronagh, H.
Journal of Construction Engineering and Management 2013 139:1, 51-59
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Comparative Study of University Courses on Critical-Path Method Scheduling
Galloway, P.
Journal of Construction Engineering and Management 2006 132:7, 712-722
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Use of Mechanistic-Empirical Pavement Design Principles to Assign Asphalt Pavement Pay Factor Adjustments
De Jarnette, V., McCarthy, L., Bennert, T., and Guercio, M.
Journal of Construction Engineering and Management 2013 139:11
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Considering Prework on Industrial Projects
Song, J., Fagerlund, W., Haas, C., Tatum, C., and Vanegas, J.
Journal of Construction Engineering and Management 2005 131:6, 723-733
Case Study Research: NO **Industry Sector**: Construction **Contribution**: Model Building

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Model of Trade-Off between Overlapping and Rework of Design Activities
Dehghan, R. and Ruwnapura, J.
Journal of Construction Engineering and Management 2014 140:2
Case Study Research: NO **Industry Sector**: Construction **Contribution**: Model Building

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Programmatic Cost Risk Analysis for Highway Megaprojects
Molenaar, K.
Journal of Construction Engineering and Management 2005 131:3, 343-353
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Discovery of Internal and External Factors Causing Military Construction Cost Premiums
Blomberg, D., Cotellesso, P., Sitzabee, W., and Thal, A., Jr.
Journal of Construction Engineering and Management 2014 140:3
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Benefit-Cost Metrics for Design Coordination of Mechanical, Electrical, and Plumbing Systems in Multistory Buildings
Riley, D., Varadan, P., James, J., and Thomas, H.
Journal of Construction Engineering and Management 2005 131:8, 877-889
Case Study Research: NO **Industry Sector**: Construction **Contribution**: Insights

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Analysis of the Higher-Order Partial Correlation between CII Best Practices and Performance of the Design Phase in Fast-Track Industrial Projects
Deshpande, A., Salem, O., and Miller, R.
Journal of Construction Engineering and Management 2012 138:6, 716-724
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

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Economic Value of Building Faster
Reinschmidt, K. and Trejo, D.
Journal of Construction Engineering and Management 2006 132:7, 759-766
Case Study Research: NO **Industry Sector**: Construction **Contribution**: Model Building

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Improving the Professional Engineering Licensure Process for Construction Engineers
Johnston, D., Thomas Ahluwalia, N., and Gwyn, M.
Journal of Construction Engineering and Management 2007 133:9, 669-677
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Best Practices for Integrating the Concurrent Engineering Environment into Multipartner Project Management
Karlsson, M., Lakka, A., Sulankivi, K., Hanna, A., and Thompson, B.
Journal of Construction Engineering and Management 2008 134:4, 289-299
Case Study Research: NO **Industry Sector**: Construction **Contribution**: Model Building

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Analysis of Techniques Leading to Radical Reduction in Project Cycle Time
Hastak, M., Gokhale, S., Goyani, K., Hong, T., and Safi, B.
Journal of Construction Engineering and Management 2008 134:12, 915-927
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

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Success of Supplier Alliances for Capital Projects
Harper, D. and Bernold, L.
Journal of Construction Engineering and Management 2005 131:9, 979-985
Case Study Research: YES **Industry Sector**: Energy Sector **Contribution**: Insights

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Education in Construction Engineering and Management Built on Tradition: Blueprint for Tomorrow
Russell, J., Hanna, A., Bank, L., and Shapira, A.
Journal of Construction Engineering and Management 2007 133:9, 661-668
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Impact of Information Technologies on Performance: Cross Study Comparison
Kang, Y., O'Brien, W., Thomas, S., and Chapman, R.
Journal of Construction Engineering and Management 2008 134:11, 852-863
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Decision Tool for Selecting the Optimal Techniques for Cost and Schedule Reduction in Capital Projects
Bayraktar, M., Hastak, M., Gokhale, S., and Safi, B.

Journal of Construction Engineering and Management 2011 137:9, 645-655
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Model Building

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Dynamics of Rework in Complex Offshore Hydrocarbon Projects
Love, P., Edwards, D., Irani, Z., and Goh, Y.
Journal of Construction Engineering and Management 2011 137:12, 1060-1070
Case Study Research: YES **Industry Sector**: Energy Sector **Contribution**: Insights

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International Journal of Project Management (IJPM)

Managing quality in projects: An empirical study
International Journal of Project Management, Volume 32, Issue 1, January 2014, Pages 178-187
Ron Basu
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

A practical approach to project scheduling: considering the potential quality loss cost in the time–cost tradeoff problem
International Journal of Project Management, Volume 30, Issue 2, February 2012, Pages 264-272
JongYul Kim, ChangWook Kang, InKeuk Hwang
Case Study Research: NO **Industry Sector**: General PM **Contribution**: Model Building

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Taxonomy for change causes and effects in construction projects
International Journal of Project Management, Volume 27, Issue 6, August 2009, Pages 560-572
Ming Sun, Xianhai Meng
Case Study Research: NO **Industry Sector**: Construction **Contribution**: Insights

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Triggers for a flexible approach to project management within UK financial services
International Journal of Project Management, Volume 25, Issue 5, July 2007, Pages 446-456
Mariano Gallo, Paul D. Gardiner
Case Study Research: YES **Industry Sector**: Financial Services **Contribution**: Insights

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A process for developing partnerships with subcontractors in the construction industry: An empirical study
International Journal of Project Management, Volume 25, Issue 3, April 2007, Pages 250-256
Ander Errasti, Roger Beach, Aitor Oyarbide, Javier Santos
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

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Project Management Journal (PMJ)

Project Management Knowledge and Effects on Construction Project Outcomes: An Empirical Study
Volume 43, Issue 5, October 2012, Pages: 47–67, Jui-Sheng Chou and Jung-Ghun Yang
Article first published online : 21 SEP 2012, DOI: 10.1002/pmj.21293
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

---

Analysis of the front-end loading of Alberta mega oil sands projects
Volume 39, Issue 4, December 2008, Pages: 95–104, George Jergeas
Article first published online : 25 NOV 2008, DOI: 10.1002/pmj.20080
Case Study Research: YES **Industry Sector**: Oil/Gas Construction **Contribution**: Insights

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Robust project network design
Volume 40, Issue 2, June 2009, Pages: 81–93, David A. Ortiz de Orue, John E. Taylor, Arpamart Chanmeka and Runi Weerasooriya
Article first published online : 28 APR 2009, DOI: 10.1002/pmj.20109
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Model Building

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Project management and high-value superyacht projects: An improvisational and temporal perspective
Volume 41, Issue 1, March 2010, Pages: 17–27, Steve Leybourne
Article first published online : 8 OCT 2009, DOI: 10.1002/pmj.20140
Case Study Research: YES **Industry Sector**: Vessels Construction **Contribution**: Insights

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Appendix 4. Results against string 3: “Fast-track” + “Life cycle” + time

Journal of Construction Engineering Management (JCEM)

Time and Cost–Optimized Decision Support Model for Fast-Track Projects
Cho, K. and Hastak, M.
Journal of Construction Engineering and Management 2013 139:1, 90-101
Case Study Research: YES **Industry Sector**: Construction **Contribution**: model building/testing

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Integrated Design/Construction/Operations Analysis for Fast-Track Urban Freeway Reconstruction
Lee, E., Harvey, J., and Thomas, D.
Journal of Construction Engineering and Management 2005 131:12, 1283-1291
Case Study Research: YES **Industry Sector**: Construction (transportation) **Contribution**:Insights

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Analysis of the Higher-Order Partial Correlation between CII Best Practices and Performance of the Design Phase in Fast-Track Industrial Projects
Deshpande, A., Salem, O., and Miller, R.
Journal of Construction Engineering and Management 2012 138:6, 716-724
Case Study Research: YES **Industry Sector**: COnstruction **Contribution**: Insights

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Model of Trade-Off between Overlapping and Rework of Design Activities
Dehghan, R. and Ruwnapura, J.
Journal of Construction Engineering and Management 2014 140:2
Case Study Research: NO **Industry Sector**: Construction **Contribution**: Model Building

---

Quality and Change Management Model for Large Scale Concurrent Design and Construction Projects
Lee, S., Peña-Mora, F., and Park, M.
Journal of Construction Engineering and Management 2005 131:8, 890-902
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Model Building

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Analysis of Techniques Leading to Radical Reduction in Project Cycle Time
Hastak, M., Gokhale, S., Goyani, K., Hong, T., and Safi, B.
Journal of Construction Engineering and Management 2008 134:12, 915-927
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

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Project Cell: Cellular Organization of the Building Design Process
Aquere, A., Dinis-Carvalho, J., and Lima, R.
Journal of Construction Engineering and Management 2013 139:5, 538-546
Case Study Research: YES **Industry Sector**: Construction **Contribution**: New Techniques

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Project Manager’s Decision Aid for a Radical Project Cycle Reduction
Hastak, M., Gokhale, S., Goyani, K., Hong, T., and Safi, B.
Journal of Construction Engineering and Management 2007 133:6, 437-446
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Model Building

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The Gulf of Mexico Decommissioning Market
Kaiser, M. and Iledare, W.
Journal of Construction Engineering and Management 2006 132:8, 815-826
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Prediction of Engineering Performance: A Neurofuzzy Approach
Georgy, M., Chang, L., and Zhang, L.
Journal of Construction Engineering and Management 2005 131:5, 548-557
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

CEM Research for the Next 50 Years: Maximizing Economic, Environmental, and Societal Value of the Built Environment1
Levitt, R.
Journal of Construction Engineering and Management 2007 133:9, 619-628
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Downside Risks in Construction Projects Developed by the Civil Service: The Case of Spain
de la Cruz, M., del Caño, A., and de la Cruz, E.
Journal of Construction Engineering and Management 2006 132:8, 844-852
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Participatory Action Research Approach to Public Sector Procurement Selection
Love, P., Edwards, D., Irani, Z., and Sharif, A.
Journal of Construction Engineering and Management 2012 138:3, 311-322
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Best-Value Model Based on Project Specific Characteristics
Abdelrahman, M., Zayed, T., and Elyamany, A.
Journal of Construction Engineering and Management 2008 134:3, 179-188
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Procurement Routes in Public Building and Construction Projects
Lædre, O., Austeng, K., Haugen, T., and Klakegg, O.
Journal of Construction Engineering and Management 2006 132:7, 689-696
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Interface Management for China's Build–Operate–Transfer Projects
Chan, W., Chen, C., Messner, J., and Chua, D.
Journal of Construction Engineering and Management 2005 131:6, 645-655
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Integration of Financial and Contract Management on the Shanghai Expo Construction Program
Le, Y., Wang, Y., Luo, C., and Peng, Y.
Journal of Construction Engineering and Management 2013 139:6, 738-748
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Decision Tool for Selecting the Optimal Techniques for Cost and Schedule Reduction in Capital Projects
Bayraktar, M., Hastak, M., Gokhale, S., and Safi, B.
Journal of Construction Engineering and Management 2011 137:9, 645-655
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Model Building

---

International Journal of Project Management (IJPM)

Managing quality in projects: An empirical study
International Journal of Project Management, Volume 32, Issue 1, January 2014, Pages 178-187
Ron Basu
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

A practical approach to project scheduling: considering the potential quality loss cost in the time–cost tradeoff problem
International Journal of Project Management, Volume 30, Issue 2, February 2012, Pages 264-272
JongYul Kim, ChangWook Kang, InKeuk Hwang
Case Study Research: NO **Industry Sector**: General PM **Contribution**: Model Building

---

Taxonomy for change causes and effects in construction projects
International Journal of Project Management, Volume 27, Issue 6, August 2009, Pages 560-572
Ming Sun, Xianhai Meng
Case Study Research: NO **Industry Sector**: Construction **Contribution**: Insights

---

Triggers for a flexible approach to project management within UK financial services
International Journal of Project Management, Volume 25, Issue 5, July 2007, Pages 446-456
Mariano Gallo, Paul D. Gardiner
Case Study Research: YES **Industry Sector**: Financial Services **Contribution**: Insights

---

A process for developing partnerships with subcontractors in the construction industry: An empirical study
International Journal of Project Management, Volume 25, Issue 3, April 2007, Pages 250-256
Ander Errasti, Roger Beach, Aitor Oyarbide, Javier Santos
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

---

Project Management Journal (PMJ)

Managing Risks in Complex Projects
Volume 44, Issue 2, April 2013, Pages: 20–35, Hans Thamhain
Article first published online : 27 FEB 2013, DOI: 10.1002/pmj.21325
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Reconstructing Project Management Reprised: A Knowledge Perspective
Volume 44, Issue 5, October 2013, Pages: 6–23, Peter Morris
Article first published online : 3 OCT 2013, DOI: 10.1002/pmj.21369
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

An Empirical Identification of Project Management Toolsets and a Comparison Among Project Types
Volume 43, Issue 5, October 2012, Pages: 24–46, Claude Besner and Brian Hobbs
Article first published online : 10 SEP 2012, DOI: 10.1002/pmj.21292
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Identifying and Acting on Early Warning Signs in Complex Projects
Volume 43, Issue 2, April 2012, Pages: 37–53, Terry Williams, Ole Jonny Klakegg, Derek H. T. Walker, Bjørn Andersen and Ole Morten Magnussen
Article first published online : 13 MAR 2012, DOI: 10.1002/pmj.21259
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

What You Should Know About Megaprojects and Why: An Overview
Volume 45, Issue 2, April/May 2014, Pages: 6–19, Bent Flyvbjerg
Article first published online : 7 APR 2014, DOI: 10.1002/pmj.21409
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Analysis of the front-end loading of Alberta mega oil sands projects
Volume 39, Issue 4, December 2008, Pages: 95–104, George Jergeas
Article first published online : 25 NOV 2008, DOI: 10.1002/pmj.20080
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

Does our literature support sectors newer to project management? The search for quality publications relevant to nontraditional industries
Volume 39, Issue 3, September 2008, Pages: 6–27, Lila Carden and Toby Egan
Article first published online : 9 SEP 2008, DOI: 10.1002/pmj.20068
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Advancing Project Management: Authenticating the Shift From Process to "Nuanced" Project-Based Management in the Ambidextrous Organization
Volume 43, Issue 6, December 2012, Pages: 5–15, Stephen A. Leybourne and Phillip Sainter
Article first published online : 13 NOV 2012, DOI: 10.1002/pmj.21306
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Project management for new product development
Volume 39, Issue 2, June 2008, Pages: 82–97, Dirk Pons
Article first published online : 23 MAY 2008, DOI: 10.1002/pmj.20052
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Knowledge maturity as a means to support decision making during product-service systems development projects in the aerospace sector
Volume 42, Issue 2, March 2011, Pages: 32–50, Christian Johansson, Ben Hicks, Andreas C. Larsson and Marco Bertoni
Article first published online : 28 DEC 2010, DOI: 10.1002/pmj.20218
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

The power of combinative capabilities: Facilitating the outcome of frequent innovation in pharmaceutical R&D projects
Volume 42, Issue 2, March 2011, Pages: 63–80, Thomas Biedenbach
Article first published online : 28 JAN 2011, DOI: 10.1002/pmj.20221
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

How Effective Are Project Management Methodologies? An Explorative Evaluation of Their Benefits in Practice
Volume 43, Issue 6, December 2012, Pages: 43–58, Hany Wells
Article first published online : 16 NOV 2012, DOI: 10.1002/pmj.21302

Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Planning knowledge for phased rollout projects
Volume 38, Issue 3, September 2007, Pages: 45–60, Douglas C. Bower and Derek H. T. Walker
Article first published online : 23 AUG 2007, DOI: 10.1002/pmj.20005
Case Study Research: NO **Industry Sector**: General Pm **Contribution**: Model Building

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The role of technology in the project manager performance model
Volume 39, Issue 1, March 2008, Pages: 34–48, Vittal S. Anantatmula
Article first published online : 26 FEB 2008, DOI: 10.1002/pmj.20038
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Issues in front-end decision making on projects
Volume 41, Issue 2, April 2010, Pages: 38–49, Terry Williams and Knut Samset
Article first published online : 3 MAR 2010, DOI: 10.1002/pmj.20160
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Best project management and systems engineering practices in the preacquisition phase for federal intelligence and defense agencies
Volume 39, Issue 1, March 2008, Pages: 59–71, Steven R. Meier
Article first published online : 26 FEB 2008, DOI: 10.1002/pmj.20035
Case Study Research: YES **Industry Sector**: Construction **Contribution**: Insights

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Building value through sustainable project management offices
Volume 40, Issue 1, March 2009, Pages: 55–72, Mimi Hurt and Janice L. Thomas
Article first published online : 25 FEB 2009, DOI: 10.1002/pmj.20095
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

The Logical Framework Approach–Millennium
Volume 40, Issue 4, December 2009, Pages: 31–44, Jean Couillard, Serge Garon and Jovica Riznic
Article first published online : 25 JUN 2009, DOI: 10.1002/pmj.20117
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Aim, fire, aim—Project planning styles in dynamic environments
Volume 41, Issue 4, September 2010, Pages: 108–121, Simon Collyer, Clive Warren, Bronwyn Hemsley and Chris Stevens
Article first published online : 2 AUG 2010, DOI: 10.1002/pmj.20199
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Contemporary knowledge and skill requirements in project management
Volume 40, Issue 2, June 2009, Pages: 59–69, Helgi Thor Ingason and Haukur Ingi Jónasson
Article first published online : 7 MAY 2009, DOI: 10.1002/pmj.20122
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

What project strategy really is: The fundamental building block in strategic project management
Volume 43, Issue 1, February 2012, Pages: 4–20, Peerasit Patanakul and Aaron J. Shenhar
Article first published online : 27 DEC 2011, DOI: 10.1002/pmj.20282
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

[Supplier's Internal Communication Network During the Project Sales Process]
Volume 44, Issue 3, June 2013, Pages: 5–20, Harri Ryynänen, Anne Jalkala and Risto T. Salminen
Article first published online : 30 MAY 2013, DOI: 10.1002/pmj.21341
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

[Discriminating contexts and project management best practices on innovative and noninnovative projects]
Volume 39, Issue S1, 2008, Pages: S123–S134, Claude Besner and Brian Hobbs
Article first published online : 25 JUL 2008, DOI: 10.1002/pmj.20064
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

[A fresh look at the contribution of project management to organizational performance]
Volume 42, Issue 1, February 2011, Pages: 3–16, Monique Aubry and Brian Hobbs
Article first published online : 16 DEC 2010, DOI: 10.1002/pmj.20213
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

[Delivering project excellence with the statement of work, second edition]
Volume 42, Issue 1, February 2011, Page: 91, Greg Indelicato
Article first published online : 6 JAN 2011, DOI: 10.1002/pmj.20228
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

[Blowing hot and cold on project management]
Volume 41, Issue 3, June 2010, Pages: 4–20, Christophe N. Bredillet
Article first published online : 11 MAY 2010, DOI: 10.1002/pmj.20179
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

[Incorporating employee resourcing requirements into deployment decision making]
Volume 40, Issue 2, June 2009, Pages: 7–18, Andrew R. J. Dainty, Ani B. Raidén and Richard H. Neale
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

[Identifying forces driving PMO changes]
Volume 41, Issue 4, September 2010, Pages: 30–45, Monique Aubry, Brian Hobbs, Ralf Müller and Tomas Blomquist
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

[Exploring research in project management: Nine schools of project management research (Part 2)]
Volume 38, Issue 3, September 2007, Pages: 3–5, Christophe N. Bredillet
Article first published online : 23 AUG 2007, DOI: 10.1002/pmj.20001
Case Study Research: N/A **Industry Sector**: N/A **Contribution**: N/A

Appendix 5. Article for SINTEF's Speed-Up project

Byggeperioden kan reduseres

(1. utkast)

TEKST: PEDRO RONDÓN OG ANANDASIVAKUMAR EKAMBARAM

Vi krever raskere leveringstid

Ingen tviler på at dagens globaliserte verden har bidratt til å forandre næringen. De intense markedsdynamikkene har tvunget prosjekteiere til å kreve raskere leveringstider uten å risikere målene av kostnad og kvalitet. Dette er en betydelig utfordring for prosjektbaserte organisasjoner som ønsker å forbli konkurransedyktige. Men, det viser seg at prosjekter ofte oppstår forsinkelser og unødvendig bruk av tid.

Ved første øyekast kan tanken om tids reduksjon i prosjekter være knyttet til å redusere omfanget eller å bruke mer ressurser på en eller annen måte. Dette er likevel oppfattet som ikke levedyktig på grunn av begrensede ressurser og kompromissene til å fullført en forhåndsdefinert hensikt og effekt med prosjektet.

Kompleksitetet er også en annen hovedelement som påvirker prosjektets evne til å forkorte varigheten. I store prosjekter fins det mange aktører og det representerer en viktig utfordring fordi det kan være vanskelig å samarbeide for å nå så mange utsiktpunkter slik som prosjekttidsplanen.

Man kan få et inntrykk av at næringen kjemper imot en tapt sak, og at det å oppnå høyt kvalitet og effektivitet i store prosjekter er umulig om man ønsker å redusere prosjekts tid. Derimot er det bevis på at alt ikke er så mørkt for prosjektorganisajonene i dag. Det finnes noen suksesshistorier av prosjekter som har brukt prosjektledelses teknikker for å levere prosjektene raskere uten å øke kostnader eller synke kvalitetet.

Disse tiltakene og teknikkene er nyttige både for næring og akademia. Dessuten er det en stor behov for en bedre forståelse av disse initiativene, samt hva risikoene og fordelen. Det er også interessant å se på innsatsene i forskjellige bransjer over hele verden for å fastlå hvor vi er nå og hvordan effektiviteten i prosjekene kan økes.

Hvorfor blir prosjekter forsinktet?

Til tross for at den store tilgjengeligheten av metoder og software i markedet lider mange prosjekter av forsinkelser. Og mange forskningstudier blitt gjennomført i løpet av det siste to tiårene. Særlig har vært forskere og utøvere opptatt av årsakene til overskridelser. De fleste av disse undersøkelsene har vært forklarende studier basert på surveys eller case-studier.

Takket være undersøkelsene er listen over årsaker stor, og den inkluderer mange forskjellige årsaker og noen av dem henger sammen med andre. Men, forskerne er enig i at de viktigste er få i forhold med den hele listen.

Tabell 1. Årsakene til overskridelsene

Issues	Authors
• Design Changes	• Mansfield et a. (1994) • Kaming et al (1997) • Kumaraswamy et al (1998) • Al Momani (2000) • Assaf et al (2006)
• Unrealistic project estimations	• Kaming et al (1997) • Kumaraswamy et al (1998) • Assaf et al (2006)
• Issues with suppliers, contractors	• Mansfield et al (1994) • Al Momani (2000)
• Project Management inexperience	• Kaming et al (1997) • Kumaraswamy et al (1998)
• Poor contract management	• Mansfield et al (1994) • Assaf et al (2006)
• Craftsmen inexperience	• Kaming et al (1997) • Assaf et al (2006)
• Poor Stakeholder management	• Kumaraswamy et al (1998)
• Tough weather conditions	• Mansfield et al (1994) • Yogeswran et al (1998) • Al Momani (2000)

Som et resultat av literaturundersøkelsen ble de vanligste utfordringene identifisert. Særlig kan man se på lista saker som designendringer, problemer med leverandører, unrealistiske prosjekts estimater, dårlig kontraktstyring og så videre. Derfor er det viktig å legge merke til disse når man letter etter veier å akselerere prosjekter.

Den viktigste årsaken er designendringene. Disse endringene påvirker projektets omfanget og skjer på grunn av mange forskjellige saker. Endringene kan osgå fremstå når som helst i prosjektets levetid, men innvirkningen er likevel knyttet til tidspunktet når det skjer. Jo seinere, jo alvorligere konsekvenser for de prosjektets kostnad og tidsplan.

En annen eksempel som vi legger fram på denne artikkelen er de unrealistiske estimatene. Til syvende er poenget til de tradisjonelle styringsmodelene å sammenligne prosjektets fremdrift mot en baseline, og derfor er det viktig at de første estimatene og prosjektets evalueringer er så nøyaktig som mulig. Feilene på tids estimater skyldes blant annet at entreprenøren føler press fra prosjekteieren til å levere prosjektet raskt. Dette fører til ufullstendige vurderinger og til misnøye klienter.

Hvordan å unngå overskridelsene

Når man snakker om tid reduksjon i prosektledelse, kan man se på problemet fra to forskjellige perspektiver. For det første er det et preventivt perspektiv som letter etter å unngå forsinkelser. Dernest er det noen teknikker for å komprimere varigheten av oppgavene.

Som sagt før kan prosjektets team sette på plass noen tiltak for å forhindre de vanligste tidsproblemene. Tabellen nedenfor inkluderer særlig eksempler av tiltak for å unngå designendringer.

Tabell 2. Noen tiltak for å unngå designendringenes problemer

Project Owner	Project Users	Project Contractor	Jointly
• Ensuring a quick resolution to decisions regarding changes	• Ensuring there is a need for the design change	• Having a design manager for reviewing information on design change process • Making sure there are enough resources for undertaking the change	• Making sure a requirement management process is in place • Ensuring the time and cost are agreed by all project stakeholders

Man må også legge merke til at flertallet av disse faktorer er knyttet til de såkalte "støtteprosesser" i prosjekter i stedet for oppgavene oppgitt på WBS-strukturen. Med andre ord mener vi at tiltakene må gjennomføres i den "soft" siden til prosjektet. Disse inkluderer ting som kommunikasjonsledelse og team utvikling.

Fast tracking

Begrpet "fast tracking" brukes vanligvis for å beskrive et prosjekt som gjennomføres raskere enn normalt (Khoramshahi, et al. 2010). Det finnes også litteratur som definerer fast track som å overlappe designen med kostruksjonen.

Til tross for at definisjonen man kan hente mange metoder og teknikker fra litteraturen og forskjellige industrier som tar sikte på å redusere prosjekts varighet og å øke prosketets produktivitet. Ifølge Khoramshahi inndeles fast-tracking tekknikkene i: Reduksjon av omfangen, forenkling av utformingen, Modularisering og Prefabrikkering. Noen eksempler kan være ”Lean” eller ”concurrent engineering”.

Concurrent engineering, er særlig en metode som ble opprinnelig knyttet med utvikling av nye produkter (NPD). Og siden NPD er en prosjektbasert aktivitet, så kan Concurrent Engineering tilpasses de fleste prosjektene også. Denne teknikken er basert på pararelliseringen av prosjektets oppgaver. Concurrent engineering kan anvendes både innenfor designfasen, anleggsfasen og ved å overlappe begge to.

Metoden kan bidra til å redusere prosjektets tid dramatiskt, men den bringer også med seg ulemper med risikoen å gjøre. Derfor er det et stort behov for å øke koordineringen med hensyn til kommunikasjonens frekvens mellom prosjektmedlemmer. Og dermed øker blant andre kommunikasjons kostnader.

Lean design og Lean Construction er også to initiativer for å anvende “Lean”-ideene i prosjektbaserte organisasjoner. Lean er hovedsak hentet fra TPS (Toyota Production System) og fokuserer på å eliminere den såkalte sløsingen (waste) og å ser på kundens opplevelse av prosjektets verdi fremfor kostnadselementer. Lean kan også bidra til å skape en kultur for kontinuerlig forbedring som til slutt skal bli oversatt til fordeler i form av kortere leveringstider.

Vi tror at en radikal tidsplan reduksjon kan oppnås ved å velge de passende teknikker for prosjektet og dets sammenheng. Men til tros for årsaken til å bruke disse tekknikkene, finnes det et behov for å organisere så mange ideer og se i hvilen grad disse kan effektivt brukes av organisajonene

Appendix 6. Most relevant academic and industry journals on PM

The Australian Institute of Project Management (AIPM) maintains the list of the most relevant academic (peer reviewed) and industry journals on Project Management.

Title	Type	Format	Publisher	Country	Editorial Description	Frequency
International Journal of Project Management	Academic Journal	Print/ Online	Pergamon	United Kingdom	Provides a focus for worldwide expertise in the required techniques, practices and areas of research; presents a forum for its readers to share common experiences across the full range of industries and technologies in which project management is used; covers all areas of project management from systems to human aspects.	8 times a year
Project Manager	Trade Magazine	Print/Online	Banksia Media Group	Australia	Covers Australia project management and people.	Bi-monthly
Project Management Journal	Academic Journal	Print/Online	John Wiley & Sons, Inc.	United States	Features articles devoted to theory and practice in the field of project management.	Quarterly
International Journal of Project Organisation and Management	Academic Journal	Print/Online	Inderscience Publishers	United Kingdom	Fosters active dialogue about successful practice and theoretical research concerned with project management.	4 times a year
PM Network	Trade Magazine	Print/Online	Project Management Institute	United States	Professional magazine covering industry applications and practical issues in managing projects. Its mission is to keep the project management decision-maker abreast of the latest news of techniques and best practices.	Monthly

International Journal of Managing Projects in Business	Academic Journal	Print/ Online	Emerald Group Publishing Ltd.	United Kingdom	Provides broad coverage of all aspects of project management, from strategy to planning and implementation.	Quarterly
International Journal of Information Technology Project Management	Academic Journal	Print	I G I Global	United States		Quarterly
Project Manager Today	Trade Magazine	Print/Online	Larchdrift Projects Ltd.	United Kingdom	Provides case studies, articles, and software reviews for project managers.	Monthly
International Journal of Construction Project Management	Academic Journal	Print/Online	Nova Science Publishers, Inc.	United States	Provides research on project management issues relevant to the built environments of developed and developing countries.	Quarterly
Journal of Project, Program & Portfolio Management	Academic Journal	Print/Online	U T S ePress	Australia	Publishes scholarly articles, case studies and research reports.	Semi-annually
Built Environment Project and Asset Management	Academic Journal	Print/Online	Emerald Group Publishing Ltd.	United Kingdom	Provides a forum for research on project management and asset management of building and civil engineering infrastructure.	Semi-annually
The Project Manager	Trade Magazine	Print	Cape Media Corporation	South Africa	Provides a vehicle for direct communication within the project management community in the fields of construction, architecture, computer networking, telecommunications, software development, design, production, service and other industries.	Quarterly