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Project Management Evolution to Improve Success in Infrastructure Projects

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Abstract. *This document provides an overview of the infrastructure megaproject industry (IMPI), the financial implications of cost and schedule overruns, and the trend towards the future impacts these may have on the global infrastructure sphere. Definitions of project management and procurement delivery models provide a framework for understanding the relevance of the subject matter. A sample of methodologies and best practices for project management indicate the breadth of diverse approaches available in the industries. A cause analysis of megaproject overruns with accompanying solutions suggests areas of industry improvement, supported by the first-hand experience by the author. The paper concludes that the IMPI and the associate methodologies must evolve to meet the demands of future infrastructure to be able to deliver the projects successfully and with the positive impact on the outcome. This evolution will be through improving and expanding knowledge, experience and intellectual capital of public and private industry Project Managers while determining some next steps to progress the industry.*

Keywords: *infrastructure, megaproject, project management.*

Introduction

There is a knowledge gap in the infrastructure megaproject industry (IMPI) in the area of project management as it exists today. Past trends show, on average, an 11% loss in major or megaprojects, across all industries, due to poor project performance. Further analysis in the infrastructure industry indicates that nine in ten megaprojects experience cost overruns with an average cost escalation of 28% (Siemiatycki, 2015). Analysis of past megaprojects in the infrastructure industry indicates project management as a contributing factor attributing to the losses. Project management relies on methodologies, intellectual capital, knowledge, innovation, and experience to manage megaprojects. These foundations will be the global infrastructure project trend of the future. Current project management knowledge and methodologies must advance and expand to provide Project Managers with the skills required to succeed in the infrastructure industry. The definition of success requires evaluation and update from its current state which is deficient and constricting criteria when assessing project success. Megaprojects will continue to evolve and grow to accommodate the infrastructure demands of cities and nations. These project management skills must expand beyond budget, schedule, quality, safety, and customer management to include:

- Expansion of knowledge and intellectual capital management;
- Risk management;
- Planning and projection;
- Expanded life cycle integration;
- Change management;
- Operations and warranty management; and
- Stakeholder management.

This will require a change in the industry to leverage the already available intellectual capital gained from successful projects, to improve megaproject delivery of infrastructure, and minimize productivity losses through expansion of the industry knowledge base. An improvement in megaproject outcomes has the ability to positively affect developed and emergent economies through the improved budget management of tax-funded initiatives. This paper is an expansion of earlier works of the author (Cole, 2017).

Methodology

This paper utilizes qualitative research to support the author's own project and program management experience in the global infrastructure industry. Due to confidentiality agreements, specific personal references will not be used. Observations about the industry, as experienced, have been supported by external and published sources from various fields of expertise to emphasize the extent of study completed and the magnitude of the industry challenge. Data was gathered from past global industry projects to extrapolate future trends and determine where project management needs to evolve to improve the state of the industry. Additional fundamental knowledge areas that will improve project management expertise include planning and risk management, change leadership, innovation, business management, negotiation and commercial management.

Definitions

A traditional project is defined as "a temporary endeavor undertaken to create a unique product, service, or result. The temporary nature of projects indicates that a project has a definite beginning and end" (Project Management Institute, 2004) or "a temporary organization and process set up to achieve a specified goal under the constraints of time, budget and other resources" (Shenhar & Dvir 2007, p.5).

Megaprojects are defined as "large-scale, complex ventures that typically cost US$1 billion or more, take many years to develop and build, involve multiple public and private stakeholders, are transformational, and impact millions of people" (Flyvbjerg, 2014, p.6).

The action of project management, defined as "the application of knowledge, skills, tools and techniques to project activities to meet project requirements" (Project

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Management Institute, 2004) or, "Project Management is the set of managerial activities needed to lead a project to a successful end" (Shenhar & Dvir, 2007, p.5).

Project success has varying definitions depending on methodology and industry. Project success can be measured "by product and project quality, timeliness, budget compliance, and degree of customer satisfaction" (Project Management Institute, 2004). This definition fails to include the impact or outcome of the result which the Diamond approach, developed by Shenhar and Dvir (2007), looked to address. The Diamond approach utilizes a diamond shaped framework that includes four dimensions: novelty, technology, complexity and pace (NTCP). As part of NTCP, the diamond approach includes these five dimensions of project success; project efficiency, impact to the customer, impact on the team, business and direct success; and preparation for the future (Shenhar & Dvir, 2007).

The Price Waterhouse Coopers (2014) definition of infrastructure includes: Extraction – Oil and Gas, natural resources; Utilities – Power Generation, Electricity, Gas, Water, Telecoms; Manufacturing – Petroleum refining, Chemical, Heavy metals; Transport – Rail, Roads, Airports, Ports; and Social – Hospitals, Schools.

Public Private Partnerships, (PPP or P3) have various structures and definitions as referenced by Plourde et al. (2009, p.6) that include "a cooperative venture between the public and private sectors, built on the expertise of each partner, that best meets clearly defined public needs through the appropriate allocation of resources, risks and rewards" as stated by The Canadian Council for P3s (CCPPP). Partnership BC (2011) defines P3s as "a public private partnership is a partnership arrangement in the form of a long-term performance-based contract between the public sector (any level of government) and the private sector (usually a team of private sector companies working together) to deliver public infrastructure for citizens. A public private partnership could be any kind of infrastructure or service such as a new hospital or bridge or highway, a new type of technology that delivers services in a faster and more efficient manner, or a new federal government building – anything that citizens typically expect their governments to provide."

In Ontario, P3s are also known as Alternative Financing and Procurement (AFP) (Plourde et al., 2009, p. 6). P3s may vary by model or by project and follow various structures or approaches. These are defined as quoted and condensed from Plourde et al. (2009, pp.14-16):

"Design-Build (DB): a public owner enters into a legal agreement with a contractor that engages with consulting engineers or other design professionals to design and build the asset according to requirements set out by the public owner.

Design-Bid-Build (DBB); the design team is engaged by the public owner and prepares the design for the asset working in closely with the owner and users. The design team then prepares detailed bid documents and invites contractors to bid on constructing the project. The design team reviews the construction of the asset and typically administers the construction contract on behalf of the owner.

Design-Build-Finance-Maintain-Operate (DBFMO): the public owner enters into a project agreement with a legal entity created to provide the design, build, finance, and life cycle maintenance/operation of the asset. The term of this project agreement can be 25 to 35 or more years. At the end of the agreement, the owner takes over the asset and responsibility for its maintenance and operation.

Design-Build-Finance-Own-Maintain-Operate-Transfer (DBFOMOT): this model builds on the DBFMO P3 with the consortium now also owning the infrastructure for the term of the project agreement, then transferring ownership of the asset to the public owner at the end of the term.

Design-Build-Finance and Maintain (DBFM): differs from DBFMO in that the operation of the asset is not included in the project agreement but remains the responsibility and an asset of the public owner. …maintenance of the asset is the responsibility of the consortium during the term of the project agreement.

Design-Build-Finance (DBF): the public owner contracts with the private sector to design and construct the asset. …the asset is always owned, maintained and operated by the public sector.

Build-Finance (BF): The original designers were engaged to review and update their designs and documents that were used to invite proposals from contractors who would construct the asset and also provide construction phase financing.

Build-Finance-Maintain (BFM): the public owner executes a project agreement with a consortium to build the asset, provide construction phase financing, and then maintain the asset during the term of the agreement."

For this paper, the Project Management Institute (2004) definitions are utilized and augmented by Shenhar and Dvir (2007), with Flyvbjerg (2014) providing further detail as it pertains to megaprojects and the expanse of the infrastructure industry beyond typical projects definition. The infrastructure focus is on megaprojects in sectors interfacing with transportation, as it is the author's area of expertise. The supporting data and conclusions will apply to all infrastructure industries defined by Price Waterhouse Coopers (2014). When referencing P3s and AFPs, they have considered the same delivery model with further clarification included when required.

Problem statement

Megaprojects valuing over US$1B in the global infrastructure industry are increasingly in the spotlight due to the scrutiny and public reporting of cost overruns and schedule delays. The consequences include negative financial results and damages to the reputation of major public and private organizations with the potential to impact nations on a global scale. This problem continues to be researched and documented without improvement.

Supporting data

In the results stated by the Project Management Institute (2014, 2015, 2016, 2017); projects continue to show industry losses of more than 10% on average and as indicated in Table 1: Project Loss Trend. That equates to $110 million loss for every billion dollars spent on projects. The loss is equalized across currencies but can compound when projects encounter multiple currencies and exchange rates due to global economic impacts over the duration of a megaproject.

Table 1. Project Loss Trend

Year	$ M Loss / $1 B	Percentage loss
2014	$109	11
2015	$109	11
2016	$122	12
2017	$97	10
4 Year Average	$109.25	11

This overrun trend is representative of all types of projects. Research indicates that smaller, simpler projects overrun less and the cost and schedule estimates are more accurate. In infrastructure, small construction and maintenance projects that can be completed over a shorter timeframe and involve fewer sub-contractors average between four and 9.5 percent in overruns. An indication that small, routine projects are less likely to suffer the effects of political impacts and cumbersome decision-making processes experienced in megaprojects (Siemiatycki, 2015).

The global infrastructure megaproject budgets are estimated at approximately 4% of the global gross domestic product per year (Flyvbjerg, 2014). The state of the global megaproject industry is well documented with research data indicating cost overruns in nine out of ten projects (Flyvbjerg, 2014). This can result in serious damage to national economies as demonstrated in Brazil with the hosting of the 2014 FIFA World Cup and the 2016 Olympics (Flyvbjerg, 2013). In the infrastructure industry, studies indicate the following overruns by discipline as provided in Table 2: Average Overrun by Discipline, which has remained constant for 70 years based on available data (Siemiatycki, 2015):

Table 2. Average Overrun by Discipline

Discipline	Average Overrun
Rail	45%
Bridges/ Tunnels	34%
Surface Roads	20%

Earlier analyses of project data found a similar conclusion of megaprojects failing to meet time and budget goals 85% of the time with an average schedule overrun of 70% and 60% overrun of the budget. (Shenhar & Dvir, 2007). Overruns of time or budget have been documented as high as 90% for infrastructure megaprojects (Banaszak, Palter, & Parsons, 2017). Project ownership, public or private, is not a factor influencing the results (Banaszak et al., 2017). The location of megaprojects does not appear to influence results as projects in Europe and the Americas have similar results for infrastructure projects and, therefore, may be disregarded as a factor to influence results (Siemiatycki, 2015).

"Most projects regarded as a failure usually do not manage to meet one or more criteria of scope, time, and quality, resulting in a low return on investment (ROI)".
(The Standish Group International, 2015)

The global infrastructure industry contains some of the largest megaprojects in either the planning stage or execution of the project life cycle process. In 2014, spending worldwide on infrastructure was $4.2 trillion. By 2025 capital project and infrastructure spending is estimated to total more than $9 trillion (Price Waterhouse Coopers, 2014). If this continues, global construction in infrastructure will outpace global GDP by 2025, with 63% of the construction occurring in emerging markets (McNichol, 2015).

Current expenditure on infrastructure reflects a $1 trillion shortfall against annual global investment demand, and by 2030 there will be a $14 trillion shortfall. Developed and emerging markets are experiencing a surge in demand in the infrastructure sectors including transportation, freight, communications, water, clean energy and stable power. This demand is increasing the need for transit systems improvement that will reduce congestion and handle increases in capacity as there is a greater focus on global urbanization, increases in population density and the impacts on climate change. This surge is attracting private investors to provide the needed funding in return for low risk investment (Arcadis, 2016). There is also a shortage of companies and experienced Project Managers that can deliver these project demands (Beckers et al., 2013; McNichol, 2015).

As demand for infrastructure megaprojects continues to increase, the trends indicate cost and schedule overruns will continue to have global impacts. The industry will have a shortfall of funds to cover the projects, and a shortage of skilled Project Managers to execute the megaprojects successfully. Investors are finding funding challenges for these projects due to the "preparation gap or a shortage of well prepared, bankable P3 projects where investors are sufficiently reassured by the commercial and technical feasibility, the risk allocation, the public sector's contractual commitment and capacity as well as the institutional and legal framework" (McNichol, 2015, p.6). In order for the industry to mitigate losses, and be able to deliver on the future demands of the infrastructure megaprojects, strengthening project management is a core requirement.

Project management as intellectual capital

Project Management is an intellectual capital commodity with its foundation being in knowledge and experience. The industry is relatively young; starting in the 1950's with military applications then dispersing to other industries as the positive affect and value of project management on delivery was realized (Shenhar & Dvir, 2004). The outputs of project management are tangible and measurable. They include plans, reports, and schedules, tracking and monitoring elements and ultimately, a final deliverable or project goal. The ability to manage projects successfully comes from the knowledge and experience gained by the Project Manager within their specific fields, over time. This experience includes the ability to utilize gained knowledge on future projects by developing an internal repertoire of best practices and risk mitigation to innovate, create continuous improvement, and ultimately project success. Megaproject management takes this experience to a higher level of expertise requiring further evolution from current practices in order to reduce project loss and ensure successful global infrastructure project delivery.

Traditional project management, in theory and practice, references the following methodologies that were developed as guidelines for execution and successful management of projects (Project Management Institute, 2004):
- PMI/PMBOK Method;
- Agile, Adaptive Life Cycles, Change Driven, Scrum, Kanban;
- Waterfall;
- Prince2;
- Critical Path Method (CPM);
- Critical Chain Method (CCM);
- Precedence diagramming method (PDM);
- Activity-on-node (AON);
- Six Sigma, Lean; and
- Program Evaluation and Review Technique (PERT) or three-point estimating.

Other methodologies include:
- NTCP Model, or Diamond Approach (Orhof, Shenhar, & Dori, 2013); and
- Strategically managed, aligned, regenerative, and transitional (SMART) (Hartman, 2000).

This list of methodologies is not exhaustive but is an indication of the vast approaches and variations of techniques that exist within the project management industry. Another theory that the above list indicates is that one methodology does not align with all project types (Shenhar & Dvir, 2007), as methodologies are developed in response to a need in the industry.

Not all of the developed methodologies are adaptable to the megaproject or to infrastructure projects. Agile, Scrum and Waterfall have focused on the software development industries. Six Sigma and Lean can be utilized to achieve reduction of variation and continuous improvement in manufacturing or process based projects through eliminating waste and improving flows. CPM and CCM are schedule analysis based with a focus on the sequence of tasks and flow versus constraints, resource availability, and uncertainty. The PMI’s PMBOK methodology focuses on structuring projects into five project lifecycle groups of initiating, planning, executing, controlling, and closing, attempting to standardize a process foundation adaptable to all projects.

Understanding infrastructure megaprojects as defined earlier provides an indication of the substantial scope and requirements and emphasizes that Project Managers must rely on a multitude of methodologies, in addition to experience, innovation and personal intellectual capital to drive a project to a successful delivery. Megaproject managers may incorporate some or all of the methodologies mentioned above and incorporate others not listed here. There may also be an amalgamation of methodologies to utilize some aspects that are appropriate for the project and reject others as the needs, phase or scope of the project requires. Since megaproject span years, impact populations and require advanced financing opportunities, the ability to adapt and utilize all methodologies is key. While megaproject exists to solve the complex infrastructure problems and may have unique elements, most are not unique in their entirety, allowing for an integration of methodologies and adaptation of previous projects lessons learned.

An alternate methodology would be to include applications of change leadership for use in megaproject management. Both rely on the soft skills and management of human capital that requires knowledge, experience, and intellectual capital applications. Although megaproject management and change leadership struggle, with cost overruns, delays and define success it's as it relates to the initiative goal or outcome, they both must address the impact of change. The leading causes of failure of change are resistance to the change from those impacted and governance behaviors that do not support the desired changes (Blackburn, Ryerson, Weiss, Wilson, & Wood, 2011). IBM has analyzed change leadership and suggested the following solutions for improvement change project success (IBM Global Services, 2008):

1) Strive for a full, realistic awareness and understanding of the upcoming challenges and complexities, then follow with actions to address them;
2) Use a systematic approach to change that is focused on outcomes and closely aligned with formal project management methodology;
3) Leverage resources appropriately to demonstrate top management sponsorship, assign dedicated Change Managers and empower employees to enact change;
4) Allocate the right amount for change management by understanding which types of investments can offer the best returns, in terms of greater project success.

Megaproject overruns: cause analysis

Megaprojects are a different type of project due to their magnitude, stakeholder involvement, complexity, and impact. Which results in megaprojects being a different type of project to lead and manage, requiring extensive experience in the specific project field (Flyvbjerg, 2017).

The magnitude of cost overruns for megaproject in infrastructure, as previously stated, will continue as owners continue to award projects to meet the growing global infrastructure needs but don't change the way megaproject management is conducted. The knowledge base is established and unchallenged but there needs to be a change in the way megaproject management is executed. The author reviewed data of cost and schedule overruns in various industries, public and private ownerships, located in various global locations, and delivered under different contractual systems. The data included the transportation infrastructure megaprojects listed below (Allport, Brown, Glaister & Travers, 2008; Cantarelli, 2011; Flyvbjerg, 2014; Siemiatycki, 2015):

- London: The Jubilee Line Extension;
- The London Underground Public Private Partnership (P3);
- Docklands Light Railway;
- Channel Tunnel (Eurotunnel), United Kingdom and France;
- New York Subway Upgrades;
- Paris Light Rail (RATP);
- Boston's Big Dig;
- Toronto Spadina Subway Extension;
- Toronto Union Station Revitalization;
- Toronto PRESTO fair collection card;
- Denver International Airport.

Of the project results data reviewed, consistent themes and conclusions emerged for causes of megaproject overruns of budget and schedule. The results are consolidated into three groups and summarized by the group.

The first theme for cost overruns of infrastructure megaprojects was a lack of project management and controls. The elements that may be included in this category are extensive and cover a number of elements that, when intertwined, and affect each other. The initial item as part of project controls is a poor organization of the project and the project governance decision making and procurement do not have the required speed and scale for the project (Changali, Mohammad & van Nieuwland, 2015). Another element is inadequate communication including reporting inconsistencies resulting in stakeholders having different interpretations and understandings of the status at any given stage in the project and flawed performance management which leaves issues unresolved and allows project risks to increase due to lack of communication and accountability (Changali et al., 2015). Project controls include commercial and contractual management. When poorly done, transfer of project responsibility from procurement in the negotiation phase to project managers for the implementation, commissioning and closeout stages may result in misinterpretation and understanding of contract issues and how to resolve or proceed (Changali et al., 2015).

Project controls also include team and resource management. Limited talent management by the owners, contractors, and consultants or not providing the best and most suited people for the project in addition to a lack of available resources with competent qualifications will impact the success of the project (Changali et al., 2015). Resource management may extend to projects being led by Managers without extensive domain experience, or that change throughout the long project lifecycle which results in weak project leadership (Flyvbjerg, 2017). A lack of leadership and constraints on qualified resources for the owners, engineers, and contractors resulting in leaders without megaproject experience and the associated skills to manage in intense contractual, operational and business environments (Patmore, 2017) may also affect cost overruns.

Infrastructure projects are complex as are the controls systems put in place to monitor and report on the project status. Only managing to time and budget constraints and not taking into account the ability to use the end product as intended at the capacity or functional level required (McManus, 2016) will affect project outcomes. Adaptation of poor procedures that are adopted by project owners including getting too involved in the project causing scope creep and rework at increased costs or being too distant from the project resulting in delays and slow decisions and involvement of external third parties (Banaszak et al., 2017) has a direct impact on cost overruns. Inappropriate delivery method or utilization of the same delivery method for all types of projects has the ability to result in cost overruns. For example, using DBB, DB, AFP, for all road projects (McManus, 2016). A lack of integration at various levels in megaprojects including considerations of management, between transportation modes, between infrastructures, land use, and jurisdictions (Allport et al., 2008) will affect cost overruns and the potential for expensive changes to integrate allow for appropriate end usage.

Project controls also includes technical challenges as stated by Siemiatycki (2015) including scope changes and change orders after the “go decision” resulting in cost increases; handover problems between the designers, contractors, owners, and operators over work quality, responsibility, integration and intended operation; and poor project reporting and performance monitoring by owners and reliance on contractors past reputation instead of current project delivery.

The second theme resulting in cost overruns to megaprojects in infrastructure evolves around poor upfront planning (Banaszak et.al., 2017; Changali et al., 2015; Shenhar & Dvir. 2007; Siemiatycki, 2015). The most prominent theme was projected biases which include various elements. Optimism bias is the most extensive and results in a tendency to assess future events in a more positive light than is warranted by actual experience (Flyvbjerg & Techn, 2006) and display overconfidence in abilities, talents, and skills (Siemiatycki, 2015). Unique Bias is a tendency of planners and managers to see their projects as firsts or unique, which impedes learning from other projects (Flyvbjerg, 2013). Cognitive biases result in systematic and predictably that is susceptible to errors when forming judgments in uncertain situations and can include overconfidence or overreliance on guidelines or concepts resulting in the underestimation of risk (Ansar, Flyvbjerg, Budzier & Lunn, 2016).

Other biases include strategic misrepresentation by the project owners (governments) and approvers of cost, schedule or benefits to get the project approved, knowing that once started, few projects will be stopped with the impact being with the operator or end user (Tax payer) (Flyvbjerg, 2014; Siemiatycki, 2015). Also, owners rely on overly optimistic budgets at the beginning of the process, bad assumptions, and aggressive value engineering that trick owners into believing budgets and margins can be achieved, and owners not questioning the

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process or oversight in the estimates (Patmore, 2017). Projects proceeding with incomplete engineering and feasibility studies may result in owners expediting approvals of urgent projects and securing inaccurate funding to meet urgent, political or election timelines (Siemiatycki, 2015). Owners having inaccurate forecasting due to project complexity, uncertainty, changes in external conditions and inappropriate estimation methods (Siemiatycki, 2015) may also result in megaproject overruns. When there is an inflation in labor and material costs caused by the need for specialized resources and materials in a time of economic demand and growth (Siemiatycki, 2015), project costs are difficult to forecast, budget and control.

Poor project planning and execution and not including operations, maintenance or end use stakeholders and interface partners (McManus, 2016) will result in changes, often late in the process which contribute to cost overruns which are difficult to control.

The third item refers to for cost overruns of infrastructure megaprojects was insufficient risk management. This includes late identification and resolution of errors or risks (Patmore, 2017) and not allowing for project delays from external stakeholders including unions and utilities, unforeseen events that may include extreme weather, contaminants or artefacts and no management plan and performance monitoring to manage and mitigate unforeseen risks (Siemiatycki, 2015). Other risk items with impact on megaprojects include owners, not including long planning horizons and complex interfaces (Flyvbjerg, 2017) and transferring risk to the consultants or contractors which results in the management of risks in isolation without collaboration (McManus, 2016).

In addition to the three themes, there are secondary causes of project failure worth noting. One is that the definition of success only follows the triple constraint model or iron triangle of: on time, within budget, within performance goals (Shenhar & Dvir, 2007) and the notion that one type of project management methodology fits all types of projects and following text book methodologies will achieve project success (Shenhar & Dvir, 2007).

Through the research process of the summarized themes and conclusions, the results for cost and schedule overruns indicate many generalized causes, but nothing specific and consistent. This broad range definition also provides insight into the complexities of megaproject management, in that there isn't one element that is key to being able to predict that a project will be unsuccessful. This may be due to the term "project management" being too broad to use as an exact cause for megaproject overruns (Cantarelli, 2011). The solutions will be complex and multi-faceted. Ahiaga-Dagbui, Smith, Love, and Ackermann (2015, p.863) concluded that "cost overrun research has largely stagnated in the refinement and advancement of the knowledge area. It has largely been superficial and replicative. A significant paradigm and methodological shift may be required to address this perennial and complex problem faced in construction project delivery.".

The methodologies mentioned in Section 6 focus on the performance and evaluation of projects and the ability to plan and control with a representation in reports, charts, graphs and calculated analysis. The focus is lineal with project status reflected in the numerical calculation which allows for recognition of issues relating to project performance. What the methodologies miss is the interpretation and analysis that comes from intellectual capital, knowledge, and experience from the project manager and leadership team.
"Everybody is concerned about *how* to do the job, not about the *outcome* if the job is done well." (Hardy-Vallee, 2012, p.3).

Solutions for infrastructure megaproject management

In researching the IMPI for causes for cost and schedule overruns, various solutions were suggested. The solutions are categorized into the same three themes as the causes. For project management and controls the concept of having a focus on strong theory and good data would help bring the field forward academically and professionally (Flyvbjerg, 2017). In the UK, implementation of the training of government Megaproject Managers, as exemplified by the Major Project Leadership Academy, Oxford England (Flyvbjerg, 2014) is an initial step. Further developments in strategic management research, broaden the notion of stakeholder management to better consider pressing issues of future generations and the natural environment (Flyvbjerg, 2017) would also be a consideration.

Owners need to improve procedures and help drive innovation vital to promoting change, stop scope creep, rework and delays through slow decision making (Allport et al., 2008; Banaszak et al., 2017; Omega Centre, 2012). Owners need to manage more than just time and budget and include the functional goals in the project success criteria. The inclusion of an independent assessor or governing entity on behalf of the owner to oversee the effective management of large-scale projects funded and delivered by governments (Flyvbjerg, 2014) and monitor the project status on all requirements (McManus, 2016; Omega Centre, 2012) has proven successful in some instances.

The PMI has evolved the "measure of success to include the percentage of projects that are completed on time, on a budget, and meeting original goals and business intent with levels of benefits realization maturity" which includes successful business outcomes (Project Management Institute, 2017). Further applications of appropriate delivery methods for each project instead of the same for all capital projects (McManus, 2016) or provision of a new delivery model for megaprojects aimed at securing innovation and flexibility in projects (Flyvbjerg, 2017) may reduce cost and schedule overruns.

Other solutions include openly sharing the megaproject status and holding stakeholders of involved businesses and agencies accountable (Flyvbjerg, 2014) and employing lean construction tools for collaborative decision making and global sourcing of materials for availability and efficient pricing relying on connected inventories (Banaszak et al., 2017).

The second grouping of solutions for megaproject cost and schedule overruns focuses on upfront planning and considering the projects' legacy to include long term benefits, skills development, economic improvement, knowledge expansion and building of capability in the industry (McManus, 2016). Involvement of operations and maintenance experts from the beginning of the project to provide insight into decisions that will affect the total cost of ownership (Allport et al., 2008; McManus, 2016) and investing to improve performance and innovation so Engineering Procurement Construction (EPC) firms have an incentive to depart "from tried and true" (Banaszak et al., 2017) may also deter cost and schedule overruns.

Implementation of procedures to curb "Optimum bias" and "strategic misrepresentation" (Flyvbjerg, 2014) and developing an understanding of the similarities to other projects will provide a means of Megaproject Managers to be able to learn from these projects and instill preventative measures. Megaproject managers that view their projects as unique perform significantly worse than other managers (Budzier & Flyvbjerg, 2013).

In the concept and design phase there are various mitigation techniques that would allow for improvement of cost and schedule overruns including (Changali et al., 2015):
1) Build only what is needed and design-to-value. Focus on a functional design and eliminate items that increase costs;
2) Consider the full life-cycle costs of a project including operations and maintenance. Insure designers and Project Managers have awareness of net present value and link incentives to improvement;
3) Optimize and take into account site constraints and external elements or conditions to reduce construction and operation costs;
4) Consider, wherever possible modular design and standardization. Borrow from others to replicate and avoid unique and expensive design, construction and end user costs;
5) Optimize engineering processes and choices in productivity, integration, provision of direction to prevent rework and inclusion of appropriate technology to improve productivity;
6) Define the contracting and procurement approach in the planning phase to minimize costs and risks and ensure the approach is assessed and appropriate for each project;
7) Use an integrated risk approach that shares risk with the owner and transfer risks to the contractor where they have influence;
8) Establish a change and claims management approach to expedite and minimize time loss and disputes;
9) Align contractor and owners' interests with defined payment structures and a balance of incentives and penalties.

Risk Management is the third proposed solution areas to reduce cost and schedule overruns in infrastructure megaprojects. Risk management concept so support project success includes "Relational Contracting" or pooling of delivery risk and sharing of profits or balancing of risks (Banaszak et al., 2017; McManus, 2016).

The owner could define rules that force accountability upon bidders and owners should provide some predictability for future available funding (Allport et al., 2008) to allow contractors and consultants insight into funding requirements and restrictions but indicate security of project funding amounts.

The creative use of insurance by offering incentives to work to avoid claims (Banaszak et al., 2017) and overinvesting in planning and set up the project organization for success over the entire life-cycle to reduce the risk of knowledge loss (Changali et al., 2015) are other risk mitigation factors to be considered. Also, paying more attention to lessons learned on positive projects (Flyvbjerg, 2014) and implementing the successful elements may provide reductions in cost and schedule overruns.

It's time to update project management not with more methodologies, but with more emotional content. Employees' and stakeholders' disengagement can make a project fail, but behavior-based management can make projects succeed. (Hardy-Vallee, 2012). The ability to manage the human capital during the project process and the impact on the outcome of the project is key to the success of megaprojects.

Perspective: inside the infrastructure industry

From a project management perspective inside the infrastructure industry, megaproject management needs to evolve to include integration management, change leadership, and project conception planning. This definition of a megaproject needs to expand to include service operation and delivery while managing stakeholders, phasing interfaces, and adapting to real time risk management. Due to the long life-cycle of megaprojects, Project Managers require an understanding of technological advancements and external impacts that allow for continuous improvements. To achieve all of this, Megaproject Managers in the infrastructure industry will need to rely on years of experience, knowledge and intellectual capital gathered from previous projects to be able to deliver megaprojects. Despite all of the recognized skills and the decades of experience, there are not any guarantees that the projects will be considered a success.

The industry requires a motivational push to improve megaproject delivery.
Awareness of the project status in the developed nations is the first step in accountability. Another step is valuing megaproject management as an intensified and strengthened skill sets supported by knowledge, innovation, and experience aligned with engineering, architecture, and planning. These skills are critical to industry success. The industry needs Project Managers that are trained, through education and project experience in the public sector as owners. These skills are equally critical in the private sector, as project implementers. Having exposure to theory and in-process projects is essential to understanding the complexities of

megaproject management. An understanding of people, commercial, contractual and integration management from concept to warranty completion is crucial.

From personal project experience on the London Underground Jubilee Line Extension, the London Underground (P3), the Dubai Light Rail Metro project, and various rail transportation projects in Ontario, Canada, the above-mentioned findings align with projects within the authors' local environment as reported in newspapers and corresponding news sites. The upfront planning requires re-evaluation on the governance and supported business cases to ensure the projects are based on accurate estimates and technical evaluation. Infrastructure planning struggles to succeed when based on political agenda instead of expert analysis and ridership demand. This can result in ineffective projects proceeding and leaving voids in other areas of infrastructure. News publications continue to report on project overruns, councils voting against the experts and consultant's findings, and politicians without experience in project and infrastructure planning or risk analysis making financing and project approval decisions. Millions of tax funds are spent on studies in an attempt to achieve the answers or promises provided in election campaigns. Accountability is lacking in project ownership and the tax base pays the ultimate prices in terms of reduced job creation or projects that do not achieve the promised capacity or purpose, or the cost of operation and maintenance exceeds the benefits anticipated.

Canada is expanding the AFP model to utilize risk transference and allow for private funding of public infrastructure. This is still in its early stages in terms of project implementation and has experienced success and failures. It is not a solution of one fits all for projects and AFP continues to need refining to determine the correct megaproject use for successful implementation. It is a system that continues to struggle with the success of on budget on schedule delivery. This is an example of developed cities and nations appearing slow to learn from the lessons learned from others. For instance, the Jubilee Line Extension as private partnership project was fraught with challenges and on structure, governance, risk alignment and goal definition (Allport et al., 2008). AFP's and P3's continue to be executed and continue to struggle with the challenges experienced. With the impact in the billions, there is a greater effect that can reach further than the initial project. Municipal and regional government projects and incentives are cut to remain within overall constraints imposed by federal government levels. Scope reduction in areas of education and healthcare may occur due to the mismanagement of infrastructure projects. One initiative includes the introduction of private financing and investing is to assist in improving project delivery and combating the impacts elsewhere.

The infrastructure sector is finding limited private firms capable of bidding of delivery of the megaprojects resulting in AFPs including P3 to bridge the resource and investment gaps (Garemo, Hjerpe & Mischke, 2015). Alternate delivery structures such as P3s, or variations of Design, Build, Finance, Operate, Maintain (DBFOM) are better at motivating project delivery goals but still focus on change notice and risk aversion which are included in the pricing. AFPs and P3s tend to be slow to react, unequaled in skill to workload, and are not structured for efficiency in project delivery (Siemiatycki, 2015). P3s have their limits including no guarantee of higher productivity, or successful project deployment, and operational success. The efforts required to deliver complex P3 projects are extreme (Garemo et al., 2015). For P3s to be effective, public governance needs appropriate structure and financing guarantees beyond yearly budgets, and election cycles (Garemo et al., 2015).

Evolution of the industry is key to change the current state of project delivery and improve for the anticipated future. Understanding of the situation and a motivation for improvement on the owners, consultants, contractors, and operators is key to invoke change. In most cases, it is the end user or tax payer that would benefit from improvements in megaproject delivery. Considerations from the industry would include improving understanding that infrastructure megaprojects are different in terms of skills and requirements for successful delivery and that focusing on the outcome of the project in addition to the how and status reporting could provide delivery improvement. Having greater coordination of megaprojects at the global level to manage the resource demand and take into account the global risks of facing the developed and emerging nations in the future would allow for integrated national prioritization with potentially positive effects on nations for pricing, qualified resources and project financial allocation improving deficit impacts.

Realizing and accounting for the effects of biases on megaprojects with improve the oversight and processes of initial estimates to allow for present and future value calculations would have a direct impact on project delivery. While, removal of megaprojects governance from public officials that are not experts in infrastructure planning, delivery or operation could eliminate strategic misrepresentation to initiate projects and progress them to the point of no return and forcing projects to completion at the costs of other project deletion or funding overruns.

Understanding of the methodologies reviewed earlier in this paper is important to provide Project Managers the authority to draw on a repertoire of methodologies at any phase in the infrastructure megaprojects to contribute to successful delivery. Acknowledging that one methodology or project delivery method does not fit all is also a key to megaproject management success.

Developing and expanding the knowledge and intellectual capital requirements of Megaproject Managers will be the starting solution point improve project success. Oxford University has started the knowledge improvement process by providing educational and practical field training for government Megaproject Managers through the Major Project Leadership Academy (Flyvbjerg, 2014). The megaproject industry needs to expand to international under graduate schools and includes private business management, as cost and schedule overruns apply to both public and private infrastructure (Siemiatycki, 2015). The experience quotient must include multiple and different methodologies, and diverse project experiences to make megaprojects successful (Gallup, 2012). To generate a certification for Megaproject Managers, will require consideration of various items in addition to education including project managers requiring experience and proven track records of project delivery prior to certification and a demonstration of people management skills for project delivery in the application of megaproject management. Project Managers need to demonstrate an understanding of, and expansion of the project life-cycle from concept to operation, involving the urban planning, social (live, work, play), economic impacts, for society and have a level of business acumen with an understanding of project impact to the success or failure to the owner, delivery organization and end user.

Megaproject Managers with the ability to innovate and implement continuous improvement with awareness in commercial and contractual management and reporting, negotiation experience of project contractual items and claims and understanding of technological applications to project success and the correct implementation of these systems (example: 7D Building Information Modelling (BIM)) can only strengthen the megaproject delivery success.

Including change leadership as a methodology and critical soft skill set vital to the management and implementation of megaproject and structuring projects with qualified people in the correct positions to deliver the project effectively with the ability to apply proven stakeholder management will support the complexities and challenges for success that megaprojects present. Finally, the ability to streamline processes and avoid project waste with repetitive functions will provide positive contributions to keeping cost and schedule overruns of projects under control

Conclusion

Project management is a relatively young industry, borne out of necessity and it continues to evolve. Where engineering and architecture have been subdivided into specific classifications including civil, structural, industrial, operational, institutional, commercial, or transportation, project management is in the midst of a divergence of skill sets depending on project type and industry application.

"Breaking from the insanity of repeating unreliable project-delivery practices is crucial if the sector is to raise productivity and deliver projects on time and to budget. Yet right now it is clear that we do not have the incentives or structures in place to drive this change" (Banaszak et al., 2017).

This paper concentrated on the Infrastructure industry with a focus on megaprojects. The findings indicate that, for the infrastructure industry, one of the crucial areas of improvement to reduce continual losses is project management. Specifically, the experience and training of Project Managers in public and private infrastructure. Project management with a singular methodology or delivery focuses not enough to solve the documented project losses and is not pivotal to improving the overall success of megaproject delivery. With the other areas of expertise required for megaproject management success, the inclusion of change leadership and people management will have a place in megaproject delivery in the operations and end user implementation.

As the delivery methods of projects continue to evolve and expand to provide private investing dollars to fund public infrastructure, project success and expectations surrounding the return on the asset and benefit in end use will change. With P3's and AFP's continuing to grow in size and popularity, private business will need to see the benefit and return on investment to be willing to provide funding. Continual overruns have the potential to impact the private sectors with ripple effects of poor financial return resulting in fewer projects and projects of smaller size, job loss, and further economic impact as effects will be on the macroeconomic scale due to the size of the projects. The need for infrastructure projects to the population expansion of urban areas will continue to grow. Improvement and management of these projects is vital to meet the continuing need for infrastructure.

Including and understanding the change leadership best practice methodologies for implementation on megaprojects is a demonstration of one area of the larger skill set required. Project management of megaprojects needs to evolve to go beyond the standard scope, cost, quality and customer management to include:
- Extensive applicable experience;
- Innovation and complex problem solving;
- People leadership;
- Enterprise risk management; and
- Expanded knowledge and intellectual capital of project delivery gained through education and practical experience.

Project Managers of megaprojects need the ability to employ numerous project management methodologies and need the experience to recognize and implement the appropriate methodology for each stage in the expanded project lifecycle. They also need to take into account the emotional needs of stakeholders and team members and not rely solely on the technical project management methodologies and processes (Gallup, 2012).

"The soft stuff is hard" (IBM Global Services, 2008)
The ability to adapt project management methodologies based on the project structure will be one key to improving the success of megaprojects. To move forward with an integrated global project management process more work is required to evaluate the need for a recognized governance or certification and alignment of the standards across countries. How will this be planned, controlled, evaluated and monitored? Who will be the governing body to plan and control it? Will Oxford University's program expand and align with leading educational institutions globally to spread the intellectual capital and continuous improvement for the industry? Is there enough motivation for public and private industry to embrace this change?

For infrastructure megaprojects, the definition of a project needs to expand to align with the procurement models and lifecycle. This will include the conceptual planning and business cases, as well as the responsibility for handover commissioning, and end user satisfaction and intended use. This aligns with expanding the definition of a successful project to include operations and the goal achievement of the end user.

To do this, owners need to share information, experience, and lessons learned from successful megaprojects (Siemiatycki, 2015). London's Crossrail megaproject as an example to provide best practices and improve project implementation. Other examples of successful projects include London's Docklands Light Rail, the Guggenheim Museum Bilbao and Paris-Lyon High Speed Rail projects (Flyvbjerg, 2014). Further analysis of the AFP models and lessons learned with applications to new projects based on the success or failure of the past is required. Ensuring the governance and owners don't continue to do what was implemented previously is also key. Which leads to the potential need for an independent checker or governing entity that can be impartial and not tied to the politics of infrastructure planning.

Expanding the conclusion, as stated by Youker (2017, p.2) "as the Project Management profession moves into working on many different types of projects we are going to have to move to a new level in the project management body of knowledge and develop extensions that define the differences in requirements and approach for different kinds of projects such as construction, new product development, and information systems."

To mitigate the demonstrated cost and schedule overrun problem, a united global project management industry requires an evaluation of the initiated solution and an expansion plan to address megaproject management in locations as led by the UK. The planned and controlled expansion will be key to reduce the loss factor, savings that can be applied to the anticipated infrastructure funding shortfall and allow implementation of infrastructure projects to meet the growing needs of developed and developing nations.

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