Exploring the Potentials of Project Controls within the Construction Industry: Drivers and Challenges

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Abstract

This paper examines the boundaries of project controls throughout the project life-cycle on construction projects. The researcher evaluates the factors contributing to the success and failures of projects, as well as identifies what project control mechanisms are currently being used in the construction industry to control projects throughout the project life-cycle. The details of the study reveal that although efforts have been made to control projects in various aspects of the construction project life-cycle, however these control mechanisms seem to be mis-jointed and scattered amongst construction professionals, and do not effectively work to address project controls, but only take effect after issues appear in a project. With the absence of a clearly defined structure to adopt project control mechanisms throughout the project life-cycle, this poses a clear gap in research towards improving construction project performance that satisfies the key stakeholders of the project. Thus, this paper proposes the development of a smart project controls framework model that would facilitate effective control of the activities identified throughout the project life-cycle, whereby the role of project controls becomes well defined within each stage of the project to ensure more sustainable project outcomes.

Keywords
project controls, smart projects, project planning, project controls system and project controls mechanism.

1. Introduction
The construction industry plays an important role in the infrastructure of countries with high interest in both government and private sectors related to the development of health, transport, education and other initiatives (HHI, 2018). Furthermore, it plays a wider role in reaching out to address issues such as driving economic growth, employment, social, climate as well as energy challenges (WEF, n.d). Thus, it is not without reason that the construction industry represents one of the most complex and dynamic environments (Abdul-Rahman et. al, 2009). It is therefore crucial that construction projects complete successfully, since constant change could increase uncertainties in the aforementioned issues which could impact on the development of initiatives (El-Sokhn & Othman, 2014). By adopting and developing appropriate strategies to decrease the uncertainties of facing unprecedented changes, construction companies should achieve the highest success percentage in their projects (Jari & Bhangale, 2013). It has been proved through various studies that 'success factors are based on good project control practices, which result in improved cost and schedule outcomes,' (Mackenzie, 2009). For example, in 1999, a study revealed that cost improvements of 10% were made as well as improvements in the project schedule due to the presence of dedicated project controls systems. In addition, another study carried out in 2000 showed that the project schedule which had slipped, was reduced by 15% due to effective Project Control mechanisms. Moreover, a number of articles have been published which show how project controls play an important role in achieving a project's overall objectives. However, despite such improvements, Spire Consulting Group (n.d) explain that there is still a lack of tilisation of project controls in the construction industry, regardless of the continuous evolution of the field of project management. Since the construction industry is one of the top industries which suffers from commercial issues such as cash flow and cost overruns, time delays and poor quality control (Abdul-Rahman et. al, 2009), effective intervention of project controls practices could help improve project performance. Since every successful construction project begins with careful planning (Spire Consulting Group, n.d), Shtub, Bard & Globerson (2005) explain that this can only be achieved through an 'effective schedule control methodology'. Thus, a project controls system is essential to help monitor work and determine if everything is proceeding as planned.

This paper therefore seeks to look into how project controls is being applied across the construction project life-cycle and how effective current project control mechanisms are in bringing about project success, in order to propose smarter project controls processes.

2. Literature Review

The aim of this section is to review a brief history of how project controls came about in the construction industry, defines 'project controls', as well as discuss the factors contributing to the success and failure of construction projects. The section also covers the Project Control mechanisms and tools used in controlling projects, as well as examines the application of Project Controls and the challenges that face the construction industry.

2.1 Emergence of Project Controls

According to Bourne and Weaver (2018) the origins of project controls goes all the way back to the 18th century in which Project Managers used Bar, Gantt charts and critical paths for monitoring their projects, through which began the emergence of schedule management. However, the applications of cost management on projects has roots all the way back to 15th century, in which actual costs were compared against the planned cost. Nevertheless, little literature shows evidence regarding predicting future completion and forecasting before the 20th century, although there were attempts in making predictions about future outcomes from a risk management perspective from the likes of mathematicians such as Newton and Pascal, who brought about the idea of probability in their calculations. Although the ***'The Gantt chart a working tool of management'*** which was disseminated through the work of Wallace Clark in 1923, was useful for showing slippages and project acceleration, however this did not assist with prediction the completion date for the works, rather simply solid planning and working to eliminate slips in accordance with the project plan. It was only during World War 2 in which the idea of predictive calculations seems to have emerged in 1940s. It was around this time when similar concepts such as CPM, PERT, MPM all came about in the UK, Europe and USA. It seems the case that prior to the 1950s, the main concern on projects was 'how far behind', and it is from these foundations that PERT Cost emerged, soon after C/SCSC, then EVM and more recently Earned Schedule. Thus, in the current times, project controls looks at 'predicted' time and cost outcomes.

In order to understand how project controls can effectively assist in the successful delivery of projects in the project life-cycle, the next section aims to gain an understanding of what the contributing factors are towards the success or failure of projects in the context of the construction industry.

2.2 Project Controls Definition

Defining project controls has been one of the challenges faced by literature. The main reason for this seems to be the ambiguous use of the word 'control' which, in Project Management could have various meanings (Kenley and Harfield, 2015). According to Olawale and Sun (2010), control can be perceived as a role, a process, or an outcome. On the other hand, Isaac and Navon (2014) define control as a practice, system or problem.

Despite the ambiguities, there have been number of attempts have been made to define project controls in the context of Project Management. For example, according to the Association of Project Management (APM) Body of Knowledge (PMBOK), project controls is defined as *'the data gathering, management and analytical processes used to predict, understand and constructively influence the time and cost outcomes of a project or program; through the communication of information in formats that assist effective management and decision making."* Given the nature of the term and where project controls applies within a project, APM have also come up with wide and narrow definitions of project controls. Where the narrow definition is defined as "*The application of processes to measure project performance against the project plan, to enable variances to be identified and corrected, so that project objectives are achieved",* the wider definition has been defined as *"The application of project, programme and portfolio management processes within a framework of project management governance to enable an organisation to do the right projects and do to do them right."* On the other hand, Stettner (2018) describes project controls as a system that *"aims to minimise the gap between project planning and project execution in order to achieve project aims, i.e., cost, time, and content."* Thus, for the purpose of this paper, the narrow definition of project controls by the APM will be utilised, since this research focuses on how to adopt smart project controls by focusing on ways of improvement of project actuals versus baseline in all aspects of the project life-cycle.

2.3 Why Projects Succeed or Fail

This section discusses the nature of construction projects and the stages of the project life-cycle. It also looks into the main reasons why projects succeed or fail in the construction industry.

2.3.1 The Nature of projects

A project is known as 'a temporary work executed to generate a unique product or service' with a definite beginning and end, whereby the 'end' is reached only when the objectives of the project has been accomplished (El-Sokhn & Othman, 2014). In the context of the construction industry, it is however often the case that construction projects are terminated earlier than expected, when either the objectives have not been met, the owner no longer wishes to proceed with the works, or the stakeholders of the project obligate the project termination (PMBOK, 2018).

Construction projects come in different types, sizes and complexities. According to Laws (n.d) construction projects can be classified into three categories, namely building construction, heavy or civil construction and industrial construction projects, whereby the latter makes up a small part of the construction industry. Whatever the project, each type will require a specialised project team to undergo the design, planning, construction and maintenance works, in order to achieve the project objectives and goals.

The main stages of a design and construction project can be classified into seven steps, from strategic definition through to handover and use at completion. These stages are shown in Figure 1 below.

Figure 1. RIBA Plan of Work (2013)

Initially, a construction project will need to go through three important structural decisions prior to the delivery of a project. These are namely project delivery; procurement method and contract method. Figure 2 below categorises the three structural decisions, with their methods. There are generally three methods for project delivery, and whilst all have different delivery systems in that project design risks and responsibilities vary, they all have a common goal in working towards assisting the client in delivering projects within the client's scope of cost, time and quality. On the other hand, the procurement method focuses more on how the client makes purchase decisions, in order to identify the correct procurers to undertake the project. The contract sets the terms and conditions of a project and will determine how the costs and profit of the project will be covered. Where the client usually dictates which contract type will be used, however this also depends on how well defined the scope of the project is (Ramos, 2017). Figure 2 outlines five contract types.

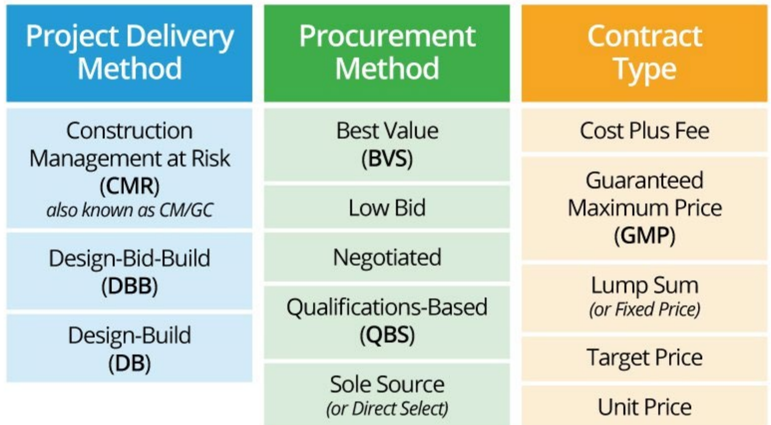

Figure 2. Construction procurement and contract selection methods. Source: Ramos, (2017)

It is ultimately the client's decision in choosing which of the above elements will steer the project. Whichever option is decided will have an impact on the project risks, costs, profit and project team responsibilities. Thus, the correct method for selection is crucial for the way in which the project is delivered.

2.3.2 Project Success Factors

Whilst the construction industry lacks a set definition and criteria of what project success is, research however has made a number of attempts to define this (Kumara & Warnakulasooriya, 2016). The majority of research reveals that the model for project success in the construction industry narrows down to three main criteria (Ghadamsi & Brimah, 2016) as illustrated in Figure 3 below. These are known as 'Critical Success Factors (CSF) and are the criteria that a project needs to satisfy (Roseke, 2018). This supports Cheung's et al. (2004) theory that time, cost and quality appear to be the three commonly preferred performance evaluation dimensions, however states that project performance can additionally be evaluated using a large number of performance indicators or criteria.

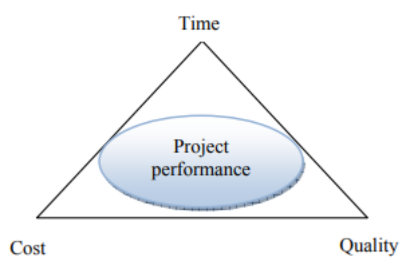

Figure 3. Project performance criteria trade-off triangle. Source: Atkinson, (1999)

In a study, carried out by Pandit and Yadav (2014) they stated that the Critical Success Factors in addition to the above criteria extend to risk and safety. The results of the study revealed the identification of ten most important project controls factors (Table 1) that contribute to the success of project, of which quality standards was the most important factor, followed by safety policies. Surprisingly cost monitoring and resource scheduling were the least important factors contributing to the success of projects (Pandit and Yadav, 2014).

Table 1. Top ten project control factors. Source: (Pandit and Yadav, 2014)

Sl. No.	Section	Factors	Global Weight	Rank
1.201	Quality	QA Policy, Procedures and Standards	12.00%	1
1.101	Safety	Safety Policy, Procedures & Standards	10.52%	2
1.203	Quality	Specification	9.51%	3
1.103	Safety	Use of Personal Protective Equipment	8.44%	4
1.401	Schedule Control	Construction Schedule (Master Schedule)	7.57%	5
1.202	Quality	Quality Audit	7.06%	6
1.504	Risk Management	Risk Monitoring & Control	4.96%	7
1.102	Safety	Housekeeping, accessibility	4.68%	8
1.402	Schedule Control	Resource Schedule	4.45%	9
1.303	Cost	Cost monitoring system	4.40%	10

In addition to the above, Xie & Liu (2014) state that in order for all construction projects to be successful, it requires continuous planning around elements such as bidding, risk management, budget scheduling, availability of building materials, logistics and construction site safety, although most of these should have been thought out by the client at the initial stage of the project.

On the other hand, according to Wai et al. (2012), what construction project outcomes define as success and failure is relative and depends much on the views of various stakeholders within a given project, and since there are a number of different project success criteria, these will not be suitable and relevant to all stakeholders involved in the construction industry. However, Chua et al. (1999) suggests that the criteria should only suit to fit the key players in the project, defined as the project manager, client, contractor, consultant, subcontractor, supplier and manufacturer.

2.3.3 Project Failure Factors

Roseke (2018) states that there are two types of theories for which projects fail:

1. Planned failure and;
2. Actual failure

Where planned failure is usually the result of poor planning such as unrealistic budgets or an undefined scope, actual failure is when the objectives of the project were well planned, however failed to achieve the objectives within the acceptable boundaries. Roseke (2018) further describes that the sum of the two theories above equates to 'perceived failure', which can be categorised into two views. The first view is that the project team 'perceives' the project to be a failure, even though the project objectives have been achieved. The second view is that the project team did not achieve all the intended objectives, however all the stakeholders in the project are satisfied with the project outcomes.

To support the above theories, projectcontrolsonline.com (n.d) states that it is widely recognised in the construction industry that failure in adequately planning and monitoring is a major cause of project failures.

Planned failure is almost usually as a result of a poor choice of procurement method as well as the contract type, which can have a significant impact on project performance. According to El Agha, (2013) the selection of an appropriate procurement system is one of the most important problems in the construction sector.

For example, the project delivery method consists of three major methods for delivering construction projects (as mentioned in the previous section, see Figure 2), in which although vary in approach, assist the client with the delivery of the project within time, budget, quality and performance. The method selected is crucial and defines the client's requirements depending on their objectives. Furthermore, failure to pick the correct procurement method could have an impact on project performance. The contract type also plays a major role in determining the costs and profit will be covered. If the wrong contract is selected, this may cause financial implications as the project progresses for both the client and contractor/consultant (Ramos, 2017).

In summary, each member of the project team should be familiar with the stages of each process in the project, as well as be clear on defining their/the company's success criteria by working towards the same goals, ultimately fulfilling the client's objectives. At the same time, since each project is unique and at risk of failure at some point in the construction stages, Jackson (2004) advises that special management techniques and mechanisms are required in order to keep the project on track.

The next section thus looks into detail what Project Control mechanisms and tools are currently being used on construction projects and how they impact on the performance of projects, in order to understand what measures should be taken to improve the projects.

2.4 Project Control Mechanisms vs Effectiveness

This section explores the project control mechanisms and tools used to control specific activities on construction projects as well as their shortfalls.

Meredith and Mantel's (2003) widely accepted theory states that there are mainly three types of project control mechanisms:

i) **Cybernetic**
ii) **Go/No-go**
iii) **Post-control** - lessons learned

Cybernetic control is the most common type of control system which deals with the comparison of the project baseline from actual work completed using project controls tools such as Schedule Variance (SV), Cost Variance (CV) and Earned Value (EV), then replan. This is often an automatic control mechanism used to detect issues and goes by a similar concept to thermostats.

The Go/No-go mechanism on the other hand is not automatic and requires manual approval prior to proceeding. This is useful when controlling whether to continue a specific project activity or stop based on precondition of risk being there, or a predetermined criterion (often a milestone).

Post-control looks at the lessons learned aspects of a project upon completion and adopts the teachings which could be used on future projects so that they can be controlled better.

Depending on which mechanisms these fall under, there are a number of project controls tools that can assist in steering a project on track. The most common of these include:

- Earned Value Management (EVM)
- Time cost trade off analysis
- Building Information Modelling (BIM)
- Milestone
- Location based management system (LBMS)

Table 2 below shows the effectiveness of these tools as a project controls function and where the gaps lie in project failures.

Table 2. Project Controls Tools vs Disadvantages

Project Control Tool	**Purpose**	**Reason for Project Failure**
EVM	EV is quantitative tool used for managing and forecasting predictive performance on a project	This tool is only effective when there is an Earned Value Management (EVM) system in place and thus projects which adopt this method tend to fail in falling short of the following elements: • No documented requirements; • Incomplete requirements; • WBS not used or not accepted; • WBS incomplete; • Plan not integrated (WBS-Schedule-Budget); • Schedule and/or budget incorrect; • Change management not used or ineffective; • Cost collection system inadequate; • Incorrect progress; and • Management influence and/or control (Lukas, 2008)
Time cost trade off analysis	Uses critical path analysis to reduce the original project duration as well as other techniques for cost-time optimisation (Elbeltagi, 2012)	This tool can be difficult in determining an optimised equilibrium between cost and time e.g. if schedule is compressed, prediction of total costs increasing or decreasing may be an issue (Abbasnia, et al., 2008).
BIM	Digital system used to construct virtually, in order to save time, cost and reduce waste prior to construction (Mineer, 2015).	Does not solve communication problems in construction and not all are expert in using the system model for effective project delivery (Mineer, 2015).
Milestone	Assists with signaling major events in a project (DSMC, 2001).	Not an accurate portrayal of actual project progress since this tool ignores non-critical activities on the critical path, that could be critical at some point in the project (DSMC, 2001)
LBMS	Useful tool in the tracking of staff and movement of resources on production tasks in scheduling and planning, especially in adopting lean principles of eliminating waste (Shankar and Varghese, 2013).	Does not protect against major delays e.g. bad weather. Also requires a database of the resources and their productivity to be effective (Shankar and Varghese, 2013).

In addition to the above, there are certain clues which indicate when project controls mechanisms are needed (Labi and Moavenzadeh, 2007) for example, in EV, when:

- CV_t is –ve

- CI_t <1

- SV_t is –ve

- SI_t is < 1

However, despite the above, literature reveals that controls only takes place when things **begin** to slip i.e indicators such as the above, however there seems to be no pre-planning of slippages. Where risk management focuses only on the probability of construction risks occurring, this is only one aspect of project controls and there seems to be no evidence of pre-planning of controls for other activities within the project life-cycle.

Therefore, the shortfalls of these tools call for new mechanisms or tools that could be used for project controls to integrate into the project life-cycle. The next section therefore looks into the application of project controls throughout the project life-cycle, in order to effectively integrate such mechanisms.

2.5 Application of Project Controls in the Project Life-Cycle

This section looks to examine the role of project controls throughout the construction project life-cycle as well as discusses the challenges that face its implementation in projects and workplaces.

2.5.1 Application of Project Controls

Where the application of project controls sits in the project life-cycle can vary, depending on the element that requires to be controlled. Figure 4 shows how project controls can play an integral part among different stakeholders in a project.

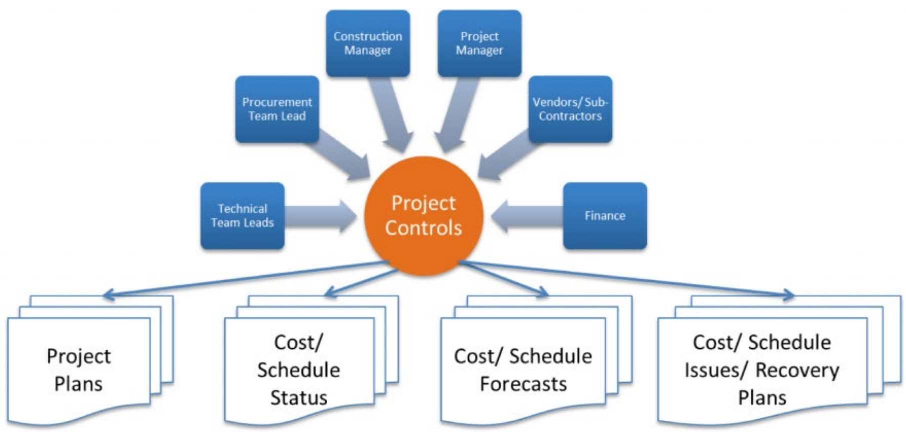

Figure 4. Project Controls among Stakeholders. Source: Ghorbani (2017)

It is often the case that project controls is confused with Project Management, in which the roles overlap somewhat. Literature is contradictory in that there does not seem to be a standardised role descriptor for project controls. For example, according to Hexagon PMM (n.d), they state that where Project Managers are concerned with all aspects of project delivery, including quality, scope, time and cost, project controls on the other hand focuses only on time and cost. This is contradictory to the perspective of the APM Body of Knowledge (PMBOK) who define the role as ten control processes (see Figure 5), of which performance management is a key player in project controls which assumes that project controls has an important input in the quality aspect of projects, and not just time and cost. In addition, the APM model suggests that project control involvement to be either focused within the project and its team members (inner loop) or around multiple projects and outside the project team, throughout the project life cycle (outer loop). Figure 5 below illustrates the applied efforts of project controls in various aspects of the project life-cycle.

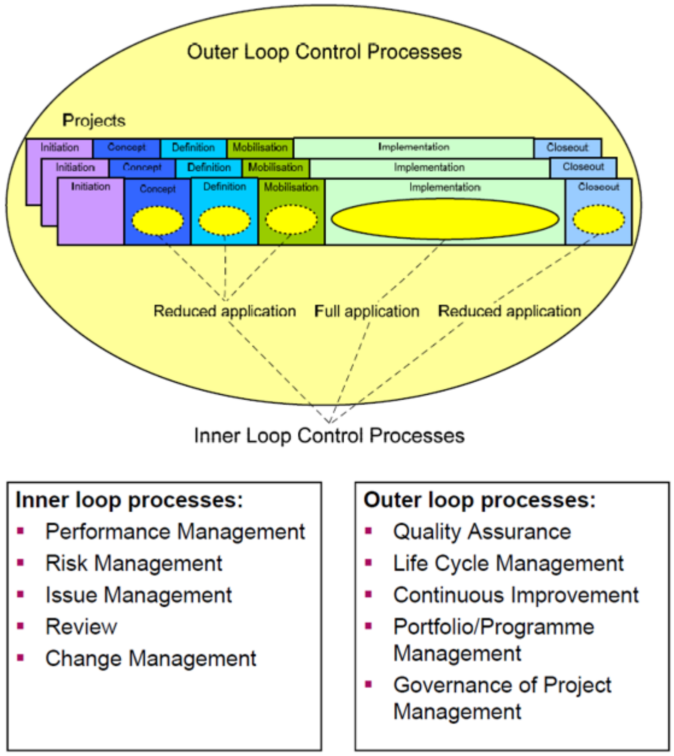

Figure 5. Application of control processes. Source: APM Body of Knowledge (PMBOK)

Consequently, project control activities can be seen as encompassing:

- Project planning, strategies and optimisation of future outcomes
- Scheduling
- Cost estimation, control and value engineering
- Risk management
- Earned Value Management and Earned Schedule, including WBS, OBS and other breakdown structures
- Contract Administration and documentation
- Performance measurement (includes time, cost, quality as well as the measurement of KPIs)
- Elements of project management (Weaver, 2013)

Having said that, according to (Coppa, 2012) it is often the case that project control activities such as the above are classed under non-professional services in contracts which include:

- Cost consultants
- Testing services
- Project administrators
- Inspectors/clerk of the works
- Value engineering services

It is also important to mention that much of the time, clients do not wish to pay for non-professional services and that the costs associated with these services are taken out of the contractor or consultant's profits. However, these roles do play an important part in the maintenance and controls of project delivery in terms of monitoring project time, completion and costs that all work to meet the client's goals and objectives internally (Nikumbh & Pimplikar, 2014). Since this study focuses on the application of project controls in construction projects, project controls activities fit under the category of 'non-professional' services since project controls would be employed in favour of the contractor/consultant and not the client, in order to improve project performance. This however does not mean to say that Project Managers are non-professionals, rather there could be an overarching lap where non-professional services could be adopted by the project team or simply employ non-professional services to carry out such tasks on the behalf of project stakeholders.

2.5.2 Challenges of Project Controls

There are a number of challenges facing project controls. The fast-growing construction industry poses a number of issues with regards to data management and how to make the vast amount of data effective for use in lessons learned. Thus benchmarking against this data makes it difficult to achieve without a solid system in place that allows for key project stakeholders to learn from project mistakes, Ghorbani (2017).

In addition, implementing project controls activities across projects face many barriers (Hexagon PMM, n.d), such as:

1. Lack of commitment and support from senior management
2. Perceived as being high overhead costs (under non-professional contracts)
3. Project controls should be blended harmoniously into the project life-cycle and not at critical points.
4. Perceived as picking on members of the team, rather than assisting to improve project performance
5. Manual and outdated processes preventing the 'controller' from seeing the big picture

Although literature reveals some research around project controls, there however seems to be a gap in research which defines the applied role of the project controls in the various aspects of the project life-cycle, in order to apply effective measures of control on projects. It is important to emphasise that project controls should be consistent and not fragmented i.e. used as needed throughout the project life-cycle, otherwise there may be project implications as the project progresses. This research therefore calls for further research to integrate project controls throughout the project life-cycle, prosing a Smarter/leaner approach to project controls.

This research therefore proposes to develop a smart project controls process for controlling projects throughout the project life-cycle as shown in Figure 6. The research will thus aim to identify the various activity areas that require critical control measures throughout the life-cycle of a project, from pre-contract through to post contract and beyond, and develop Smart/lean mechanisms that would facilitate effective control of the activities identified, whereby the role of the project controls becomes well defined within each stage of the project to ensure more sustainable project outcomes.

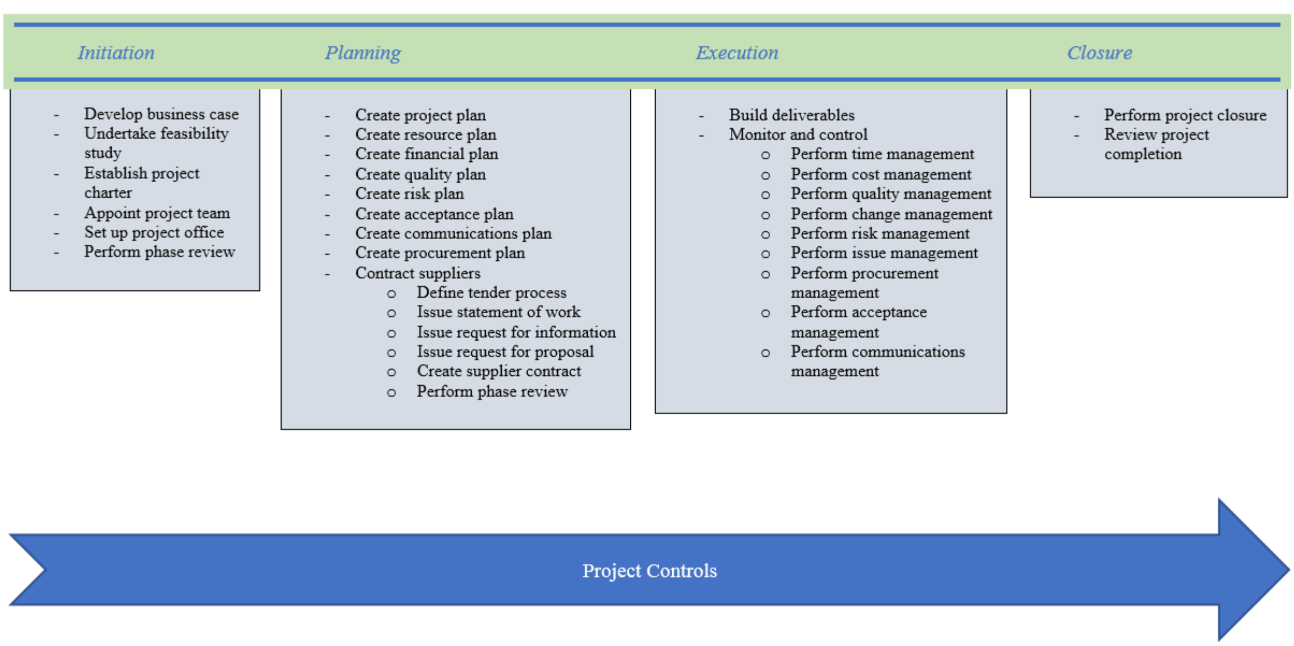

Figure 6. Smart Project Controls Process. Source: author adapted by Method123 (n.d)

3. Summary & Conclusions (Gap)

Taking the above into consideration, little literature reveals details of where project controls lies within the project life-cycle, which could assumes that project controls is simply applied to monitor and control specific aspects of a project, and thus there seems to be no real evidence amongst literature if project control activities do stand as defined valuable inputs amongst projects in the construction industry, although studies suggest many benefits and effects of project controls outcomes on project success.

Thus it is necessary to point out the significance of project controls not just controlling specific aspects of a project, but rather needs to be present in all aspects of the project life-cycle and if attention is given in this aspect, particularly in the initial stages of a project, then there is a higher chance of project success rates. Furthermore, there are critical factors which determine project success and failures, although success and failure factors may be relative in view of the key stakeholders to a project. However, project controls could play an integral part in controlling various aspects of the critical factors for success on projects. Although there are project control mechanisms and tools in place which are used heavily in Project Management and controls, however there are drawbacks which could hint why projects are not as successful as they are. Therefore, there needs to be 'Smarter' or 'leaner' ways of controlling projects, with project controls being required in each aspect of the lifecycle through planning, monitoring and control of each aspect.

Thus, this paper aims to carry out further research in order to develop a decision-based model and framework, which would seek to identify which project controls tools and mechanisms are required and their associated timing in each step of the project life-cycle to assist in contributing to project success.

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Biographies

Heveine Baban has a First-Class BSc in Quantity Surveying from the University of Salford, UK and is a Project Controls Commercial Manager with 6 years' experience working for Jacobs Ltd UK. She has been the point of reference in managing circa 30 Project Managers on the £4.6billion AMP6 United Utilities Framework in the UK, which runs roughly 120-200 projects simultaneously/annually. Within her role, Heveine has experience in the commercial and contract management aspects of NEC3, setting up projects, carrying out monthly applications for payment and has worked to assist numerous Project Managers with their projects, including assistance with forecasting issues and payments. Heveine is currently a PhD student at the Heriot Watt University, Dubai Campus.

Dr. Krisanthi Seneviratne is an Assistant Professor at Heriot Watt University (Dubai Campus). Krisanthi Joined Heriot Watt Dubai Campus in 2014 after completing her PhD at Salford University, UK. She worked on two research projects at Salford University: Royal Foreign and Commonwealth Office funded research project titled 'Conflict Prevention through Infrastructure Reconstruction' and Royal Institution and Chartered Surveyors (RICS) Education Trust funded research project titled 'ISLAND - II'. Krisanthi also a Chartered Member of RICS and Fellow of Higher Education Academy. Krisanthi's current research interests include construction management; sustainable construction; construction procurement and contracts; and construction health and safety. She has published her research related to construction management in numerous conferences and journals. Scopus profile: https://www.scopus.com/authid/detail.uri?authorId=37003053700

Dr. Yasemin Nielsen is an Associate Professor and the Lead of EngD Construction at Heriot Watt University Dubai campus. She has over 25 years of academic and industrial experience. She is currently active in post-graduate education and research. She has supervised over 150 MSc and PhD theses. Her industrial experience includes Sustainability Management positions of some prestigious projects in the UAE. She has collaborated with universities in the US, UK and Turkey as well as with both public and private organizations in funded research projects and organized and chaired international conferences. Her research output includes book chapters, numerous papers in peer-reviewed journals and refereed conferences.