PROJECT SUCCESS CRITERIA, LEVEL OF DIFFICULTY AND PERFORMANCE IN LARGE ENGINEERING PROJECTS

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Abstract
This study examines the level of difficulty and performance in large engineering projects and key stakeholders perception of success criteria. The rationale for this study is that large engineering projects have different stakeholders with conflicting interests which scholars consider as causes of project difficulties. It is however not known whether there is a relationship between important project success criteria and the level of difficulty within large engineering projects in South Africa. The study employed a systematic review of extant literature and a mixed method approach to elicit empirical data from key stakeholders working on a State Owned Company's (SOC) projects in South Africa to achieve the research objectives. The study results established that there is a high level of difficulty encountered by stakeholders on the sites, delays and potential cost overrun. It also emerged that while there is no significant difference in the perception of stakeholders of important project success criteria, there is a significant relationship between quality project success criterion and project difficulty. This knowledge and the findings that the projects procured by the SOC in this study are not at optimal performance levels suggests that the lack of emphasis on quality by the project stakeholders may be responsible for the poor project performance experienced on these projects. This will therefore form the basis of future research in this area of engineering project performance.

Keywords*: Large engineering projects; project difficulty; project management; project performance and project success factors*

INTRODUCTION

According to Lim and Mohammed (1999), project success criteria are a set of principles or standards by which project success is judged. Griffith *et al.* (1999) posit that what makes the concept of project success difficult and complicated in practice is the fact that there is no consensus on how it should be measured, and the unlikelihood of reaching consensus further complicates this issue. Westerveld (2002) concedes that it is impossible to generate a universal checklist of project success criteria for all projects. Project success criteria can therefore be said to be relative. Frödell *et al.* (2008) view that the multitude of ways of measuring success is due to the variety of different perceptions of success depending on each project stakeholder's interests and business goals. Hillman and Klein (2001) opine that it is common for project stakeholders to have conflicting interests, which according to Toor and Ogunlana (2010) have resulted in difficulties for project management teams, who have to satisfy stakeholders and clients by delivering successful projects.

Therefore, this study examines stakeholders' perception of project success criteria on four large infrastructure projects procured by a State Owned Company (SOC) in South Africa and whether there are significant differences in their perception of important success criteria. The rationale for this study is that over the past five years, while the SOC's capital expansion budget has tripled, there have been delays in the planning and construction phases of these construction projects (SOC, 2012). It is however not known what the causes of these delays and poor project performance are. In order to understand the causes of delay in the large engineering projects being procured by the SOC, this study examines whether there is a relationship between project stakeholders' rating of important success

criteria and difficulties experienced in the project construction phase. Kolltveit and Gronhaug (2002) and Liu *et al.* (2012) posit that when large numbers of stakeholders, each with different perspectives of success, disciplines and skilled in a variety of technologies, are engaged on a project, the project becomes complex and hence difficult to manage. In addition, infrastructure projects are complex by nature because they are dynamic and involve many stakeholders. Cooke-Davies (2002) describes complex projects as those that include multiple and interacting relationships. The client, Project Manager (PM), other consultants and contractors, who take part in the execution phase of most construction projects, are the focus of this study.

Research Questions

The research questions addressed are as follows:

a) What is the level of difficulty and performance achieved on large engineering projects?
b) How do stakeholders on large engineering projects perceive project success?
c) To what extent do the rating of project success criteria differ among the various stakeholders on large engineering projects?
d) What is the relationship between the rating of important project success criteria and difficulty/performance experienced on large engineering projects?

Hypotheses of the Study

The following hypotheses were proposed to guide the direction of the study:

$H1_A$: There is significantr difference in the rating of important Project Success Criteria (PSC) by project stakeholders in large engineering projects; and

$H2_A$: There is a significant relationship between project stakeholders' rating of important success criteria and difficulties experienced in the construction phase of the SOC projects studied and that this is responsible for the poor performance (delays) experienced.

Structure of the Paper

The first part of this paper presents the review of extant literature on project success criteria within the construction industry. The second section presents the concept of the study. The following section appraises the research methodology, stakeholders and the large engineering projects used in the study. Thereafter, the paper outlines the results of an empirical survey examining the important project success criteria, level of project difficulty and performance of four large engineering projects undertaken by an SOC in South Africa. Finally, the paper discusses the implications of the results for improving the management and future performance of large engineering projects.

PROJECT SUCCESS CRITERIA (PSC) OBTAINED FROM LITERATURE

PSC can constitute a significant advantage through their effect on project management and project success, provided, there is agreement, proper identification and planning of project success related issues (PMI, 2008). Toor and Ogunlana (2010) note that construction projects are slowly moving away from traditional measures (Iron Triangle of time, cost and quality) towards a mix of qualitative and quantitative measures as Project Success Indicators (PSI) for large-scale public sector development projects.

Wang and Huang (2006) added two success criteria to the Iron triangle: the relationships amongst stakeholders, and overall success. On the relationship aspect, Wang and Huang (2006) emphasise the importance of the quality of good relationships amongst the key stakeholders (Project Sponsor, Client and Construction Contractor), which will never be easy to achieve and maintain, particularly in complex construction projects. They view that this will also add complexity to the management of the project due to the difference in stakeholders' success perspectives. According to Wang and Huang (2006), the relationship amongst the main Stakeholders in China is the most important determinant of

overall project success rate. Wang and Huang (2006) further suggest that key stakeholders can be integrated into a big project team and the Project Manager (PM) should pay more attention to the interests consistent among them (common ground), and not just to the conflicts in their interests. Abdullah and Ramly (2006) conclude that overall stakeholder appreciation (satisfaction) of the project is the major determinant of project success, as this would have the advantage of the stakeholders being prepared to overlook schedule and cost over-runs and other requirements.

Shenhar *et al.* (1997) introduced four dimensions of project success namely: project efficiency (meeting schedule and budget goals), impact on the customer (meeting functional performance and technical specifications, fulfilling customer needs, solving a customer's problem since the customer is using the product, and customer satisfaction), business success (commercial success and creating a large market share), and preparing for the future (creating a new market, creating a new product line and developing new technology). Shenhar *et al.* (1997) did not explicitly include health and safety (HS) and environmental sustainability in these dimensions but it can be assumed that these would be part of fulfilling customer needs (impact on the customer). The selected factors shown in Table 1 cover the most relevant literature on PSC. These are further detailed below.

Table 1: Project Success Criteria obtained from Literature Sources (arranged from the most to the least cited criteria)

Project Success Criteria	**Authors**															
	De Wit (1988)	Shenhar et al. (1997)	Songer et al. (1997)	Lim & Mohamed (1999)	Atkinson (1999)	Shenhar et al. (2001)	Chan et al. (2001)	Chan (2002)	Westerveld (2002)	Bryde & Robinson (2005)	Abdullah & Ramly (2006)	Wang & Huang (2006)	Lam et al. (2007)	Muller & Turner (2007)	Frödell et al. (2008)	Toor & Ogunlana (2010)
On time completion	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
User satisfaction	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔		✔
Quality	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔	✔
Client satisfaction	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔		✔
Within Budget	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔
Stakeholders' satisfaction	✔	✔		✔	✔	✔	✔	✔	✔		✔	✔	✔	✔		✔
Project team satisfaction	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔		✔	✔		✔
Meeting design goals	✔	✔	✔	✔	✔		✔	✔		✔			✔	✔		✔
Profitability		✔		✔	✔	✔	✔	✔	✔		✔	✔			✔	
Organisational benefit				✔	✔	✔		✔	✔				✔	✔		
Future potential		✔		✔		✔	✔	✔							✔	
Fewer disputes			✔				✔	✔	✔				✔			✔
Environmental sustainability					✔		✔	✔					✔			
Health & Safety				✔									✔			✔

Client Satisfaction

An overview of the literature presented in Table 1 highlights client satisfaction as one of the key measures of project success. According to De Wit (1988), client satisfaction is amongst the six success criteria most frequently used in measuring success on construction projects. Shenhar *et al.* (1997) posit that other PSCs have an impact on client satis-

faction, such as meeting the project specifications and quality standards. Client satisfaction is composed of four factors namely: fulfilling client needs, solving major operational problems, the use of the product by the customer and the level of customer satisfaction (Shenhar *et al.,* 1997). Chan *et al.* (2001) point out that these subjective issues form the basis for meeting client's expectations. While Rad (2003) states that clients place a lot of value on their satisfaction when procuring projects, Belassi & Tukel (1996) posit that quality and client satisfaction are the most significant measures of project success. Thus, according to Chan (2002), in addition to meeting the traditional PSC, there should be a high level of client satisfaction.

User and Stakeholder Satisfaction

Scholars also view user and stakeholder satisfaction as one of the key measures of project success. According to Chan *et al.* (2001), project users include third parties such as operators, plant engineers and the client. Users need to be happy with the project, the functionality of the end product, and the project outcomes (Westerveld, 2002) and they need to derive benefit from the project (Atkinson, 1999). According to Lim and Mohamed (1999), the higher the level of user satisfaction, the higher the level of the perceived project success and users also look at project success at a macro level. The view of De Wit (1988) in his investigation into project success is a narrower one, while he recognises the organisational role in achieving project success, Westerveld (2002) takes a broader view but still with his focus being within the Stakeholder community and their appreciation of the project.

On-Time Project Completion

On time completion criteria serves as a holistic measurement of performance according to schedule duration (Cox *et al.,* 2003). Atkinson (1999) opines that timely project completion is more crucial to project success than any other success criteria. In a related study conducted in Thailand, Toor and Ogunlana (2010) found that timely completion of projects carried more weight than other success criteria. Their study revealed that while project stakeholders tend to differ on how to measure project success using other criterion, they unanimously agreed on timely project completion.

Within Budget

According to Lam *et al.* (2007), project stakeholders use cost as a measure of success due to the interrelationship between time and cost. However, while Atkinson (1999) posits that in projects where money is the major constraint, finishing the project within budget is an overriding criterion for measuring success, Frödell *et al.* (2008) view that exceeding the budget may not necessarily be a bad thing, especially if it results in increased profitability.

Quality

Quality is described as the degree to which a set of inherent characteristics fulfills requirements (PMI, 2008) and it is also subjective (Chan, 2001). While Atkinson (1999) sees quality as an overriding criterion above all the other criteria, including cost and time, and linked to the organizational benefits of meeting project goals and functional specifications, Chan (2002) sees it as fundamental to the overall success of a project. Shenhar *et al.* (2001) also view quality as a customer benefit, one of the PSCs that the construction project must meet. Poor project quality according to Toor and Ogunlana (2010) can result in construction delays, disputes and conflicts.

RESEARCH METHODS

This study is premised on the objectivist philosophy and paradigm (Perry, 1998; Noor, 2008). The approach used to collect, assess and analyze the data is both quantitative and qualitative or a mixed method approach because the study seeks to understand the perception of project stakeholders on the level of project difficulty, rating of important PSC and

to measure project performance quantitatively. An exploratory case study research design was used in achieving the project objectives. Data was collected in the study using multiple sources of evidence: documentation, archival records, interviews and direct observation, a process known as Construct Validity (Yin, 1994). Using multiple sources of data is also referred to as Data Source Triangulation (Yin, 1993).

The SOC studied was established by the government of the Cape in 1928 with the purpose of creating an enabling environment for the development and sustainability of the economy through energy supply. Over the last decade, SOC has embarked on capital expansion projects by constructing vast new infrastructure so as to meet its objectives of rising to the challenges of the growing South African economy. SOC is considered to be a suitable setting for this research for the following reasons: (a) it is engaged in construction projects, which are intended to benefit the public; (b) its performance can be used to benchmark other SOC construction projects; and (c) the construction projects undertaken is unequalled in terms of values for the past five decades in South Africa.

The sample for the study was drawn using a purposive sampling technique (Noor, 2008) from a population of construction project practitioners (SOC Management, Funding Organisation, Project/Contracts Managers, Project Supervisors, Contractor Site Managers, Construction Managers, Project Sponsors and Project Support Managers) working on the SOC's four large engineering project sites. The purposive sampling technique was used because the knowledge of the project operations was not normally distributed within the target population. These construction project practitioners were perceived to be able to contribute valuable information to the research. The list of construction project practitioners to be interviewed was obtained from the SOC database, with the exception of the contractor's staff that was randomly selected on each site. Questionnaires were self-administered to 92 selected construction project practitioners from July 2012 to January 2013 (a six month period). To obtain information on the level of project difficulty, the stakeholders were requested to rank the projects on a five-point likert scale of perceived difficulty, where 1 = none and 5 = extreme. Descriptive statistics including the Mean Item Score (MIS) were used in analyzing and rating the data obtained from the questionnaires and interviews so as to establish common trends and differences amongst the respondents on each project site.

In addition, inferential statistics such as the Kruskal-Wallis test (k) and the Spearman rank correlation coefficient test (rho) were used in determining whether there are significant differences in the perception of the project stakeholders regarding important PSC and whether there is a relationship between PSCs and difficulty experienced on project sites. The research findings were limited by the following: (a) the exact project costs could not be revealed by the SOC because of confidentiality reasons; (b) the construction sites were far apart in terms of distance (minimum 400 km); and (c) available archived records and company documentation were not sufficiently explicit and comprehensive in providing details of the existing project performance indicators.

RESULTS AND DISCUSSION OF FINDINGS

Data collected from the survey conducted within the SOC four project sites are presented in the following sections:

Distribution of Stakeholders by Project and Groups

Table 2 shows the distribution of the respondents in the study by project and stakeholder group.

Table 2: Distribution of Respondents by Project and Group

Stakeholder Group	Engineering Project Sites				Total	Percentage (%)
	1	2	3	4		
Project Supervisors	10	9	10	10	39	42.4

Project Managers	4	4	4	4	16	17.4
Contractor representatives	2	3	2	3	10	10.9
Client (SOC)	2	2	3	3	10	10.9
Consultants	2	2	3	2	9	9.8
Project Sponsor/Financier	1	2	2	3	8	8.7
Total	**21**	**22**	**24**	**25**	**92**	**100**

Table 2 shows that the highest number of respondents by group is the project supervision team, which comprises of engineers and project managers who oversee the construction of large engineering projects on behalf of the client. Designated project managers who are in charge of the individual project sites and who are employees of the SOC constitute the second highest respondents in the study. Table 2 also reveals that the highest number of respondents was from Site 4 followed by Sites 3, 2 and 1 respectively.

Difficulty and Performance achieved on SOC Large Engineering Project Sites

The study sought to know the perceived level of difficulty encountered by the project stakeholders. The data collected in this regard is presented in Table 3.

Table 3: Level of Difficulty encountered by Project Stakeholders on Construction Sites

Stakeholder Group	Level of difficulty: 1=none; 5=extreme					MIS	Rank
	1	**2**	**3**	**4**	**5**		
Contractor Representatives	0	0	1	5	4	0.86	1
Client (SOC)	0	0	2	5	3	0.82	2
Consultants	0	0	1	6	2	0.82	2
Project Managers	0	2	2	5	6	0.80	4
Project Supervisors	1	2	8	17	11	0.78	5
Project Sponsor / Financier	0	0	1	6	0	0.77	6

Table 3 shows that the level of project difficulty on the project sites is extreme. From a ranking perspective, the contractors are experiencing more difficulty than the other project stakeholders. The client, other consultants and project managers also encountered extreme difficulty on the project sites. The types of difficulties encountered according to the project managers are caused by project stakeholder differences, disputes and disagreements and these results in work stoppages and delays of at least a week in most cases.

Secondary data were also used in evaluating the level of performance of the SOC projects. Performance of these projects is viewed in objective terms of both financial - cost and non-financial – time. The cost and time performance of the SOC projects studied are presented in Table 4.

Table 4: Quantitative Level of Project Performance

Sites	**Overall Budget (Billions of Rand)**	**Expenditure (B' Rands)**		**Percentage Completion**	
		Budget	**Actual**	**Planned**	**Actual**
1	180	12.3	0.8	N/A	7.0
2	310	53.6	48.5	32.5	17.6
3	425	76.9	79.1	61	52
4	518	85.9	74.8	59.4	52

Table 4 shows that while Sites 2 and 3 are not operating within budget, Sites 1 and 4 are still operating within the budget allocated. It also emerged that these projects are at different stages of completion with Site 3 being at the most advanced stage of completion and Site 1 still to take-off. Table 4 also reveals that there will be a need to extend the budget allocation made to Site 3, and that the target completion time on all these SOC

project sites has not been met. Site 2 emerged as the worst site in terms of time performance followed by Site 3.

Stakeholders Rating of Important Project Success Criteria (PSC)

The study sought to know the importance ascribed to the PSC identified in literature by the stakeholders and whether there is a significant difference in stakeholders' rating of the PSC ($H1_A$). Data collected in this regard is presented in Table 5. Project stakeholders are grouped together in Table 5 according to the classification of Wang and Huang (2006) who emphasise the importance of the quality of good relationships among the key stakeholders (project sponsor, client and construction contractor). Table 5 shows that the PSC are rated fairly high by the stakeholders in the construction projects studied. It also emerged that from a ranking perspective, the respondents view cost as an overiding criterion above the other criteria of time and quality. User/stakeholder and client satisfaction although important, were rated the least by the respondents.

Table 5: Important Success Promoting Factors Used by Stakeholders on Sites

Project Success Criteria	Project Stakeholders			Overall MIS	Rank
	Project Mgt Team & Consultants	Client & Project sponsor	Contractor		
Cost	0.994	1.00	1.00	0.996	1
Time	0.997	1.00	1.00	0.989	2
Quallity	0.981	0.989	1.00	0.985	3
User/Stakeholder satisfaction	0.870	0.889	0.84	0.868	4
Client satisfaction	0.794	0.863	0.78	0.815	5
Kruskal-Wallis Test (K) = - 1.06					

Furthermore, Table 5 reveals that there is no significant difference in the way project success criteria are rated among the respondents when grouped according to supervision (project supervisors, project managers and consultants), customer (client and project sponsor) and service provider (contractor). The hypothesis ($H1_A$) is tested using Kruskal-Wallis (K) test. It emerged from the test that the calculated value of K (-1.06) is less than the tabulated value of χ^2, the sample lies within the acceptance region, so the hypothesis that there is no difference in stakeholder rating of important PSC is accepted.

Relationship between Project Success Criteria and Project Difficulty

The study sought to test the hypothesis ($H2_A$) that there is no significant relationship between project stakeholders' rating of important success criteria and difficulties experienced in the construction phase of the SOC projects studied. Data presented in Tables 3 and 5 were further analysed using the Spearman Correlation Coefficient (rho). Results of this analysis are presented in Table 6.

Table 6: Test for relationship between Project Succes Criteria and Project Difficulty

	Project Success Criteria				
Project Difficulty	Cost	Time	Quality	Stakeholder Satisfaction	Client Satisfaction
Correlation Coefficient	0.833	0.500	0.949*	-0.316	-0.632
Significant (2-tailed)	0.083	0.250	0.026	0.342	0.184

*Correlation is significant at 0.05 level (2-tailed)

Based on the results presented in Table 6, the hypothesis that there is no sigmificant relationship between project stakeholders' rating of quality and difficulties experienced in the construction phase of the SOC projects studied is rejected. It can be concluded therefore that there is a relationship between project stakeholders' rating of quality and project difficulty, while there is no relationship between project difficulty and the other PSC – cost, time, stakeholder/client satisfaction .

DISCUSSION OF FINDINGS

The data collected in this study does not support the view that there are significant differences in the rating of important project success criteria between the stakeholder groups working on the four SOC projects studied. Contrary to the view of scholars such as Hillman and Klein (2001), Wang and Huang (2006) and Toor and Ogunlana (2010), this study discovered that there is no significant difference in how project stakeholders rate important success criteria. Perhaps, this can be attributed to the fact that the SOC is experienced in implementing large construction projects and it has in place documented procedures, standards and processes which it uses on its projects and hands these out to its employees and service providers to use as reference in project implementation.

However it emerged that the level of importance attributed to project quality is related to project difficulties. The level of project difficulty established is aligned to previous studies by Kolltveit and Gronhaug (2002) and Liu *et al.* (2012) who posit that large projects are complex and hence difficult to manage because they involve a large numbers of stakeholders, each with different perspectives of success, disciplines and skill in a variety of technologies. The cause of the project difficulty in this study is narrower and attributable to quality and its level of importance among the stakeholders. The difference lies in how quality is rated. According to the findings, cost, time and quality are the top criteria used by stakeholders in measuring project success however, quality has a lower rating among project supervision and client teams than among the contracting team. This may be because these large contractors are at a higher level of project management maturity than the project supervision team engaged to manage the billion Rands projects and this creates disparities in terms of understanding project issues and meeting quality requirements. The poor performance on project sites 2, 3 and 4 (see Table 4) especially in terms of all the project sites being behind schedule may be as a result of these differences in quality issues. According to the project managers interviewed, the extreme difficulties experienced on the projects result in work stoppages of more than a week in very extreme cases and delays.

The data collected has not confirmed that differences exist in stakeholders rating of PSC on the construction projects studied due to similarities in the level of importance of these factors by stakeholders within and between the SOC sites. However, the difficulties and poor project performance witnessed on these sites may be attributed to the stakeholders varying perception of project quality requirements, which is not the top overall criterion among the project stakeholders. The quality criterion which involves both objective and subjective issues are project and stakeholder dependent. Conflicts, disputes and project delays are caused by differing stakeholder perception of important criteria because more time will be spent discussing and resolving them, creating a burden for the project management team and increasing the risk of delay in completion.

CONCLUSION

This study examined project success criteria used in large engineering projects procured by an SOC in South Africa. The study made use of literature and empirical survey in achieving its objectives. PSC which are found to be relevant to the current environment of the SOC are mostly established by De Wit (1988) Shenhar *et al.* (1997), Songer *et al.* (1997), Lim and Mohomed (1999), Atkinson (1999), Chan *et al.* (2001), Chan (2002), Westerveld (2002), Bryde and Robinson (2005), Abdullah and Ramly (2006), Wang and Huang (2006), Lam *et al.* (2007), Muller and Turner (2007), Frödell *et al.* (2008) and Toor and Ogunlana (2010). The study established that there is significant relationship between project quality and the levels of project difficulty experienced on the projects and this may have influenced the poor levels of performance in terms of cost and time attained on the projects.

Based on these findings, the study concludes that the delays and poor performance recorded in SOC projects are as a result of the variation in importance placed on the quality criterion by the project stakeholders. It is recommended that the SOC works towards developing a clear comprehensive, agreed upon project quality criteria as supported by Lam *et al.* (2007), which may improve the overall performance of construction projects procured. These criteria may also be used on other projects and industry sectors. However, further studies will need to be undertaken to establish the important quality metrics used on construction projects and whether these differ among project stakeholders.

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