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From the next issue the editorial address is Dr Abel Usoro, School of Computing, University of Paisley PA1 2BE; tel (+44) 141 848 3959; fax (+44) 141 848 3542, e-mail: cis@uws.ac.uk or abel.usoro@uws.ac.uk.

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An ELECTRE Approach for Solving Personnel Training Selection Problem

Mohamed F. El-Santawy

Department of Operations Research
Institute of Statistical Studies and Research (ISSR)
Cairo University, Egypt
E-mail: lost_zola@yahoo.com

Abstract: An adequate personnel training have a dramatic effect on improving the employees’ performance, which will be reflected on the growth and competence of the whole organization, especially in large-size and multinational companies and organizations. Training and education are designed to meet personal needs for knowledge, talents, and skills, as well as the organization’s need for qualified personnel. In this article the Elimination Et Choice in Translating to REality (ELECTRE) method is adopted to solve a Multi Criteria Decision Making real-life problem which existed in an international company.

Keywords: ELECTRE; Multi-Criteria Decision Making; Outranking Methods; Personnel.

1. Introduction

Over the last three decades a large body of research in the field of ELECTRE family methods has appeared. This research has been conducted by several researchers mainly in Europe. The ELECTRE method has several unique features not found in other solution methods; these are the concepts of outranking, indifference and preference thresholds. It takes into account the uncertainty and vagueness in the decision process.

Personnel training process is very crucial in developing organizations. It implies more than one dimension to be optimized (El-Santawy, 2012a). Many conflicting criteria should be considered when comparing alternatives to choose among or rank them (El-Santawy, 2009). There is high interest in analyzing the criteria of selecting personnel for training as well as their educational services provided locally or in other countries (El-Santawy, 2011).

MCDM includes many solution techniques such as Simple Additive Weighting (SAW), Weighting Product (WP) (Hwang, 1981), and Analytic Hierarchy Process (AHP) (Saaty, 1980). The personnel selection problem, from the multi-criteria perspective, has attracted the interest of many scholars as in El-Santawy (2012b) and Saremi (2009). In this paper the ELECTRE method, a branch of MCDM methods, is applied to rank the candidates for an international course of one year duration provided by an international company to its employees. This paper is structured as following: section 2 is made for the ELECTRE method; section 3 is devoted to the case study of the personnel training problem; and finally in section 4 conclusion is presented.

2. ELECTRE

A MCDM problem can be concisely expressed in a matrix format, in which columns indicate criteria (attributes) considered in a given problem; and in which rows list the competing alternatives as shown in Eq. (1):

\[ D = \begin{bmatrix} C_1 & C_2 & C_3 & \cdots & C_n \\ A_1 & x_{11} & x_{12} & x_{13} & \cdots & x_{1n} \\ A_2 & x_{21} & x_{22} & x_{23} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ A_m & x_{m1} & x_{m2} & x_{m3} & \cdots & x_{mn} \end{bmatrix} \]

Specifically, a MCDM problem with \( m \) alternatives (\( A_1, A_2, \ldots, A_m \)) that are evaluated by \( n \) criteria (\( C_1, C_2, \ldots, C_n \)) can be viewed as a geometric system with \( m \) points in an \( n \)-dimensional space. An element \( x_{ij} \) of the matrix indicates the performance rating of the \( i^{th} \) alternative \( A_i \), with respect to the \( j^{th} \) criterion \( C_j \) (El-Santawy et al., 2012).
For most ELECTRE methods, there are two main stages. These are the construction of the outranking relations and the exploitation of these relations to get the final ranking of the alternatives. Different ELECTRE methods may be different in how they define the outranking relations between alternatives and how they apply these relations to get the final ranking of the alternatives.

The ELECTRE methods are based on the evaluation of two indices, the concordance index and the discordance index, defined for each pair of alternatives. The concordance index for a pair of alternatives \( a \) and \( b \) measures the strength of the hypothesis that alternative \( a \) is at least as good as alternative \( b \). The discordance index measures the strength of evidence against this hypothesis (Belton and Stewart, 2001). There are no unique measures of concordance and discordance indices. In ELECTRE II, the concordance index \( C(a, b) \) for each pair of alternatives \( (a, b) \) is defined as follows:

\[
C(a, b) = \frac{\sum_{i \in Q(a, b)} w_i}{\sum_{i=1}^{m} w_i},
\]

where \( Q(a, b) \) is the set of criteria for which \( a \) is equal or preferred to (i.e., at least as good as) \( b \), and \( w_i \) is the weight of the \( i^{th} \) criterion.

The discordance index \( D(a, b) \) for each pair of alternatives \( (a, b) \) is defined as follows:

\[
D(a, b) = \frac{\max_i [g_i(b) - g_i(a)]}{\delta},
\]

where \( g_i(a) \) represents the performance of alternative \( a \) in terms of criterion \( C_i \), \( g_i(b) \) represents the performance of alternative \( b \) in terms of criterion \( C_i \), and \( \delta = \max_i |g_i(b) - g_i(a)| \) (i.e., the maximum difference on any criterion).

After computing the concordance and discordance indices for each pair of alternatives, two types of outranking relations are built by comparing these indices with two pairs of threshold values: \((C^*, D^*)\) and \((C^-, D^-)\). The pair \((C^*, D^*)\) is defined as the concordance and discordance thresholds for the strong outranking relation and the pair \((C^-, D^-)\) is defined as the thresholds for the weak outranking relation where \(C^* > C^-\) and \(D^* < D^-\). Next, the outranking relations are built according to the following two rules:

1. If \( C(a, b) \geq C^*, D(a, b) \leq D^* \) and \( C(a, b) \geq C(b, a) \), then alternative \( a \) is regarded as strongly outranking alternative \( b \).
2. If \( C(a, b) \geq C^-, D(a, b) \leq D^- \) and \( C(a, b) \geq C(b, a) \), then alternative \( a \) is regarded as weakly outranking alternative \( b \).

The values of \((C^*, D^*)\) and \((C^-, D^-)\) are decided by the decision makers for a particular outranking relation (Belton and Stewart, 2001).

3. Case Study

A multi-national company is willing to select one employee from its personnel to join a two-year course provided by one of its suppliers in Europe. The company restricted the selection to middle management in the technical support department found in the whole company branches and offices. After many procedures and tests, five candidates were eligible to have the opportunity of the course. The multi-national company Human Resources department then specified seven criteria to compare the five candidates and put them through many tests in order to select only one. The process of ranking the five candidates in order to select optimally one is a typical MCDM problem (El-Santawy and Ahmed, 2012a).

The Human Resources department set two exams to the five candidates; first, the fluency in the foreign language test was set to be out of 100 points; and second, computer skills test including basic programming concepts to be out of 20 points. \( C_1 \) is set to be the experience years in the relevant field; \( C_2 \) is the number of years passed by the candidate inside the company.

\( C_3 \) and \( C_4 \) are the grades obtained by each candidate in the two exams set by Human Resources department. \( C_5 \) is set to describe the general health status of the candidate by having some medical checks and tests on a scale from 1 to 9; \( C_6 \) is the average points attained by the candidate on the performance assessment annual report during the last 5 years; finally \( C_7 \) is the education background including the graduation, postgraduate studies, and certificates relevant to the course provided (El-Santawy and Ahmed, 2012b).

The points are given by the Human Resources department to each candidate. Table 1 shows the seven criteria, and their computation units.

| Table 1: Criteria and their computation units |
The human resources department presented the data included in decision matrix found in Table 2 showing the performance ratings with respect to all criteria and their relevant weights assigned by the management. For simplicity, every candidate is indexed by the term CANDn, where n is the serial number of the candidate.

The management assigned the following values of \( C^* = 0.5 \), \( C^- = 0.3 \), \( D^* = 0.4 \) and \( D^- = 0.15 \). According to these two pairs of thresholds and the two rules mentioned before, the outranking relations' matrix is shown in Table 5.

### Table 2: Decision matrix and relevant weights

<table>
<thead>
<tr>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>C6</th>
<th>C7</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAND1</td>
<td>7</td>
<td>83</td>
<td>8</td>
<td>70</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td>CAND2</td>
<td>7</td>
<td>78</td>
<td>7</td>
<td>82</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>CAND3</td>
<td>9</td>
<td>90</td>
<td>8</td>
<td>95</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>CAND4</td>
<td>6</td>
<td>80</td>
<td>6</td>
<td>72</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>CAND5</td>
<td>5</td>
<td>88</td>
<td>6</td>
<td>74</td>
<td>10</td>
<td>12</td>
</tr>
</tbody>
</table>

### Table 3: Concordance matrix

<table>
<thead>
<tr>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>C6</th>
<th>C7</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAND1</td>
<td>1</td>
<td>0.529</td>
<td>0.265</td>
<td>0.59</td>
<td>0.477</td>
<td></td>
</tr>
<tr>
<td>CAND2</td>
<td>0.683</td>
<td>1</td>
<td>0.306</td>
<td>0.803</td>
<td>0.948</td>
<td></td>
</tr>
<tr>
<td>CAND3</td>
<td>0.855</td>
<td>0.694</td>
<td>1</td>
<td>0.755</td>
<td>0.839</td>
<td></td>
</tr>
<tr>
<td>CAND4</td>
<td>0.41</td>
<td>0.197</td>
<td>0.245</td>
<td>1</td>
<td>0.577</td>
<td></td>
</tr>
</tbody>
</table>

### Table 4: Discordance matrix

<table>
<thead>
<tr>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>C6</th>
<th>C7</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAND1</td>
<td>0</td>
<td>0.48</td>
<td>1</td>
<td>0.16</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>CAND2</td>
<td>0.2</td>
<td>0</td>
<td>0.52</td>
<td>0.08</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>CAND3</td>
<td>0.24</td>
<td>0.4</td>
<td>0</td>
<td>0.16</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>CAND4</td>
<td>0.16</td>
<td>0.4</td>
<td>0.92</td>
<td>0</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>CAND5</td>
<td>0.32</td>
<td>0.32</td>
<td>0.84</td>
<td>0.24</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

By applying the procedures of the ELECTRE method previously discussed, the concordance and discordance indices are computed based on Eqs (2 and 3) as shown before. Then, the concordance and discordance relations between the alternatives are shown in Tables 3 and 4, respectively.

In the above notation \( S^F \) stands for the strong outranking relation. For example, \( CAND1 S^F CAND4 \) means that alternative \( CAND1 \) strongly outranks alternative \( CAND4 \).

On the basis of the outranking relations, the complete pre-order of the alternatives will be: \( CAND3 > CAND2 > CAND5 > CAND1 > CAND4 \) and obviously \( CAND3 \) is the optimal candidate at this point to be chosen for the course.

### 4. Conclusion

The ELECTRE method is firstly introduced to solve a real-life personnel selection training MCDM problem. The MCDM should be reformulated and solved if any parameter or alternative is added or deleted because of the sensitivity of MCDM problems to any changes.

### References

Belton, V. and Stewart T. J. (2001), Multiple Criteria Decision Analysis: An Integrated


Usability in Ensuring a Successful Post Implementation Adoption of Cloud Enterprise Resource Planning Systems: A Proposed Research

Onome Mac-Anigboro and Abel Usoro
School of Engineering and Science
University of the West of Scotland (UWS)
United Kingdom
E-mail: onome.mac-anigboro@uws.ac.uk and abel.usoro@uws.ac.uk

Abstract: In recent years, there have been many studies on Cloud ERP along with the benefits and problems associated with adoption but very few delved deeper into how to resolve these problems. Despite the assumed improved usability cloud ERP provides, there are still concerns on the user acceptance of Cloud ERP. This paper presents existing studies and points out areas for further investigation especially the investigation of the usability issues of Cloud ERP.

Keywords: Cloud, ERP, cloud computing, usability

1. Introduction

Technology is fast becoming the means by which organisations improve performance, and minimise operational costs (Beheshi and Beheshti 2010). It enables these organisations to compete on a level ground against larger firms (Ozcan 1995: 38). Cloud Enterprise Resource Planning (ERP) system is an emerging computing concept which is currently being adopted by more industries. It is based on three existing technologies, namely grid computing, virtualisation and the internet.

The current economic recession and technological advancements have culminated in further strengthening the adoption of Cloud ERP systems. This is especially more so as organisations strive to keep costs to a minimum while maintaining competitive advantage. By subscribing to a service provider, organisations are able to minimise overhead costs, and no longer need to invest in specialist software. It provides simplified software management and improves performance levels. Cloud ERP systems also provide a pay-per-use payment method, which has made more organisations more willing to adopt this technology.

The ease of deployment makes this application more attractive to organisations, as installations and upgrades are handled by the service providers. With more enterprise resource planning vendors offering Cloud solutions, more organisations are beginning to consider and even implement these solutions in a bid to offer better customer relationships, gain new markets and increase profits.

However, despite these immense benefits organisations still struggle with ensuring a smooth transition from manual systems to an automated system. A task heightened by the fact that Cloud ERP systems are often hosted by a vendor in a different location. This leads to limited physical interaction between the vendor and the end user. By focusing on automating processes and refining existing technology, the human element is slowly being eroded and organisations are limited on their ability to adapt their Cloud ERP systems to their business needs.

These cloud based ERP systems are unable to meet the demands for major functional customization on these hosted systems (Johansson et al., 2014). Scavo et al(2012) in an article for the Computer Economics Report pointed out that the Cloud ERP systems are not functionally competent enough to “satisfy the back-office needs of organizations in every type of industry”. There is therefore the need for new and innovative platforms to handle the diversity and complexity of today’s business solutions.

There have been many research in the field of ERP, most of which are concerned with the issues surrounding the adoption and
implementation of ERP systems, very few go on to discuss the user interactions with the system. It has been deduced by a number of researchers (e.g. Topi, Lucas and Babaian, 2005; Oja and Lucas, 2011; Lambeck et al., 2014; Wong, Veneziano and Mahmud, 2015) that the main problem associated with the user interface of ERP systems is its complexity. As a result of insufficient research in ERP usability, an adequate solution to this problem has not yet been proposed. The subsequent sections will present existing work and point out areas for further research before concluding.

2. Related Work

In their review, Salleh, Teoh and Chan (2012) deduced that academia and industry have different understanding of Cloud ERP but both sides failed to provide an adequate definition of the term. Even with this, it is safe to say it is undisputed that Cloud ERP is coined from both ERP systems and Cloud Computing.

2.1 ERP Systems

Over the years, there has been several definitions of ERP with each definition a little less complex than the next. We can therefore assume people are developing a better understanding of ERP. Shehab et al., (2004) define ERP as a business management system that comprises integrated sets of comprehensive software, which can be used, when successfully implemented, to manage and integrate all the business functions within an organisation. Enterprise Resource Planning (ERP) systems are commercial-off-the-shelf (COTS) packages which enable organisations to integrate information systems to maintain competitive advantage (Vilpola et al 2007; Rashmi et al 2008). Addo-Tenkorang and Helo (2011) define it as enterprise information systems which integrate and optimise business processes in an organisation. Bhattacharyya and Dan (2014) defined ERP as a software architecture that facilitates the flow of information among the different functions within an enterprise.

Through the technology Material Requirement Planning Systems (MRP), ERP functionalities can be traced to as far back as the 1960s (Amar, Vasileios and Achilles, 2013; Parthasarathy, 2013; Chen, 2010). In the 1990s, ERP manifested from a version of MRP termed MRP II (Amar, Vasileios and Achilles, 2013; Chen,2010) and became official. According to Sridharan and Lawrence Laforge (2000), ERP is essential for the ever changing business needs and was easily transitioned from MRP II because the activities of MRP are closely related to
various business functions such as finance, marketing, human resource management, operations and engineering.

With the ERP systems, organisations have to deal with hosting the physical infrastructure therefore having quick access to facilities during downtime, maintaining the infrastructure and all

around implementation challenges Duan et al (2014). Organisations are always looking for ways to stand out and have competitive advantage over other businesses. Therefore, ERP vendors are continually putting out offers to facilitate organisations’ competitive edge. This is where Cloud ERP comes in.

Figure 2: 2010 Gartner hype cycle (Source: Hobson, 2010)

2.2 Cloud Computing

Before discussing Cloud ERP, we first have to look at Cloud Computing. Though the Cloud is a relatively new concept in computing, it has played and continues to play a major role in the evolution of technology in the world today and organisations are showing great interest in the promise of Cloud Computing.

In 2011, the National Institute of Standards and Technology (NIST) defined Cloud computing as “a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction” (Mell and Grance 2011, p 2).

In an attempt to differentiate between Clouds and Cloud Services, McKinsey & Company (2009) came up with three characteristics of a Cloud which are as follows:

1) Hardware management is highly abstracted from the buyer
2) Buyers incur infrastructure costs as variable Operational Expenditure (OPEX)
3) Infrastructure capacity is highly elastic (up or down)

The characteristics are the major difference between a Cloud Service (e.g. Gmail) and a Cloud (e.g. Amazon web services). Cloud Services exhibit just two (1, 3) whereas Clouds exhibit all the three characteristics.

The benefits of cloud computing are exponential ranging from the lower start-up cost for businesses, on demand access to resources, lower operating cost, scalability (Avram, 2014) to so many other benefits but there are also major concerns that arise with cloud computing such as
data confidentiality and security, reliability, business continuity, service availability, and interoperability (Avram, 2014; Armbrust et al., 2010) and so on.

Because of the Cloud component of Cloud ERP, these issues are very similar to Cloud ERP and will be discussed further in this paper. Figures 1 to 4 depict the Gartner IT hype cycle, highlighting four years of a seven year period, showing the progression of Cloud Computing.

2.3 Cloud ERP

Unlike traditional ERP systems, Cloud ERP isolates the need to own the infrastructure to
achieve a desired level of performance (Elfatatry and Layzell, 2002; Addo-Tenkorang and Helo, 2011). It involves enabling consumers to utilise applications running on cloud infrastructure (Zissis and Lekkas 2012).

Software-as-a-Service is a new technique of computing infrastructure which is currently transforming organisations around the world (CIO 2008). Its focus is on the separation of software ownership from its use (Turner et al 2003).

Cloud ERP inherited many of the qualities and characteristics of both cloud computing and ERP and also share in some of their advantages and disadvantages.

Huang et al (2009) attributed improvements in business processes and increases in organisation’s value to ERP systems. It is therefore an important element of the infrastructure of modern businesses in aiding the organisation attain competitive advantage in a digitally empowered environment (Damirchi and Rahimi 2011). ERP systems support efficient operations of business processes thereby making the organisation more competitive (Monk and Wagner 2009, p 17). The integration of disparate business functions, and exchange of data and information across various divisions are promoted (Metaxiotis, 2009; Maguire et al, 2010). Thus as information is shared, the organisation becomes more flexible and performs more efficiently and effectively (Maguire et al 2010).

Since the inception of ERP, research in this field has focused least on the user interface of ERP systems. Even with the little though significant research that has been carried out with relation to human-computer interaction in ERP, the research has focused mainly on the user involvement with the system rather than the usability barriers associated with the system (Lambeck et al., 2014). There are a few shortcomings associated with ERP user interface. These shortcomings may vary from over complexity of the system, inadequate functionality to poor graphical user interface (Lambeck et al., 2014).

Thus, as this application gains popularity and more organisations consider the adoption of Cloud ERP systems, there is a need for organisations to take into consideration both the shortfalls and advantages of the Cloud ERP.

### 3. Features of Cloud ERP

Table 1 below denotes work done on the advantages and disadvantages of Cloud ERP and the sources used in this review. Table 3.2 shows the key benefits of Cloud ERP identified from the reviewed literature.

<table>
<thead>
<tr>
<th>S/N</th>
<th>Authors</th>
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<th>Year</th>
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<td>2</td>
<td>Duan, J., Faker, P., Fesak, A. and Stuart, T.</td>
<td>Benefits and drawbacks of cloud-based versus traditional ERP systems</td>
<td>2014</td>
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<tr>
<td>3</td>
<td>Alajbegovic, A., Alexopoulos, V. and Desalermos, A.</td>
<td>Factors Influencing Cloud ERP Adoption: A Comparison Between SMEs and Large Companies.</td>
<td>2013</td>
</tr>
<tr>
<td>Benefit</td>
<td>Description</td>
<td>Sources</td>
<td></td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------</td>
<td></td>
</tr>
<tr>
<td>Reduced start-up cost</td>
<td>Businesses have the opportunity to adopt ERP systems at a much lower cost, especially SMEs, because they do not have to worry about user licenses, hardware and any other expenses that results from implementing ERP systems.</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 10</td>
<td></td>
</tr>
<tr>
<td>Reduced operating costs</td>
<td>Cloud ERP helps with operating cost reduction as there will be no need for maintenance, upgrades or cost of employee to handle the system.</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 10</td>
<td></td>
</tr>
<tr>
<td>Speedy implementation</td>
<td>With Cloud ERP, implementation is much faster than with traditional ERP as organisations deal with the actual deployment.</td>
<td>1, 2, 3, 4, 5, 6, 8, 10</td>
<td></td>
</tr>
<tr>
<td>Scalability</td>
<td>Cloud ERP can easily change with the business conditions without organisations being directly concerned with how flexible they make their business needs.</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 10</td>
<td></td>
</tr>
<tr>
<td>Focus on core competencies</td>
<td>Since organisations do not have to worry about managing their ERP, they can focus all that resources to other areas of the business.</td>
<td>2, 3, 4, 5, 6, 8</td>
<td></td>
</tr>
<tr>
<td>Access to advanced technology</td>
<td>Organisations especially SMEs have easier access to more advanced technology which they may otherwise not be able afford because it’s up to the Cloud ERP vendors to provide an advanced system.</td>
<td>2, 3, 4, 5, 6, 8</td>
<td></td>
</tr>
<tr>
<td>Faster updates and upgrades</td>
<td>Any update and upgrade that the organisation requires will be done a lot quicker with Cloud ERP.</td>
<td>2, 3, 4, 5, 6, 8, 10</td>
<td></td>
</tr>
<tr>
<td>Improved accessibility, mobility, and usability</td>
<td>Even though Cloud ERP inherits most of the features of traditional ERP, it has a better usability and user friendliness.</td>
<td>1, 2, 3, 4, 5, 6, 7, 10</td>
<td></td>
</tr>
<tr>
<td>Easier integration with cloud services</td>
<td>Integration with other cloud services is a lot less complicated with Cloud ERP.</td>
<td>2, 3, 5, 9</td>
<td></td>
</tr>
<tr>
<td>Improved system availability and disaster recovery</td>
<td>In cases of system failures, backups and recoveries are a lot easier since the system is stored outside the organisation.</td>
<td>2, 3, 4, 5, 9</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Benefits of Cloud ERP

Note: The numbers matches the serial numbers of the articles in table 1
<table>
<thead>
<tr>
<th>Shortcomings</th>
<th>Description</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subscription expenses</td>
<td>Though subscription fees are a lot less than the start-up cost of conventional ERP, overtime the subscription can only increase unlike the start-up cost that is a one off expense.</td>
<td>2, 9</td>
</tr>
<tr>
<td>Security risk</td>
<td>Organisations are concerned about how secure their data is and who really has access to them. This is more of a concern for larger companies than SMEs.</td>
<td>1, 2, 3, 4, 5, 6, 8, 9, 10</td>
</tr>
<tr>
<td>Limitation on hybrid deployment strategy</td>
<td>Cloud ERP is not so flexible when it comes to retaining or merging in-house systems.</td>
<td>2, 4, 5, 6, 8, 9</td>
</tr>
<tr>
<td>SLA issues</td>
<td>The SLA agreement is usually not comprehensive enough to state who bears the liability for damage or cover issues of confidentiality.</td>
<td>1, 2, 4, 9</td>
</tr>
<tr>
<td>Performance risks</td>
<td>Organisations have no control over or alternatives system failures/downtime as they have no direct access. And cases where the provider goes bankrupt, organisations are completely helpless.</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>Functionality limitations</td>
<td>Because the ERP system is not physical, organisations are concerned that the Cloud ERP may not be able to fully cater for back office operations.</td>
<td>2, 5, 8, 9</td>
</tr>
<tr>
<td>Customization and integration limitations</td>
<td>The Cloud ERP is customised in a standard manner whereby the functionalities meet a general business requirement and it is a major constraints for Cloud ERP providers to integrate Cloud ERP with in-house systems. Organisations are unsure if they can switch between Cloud ERP providers.</td>
<td>1, 2, 3, 4, 5, 8, 9, 10</td>
</tr>
<tr>
<td>Vendor Dependency</td>
<td>Organisations are concerned that they are unable to easily migrate from one provider to the other when they find their unsatisfied with their current provider. Therefore increasing the company’s strategic risks by being tied down to a specific vendor.</td>
<td>1, 2, 3, 4, 5, 8, 9, 10</td>
</tr>
<tr>
<td>Compliance risks</td>
<td>It is difficult for Cloud ERP generally to comply with data, power and environment standards and regulations as the physical system may be located at any part of the world. For instance certain data might be kept offshore which may be against law especially if the location of the physical system is not disclosed by the provider.</td>
<td>1, 2, 3, 5, 10</td>
</tr>
<tr>
<td>Loss of IT competencies</td>
<td>Because everything about the ERP system is being handled by the provider, there is a deficiency in innovation when it comes to ERP system.</td>
<td>2, 4</td>
</tr>
<tr>
<td>Maturity</td>
<td>Because of the newness of Cloud ERP, researchers feel the system is not mature enough to cater for all ERP responsibilities like that of traditional ERP</td>
<td>10</td>
</tr>
<tr>
<td>Ownership of data and control</td>
<td>Because the ERP system is owned by the vendor so also is the data stored on the system. Organisations worry about how these data are used and who has control over them. In terms of development, organisations have to move with the pace of the vendor. Whether they are not ready for such progress or they want to move faster is non-essential as they have no control.</td>
<td>1, 3, 4, 8, 10</td>
</tr>
<tr>
<td>Resistance to change</td>
<td>Most organisations are unwilling to try new technology because they are either too comfortable with the current system (traditional ERP) or do not want to deal with the uncertainties of this new advancement.</td>
<td>3, 8, 9, 10</td>
</tr>
<tr>
<td>System reliability</td>
<td>There are concerns to how reliable Cloud ERP systems are. How much downtime will they incur and the guarantee of adequate recovery when the</td>
<td>2, 4, 5, 10</td>
</tr>
</tbody>
</table>
system fails.

<table>
<thead>
<tr>
<th>Latency and Network Limits</th>
<th>There is a potential issue of a limitation in the speed and reliability of the network.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Scalable Storage</td>
<td>Storage facilities cannot be enlarged at will by the organisation.</td>
</tr>
</tbody>
</table>

Note: The numbers matches the serial numbers of the articles in table 1

4. Areas for further investigation

Since the inception of Cloud ERP, there has been a limited body of academic research done. Many of the existing researches have addressed the advantages of Cloud ERP over the traditional ERP and the reason for the rapid adoption of this technology. Though Cloud ERP has proved quite beneficial, the shortcomings need to be tackled to ease adoption decision. Many of the Cloud ERP researchers have suggested an investigation into the suitability of Cloud ERP for different sizes of businesses (Duan et al 2014).

Compared to the complexity of conventional ERP system interface, Cloud ERPs interfaces are friendlier and more interactive but according to Elragal and El Kommos (2012) further investigation is required into determining the quality and user acceptance of the system in post-live implementation, hence the foundation of this study. Because Cloud ERP systems are standardised to cater to a wide range of users, the system is unable to support all users’ needs for fear of the system becoming complex (Mijač, Picek and Stapić, 2013). Scavo et al. (2012), cited in Duan et al. (2014) observed that Cloud ERP may be functionally incapable of meeting the back end needs of all types of industries due to its immaturity.

5. Conclusion

Because of the relatively new nature of Cloud ERP, there have not been much research in this field and further investigation is definitely required. The focus area for this research is the usability of the Cloud ERP system. Does the functionality of Cloud ERP really not satisfy all kinds of business? Is the quality of the system accepted by the users and what can be done to improve the usability in Cloud ERP?

This research will not be restricted to a specific industry in order to obtain a noteworthy result. Most of the reviewed research papers discuss more on the sources of challenges in Cloud ERP and less of a proposed solution. This study will determine if there is truly a cause for concern when it comes to usability of Cloud ERP and if there are issues with the usability what can be done to improve this. If this study proves successful, Cloud ERP would be able to overcome one of its substantial stumbling blocks therefore increasing adoption and shifting focus to other barriers.

References


A CV-COPRAS Approach for Solving Multi-Criteria Decision Making Problems

Mohamed F. El-Santawy
Department of Operations Research
Institute of Statistical Studies and Research (ISSR)
Cairo University, Egypt
E-mail: lost_zola@yahoo.com

Abstract: Multi-criteria decision making (MCDM) methods can select the best solution from several alternatives. Each candidate solution has multiple attributes with different effects; each attribute is relevant to some criterion. The technique used in this paper named COMplex PRoportional ASsessment (COPRAS) is combined to the Coefficient of Variation (CV) to constitute a new approach called CV-COPRAS. The Coefficient of Variation (CV) is employed to allocate weights when no preference existed among the criteria considered. Also, a given numerical example is solved to illustrate the proposed method.

Keywords: COPRAS; Coefficient of Variation; Multi-Criteria Decision Making.

1. Introduction

Multi-Criteria analysis, often called Multi-Criteria Decision-Making (MCDM) or Multi-Criteria Decision Aid methods (MCDA), is a branch of a general class of Operations Research (OR) models which deal with the process of making decisions in the presence of multiple objectives (El-Santawy et al., 2012). These methods, which can handle both quantitative and qualitative criteria, share the common characteristics of conflict among criteria, incommensurable units, and difficulties in design/selection of alternatives (El-Santawy, 2009).

In the context of Multi Criteria Decision Making (MCDM) field, we might find many solution techniques to solve such problems which involve many conflicting attributes. The merit of MCDM techniques is that they consider both qualitative parameters as well as the quantitative ones; MCDM includes many solution techniques such as Simple Additive Weighting (SAW), Weighting Product (WP), Analytic Hierarchy Process (AHP), TOPSIS (El-Santawy, 2012a), and VIKOR (El-Santawy, 2012b; El-Santawy and Ahmed, 2012a; El-Santawy and Ahmed, 2012c).

In probability theory and statistics, the coefficient of variation (CV) is a normalized measure of dispersion of a probability distribution. In this paper, we try to tackle the problem of the preference absence among criteria, by using the Coefficient of Variation (CV) statistical measure. First, the weights are assigned to criteria by using CV method. Then, the alternatives are ranked by the COPRAS method. The rest of the paper is structured as following: in section 2 the COPRAS method is illustrated, section 3 is made for the Coefficient of Variation method, a numerical example is presented in section 4, and finally section 5 is for conclusion.

2. COPRAS

A MCDM problem can be concisely expressed in a matrix format, in which columns indicate criteria (attributes) considered in a given problem; and in which rows list the competing alternatives. Specifically, a MCDM problem with m alternatives (A₁, A₂, ..., Aₘ) that are evaluated by n criteria (C₁, C₂, ..., Cₙ) can be viewed as a geometric system with m points in an n-dimensional space (El-Santawy, 2011). An element xₘᵢ of the matrix indicates the performance rating of the i-th alternative Ai with respect to the j-th criterion Cj, as shown in Eq. (1):

\[
\begin{bmatrix}
C₁ & C₂ & C₃ & \cdots & Cₙ \\
A₁ & x₁₁ & x₁₂ & x₁₃ & \cdots & x₁ₙ \\
A₂ & x₂₁ & x₂₂ & x₂₃ & \cdots & x₂ₙ \\
\vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\
Aₘ & xₘ₁ & xₘ₂ & xₘ₃ & \cdots & xₘₙ
\end{bmatrix}
\]

The COPRAS (COMplex PRoportional ASsessment) method is presented by Zavadskas and Kaklauskas (Zavadskas et al., 1994).
Description of COPRAS methods and possibilities of its application are published in a large number of papers (Zavadskas et al., 2001; Vilutiene and Zavadskas, 2003; Zavadskas et al., 2004; Kaklauskas et al., 2005; Kaklauskas et al., 2006; Zavadskas et al., 2008; El-Santawy and Mohamed, 2014). The determination of significance and priority of alternatives, by using COPRAS method, can be expressed concisely using four stages (Ustinovichius et al., 2007; Viteikiene and Zavadskas, 2007):

**Step 1.** Normalize the Decision matrix \( D \) using the following formula:

\[
\tilde{x}_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}
\]

where \( x_{ij} \) is the performance of the \( i \)th alternative with respect to the \( j \)th criterion, \( \tilde{x}_{ij} \) is its normalized value, and \( m \) is number of alternatives.

**Step 2.** Calculate the weighted normalized sums for each alternative:

\[
S_{+i} = \sum_{j=1}^{k} \tilde{x}_{ij} \cdot q_j
\]

\[
S_{-i} = \sum_{j=k+1}^{n} \tilde{x}_{ij} \cdot q_j
\]

where \( k \) is number of maximizing criteria; \( n \) is total number of criteria; \( q_j \) is significance of the \( j \)th criterion; \( S_{+i} \) is sum of maximizing attributes (optimization direction is maximization), and \( S_{-i} \) is sum of minimizing attributes (optimization direction is minimization). In order to simplify calculation of \( S_{+i} \) and \( S_{-i} \) in the decision-making matrix, columns first of all are placed maximizing criteria and then minimizing criteria.

**Step 3.** Calculate the relative weight of each alternative \( Q_i \):

\[
Q_i = S_{+i} + \frac{\sum_{i=1}^{m} S_{-i}}{S_{-i}} \frac{\min_i S_{-i}}{\sum_{i=1}^{m} S_{-i} - \min S_{-i}}
\]

Eq. (5) can also be written in simplified form as follows:

\[
Q_i = S_{+i} + \frac{\sum_{i=1}^{m} S_{-i}}{S_{-i} \sum_{i=1}^{m} S_{-i}}
\]

**Step 4.** Determine the priority order of alternatives:

\[
A^* = \left\{ A \mid \max_i Q_i \right\}
\]

The alternative with higher relative weight has higher priority (rank), and the alternative with the highest relative weight is the most acceptable alternative.

3. Coefficient of Variation

The weight of the criterion reflects its importance in MCDM. In this paper, a new method is proposed to allocate weights in MCDM problems with no preference. The new method relies on the well known Coefficient of Variation (CV) to allocate the weights of different criteria (El-Santawy and Ahmed, 2012b). Range standardization was done to transform different scales and units among various criteria into common measurable units in order to compare their weights.

\[
D' = (x')_{max}
\]

\[
d_{ij} = \frac{x_{ij} - \min_{1 \leq j \leq n} x_{ij}}{\max_{1 \leq j \leq n} x_{ij} - \min_{1 \leq j \leq n} x_{ij}}
\]

\[
\sigma_j = \sqrt{\frac{1}{m} \sum_{i=1}^{m} (x_{ij} - \bar{x}_j)^2}
\]

where \( \bar{x}_j \) is the mean of the values of the \( j \)th criterion after normalization and \( j = 1, 2, \ldots, n \). After calculating \( \sigma_j \) for all criteria, the (CV) of the criterion \( (j) \) will be as shown in Eq. (10)
The weight \( W_j \) of the criterion \( j \) can be defined as

\[
W_j = \frac{CV_j}{\sum_{j=1}^{n} CV_j}
\]

(11)

where \( j = 1, 2, ..., n \).

4. Illustrative Example

An example of six alternatives to be ranked through comparing five criteria is presented in order to explain the approach proposed. As shown in Table 1, the six alternatives and their performance ratings with respect to all criteria are presented. The first three criteria are from the maximization utility type (the maximum is better) while the fourth and fifth criteria are minimization type.

<table>
<thead>
<tr>
<th>Criteria Utility type</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alt. 1</td>
<td>50</td>
<td>5</td>
<td>45</td>
<td>65</td>
<td>856</td>
</tr>
<tr>
<td>Alt. 2</td>
<td>32</td>
<td>8</td>
<td>60</td>
<td>70</td>
<td>1120</td>
</tr>
<tr>
<td>Alt. 3</td>
<td>69</td>
<td>2</td>
<td>30</td>
<td>58</td>
<td>1356</td>
</tr>
<tr>
<td>Alt. 4</td>
<td>54</td>
<td>7</td>
<td>86</td>
<td>82</td>
<td>1589</td>
</tr>
<tr>
<td>Alt. 5</td>
<td>70</td>
<td>6</td>
<td>75</td>
<td>35</td>
<td>659</td>
</tr>
<tr>
<td>Alt. 6</td>
<td>92</td>
<td>1</td>
<td>62</td>
<td>22</td>
<td>724</td>
</tr>
</tbody>
</table>

Table 3 shows the values of Mean \( \bar{x}_j \), Standard Deviation \( \sigma_j \), the Coefficient of Variation \( CV_j \), and the weight assigned to each criterion \( W_j \) as shown in Eqs. (9-11).

<table>
<thead>
<tr>
<th>( x_j )</th>
<th>( \sigma_j )</th>
<th>( CV_j )</th>
<th>Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>0.4861</td>
<td>0.3429</td>
<td>0.7055</td>
</tr>
<tr>
<td>C2</td>
<td>0.5476</td>
<td>0.3981</td>
<td>0.7270</td>
</tr>
<tr>
<td>C3</td>
<td>0.5298</td>
<td>0.3598</td>
<td>0.6791</td>
</tr>
<tr>
<td>C4</td>
<td>0.5556</td>
<td>0.3765</td>
<td>0.6777</td>
</tr>
<tr>
<td>C5</td>
<td>0.4211</td>
<td>0.3982</td>
<td>0.9456</td>
</tr>
</tbody>
</table>

After deriving weights, the final rank of alternatives can be attained by applying the procedures of COPRAS method. The values of \( S_{+i} \), \( S_{-i} \) and \( Q_i \) values are shown in Table 4.

<table>
<thead>
<tr>
<th>Rank</th>
<th>( S_{+i} )</th>
<th>( S_{-i} )</th>
<th>( Q_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0.082247</td>
<td>0.0698</td>
<td>0.148738</td>
</tr>
<tr>
<td>4</td>
<td>0.100775</td>
<td>0.0831</td>
<td>0.156609</td>
</tr>
<tr>
<td>6</td>
<td>0.064234</td>
<td>0.086</td>
<td>0.181166</td>
</tr>
<tr>
<td>3</td>
<td>0.118599</td>
<td>0.1085</td>
<td>0.161377</td>
</tr>
<tr>
<td>1</td>
<td>0.114522</td>
<td>0.0455</td>
<td>0.216445</td>
</tr>
<tr>
<td>2</td>
<td>0.085622</td>
<td>0.0411</td>
<td>0.198665</td>
</tr>
</tbody>
</table>

5. Conclusion

In this paper, the CV-COPRAS proposed approach is presented and illustrated. The new method employed the Coefficient of Variation to allocate the weights in MCDM problems. The proposed approach is illustrated by solving a numerical example, showing its efficiency. The COPRAS method is preferred to other additive techniques due to its ability to overcome limitations found in other techniques like Simple Additive Weighting (SAW) technique.

References


Beyond the Iron Triangle: Evaluating Aspects of Success and Failure using a Project Status Model

Malcolm Bronte-Stewart
School of Engineering and Computing
University of the West of Scotland (UWS)
United Kingdom
E-mail: malcolm.bronte-stewart@uws.ac.uk

Abstract: In the field of project management, time, cost and output are three fundamental factors that have been used to judge whether a project may be considered a success or a failure. The project management "Iron Triangle" has been used as a way to represent and highlight the connection between these three factors. Although the Iron Triangle can provide a useful tool for discussing the inevitable compromises inherent in most projects, especially when deciding constraints and objectives, it can be criticised. It is suggested here that the Iron Triangle model represents a limited view of project perspectives since it only focuses on three aspects, it ignores many of the more subjective and context specific issues and it fails to take into account important success criteria relating to emergent properties of what is produced by the project. A project may fail time, cost and output specifications yet be a success in the long run as far as the customer or the public are concerned. Conversely, a project may keep within these three constraints but be seen as a waste of time, money and effort. In this paper the author examines some famous project examples and discusses the difference between project success and product success. It is suggested that it would be beneficial to go beyond short term measurements such as meeting price, duration and specified requirements targets to include a wider range of indicators such as: benefits realization, risk management, stakeholder views, process simplification and efficiency, team performance, methodology issues and lessons learnt. Arguments are made for the establishment of a set of evaluation factors and the Project Status Model (PSM) is presented as a powerful way of analysing and illustrating these project assessments. The PSM offers a clear, visual way of displaying aspects of projects’ current and historic success and/or failure from a number of viewpoints.

Keywords: Project success; Project failure; Iron Triangle; Project Status Model.

1. Introduction

This paper begins by exploring briefly the apparent frequency and cost of problematic projects. It suggests that attempts to categorise a project as either a success or a failure are often simplistic and misleading. Using examples, it discusses notions of project success and failure, comments on various qualitative aspects of assessing success and failure and recommends a technique for visualising key success criteria at important stages of a project.

2. Background

For many years, surveys, research and government reports show that, judged against time, cost and scope criteria, many projects seem to go wrong. ICT projects in particular are prone to failure with rates as high as 80% being suggested by many researchers (Clegg et al, 1997; Keil et al, 1998; The Register, 2002; BCS, 2004; McManus and Wood-Harper, 2008; Savolainen et al, 2012). These reports tend to classify the outcome of the projects they sampled under two headings, success or failure. Such decisions are usually determined by reference to three factors, sometimes described as "the iron triangle" of project management, namely time, cost and output (Atkinson, 1999; Barnes, 2006). In other words many influential surveys on project performance categorise a project as a failure if it runs over schedule and / or over budget and / or does not meet the original specification (and sometimes client expectations). This paper will discuss reasons why this type of crude analysis may be short-sighted, unfair, deceptive and vague. Examples of some famous projects are used to highlight issues. The paper suggests a broader and potentially more insightful approach to analysing
project outcomes and presents a Project Status Model (PSM).

3. The Extent and Costs of Project Failure

Much has been written about the extent, causes and costs of project failure. For example numerous studies have claimed that the majority of ICT projects are not successful and the finger of blame has been pointed at a variety of critical success factors such as: project leadership and management, organisational culture and structure, commitment and patterns of belief, user involvement and training, developer expertise, technology planning, scope and objectives setting, estimation and choice/use of methodology, (NAO, 2006; Sauer, Gemino and Reich, 2007; ICACA, 2008; Verner et al., 2008; Hashmi, 2009; Bronte-Stewart, 2009; The Standish Group, 2013; Stoica and Brouse, 2013; Cui and Loch, 2014).

While it is difficult to find reliable data about the costs of project failure it is apparent that a lot of time and money is spent on ICT and a great deal of this is considered to be wasted (BCS, 2004; Telegraph 2005; McManus and Wood-Harper, 2008). The PMI (2014) reports that organisations are losing an average of between $109m and $135m for every $1 billion spent on projects. Sessions (2009) attempted to develop a model for calculating the total global cost of IT failure based on assumptions about the percentage of projects that are late, go over-budget, or do not deliver the expected results. He concluded that ICT failure costs the global economy $6.2 trillion per year. Krigsman (2012) suggests that there are flaws in Sessions' calculations and revises the global economic impact of ICT project failure down to around $3 trillion. Michaels (2007) comments that no-one can be certain of the actual cost of failed software projects, but he estimates that in the United States of America alone re-work and abandoned systems cost $75bn a year.

Costs of failure are not limited to narrow considerations of budget and schedule. Perceptions of poor success rates and wasted resources affect decision making. The more projects are seen to go wrong the more the public learns to expect problems and delays, the more business people are nervous of change, the more developers may think that much of their work is likely to be a waste of effort, the more those holding the purse strings may view any innovative project as too risky. Users may fear and be hostile to change and disruption. Staff can become cynical and may lose goodwill (Kendrick, 2015). For all these reasons careful consideration should be given before pronouncements are made about project failure. A broader view is likely to highlight richer aspects of success and failure in any project. It is argued here that more should be done to reduce the incidence and effects of project failure and to encourage analysis of project outcomes including lessons learned.

4. Definitions of a Project

To be successful, organisations must not only maintain current operations, but also transform processes and products in order to improve and survive in the future. They must consider and plan how changes can be introduced to best effect. Projects introduce change. This paper will discuss notions of project success and failure. To gain a better understanding of the meaning of project success and failure it may be useful to begin by reviewing authoritative statements about their nature and purpose. The following definitions are provided by four respected project management standards organisations.

PRINCE2 (2009) “A project is a temporary organisation that is created for the purpose of delivering one or more business products according to an agreed Business Case.”

PMI PMBOK (2013) “A project is a temporary endeavour undertaken to create a unique product, service or result.”

APM BOK (2012) “A project is a unique, transient endeavour, undertaken to achieve planned objectives, which could be defined in terms of outputs, outcomes and benefits. A project is usually deemed to be a success if it achieves the objectives according to their acceptance criteria within an agreed timescale and budget.”

BS6079: (2010) “A unique set of coordinated activities, with definite starting and finishing points, undertaken by an individual or organisation to meet specific performance objectives within defined schedule, cost and performance parameters.”

While there are some similarities, different stances and views are displayed by these
definitions. The definitions seem to agree that projects are temporary, unique and involve the achievement of objectives or creation of end-products. PRINCE2 stands apart because it defines a project as an organisation delivering (a) product(s) or end result; whereas the other three refer to endeavours or activities. The project’s business case is clearly of primary importance in PRINCE2 and this emphasis is consistent throughout the stages and principles of the PRINCE2 methodology. The APM and the BS6079 seem to regard iron triangle parameters as important enough to include in the definition.

5. The Iron Triangle

In many cases the answers to three questions have been used to determine if a project is a success or a failure soon after its closure. Was it on schedule, within budget and was the delivered product to specification? Traditionally, if the answer to any of these tests is no then the whole project may be branded as a failure (even though it passes the other two). The three factors (Figure 1) have been called “the Iron Triangle of project management” because they are so strongly integrated (Oisen, 1971; Barnes, 1988; Weaver, 2007).

Whilst the three constraints are relevant to aspects of project management success, the implications of the way the triangle of factors interact is not intuitive (Weaver, 2012). For example, output is connected inversely to the other two dimensions: less output may be bad, but less time or cost is potentially good. Increases in scope are likely to increase time and cost but increases in cost and / or timescale may not be directly related to scope. Attempts to reduce a project’s duration may increase its cost and decrease its scope. Cutting a project’s budget, even by a small percentage, can have a disproportionate effect on its scope and timescale.

Doubling a project's budget is unlikely to halve its duration. Despite these issues, the model does provide a vehicle for investigating and addressing project priorities, conflicts and compromises. For example, positioning the blue circle (in Figure 1) at different places inside the triangle of the model can be used as a representation to assist discussion of the relative importance of different factors and their dependencies. In this case if the priority is to keep costs down there may need to be reductions in scope and increased allowance of time.

Many software developers have agreed with this combination of criteria for measuring aspects of project success (Lai, 1997; Atkinson, 1999; Yeo, 2002; Jugdev & Muller, 2005; Kappelman et al, 2006; Sumner et al., 2006; Lock, 2007; El Emam and Koru, 2008; Anda et al., 2009; Savolainen et al, 2012). This may be one of the reasons why so many IT projects are judged as failures. Atkinson (1999) says "Could it be the reason some project management is labelled as having failed results from the criteria used as a measure of success?" Using time, cost and scope as the only criteria or aspects to investigate when assessing project success is bound to bias what could be a broader and more rounded process of evaluation (Pinto & Slevin, 1988; Turner, 1993; Maylor, 2010; De Bakker et al., 2010)

Another potential problem with the iron triangle is that the emphasis on time, cost and scope may be said to relate to the narrow perspective of the project management team being appraised on their ability to deliver to these criteria (Wateridge, 1998). Several authors (De Wit, 1988, Munns and Bjermi, 1996; Baccarini, 1999; Cooke-Davies, 2002; Dvir et al, 2003) have pointed out the difference between achieving project product success (measured against the realised benefits of the project) and managing the project successfully (measured against the three iron triangle constraints). One looks at deliverables, the other at process. For example, the first generation of the Ford Taurus was such a business success it became the best-selling car in America in the late 1980s, but the project manager was sacked because the project was 3 months late. The second generation Ford Taurus met all three iron triangle constraints but was a business failure (Shenhar, 2004).

6. Visualizing Project Status

We have noted that one of the failings of the iron triangle is that it does not show overall project
status. Distorting the triangle (figure 2) might provide a very simple representation of actual status against plan estimates but this would only be a weak illustration of the complexity of success and failure. While certain techniques and diagrams (e.g.: Gantt charts that display progress against schedule plan; BCWP and ACWS variance relative to BCWS calculations and graphs that show financial status information; a product status matrix that shows progress of deliverables), help to demonstrate aspects of a project’s lifecycle, it could be more useful if, to allow comparisons and analysis of relationships, these important aspects could be displayed side by side. This type of display could be especially useful if the information was included within a more comprehensive project status model that captured some of the other status information that should be tracked throughout, for example illustrations of: benefits, risk status, stakeholder acceptance and the project quality plan.

We can use the Scottish Parliament Building project as an example to illustrate the first part of the proposed Project Status Model, (Figure 3) the Iron Triangle factors. The cost to construct the Scottish Parliament building was initially estimated at around £40m in 1997, however actual costs rose to over £400m. The project was well over budget and schedule and (because it was not finished properly) below specification. The project became infamous. “Even by the standards of some of this country's most notorious high-profile construction projects, the cost overruns of the Scottish parliament building in Edinburgh are pretty spectacular. The Millennium Dome, where costs rose by 90% from first approval to completion, now seems almost a model of budgetary accuracy by comparison. Likewise even with the new Wembley, which is set to cost 240% of its original estimate. On Cardiff Bay, the Welsh assembly chamber is being built for 400% of the original estimated cost. Holyrood, though, dwarfs them all.” (The Guardian, 2003)

Figure 3: The first three parts of a Project Status Model

Figure 3 shows time, cost and scope factors as individual quantities and displays aspects of project management performance in relation to original estimates and plans. This PSM shows the extent to which the Scottish Parliament Building project failed all three of the criteria. The left side of the model provides a scale so that each factor or criteria can be represented as a percentage of the size or quantity noted in the plan. The central horizontal axis is the zero (or 100%) line. Histogram bars that extend above this line display the extent to which certain factors are / were more than planned. Bars that extend downwards, below the line, indicate aspects or factors that are below forecast and symbolise how far below plan they were. The model can be used to evaluate, compare and explain views of project status.

While the Scottish Parliament building project may be regarded by many as a spectacular failure, other projects are less easy to classify. Defining and assessing project success should be part of strategic management and help to align project efforts with the aims of the organisation. Collins and Baccarini (2004) suggest that “There appears an urgent need to educate the project management community that there is more to project success than just meeting time, cost and quality objectives.”

7. Investigating and Evaluating Notions of Success and Failure

The iron triangle’s three constraints pay little attention to the broader assumptions and complexity that underlie notions of success and
failure. The next section discusses views of these concepts.

Projects are often defined as having particular characteristics (PMBOK, 2013; APM, 2015; PRINCE2, 2009; Nicholas & Steyn, 2012). A project is likely to:

- be a unique set of coordinated activities, a one-off programme,
- have underlying principles and assumptions, and an overall purpose
- have a few, clear, specific objectives,
- have a life-cycle, usually categorized into manageable stages,
- have an identifiable start and end,
- have defined budget, schedule and performance parameters,
- organize and use many resources that may also be needed on other projects, and
- need a special team of people.

These guidelines help to distinguish projects from ordinary, business-as-usual, routine operations. Despite the apparent clarity of these characteristics, defining success or failure for projects can be problematic (Oakes, 2006; Standing et al. 2006). For example a project may keep within set budget and time scales, meet the specification criteria, yet fail to provide benefits or be out of date when delivered. The operation was a success but the patient died. On the other hand a project may over-run time and financial constraints due to increases in scope and / or requirements creep but still produce a worthwhile delivered result. Is it reasonable or correct to judge these amended projects by the constraints set in the original terms of reference?

Table 1 illustrates part of the complexity. If just four criteria, the iron triangle and an overall verdict (to represent an assessment of project outcomes including realised benefits and stakeholder acceptability) are rated as either success (S) or failure (F) a project could be classified into one of sixteen categories. In column 1 for example a project has been judged to be successful in all four criteria, it has been completed to specification, on time, on budget and is regarded as a success. Column 8 is the category in which a project has overrun its budget and timescale and not achieved its objectives yet is called a success. Column 9, on the other hand, applies to a project that passed all the iron triangle assessments but is regarded as a failure. This table is, of course, simplistic as there are only four criteria and each criterion should be rated on a continuum, not as a yes or no decision.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>5</th>
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<td>S</td>
<td>F</td>
<td>S</td>
<td>F</td>
<td>S</td>
<td>F</td>
<td>S</td>
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<td>S</td>
<td>F</td>
<td>S</td>
<td>F</td>
<td>S</td>
<td>F</td>
<td>S</td>
<td>F</td>
</tr>
<tr>
<td>Cost</td>
<td>S</td>
<td>S</td>
<td>F</td>
<td>F</td>
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<td>F</td>
</tr>
<tr>
<td>Time</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
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<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>Verdict</td>
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<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
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<td>S</td>
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<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
</tbody>
</table>

Maylor (2010) stresses the importance of considering stakeholders' objectives. A project may remain within budget and timescale but exceed specification and therefore be rejected. Users may be happy with the final products even though the project delivered them late. For example the new British Library was years late yet is now the world’s largest library housing 170 million items. It may be regarded as a failed project but a successful product.

Binary success or failure definitions are blunt and do not illustrate dimensions. A project that is a day late but makes a profit may be treated the same way as a project which goes well over schedule, gets cancelled, and does not realise any revenue or improved productivity. Sauer (1988) highlights the difficulties of establishing simple either/or definitions of success and failure quite well when he comments that “Some systems never work. Some are never made operational because they will be unacceptable to the user. Some work but come in cripplingly over budget, very late or both. Others are pared down while still others are literally forced into place in their host organisation, despite their being either inappropriate or unacceptable. Some perform to specification but turn out to be so inflexible that maintenance and enhancement assume
nightmarish proportions. Others are thought to work, but turn out not to.”

It may be almost impossible to reach general agreement about whether a project succeeded or failed. Making sense of the ambiguity of notions of success and failure is subjective. "Beauty is in the eye of the beholder". Naughton and Peters (1976) acknowledge that one person’s failure might be another’s success. If a project is called a failure it may be because it did not meet certain people’s objectives or it produced what were seen by some as undesirable outputs. Project instigators may wish to think of their “baby” as a success despite negative comments by others. Vickers (1981) suggests “A human system fails if it does not succeed in doing what it was designed to do; or if it succeeds but leaves everyone wishing it had never tried.” The impact and consequences of the project may not be fully appreciated before implementation.

Lyytinen and Hirschheim (1987) view information system failures as problems that stakeholders perceive. This sounds like a straightforward policy until one asks how bad are the problems and who are the stakeholders they refer to? If ‘problems’ include what many would call minor niggles and stakeholders includes all those who might have an interest in the project it is likely that few projects will succeed. Robinson (1994) points out that a project’s failure or success is often defined in relation to a particular group or tribe with its own roles, goals, interests and expectations which are assessed in the context of an organization and its political and social environment.

A project may be both a success and a failure, simultaneously, depending which criteria, which viewpoints and which aspects are used to make the evaluation. A project may be recorded as a failure because it overran its original budget even though this was caused by the customer making additional demands, which expanded the scope and amount of work. In some cases stakeholders change their minds. Newton (2008) refers to this when he writes “Perceptions can be influenced and manipulated, and they are not totally rational or based on fact. Perceptions change, and stakeholders’ memories of them may not be reliable. A stakeholder may feel dissatisfied with a project forgetting that they were satisfied previously and it was their direction that drove the project to its current state.”

A customer may feel pressurised to pay an invoice for work because it was completed on time, on budget and to the agreed scope, even though they do not like the final product. From the supplier’s perspective this project is a success, the customer however may have a very different opinion.

Ewusi-Mensah (1997) states that information system projects are unique in that they are conceptual in nature and require the intense collaboration of several different groups of stakeholders including IT staff, users and management. Most projects are undertaken in teams and therefore subject to the vagaries of group dynamics, interactions, coordination and communication. Elvin (cited in Senior, 2003) takes this further when he mentions some of the incongruities and awkward balances inherent in information system projects: “The management of IS projects is a difficult and complex task and there are no magic bullet solutions. IS projects are intrinsically uncertain. The management complexity arises from the necessity to deal simultaneously with several tensions:

- Innovation versus risk
- Learning versus control
- The need for organisational change to deliver business benefit versus stakeholder resistance to change
- Multiple stakeholder perceptions of the purpose of the project
- The need to deliver value to the organisation versus managing effectively to satisfy time, quality and cost objectives
- Managing detail and the big picture”.

In other words most projects involve compromise. Scope ambitions depend on available resources. Sponsors seek to achieve useful outcomes while accepting that projects create uncertainty. It is likely that there will be a variety of attitudes and opinions about the need for, and objectives of, a project and it is possible that that some of these may change. There must be investments in effort, time and money to produce benefits. These investments are speculative to an extent and evaluations of how worthwhile a project is, or has been, may be different at different stages of its lifecycle.
8. When Should an Assessment be Done?

At what point or points should success be measured? The decision to call a project a success or a failure is usually made soon after the project ends, yet project outcomes and benefits may take a long time to materialise. Furthermore success and failure assessments may change over the life of a project and it is not always obvious when a final assessment should be made. For example, the introduction of a new Passport Agency IT system led to long delays (which cost an estimated £12m including £16,000 spent on umbrellas to shelter those queuing in the rain) in issuing passports in the summer of 1999. Four years later the system was working well with 99.5% of straightforward applications being turned around within 10 days (UK Passport Service Annual Report and Accounts, 2003). The Portsmouth Spinnaker Tower was originally to be called the Millennium Tower but was six years late. Despite that it won the Institute of Chartered Surveyor’s best project of the year award in 2006.

Peterson and Kim (2000) suggest that information system project success can be analysed and classified with reference to a table that includes four different viewpoints taken at two different stages, (table 2). Short-term and long-term objectives are assessed according to views of the system, the users, the organization and strategic considerations.

<table>
<thead>
<tr>
<th>Short-term Objectives</th>
<th>User</th>
<th>Organisational</th>
<th>Strategic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliable (bug-free) system</td>
<td>Satisfying user needs</td>
<td>Improving the effectiveness of business operations</td>
<td>Improving customer service</td>
</tr>
<tr>
<td>Easily maintainable system</td>
<td>Improving productivity of managers</td>
<td>Generating operational benefits</td>
<td>Enabling cooperative partnership</td>
</tr>
</tbody>
</table>

Table 2: a classification of short and long-term objectives

In fact it may be short-sighted to write off a project too soon and without putting it in a wider context. Aspects of the legacy and benefits of a project may be passed on and inherited. Even though a project is a failure it may provide valuable lessons for future projects. The budget for hosting Canada’s Montreal Olympics in 1976 was estimated at $310m. Various unexpected extras, mistakes and increases raised this bill to over $1,000m. Important lessons from this runaway were learnt and the Calgary Winter Olympics in 1988 came in on time, on budget and to specification. Elegant, slender and graceful, the first Tacoma Narrows bridge was the third longest suspension span in the world when it was built. It collapsed just four months after it was opened in 1940. Scientists, engineers and bridge builders learnt important lessons from this disaster.

To try to take account of assessment timing considerations, one might count the following five project milestones as important stages for interpreting views of success.

a) Pre-project – before the project starts to check that important aspects of the project have been considered and defined. Studies have shown that projects have a habit of failing when insufficient attention is paid to setting and defining the terms of reference (Bronte-Stewart, 2009).

b) During the project – to monitor and track the significant variables that are indicators of project progress and product delivery.

c) At implementation – handover, acceptability testing and project closedown.

b) Immediately post-implementation – early analysis of the project’s management including the traditional Iron Triangle parameters.

e) Longer-term, critical, reflective review - looking back at overall project success, legacy, performance and benefits realisation.

Hence, arriving at straightforward, unambiguous definitions about what constitutes success and
failure in projects and when to make these assessments is problematic. Projects are often complex, involving many vested interests, attitudes, viewpoints and agendas. Some emergent outcomes are likely to be difficult to predict and evaluate. Even selecting which outcomes and indicators to take an interest in is prone to bias, especially since some will be less visible and more difficult to gauge.

A list of indicators of success might include the following:

- To what extent were the project’s products deployed or rejected?
- Did actual costs remain within or overrun budget?
- Was more time and effort required than scheduled?
- Were gains, improvements and business benefits realised?
- Did the project produce useful and important innovation for the firm?
- Did the project enable the firm to move towards its strategic objectives?
- Are the changes the project produced sustainable?
- How satisfied or happy are the sponsors, users and other stakeholders?
- Are the project team pleased with the results and do they feel rewarded?
- Were risks anticipated and dealt with well?
- Were the team able to manage new requirements and changes?
- What did the firm, the team and other stakeholders learn from the project?

It appears that we could try to measure not only aspects of the delivery and operation of the project but also the advantages and detrimental effects it seems to produce. Information about project status (beyond the narrow focus of time, cost and scope to take into account issues including eventual value for money / business advantage, staff and customer happiness, risk, process improvement and lessons) should be available to important stakeholders throughout the project. It is the contention of this paper that it would be useful if some form of dashboard summarised and displayed this data in a way that was easy to digest and include in reports.

9. How Should We Measure Success?

The long list of indicators of success shown above would be difficult to capture and display effectively. It is argued here that these indicators can be boiled down and assimilated with six well-known project criteria to produce a Project Status Model. Before doing that it might be helpful to reflect on examples of some famous projects to appreciate important aspects that should be considered when making judgements about success and failure.

- The London Eye was late, over budget and smaller than originally specified but it has become the UK’s most popular paid-for attraction.
- The Empire State Building achieved its objective. It was completed well ahead of schedule and well below budget. Yet it was a financial flop for decades. The main project objective in 1929 was that it should be the highest building in New York (to beat the Chrysler Building). But for the same reason that anticipated costs had been halved - the great depression - rental rates were low and for many years it was called the “Empty State Building”. It did not turn a profit until 1947. These days it is 97% occupied and world famous. So is it a failure or a success? Much depends when you do the assessment and what criteria are used.
- The Sydney Opera House was well over budget and schedule yet has become one of Australia’s most famous icons. Begun in 1957 the estimated opening date was January 1963 but because it was such a complex and innovative project, it was not finished until 1973. The original budget was $7m but the final bill was $102m, a 1,457% increase! By iron triangle measurements it was a disaster. Based on those three criteria alone it might have been cancelled or abandoned. Now it hosts 1,500 performances and has millions of visitors each year. When and how should benefits be measured?
- The channel tunnel was far more expensive than original estimates. Initially costing at $7 billion, it entered service in 1994 with a price tag of over $13 billion. In 2004 it was still burdened by $10 billion in debt. However it the biggest civil
engineering project of the 20th century and the longest underwater tunnel in the world. It has carried 346 million passengers since 1994 and has one of the most heavily used railway tracks in the world. Although the cost estimate of the channel tunnel was revised many times during construction the product it is now regarded by many as a success.

- The 1997 movie “Titanic” cost $200m. At the time it was one of the most expensive films ever made. There were lots of problems during shooting, it went well over schedule and budget, the producers wanted to cut it by 1 hour, yet it became the highest grossing movie ever, has earned an estimated $2.18 billion, won critical acclaim and 11 Oscars. Many lessons were learned from making this film and the director went on to create a film that was nominated for 9 academy awards, won 3, and made even more money (Avatar).

- A New Zealand Financial Services firm instigated a consultancy led BPR project to improve customer service, reduce costs and improve the quality of work performed. They implemented a standard ERP system (SAP). Initially the project was regarded as a success, with a 64% reduction in staff and projected savings of $2million per annum. Two months later however the unintended consequence of the BPR project was that all in-house expertise had disappeared from the accounting group and no one could operate the SAP system properly. (Larsen & Myres, 1999)

- The Airbus A380 project aimed to create a superjumbo jet with a capacity of 800 passengers. Started in 2000 the A380 was due to take to the skies in 2006. The project required coordination between many sites. When the aircraft was being assembled in Toulouse, it was found that a wiring harness produced in Hamburg did not fit the airframe. This error was blamed on incompatible computer aided design software. Each year the project was overdue cost €1 billion in penalties. The recovery plan required job losses in the UK and Germany. On the other hand, the aircraft has a high payload, only needs a short runway and is well liked.

- The Millennium Dome hit financial difficulties and needed an additional £179 million of National Lottery funding in 2000. Initially viewed by many as a white-elephant failure it attracted 5.5 million paying visitors: twice as many as any other UK visitor attraction. The vast majority of visitors (87%) were satisfied with their day out and it opened its doors on time. It is generally perceived as a success in its second life as a music arena and was voted the world’s best venue by Pollstar.

- The Thames Barrier project was originally estimated to cost £55 million and take 5 years to build. It actually cost £534 million and took 8 years. It failed to keep within its budget and timescale by large margins yet, to many, it provides invaluable reassurance. Up to July 2014 there had been 174 flood defence closures.

- The Concorde supersonic airliner provided a fast transatlantic flight option (less than half the time of competitors). The result of Anglo-French collaboration it was regarded proudly by many as a classic and an engineering marvel. But only 20 were ever built, development costs were very high and eventually there were worries about crashes.

- The Rural Payments Agency is responsible for allocating billions of Euros of subsidies every year but thousands of UK farmers were underpaid, threatening the livelihood of many, while others faced demands for cash to be repaid years afterwards because of overpayments. A damming report from the NAO said that the Single Farm Payment scheme was “a master-class of misadministration”. Despite continuing problems it has not been withdrawn.

- Edinburgh's problem-plagued tram system opened three years behind schedule, more than two times over budget and limited to a route that covers less than half the network that had originally been planned for it. The cost of the project was originally estimated at £375m but the final cost is likely to be over £1bn. City residents endured six years of disruption as roads had to be closed for construction and businesses complained of lost trade. Described by some of those in charge of the project as “a shambles”, “damaging to
Edinburgh” and “hell on wheels”, Edinburgh's trams project was almost cancelled a few weeks before construction began in 2007 and later ground to a halt for months when the company in charge of the project fell into a bitter dispute with city authorities. This project was over budget, over schedule and incomplete, time will tell if it can ever be regarded as a success.

- A computer project to upgrade the NHS 24 telephone helpline is 55% over budget, 2 years behind schedule and beset with problems in December 2015, yet it was described as "a particularly strong exemplar of good practice" in the August 2013 Programme and Project Management Centre of Expertise review.

Table 3 summarises the examples and shows how many famous projects would be likely to qualify as failures if the iron triangle parameters were the only assessment criteria.

<table>
<thead>
<tr>
<th>Name of Project</th>
<th>Cost (budget)</th>
<th>Time (schedule)</th>
<th>Output (Scope)</th>
<th>Short Term</th>
<th>Long Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>London Eye</td>
<td>Over</td>
<td>Over</td>
<td>Complete</td>
<td>Success</td>
<td>Success</td>
</tr>
<tr>
<td>Scottish Parliament Building</td>
<td>Over</td>
<td>Over</td>
<td>Incomplete</td>
<td>Fail</td>
<td>Success?</td>
</tr>
<tr>
<td>UK Passport Agency</td>
<td>Over</td>
<td>Over</td>
<td>Complete</td>
<td>Fail</td>
<td>Success</td>
</tr>
<tr>
<td>Portsmouth Spinnaker Tower</td>
<td>Over</td>
<td>Over</td>
<td>Complete?</td>
<td>Fail</td>
<td>Success?</td>
</tr>
<tr>
<td>First Generation Ford Taurus</td>
<td>On</td>
<td>Over</td>
<td>Complete</td>
<td>Fail</td>
<td>Success</td>
</tr>
<tr>
<td>Empire State Building</td>
<td>Below</td>
<td>Ahead</td>
<td>Complete</td>
<td>Success Or Fail?</td>
<td>Success</td>
</tr>
<tr>
<td>Sydney Opera House</td>
<td>Over</td>
<td>Over</td>
<td>Complete</td>
<td>Fail</td>
<td>Success</td>
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<tr>
<td>Channel Tunnel</td>
<td>Over</td>
<td>Over</td>
<td>Complete</td>
<td>Fail</td>
<td>Success</td>
</tr>
<tr>
<td>Titanic (the movie)</td>
<td>Over</td>
<td>Over</td>
<td>Incomplete</td>
<td>Fail</td>
<td>Success</td>
</tr>
<tr>
<td>New Zealand Financial Services</td>
<td>On</td>
<td>On</td>
<td>Complete</td>
<td>Success</td>
<td>Fail</td>
</tr>
<tr>
<td>Airbus A380</td>
<td>Over</td>
<td>Over</td>
<td>Complete</td>
<td>Fail</td>
<td>Success</td>
</tr>
<tr>
<td>Millennium Dome</td>
<td>Over</td>
<td>Over</td>
<td>Complete</td>
<td>Fail?</td>
<td>Success?</td>
</tr>
<tr>
<td>Thames Barrier</td>
<td>Over</td>
<td>Over</td>
<td>Complete</td>
<td>Fail</td>
<td>Success</td>
</tr>
<tr>
<td>Concorde</td>
<td>Over</td>
<td>Over</td>
<td>Complete</td>
<td>Success</td>
<td>Fail?</td>
</tr>
<tr>
<td>Rural Payments</td>
<td>Over</td>
<td>Over</td>
<td>Incomplete</td>
<td>Fail</td>
<td>Fail?</td>
</tr>
<tr>
<td>Montreal Olympics 1976</td>
<td>Over</td>
<td>On</td>
<td>Complete</td>
<td>Fail</td>
<td>Fail?</td>
</tr>
<tr>
<td>Calgary Winter Olympics 1988</td>
<td>On</td>
<td>On</td>
<td>Complete</td>
<td>Success</td>
<td>Success</td>
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<tr>
<td>Tacoma Narrows Bridge</td>
<td>On</td>
<td>On</td>
<td>Complete</td>
<td>Success</td>
<td>Fail</td>
</tr>
<tr>
<td>Edinburgh Trams</td>
<td>Over</td>
<td>Over</td>
<td>Incomplete</td>
<td>Fail</td>
<td>?</td>
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<tr>
<td>NHS 24 system upgrade</td>
<td>Over</td>
<td>Over</td>
<td>Incomplete</td>
<td>Fail?</td>
<td>?</td>
</tr>
</tbody>
</table>

10. Project Status Criteria

We have noted (and table 3 demonstrates) that the three iron triangle variables are insufficient to judge project success. On the other hand the long list of success indicators is difficult to capture and display succinctly. The question arises, what criteria are needed to create a fundamental and reasonable project success appraisal? It seems sensible to reconsider the
limited iron triangle concept by extending and amplifying the evaluation to include impressions of: long-term effects, benefits and drawbacks, stakeholder acceptance, the successfulness of the team and the methodology that was used, any lessons gathered from the whole process and approach.

Nelson (2005) suggests three process related criteria, Time, Cost and Product; and three outcome related criteria Value (the project produces improvements in efficiency and/or effectiveness), Use (the project’s products are being used), and Learning (the project increased knowledge and helped to prepare the organisation for future challenges). Similarly three popular and famous project management texts define certain criteria that provide useful clues about overall project success.

PRINCE2 asserts that there are six variables or tolerances that should be considered throughout any project and therefore six aspects of project performance to be managed. These are: time, cost, scope, risk, benefits and quality.

The Project Management Institute’s Project Management Body of Knowledge Guide (PMI PMBOK) states that managing a project typically includes: identifying requirements, addressing various needs concerns and expectations of stakeholders as the project is carried out and balancing competing project constraints including: time, cost, scope, resources, quality and risk.

The Association for Project Management’s Book of Knowledge (APM BOK) explains that success factors are management practices such as: defining clear goals and objectives, maintaining a focus on business value, implementing a proper governance structure, ensuring senior management commitment and providing timely and clear communication. Key areas include: schedule, finance, scope, resources, quality and risk.

There seems to be a reasonable amount of agreement about the main project variables among the three well-established authorities. These and Nelson’s suggestions, are summarised in table 4.

<table>
<thead>
<tr>
<th>Table 4: Six project status criteria</th>
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<tbody>
<tr>
<td><strong>Six Project Variables or Project Status Criteria</strong></td>
</tr>
<tr>
<td>Nelson</td>
</tr>
<tr>
<td>Time</td>
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<tr>
<td>Cost</td>
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<td>Product</td>
</tr>
<tr>
<td>Value</td>
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<tr>
<td>Use</td>
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<td>Learning</td>
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The fifth column in table 4 lists the six status criteria that it is proposed should be measured to obtain interpretations of a project’s success at various stages in its lifecycle. These six criteria are explained in more detail below. Most of them are similar to, or the same as, those described in the established texts. Two of the six have been adapted to include other factors. Quality includes stakeholder views and risk includes assessment of methodology and team performance.

It is the contention of this paper that evaluating, monitoring and displaying these six aspects of a project's status can provide a useful view of the overall health of a project. It may be easier to appreciate the levels or status of the six status aspects if they are displayed in a diagram, side by side. Figure 4 shows such a diagram. Using an example of one of the cases previously described, (the Titanic movie), it shows the six evaluations in a Project Status Model. The PSM provides views of the project situation, plotted as a dynamic, dashboard of histograms, that give a visual summary of various important evaluations as the project develops and after the product(s) have been delivered. The zero line of the X axis on these histograms represents original baseline.
(eg BCWS). Actual outcomes (such as project duration, total cost, ROI and the extent to which the project’s products met customer quality expectations) are plotted as percentages above or below this line (+ or -). The vertical line that divides the two factors on the left from the four on the right has been included to remind the viewer that values above the 100% axis are undesirable on the left but desirable on the right.

A successful project is one in which the budget and time histogram bars appear on or below the X axis while the other four are on, or better still, above the X axis.

It is suggested that a viewer can obtain a quick impression of six important aspects of the Titanic movie project from the PSM in Figure 4. The model shows that this movie was over budget, over schedule and below scope, yet became an acknowledged business success with acclaimed popular appeal and useful lessons that were applied in future projects. In other words, despite very poor initial performance in iron triangle assessments the project produced excellent results once it was released. The model illustrates that, in this case, a project that would have been recorded as a project management failure may, later, be regarded as an outstanding success. It is argued here that this type of model can provide a more complete and rounded view of overall project status than the iron triangle factors and that it is the type of model that could be included in status reports.

![Figure 4: Project Status Model of The Titanic Movie Project](image)

It may be helpful to explain the six aspects or evaluations in more detail. The six PSM criteria are:

- **Timescale**
  The estimate of amount of time required to conduct the project and produce the product(s) usually converted into a schedule, possibly including milestones and other stage or development information. Often displayed as schedules and plans on Gantt charts which may be related to Work or Product Breakdown structures. Question: to what extent is / was the project on schedule?

- **Cost / budget**
  The budget that has been allocated to the project, including all estimates of costs, possibly broken down into more detailed predictions of expenditure that may be used to create a BCWS. A forecast of spending against time. Question: to what extent is / was the project within budget?

- **Scope including deliverable(s) and product(s)**
  The statement of what the project should produce, the scope of the work to be done. What is and what is not to be included. Question: was the scope properly considered and defined? To what extent is (has) the project meeting (met) the objectives, specification of requirements, and functionality and features. What percentage of the scope is / was delivered?

- **Benefits**
  The purpose, effects and impact of the project. The reasons why is it important.
The changes it will bring to the organisation. The return on investment. Business and organisational benefits may not be realised quickly, it will often take time for the products to produce improvements. Unexpected drawbacks and advantages may appear once the products are in use. The PRINCE2 project management method, (2009) recognises and confirms the importance the Cabinet Office (2012) and others have given to a project's business case and attempts to ensure that the business justification is reviewed at every stage of the project. Questions: is (was) there a clear and regularly reviewed business case? To what extent has the project produced improvements in: reputation, turnover, income generation, sales, profits, process improvements, efficiencies, cost reductions, customer and supplier service and satisfaction. Was this money and effort well spent?

- Quality including meeting standards and stakeholder views. Quality identifies and defines a product’s characteristics and features. It provides an explicit explanation of the criteria the project’s products are measured and judged against. There are normally several parties interested in, dependant upon and possibly hostile to the implications and outcomes of any ICT project. It will often cause organisational change and disrupt the status quo. Different stakeholders may hold differing views about what they want from (and fear about) the project. Each group of stakeholders may judge the success of the project according to different feelings, beliefs and measures. Questions: is (was) there a quality management strategy? Do the project’s products meet required standards and are they fit for purpose? To what extent are clients, customers, users and others pleased with the work and the results? Have users accepted and adopted it? Are stakeholders delighted, satisfied or unhappy with the eventual outcomes?

- Risk including team and approach lessons
Risk identification, assessment, prioritisation and management. An evaluation of the combination of the probability of perceived threats occurring and the magnitude of their impact. This analysis also considers the project’s methodology and team. Conducted before and during the project with the maintenance of a risk register, the analysis may also be carried out some time after the end of the project. It looks back over the whole experience and asks what lessons can be learnt. It takes an interest in the opinions and experience of the project team. It might review: the effectiveness and productivity of techniques and tools, the performance of the team (for example – governance, leadership, group size and composition, abilities, technical strengths and weaknesses, training, cooperation, team work), project management procedures and methods, project administration (the work of collecting, recording, monitoring and controlling aspects of the project), the strategy for anticipating and dealing with risks, the effort required to correct errors and the appropriateness of the methodology. Questions: is (was) an effective project risk management strategy in place? Are (were) risks identified, assessed and controlled? Is (did) the project going (go) according to plan? Was it well managed? How easy was it to deliver? What did it teach us?

The PSM may also be used to monitor, and show changes in, a project’s status. The model may be updated frequently during the project and at certain points after it ends. These views can assist the project manager and others to visualise how the project is getting on and what it has produced. A project manager might use the model as part of a general overview of a project that can be included in standard reports and made available to sponsors, other stakeholders and, in some cases, the public. In this way the evolving, dynamic status of a project can be analysed and displayed in a PSM as a project progresses and as views change over time. Figures 5 and 6 illustrate an example of this change of status.
Figure 5: Project Status Model of the Empire State Building project soon after completion

Figure 5 displays a view of the Empire State building project soon after it was handed over, under budget, ahead of schedule, on specification but a business flop. Figure 6 exhibits a different perspective 50 years later when the Empire State building is popular and producing financial benefits.

Figure 6: Project Status Model of the Empire State Building 50 years after completion

11. Conclusions

Most organisations strive to improve. They resource speculative research and development projects. Projects create more uncertainty and risk than business-as-usual. While some projects may produce useful benefits, experimentation and innovation are bound to involve failure. Without (failed) projects a firm is likely to stagnate. Professions, organisations, teams and individuals learn through failure, they may gain value from projects in many ways and use project experiences to test, to learn and to prototype worthwhile changes. Though some projects may fail, overall the firm progresses.

It has been common to apply the iron triangle parameters as criteria for judging project success, but this triumvirate has been criticised as insufficient by a number of authors. The triangle provides a useful model to explore and clarify priorities but is not normally used to demonstrate qualities or dynamics of success. The model does not clarify the extent and nature of success.
and/or failure. It does not differentiate near successes from disasters but the three factors have been used as the only criteria to decide which projects are to be regarded as failures. Project failure statistics may be misleading as it could be argued that they do not show enough detail of the circumstances which led to the projects being labelled failures for the reader to make informed assessments about the nature or extent of failure.

Some projects are abandoned, some are incomplete but in use, some slightly overrun budget or schedule constraints; others are total disasters. Projects may produce useful products despite breaching the boundaries normally ascribed as failure. The project management process may be a mess and/or the delivered product may be useless or unwanted. A project may be written off and categorised as a failure no matter the extent to which it overruns its scheduled budget and/or timescale and/or underdelivers its scope. A project may be categorised as a failure because it is delayed and over-budget, yet the project’s products may become popular. We should aim to clarify important features and highlight aspects of success and failure to improve project management practice and to develop better ways to analyse and appreciate project status.

Each project is unique. Project evaluation should include interpretations of: long-term effects, benefits and drawbacks, process improvements, efficiencies, cost reductions and income generated. Balanced Scorecard performance measurements can provide valuable insights but only tell part of the story. We should also evaluate stakeholder acceptance, judge how successful the team and the methodology that was used were, and look for lessons on approach and governance. Was the right project done and was it done right?

There will be challenges and compromises even on the best run and most predictable of projects. Valuable lessons are often learned from projects that, in many other ways, fail. Critical analysis of the way that a project was planned, monitored, controlled and handed-over frequently highlights a mixture of good and bad, including issues such as lack of preparation, bad decisions and lucky breaks amongst others. Even small and apparently unimportant issues may seem to have disproportionate effects, much depends on the project’s context and circumstances. It has been suggested that it might be useful to consider a range of sometimes conflicting criteria and evidence when judging project success to explore a deeper analysis.

This paper discussed the nature and measurement of project success and failure. It has argued that more should be done not only to look for ways to reduce the incidence and effects of failure, but also to encourage a reflective review of the positive and negative aspects of what was achieved by the project, what impacts it has had and what products and lessons emerged. Furthermore there is a need to illustrate and display these important characteristics in a clear and useful way, in a project status model. The PSM includes a set of histograms that may assist project managers and others to assess and show how any project is performing, or has performed, against both short-term and longer-term assessment criteria. Software could be developed to automate the calculation and presentation of the PSM. Further work is needed to test the model.

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