UTILITY FACTORS AFFECTING FOR SELECTING DELAY ANALYSIS TECHNIQUE

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ABSTRACT

Delays in the completion of scheduled activities as per the work plan will invariably lead to delays in construction. Such delays play havoc in the construction industry especially in a sustainable environment leading to many issues and disputes which in many cases retard the progress of the project. Therefore, minimizing delays is one of the most important factors in sustainable construction. Due to its criticality, a wide range of Delay Analysis Techniques (DAT) has been developed by various analysts over the years to address the issue. Further, with the emergence of new scenarios in sustainable construction with the passage of time, analysts have identified the inherent properties of each of these methodologies. These inherent properties or factors in turn become indicators for measuring the suitability and accuracy of DAT in a given context where they can be grouped into filter and utility factors. However, in the Sri Lankan construction industry, the resolving and managing of construction delays remain at an elementary stage with most analysts opting for an ad-hoc selection rather than being governed by considerations of suitability. This paper contains the findings of a literature review and interviews with experts which compare DAT and factors affecting the selection of DAT. The methodology adopted in undertaking this research is a case study and document reviews. The findings of the study will direct analysts to select the most suitable DAT and to reduce the error margin in delay analysis while aiding the increase in accuracy of delay analysis.

Keywords: *Construction Delays, Delay Analysis Techniques (DAT), Utility Factors*

1. INTRODUCTION

Delay is one of most common claim types occurred in construction industry. Sometimes these claims may place havoc and be more complex and be difficult to resolve. Hence it is necessary to focus on the delay analysis methods adopted in resolving claims as the result of the delay analysis may be influenced by the method or technique selected. Therefore selecting most appropriate technique is more important to concern all parties. For that analyst has to consider factors affecting for selecting Delay Analysis Technique (DAT). However, despite of its importance, in Sri Lankan construction industry there is no proper way to select appropriate delay analysis technique for particular scenario. The work is a part of an on-going research with a broader aim of building up a framework for selecting most suitable delay analysis technique by using utility factors into Sri Lankan building construction industry.

2. AIM AND RESEARCH METHODOLOGY

The aim of this paper is to provide a conceptual frame work for selecting suitable DAT for particular scenario by considering utility factors. The methodology adopted in undertaking this research is a comprehensive literature review and a series of interviews with experts from the construction industry. The findings from the literature review were modified according to the Sri Lankan context with the use of interviews. The interviews were carried out with four experts, who have more than 20 years' experience in the construction industry.

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3. CONSTRUCTION DELAYS

Construction delays can be defined as "the late completion of work compared to the planned schedule or contract schedule" (Wei, 2010, p.05). Delay is often used to refer the time period during which some part of the construction project has been extended beyond what was originally planned due to unanticipated circumstance (Bramble and Callahan, 2000). Further, they mentioned that the time that is allowed to perform particular construction is usually an important consideration for both the client and the main contractor. However, it is typical for construction projects to be delayed due to several reasons (Kraiem and Diekmann, 1987). Delays in construction can cause a number of changes in a project such as late completion, lost productivity, acceleration, increased costs, and contract termination (Semple *et al*., 1994). When construction delays occur, it is necessary to ascertain the liabilities of the contracting parties and to direct the appropriate amount of resources to recover the schedule (Lyons and Skitmore, 2004).These construction delays can be categorized into different types according to the responsibility of the party.

4. CONSTRUCTION DELAY TYPES

Number of authors (Kraiem and Diekmann, 1987; Menesi, 2007; Keane and Caletka, 2008; Enshassi *et al*., 2009) has proposed various delay types which occurred in construction environment. Further, certain authors used different names to introduce or address same delay type such as Kraiem and Diekmann, 1987 and Keane and Caletka, 2008. Keane and Caletka, 2008 used the name Non-excusable delays whereas Enshassi *et al*., 2009 and Menesi, 2007 used it as Inexcusable delays. According classification introduced by those authors and the results of the interviews the following summary was derived.

Table 1: Delay types by Literature and Availability of Delay Types in Sri Lanka

Author(s) / Delay Type		**Kraiem and Diekmann, 1987**	**Keane and Caletka, 2008**	**Enshassi *et al*., 2009**	**Menesi, 2007**	**Availability in Sri Lanka according to interviews**
D_4	Excusable	√	√	√	√	4
D_3	Inexcusable			√	√	3
	Non-excusable	√	√			
D_1	Compensatory	√				1
	Compensable		√		√	
D_2	Non-compensable		√		√	2
D_5	Concurrent			√	√	5

However, considering most of the classifications made by different authors and experts in the Sri Lankan construction Industry, following delay types can be identified as most common delay types.

- Non-Compensable Delays - Delays for which the contractor is entitled to a time extension and however, contractor is not entitled to any additional monetary compensation.
- Compensable/ Compensatory Delays - Delays that are unforeseeable and beyond the contractor's control, but for which the contractor is entitled to not only a time extension but also additional compensation.
- Non-Excusable/ Inexcusable Delays - Delays that are foreseeable or within the contractor's control.

- Excusable Delays - Delays that are unforeseeable and beyond the control of the contractor.
- Concurrent delays – Delays which are two or more delay events occurring within the same time period, each independently affecting the Completion Date.
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In almost all instances though it is relatively a simple project, the analysis of delays in construction project is difficult and complicated because of the large number of individual activities that have to be dealt with (Shi *et al*., 2001). In order to manage that complexity of processing construction delays, number of techniques introduced in many literature sources, journals, articles and books (Yang *et al*., 2006).

5. DELAY ANALYSIS TECHNIQUES (DATS)

Construction Law delay and disruption protocol (2002) illustrated that there are five commonly used Delay Analysis Techniques (DATs), which are namely Impacted as-planned method, Time impact analysis method, Collapsed as-built or 'but-for' analysis method, Snapshot/ windows/ time slice analysis method and As-planned versus as-built method. Further, Yang *et al*. (2006) also identified As planned versus as built technique, Impacted as planned technique, But-for technique, Time impact technique and these are some special and famous techniques use in construction industry to analyse construction delays.

Other than the above DAT, various delay analysis techniques have been proposed in many literature sources and alternative names used by different authors for same method (Hegazy and Zhang, 2005). Sometimes different researchers used different names (Highlighted techniques in Table 2) to express same technique. For an example Yang *et al*. (2006) used the name "Windows technique" to express DAT whereas Alkass *et al*. (1995) used it as "Snapshot technique". Following table (Table 2) refers various delay analysis method proposed by different authors. In addition based on the interviews results, in the last column of table 2, it shows that the level of usage of methods in Sri Lankan construction industry.

The interviews conducted with the experts in Sri Lankan construction industry, shows that following techniques can be identified as techniques which are currently use in Sri Lankan building construction industry. Not only that but also these are the delay analysis techniques which most authors identified as most famous and special DAT (Refer table2).

- Global impact technique
- As planned vs as built
- Impacted as planned
- Time impact technique
- Collapsed As-built

Each and every DAT has own inherit qualities and therefore selecting the most appropriate DAT leads to a fair and effective evaluation which impact on delay and also with the available information it will provide a reliable solution within the time and cost allocated for this purpose (Arditi and Pattanakitchamroon, 2006). Bubshait and Cunningham (1998) argued that all situations cannot be fulfilled by one particular DAT and it is necessary to identify the most appropriate technique for each scenario. Braimah and Ndekugri (2008) mentioned that the result of the delay analysis is influenced by the method or technique selected. Further they have discussed that while identifying the most appropriate technique for particular scenario will give fair result for both parties.

Table 2: Various DATs in literature and Use of DATs in Sri Lanka

Delay Analysis Technique / Author(s)	Yang *et al.*, 2006	Yang and Kao, 2007	Lee, 1983	Kraiem and Diekmann, 1987	Reams, 1989	Wickwire *et al.*, 1991	Alkass *et al.*, 1995	Leary and Bramble, 1998	Chehayeb *et al.*, 1995	Rubin *et al.*, 1999	Pinnell, 1998	Lucas, 2002	Stumpf, 2000	Lovejoy, 2004	Wickwire and Groff, 2004	Interviews Result (Whether use in Sri Lankan industry or not)
Global impact technique	√	√	√	√	√	√	√	√	√		√					Using
Net impact technique	√			√					√							Not used
Adjusted as-built CPM technique	√	√					√	√								
As planned vs as built			√	√		√			√			√	√	√		Using
Total time															√	
Impacted as-built CPM					√						√					
As planned but for							√				√					Not used
Impacted as planned		√	√	√	√	√			√	√	√	√			√	Not used
Collapsed As-built	√	√	√	√	√	√	√	√			√			√	√	Using
As-planned expanded technique	√	√														Not used
Collapsed but-for technique	√						√	√	√							Not used
Snapshot technique			√	√	√	√	√	√	√							Using
Windows technique	√	√												√		
Time impact technique	√	√	√	√	√	√	√	√	√							Using
Isolated delay type technique	√							√								Not used
Apportionment delay					√		√		√							Not used
S- Curve										√						Not used

6. FACTORS AFFECTING THE SELECTION OF DELAY ANALYSIS TECHNIQUE

6.1. IDENTIFICATION OF FACTORS

Selection of the most appropriate technique is more important to concern by all parties (Braimah and Ndekugri, 2008). Society of Construction Law's protocol (SCL) (2002) has identified number of requisites that analysts should focus in order to identify the most suitable DAT for the respective scenario. Ramanathan *et al*. (2012) illustrated that selection of DAT depends on time of analysis and capabilities of the method, the relevant conditions of contract, the nature of the causative events, the value of the dispute, the programme information available and the programmer's skill level and familiarity with the project characteristics and characteristics of baseline programme can be considered as some main group factors followed by several sub factors for the selecting of an appropriate DAT. Similarly Arditi and Pattanakitchamroon (2006) and, Braimah and Ndekugri (2008) also introduced well developed six number of group factors which included eighteen sub factors that influence the selection of DAT for United Kingdom construction industry.

However, it is necessary to elaborate that in the perspective of Sri Lankan construction industry professionals, they may have different perspectives and attitudes compared to United Kingdom construction industry professionals. Therefore based on all of the above findings, twenty numbers of factors can sum up as follows which are influenced to implement an accurate delay assessing method in Sri Lankan construction industry (Refer table 3). These factors were identified through an interviews carried out among four professionals in the Sri Lankan industry. Further, in order to get a better insight to this research previously identified factors through the literature were brought to the attention of the industry professionals and the most suited factors in the Sri Lankan context were identified.

6.2 CATEGORIZATION OF FACTORS

All factors including sub factors affecting for selection of suitable DAT can be divided into “Filter factors and Utility factors” (Gunarathne, 2012). Further he illustrated that utility factors represent the required level of utility of the factors to be considered by parties, when selecting a single DAT against the inheriting properties. Furthermore Gunarathne (2012) has mentioned that to select most appropriate DAT, primary screen out can be done by using filter factors and after filtering out certain techniques from filter factors, selecting appropriate method depends on weighting of DATs and utility factors. Therefore considering utility factors for selecting DAT is a more advanced method than selecting from filter factors. Simultaneously, the systematic and accurate consideration of the utility factors will increase the accuracy level of delay analysis while decreasing the potential error margin.

Among the factors which have mentioned above some have conceives as utility factors by the selected four experts who were involved in the survey. The other remaining factors are considered as filter factors which consists 0.5 probability to each of “yes” and “no” responses by the relevant context properties. According to the delay analyst's approach the utility factors would vary along the utility of the analyst whereas the filters would remain unchanged. As a conclusion identified factors and the categorization can be presented as below.

Table 3: Factors Affecting for Selecting DAT

	Factors Identified	Utility factor	Filter factor
U_1	Record availability	√	
U_2	Nature of baseline programme	√	
U_3	The other party to the claim	√	
U_4	Applicable legislation	√	

	Factors Identified	Utility factor	Filter factor
U_5	The form of contract	√	
U_6	Skills of the analyst and familiarity with the project	√	
U_7	Size of the project	√	
U_8	Duration of the project	√	
U_9	Complexity of the project	√	
U_{10}	The amount in dispute	√	
U_{11}	Dispute resolution forum	√	
U_{12}	Time availability for delay analysis	√	
U_{13}	Cost of using the technique	√	
F_1	Nature of the delaying events		√
F_2	Baseline programme availability		√
F_3	The number if delaying events		√
F_4	Updated programme availability		√
F_5	Time of the delay		√
F_6	Reason for the delay analysis		√
F_7	Nature of the proof required		√

6.3 IMPACT OF THE UTILITY FACTORS TO INCREASE THE ACCURACY LEVEL OF DELAY ANALYSIS

Record availability - Under record availability, it concern about the project's factual records required for delay analysis. Those can be identified as contract documents, letters, minutes of meetings, notes, material receipts, supervision and inspection reports, resource data and costs, daily reports, extra work orders and progress reports. (Gunarathne, 2012)

Nature of baseline programme - This consider about the format of the baseline programme such as bar chart or critical path method and its quality or the accuracy level to carry out an accurate delay analysis (Braimah and Ndekugri, 2008).

Applicable legislation - Applicable legislation means the contract clauses relating to programming and progress control requirement may have a bearing on the availability of contract programmes and its updates, which in turn facilitate the use of certain delay analysis technique to a greater extent than others.

The form of contract - Form of contract itself provides the requirements which would affect the analysis directly.

Cost of using the technique - Analysing delay claims can be costly and time-consuming process particularly when using methods such as time impact analysis and window analysis. This makes it necessary to consider the value of the claims in dispute in relation to the cost involved in resolving it to ensure the selection of a cost effective methodology (Kean and Caletka, 2008).

The other party to the claim - This implies the behaviour of the opposing party to the claims. Determining which technique is the most appropriate to use under given circumstances is a subjective decision, guided by experience, the availability information and other relevant factors.

Skills of the analyst and familiarity with the project - Duties and key professional requirements of a skilful delay analyst can be identified as a detailed knowledge and understanding of a variety of delay analysis techniques is required, major multi-disciplinary, multi contractor infrastructure project experience, demonstrable skills in delay claim management. (Arditi and Pattanakitchamroon, 2006)

Duration of the project - Project duration mostly depends upon the project definition, project implementation and project completion phases of the project life cycle. If the time duration of such

phases extends, then automatically project duration will also increase (Ramanathan *et al*., 2012). Sophistication level of the delay analysis method has to be considered here on this factor, because prolongation cost has significant effects through this kind of project.

Complexity of the project - Project complexity can be defined as consisting of many varied interrelated parts and can be operationalized in terms of differentiation and interdependency. Due to consisting of many varied interrelated parts and interdependency activities, single and simple error of delay analysis may ended with a huge loss to the single party of the contract or to the both parties. Therefore, well sophisticated DAT should be adopted when computing delays in complex projects.

The amount in dispute - In order to avoid or at least minimize the conflicting suggestions over the methodology, it is recommended that the interested parties try to agree an appropriate method of analysis before the disputing partied begin their retrospective delay analysis prior to litigation or arbitration has been commenced. Further, in the absence of an agreement, careful consideration should be given in obtaining the decision of the judge or arbitrator as to the appropriateness of the method proposed, before proceeding with a fully delay analysis.

Dispute resolution forum - The dispute resolution forum is the contract clause or agreement in a contract that sets out the process whereby the parties will seek a resolution to any dispute that may arise between them, as well as the venue where the dispute is to be resolved (Ramanathan *et al*., 2012)

Time availability for delay analysis - When comparing retrospective delay analysis techniques, as planned vs as built and impact as planned are the quick and simplest method of analysis. Collapsed as built is also an analysis simple to perform but more time consumption than above and time impact analysis is the most thorough method of analysis, although it is generally the most time consuming and costly when performed forensically (SCL delay and disruption protocol, 2002). Hence, based on the timing constraint for the delay analysis, the most suited DAT must be selected.

Size of the project - As the project size increases, the complexity and the risks of the project will automatically increase. In large projects minimizing global claims is one of the top most aspects of the Engineer (Lovejoy, 2004).

7. CONCEPTUAL FRAMEWORK TO SELECT MOST SUITABLE DELAY ANALYSIS TECHNIQUE FOR PARTICULAR SCENARIO IN SRI LANKAN CONSTRUCTION INDUSTRY

Through the findings of the literature review and the interviews with experts, a conceptual model to select most suitable DAT for particular scenario was developed. The model takes into account all four main phases of a scenario: Identify the delay type, identify filter factors, select DAT and utility factors. This model is presented in Figure 1. Therefore prior to consider DAT going to use, the analyst should identify which type of delay occurred. Then only analyst can filter out certain techniques according to the context might be the first step prior to taking a decision with the utility factors. After filter out certain techniques from filter factors (as shown in the Figure 1; yes/no situation), selecting a one of the best method from those depends upon the scoring or weightings of DATs and utility factors.If only analyst go through this process, it will help to derive a fair conclusion for all parties involved.

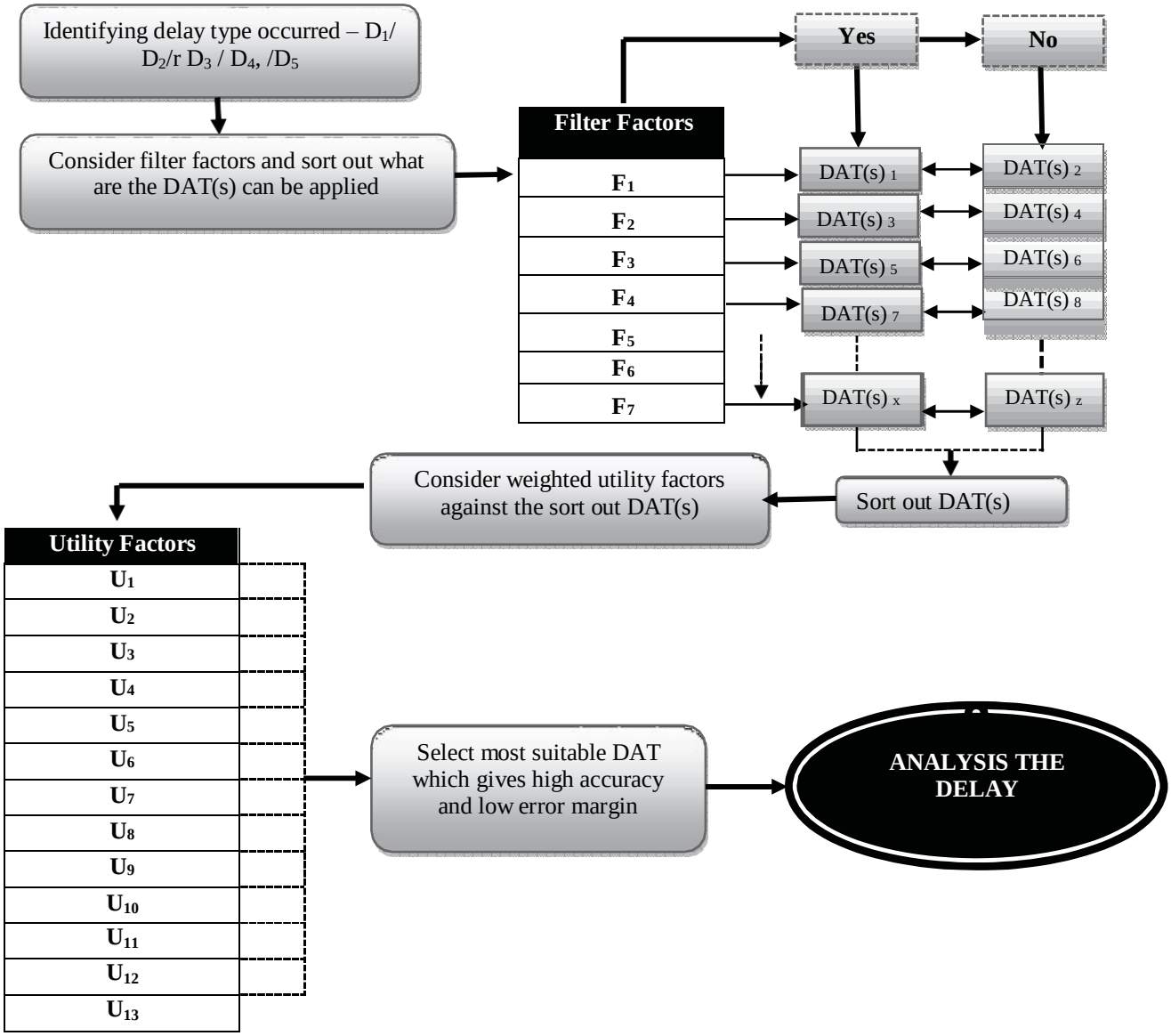

Figure 1: Conceptual Frame Work for Select Most Suitable DAT

7. FUTURE DEVELOPMENT

In order to increase the accuracy level and to decrease the level of error margin, more priority has to be given to the utility factors. Therefore it is need to rank and weight/scoring utility factors according to the Sri Lankan construction industry. In addition to select most suitable DAT among sort out DATs, there should be a comprehensive framework for consider utility factors. As a further development of above conceptual frame work, it going to rank and weight on each utility factors according to the Sri Lankan context and develop more comprehensive model to select most suitable DAT for particular scenario and meanwhile to give fair conclusion for involved parties. As well as ranking it will prioritise identified thirteen utility factors according to the Sri Lankan Context. In addition a frame work will be developed to select best DAT among sort out DAT(s) for particular scenario by using utility factors. Not only that but also it will derive a most suitable new DAT based on field scenario related to building construction industry.

8. CONCLUSIONS

Construction delays are very common in the construction industry. There are various types of Delays such as excusable, inexcusable, compensable, non- compensable and concurrent delays. To analyse and to give fair conclusion for parties who involved in delay analysis process, this process should be a comprehensive process. Within this comprehensive process, the analyst should be able to identify which delay type occurred and then consider seven filter factors to sort out DAT(s) which can be applied for that particular scenario. As a next step of this process, analyst should consider thirteen utility factors to select highly accurate and most error free technique to gives best conclusion for analyse. Proposed conceptual frame work (Figure 1) provides some sort of idea for select most suitable DAT for particular scenario. But to select most accurate method there should be a comprehensive frame work. Therefore, it is crucial at this point of time to develop a comprehensive framework to select most suitable delay analysis technique for particular scenario by considering utility factors in Sri Lankan construction industry. That will be achieved at the of the total research process.

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