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THE DECISION CONSTRAINTS IN CONSTRUCTION PROJECT SCHEDULING USING THE MS PROJECT PLANNER

Mr. Efole Friday eziodawhe.

Department of Quantity Surveying,University of Jos, Jos. Plateau State, Nigeria.

ABSTRACT: *This paper reports a library research which investigated the way decisions of early start or late start schedules are applied in the MS Project. The problem intended to solve or clarify is whether literature holds the scenarios where options of early or late start schedules may show superior schedule performance. It is noted that key scheduling processes and procedures such as choice of early start schedule and late start schedule will significantly impact project performance. This literature search proposed answer to the question: How can the planner make better scheduling decisions and explore relative benefits of alternative options? It shows that project performance evaluation results may provide evidence that some choice influence schedule variability which in turn, is strongly and positively correlated to productivity. It is imperative for contractors to continually monitor the scheduling practices adopted, the choice made when the schedule is developed and relate these to project performance in order to identify particularly effective scheduling practices for use in scheduling future projects. Strong argument is developed from literature that if network scheduling methods fail to address the issue of start time constraints for various project tasks, it is likely that the schedules generated will be inaccurate. This is because changes in the schedule are inevitable occurrences in construction projects. The causes of such changes are numerous and well catalogued in the literature: weather, owner-directed changes, information request and information release problems, period for approval of submittals, unexpected soil conditions, long lead supply items, delays, accelerations, and rework that affects schedule coordination difficulties. Such changes are challenging and difficult to proactively accommodate in the initial schedule development because they affect multiple activities, often leading to disruption of activity start dates of succeeding tasks. It is therefore important to satisfy practical scheduling requirements, such as scheduling an activity to start only when all information requests, all prerequisite work and materials required for its commencement are available. The paper concludes that a good understanding of the tasks affected by these listed delay causes is important so that a right choice of start date is made to proactively nip the delay situation at the bud. If disruption of activity start is reduced to zero particularly for the critical activities, then the project may finish on the due date, with optimum overall project cost.*

KEYWORDS. Decisions, Construction Scheduling, MS Project, Project Calendars, Optimism, Pessimism, Most likely.

INTRODUCTION

The idea that an effective and dynamic project schedule model can only be achieved if it meets the requirement that the number of hard dates (constrained dates) are minimised to represent only 'real' constraints such as contracted completion due dates suggests that as much as possible only the default options of constraints should be used. This is without regards for project attributes, task attributes and resource attributes, (Allan, 2011). However, it should be

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noted that key scheduling processes and procedures such as choice of early start schedule and late start schedule and amount of float consumption built into the schedule will significantly impact project performance, (Allan, 2011). How can the planner make better scheduling decisions and explore relative benefits of alternative options? Project performance evaluation results may provide evidence that some choices influence schedule performance variability which in turn, is strongly and positively correlated to productivity. It is imperative therefore for contractors to continually monitor the scheduling practices adopted, the choice made when the schedule is initially developed and relate these to project performance in order to identify particularly effective scheduling practices for use in scheduling future projects.

THE CONSTRAINT DECISIONS IN CONSTRUCTION PROJECTS SCHEDULING

If network scheduling methods fail to address the issue of start time constraints for the various tasks, it is likely that the schedules generated will be inaccurate. This is because changes in the schedule are inevitable occurrences in construction projects. The causes of such changes are numerous and well catalogued in the literature O'Brien, and Fischer, (2000): weather, owner-directed changes, information request and information release problems, length of period for approval of submittals, unexpected soil conditions, long lead supply items, delays, accelerations, rework that affects schedule and coordination difficulties. Such changes are a huge challenging and are difficult to proactively accommodate in the initial schedule development because they affect multiple activities, often leading to disruption of activity start dates. It is therefore important to satisfy practical scheduling requirements, such as scheduling an activity to start when all information requests needed and all prerequisite works and materials required for its commencement are available. A good understanding of the tasks affected by these listed delay causes is important so that a right choice of start date is made to proactively nip the delay situation at the bud. For non-repetitive projects, the acceleration of critical activities often lead to a shorter overall duration for the project. On the other hand if disruption of activity start is reduced to zero particularly for the critical activities, then the project may finish on the due date, with optimum overall project cost.

Mawdesley., Askew and O'Reilly, (1997) shows that the construction scheduling process involves three distinct but related stages:

- Initial schedule development
- Schedule implementation and
- Schedule update, schedule revision and schedule control.

Different types of decisions are usually made during each of these stages in the construction scheduling process. As pointed out by Carl and Timothy (2013), options taken in these decisions have very different effects on the schedule performance. The focus of interest in this study is the initial schedule development and the effects of options of decisions taken on project performance. During this stage five important decision aspects are identified from Mawdesley et al (1997) as:

- Activity dependency consideration
- Activity start date consideration determined by jobsite uniqueness
- Durations assessment

- Resource assignment and
- Schedule time analysis

In support of the need for best practice and standardised procedures in construction and scheduling, many researchers, Cohenca et al (1989), Olusegun et al (1997 and 1998), Laufer and Turker (1987) & Laufer, (1991), have called that much research has been done in planning techniques and that it was time to shift research paradigm and emphasis from investigating the techniques to now focus on investigating the process of planning itself. These reported studies which investigated how planning is done, (i.e., the process) focused on measuring the quantum of effort invested in planning, frequency of major revisions and the likely project outcome. Since this call, Efole (2009) reports study attempts which mapped the planning process in industry, identifying it's components, best practice and procedures, and how scheduling decisions are being made. It is further shown that regardless of the planning technique being adopted; whether Gantt chart, Network based techniques, Line of Balance etc, a common procedure is followed. The process involves viewing general work in more specific work scope as in a work breakdown structure; sequencing and logic development; task start and finish dates as in project calendar; and activity duration and resource allocation, (Olusegun et al, 1997 and 1998). Davis and Kanet, (1997) notes that to create a schedule requires accounting for tasks attributes. The scheduling process has long been regarded as an intuitive art not a precise science a sort of hit and miss approach, Galloway (2006). For instance, sequencing and timetabling which determines when tasks will start has options such as:

1. As soon as possible: Yielding early start schedule;
2. As late as possible: Yielding late start schedule.

Or other options in between these two extremes: Start no earlier than; Finish no earlier than; Start no later than; Finish no later than; Must start on; Must finish on etc. The basis of choosing any of these options in the MS Project is not scientifically structured. Decision is still mainly intuitive. This research is an attempt to replace intuition with scientific reasoning. A survey of the production planning practices in the United Kingdom by Dawood and Neale, (1990) revealed that the planning practice employed were still fairly basic and depended greatly on experience and subjective approaches. They reported that inefficient resource utilization and overstocking were commonplace. Industry practitioners were unfamiliar with formal scheduling models based on mathematical programming. These models tended to simplify the details of practical scheduling (like conflicting objectives and production scheduling constraints), as these complicated the solution procedure. Their solution procedures did not incorporate the experience of human schedulers, and the technical sophistication required to use them may have contributed to their slow adoption in the industry. Another survey of scheduling practices adopted in Singapore identified many of the key production scheduling constraints and the manner in which these constraints were met in order to construct good, feasible production schedules, (Wong, 2000 in Chan and Hu, 2002). Wong concludes that the processes used by planners were largely manual and guided by experience and intuition. It is important to make informed decisions in the scheduling process, i.e., those decisions which are based on information and knowledge of the attributes of task being scheduled, the attributes of resource being scheduled and the attributes of project being scheduled. As discussed earlier, Mawdesley et al (1997) notes four common decisions made during the initial scheduling process as:

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- A choice of start date for tasks: early or late start consideration;
- A choice of the project calendar: a workdate consideration;
- The allotment of different types of buffers and
- A choice of activity relationships

Carl and Timothy (2013) further points out that options taken in these decisions have significant effects on the schedule performance. Primavera systems (2007) stressed that whether one is an experienced planner or is new to the scheduling software, the user's guide contains important information needed to organize the scheduling process successfully. Further it is noted that the reason for some choice of alternatives in the scheduling process are very clearly fixed by the nature and uniqueness of what is considered. While for others this reason is not that clear. For instance in the case of choice of activity relationships, beams are constructed after the columns to support them are built, and not vice versa. This fixes the choice decision option of 'finish to start' and not 'start to start' or 'start to finish' as may be required in some instances. However the reason for choice in the case of start time constraints and choice of the project calendar are not that clear and simple. A study by Efole (2010b) showed clearly that only two in every ten use options other than the default options of start time. Scheduling every floated activity to start as soon as possible. That study concludes that both experienced and young scheduling engineers lack the ability to go beyond the default option with reason. More importantly if different choice would have different effects on the project schedule, then the appropriate choice in the scenario should be sought.

CHOICE OF START DATE CONSTRAINTS FOR TASKS: EARLY OR LATE START

The schedule is not realistic if the startability of certain activities is not well determined. There is a need to make appropriate start date choice: early or late start schedule. This choice is actually the amount of consumption of available float in floated activities, (Weaver, 2006b). If some or all available float is consumed in fixing a start date for an activity, a late start schedule results. On the other hand if none of the available float is consumed then an early start schedule results. Hegazy and Petzold, (2003), infers that if all floated tasks are scheduled as-late-as possible there can be only 50% probability of meeting the project's due date. Equally too if all floated tasks are scheduled as-early-as possible there can also be only 50% probability of meeting the project's due date. The basis of this assertion is not clear and it will need a confirmatory research. Traditional scheduling techniques normally generate single fixed early start schedule. However, there could be alternative start and finish dates for floated activities in the same schedule without delaying the project completion date (Bowers, 2000). If these alternative schedules are comprehended initially, the schedule will be more flexible and thus better able accommodate unanticipated events, such as equipment failure, delays in material delivery, and late receipt of information requests etc. Following from this and the posit of Bowers, (2000) it is clear that deviations between as-built and as-planned schedules are not always the fault of project implementation i.e., lack of conformity to plans, but mostly due to inappropriate schedules rather than inadequate performance, (Abdul-Rahman, et al. 2006).

All project activities should have a start date as well as an end date. Unless a date is specified, MS Project schedules all floated activities to start or finish using the default start date or default end date, Carl and Timothy, (2013). The type of constraint applied to tasks in the project depends on what is needed. They further observed that inflexible constraints are used only if the start or finish dates of a task is fixed by factors beyond the control of the project team.

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Examples of such tasks include handing over to clients on a fixed or mandatory date and the end of a funding period from donor agency after which funds cannot be accessed. For tasks without such limitations, it is advisable to use flexible constraints. Flexible constraints provide the most discretion in adjusting start and finish dates, and they allow Project to adjust dates if the plan changes. The only problem with the use of flexible constraint is that by their nature a date is not actually fixed so prior arrangement cannot be made for resources of labour, materials and equipment. For example, if ASAP constraints are used and the duration of a predecessor task changes from four days to two days, Project adjusts, or pulls in, the start and finish dates of all successor tasks earlier than scheduled. However, if a successor task had an inflexible constraint applied, Project cannot adjust its start or finish dates. If task 20 is re-scheduled to start on July 17, instead of its initial scheduled date of July 15. All tasks that depend on it are also re-scheduled; this is the multiplier effect of the choice of start time. This is the philosophy behind the assertion that observed labour utilization divided by Schedule variability index = total factor productivity. That is, if it is observed that 150 Manhours was recorded utilised on a site with 5 value Schedule variability index defined in terms of activity start time variability, then its true total factor productivity will be 150/5 = 30. Whereas another site with the same 150 Manhours recorded utilised and a 10 value Schedule variability index will have a total factor productivity 150/10 = 15 because of the multiplier effect of the start time discussed above, (Weaver, 2008).

One key element in earned schedule is the recognition of the 'P-Factor'. The P-Factor measures how well the project is following its planned schedule i.e., its schedule adherence to planned sequence as well as planned start and finish dates for all activities, (Weaver, 2008). Adhering to the planned sequence of tasks and ensuring minimal start date and finish date variances are frequently an early warning indicators of other problems. For different case projects it is possible to develop their P-Factors by comparing their As-built dates (start and finish) with their As-planned dates (start and finish). As float is reduced in fixing actual start and finish dates for tasks on sub-critical paths, the probability of project completion on the due date reduces because the likelihood of the sub-critical path becoming the key delay to completion increases, (Weaver, 2008).

Most duration estimates are based on a 'most likely' duration. Because CPM only allows one estimate, this most likely duration is itself optimistic thereby ignoring any pessimism. However with most project activities, the numbers of things that may go wrong significantly outweigh the number of things that may go better than estimated, (Weaver, 2008). Also there is a considerable knowledge about the things that may go wrong and the consequences of ineffective decision making, but there is limited published information about what procedures and steps to follow to avoid cost overruns and time delays, (Thomas., Riley and Messner, 2005). Optimism is the tendency for people to be overly optimistic about the outcome of planned actions. It is over-estimating the likelihood of positive events and underestimating the likelihood of negative events. Effective construction scheduling which has its objective of making the construction process efficient should yield a process model which is realistic, flexible, reliable and predictable; ensuring that events occur the way they are planned. Though the best results come from a tightly programmed, speedily completed jobs, the durations and dates should be practical and realistic. As much as possible, the programmer should avoid optimism. Optimism about information coming in as required, optimism about material availability and optimism about finishing early reduce programme practicality and they result in unrealistic process model, (Clark, 1988). To put it bluntly a pessimistic view is encouraged in which nothing is taken for granted.

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There is no 'right' or 'wrong' in decisions of early start or late start date of activity. The optimum choice should be one that will inherently benefit in on-time and on-cost and quality project delivery. Such a choice must recognise case scenarios of projects being planned and adopt options or choice suitable to various unique instances. Project specific attributes, task specific attributes, and resource specific attributes must be important guides in making choice of alternative start date in the construction schedule (Efole, 2009). Care in appropriate choice of alternative start date is important because the real objective of scheduling in addition to estimating the pre-determined duration and sequencing of activities is to keep the resources working efficiently with minimal disruption of start and finish dates for all project activities. It is important to note that in operating all pieces of scheduling software the human factors and judgments which are required as an essential part of the analysis process cannot be neglected. Pieces of scheduling software do not make decisions by themselves. They merely present information and the environment required by managers to make more effective decisions. The best scheduling software or any project-management tool can never replace good personal judgment in decision making.

The construction scheduling process involves several decision options which are applied to control how different aspects of the schedule behave. Often these options state the default as well as the several other alternatives. Atchison and Kennemer (2011) posits that it is probably best to use the default settings until one has a better idea of specific project management needs. When one begins to observe that things aren't working the way one would like, then a need to change some of the default choice options becomes necessary.

Constraints are artificial dates not based on explicitly stated logic (Jerry, 2011). They are placed on activities or milestones and these dates can be start dates or end dates. Constraints override activities' interdepencies or logic. Although constraints can be useful, they may distort the project float and critical path. Using hard constraints will prevent tasks from being moved by their dependencies and, therefore, prevent the schedule from being logic driven, (Jerry, 2011). This is why Allan (2011), posits that an effective and dynamic CPM model can be achieved only if it meets the requirement that the number of hard constraint dates in the schedule are minimised and represent only 'real' constraints such as contracted completion dates. Carl & Timothy (2013) and Jerry (2011) divide constraints into hard and soft constraints. While Christian (2008) divides constraints into three categories as:

- Flexible constraints
- Semi-flexible constraints
- Inflexible constraints.

A hard constraint overrides the network logic and is a restriction that sets the early and late dates to the imposed date. Examples of hard constraints are: Mandatory start date which prevents the start of an activity before or after the specified due date, even if the predecessors are complete; Mandatory finish date which prevents the finish of an activity before or after the specified due date, even if the predecessors are complete or the successors have started.

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Figures 1 and 2 illustrates the different types of project constraints dialog box in Microsoft Project.

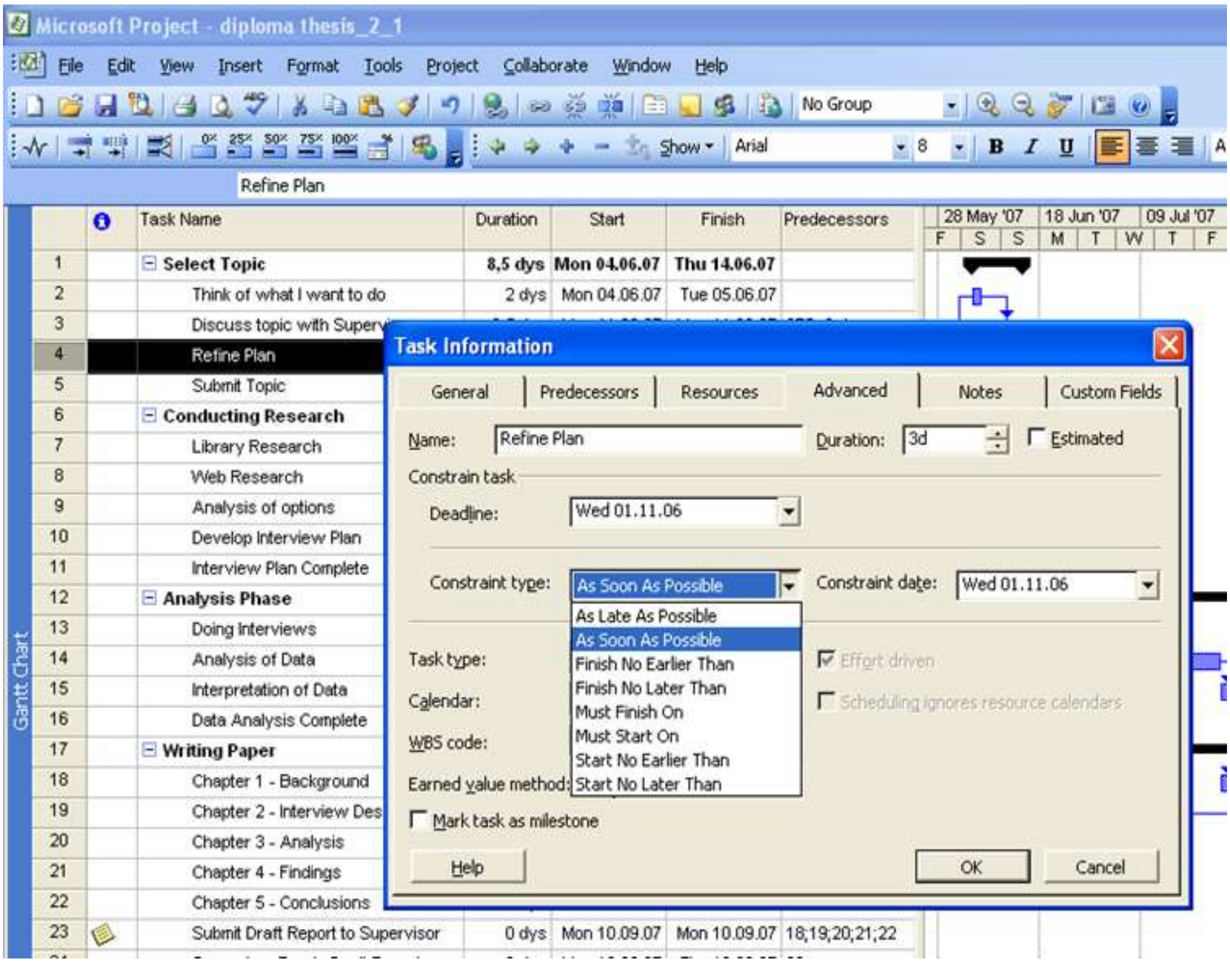

Figure 1. The Project Constraint Dialog Box in Microsoft Project.

Source: Christian (2008)

A soft constraint protects the schedule logic. Examples of soft constraints are: 'Start on' or 'finish on' date which is a restriction that could delay the early start or finish and or accelerate the late start or finish to satisfy the imposed date. As late as possible date is a restriction that uses positive float to delay an activity as long as possible without delaying its successor. Its purpose is to improve financing and resolve resource conflicts like late release of information and delayed submittal approval, (Hegazy and Petzold, 2003). This again as pointed out by GAO, (2009), should be used with caution because using as late as possible schedules introduces a false level of criticality due to their effects on float consumption. When much of the available float in an activity has been consumed in fixing a start date as late as possible, it implies a false criticality is created for that activity and therefore not representing the likely true situation. Though the research scope covers Microsoft Project, it is observed that primavera project planner (P3) scheduling software, have similar constraints features with

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those in Microsoft project planner, (Primavera systems, 2007). P3 provide eight such constraint types:

As soon As possible (ASAP); As Late As possible (ALAP);

Start No Earlier Than (SNET); Start No Later Than (SNLT);

Finish No Earlier Than (FNET); Finish No Later Than (FNLT);

Must Start On (MSO); Must Finish On (MFO)

Contractors often prefer to work to an early start schedule. But the extent to which this is a practical and effective scheduling option is in question. It should be realized that with most project activities, the numbers of things that may go wrong significantly outweigh the number of things that may go better than estimated. This produces a skewed probability distribution that events may occur as late as possible in reality, (Weaver, 2008). Early start schedules adopts the earliest dates floated activities may start or as soon as possible.

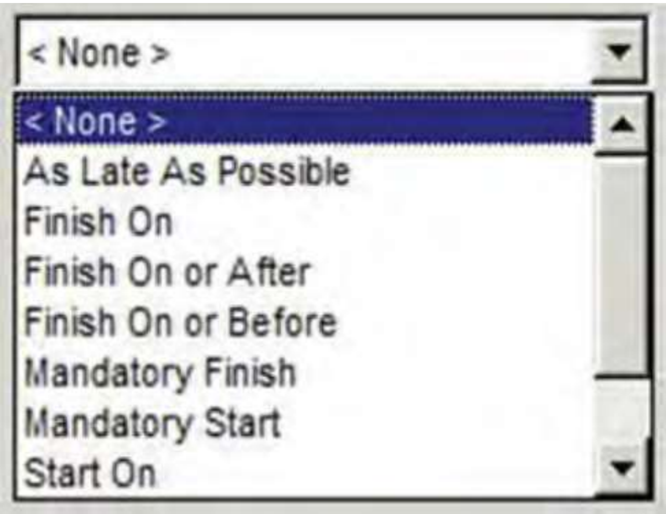

Figure 2. The Constraint Pull down menu

Source: Carl and Timothy (2013)

And resources of men and machines are called to site based on this arrangement and timing. In reality numerous factors such as weather, current workload, long-lead supply items, information requirement needs and submittal approval may call for deferring some work until the late start dates in the schedule to effectively resolve some or all of these constraints, (Diekman et al, 1992). A least commitment approach for some tasks which aims to delay decisions and actions until the system has enough useful information and right conditions for making them is important for scheduling construction projects, (Levitt and Kartam, 1989). The idea of least-commitment planning for some tasks is fundamentally different from the thinking of Andersen (1996), who warned that detailed activity planning is hazardous to the project's health! Andersen proposed establishing milestone plans and viewing the schedule as 'targets' not full commitment. This may enhance efficient operations as resources will be called to site only when conditions are right. But work progress is likely to be slow since no firm direction

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is previously laid out, and the scheduling process would seem to be starting all the time from the beginning. This is why Cori (1985) opines that detailed planning as a means of preventive proactive action anticipates potential difficulties and proposes how to cut the corners, making field operations fast and efficient. Herman (2001), however, maintains a similar view as Andersen. Herman posits that due to the unavailability of accurate data on activity durations, resources and other information, the development of a "perfect" project schedule is a myth. The input data into the schedule model to simulate and optimise it are mere estimates and are by no means accurate. This means that there might be more than one scheduling solution that is feasible and is "good enough" for the purpose. The argument is that except for the purpose of identifying a project due date, long-term schedules should indicate 'targets' only and not full commitment. While short-term schedules should be viewed as statement of intent, of full commitment of resources and of a guide for making them available.

Most advanced pieces of scheduling software, such as the Primavera Project Planner and the Microsoft Project etc, have facilities for specifying use of a resource as "propose" resulting in a target schedule called for by Andersen (1996) and Herman (2001). They also have options which specify the use of resource as fully committed, yielding a firm, clearly defined time-scaled schedule. The only problem with these pieces of software is that they do not support the decision making process. When to apply early or late start or as soon as possible, what workweek for which tasks and when should resources be fully committed or only stated as "propose" etc, are decisions which are still being made based on intuition. The MS Project guide, help facility and numerous users' manuals do not have information to assist young and inexperienced scheduling engineers who use only the default options as they lack the ability to choose with reason options other than the default.

The schedule alert system is a new innovative feature of MS Project 2010 and 2013, (Atchison and Kennemer, 2011). This feature shows warnings and or suggestions when MS Project identifies possible scheduling conflict and is helpful in producing effective and realistic schedules. The schedule alert system should be extended beyond resolving scheduling conflict to include displaying warning messages and or suggestions when faced with decisions like, when to apply early or late start schedule, what workweek for which tasks and when should resources be fully committed or only stated as "propose" etc. The same reason discussed earlier applies here, that because of the diversity of numerous users scheduling fundamentally different processes, Microsoft corporation cannot possibly design a guide and help facility or an alert system that is both generic and capable of addressing specific needs of all different industries that use the software.

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Table 1. Flexible Constraint Types in MS project

Constraint category	Constraint Types	Means of Scheduling
Flexible	As Soon As Possible (ASAP)	Project will schedule a task to occur as soon as it can occur. This is the default constraint when scheduling from project start date.
	As Late As Possible (ALAP)	Project will schedule task to occur as late as it can occur. This is the default constraint type applied to all new tasks when scheduling from project end date.

Source: Carl and Timothy (2013)

CHOICE OF THE PROJECT CALENDAR: THE WORKDATE CONSIDERATION

Project calendar, schedule flexibility and schedule elasticity are key concepts the scheduling engineer should consider when initially developing the schedule. The project calendar is the time a resource is specified being active on a task, (Gwen and Stover, 2001). This could be the number of hours in a workday or the number of days in a workweek. All pieces of scheduling software support the manipulation of both workday and the workweek calendar illustrated in Figure 6. Generally both workdates and calendar dates are considered and applications of these could be in defining:

- A resource calendar
- A task calendar and
- A project calendar

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The default calendar date is the Project calendar. This means both resources and tasks are scheduled to be active during this calendar date. Mostly, it is better to prepare a schedule initially on a workday and a workweek less than the company normal or regular workdate regime for some tasks and for some resources, and increase these during schedule implementation if conditions allow, (Gwen and Stover, 2001).

The use of multiple calendars introduces significant complexity to the calculation of float and the critical path. However, while scheduling is simplified by the use of a single calendar, one calendar may be inadequate for managing the project successfully, (De la Garza, and Kim, 2005 & 2006., Lu, 2006., and Francis and Miresco, 2006). Generally accepted practice is to use a project calendar which is adequate and reasonable to perform the work, based on normal working times. The project calendar then may be used as the primary or default calendar for the project. A limited number of special calendars may then be used for areas of the project (or resources) needing different working times. Figure 4 illustrates three different representation of project Multiple Calendars. Case 1 shows a 5-day workweek for two different resources or tasks. Case 2 shows where some resources and tasks are scheduled for a 3-day workweek, a 2-day workweek and so on.

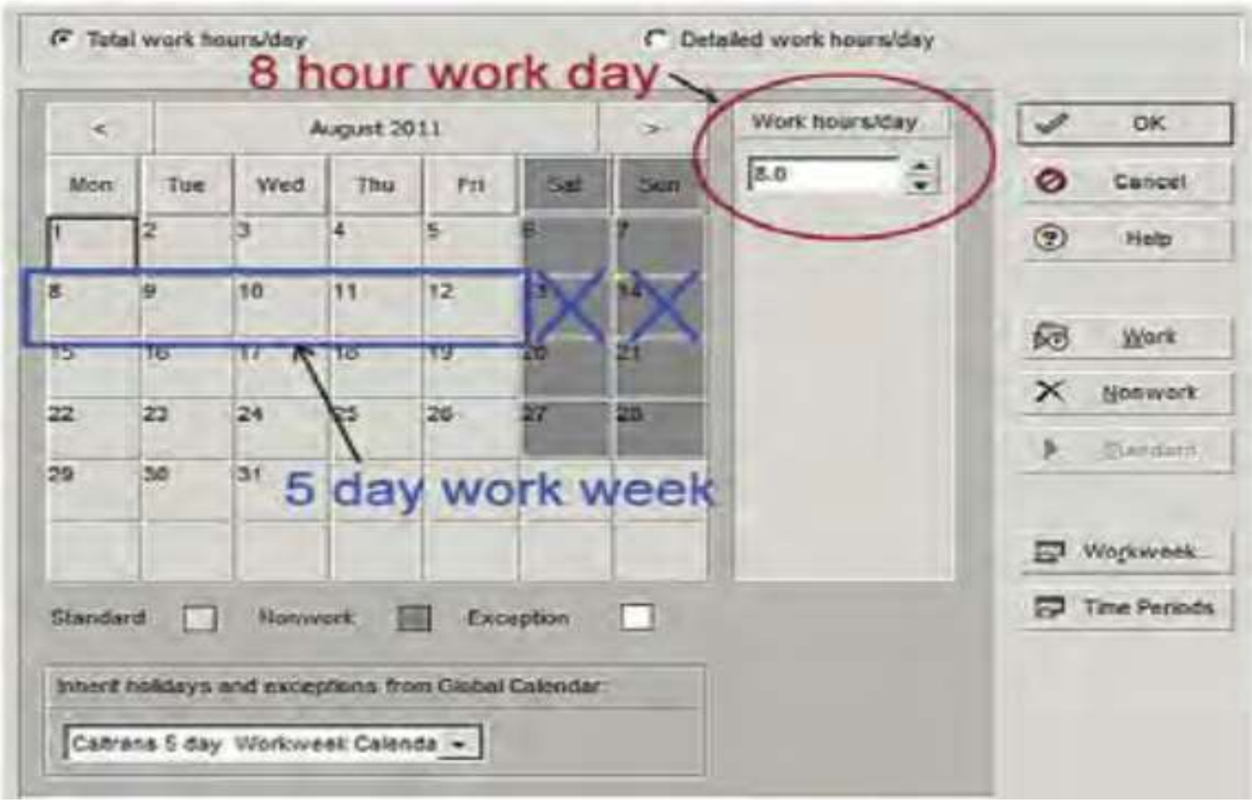

Figure 3. Example of an 8-hour Workday and a 5-day Workweek Calendar

Source: Jerry (2011)

If the upper limit of a workweek is used in the initial schedule development, the elastic limit has been reached and no further upwards move is possible to optimise operations. And often

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the large amount of man-hours and machine-hours moved to site may be rendered idle should a delay event occur. Therefore specifying a workweek less than the regular for some resources builds in a programme flexibility enough to accommodate unanticipated project delays and project change. This also serves as a reasonable safety factor against downtime of resources for some tasks.

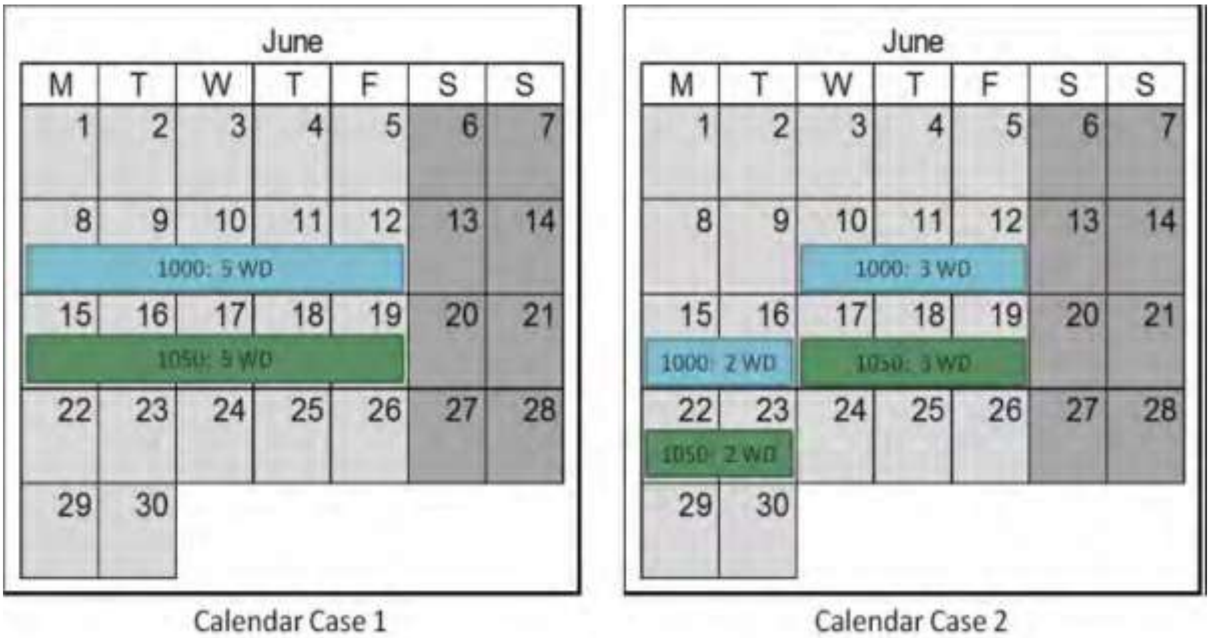

Figure 4. Example of Project Workdays in Multiple Calendars

Source: Jerry (2011)

Hanna., Taylor and Sullivan, (2005), show that different calendar options of:

- 4 dayweek & 10 hourday
- 5 dayweek & 8 hourday
- 5 dayweek & 10 hourday
- 6 dayweek & 8 hourday
- 6 dayweek & 10 hourday

Have different effects on the schedule performance. Using statistical medians and averages they developed productivity indices for different calendar dates and contend that an appropriate choice might improve effectiveness of the schedules developed and improve project performance as illustrated in Tables 2 and 3. Table 2 shows that highest average productivity was observed when a calendar date of 4 dayweek and a 10 hourday is applied. But a maximum productivity index was observed when a 5 dayweek and an 8 hourday was applied. This finding is consistent and reliable as indicated by the very low reported standard deviation which is as low as 0.089 and 0.14. A visual inspection of Table 2 suggests different project performance for different calendar date considering median productivity index, average productivity index, maximum productivity index and minimum productivity index. Calendar dates that work 40

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days a week like the 4 dayweek & 10 hourday and the 5 dayweek & 8 hourday tend to have better schedule performance than those that work 50 or 60 hours a week like the 5 dayweek & 10 hourday; 6 dayweek & 8 hourday and 6 dayweek & 10 hourday calendar dates, (Hanna, Taylor and Sullivan, 2005).

Table 3 presents the results of hypothesis testing for different calendar options by Hanna, et al. (2005). This confirms the visual inspection of Table 2. It reveals very clearly that calendar dates of 4 dayweek & 10 hourday and the 5 dayweek & 8 hourday have the same productivity. The hypothesis testing also shows that 4 dayweek & 10 hourday has a higher schedule performance than the 5 dayweek & 10 hourday and 6 dayweek & 10 hourday calendar dates. Therefore this finding of Hanna, et al. (2005) shows very convincingly that the MS project guide and help facility need to be customized to capture this knowledge to help users make informed choice of project calendar date knowing fully well that one calendar date has better performance than the other in different project scenarios.

Table 4, presents partial results of effects of calendar dates on project schedule performance. It shows that there is a high rate of progressive decline in productivity as the average hours worked each week increases due to project calendar. If for instance a schedule is based on a 5-day workweek and an 8-hour workday, giving an average 40 hour workweek and employing actual manhours of 200,000 during the week, productivity index is 1.02, which is a lot more than when the project scheduled on a 6-day workweek and 10-hour workday giving an average of 60 hours workweek which results in as low productivity index of 0.88. It is clear from visual inspection of table 4 that though there is some decline in productivity index as the actual manhours expended each week increases, the rate of decline is lower than that occasioned by the effect of the calendar date regime of 32, 35, 40, 45, 50, 55, 60 and 65 illustrated in table 4. For instance when actual manhours expended each week was varied from 240,000 to 280,000, productivity index for a 5-day workweek and an 8-hour workday (i.e, 40 hour workweek) remained average of 1.00. This visual inspection of table 4 gives a reasonable conclusion that actual manhours expended on the site each week has less significant effects on productivity index than that experienced with variation of workdate regime, (Hanna. et al., 2005).

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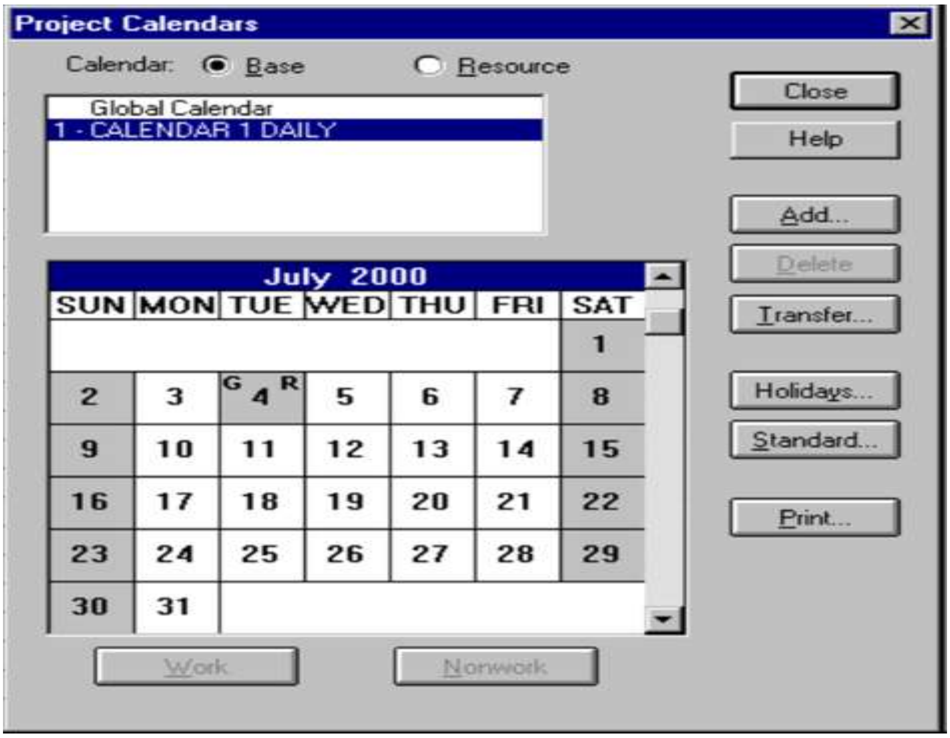

Figure 5. A 5-day Workweek Calendar with Indicated Holidays

Source: University of North Carolina (2008)

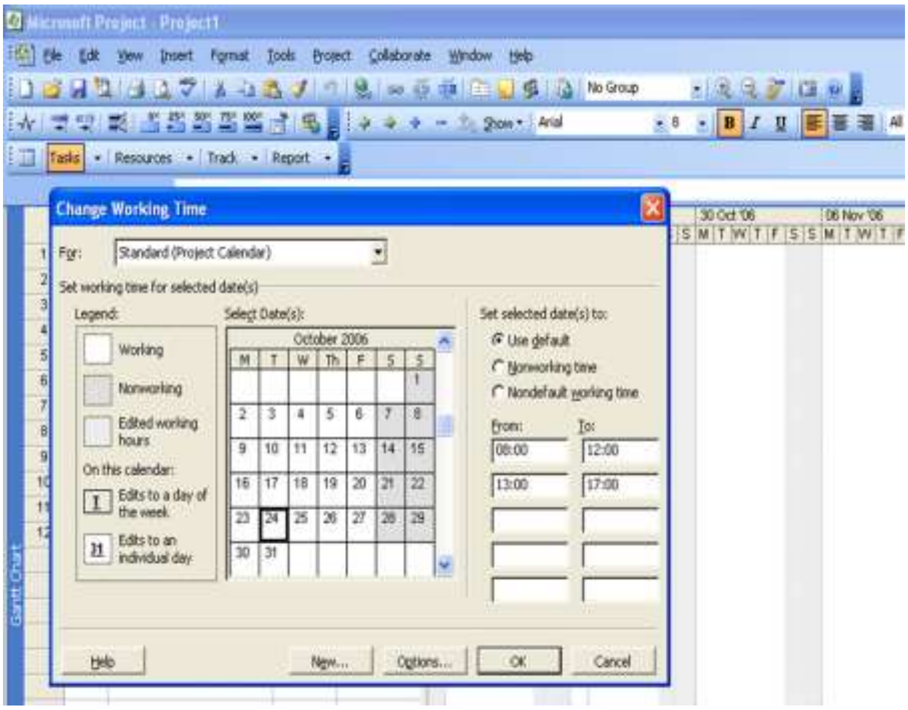

Figure 6. A Project Calendar Indicating Nonworkday

Source: University of North Carolina (2008)

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Table 2. Schedule Productivity Characteristics of Calendar Date

	Project calendar Days (h)			
Schedule productivity characteristics	5(8)s	4(10)s	5(10)s	6(10)s
Median productivity index	1.00	1.05	0.93	0.79
Average productivity index	1.04	1.06	0.90	0.78
Maximum productivity index	1.33	1.25	1.30	1.00
Minimum productivity index	0.81	0.81	0.47	0.49
Standard deviation	0.14	0.089	0.21	0.17
Sample size	23	22	30	13

Source: Hanna., Taylor and Sullivan, (2005)

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Table 3. Hypothesis Testing Results for Project Calendar Options

Test Days(h)	Days(h)	Null hypothesis	Alternative hypothesis Days(h)	*P* Value	Result
5(8)s versus	4(10)s	Same productivity	4(10)s more productivity	0.28	Same productivity
5(8)s versus	5(10)s	Same productivity	5(8)s more productivity	0.00	5(8)s more productivity
5(8)s versus	6(10)s	Same productivity	5(8)s more productivity	0.00	5(8)s more productivity
4(10)s versus	5(10)s	Same productivity	4(10)s more productivity	0.00	4(10)s more productivity
4(10)s versus	6(10)s	Same productivity	4(10)s more productivity	0.00	4(10)s more productivity
5(10)s versus	6(10)s	Same productivity	5(10)s more productivity	0.00	5(10)s more productivity

Source: Hanna., Taylor and Sullivan, (2005)

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Table 4. Partial Results of Effects of Calendar Dates on Schedule Performance

	Average hours per week							
	32	35	40	45	50	55	60	65
Actual work hours	Productivity Index							
200,000	1.09	1.06	1.02	0.97	0.92	0.88	0.83	0.78
210,000	1.09	1.06	1.02	0.97	0.92	0.87	0.83	0.78
220,000	1.09	1.06	1.01	0.97	0.92	0.87	0.82	0.78
230,000	1.09	1.06	1.01	0.96	0.92	0.87	0.82	0.77
240,000	1.08	1.06	1.01	0.96	0.91	0.87	0.82	0.77
250,000	1.08	1.05	1.01	0.96	0.91	0.86	0.82	0.77
260,000	1.08	1.05	1.00	0.96	0.91	0.86	0.81	0.77
270,000	1.08	1.05	1.00	0.95	0.91	0.86	0.81	0.77
280,000	1.08	1.05	1.00	0.95	0.90	0.86	0.81	0.76
290,000	1.07	1.04	1.00	0.95	0.90	0.86	0.81	0.76
300,000	1.07	1.04	1.00	0.95	0.90	0.85	0.81	0.76
310,000	1.07	1.04	0.99	0.95	0.90	0.85	0.80	0.76
320,000	1.07	1.04	0.99	0.94	0.90	0.85	0.80	0.75
330,000	1.06	1.04	0.99	0.94	0.89	0.85	0.80	0.75
340,000	1.06	1.03	0.99	0.94	0.89	0.84	0.80	0.75
350,000	1.06	1.03	0.98	0.94	0.89	0.84	0.79	0.75
360,000	1.06	1.03	0.98	0.93	0.89	0.84	0.79	0.75
370,000	1.06	1.03	0.98	0.93	0.89	0.84	0.79	0.74
380,000	1.05	1.02	0.98	0.93	0.88	0.84	0.79	0.74
390,000	1.05	1.02	0.98	0.93	0.88	0.83	0.79	0.74
400,000	1.05	1.02	0.97	0.93	0.88	0.83	0.78	0.74

Hanna., Taylor and Sullivan, (2005)

CONCLUSION AND CONTRIBUTION TO KNOWLEDGE

The hit and miss approach of current scheduling practice due to lack of understanding of implications different alternative choice in the MS Project is not healthy. This discuss has demonstrated very clearly from literature should schedules generated based on as soon as possible and those on as late as possible have different project performance. Also this library research convincingly demonstrated that different calendar dates applied to schedule the project yielded different productivity levels. This is the knowledge contribution. This finding shows very convincingly that the MS project guide and help facility need to be customized to capture this knowledge to help users make informed choice of project calendar date as well as the start date constraint of as soon as possible or as late as possible knowing fully well that one calendar date has better performance than the other in different project scenarios. If context-sensitive guide and help facility is built to capture this knowledge in the scheduling process, it is hoped that would significantly reduce the intuitive practice and promote precise scientific procedures called for by Galloway (2006).

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