Project Services Pty Ltd

Scheduling Complexity

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For more Scheduling papers see:
https://mosaicprojects.com.au/PMKI-SCH.php

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Synopsis

No matter how sophisticated the software or how complex the project schedule, no project schedule can foretell the future. Project planners and schedulers are not oracles (even if they use Primavera). Unfortunately convincing many lawyers and some superintending engineers of this simple fact is proving difficult. Probably as a consequence of the way schedules are perceived and developed, many projects finish late, disputes over contract delays are commonplace and the trend is getting worse.

Regardless of the terms of contract, a schedule is not a document that 'predicts the future'; at best it is a statement of intent describing how the contractor intends to fulfil its contractual obligations. At worst, the schedule is a document fabricated to 'comply with the contract', which bears no resemblance to the way the work will be accomplished; and is occasionally designed with the specific intention of facilitating the development of prolongation and delay claims.

The response by clients of the project delivery process to these problems has been to increase penalty payments for delayed completion, demand ever more highly detailed schedules and frequently draft contract clauses that make changing the schedule difficult if not impossible. All of these tactics have failed to change the steadily worsening trends of delayed completion. And as the apparent ability of contractors to manage time declines, the projects they are being asked to manage are becoming increasingly larger and more complex[1]. Without a paradigm shift in thinking, the only people who will benefit from these trends will be the lawyers and the claims experts. Fortunately there are alternatives, some of which are outlined in this White Paper!

Research by the Chartered Institute of Building (CIOB), adopted in part by the USA Government Accountability Office (GAO) offers a radically different approach to managing the use of the available time within a contract! Rather than setting up a schedule to record failure and support claims, the CIOB advocate a layered approach to time management that focuses on adapting behaviours to overcome problems and avoiding the waste of time associated with developing esoteric detail (outlined in the section on 'Schedule Density' below).

The balance of the white paper summarises the work of the CIOB and suggests a range of practical options for the improvement of time management within the Australian context, including the professionalization of the scheduling discipline.

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1. The current state of scheduling

1.1 CIOB

The Chartered Institute of Building (CIOB) conducted research into the methods by which time is managed by the construction industry, between December 2007 and January 2008 (CIOB, 2008). The essence of the research was to understand industry performance in managing time on construction projects, and in particular the techniques used and the competence of those engaged in the process. The hypothesis for the research was that, despite the development of sophisticated critical-path network software tools little had changed in the practice of time-management since the development of the bar chart nearly 100 years ago[2].

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[1] For more on factors affecting the 'size' of a project see ***WP1072 Project Size and Categorisation***: https://www.mosaicprojects.com.au/WhitePapers/WP1072_Project_Size.pdf

[2] The origins of barcharts are much older than suggested in the CIOB report, the concepts were defined in the latter part of the 18th century and sophisticated time management processes were in use by the beginning of the 20th century (the 100 year timeframe reference the work of Henry L. Gantt). See: https://mosaicprojects.com.au/PDF_Papers/P042_History_of_Scheduing.pdf

While it was apparent that some projects were managed very well, the survey showed that the quality of time-management on construction projects was generally poor. Some of the key findings in the CIOB report are:

- Over half of the respondents were familiar with only a master schedule being used, with no short term planning. Such schedules would typically be in bar chart form with no linked sequencing.
- The growth in training, education and skill levels within the industry in the use of time-management techniques has not kept pace with the technology available.
- There was a trend towards developing contracts which are increasingly punitive if the work is not executed efficiently, with good quality time-management and project controls.
- The recording of progress against plans was generally not systematic and there appeared to be a reluctance to face the consequences of delay.
- Only 33% of high rise buildings were completed on or before the completion date, 13% were completed between three and six months late while 18% were completed more than six months after their completion date.
- 58% of engineering projects were completed on or before the completion date but 18% were more than six months late in completion (predominately in the oil and gas sub-group).

The experience of the respondents was that there was little collaborative discussion with project participants, including subcontractors and suppliers, in developing project plans. Additionally, project plans, are not generally coupled with well thought out written method statements. Too often schedules were used solely as a political tool to protect companies and management from accusations of blame for delays.

This failure of management to effectively control time is best shown through the performance of the industry. The survey showed that simple, repetitive, low-rise projects have a high chance of success within traditional management processes. However, the more complex the project; the less likely it is to be completed on time. The majority of delay-related costs are perceived to be predominately at the risk of the contractor, and in many cases the contractor was perceived to be predominately to blame.

The survey makes the case for systematic project planning and control, using available technologies, in order to minimise delays and risk to clients, contractors and other parties. Competent planning engineers and project schedulers are vital to the success of this process.

1.2 Scope for improvement reports

Between 2006 and 2014 there have been four reports in the 'Scope for Improvement' series focused on major construction and engineering projects. The latest report published in July 2014 (Ashurst, 2014) identifies some improvement in the delivery of 'mega projects' but also highlights the lack of skills and a continued problem of late delivery. The report's key finding is *'The widely held industry view is that there is still significant scope for improvement in many aspects of project delivery in both the public and private sectors.'* One of the key issues highlighted is the step shift in project scale; typically up from $800 million to $2billion that occurred in the mid-2000s.

Whilst the size and complexity of projects is increasing, issues identified in 2006 continue to cause problems including overly optimistic scheduling and cost estimates, particularly in fast tracked projects.

1.3 Standish Group, CHAOS Reports

These findings are consistent with the well-reported studies into IT projects conducted over many years by the Standish Group (Standish, 2013). For the last 20 years each project in their CHAOS database was considered successful if they were on-time, on-budget and on-target (scope) with some reasonable flexibility. Challenged projects were considered late, over budget or did not meet the target. Failed projects were cancelled or not adopted by the users. The latest Chaos Manifesto classifies an 'improved' 39% of projects as successful, 43% as challenged and 18% as failed. Time

performance in this series of reports has improved from 84% of being late in 2004, to *only* 74% finishing late in 2012 (a slight regression form the 71% in 2010).

However, averages can be very misleading! The report also states that *'very few large projects perform well to the project management triple constraints of cost, time, and scope. In contrast to small projects, which have more than a 70% chance of success, a large project has virtually no chance of coming in on time, on budget, and within scope'.*

Whilst these reports focus on IT projects, they are important for two reasons; firstly the amount of IT embedded in construction and engineering projects is increasing steadily, second, the fail rates are similar for complex engineering project and IT projects potentially indicating a systemic problem.

1.4 The Challenges

The challenge confronting contractors and clients is reframing the value of schedules and scheduling to optimise the timely delivery of projects. For any given scope and design parameter, the two factor that drive cost outcomes are procurement and time management. Procurement determines the cost paid for goods and services, time management ensures that once the goods and services are procured, they are used efficiently. The combination of these two factors determines the 'cost'.

The primary tool for effective time management is 'the schedule'. However, to make effective use of any tool its capabilities and limitations need to be understood. Some of the misconceptions surrounding schedules are:

- The schedule predicts the future outcomes of the project. This is fundamentally flawed on two counts:
  - Accurately predicting the future is impossible (and always has been) – every prediction is subject to a range of possible outcomes.
  - Barcharts and CPM networks were never designed to predict outcomes; they are designed to optimise workflows.
  - At best the schedule offers one possible way of achieving the desired outcome – there are always alternative options.
- The accuracy of the schedule is improved by adding detail. This may be true if the detail is supported by knowledge of exactly who will do the work, the way they will perform the work and the efficiency they will work at (information that may be reasonably expected to be available for work in the near future). However, adding esoteric detail about work that will not happen for several months or years into the future is pointless. At best it makes the scheduled unwieldy and usually reduces its accuracy.
- The 'critical path' is a fact. In reality a skilled scheduler can make the critical path go more or less where he/she wants it to go.
- Float is real. Float is simply a by-product of the Critical Path Method of schedule development. It can provide useful insights but only exists because of the processes used to develop the schedule (Weaver 2009).

The consequence of these misconceptions is the routine development of contracts that demand detailed schedules before the knowledge to support the detail can possibly be developed. They assume the schedule is a 'truth' that cannot be changed and encourage the use of the schedule for apportioning blame rather than as a tool for crafting a successful project outcomes.

1.5 Skills

Very few schedulers are properly trained. Less than 3000 people world-wide hold an advanced scheduling qualification such as the AACEi PSP or the PMI-SP. Most 'working schedulers' have learned by trial and error how to use one or more 'brands' of scheduling software (some have been trained), their focus is the tool, rather than the processes of planning and scheduling. This 'tool centric' focus is compounded by job advertisements and employment agencies, most of which demand skills in the use of a particular type of scheduling software.

As a consequence, people attracted to the role tend to have a preference for using sophisticated software rather than working with people. This is a major problem; planning and scheduling are social activities requiring good interpersonal skills and very few schedulers are appropriately trained in these fundamental abilities (Weaver, 2010).

The lack of properly skilled planners and schedulers means most project managers and organisation executives lack any understanding of the value effective time management can bring to the overall discipline of project management. This lack of appreciation feeds into a lack of investment in skills development and training compounding the shortage of skilled planners and schedulers. This is a vicious downward spiral that has been running for more then 20 years and can be seen in the poor time management practices used (or not used) on most projects.

This problem is global. A recent update provided to the 2014 Project Governance and Controls Symposium in Canberra by Karen Ritchie of the USA Government Accountability Office (GAO) comparing time management performance across the full spectrum of USA government agencies against a set of defined 'good practices' (discussed in Section 5.1) highlights this lack of skills:

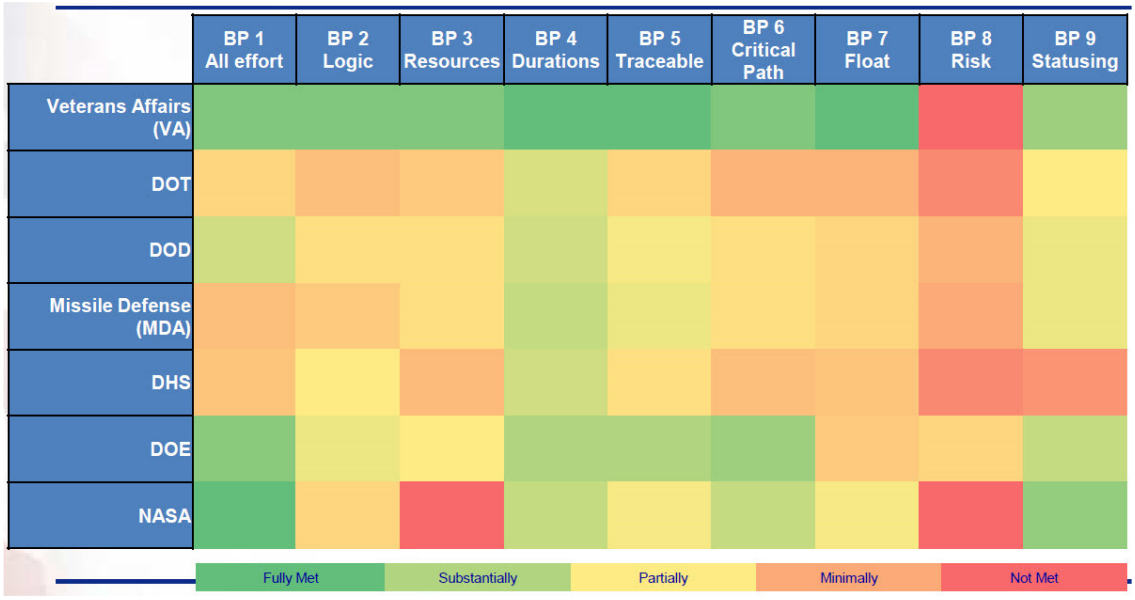

Figure 1: GAO schedule compliance overview.

Another keynote presentation at the symposium, this time from the Australian National Audit Office suggests the situation in Australia is no better! The lack of skills and the lack of management willing to invest in skills development, and then make use of the information provided, is a global issue!

2. The adversarial / punitive reaction

The poor delivery outlined in the CIOB and 'Scope for Improvement' reports is not influenced by the form of contract used. The CIOB survey could find no discernible difference based on the severity of the Liquidated Damages imposed by the contract or the form of contract:

- Imposing harsh penalties may increase the price quoted for the work, but had no effect on delivery.
- The form of contract, 'Alliance', 'Partnership', 'Traditional' made no discernible difference.

The only factor that showed a significant correlation between completion on or close to the contract date and late completion was the use of an effective schedule control process by the contractor. Those projects that were managed by having a competently developed CPM schedule that was

regularly updated and maintained achieved a significantly better time outcome then those that did not. The findings from the CIOB study seem to be supported by commentary in the 'Scope for Improvement' reports.

The paradox is that many contracts actively work against having a dynamically maintained schedule by making any changes to the schedule the subject of specific approvals by the superintendent or refusing to allow changes, particularly to the 'critical path'. This approach is demonstrably counterproductive.

The adversarial / punitive responses to late delivery have not worked and are unlikely to work in the future; a different paradigm is needed to focus everyone's attention on completing the work on schedule. No one benefits if the project is completed late. The contractor is exposed to additional time related costs and penalties, the client loses the use for the facility for the period of the delay and the professional organisations supporting the project often have increased costs without compensation.

3. Understanding the limits of CPM

Before discussing an improved option for the management of time, particularly on complex projects, it is important to understand the significant limitation in the Critical Path Method (CPM) scheduling methodology. CPM is a very simplistic approach to the planning and managing of time (Weaver, 2011); a few of the limitations inherent in CPM include:

- Single point estimates – any 'point estimate' will be incorrect, a range estimate is more likely to be realistic.
- Limited logical statements – the relationship between any two activities has far more possibilities than the four simple options[3] allowed in CPM.
- Very poor resource calculations – the work is done by resources but these are very much an afterthought in the CPM methodology. There is no provision for optimisation (despite this being one of the original objectives defined in 1957) and resource flows are not mapped[4]. Currently available resource levelling options are simplistic and ineffective (Weaver, 2012). The limitations in most scheduling tools is a key reason most project schedules are not resource balanced.
- Absolutely no predictive capabilities – CPM is based on a presumption that immediately after the current status date, all future work will be performed at the originally planned rate. CPM is no designed to predict a realistic end date for the schedule! At best the tool is designed to manage current work; realistic prediction of a completion date requires alternative processes such as 'Earned Schedule' (Weaver, 2010).

CPM is a useful, if somewhat limited tool, designed to facilitate a collaborative planning process to determine the agreed way forward. It can certainly provide useful insights and create a plan for the way future work is intended to be accomplished but that is about all.

With regular statusing and updating the 'useful life' of the schedule can be extended, provided the planner is allowed to modify and adapt the schedule to take account of the current situation and productivity. Unfortunately most contracts prohibit this type of effective time management.

[3] Standard PDM networks only allow Finish-to-Start, Start-to-Start, Finish-to-Finish and Start-to-Finish, links with a single value lead or lag. From more on leads and lags see: https://mosaicprojects.com.au/PDF-Gen/Links_Lags_Ladders.pdf

[4] There are a number of methodologies and tools available that address some of these issues but they are not in general use.

4. Schedule Density – a practical alternative

As a result of the survey conducted in 2008, the CIOB embarked on a five-year plan to put it in place a framework designed to improve the management of time in complex projects. As a starting point, the CIOB development team concluded that the cost outcome on a project is a symptom of two controllable factors:

- First how effectively resources[5] are being procured for a project (administration).
- Second how efficiently the resources are being used (time management).

Particularly on complex projects, attempts by management to simply to cut costs, without changing at least one of the two root causes identified above, starts a negative feedback loop that typically destroys quality and usually leads to increased costs in the long term.

The CIOB Time Management approach is focused on making the most efficient use of the resources actually available to the project to optimise time outcomes which should flow through to affect/improve cost outcomes (improving procurement/administration was deemed to be 'out of scope' for this project).

- In 2010 the CIOB published the ***Guide to Good Practice in the Management of Time in Complex Projects*** (CIOB, 2010)
- In April 2013 the CIOB launched the world's first ***Complex Projects Contract***, which is designed to exploit the advantages of the latest Building Information Model software, and to put time management procedures at the heart of project documentation (CIOB, 2013).
- And in 2014 the CIOB are rolling out the Project Time Management certification discussed in Section 6 below.

The ***Guide to Good Practice in the Management of Time in Complex Projects (The Guide)*** introduces a range of practical ideas to enhance the effective management of time in complex projects including:

- Differentiating between project planning and scheduling[6].
- The concept of *'schedule density'* discussed below.
- The need for on-going dynamic scheduling to manage time.
- The need to contemporaneously assess the impact of delaying events.

Implementing the ideas contained within ***The Guide*** requires changes in the way projects are managed, as well as educating construction managers and clients world-wide about ***The Guide*** and the financial benefits that can be achieved if time is managed pro-actively.

4.1 The 'Schedule Density' concept

Effective scheduling needs to be based in 'reality' and recognise that change is inevitable. The two fundamental tenets of *schedule density* are:

- Change needs to be proactively managed as it occurs, regardless of the cause.
- Detail needs to be added at an appropriate time when the requisite knowledge is available. Unless you know exactly who will be doing the work, the methodology they will use and how 'good' they are; creating a detailed schedule extending years into the future is an arcane exercise, guaranteed to be wrong.

The concept of *schedule density* advocates developing an overall 'time budget' for the project based on a carefully thought through strategy and method statement for delivering the overall project,

[5] In this context resources include all of the plant, equipment, materials and people used in the performance of the project's work.

[6] For more on the difference between ***planning and scheduling*** see: https://www.mosaicprojects.com.au/WhitePapers/WP1039_Project_Planning.pdf

expanding the detail and proactively resolving tactical problems for work in the current year and then expanding the schedule to the level of detail needed for effective control of the workforce within the current 3 month timeframe.

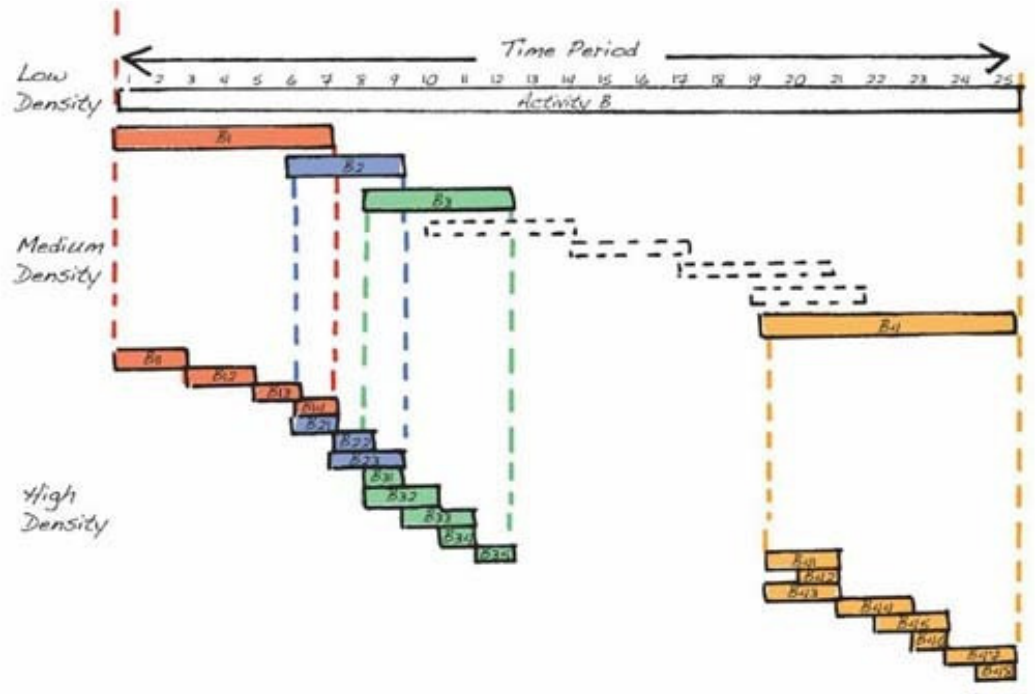

Figure 2: Schedule Density concept diagram

The 'Low Density' schedule sets the overall time budget for the project with activities that define the sequence of major components of work, of several months duration. A typical activity would be 'Construct Building G'. This overall time budget is the project's baseline schedule and represents the project team's commitment to the client.

The 'Medium Density' level of detail is added for work in the current year, in consultation with the project's suppliers and subcontractors. The level of detail is expanded to 'trade packages' of several weeks duration. Typical activities would be 'Foundations', 'Ground Slabs', 'Walls', etc. This planning exercise, undertaken every couple of months to add the next tranche of detail, is where currently identified scheduling issues are resolved. Adjusting work planned to occur 6 to 12 months in the future allows everyone time to reorganise and overcome problems.

The 'High Density' level of detail is added for work in the next 2 to 3 months, in consultation with the project's site supervisors and team leaders. The level of detail is expanded to 'detailed activities' of several days duration. Typical activities would be 'Excavate Ground Beams A, B and C', 'Place reinforcement', etc. The time allowed for these activities are based on measured performance – the short term schedule needs to be realistic and achievable with the currently available resources working at their current (or anticipated) level of productivity. If this causes a problem, the issue is resolved in the Medium Density updates. There is absolutely no point in developing an unachievable High Density schedule if the schedule is going to be used to control the work of the project[7].

This approach to time management has many advantages over the traditional approach to scheduling which seems focused on 'measuring failure' but the concepts in ***The Guide*** cannot be implemented in isolation, a support framework is needed.

[7] This is a brief overview of 'Schedule Density' more information is available in ***WP1016 Schedule Density***: https://www.mosaicprojects.com.au/WhitePapers/WP1016_Schedule_Density.pdf

4.2 The 'Schedule Density' support framework

The two key changes needed to implement 'Schedule Density' effectively are"

- A sympathetic contractual framework
- Appropriately skilled and knowledgeable schedulers and planners.

The CIOB ***Complex Project Contract 2013*** provides a framework that requires the proactive management of time. Launched on 23rd April 2013, the *Complex Projects Contract 2013* (CPC2013) focuses on managing time to ensure projects are delivered to specification on budget and without delays. Unlike existing contracts, which target failure by requiring financial compensation for late completion, CPC2013 provides the procedures to enable parties to manage time, cost and risk events in a modern and proactive fashion. It is also the first standard form contract to cater for Building Information Modelling (BIM)[8] and collaborative design. The contract is designed for projects of high value or complexity such as major real estate, engineering and infrastructure projects, with an experience client focused on achieving success[9].

Developing the knowledge and skills needed to implement schedule density is more difficult. Organisations need to be prepared to invest in the proper training of staff, to develop people that are capable of implementing effective project controls. Unfortunately most job advertisements for schedulers focus on their knowledge of the software tool being used, not the person's understanding of good scheduling practice. As a consequence, many projects have massive schedules developed in sophisticated software that are simply not used for the day to day management of the work, many others simply ignore the need for a schedule.

The basics of good scheduling practice are almost universally agreed among experts, but largely ignored in practice. ***A Guide to Scheduling Good Practice*** (Weaver, 2007) is just one of many freely accessible documents that describe the work undertaken by a scheduler to create an effective 'dynamic schedule' and is consistent with most published authorities. In addition, there are of course also many books and standards readily available.

5. Other options for defining schedule quality

A high quality schedule has two aspects, the first is it is realistic, achievable and represents the intended method of working. This aspect is subjective and contextual, useful schedules are only 'useful' if they are used! The two 'guides' discussed in section 5.1 have a strong focus on 'usability'. The second aspect is the schedule is technically correct; this aspect is now easy to assess using the automated tools discussed in 5.2 below.

5.1 CIOB and GAO Scheduling guides

Determining if the schedule is 'sensible' will always remain subjective, what is 'common sense' to one person may be seen as a radical idea by another and there is no 'one-right-way' to accomplish the work of any project. There are two references that provide guidance in this area (interlinked with technical correctness) that I find useful:

- The ***Guide to Good Practice in the Management of Time in Complex Projects*** (CIOB, 2010) was written by an international team as a handbook for practitioners. It uses logical step by step procedures and examples from project inception and risk appraisal, through design and construction to testing and commissioning, to show how an effective and dynamic time model can be used to manage the risk of delay to completion of any project.
- USA Government Accountability Office (GAO) has developed the GAO Schedule Assessment Guide (currently at exposure draft stage. GAO,2012). This schedule guide is a

[8] For more on ***BIM***, including links to freely available UK sourced reference materials see: https://www.mosaicprojects.com.au/WhitePapers/WP1082_BIM_Levels.pdf

[9] For a more detailed overview of ***CPC2013*** see: http://mosaicprojects.wordpress.com/2013/07/05/the-new-the-complex-projects-contract/

companion to the GAO Cost Estimating and Assessment Guide (GAO, 2009). Together they provide a consistent methodology for developing, managing, and evaluating capital program cost estimates including the concept of scheduling the necessary work to a timeline, as discussed in the Cost Guide and implemented through the Schedule Assessment Guide.

The GAO 'scheduling best practices' are similar to other standards. A well developed schedule will have been developed using these nine 'best practices':

- BP 1: Capturing all Activities
- BP 2: Sequencing All Activities
- BP 3: Assigning Resources to All Activities
- BP 4: Establishing the Duration of All Activities
- BP 5: Integrating Schedule Activities Horizontally and Vertically
- BP 6: Establishing the Critical Path for All Activities
- BP 7: Identifying Float Between Activities
- BP 8: Conducting a Schedule Risk Analysis
- BP 9: Updating (Statusing) the Current Schedule
- Additional BP 10: Create a Baseline Schedule (to be included in the final version)

Applying either or both of these references provides both a framework for developing a 'sensible schedule' and a methodology for assessing the 'usefulness' of a schedule. It is a far simpler and more rigorous process to specify schedule conformance to these standards than to attempt to write complex clauses.

5.2 Schedule assessment tools

Probably the biggest single area of change in scheduling practice during the last 5 years has been the development of effective analytical tools that automate the schedule checking process. These tools reverse engineer schedules created in a range of software tools and check for errors and inconsistencies. Some of the better options include:

- **Acumen Fuse**: A relatively expensive, but powerful analytical tool that integrates with most major scheduling tools[10]. Acumen is a comprehensive analysis and correction tool that includes:
  - Schedule Quality Assurance: Use industry standard checks or set your own metrics and thresholds to use as a benchmark against future plans or status updates.
  - Performance Evaluation & Schedule Acceleration: Identify potential problems while there is still time for recovery and automatically generate scenarios to get your project back on track, or even ahead of schedule!
  - Schedule Comparison & Forensic Analysis: Fuse can compare an unlimited number of schedule updates and identify not only the differences, but the impact of those changes.
  - Customisation: Evaluate schedule, cost, risk, earned value and performance using a combination of Acumen-specific and industry-standard metrics, all customisable to meet your project's specific needs.
  - Project Reporting: Quickly generate reports on quality, performance, or status of the project from Fuse. Even use the API to automatically publish these reports to 3rd party applications, the web, or Microsoft Sharepoint.
  - Acumen Cloud™: is a web-based schedule benchmarking utility built directly into Fuse that gives you the power to compare your Fuse diagnostics results to other similar projects in terms of size and/or nature.

[10] See: http://www.projectacumen.com

  - Acumen 360 gives you the ability to create schedule scenarios that accelerate time frames and recover delays.
  - Acumen Schedule Index™ Calculator: is a free web-based utility that scores schedule quality and compares it with industry benchmarks for a more comprehensive level of project analysis.
- **Schedule Analyzer**: For Primavera P3 or P6, offers detailed analysis and expert recommendations with a wide range of capabilities and reports for schedule maintenance add the eForensic package for forensic analysis[11].
- **Schedule Inspector**: Barbecana's Schedule Inspector does 30 different tests on your schedule, including all 14 points in the Defense Contract Management Agency's (DCMA's) assessment guide[12] for Microsoft Project 2007 or later schedules, plus many others including: redundant relationships, out-of-sequence progress, connectivity index (ratio of relationships to tasks), and resources or relationships on summary tasks[13].

These tools vary in price and specifications but have largely eliminated the difficulty of assessing the technical competence of any schedule. One of the more interesting developments associated with this emerging capability is that where schedule checking is performed on a regular basis, the quality of the schedules improves as does the on-time performance of the associated projects.

5.3 The value proposition

Good scheduling practice really does contribute to good project outcomes! Figure 3 is based on data from hundreds of projects uploaded to the Acumen Cloud™ web-based schedule benchmarking utility.

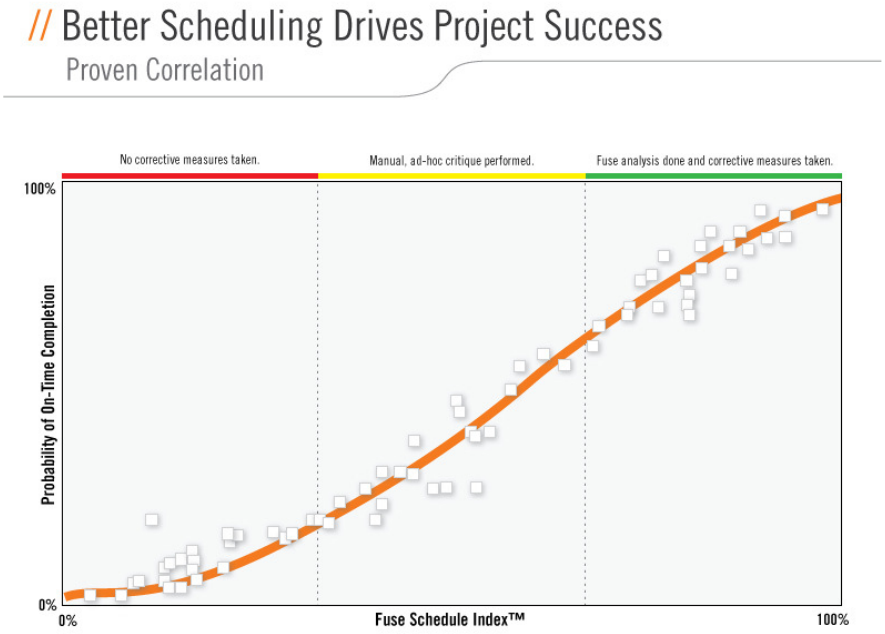

Figure 3: Data provided by Acumen.

The correlation is in two parts; good quality schedules are directly correlated with good time outcomes and underpin proactive time management. The addition of proactive time management through the

[11] See: http://scheduleanalyzer.com

[12] For more on the ***DCMA 14 Point Assessment*** check see: https://www.mosaicprojects.com.au/WhitePapers/WP1088_DCMA-14-Point.pdf

[13] See: http://www.barbecana.com

life the project then significantly increases the probability of achieving the project's time objectives. This was the conclusion derived from the CIOB 2008 survey, reinforced by current data collected by Acumen.

Given the costs associated with implementing effective planning and scheduling are a fraction of the costs associated with project failure for both the contractor and the client, why are so few organisations prepared to invest in effective project controls? Part of the answer is the difficulty of finding appropriately skilled people.

6. Closing the skills gap

Good schedules do not happen by accident. Skilled planners and schedulers, working with project teams committed to on-time performance create the 'good schedules'. The scheduler's skills are many and varied, and probably the easiest to acquire and the least valuable is being able to use a set of scheduling software[14]. There are a range of qualifications and certifications available to demonstrate the planner or scheduler has domain knowledge, all that is missing is the requirement in most standard contracts that the schedule be developed and maintained by a 'qualified scheduler'.

The currently available options include:

- PMI-SP℠ Scheduling Professional Credential - PMI's credential for professional schedulers with at least three years experience.
- AACEi Planning and Scheduling Professional™ (PSP™) – An advanced credential focused on construction & engineering professionals with 4 to 8 years experience[15].
- AACEi Certified Scheduling Technician (CST) – Designed for younger professionals with 4 years industry related experience or a □4-year industry related college degree.
- The Guild of Project Controls Scheduling Qualifications - The Guild of Project Controls (GPC) have announced the development of a scheduling certification structure[16].

The merits of the different certifications vary, but with the range available there is no longer any excuse for using unqualified people as planners and schedulers.

7. Conclusions

The traditional paradigm reinforced by most contracts assumes projects are relatively predictable entities, with known ways of achieving a successful outcome. Therefore all the contractor has to do to be successful is map this knowledge into a schedule and 'follow the plan'. If this paradigm was ever 'true' it certainly does not apply to complex projects.

In the modern world, the term 'simple project' is an oxymoron – every project is complex, some are big and complicated as well! Complexity introduces nonlinearity, emergent characteristics, and unpredictability[17].

Given there is a degree of complexity in every project, exponentially magnified by size, and influenced by technical difficulty; attempting to manage the dynamic, unpredictable environment that characterises a modern project using a static plan developed in the past is a recipe for failure. Planning remains vitally important but as the military have recognised for centuries, *'no plan of*

[14] For a discussion on the skills and capabilities required of a planner of scheduler see: https://mosaicprojects.com.au/PDF-Gen/Attributes_of_a_Scheduler.pdf

[15] For more on the AACEi certifications see: http://www.aacei.org/cert/whatCertOffers.shtml

[16] For more on the GPC see: http://www.planningplanet.com/guild

[17] For more on complexity see: https://www.mosaicprojects.com.au/WhitePapers/WP1058_Complexity_Theory.pdf

operations extends with any certainty beyond the first contact with the main hostile force[18]' – once the project's work commences the plan needs to be continually adapted and modified to deal with the ever changing dynamics of the workspace. 'Schedule density' is designed to operate effectively in this environment.

It is impossible to change the past, the focus of planning and scheduling needs to be on optimising future outcomes. When applied effectively, a proactive scheduling process can be a powerful influence on future behaviours that will contribute significantly to project success. But achieving the 'forward looking focus on success' advocated in this paper will require a paradigm shift in thinking and attitudes. Within this paradigm, understanding trends and current performance is important to underpin proactive forward looking management actions rather than for recording past failures for use in litigation.

Effective schedules are technically competent, grounded in current reality, realistic, achievable and above all used in the management of the project. All of the components needed to make scheduling effective are in place with two exceptions:

- Management need to be willing to invest in skills development and allow time and budget to do the work of schedule development.
- Clients need to be far more sophisticated in the way they specify the scheduling requirements to be fulfilled by their contractors.

We know current practices are not effective, maybe it is time for a change?

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