Project Services Pty Ltd

SCHEDULING IN THE AGE OF COMPLEXITY

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Introduction

Critical path scheduling was developed as a scientific, computer based, modelling process at a time when command and control was the dominant management paradigm supported by the ideas of scientific management[1]. As the discipline emerged, the artefacts created by schedulers generated the impression that the mathematical certainties calculated by their leading-edge computer tools somehow translated into certain project outcomes. Fast forward 50 years and the certainties are no longer so apparent:

- Most project run late;
- Knowledge workers cannot be effectively managed using command and control paradigms;
- The art of effective scheduling has largely disappeared from the project landscape; and
- Uncertainty and complexity are starting to take centre stage.

The challenge facing schedulers world-wide is to develop new understandings and skills that will reinvigorate the profession so they can once again make a significant contribution to the successful delivery of projects and programs.

This paper will firstly identify the various dimensions of a project and how these dimensions impact the difficulty associated with successfully managing the project. It will then briefly outline the evolution of project management and scheduling to understand why the current assumptions and management paradigms are as they are, and highlight some of the problems that currently prevent the schedule from being seen as a useful project management tool.

The second part of the paper will briefly outline the salient aspects of Complexity Theory as it applies to project management and highlight the critical role that individual decision making and relationships play in the project team's endeavours to successfully deliver their project. From these two threads, the final section of the paper develops the framework for a new role for the project schedule as a key communication and motivation tool vital for the successful delivery of larger, more complicated projects and identifies the skills needed by a scheduler in the 21st Century.

The Dimensions of a project

There are four basic dimensions to every project:

- Its inherent size usually measured in terms of value;
- The degree of technical difficulty in creating the output;
- The degree of uncertainty involved in the project; and
- The complexity of the relationships ('small p' politics) both within the project team and surrounding the project.

The difference between how complicated the work is and complexity theory is that managing complicated work (ie, work with a high level of technical difficulty) is achievable by implementing appropriate systems such as quality management and configuration management. The consequences of technical difficulty are definable, predictable and manageable with the right people. As will be demonstrated below, the essence of complexity theory is that the future is inherently unpredictable.

Interestingly, whilst all of these factors impact on the degree of difficulty associated with successfully managing the delivery of the project, the Project Manager can only significantly influence, as opposed

[1] See: ***The Origins of Modern Project Management*** - https://mosaicprojects.com.au/PMKI-ZSY-005.php#Overview

to manage, the last two elements. Reducing the degree of uncertainty and enhancing the relationships with and between project stakeholders (including the project team)[2].

One should also note there is a significant difference between a program and a project and the associated skill set required by their respective managers. These issues are discussed in *Understanding Programs and Projects - There is a difference!*[3] However, from a scheduling perspective the only real difference is the need for all of the key stakeholders to recognise a program schedule is:

- Firstly, operating at a higher level and should be focused on the gaps between the projects; and
- The whole program likely to change from time to time as it is re-focused to maximise the realisation of value from its outcomes, to the benefit of its host organisation and to deal with changes in the environment and the strategic objective of the organisation.
- Size and technical difficulty are not differentiators between projects and programs. Projects are focused on producing a defined output or deliverable. Programs are focused on achieving an outcome by managing multiple projects together.

Therefore, whilst this paper focuses on project schedules the concepts discussed are equally applicable to program schedules.

Project Size

The size of the project or program will impact the degree of difficulty in achieving its objectives but large projects are not necessarily complicated or complex. There are projects in Australia to shift millions of cubic meters of overburden from mine sites with expenditures rising to several $million per day but the work is inherently simple (excavating, trucking and dumping dirt), and the relationships in and around the project are relatively straight forward. The management challenges are essentially in the area of logistics. One only has to contrast this type of mega project with the difficulties of successfully delivering a small culture change within an established bureaucracy (say a new timesheet system) to appreciate size is only one dimension of a project.

Technical Difficulty (degree of complication)

It is also obvious that complicated *high-tech* projects are inherently more difficult to manage than simple projects. The nature of the technical difficulties and the degree of certainty largely depend on how well understood the work is. Bleeding edge research has a far higher level of uncertainty associated with every aspect of its management than a project of similar technical difficulty that has been undertaken several times before. The degree of understanding of both the project's characteristics and the way they will be accomplished on the part of the project's client is as important to the success of the project as the understanding of the project team. The lower the levels of knowledge, the more difficult it is to achieve a successful project outcome that delivers the benefits expected by the client. This lack of knowledge impacts the schedule in several ways; it will lead to:

- Less accurate estimates of activity duration, sequence and resource requirements;
- Less certainty the schedule contains 100% of the project scope; and
- Greater needs for schedule updates and modifications to maintain relevance.

Paradoxically, the less that is known about the overall work of the project, with the associated reduction in accuracy of the schedule, the more important the schedule becomes as a tool for guiding the execution of the work and managing change. Research by the CIOB in the UK construction industry suggests critical path schedules are almost irrelevant on simple well understood building projects (there was no overall difference in on-time performance between projects with a schedule and those without).

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[2] For more on ***Stakeholder Management*** see: https://mosaicprojects.com.au/PMKI-SHM.php

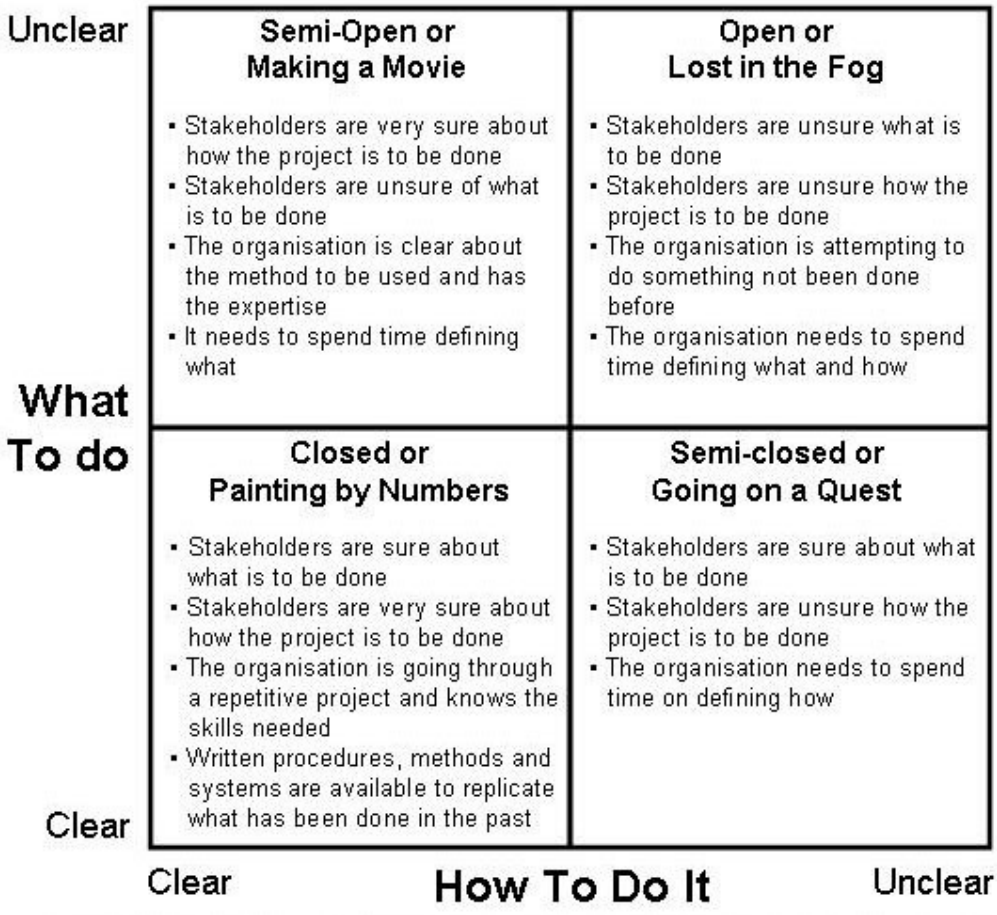
[3] See: ***Understanding Programs and Projects*** - https://mosaicprojects.com.au/PMKI-ORG-035.php

However, as soon as the projects became moderately complex, the value of the schedule as a tool to help achieve on-time completion was significant. The more complex the project, the more significant a well maintained schedule became in achieving on-time completion (CIOB, 2008).

Uncertainty

The degree of uncertainty associated with the desired output from the team's endeavours has a major impact on the management of the project. This is different to the issues around bleeding edge projects discussed above. The less certain the client is of its requirements, the greater the uncertainty associated with delivering a successful project and the greater the effort required from the project team to work with the client to evolve a clear understanding of what's required for success. This is not an issue as long as all of the project stakeholders appreciate they are on a journey to initially determine what success looks like, and then deliver the required outputs. Budgets and timeframes are expected to change to achieve the optimum benefits for the client; and the project is set up with an appropriately high level of contingencies to deal with the uncertainty. Problems occur if the expectations around the project are couched in terms of achieving an 'on time, on budget' delivery when the output is not defined and the expected benefits are unclear[4]. Managing uncertainty is closely associated with and influences the complexity of the relationships discussed below.

One measure of uncertainty developed by Eddie Obeng measures how much is known about what has to be achieved and how much is known about the methods of achieving the outcomes. The four options are detailed below.



Source: Obeng E (1994) *The Project Leader's Secret Handbook*. Financial Times Prentice Hall

[4] For more see: *Avoiding the Successful Failure* - https://mosaicprojects.com.au/PMKI-SHM-005.php#Practical

When a bleeding edge project has a clearly defined end point you are on a *quest* the challenge is finding the optimum route to the end. When the end point is unclear you are either *making a movie* – the process are well known but the outcome is uncertain or on a *walk in the fog* where neither the route nor the outcome are defined[5].

Complexity = The People

Complexity Theory has become a broad platform for the investigation of complex interdisciplinary situations and helps understand the social behaviours of teams and the networks of people involved in and around a project. These ideas apply equally to small in-house projects as to large complicated programs. In this regard, complexity is not a synonym for complicated or large[6].

Complexity Theory has developed from and includes the earlier field of study known as Chaos Theory. Complexity Theory can be defined as the study of how order and patterns arise from apparently chaotic systems and conversely how complex behaviour and structures emerge from simple underlying rules (Cooke-Davies, Cicmil, Crawford, Richardson. 2007). Some of these ideas appear directly relevant to understanding project management from a relationship perspective.

Chaos Theory

Some of the foundations of complexity derived from Chaos Theory include the Tipping Point, Nonlinearity and Emergence.

One of the earliest ideas to emerge was the Tipping Point (Gladwell, 2000). This describes the way natural systems can absorb influences with minimal, or predictable, change until the Tipping Point is reached and then there is a sudden catastrophic change. The idea of Nonlinearity builds on from this and suggests that you can do the same thing several times over and get completely different results. Small differences at the start may lead to big changes (the *butterfly effect*) whilst big variations may have minimal effect. Importantly, all human relationships are non-linear.
The complete unpredictability of Nonlinearity is counteracted by the idea of Strange Attractors. Strange Attractors are most easily thought of as recurring patterns that have quasi-predictable features. The behaviour of dynamical systems in nature, such as the weather, has a degree of predictability. However, dynamical systems can follow a number of qualitatively different attractors depending on minute changes in their initial starting condition and the effect of external influences. The idea of a *normal degree of predictability* underpins modern civilisation[7] and most project processes including estimating, scheduling and risk analysis; however, the actual outcomes are highly dependent on the starting condition and the Strange Attractors encountered along the way (Cooke-Davies, et al. 2007).

This brings us to the concept of Complex Dynamical Systems. These systems are continuously both receiving and transmitting energy to their environment (eg, a Hurricane); at the detail level they are in chaos but overall are a quasi-predictable system. After a period of time transferring energy, these systems reach a point of irreversible change (bifurcations) where the outcome is inherently unpredictable. Open systems such as these tend to be bounded at one level to rules of conduct and yet at a more detailed level act randomly. The name for this type of bounded disorder is chaordic, meaning there is unpredictability within order. Projects can be thought of similarly, there is a general set of predictable rules in play at the higher levels of organisation, but at the detail level the precise actions of individuals reacting within their network of relationships are largely unpredictable (Woolf, 2007).

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5 For more see *Projects aren't Projects* http://mosaicprojects.wordpress.com/2009/04/09/projects-arent-projects2/

6 For further discussion see: *A Simple View of 'Complexity' in Project Management* - http://www.mosaicprojects.com.au/Resources_Papers_070.html

7 See: *The Meaning of Risk in an Uncertain World* - http://www.mosaicprojects.com.au/Resources_Papers_040.html

Complex Adaptive Systems and Emergent Behaviours

Complex Adaptive Systems are self-organising complex dynamical systems that have the capacity to learn from their experience. This system description appears to relate very closely to a project team, living on the *edge of chaos*; responding and adapting to its surroundings (ie the project's stakeholders) and learning, or creating new knowledge, as it advances. The key strand of research into complex adaptive systems that this paper will focus on is the concept of Complex Responsive Processes of Relating.

Complex Responsive Processes of Relating (CRPR) puts emphasis on the interaction among people and the essentially responsive and participative nature of the human processes of organising and relating. *Organisation is an emergent property of many individual human beings interacting together through their complex responsive processes of relating*. (Stacey, Griffin, Shaw. 2000) They use language in conversations to simultaneously transfer information and ideas, negotiate social status and develop power relationships (Cooke-Davies, et al. 2007).

The people's intentions, choices and actions/reactions are influenced by and influence their conversations as they operate within the dynamic of their daily interactions with other people in the project team. The process of *organising* is the human experience emerging from the interactions between people who are all continual forming intentions, choosing and acting in relation to each other as they go about their daily work together implementing the project. The future seen from this perspective is therefore under perpetual construction by the movement of the human action itself.

The people's interactions and emerging organisation are:

- Located in the specific context of the organisation's social network, culture and the project team; and
- Oriented towards an unknown future (the project outcome) that the group is in the process of continually creating (or working to achieve).

In this context, the intended (or planned) future needs to be differentiated from the actual future that unfolds over time.

The key characteristic is *emergence*, the way complex systems and patterns arise out of a multiplicity of relatively simple interactions. Emergence is largely unpredictable and can have remarkable intensity. A recent example was the sudden collapse of the share markets around the world in October 2008. There were certainly triggers but the overall consequences were far larger than anyone predicted.

Temporary Knowledge Organisations

Viewing a project as a Temporary Knowledge Organisation (TKO) (Sbarcea, Martins. 2003) moves the focus of project management from the observation of the output of the project (ie, its deliverables) to the processes needed to transform inputs received by the project team into the project deliverables. This transformation is achieved by the gathering, melding, processing, creating and using of knowledge. TKOs share characteristics such as uniqueness, finiteness, uncertainty, and transience with the traditional concept of a project. The difference is the recognition that *linearity and predictability are not the realities of project management,* and that resolution of *multi-causal problems within a complex and chaotic environment* requires the team members as knowledge workers to generate new knowledge (Cooke-Davies, et al. 2007). This represents a shift from viewing projects as tools applied to solving problems, where people are outside the project; to the creation of a sense-making community of practice by the people involved in the project. This requirement for project team members to also be knowledge workers leads to additional expectations of the role of the schedule to coordinate, inform and assist the team members in their work (Bourne, 2005).

Social Network Theory

A social network is a social structure made of nodes (which are generally individuals or organisations) that are joined by some form of relationship. The shape of a social network helps determine a network's usefulness to its individual members. The project team is a social network and it exists within a larger network primarily consisting of the project's stakeholders. The project network can be considered as being both independent of the larger organisational network and an integral part of it.

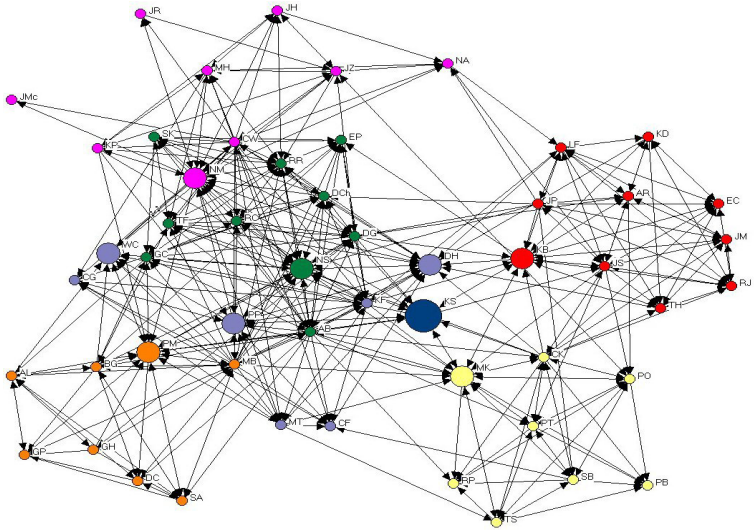

Figure 1 – Influence Networks (Bourne 2007)

Each network contains a level of *social capital* - the sum of the actual and potential resources embedded within, available through, and/or derived from the network of relationships that connect its members or *actors*. In the context of this paper, the two key aspects of social capital are the knowhow required to create and deliver the project outcome and the willingness to exert effort to achieve the project outcome. Importantly, the level and availability of social capital within a social network is not fixed, it can be increased by developing:

- A more effective network by creating stronger relationships (links);
- A better alignment of the actor's objectives through developing clear, agreed goals; and
- Effective collaboration and leadership (ie, by developing a high-performance team).

Conversely social capital can be dissipated by ineffective leadership, lack of agreement and contradictory visions. The Tipping Point that can throw a group of people into a high-performance team or into a dysfunctional team cannot be predicted but the processes that help create successful teams are well known and are founded on effective communication.

Combining TKOs, Social Networks and CRPR

Combining these ideas, the actual transfer of knowledge through the relationships that create the social network is the factor that allows the project team, functioning as a TKO, to develop the new knowledge needed to create the project's unique deliverables. It is also important to note the actual transfer and creation of knowledge and the implementation of the new knowledge to create the project deliverable is absolutely controlled by the willingness of each of the people within the network to decide to engage positively in the work. Therefore, the effectiveness of these processes is constrained in part by:

- The extent of knowledge actually available to the network;
- The efficiency of the network in transmitting the information to and between the people who need to make use of it;

- The willingness of the people to actively engage in the process and implement the knowledge in an aligned and effective manner; and
- The decisions made by the people within their relationships that influence their future behaviours and the effect of their behaviours on the other actors.

The observation of a high-performance team is evidence of the knowledge processing and social networking systems working effectively.

The core role of the schedule within the concept of a TKO is to inform the team members of what's required of them. The people's individual decisions to act to achieve the objectives described in the schedule (or not) is a function of:

- How well they each understand the schedule's message in the first place; and
- Secondly the positive strength of their relationships which will encourage appropriate action (negative relationships or no relationship will tend to encourage resistance).

To understand the seismic shift these ideas represent, it is now necessary to understand the origins of scheduling and modern project management.

The Origins of Scheduling

A Brief History of Project Management[8]

Projects in one form or another have been undertaken for millennia:

- The ancient Egyptians constructed the pyramids some 4500 years ago;
- Sun Tzu wrote about planning and strategy 2500 years ago: *every battle is a project to be first won; then fought* (Chin-Ning, 2006);
- Numerous transcontinental railways were constructed during the 19th century; and
- Buildings of different sizes and complexity have been erected for as long as mankind has occupied permanent settlements.

However, it was only in the latter half of the 20th century people started to talk about project management. Earlier endeavours were seen as acts of worship, engineering, or nation building. And the people controlling these endeavours called themselves priests, engineers, architects or frequently military leaders.

The ideas that led to the development of modern project management can be traced back to the protestant reformation of the 15th century. The Protestants and later the Puritans introduced a number of ideas including *reductionism*[9], *individualism*[10] and the *protestant work ethic* (PWE)[11]. These ideas resonate strongly in the spirit of modern project management. From the perspective of the evolution of modern project management, these ideas were then incorporated into two key philosophies, Liberalism and Newtonianism (Whitty, Schulz. 2007).

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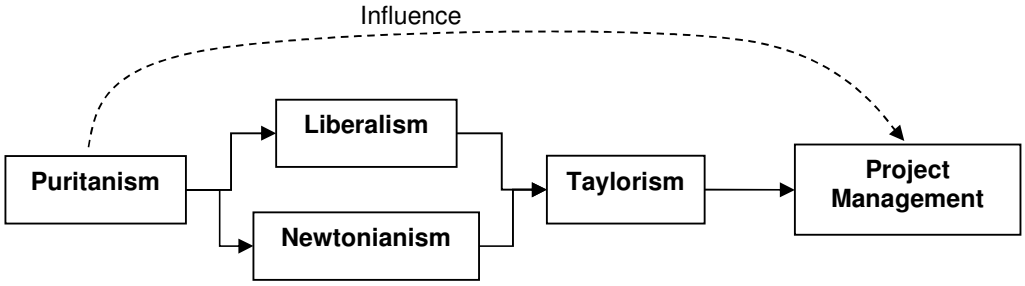
8 See: ***The Origins of Modern Project Management*** - https://mosaicprojects.com.au/PMKI-ZSY-005.php#Overview

9 Reductionism = Removing unnecessary elements of a process or 'ceremony' and then breaking the process down into its smallest task or unit to 'understand' how it works.

10 Individualism = we are active, independent agents who can manage risks. These ideas are made into 'real things' by social actions contingent upon the availability of a language to describe them.

11 PWE = Prior to the protestant reformation most people saw work as a necessary evil (or at least as only a means to an end). For Protestants, serving God included participating in, and working hard at, worldly activities as this was part of God's design and purpose for each individual.



For a full discussion of this diagram see 'The impact of Puritan ideology on aspects of project management'. International Journal of Project Management 25 (2007) 10-20. Whity, J.

Figure 2 - The Origins of Modern Project Management

Liberalism included the ideas of capitalism (Adam Smith), the division of labour, and that an industrious lifestyle would lead to wealthy societies.

Newtonianism marks the era of scientific enquiry. Newton saw the world as a harmonious mechanism controlled by a universal law; the 'clockwork universe'. Applying scientific observations to parts of the whole would allow understanding and insights to occur and eventually a complete understanding of the universe.

These philosophies influenced the theories of Frederick Taylor, who is known as the Father of Scientific Management. Taylor was undoubtedly influenced by his Quaker roots (Protestantism), worked in an intensely capitalistic society (Liberalism) and used the scientific approach of Newtonianism in his work developing the Classical School of scientific management in 19th century America.

Scientific management focuses on the worker as part of the machinery of production and assumes productivity can be increased by increasing the efficiency of production processes. One of Taylor's famous experiments had to do with increasing the output of a worker loading pig iron into a rail car. He broke the job down into its smallest constituent movements and timed each movement with a stopwatch. The job was redesigned with a reduced number of motions as well as reduced effort and a reduced risk of error. The Taylor model gave rise to dramatic productivity increases.

This reductionist approach to complex endeavours, supported by the division of labour is central scientific management as well as many modern project management processes such as developing the Work Breakdown Structure (WBS) and traditional scheduling. The current challenge is to adapt the useful ideas contained within modern project management to a society where the command and control ideas of scientific management have been largely superseded.

The ongoing development of general management theory in the USA through to the 1960s was a critical underpinning for the creation of modern project management and is firmly rooted in the ideas of Scientific Management. However, project management did not emerge spontaneously from within general management. The forces that created modern project management were a synthesis of general management theory and the spread of scheduling.

The mechanism appears to have been:

1. The genesis of modern project management was the schedulers need to create forums to discuss and develop their new discipline; and consequently
2. The schedulers formed most of the world's project management associations in the early 1960s; and

3. The codification of project management theory and the creation of the emerging profession of Project Manager is largely the result of efforts by the project management associations world-wide; therefore arguably, scheduling was central to the creation of modern project management (Weaver, 2007a).

A Brief History of Scheduling

The science of scheduling as defined by Critical Path Analysis (CPA) celebrated its 50th Anniversary in 2007. In 1956/57 Kelly and Walker started developing the algorithms that became the Activity-on-Arrow or ADM scheduling methodology for DuPont. The PERT system was developed by the US Navy at around the same time but lagged CPM by 6 to 12 months, although the term critical path was invented by the PERT team. Also, starting around the same time, the Precedence (PDM) methodology was developed by Dr. John Fondahl and published in a paper in 1961 as a non-computer alternative to CPM[12].

Interestingly, all three developments seem to have been autonomous, as were other similar developments from around the same time in Europe such as MPM. It would appear there was a general need for more sophisticated tools to manage the time aspect of projects, compared to the static Barcharts and Milestone Charts that had been in use for many decades. Certainly in the USA, the arrival of the first commercial computers was the catalyst for starting the development of CPM scheduling.

From this beginning, the evolution of scheduling closely tracked the development of computers. The initial systems were complex mainframe behemoths. Scheduling tools migrated to the mini-computers of the 1970s and 80s but remained expensive, encouraging the widespread use of manual scheduling techniques. Only the larger (or more sophisticated) organisations were able to afford a central scheduling office and the supporting computer systems.

The advent of the micro-computer (ie, personal computer, or PC) in the 1980s and 90s changed scheduling for ever. The evolution of PC based scheduling moved project controls from an environment where a skilled cadre of schedulers made sure the scheduling was right to a situation where anyone who could learn to drive a scheduling software package was allowed to develop schedules. Schedules became islands of data sitting on peoples' desktops and in many organisations the overall quality of scheduling declined sharply.

The current trend back to Enterprise Project Management (EPM) systems supported by networked computers (the Internet) and PMOs, seems to be partially redressing the balance and has the potential to offer the best of both worlds. From the technology perspective, information is managed centrally, but is easily available on anyone's desktop via web enabled and networked systems (Weaver, 2006).

The challenge for PMOs using EPM tools is to make the schedule information useful and flexible. To achieve this, skilled schedulers will need to focus on the needs of the people who should be using the information rather than their tools; the mountains of data produced by 'powerfool'[13] software jockeys are not much use to anyone except possibly claims consultants and lawyers after the project is finished[14].

Where We Are Today

As a direct consequence of its evolutionary roots modern project management and more particularly scheduling, were founded on a philosophy based on the concept of project controls. However, project management is beginning to transition from a focus on controls and the iron triangle of time, cost and

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[12] See: ***A Brief History of Scheduling*** - https://mosaicprojects.com.au/PMKI-ZSY-020.php#Overview

[13] Quoted by Mark 'Doc' Dochtermann - PMI CoS Webinar, Feb. 25th 2009 http://www.pmicos.org/ondemandlearning.asp

[14] See: ***Improving Schedule Management*** - https://mosaicprojects.com.au/PMKI-SCH-010.php#Process2

output (scope + quality) defined in the late 1960s, to a focus on leadership, motivation and communication. 21st Century project management as defined by *The Guide to the Project Management Body of Knowledge (PMBOK® Guide)* 4th Edition (PMI, 2008) is moving towards a future that seeks to maximise stakeholder value through the effective application of 'soft skills'; in an environment that recognises risk, uncertainty and complexity as key challenges facing the project team[15].

For the tools that defined project management to remain relevant in the C21 a new paradigm is needed, built around collaboration, negotiation, motivation and coordination. This means changing the project schedule from a detailed backward looking tool to an effective forward looking communication and collaboration medium.

Developing a Competent Schedule

Shifting the role of the schedule from a detailed backward looking control tool to a key communication tool does not negate the necessity for the schedule to be as accurate as possible. One of the fundamental tenets of communication theory is the requirement for a message to be credible before you can expect the receiver to act on the information (Weaver, 2007b). The key difference is in addition to accuracy, a competent C21 schedule also has to be easily understood! Understandability is essential to create an effective communication tool that can be used to motivate, influence and align the future actions and decisions of the project team.

PMI's Contributions and Emerging Guides and Standards

The Project Management Institute (PMI®) has been at the forefront of developing standards focused on improving project management practice for over a quarter of a century. The *PMBOK® Guide* (PMI, 2008) has contained a chapter on Time Management since the first edition in 1983. More recent initiatives have included the founding of the PMI College of Scheduling and later the publication of The *Practice Standard for Scheduling* (PMI, 2007).

The *PMBOK® Guide* and the Practice Standard between them offer a solid framework for the development of an effective schedule; although of necessity the guidance is at a relatively high level and generic. PMI have followed on from the publication of its standards with the release of the PMI-SP (Scheduling Professional) credential in 2008.

With the creation of the PMI-SP credential, for the first time there is a framework of standards and supporting certifications from one organisation to recognise knowledgeable project schedulers.

Other Initiatives

There are a number of other initiatives focused on improving scheduling practice:

- The Association for the Advancement of Cost Engineering has a well respected and long standing Scheduling credential (primarily focused on the construction industry);
- The Association for Project Management (UK) has released its *Introduction to Project Planning* (APM, 2008)
- The UK based Chartered Institute of Building is developing a *Best Practices Guide* for scheduling construction projects;
- Several training organisations have launched or announced training courses focused on scheduling best practice and credentials (as opposed to courses focused on the use of

[15] See: ***Project Controls in the C21 – What works / What's fiction*** - https://mosaicprojects.com.au/PMKI-SCH-005.php#Process2

scheduling tools). My own organisation, Mosaic has upgraded and re-launched its 5-STEPS scheduling course (originally developed in 1989). The new course is based around the PMI Practice Standard for Scheduling[16].

These initiatives are likely to continue to expand and should together contribute to the renaissance of the professional scheduler, a person capable of developing a competent schedule and working effectively in the age of complexity.

The basics of a Competent Schedule

A competent schedule has three elements:

1. It needs to be complete and logical. Generally developed in accord with the principles outlined in Chapter 3 of *The Practice Standard for Scheduling* and conforming to good practice as defined in Chapters 4 and 5.
2. It needs to be an effective communication medium. This requires the output from the schedule to be capable of being easily understood by non-schedulers (managers and team members). Generally, this requires an effective coding system to allow the extraction of targeted reports, focused on the needs of key stakeholders both at the project workface and in management roles. Larger projects may benefit from adopting a schedule level[17] approach. A strong personal preference is to avoid developing any single schedule network larger than around 500 tasks; larger networks simply confuse non-schedulers. On a large project this may require a summary schedule (possibly Level 2) supported by several Level 4 schedules and maybe a coordination schedule at Level 3.
3. The degree of uncertainty and level of risk inherent in the schedule needs to be clearly understood and communicated. The schedule should contain:
    - Contingency allowances of identified risks such as industrial strikes, rain and test failures;
    - Contingency allowances for the inherent variability in duration estimates; and
    - Reserves for *unknown unknowns*.

The effective C21 scheduler also needs to clearly understand the limitations of a CPM schedule to avoid over-promising its capabilities.

The Limitations of CPM

CPM is a modelling process. The key thing to remember is *all models are wrong – some are useful* and that *the practical question is how wrong do they have to be, to not be useful?* [18] Any practicing scheduler who believes their CPM schedule is 100% correct probably also believes in the tooth fairy and Father Christmas. Our challenge is to communicate the usefulness of the CPM schedule to management despite knowing it is not a 100% accurate prediction of what will actually happen in the future. My personal experience suggests many managers and lawyers actually want to believe in the tooth fairy and become very disappointed when they realise I cannot accurately predict the future!

The solution to the inevitable errors in the original schedule is, of course, the routine statusing and updating of the schedule to maintain its relevance[19]. There are however a number of issues that remain including the inability of a CPM tool to scale remaining durations and issues around determining durations, logic and float.

The inability to scale remaining durations

[16] See: https://mosaicprojects.com.au/Training-WS-CPM.php

[17] For more on ***schedule levels*** see: http://www.mosaicprojects.com.au/PDF/Schedule_Levels.pdf

[18] George E. P. Box, Professor Emeritus of Statistics at the University of Wisconsin

[19] For more on updating see: *Managing for Success - The power of regular updates*, at https://mosaicprojects.com.au/PMKI-SCH-014.php#Process6

Probably the biggest difference between CPM and Earned Value (EV) is the underlying assumption in EV that past performance is the best indicator to future performance. EV formulae include the built in scaling of future expenditure based on the ratio between actual costs and the earned value to date (the Cost Performance Index or CPI). The underlying assumption built into CPM is that all work after the data date (or Time Now) will be performed as planned. One potential solution to this problem is the ideas emerging in the Earned Schedule (ES) debate[20]. However, whilst ES scales the time required for the remainder of the project based on performance to date, its key measure is the volume of work performed relative to the plan rather than progress on individual activities and the critical path.

To date schedulers lack a standardised methodology to effectively transpose current performance forward into the planned performance space.

The Issues around Durations, Float and Logic

The basic building blocks of the CPM modelling process, activities and links are very simplified assumptions about what might happen in the future.

Assuming a schedule activity is clearly and unambiguously described (as recommended in the *Practice Standard*, but difficult to achieve) the estimation of the activity's duration is always a subjective guess! This is true even when carefully measured quantities are divided by production rates and the resulting time is divided by the optimum crew size and the resulting net duration is multiplied by a *difficulty factor* to arrive at a precisely calculated duration for the activity[21].
Unfortunately, no one can accurately predict who will actually turn up to do the work, how skilled or motivated the workers will be or how many interruptions will occur.

A similar set of issues surround the construction of the logic diagram and the consequential calculation of float values. All of the relationship types used in a CPM network are gross simplifications of the possible overlapping of the work involved in two adjacent activities. The actual boundaries between the work on two activities are always fuzzy with thousands of different options and even the division of project work into discrete activities is very often an artificial convenience[22].

The issues raised in this brief section are not focused on poor scheduling practice; although poor practice will make the situation worse. They are inherent in the CPM modelling process. CPM is not a perfect tool and skilled practitioners need to understand its limitations.

Dealing with Uncertainty

As soon as the culture of an organisation using CPM is prepared to recognise the inherent limitations of the process, it opens up the possibility of testing each CPM model to develop insights into the dynamics and sensitivity of the project it represents. Knowing the schedule is wrong allows the question *how wrong?* to be asked and two follow up questions:

- Is the level of error low enough to allow the CPM to still be of use?
- What actions do we need to take to maintain the level of error in an acceptable range?

One of the options is to analyse the level of error in the schedule using PERT or Monte Carlo analysis to assess the range of possible outcomes. Other options include developing 'buffers' within the CPM model to protect the overall outcome from variability (Critical Chain is one example) or using more sophisticated modelling techniques such as RDM.

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[20] For more on Earned Schedule see: http://www.earnedschedule.com

[21] For more on durations see: ***The Cost of Time - or who's duration is it anyway?***, at https://mosaicprojects.com.au/PMKI-SCH-012.php#Overview

[22] For more on issues around float and logic see: ***Float - Is It Real?***, at https://mosaicprojects.com.au/PMKI-SCH-012.php#Process5

PERT and Monte Carlo

PERT is as old as CPM, it was developed to focus management attention on the probability of achieving a milestone date. PERT uses a standard modified Beta Distribution and simple calculations to assess the most likely duration for a chain of activities and their Standard Deviation to allow various levels of certainty to be assessed.

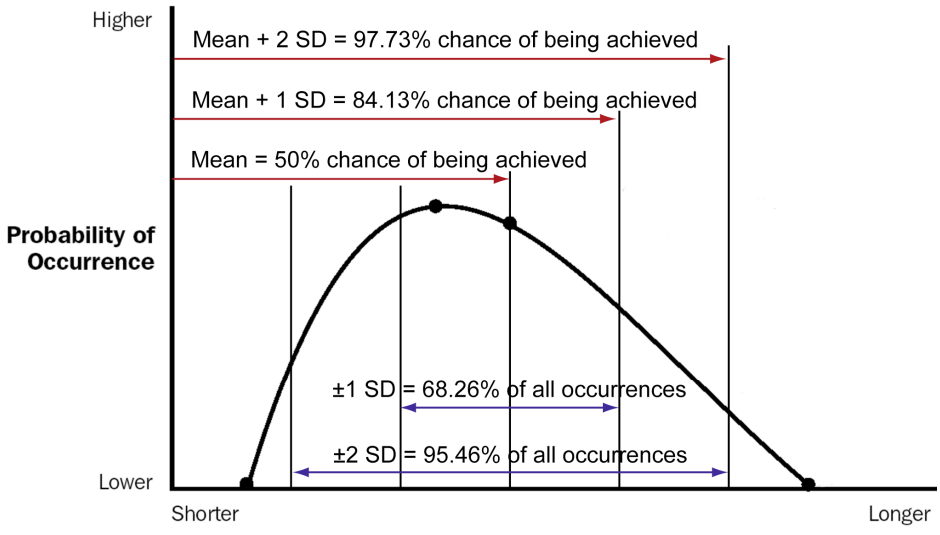

Figure 5 - Basic PERT Distribution

PERT is limited in two ways, firstly only one distribution option is available and secondly the calculations were typically only made along the critical path. An error known as the *PERT Merge Bias* means the results underestimate the likely completion date because the potential for other paths to become critical and delay the completion is ignored.

Monte Carlo analysis has largely supplanted PERT as the method of choice for analysing uncertainty in schedules. Most proficient tools allow multiple distributions including; Triangular, Beta, Normal and Uniform Distribution. The analysis considers all of the tasks and all of the options every time over several hundred iterations.

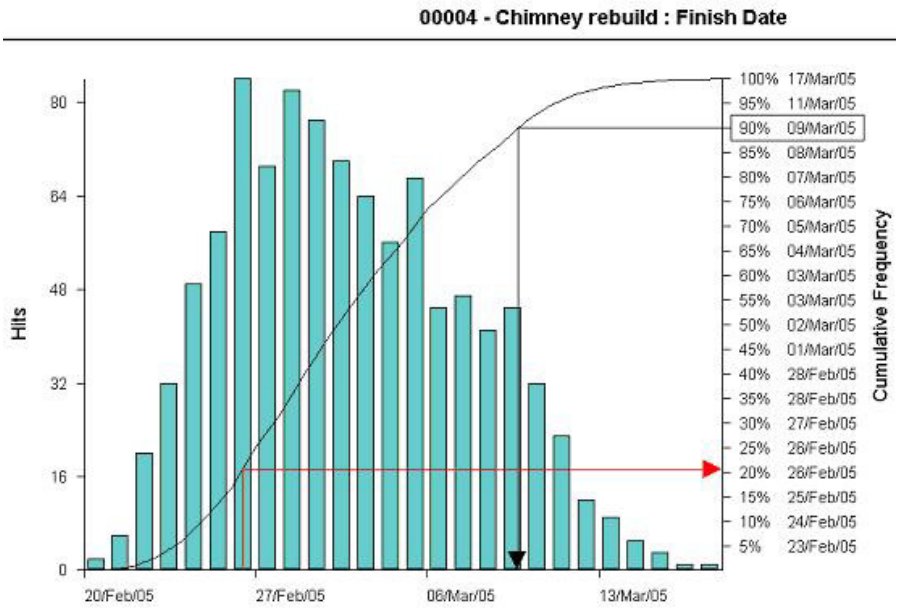

Figure 6 - Monte Carlo Analysis from Pertmaster

The resulting reports provide clear insights as to the potential range of outcomes for the overall project, the probability of completing by any particular date (Fig. 6) and the relative percentage of times each task is on the critical path (Fig. 7).

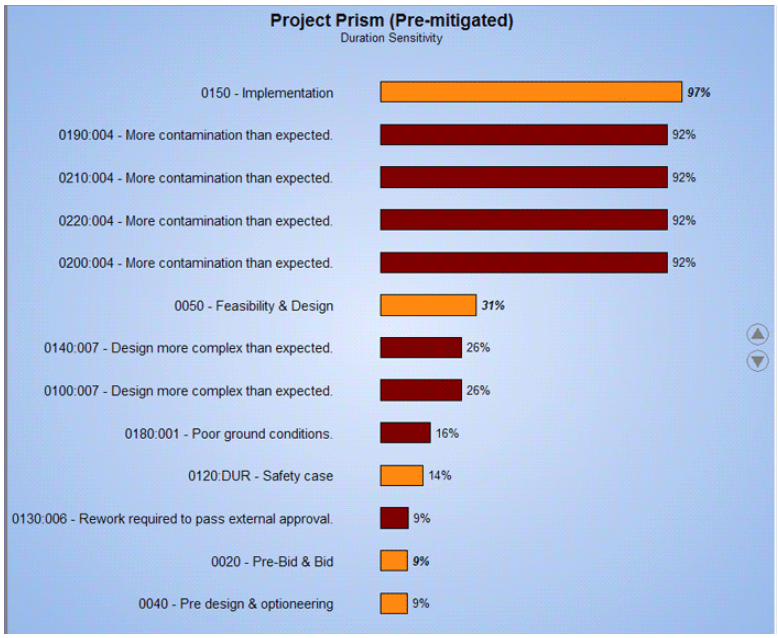

Figure 7 – Pertmaster Tornado Chart

However, whilst Monte Carlo analysis can be used to develop an appreciation of which tasks really matter and the degree of uncertainty in a project, the assumptions on which the analysis is based are flawed. Whilst the insight can be very useful, the construct of the data is not correct!

The basic assumption underlying Monte Carlo analysis is the presumption that a predictable distribution for the duration of each task can be obtained and as a consequence, the range of outcomes for whole project may be assessed with a degree of certainty. This fundamental assumption is based on a false premise.

The ideas of a Normal (Gaussian) Distribution and the calculation of a Standard Deviation were based on measuring hundreds of similar events and the Standard Deviation defines the degree of error within the data set; not the accuracy of a single estimate. A project is not part of a large data set, it is a unique entity. The difference is similar to car accidents – the insurance company can quietly calculate the accident rate per million kilometres driven and using statistical modelling determine its premiums for different classes of driver, based on the overall risk profile of each segment of the driver population. It is not worried who has an accident just how many accidents occur within each population of drivers. However, if you are the driver of the car about to be involved in an accident the situation is rather more compelling; you are in a unique and somewhat challenging position! Each project is by definition unique and the role of the project manager is more closely aligned to the driver of the car than the actuary in the insurance business.

There are two ways data can be statistically significant (Bernstein, 1996). The first (favoured by insurance company actuaries, casino owners and the like) is based around the Law of Large Numbers. First described by Jacob Bernoulli in 1713, this is a theorem in probability that describes the long-term stability of the mean of a random variable. Given a random variable with a finite range of expected values, if its values are repeatedly sampled, as the number of these observations increases, their mean will tend to approach and stay close to the expected mean. This is important because it *guarantees* stable long-term results for random events. For example, while a casino may lose money in a single spin of the American roulette wheel, it will almost certainly gain very close to 5.3% of all gambled money over thousands of spins. The range of outcomes is constrained by the numbers on the wheel and any winning streak by one player will eventually be overcome by the parameters of the game.

There is no corresponding principle that a small number of observations will converge to the expected value.

The alternative is statistical sampling (favoured by pollsters and quality testers) in which the likely situation of the whole population can be inferred with a reasonably high level of certainty from a relatively small **random** sample. However, for this approach to work the population has to exist and be known and the sampling has to be truly random. Project activity data is focused on a single future occurrence that by definition has not yet occurred.

The problem with project data is that any Normal distribution curve is based on the assumption of a finite range of variables (Taleb, 2008). There are no limits to many aspects of project risk. Consider the following:

- You plot the distribution and average the weight of 1000 adult males. Adding another person, even if he is the heaviest person in the world only makes a small difference to the average. No one weighs a ton! The results are *normal* (Gaussian-Poisson) and theories such as the Law of Large Numbers and Least Squares (Standard Deviation) apply.
- You plot the distribution and average the net wealth of 1000 people. Adding Bill Gates to the group causes a quantum change in the values. Unlike weight, wealth can be unlimited. Gaussian-Poisson theories do not apply!

Most texts and discussion on risk assume reasonable/predictable limits. Managing variables with no known range of results is rarely discussed and many project variables are in this category[23].

Monte Carlo modelling of a project schedule is influenced by:

- The lack of empirical data pertaining to task durations;
- The fact estimates are neither random, nor is there a large number of identical occurrences to base each estimate on; and
- Many variables are not constrained!

The bias of the people making the estimates is also a factor. An optimistic person will tend to give optimistic estimates for the optimistic, most likely and pessimistic durations; a pessimist will tend to shift in the opposite direction. This lack of objective data, coupled with the imprecise nature of the schedule logic being analysed, destroys the analytical basis of the analysis **but not its usefulness**. Monte Carlo is a valuable way to gain insight as to what matters in a project, it is just the results are not likely to be statistically valid. The important message is that statistical validity and accuracy are not synonyms for usefulness; as previously quoted, *all models are wrong – some are useful.*

Critical Chain

The idea behind Critical Chain seeks to improve upon CPM from a different direction and also opens up one of the key values of the CPM technique. In essence, Critical Chain uses very optimistic estimates for the duration of each activity and then allocates contingency time to *buffers* at the end of each chain of activities and the end of the critical path. The power of this technique is not in the pseudo processes used to calculate the activity durations and buffers, rather in the way workers' expectations are set by the calculation of the target durations.

If a worker believes an activity's duration is reasonable even if it's optimistic and the person remains properly motivated, they will change their behaviours to achieve the stretch target and consequently change the outcome.

A very similar occurrence to the performance improvements attributed to Critical Chain was observed in the deep level maintenance of the RAAF C130 Hercules fleet following the introduction of the

[23] For further discussion see: *Do Most Project Managers Still Live Under the Bell Curve*. Manon Deguire: http://www.valense.com

VIPER maintenance management system (Weaver, et al. 2002). Each servicing was treated as a project lasting several months with several aircraft being maintained simultaneously. The way VIPER was used introduced a statistical anomaly whereby most task durations imported into the system to calculate the rolling average duration for each activity were close to or below the current average (longer durations were excluded by the workers). The inevitable consequence was the progressive reduction of the time allowed to complete each activity. Over a number of years, the time needed to complete a servicing was cut by between 30% and 50% and overtime by 90%. The key change, given the aircraft were getting progressively older and more difficult to maintain, was the expectation of the people working on the servicing, and their expectations were influenced by the durations in their schedules.

RDM and Momentology

Relatively new variants on CPM include Momentology proposed by Murray Woolf (Woolf, 2007)[24] and the Relationship Driven Critical Path Method (RDM or RD-CPM™) developed by Fredric L. Plotnick (2008)[25]. Both scheduling methodologies have much to commend them.

Momentology focuses on building and maintaining the momentum and the performance intensity in a project. This is a critical factor in setting expectations and motivating the project team.

The structure of a RDM network is similar to the events and activities found in the original ADM / PERT with events framing tasks. The focus of its analysis is on the relationships between tasks (a topic also focussed on in Woolf's book) and the various types of duration and events within the schedule. These ideas have very strong roots in the ideas that started CPM. Many facets of RDM are similar to VME PERT[26] and Micro Planner's progressive feed found within *ladders*. The Meta Potential Method (MPM) as implemented in ACOS also has some similar link types[27]. However, whilst RDM is founded on strong traditions, seeks to standardise calculations and manage the space between tasks by codifying the reason for leads/lags (as does Murray Woolf), the methodology adds significant layers of complication in search of accuracy and control.

Both of the authors/developers have had decades of scheduling experience and the added sophistication of the tools will certainly assist in gaining insights to the dynamics of a proposed project. However, I would suggest neither option will garner much support because they are seeking to challenge the embedded belief in CPM.

The problem with expecting project scheduling to produce an accurate forecast of the future is it is impossible to accurately forecast or control the future. The solution to effective project delivery lies in a different direction; using the schedule to influence the future actions and decisions of people.

The Role of the Schedule in a C21 Project

By accepting that it is impossible to accurately forecast and control the future of a unique event such as a project, the possibility of creating a successful outcome opens up. Realistic and achievable objectives for a project schedule in an environment of uncertainty include:

- Developing an agreed strategy for the execution of the works;
- Obtaining buy in to the strategy from project team members and other key stakeholders;
- Assessing an approximate degree of risk in achieving the desired outcome;

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[24] For more on Momentology see: http://www.mosaicprojects.com.au/WhitePapers/WP1036_Momentology.pdf

[25] For more on RD-CPM see: http://www.mosaicprojects.com.au/WhitePapers/WP1035_RD-CPM.pdf

[26] VME PERT was a mainframe system developed in the UK by ICL in the 1960s and 70s. It was used by the Author through to 1985

[27] See more on ***links lags and ladders*** at: https://mosaicprojects.com.au/PDF-Gen/Links_Lags_Ladders.pdf

- Setting realistic expectations as to the required performance of the work in the minds of team members;
- Setting reasonable expectations on the overall delivery of the project in the minds of key stakeholders;
- Motivating and coordinating the project team to achieve their pre-set expectations embodied in the schedule;
- Identifying and assessing deviations from the agreed strategy and timings relatively early/promptly;
- Providing a tool to allow the re-planning of the work to lock in gains and mitigate losses;
- Communicating the current best plan to both the team and the key stakeholders.

None of these objectives require the schedule to be correct or precisely accurate but the closer the schedule is to reality the easier it is to maintain. However, as demonstrated in numerous projects using the Critical Chain methodology, and by VIPER using standard CPM, the real key to success is using the schedule as a tool to motivate the project team. People will work to achieve the outcomes in the schedule as is if they believe the schedule represents a realistic and achievable objective, and they consider achieving the objective is important to them.

Agreeing the Strategy

One of the biggest failings of scheduling in most current projects is the total absence of strategic planning. Effective strategic planning requires a simple dynamic schedule that is easily understood by the project management team and easily manipulated by the scheduler. As the team are deciding how to tackle the overall work of the project, the options need to be quickly tested and decisions validated before work starts on the execution schedule. The scheduler as a key part of the strategic planning process works with the management team to optimise the strategy. Project leaders would do well to remember Sun Tzu: *All men can see these tactics whereby I conquer, but what none can see is the strategy out of which victory is evolved.*

Once the project leadership has set the strategic direction for the project and agreed the overall framework for the schedule (the Scheduling Method and the Scheduling Tool) the scheduler is free to work with the project team to develop the Project Schedule Model[28].

Motivating and Aligning the Team

The only way to motivate and align the team to the objectives contained in the schedule is to involve task owners, team leaders, sub-foremen, supervisors and other key team members in the development of their part of schedule. This requires the scheduler to refrain from assuming the role of expert and knowing the *right* answers and engage with the project team to help them understand and develop their optimum solution. This is one of the key underpinnings of *'The Last Scheduler'* although it is hardly a new or radical idea.

To make this process successful, the scheduler needs a high level of interpersonal skills. The scheduler remains responsible for the technical integrity of the schedule and for developing the working level schedule to achieve the strategic objectives set by the project leadership. At the same time the scheduler needs to ensure the task owners completely own the durations and sequencing of tasks in their part of the project and understand the related dependencies to and from other peoples' work. This requires the scheduler to deploy a subtle blend of suggesting and questioning to tease out the *right ideas* from the task owners and demonstrate via quick analysis of the data where the situation currently stands. The process should not be manipulative or one way. The objective is to develop a realistic and achievable overall schedule based on the knowhow of the task owners, which is completely owned by

[28] For more on developing an effective schedule see: *A Guide to Scheduling Good Practice*, at https://mosaicprojects.com.au/PMKI-SCH-012.php#Overview

the people responsible for executing the work. The role of the scheduler is not dissimilar to that of an orchestra conductor, coaching, leading and harmonising the inputs from the numerous players involved in the project execution. The communication also flows upwards. Pertinent information from the wider team needs to be communicated to the project's management team, particularly where changes to the strategy are needed to deal with the new insights.

A new standard developed by the Chartered Institute of Building[29] (CIOB) has introduced the concept of schedule density, this works with Schedule Levels to create an integrated series of schedules that have been 'right sized' for their intended audience[30].

Developing the optimum schedule is only the beginning. The schedule needs to be maintained and kept relevant in the minds of the project task owners by involving them in the routine statusing and updating of the schedule[31]. All of the base data needed for an update including the actual start and finish dates, remaining duration and resources used should come from the task owner and be the responsibility of the task owner. The scheduler's role is to ensure the information is accurate and relevant.

The Role of the Scheduler in a C21 Project

As demonstrated above, schedulers in the C21 will need a combination of skills including the ability to:

- Synthesise information from disparate sources into an integrated and sensible schedule;
- Analyse and validate this preliminary schedule against the overall project objectives;
- Work with the project team to optimise and refine the execution schedule, with the scheduler using his/her special skills to identify and suggest options, test what-if scenarios and validate the logic, until an agreed schedule has been developed;
- Effectively communicate the outcome of the schedule development (or update) process by presenting targeted and relevant information from the schedule in effective formats. That is reporting the right information to the right stakeholder at the right time; and
- Assist the various project stakeholders, and in particular the project manager, understand and manage the project from a time perspective.

Philosopher Friedrich von Hayek in his *Theory of Knowledge* argues that all knowledge is partial and the closest you can get to the truth comes from the aggregation of as many partial understandings as possible (Feser, 2006). The skilled C21 scheduler will facilitate the exchange, sharing and aggregation of knowledge from all of the disciplines and work areas involved in the work, to develop and disseminate the most complete understanding of the time management aspects of the project.

He/she is able to communicate with team members in different areas of the project and let them know how their work and plans fit in with other areas, thereby enabling work to flow smoothly across the project. As well, the scheduler is uniquely positioned to advise the project manager and team on ways to avoid potentially costly conflicts between different areas of the work and to facilitate the allocation and sharing of resources across the project. In short, the scheduler becomes the forward-looking, eyes and ears of the project team.

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[29] For more on *The Guide to Good Practice in the Effective Management of Time in Complex Construction Projects*, see http://www.ciob.org.uk

[30] For more on ***'schedule density'*** see: http://www.mosaicprojects.com.au/WhitePapers/WP1016_Schedule_Density.pdf

[31] See: ***Managing for Success - The power of regular updates*** at: https://mosaicprojects.com.au/PMKI-SCH-014.php#Process6

To fulfil these roles and deliver the value proposition outlined above, schedulers need to be pro-active and constructively inquisitive; continually seeking to understand, clarify and explain the scope of their project and the dynamics of the work flow to the project team they support. They have the courage to paint a time picture of the project when details are scarce or almost non-existent and then willingly update and modify their starting point as more information becomes available. When filling gaps or creating an overview, the scheduler is totally confident in his/her ability and knowledge. But as real information emerges, and/or the project team members become more familiar with the project and start to develop their own ideas, the scheduler is happy to defer to the team members' opinions and views; testing the validity of their ideas with questions but always acknowledging it is the project manager and project team who are responsible for delivering the project's outputs in accordance with the agreed schedule.

This is a sophisticated and challenging role that combines the technical competence needed to use the scheduling tool effectively with a keen analytical ability whilst at the same time being a great communicator and an empathetic friend to the team members[32]. Similar to an effective project manager, a skilled scheduler will need balance three personality traits, IQ[33] (expertise), EQ[34] (people skills) and SQ[35] (leadership skills) and the optimum balance will change depending on the nature and phase of the project and the characteristics of the project team (Thomas, Mengel, 2008).

Aligning Scheduling with Complexity Theory

CRPR and Social Network Theory

The essence of CRPR and Social Network Theory is that the eventual outcome of the project, its success or failure, is created by thousands of individual decisions made by the project team members in the course of their daily interactions with each other, through the medium of conversations, embedded in their relationships. It is impossible for the Project Manager to be aware of every conversation and decision.

From a time management aspect, the key roles of the Project Manager, supported by the Project Scheduler are:

- The ability to build relationships with and between key stakeholders, including the project team;
- To add information into the project relationships that inform the team members (actors) of the required activities and timeframes for their work;
- To lead and motivate the project actors to commit to achieving the time aspects of their work; and
- To proactively deal with issues, opportunities and problems as they arise so as to maintain the actor's motivation and commitment.

The key medium for storing and communicating time related information is the Project Schedule Model. However, for the schedule to be an effective vehicle for the clear communication of ideas to team members, it needs to be as simple as possible, concise and elegant. The creation of information is

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[32] For more on the attributes of a scheduler see: ***The Roles and Attributes of a Scheduler***, at: https://mosaicprojects.com.au/PMKI-SCH-007.php#Overview

[33] IQ = Intelligence Quotient, a normalised measure of knowledge and expertises (hard skills)

[34] EQ = Emotional Intelligence Quotient, the ability to perceive emotion, integrate emotion to facilitate thought, understand emotions and to regulate emotions to promote personal growth in one's self and others.

[35] SQ = Social Quotient, an index of social maturity and in this context leadership abilities in complex and uncertain situations.

not the challenge; the challenge is the communication of information to the right person at the right time in a format that encourages understanding.

Only when an actor has received, understood and believed the information from the schedule will it have a positive influence on his/her conversations with other actors and their individual or joint decision making about their future actions. No one can influence the past. The critical role of the schedule is to inform decisions being made by people about their future actions so that the optimum decisions are made to drive the project to a successful conclusion.

This process does not operate in isolation, many other factors including the morale and motivation of the team, the ethics of the team and the surrounding organisation and the previous experiences of the actors, to name a few, play their part in creating an overall team environment focused on success: a high-performance team. Conversely, bad prior experiences coupled with ineffective leadership and direction can lead to in-fighting and failure: a dysfunctional team. The Strange Attractors and environmental pressures leading to the Tipping Point where the team becomes either dysfunctional or high performance, are not predetermined. Effective project leadership can influence the outcome.

Good scheduling practice is not a cure-all. On its own, good scheduling practice will not overcome the road blocks preventing the adoption of collaborative management in projects or generate a high-performance team; but assuming most of the other factors are positive, the schedule can be a powerful tool to drive successful performance.

The Central Role of Communication

The conclusion to be drawn from the above is the primary need for the schedule to be an efficient communication medium. The rich symbolic language of a well constructed CPM is a far more effective way to communicate the complex ideas of timing, sequence and dependencies than words, provided the project actors are prepared to make the effort needed to understand the value and richness of the message.

Communication is a two-way street, the easy bit is sending a message, the important part of communication is ensuring the message has been received and understood. Without the receiver's understanding there will be no action and there is no point in communicating with someone if you do not want them to take an appropriate action.

This basic requirement poses a number of challenges to the C21 scheduler:

- Most people will not admit to not understanding. The scheduler needs to be skilled at active listening to test for understanding and a great coach and teacher;
- The simpler the message, the easier to ensure correct understanding of its content – if the understanding is not correct, the consequential decisions and actions are unlikely to be correct[36]. The challenge for the scheduler is to crate elegant, accurate and easy to understand information; not masses of data. The solution lies in Schedule Levels[37] and/or cross linking several small schedules using external dependencies;
- Decisions are driven by emotion as much as intellect. Relating at the personal level to encourage active participation by the project actors is as important for the successful C21 scheduler as the creation of useful information.

[36] The maximum number of pieces of information most people can process simultaneously are between 5 and 9 (Miller, 1956). Beyond this number the brain needs to start packaging, parking and grouping information. Skilled schedulers may claim to be able to remember and manage schedules of 10,000 or more tasks (and may have developed mental techniques to deal with this) 99.99% of project mangers and team members cannot. As soon as there are more then 5 or 6 tasks in parallel and requiring active consideration together, most people lose concentration or focus. The solution is to keep individual schedules small and tidy to enhance understanding.

[37] For more on ***Schedule Levels*** see: http://www.mosaicprojects.com.au/PDF/Schedule_Levels.pdf

Interesting research by Jon Whity of the University of Queensland has found many project artefacts trigger emotional reactions in people familiar with their use. Barcharts create a feeling of control and confidence in the minds of viewers. Having a schedule (or at least a barchart) triggers positive emotions. One key aspect of the chart needed to trigger this desirable response is the requirement for the information to be laid out in a tidy, organised manner. This research fits with the experience of the author that artistically laid-out schedules seem to receive a better reaction than those that are not well presented. In the 1970s and 80s a well drafted hand-drawn network seemed to be better received than the more computationally accurate, data intense printouts from the new mini and micro computer systems.

The trend I find most interesting in the current development of schedule tools is the emergence of a range of new tools designed to facilitate the production of easy to understand schedules. These tools appear to be focused on the communication and understanding aspects of our profession, supported by sufficient data and analytical capabilities and are a stark contrast to the ever more capable and complicated analytical engines focused on developing EPM data.

Three tools that integrate effective communications with reasonably rigorous analysis are:

- CASCAD-e. A new graphical tool for interactive project scheduling and management using Time-Scaled Precedence Diagramming (TSPD). See: http://www.cascad-e.net
- NetPoint. An intuitive Graphical Planning Method™ (GPM) application that provides an activity network-based process for simplified and collaborative interactive planning and scheduling. See: http://pmatechnologies.com/netpoint.htm
- Asta Power Project. Based on a logic linked barchart. See: http://www.astadev.com/software/powerproject/index.asp

The focus of these tools is expressing the project information in a tidy, elegant and colourful way that encourages understanding of the logic of the schedule. The planner is literally encourage to *paint a picture* of the project's future.

More traditional EPM tools such as Deltek Open Plan and Oracle's Primavera, can generate colourful reports but their primary focus in on data aggregation and analysis. Effective communication is secondary and consequently, the challenges facing schedulers using these tools to develop effective communication with their stakeholders is greater. The data resource is certainly richer but the schedulers using these tools need to be highly skilled to turn this data into timely, useful information.

Conclusions

If scheduling is going to be more effective in the 21st Century, and deliver a positive contribution to the management of projects a rethinking of our role will be required.

The primary shift has to be to a collaborative communication model. Command and control is dead:

- Managers and workers from Gen X and Gen Y simply refuse to accept command and control, they expect to be consulted;
- Command and control is impossible for any form of knowledge work and in the C21 every project incorporates a substantial proportion of knowledge work. Knowledge workers need motivating and leading.

To be effective in a collaborative communication mode, the information in the schedule has to be easily understood by the project actors if they are going to use the information to inform their actions. This requires the simple presentation of useful information in a relevant and timely way that is both believable and believed; all viewed from the perspective of the receiver.

Large volumes of complex, detailed data are useless; as is tracking information about yesterday (eg, timesheet data). No one can influence yesterday, the sole purpose of the schedule (or at least its primary purpose) should be to positively influence decisions and actions about the future. Similarly, the primary purpose of collecting historical information should be to help inform future decisions.

Credibility of the schedule information is totally dependent on stakeholders understanding its usefulness and its limitations. Writing data into a scheduling tool cannot control the future and every guess about the likely duration of an activity, or sequence of a series of activities is potentially wrong. The value of the schedule lies in showing the best agreed objective for the project at this point in time and providing a vehicle to pro-actively manage change as it occurs. All of the key project stakeholders need to appreciate the need for appropriate contingencies in every schedule.

The most interesting paradox in C21 is that by actively embracing the uncertainty that is inherent in the scheduling process, and managing accordingly, the project has the best chance of achieving its overall schedule objective.

See also: ***Resource optimisation - a new paradigm for project scheduling*** *(2012)*
https://mosaicprojects.com.au/PMKI-SCH-013.php#Process5

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