Calculating Completion [1]

Patrick Weaver

Introduction

Predicting the likely completion date of your project has been important to project managers and their stakeholders for millennia. In ancient time the builder who finished a project late, embarrassing the local Emperor, could find the concept of a 'project deadline' had a more literal interpretation. Fast forward a few centuries and a contract deadline is central to the plot in Shakespeare's The Merchant of Venice, but for an ambiguity in the drafting of the contract the play would have a very different ending.

On a more practical level, most of the fundamental law relating to contract delays, extensions of time, and damages for delay, had been settled by the courts by the end of the 19th century. This means people entering into a contract had to have processes for determining a reasonable time for the completion of the works, then assessing how well progress was tracking towards achieving the date. What is missing from the records is how this was achieved prior to the 20th century. Most likely a combination of intuition and experience were the primary tools of the project manager.

Tools used for predicting the completion of projects in more modern times include: Bar Charts, Burndown Charts, Kanban Boards, Velocity, CPM, EVM + ES, and WPM. This paper will consider each of these options against a highly simplified project, with a focus on the subjective and objective information available from each tool and how they compare.

Project for analysis

The hypothetical project for this assessment is a deliberately simplified IT project; the data is designed to highlight and amplify the benefits and limitations of the information available from the different tools.

Project parameters

The overall project has the following parameters:

- Duration, 4 months
- Work to be produced, 80 Story-points (uniformly sized)
- Production rate, 20 Story-points per month
- Value, $500 per Story-point

[1] How to cite this paper: Weaver, P. (2023). Calculating Completion; *PM World Journal*, Vol. XII, Issue VII, July.

- Staffing, A single team working continuously

Status at the half-way point (end of month 2)
- Time Now (data date) 2 months
- Work accomplished 20 Story-points (1 month's work)
- Planned Value $20,000
- Earned Value $10,000
- Actual Cost $ not required for a time assessment

These values have been selected to make manual assessment easy, allowing readers to mentally validate the calculations and commentary below. Real-world data is usually much more complex and confusing, but the tools and processes do not change.

Bar Charts (Gantt Chart)

Bar charts have been used since 1756 to show events or activities against a timescale. By 1912 they had developed into sophisticated project control tools. While bar charts are very useful as both a thinking aide and for communicating information, in its basic form a bar chart is a static diagram.

This bar chart shows both the plan (green bars) and progress (grey bars). The progress update shows 75% of Task 1 work is complete and 25% of Task 2's work; in aggregate one month's worth of progress has been achieved.

Based on this information, the project is obviously running late but should you report the worst case (5 weeks), the best case (3 weeks), or the average shown in the summary? When there are multiple activities to consider, working out how far behind the project is, becomes a subjective assessment. And, because it is a static drawing, a simple bar chart cannot project the consequence of the delay forward to calculate an updated completion date.

One technique that overcomes this limitation is Earned Duration (ED). ED counts the number of days' work accomplished compared to the total planned to have been done

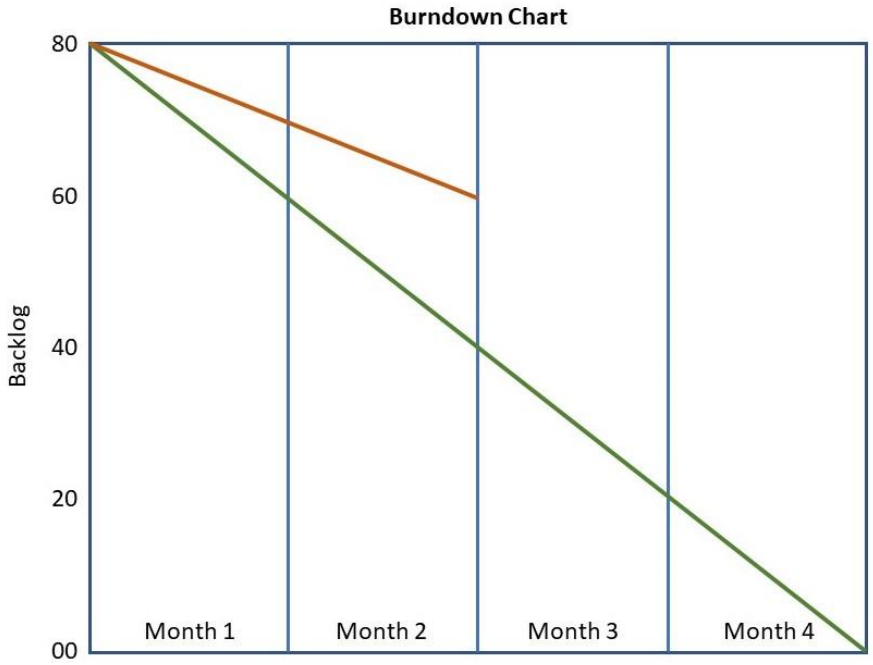
before Time Now, and uses this ratio to assess the new projected completion date. Unfortunately, ED needs a sophisticated template, and appears to be rarely used.

Both bar charts and ED are also affected by the challenge of assessing how much work has been completed on each of the activities in progress. This is usually a subjective assessment expressed as a percentage and is prone to seeing people overstating progress, particularly during the early stages of work on an activity.

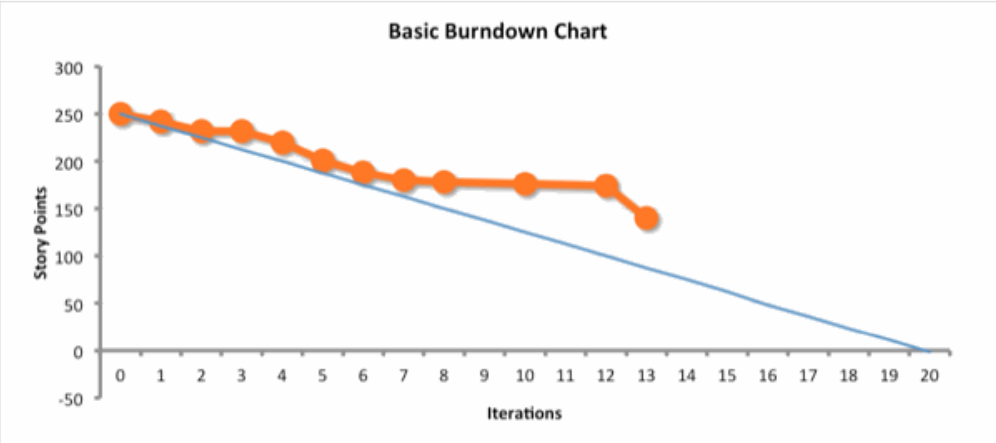
An alternative option for calculating a revised completion date is to use a critical path (CPM) schedule, most CPM software displays its activity data in the form of a bar chart, but the key difference is the activities are logically connected and their positions on the bar chart are the result of calculations (see CPM below).

Burndown (up) Chart

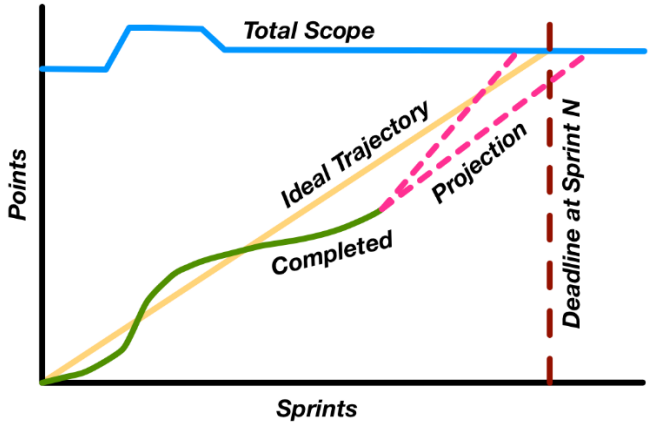
A burndown chart (or burn down chart) is a graphical representation used in many Agile projects showing the amount of work that has been completed compared to the planned work over time. The outstanding work is typically on the vertical axis, with time on the horizontal. It is a useful tool for predicting likelihood of completing your project's work (or sprint) in the time available. If the 'work accomplished' line is above the 'work required' line insufficient work is being produced by the project team to meet the target date for zero work in the backlog. However, while the chart below shows the project is in trouble, projecting the likely completion date from a real chart is a subjective guess.



Where do you think this project will finish?

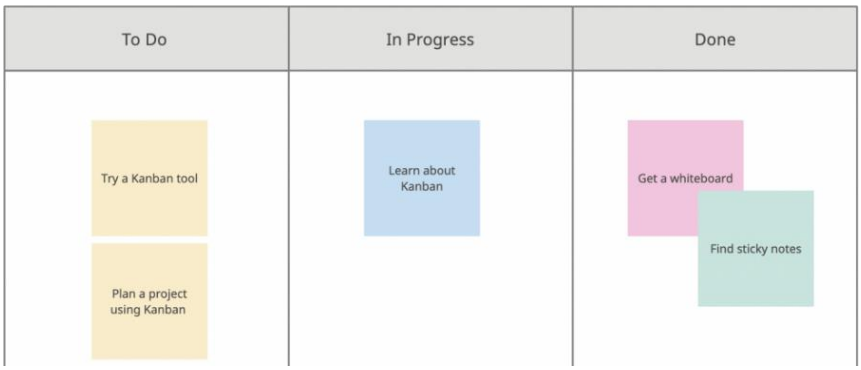


Burnup charts simply reverse the backlog scale to look more like normal business graphs, reaching 100% of the work finished at the top right corner. The challenge of predicting the projected completion date remains the same.



Kanban Board

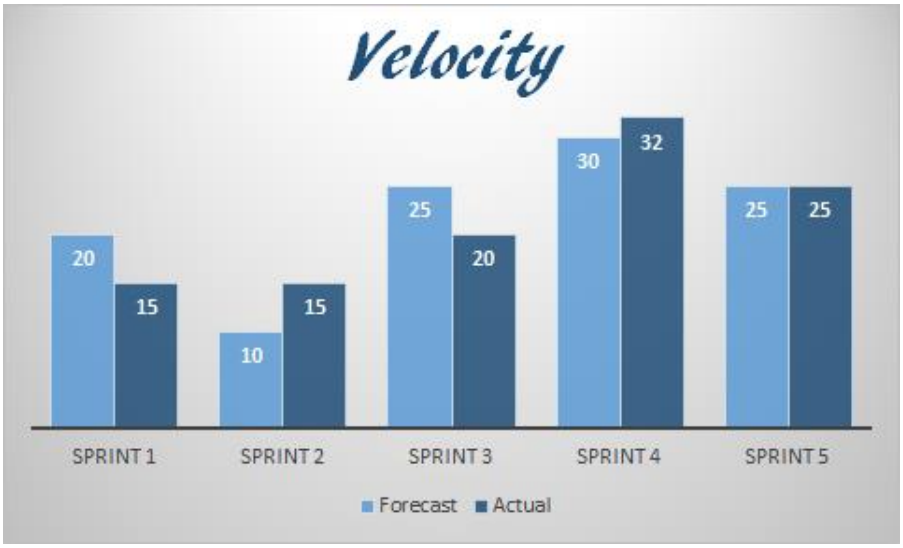
Kanban boards are another popular Agile tool. The board shows work not started, work in progress and work completed. The 'in-progress' section may have several columns such as 'in-development', 'in-testing', 'pre-release', etc. Kanban is a good way to see what is happening on a project, but has no capability for assessing progress and predicting the likely completion date.



Velocity (Scrum)

Velocity is an indication of the average amount of product backlog that is turned into delivered product by a scrum team, during each sprint. Its primary use is during sprint planning; a team's velocity is used to determine the number of backlog items to incorporate in the next sprint so that the completion of that sprint can be expected to occur within the designated timebox. Based on this, the amount of work and the delivery date for the sprint can be balanced and controlled. At the end of the sprint the team's velocity is added to the velocity calculation, and the updated velocity is used in the planning for the next sprint.

This technique is specific to projects applying the scrum methodology, limiting its general application, never the less the 'velocity' concept introduces some interesting ideas.



Using the velocity data, it is possible to divide the remaining backlog with the updated average velocity to determine the number of sprints needed to complete a project. Based on this estimate, if the average duration of a sprint is known (plus the number of available sprint teams), the time needed to complete the remaining work of the project can be assessed.

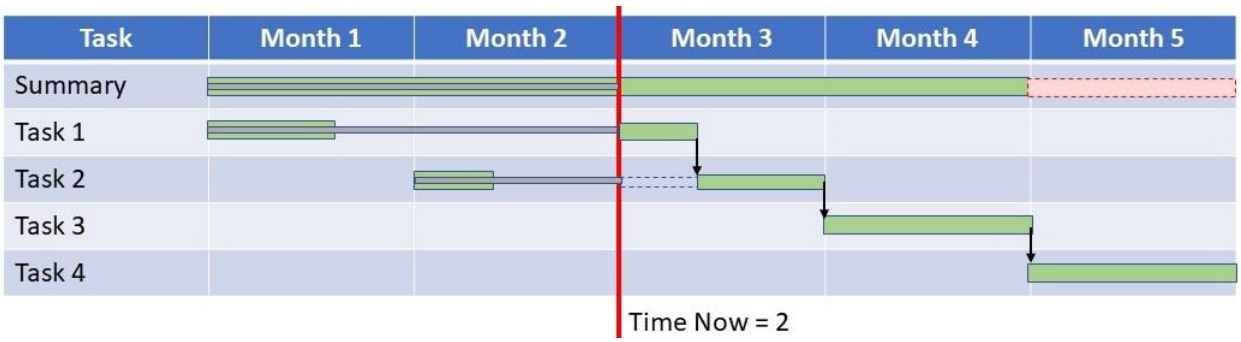
While this approach is viable, all the Agile proponents I am aware of see Velocity as a sprint planning tool and they also see the burndown chart discussed above as a sprint management tool. Neither are seen as overall project management tools capable of predicting the expected project completion. Overall control is assigned to the project 'road map', typically developed as either a bar chart or a CPM schedule.

Critical Path (CPM) Scheduling

Critical path scheduling (CPM) came into common use in the 1960s and has remained fundamentally unchanged since. The essence of a well-constructed CPM schedule is that the work to be performed is represented by a series of logically connected activities, in a dynamic schedule, which allows the start and completion of each activity to be calculated. The dynamic schedule network means any change in an activity are

automatically flowed through the network logic to all of its linked predecessors and successors. The other key factor is when the schedule is updated, all of the incomplete work is moved into the future; it is impossible to go back in time to work on an activity last week! The dividing line between the past and the future is called Time Now, or more generally the data date.

Taking the bar chart discussed above and converting it into a CPM schedule, updated with progress information as at the end of Month 2, we find the expected project completion date has been delayed by one month. The project team has to complete the remaining 25% of Task 1, then the remaining 75% of Task 2, before moving onto Tasks 3 and 4 in the planned sequence.



However, the above scenario may not represent what is actually occurring. If there are adequate people to work on both tasks simultaneously and complete them in the allowed time, the project may only be three weeks behind schedule as shown below.

These two updating options are supported by most scheduling tools; the retained logic option shows a 4-week delay, the progress override option a 3-week delay. Neither option is right, or wrong, which is best to use depends on the circumstances and is controlled by the scheduler.

CPM has been mainstream for over 60 years, but it is becoming increasingly apparent CPM does not work well on a range of projects including those using various Agile and Lean approaches, other soft projects, and distributed projects. CPM was developed on the assumption there is one best way to accomplish the work of a project. But, in most agile and distributed projects, while there may be a high level 'road map' outlining the desired route to completion and/or specific constraints on parts of the work, there remains a lot of flexibility in the way most of the work is accomplished. And, in many cases there

is a deliberate management intent not to follow a predetermined sequence of activities defined in a CPM schedule![2]

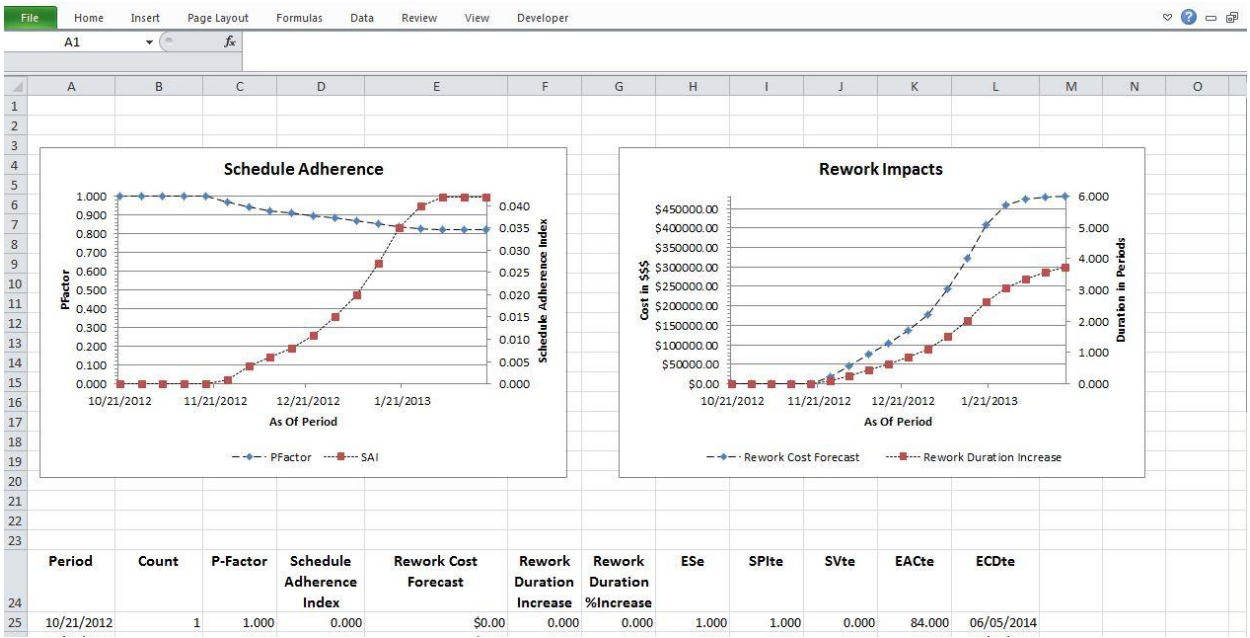
EVM & ES

Earned Value Management (EVM), enhanced with Earned Schedule (ES) is an effective option for assessing performance on all types of project. EVM can be implemented with, or without, a sophisticated CPM schedule. From a time perspective, all that is needed is a reasonable assessment of when each of the work packages are planned to start and finish. This information can be taken from a CPM schedule, or from any other plan for the project's work. EVM does not need to be complex.

When EVM is applied effectively, the question of progress and the predicted completion date are resolved by using Earned Schedule. ES uses EVM data to:

- Determine the current status ahead / behind plan, and
- Determine the predicted completion date.

Schedule input is only required to create the EVM Performance Management Baseline (PMB). This information sets the time frame for the project, then the EVM/ES processes focus on the value of work planned and achieved. The application of ES can be very straightforward (as demonstrated below) or enhanced by the use of sophisticated analysis options such as the P-Factor (schedule adherance), and various range indicators to provide management with information on the reliability of the calculations[3].

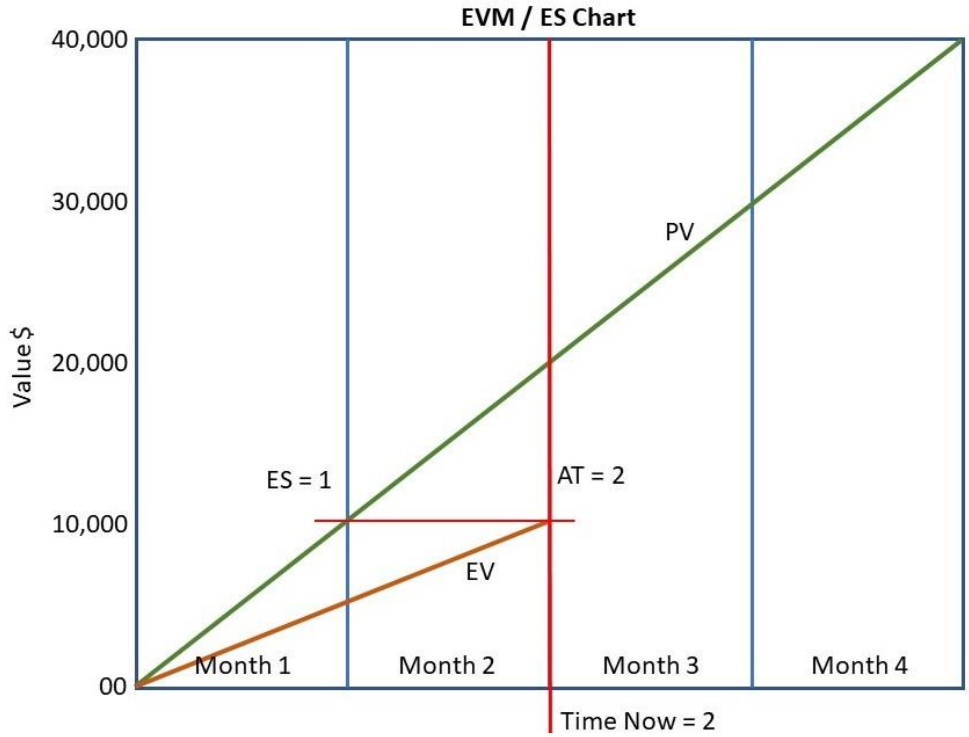


Period	Count	P-Factor	Schedule Adherence Index	Rework Cost Forecast	Rework Duration Increase	Rework Duration %Increase	ESe	SPIte	SVte	EACte	ECDte
10/21/2012	1	1.000	0.000	$0.00	0.000	0.000	1.000	1.000	0.000	84.000	06/05/2014

[2] A detailed analysis of the challenges encountered when the CPM paradigm does not fit with the management approach, and/or the nature of the project is discussed in *Scheduling Challenges in Agile & Distributed Projects*: https://mosaicprojects.com.au/PDF_Papers/P208_Scheduling_Challenges_in_Agile_+_Distributed_Projects.pdf

[3] This example is from the Project FlightDeck's Schedule Performance Analyzer©: http://www.projectflightdeck.com/

For our simple project we will just use the basic Earned Schedule calculations:



The calculations are:

1) SPI(t) = ES/AT = 1 / 2 = 0.5
2) IEAC(t) = PD/SPI(t) 4 months / 0.5 = 8 months.

The schedule variance are

1) SV(t) = ES - AT = 2 - 1 = -1 month
2) VAC(t) = PD - IEAC(t) = 4 - 8 = -4 months

This set of calculations shows the project is predicted to need 8 months to from start to finish, there are 6 months' work remaining, and the finish will be 4 months late if nothing is done to correct the performance issues highlighted by this set of calculations.

EVM and ES are the gold standard for project controls and reporting, but do need to be implemented as part of an overall management structure to obtain the maximum benefit. Significant investment is needed to develop the skills and information flows needed to run the system and understand the information generated.

Note: The difference between the predicted completion calculated by ES and by CPM is due to the way future work is considered:

- CPM assumes all future work will be completed exactly as planned (activity durations do not change)

- EVM and ES assume the best predictor of future performance is the performance achieved to date, and scale the time needed to complete the future work accordingly.

This difference in approach, and its influence on project controls is discussed in Why Critical Path Scheduling is Wildly Optimistic . Which option more accurately represents the probable future outcome of a project is debated by some, however extensive academic and practical research has shown the ES predictions tend to be more reliable than CPM and most other options[4].

Work Performance Management (WPM)

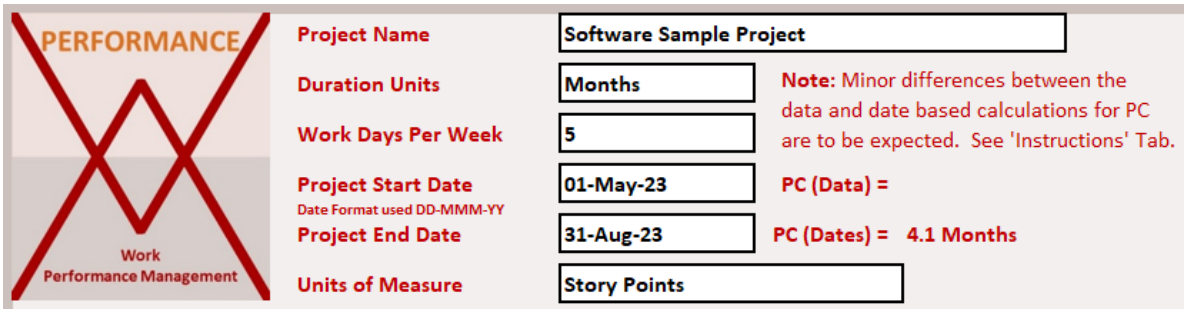
Work Performance Management (WPM) has been developed to aid the overall management of Class 3[5] projects by calculating the current status (ahead or behind plan), and predicting the likely project completion date. This is achieved by comparing the amount of work accomplished to date with the amount included in the original plan. It is designed as a robust and practical solution for determining the current status and predicted completion date of projects that are not using EVM, and are not suited to the CPM paradigm. It is not intended as a replacement for either CPM or EVM and ES on larger, more complex projects.

The original concept of WPM was defined in Predicting Completion in Agile & Distributed Projects[6].

Using the WPM tool

To set up a WPM analysis for the simple project used in the sections above the following steps are required:

1. Set up the project file, key information needed are a name, start and end dates and the time unit:

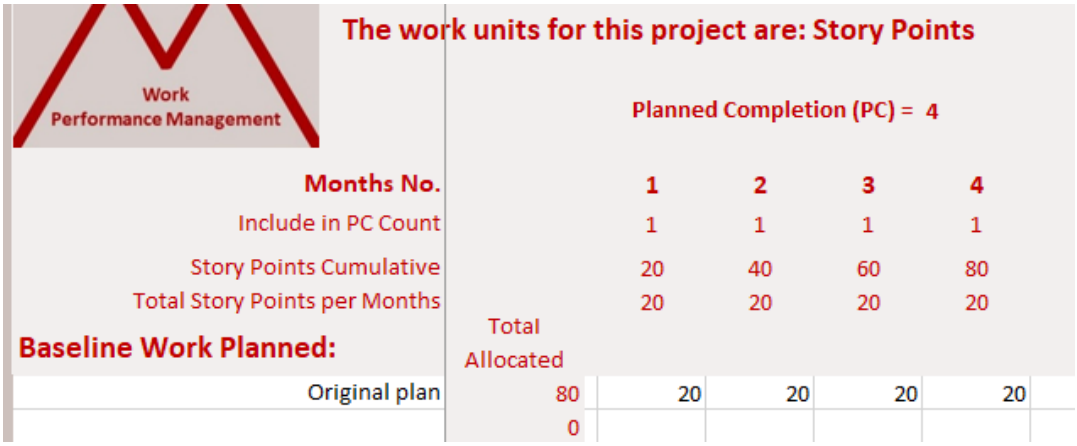


[4] Download Why Critical Path Scheduling is Wildly Optimistic from: https://mosaicprojects.com.au/PDF_Papers/P117_Why_Critical_Path_Scheduling_is_Wildly_Optimistic.pdf

[5] Class 3 projects are defined in in Scheduling Challenges in Agile & Distributed Projects and encompass most soft and distributed projects (particularly those using an Agile methodology). An overall sequence of works may be required, but some, or all, of the detail can be accomplished in almost any sequence. See: https://mosaicprojects.com.au/PDF_Papers/P208_Scheduling_Challenges_in_Agile_+_Distributed_Projects.pdf

[6] See Predicting Completion in Agile & Distributed Projects: https://mosaicprojects.com.au/PDF_Papers/P214_Predicting_Completion_In_Agile_+_Distributed_Projects.pdf

2. Set up the baseline plan, in this case production is planned at a rate of 20 Story Points per month for 4 months (the spreadsheet is designed for a maximum of 60 time periods).



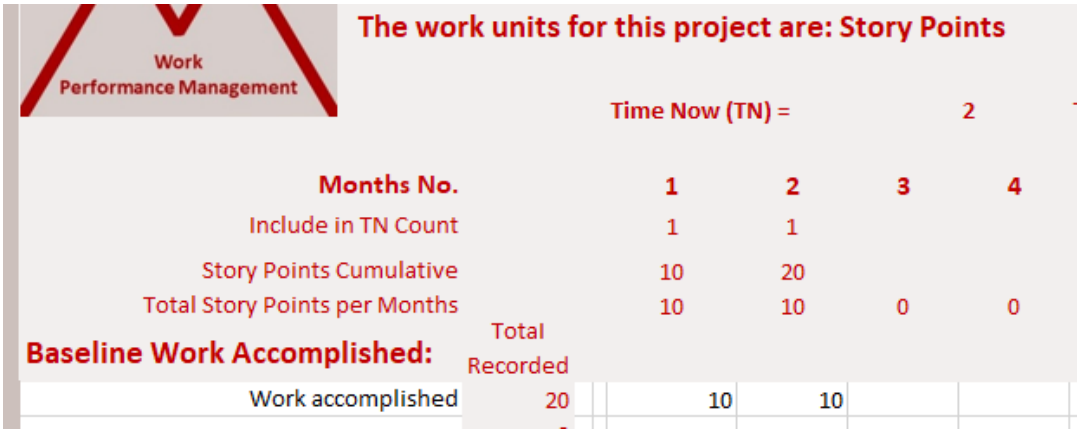
Work Performance Management

The work units for this project are: Story Points

Planned Completion (PC) = 4

Months No.		**1**	**2**	**3**	**4**
Include in PC Count		1	1	1	1
Story Points Cumulative		20	40	60	80
Total Story Points per Months		20	20	20	20
Baseline Work Planned:	Total Allocated				
Original plan	80	20	20	20	20
	0				

3. Enter the Time Now date and progress data (in this case it does not matter if we did 10 Story Points per month, or 0 in the first months and 20 in the second month).



Work Performance Management

The work units for this project are: Story Points

Time Now (TN) = 2

Months No.		**1**	**2**	**3**	**4**
Include in TN Count		1	1		
Story Points Cumulative		10	20		
Total Story Points per Months		10	10	0	0
Baseline Work Accomplished:	Total Recorded				
Work accomplished	20	10	10		

4. Review the results:

Results:

Planned Completion	**4 Months**	
Time Now	**2 Months**	
Time Earned	**1 Months**	
Work Performance Variance	**-1 Months**	**(-21.4 Working Days)**
Work Performance Index	**0.5**	
Expected Completion	**8 Months**	
Variance At Completion	**-4 Months**	**(-120 Calendar Days)**
Expected Completion Date	**29-Dec-23**	

Note: This date is an approximation, WPM does not include a detailed calendar.

The WPM spreadsheet takes a couple of minutes to set up and process information. It includes several checks and a comprehensive output report.

The reliability of the WPM calculations depends on the consistency of the measurement of work planned and work performed. Ideally this metric should be aligned with practical measurements used within the project for other functions such as the kanban board, burndown chart and/or velocity calculations and the team's definition of 'done'. Provided the planned and actual measurements are consistent and the metric is uniformly applied across the project WPM calculations are expected to produce similar results to Earned Schedule.

Calculating Completion - Conclusions

The tools listed above have different intrinsic capabilities to calculate the current projected completion date for a project:

- **Bar charts (Gantt charts)**, all that is possible is a visual assessment of the current status. However, bar charts can be a very useful tool for short term look-ahead planning and overall project 'road maps'.
- **Burndown / burnup charts**, all that is possible is a visual assessment of the current status and trends.
- **Kanban**, has no indication of status compared to a baseline plan, all that is shown is the current situation.
- **Velocity** may have useful data recorded within the system, but this is not used for predictive purposes.
- **CPM schedules** do predict completion, but tend to be optimistic. A CPM schedule is also a valuable forward planning tool.
- **Earned Schedule (ES)** requires EVM to be implemented. It has a very reliable calculation of the current status and the likely project completion date. However, ES cannot be used for the day-to-day control of the work (it is a predictive tool). EVM has some capability in this regard, but detailed forward planning needs other techniques such as bar charts or CPM schedules.
- **Work Performance Management (WPM)** is a predictive tool, similar in its approach to ES, but can operate sand-alone. Detailed forward planning needs other techniques such as bar charts, CPM schedules, or other Agile techniques.

Looking at the above results, and previous papers that define the types of projects where CPM is effective as a predictive tool (and those where it is not), CPM remains viable:

1. As a predictive tool in traditional Class 1 and Class 2 projects where there is one best way of competing the project's work. However, there is an optimistic bias in the technique's calculation of the predicted completion date.
2. For planning the work sequence going forward from Time Now.

Earned Schedule is the gold standard for predicting project completion, the full system is sophisticated and reliable and can be applied to works on all types of project. The

limitation of ES is the need for an EVM system to be operating to generate the data used by ES. The EVM system does not have to be a heavy bureaucratic function, there are options for EVM lite but these do not seem to be widely used. There is also the need for other tools and techniques for short term look-ahead planning.

Work Performance Management (WPM) is simple alternative to ES designed for in-house and other smaller, straightforward projects where management need to know the projected completion date, but choose not to invest in either Earned Schedule or CPM. The design of WPM allows any reliable project metric to be used in its calculation so it is ideal for supporting projects using scrum, kanban and other Agile approaches that incorporate sizing the project's work for use in burndown charts and/or scrum planning. Other viable metrics include physical units of production, hours of effort, and financial data.

When considering the predicted project completion date, the prediction generated by both ES and WPM assumes there will be no change in the average rate of production by the project team. But, given the objective of any controls system is to highlight the need for change, this more pessimistic set of calculations is likely to be more useful than the optimistic assumptions in CPM (which assumes everything will immediately revert to the planned rate of production).

The key difference between ES and WPM is:

- ES is linked to EVM, so performance data can be drilled down to the work package level. EVM reporting is focused on work packages and encouraging management action to identify and resolve negative variance and other challenges. This is a rich data environment.
- WPM highlights the issues with a similar degree of reliability, but is a simple stand-alone tool. Direct observation of the project work is needed to identify problems and opportunities.

In summary, the best tool for predicting the current expected project completion date is Earned Schedule, but investing in establishing an effective EVM and ES function in a project, or in an organization, requires a suite of specialist skills and the allocation of adequate resources to run the system. Where organizations choose not to implement EVM and ES, WPM offers a simple cost-efficient alternative, that is ideal for most smaller simpler projects.

What is clear is that with the introduction of WPM, there is no longer any excuse for management within organizations choosing not to know when their projects are likely to finish.

About the Author

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Patrick Weaver, PMP, PMI-SP, FAICD, FCIOB, is the Managing Director of Mosaic Project Services Pty Ltd, an Australian project management consultancy specializing in project control systems. He is a Fellow of the Chartered Institute of Building, Australasia (FCIOB) and a Fellow of the Australian Institute of Company Directors (FAICD). He is a member of the PMI Melbourne Chapter (Australia), as well a full member of AIPM, and the Project Management College of Scheduling (PMCOS).

Patrick has over 50 years' experience in Project Management. His career was initially focused on the planning and managing of construction, engineering and infrastructure projects in the UK and Australia. The last 35 years has seen his businesses and experience expand to include the successful delivery of project scheduling services and PMOs in a range of government, ICT and business environments; with a strong focus on project management training.

His consultancy work encompasses: developing and advising on project schedules, developing and presenting PM training courses, managing the development of internal project control systems for client organizations, and assisting with dispute resolution and claims management.

In the last few years, Patrick has sought to 'give back' to the industry he has participated in since leaving college through contributions to the development of the project management profession. In addition to his committee roles, he has presented papers at a wide range of project management conferences in the USA, Europe, Asia and Australia, has an on-going role with the PGCS conference in Australia and is part of the Australian delegation to ISO TC258.

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