CONSTRUCTION LAW INTERNATIONAL

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Focus on delay analysis

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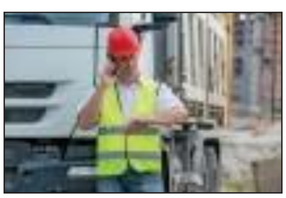
FEATURE ARTICLES



Cover: A skyscraper boom in the City of London, which includes the 278 m (912 ft) 22 Bishopsgate, the tallest building ever to be constructed in the Square Mile. Credit: Joe Dunckley Shutterstock.

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Continuity in analysing delay

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There is a basic misinterpretation of data in delay analysis that is common practice in assessing delays. Specifically, it is to quantify delay using the estimated per cent complete of ongoing work found in progress updates. In doing this, an inconsistent unit of measure is being introduced, and the results can cause a premature assessment of delay or recovery and a breakdown of continuity. This practice is derived from confusing per cent work (an integral measure in planning) with percent time (an integral measure in delay analysis). Although both the work and time for an activity start simultaneously at zero per cent and end at 100 per cent, their paths along the way are typically very different. It is a common misconception that because the work done for an activity does not necessarily progress linearly, using a linear distribution of time in delay analysis poorly approximates the work. On closer inspection, the exact opposite is true: using the per cent work poorly approximates the time. This is because time is the fundamental unit in the critical path method (CPM) and it progresses linearly (actually, time does not exactly progress linearly, but close enough if you are not approaching the speed of light or under the influence of an intense gravitational field where you would probably have things other than delay analysis on your mind anyway).

To have reliable results in any nested calculation, it is important to use consistent units of measure and apply them uniformly over the scope of an analysis. In quantifying impacts, the use of per cent complete values based on the work accomplished involves using data with a different unit of measure than initially used in the baseline plan. Also, it is being applied in a non-uniform manner and is based on needlessly subjective data. The per cent complete of in-progress activities already has an objective quantification based on its allotted time. The CPM at the heart of planning software has only one original and fundamental unit of measure, and that is time (planned duration). To hold the units consistent, as an activity progresses, the per cent of the planned duration is the most reliable unit of measure to use when analysing delay.

To understand why this is so important, it is first essential to understand how the CPM computer model measures project time. The CPM is used in almost every form of forensic delay analysis. It is the basic model used by nearly all planning software. At its heart is a simple path finding algorithm that has nodes that are point-in-time events, and a distance between nodes that is measured in time. An activity in the CPM does not measure an amount of work; it measures the amount of time to do that work. More specifically, it measures the amount of time to get from one node, the start, to another, the finish. The plan is made up of either the measure of time between the start and finish of an activity, or the measure of time between activities, which is known as lag. Together, they make up the core of the network.

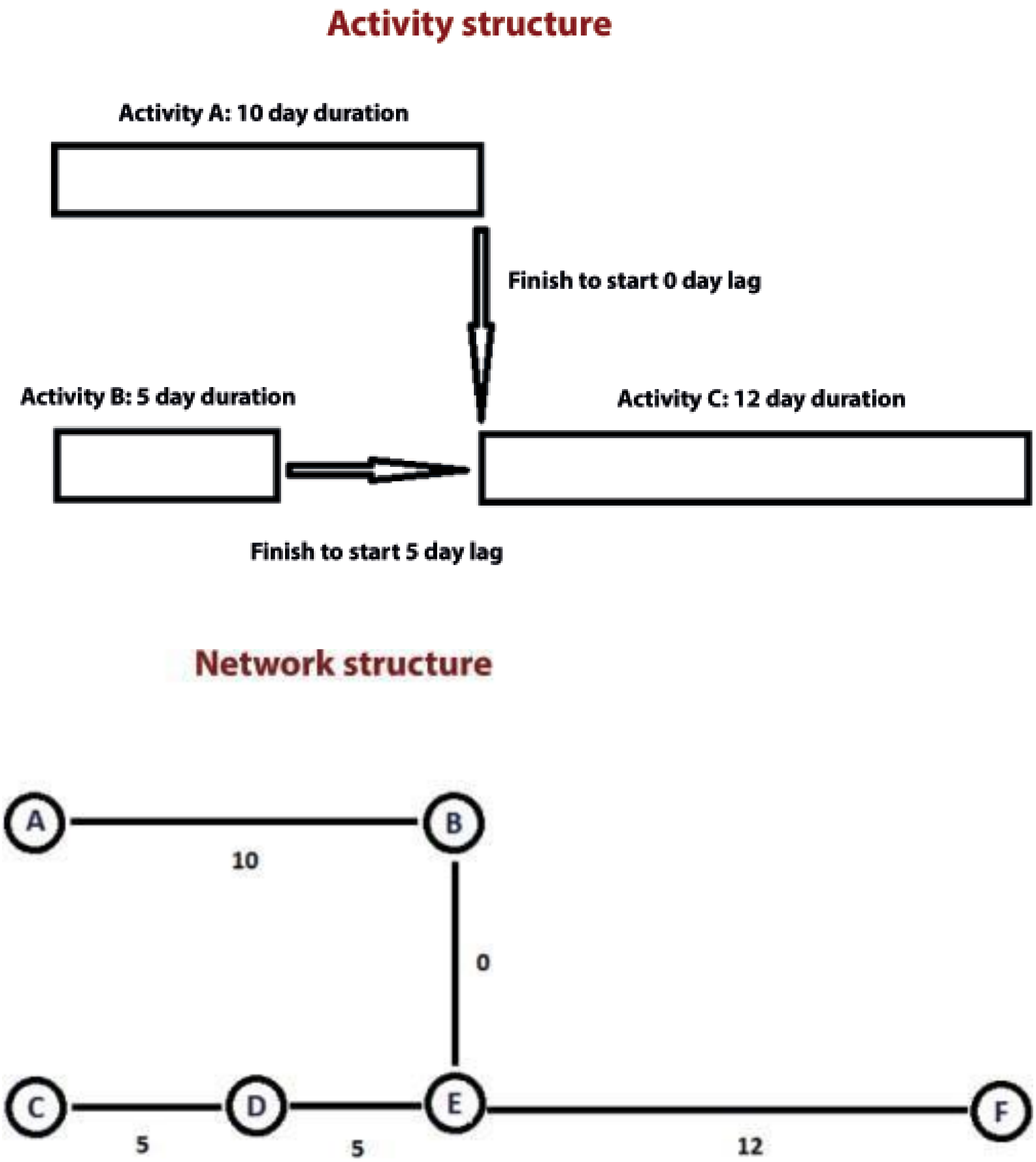


Figure 1: node structure of the CPM computer model

The computer travels down every possible path of this network, primarily to find the sequence of nodes with the longest duration. This longest chain is the critical path, which is the barometer of how long the project will take to complete at any given point in time. Because the measure between the start and finish nodes of an activity is the allotted time between them, to maintain continuity, the per cent complete value for in-progress activities should be the per cent complete of the allotted time and not the per cent complete of the allotted work.

The concept of updating in-progress activities using time goes against the grain of how project controls are taught, which is often projected onto delay analysis. It seems counterintuitive, as an example, if almost no work has been done on an activity, to declare it 90 per cent complete just because 90 per cent of the time has expired. But for reliable results in delay analysis, that is precisely the appropriate measure to use. In delay analysis, to say that an activity is 90 per cent complete does not mean the work is 90 per cent complete, but that the allotted time is 90 per cent complete. That is what you are measuring in a CPM schedule when using it for delay analysis. The amount of work does not have a bearing on quantifying actual impact until it crosses the threshold of the allotted time or it finishes. You lose sight of that threshold if the units in your calculations change from allotted time to allotted work. That is a subtle difference between planning and delay analysis. And that is why, for delay analysis, it is important to keep the units you are measuring consistent. To be clear, it is *not* being stated here that the per cent work of an in-progress activity is immaterial. In planning, it is essential to know where you are, and for progress payments, resource allocation, earned value, cost and project controls. However, it is not a consistent unit of measure for quantifying impacts in forensic delay analysis. This is because, in switching units to work, essentially lateness or potential earliness is being assessed before an activity is due. To express the difference simply, it is like any assignment with a due date, for example, a homework assignment: if you have ten days to do it, then you can do essentially nothing for nine days and pull an 'all-nighter' on day nine. If you can deliver it by the due date, then no harm is done. It's not late, until it's late. Using per cent work on in-progress activities is analogous to the teacher looking at your work on day five, noting that you are running five days behind and marking your paper down for being five days late before it is even due. By contrast, by using per cent time of planned duration, at the end of day one, you have exhausted ten per cent of the time and have nine days to complete the assignment. On day two you have exhausted 20 per cent and have eight days to complete it. If you have not completed it by day 11, then you are one day late; by day 12, two days late, etc. Once consistent units of measure are used in delay analysis, continuity is exposed, which can uncover not only a clear and precise quantification of impact, but if used actively in planning alongside the per cent work, it can expose potential delays virtually in real time, and often before they impact a project.

As an example of why this is important in analysing delay, consider the following scenario of a simplified plan for building a wall with only three activities: wall permit, material delivery and wall building. In this example, we assume that once the wall permit is submitted, it is typically approved in 18 days. Let's also say it will take 20 days for the materials to be delivered to the site, and once you have both the permit and materials, you can build the wall, which takes 15 days.

This baseline plan would appear as illustrated, with the wall permit activity initially having two days of float (time before the activity becomes critical). Let's assume the following progress: on day one, the permit was not submitted because there was a disparity in the survey. Let's also assume that the truck was loaded with the materials for delivery on the first day, but on the following morning, because of a mechanical failure, it was stuck at the warehouse until the end of day 19. On day 20, the materials were put on a plane and flown to the site, arriving as agreed in the baseline plan. On the permit side, let's assume that the resolution of the survey problem did not occur until day 20. The application was received on that day and approved 18 days later, and the wall construction began.

If this plan was updated and impact was assessed using per cent work, the finish of the material delivery would be responsible for all of the delay, despite it starting and finishing on time. In addition, using the per cent work, the permit application was never responsible for any delay. This is despite the obvious fact that

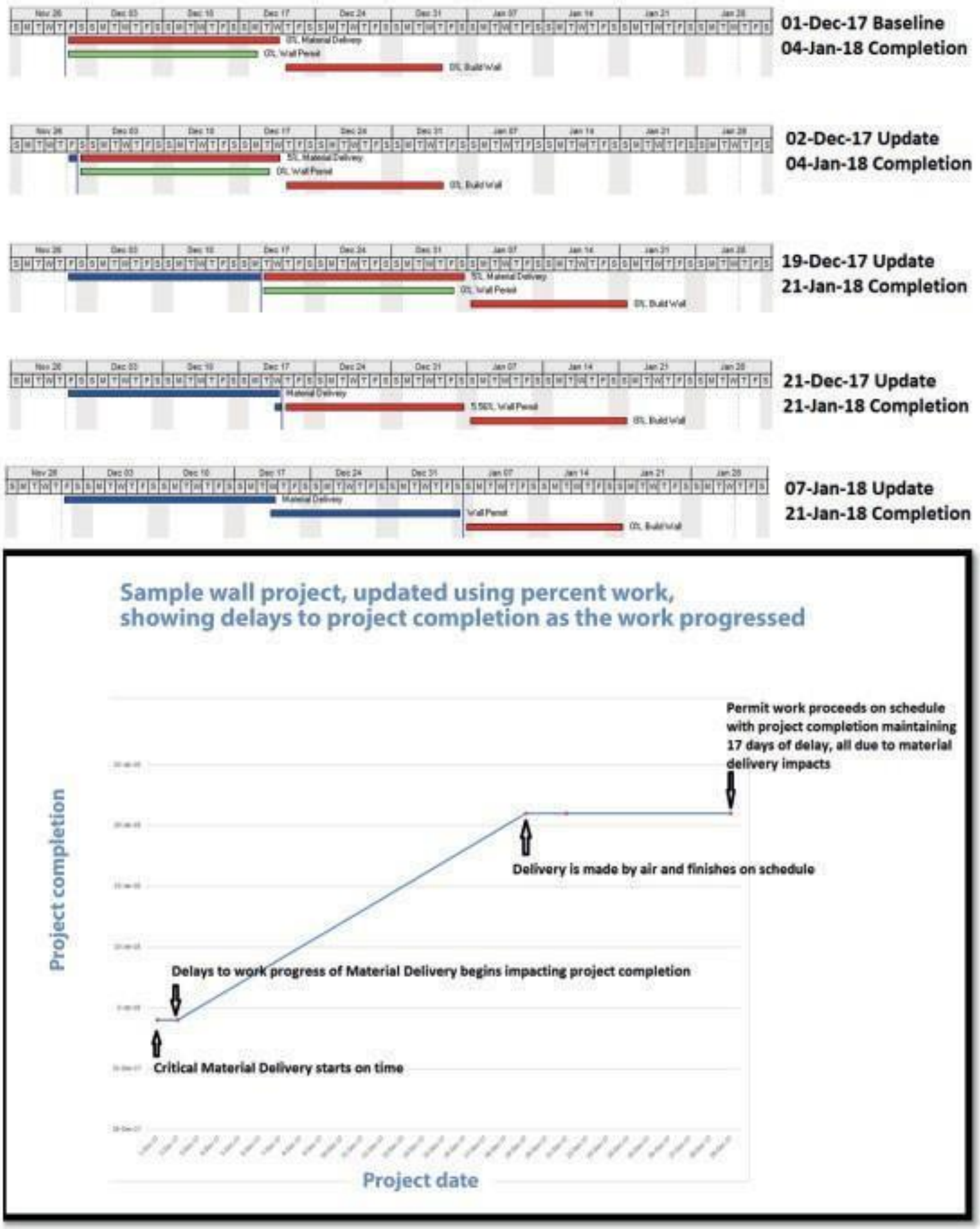


Figure 2: impact analysis using % work for in-progress activities

the permit approval was the sole reason for the delayed start of the wall, because the materials were on site, but wall construction could not begin because of a wait of 17 days for the permit. The reason the delay analysis is flawed is because, although a critical activity (material delivery) was 18 days behind schedule at a certain point in its progress, it could not have impacted the project at that time for the simple reason that it was not yet due. But the due date is lost in the calculus if you are updating progress using the estimated per cent of the work rather than the per cent of the time. Using per cent work, the impact is assessed before the time has expired to do the work. There is no commitment in a plan to have 60 per cent of the work done when 60 per cent of the time has expired; the commitment is to

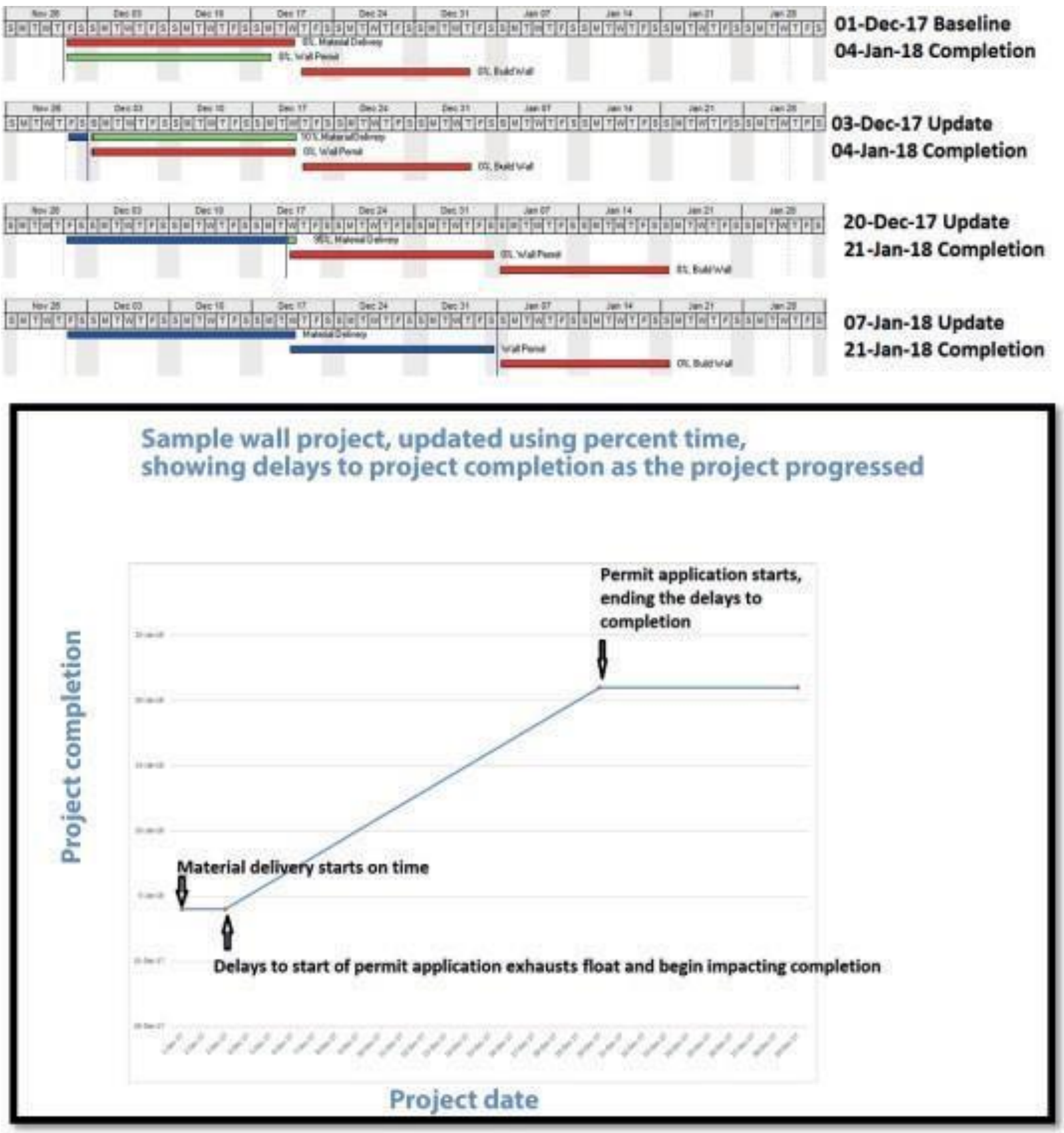


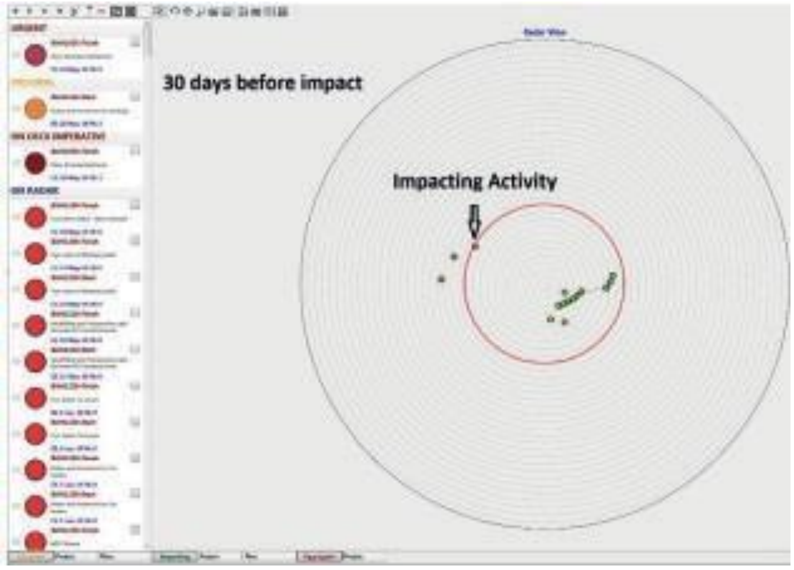
Figure 3: impact analysis using % time for in-progress activities

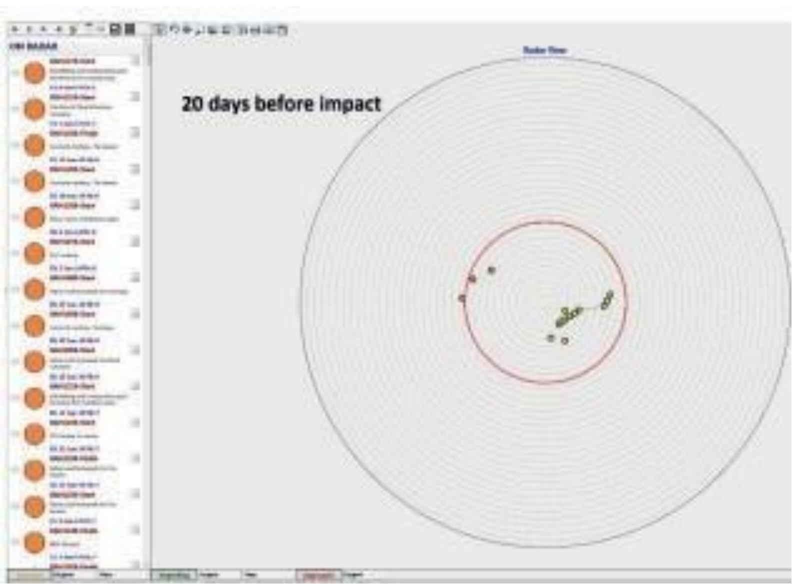
have 100 per cent of the work done when 100 per cent of the time has expired.

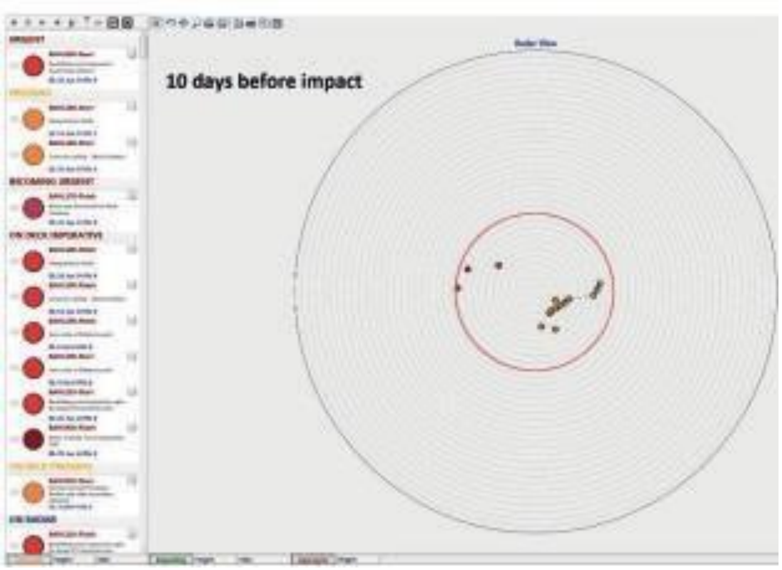
To further underscore the unreliability of using per cent work in delay analysis, suppose the same material delivery activity was represented as two milestones: one for 'begin loading materials' and the other for 'deliver materials on site', with a 20-day lag between them. Under this scenario, it would be updated completely differently than the model that made the same representation using a single activity. This is because lag between activities is progressed using per cent time. In this instance, the method of progress would not be applied uniformly: you would be progressing half the model using per cent work and the other half using per cent time, with completely different outcomes using the same basic data. There is also the matter of the subjective nature of using per cent work. It is an ambiguous unit that is estimated by a person responsible for the data. If one person believes it is ten per cent and another that it is 11 per cent, then the completion date, critical path and impact can be entirely different.

In the wall scenario, if per cent time of the planned duration is used for quantifying impact, the results are consistent and uniform in both measure and application, and they agree with common sense. Namely, delays to submitting the permit were the sole cause of the 17 days of delay, which began after the late start consumed the two days of float, and ended when the permit application was submitted. The findings are the same whether you represent the activities as a single task or two milestones with a lag. But there are considerably more benefits to using a consistent unit of measure for in-progress activities. It opens a whole range of possibilities to impact analysis because it brings speed, accuracy and, especially, continuity to updating and assessing impacts. This is because per cent work is based on a subjective judgement, and it proceeds in a nonlinear manner, whereas time progresses uniformly. This means that between the actual start and actual finish of an activity, you know precisely what the per cent complete is, and so you can use a computation to progress plans through time, instead of stopping at periodical intervals to make a subjective estimate. With less effort and more accuracy, the typical 30-day time windows for analysis can be converted to daily window analysis in a fraction of the time, and quantify exactly how a project loses and gains time. Additionally, if using time impact analysis, it can be performed on the exact day of impact rather than the beginning of a monthly update. In fact, the entire plan, instead of being an aggregate of disconnected updates, can become a single fluid plan, which evolves through time,

Figure 4: continuity with assessing delays over a project's duration, with revisions incorporated as the project progresses







incorporating revisions and actual dates as it progresses towards completion.

Moreover, because of this continuity, patterns can emerge that can forecast delays before they impact a project. Take, for example, the radar view graphic. Activities are represented by coloured dots. Their location radius in the graph corresponds to the early start date and the colour indicates how critical the activity is: green is non-critical and red is critical. Because of the continuity of using per cent time of the activity's duration, you can view the project status at any time selected or animate project activities as they progress. For most delays, if you move through time from a position prior to an impact, you can often detect a pattern developing that forecasts an impending impact long before it actually occurs. Using the radar graph, this can be detected by seeing critical activities coming in from the side, or rapidly advancing their colour from green to orange to red. A computer algorithm can be used to warn of an impact before it occurs and accurately document it during and after. The screenshots in Figure 5 are of progress on a project 30, 20 and ten days before an activity impacted project completion. The impacting activity can be seen closing in on the centre of the screen and changing colour from orange to red as it is animated through time and comes closer to its due date, and is more critical along the way.

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