Calculating and Using Float

Origin of Float

The concept of schedule float is the creation of the Critical Path Method (CPM) of scheduling. Before 1957 'float' only had one meaning now it has several.

The origins of scheduling and consequently float is discussed in two papers:
- *A Brief History of Scheduling*[1].
- *The Origins of Modern Project Management*[2].

The issues of creating float within networks and the options for manipulating float (legitimately or otherwise) through the structure of the schedule is discussed in the papers:
- *Float - Is It Real?*[3]
- *The Cost of Time - or who's duration is it anyway?*[4]
- *Schedule Calculations*[5]

The purpose of this paper is to support the concepts discussed in these earlier papers by analysing the various types of float that have been defined in the last 50 years and considering how they may be used in modern scheduling practice.

CPM scheduling originated in the late 1950s as a computer based process using the Activity-on-Arrow (or ADM) technique with its roots in linear programming and operational research. Most of the initial work on float was based on ADM schedules and constrained by the limitations of early mainframe computers in the days of punch cards and tabulating machines. In the 1960s John Fondahl's precedence networking (PDM) came to prominence, initially as a 'non-computer' approach to scheduling which sought to simplify calculations, and only later as a computer based methodology. Consequently, PDM has never had the same disciplined view of float as ADM which may be detrimental to the practice of scheduling today.

Float in ADM Networks

The biggest difference between ADM networks and PDM networks is the importance of the events (nodes) at the beginning and end of each activity.

Events and Activities:
Structurally, the key feature of an ADM network is that the Start Event (i) for the activity in focus in Figure 1 is the end event (j) for the preceding activities and also the start event for the second activity shown angling downwards. Similarly, the end event (j) for the activity in focus is the start event for the succeeding activities. Events occupy no time. The Event Early (EE) and Event Late (EL) times are calculated from time analysis as follows:

---

[1] *A Brief History of Scheduling*: www.mosaicprojects.com.au/Resources_Papers_042.html

[2] *The Origins of Modern Project Management*: www.mosaicprojects.com.au/Resources_Papers_050.html

[3] *Float - Is It Real?*: www.mosaicprojects.com.au/Resources_Papers_043.html

[4] *The Cost of Time - or who's duration is it anyway?*: www.mosaicprojects.com.au/Resources_Papers_009.html

[5] *Schedule Calculations*: http://www.mosaicprojects.com.au/PDF/Schedule_Calculations.pdf
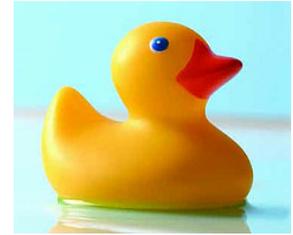
- Forward Pass: An event is not achieved until all of its preceding activities are complete. Consequently EE = the latest early finish of its preceding activities. An activity cannot start until its preceding event is achieved.
- Backward Pass: The Event Late (EL) time is the earliest of the late start times for its succeeding activities.

ADM float Calculations

In an Activity on Arrow network, the computers calculate data for both the events at the end of the arrows and the activity itself (the arrow). As a consequence, a rich data set is available to define:

- the scheduling flexibility at the start of the activity,
- the scheduling flexibility of the activity itself and
- the scheduling flexibility at the end of the activity.

The options are outlined in Figure 1 below. In this portion of a network, the two events are fixed by activities other then the one in focus; ie, you could remove the activity and the schedule times for the events would not change (this is necessary to allow all of the float types to be visible - Figure 1 is not to scale).
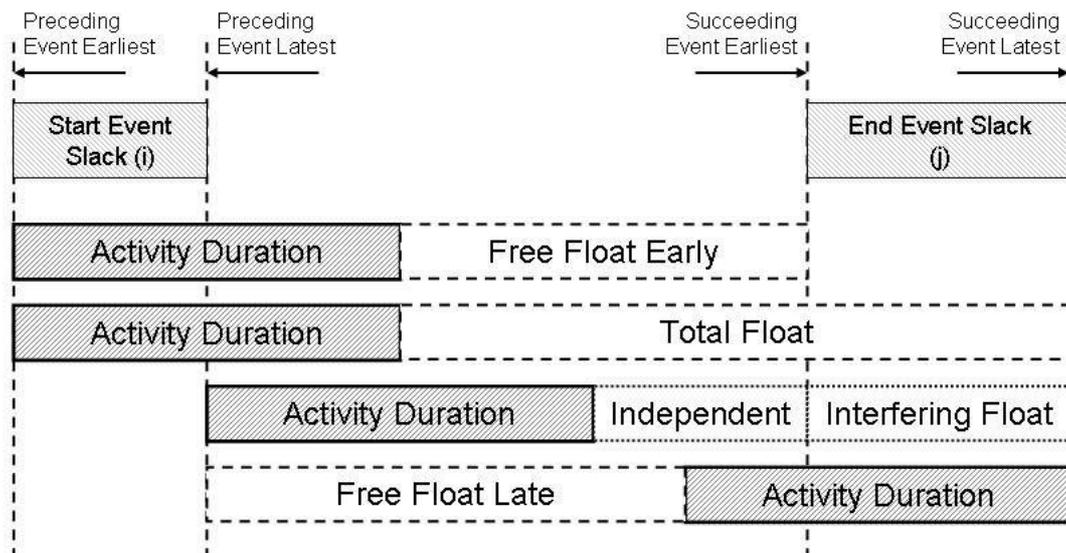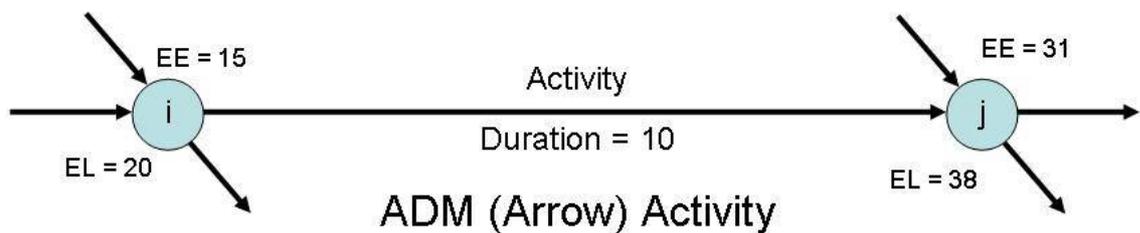

Figure 1 - ADM Float

The calculations of the Event Slack times are:

- Start Event Slack: EL – EE = 20 -15 = 5
- End Event Slack: EL – EE = 38 -31 = 7

The calculations of the activity's Early and Late, Start and Finish Times are a factor of the event start and finish times shown in the diagram and the activity's duration:

- Early Start Time (EST) =   EE(i) = 15
- Early Finish Time (EFT) = EST + Dur = 15 + 10 = 25
- Late Finish Time (LFT) =   EL(j) = 38

- Late Start Time (LST) =   LFT - Dur = 38 - 10 = 28

If the activity is scheduled at its Early Start Time (EST) Free Float Early and Total Float can be calculated:
- Total Float (TF): The time the activity can be delayed without delaying the end of the schedule or an imposed constraint.   TF = LFT - EST - Dur = 38 - 15 - 10 = 13
- Free Float Early (FFE): The time the activity can be delayed without delaying the start of any succeeding activity (this is determined by the EE of the (j) node).   FFE = EE(j) - EFT = 31 - 25 = 6

Three other types of float were considered/calculated[6]:
- Independent Float (IF): The amount of scheduling flexibility available on the activity without displacing any other activity (before or after). It is the float available to the activity regardless of the timing of either node. This is calculated as EE(j) - EL(i) - Dur: IF = 31 - 20 - 10 = 1
- Free Float Late (FFL): The amount of scheduling flexibility available on the activity when every operation is scheduled at its latest possible time. This is the 'free float' used for resource levelling on the 'back pass'.
- Interfering Float: This is the same value as End Event Slack but calculated as TF - FF. The reason Interfering Float was calculated was so that it was part of the activity record (with punch cards, etc it was very difficult to include data from different record types in a report).

Free Float Late (FFL) – the ICL Alternative

The representation of FFL used above is based on the published work of H.S. (Sam) Woodgate[5]. The British computer company ICL (now part of Fujitsu) developed a range of mainframe and mini computer scheduling tools from the 1960s through to the early 1980s. The ICL 'x[7]' Pert programs used a different definition for FFL based on all activities being scheduled at their preceding event late time EL(i). The ICL version of FFL is shown in Figure 2.
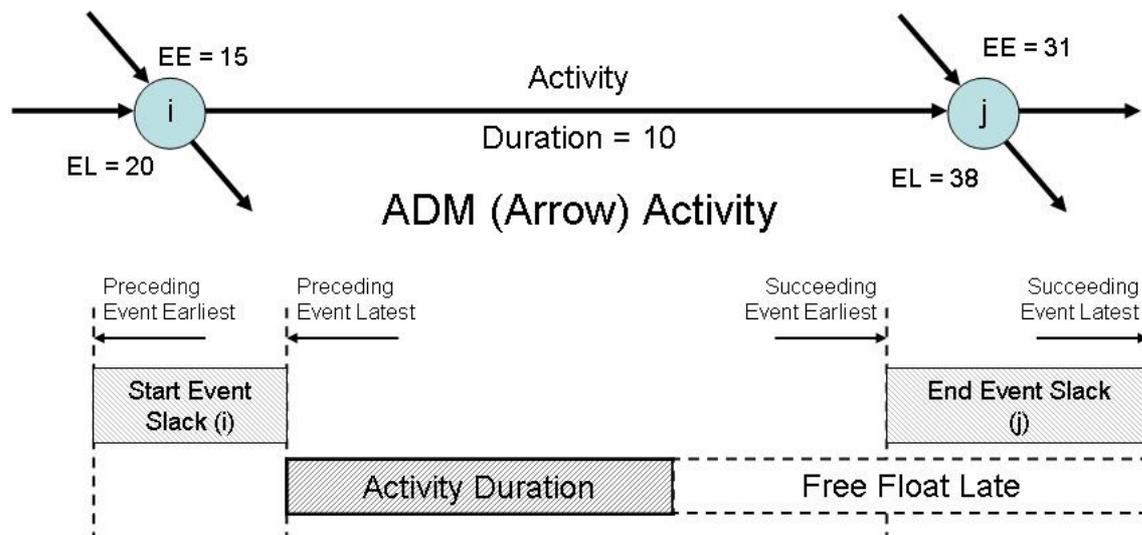

Figure 2 – ICL Pert FFL

The calculation of the value of FFL would yield the same value in both the Woodgate and ICL representations; The calculation is: FFL = EL(j) - EL(i) - Dur: FFL = 38 - 20 - 10 = 8

---

[6] *Planning by Network* H.S. Woodgate. Brandon/Systems Press, New York. 1964

[7] The range of ICL PERT programs included 1500 PERT (1962), 1900 PERT (1964), ICL ME29 PERT, ICL 2900 Series PERT and VME PERT (1985); plus many ancillary tools.

The only difference between ICL and Woodgate is the positioning of the activity and consequently the float in the diagrams.

Drift

Drift[8] refers to the amount of time an activity has been delayed from its earliest start date, but within its overall float. If a non-critical activity is scheduled to start at a time between its early and late start dates, 'drift' is the time between its constrained/scheduled start and the early start. Once the activity has been moved back in time its 'float' is reduced (float being the time it can be further delayed) and the time it can be moved forward again if needed (ie, the time it was 'manually' pushed back) is called 'drift'.

Negative Float

Negative float is created when the earliest times an activity or event can occur are later than an imposed constraint. In this circumstance, the late dates calculated during the back pass are earlier than the early dates. From a practical viewpoint this tells the scheduler the schedule logic needs modification or the constraint will not be met. Whilst theoretically negative float can be calculated for any of the floats described above, in practice it is only calculated for Total Float and Event Slack.

Float in PDM Networks

Precedence networks position the activities on the 'node' (ie, the event in an arrow network) and connect the activities with 'arrows' called links. The PDM methodology does not attempt to calculate any values for its links; each link merely defines a logical relationship between two activities[9].

However, given links can be connected to or from the start and the end of a precedence activity, the issues of the existence of pseudo start and end events independent of the activity duration remain; refer Figure 3. But, whereas Arrow diagrams had discrete components and precise rules as to how these were calculated, the PDM methodology has never defined an agreed set of calculations to deal with the same issues.
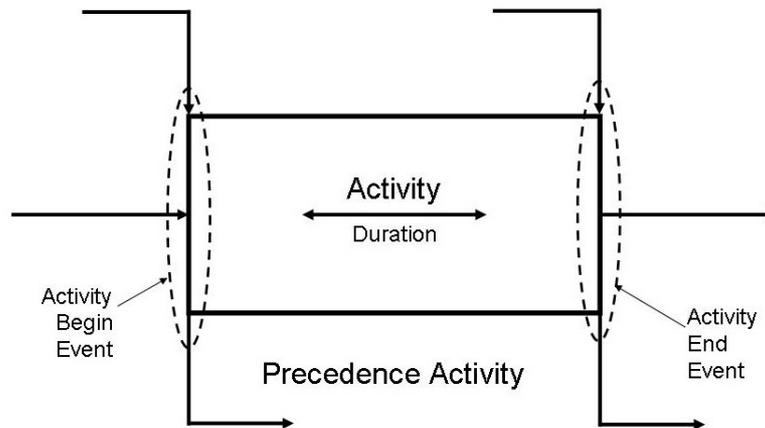

Figure 3 - PDM Activity

PDM float Calculations – Contiguous Durations

The only two 'floats' that can be reliably calculated in a PDM schedule where the activity durations are defined and the activity's work is assumed to be continuous are the Total Float and Free Float which is calculated by measuring the time gap between the Early Finish of the preceding task and the earliest of the

---

[8]   Drift seems to be an invention of GPM (Netpoint) technique, see : http://en.wikipedia.org/wiki/Graphical_path_method

[9]   For more on links see, **Links, Lags & Ladders**: www.mosaicprojects.com.au/PDF/Links_Lags_Ladders.pdf

Early Starts of its successors[10]; refer Figure 4. Scheduling based in contiguous durations forces the activity to meet the latest of the 'early start' conditions imposed by different link types connected to either its finish or start; this can cause the work to be 'pulled back' to conform with the requirement of links connected to its finish (sometime causing 'lag drag'[11]). Calculating the other floats, described in the ADM network above, for a PDM network requires the activity's work to be allowed to stretch, split (see below).

The calculation of Total Float in a PDM network is contained within the activity and is basically the same as for an ADM activity. The calculation of TF is either:

- LFT - EFT
- or more universally correct, LFT - EST - Dur +1.

The calculation of Free Float in a PDM network is more complex!

The three tasks highlighted in by the red circles Figure 4 determine the Free Float for Task A and define the time gap between the early finish of the task and the earliest start of any of its successors[12].
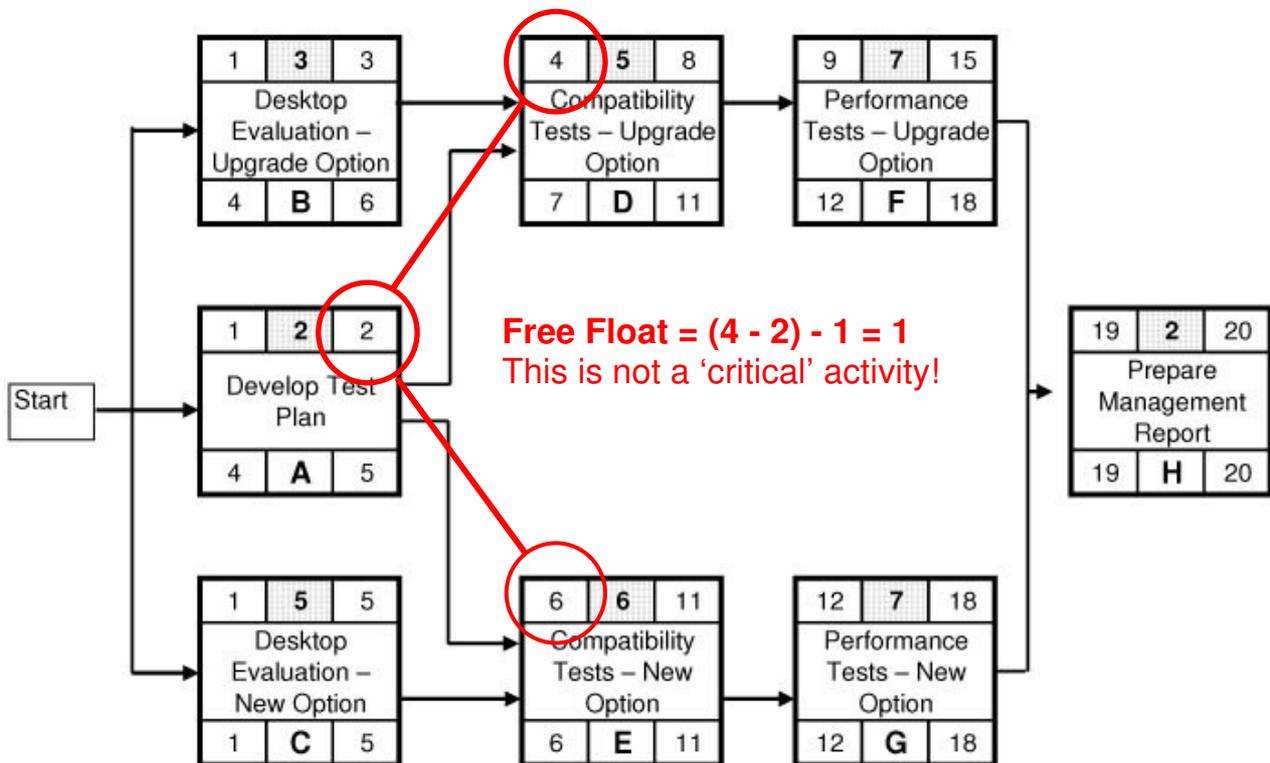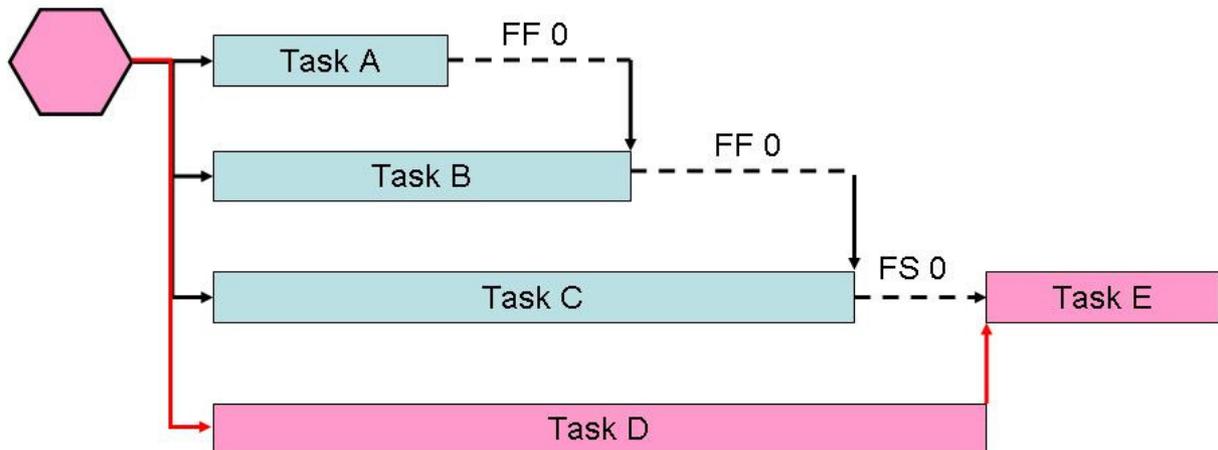

Figure 4 - PDM Free Float Calculation

---

[10] The standard definition for Free Float is: ***The amount of time a schedule activity can be delayed without delaying the early start date of any successor or violating a schedule constraint***. Correctly interpreting this definition is difficult where the only successor to an activity is a finish-to-finish link (see below).

[11] For more on 'lag drag' see, ***Links, Lags & Ladders***: www.mosaicprojects.com.au/PDF/Links_Lags_Ladders.pdf

[12] The end activity (or more accurately Milestone) in a schedule can create a special circumstance. In some software, if the end date is set by a fixed constraint (must finish on, or a project completion date) the 'Late Finish Date' will be later than the 'Early Finish Date' calculated by the schedule logic, and the Milestone or activity will show Total Float (but by definition there is no successor). In this circumstance, the constraint is considered as the 'successor' and the Milestone's FF = TF. The critical path in these circumstances will also show positive float, see: http://www.mosaicprojects.com.au/WhitePapers/WP1043_Critical_Path.pdf.

For more Scheduling Papers see: http://www.mosaicprojects.com.au/Planning.html#Roles

The calculation requires data from all of the task's successors (which is an unknown, unconstrained number – there can be many succeeding links, the example is a very simple network). This complication is probably the reason FF was not regularly calculated by many early PDM software tools, only after the processing power of computers improved dramatically in the 1990s has the calculation of FF become routine[13].

The calculation shown in Figure 4 is the simplest option[14]. As soon as some of the successors to Task A are connected using Start-to-Start or Finish-to-Finish links the amount of free float becomes dependent on how any conflicting schedule information from the different links is interpreted by the software and the rules set by the scheduler as this example below shows:

Free float for Task C is defined by the standard definition based on delaying the start of a successor.

Is the Free Float for Task B defined by the finish of C or the start of E?

Similarly is the Free Float for A defined by the finish of B or the start of E??

My suggestion for a better definition of Free Float is: ***The amount of time a schedule activity can be delayed without delaying the early start, or the early finish, date of any successor or violating a schedule constraint***. This definition would limit the free float on task A by the Early Finish date of Task B. But this is not the current definition.

The last time I heard Dr. John Fondahl speak, shortly before his death in 2008, he was still opposed to the use of SS and FF links because of the analytical issues of lag drag, etc. If you create a PDM schedule using FS links exclusively, you effectively have an ADM schedule! It's just arguably easer to edit the logic by changing links.

---

13   For more on PDM calculations see, **Schedule Calculations**:
         http://www.mosaicprojects.com.au/PDF/Schedule_Calculations.pdf

14 For more on complex PDM calculations see, **Schedule Calculations**:
         http://www.mosaicprojects.com.au/PDF/Schedule_Calculations.pdf

PDM float Calculations – Non-contiguous Durations[15]

Allowing the overall duration of an activity to stretch to accommodate both start and finish constraints removes the problem of 'lag drag' but introduces a set of float calculations ignored in most current scheduling tools. There is now only one correct calculation for Total Float the value is:
LFT – EST – Duration (this is almost invariably calculated incorrectly in modern software).

It is the total amount of time the **work** on the activity can be delayed or extended without delaying the completion of the project or a constraint. The values of the start and end event slack times which are the times the start and end of the activity respectively may be delayed may be equal to, or less than this 'total' value depending on the effect of the succeeding links from the start and finish 'events' associated with the activity. The start of an activity can be constrained through a series of SS links and the finish through a series of FF links with the Total float being significantly greater than either of the end floats (due to presence of 'Independent Float').
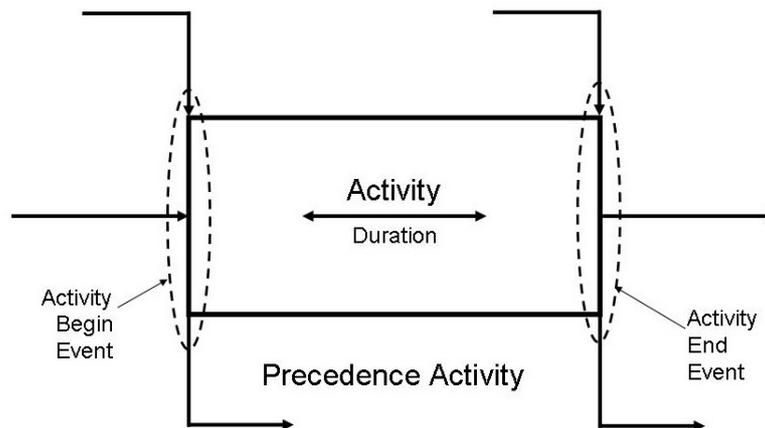

Figure 5 - PDM Activity With Float

Assuming the schedule information in the above activity is:

- Activity 'begin event' ES = 15, LS = 17 (constrained through the S-S links)
- Activity duration = 5 (non-contiguous)
- Activity 'end event' EF = 27, ES = 33 (constrained through the F-F links)

The various float options are:

- Start Float (Start event slack) = 17 - 15 = 2
- End Float (End event slack) = 33 - 27 = 6
- Activity Total Float = [(33 - 15) - 5] + 1 = 14
- Activity Free Float depends on the early start of its successors.

This means the work has to start within 2 days of the ES date of 15 so as not to delay the start of the successor connected via the S-S link, but the 5 days of work cannot be finished until day 27 or later due to the finish constraint set by the F-F link; and all of the work must be finished by day 33 to avoid delaying the finish of the project (or a constraint).

These calculations are effectively identical to ADM Float calculations above and are implicit in scheduling software developed to the RD-CPM®[16] standard. Unfortunately most scheduling tools that use the PDM

---

[15] For more on the calculation differences between contiguous and non-contiguous settings see
Basic CPM Calculations - *PDM Analysis using different settings for calculation* (page 19 - 21):
http://www.mosaicprojects.com.au/PDF/Schedule_Calculations.pdf

method, and allow non-contiguous durations, fail to deal with these calculations in any effective way; thereby leaving their users with incomplete and often inaccurate information.

Calendars and Float

Calendars can have a significant (and variable) effect on float calculations. For example, if the engineering work on your project is scheduled to work on a 24 x 7 calendar; but the commissioning work requires client staff in attendance and is scheduled on an 8 to 5, 5 day week calendar the following situation can occur.

The last engineering task on the critical path, needed to allow commissioning to start finishes at 21:00 (9:00PM) on Friday, its immediate successor on the critical path, with Zero days float is scheduled to start at 8:00 on Monday. The engineering activity has 59 hours float (2 days if the time unit is days) and is on the critical path because it does not have to finish until 8:59 on Monday morning.

Now assume the project team focus on the 'critical activities' and accelerate the work by 6 hours. The Engineering activity now finishes at 15:00 (3:00pm) and the commissioning work can start immediately - the engineering activity float changes to Zero - same activities, same logic but the 'float values' are changed by effect of the activity calendars and the precise timing of when the work occurs.

Negative Float

Negative float is created when the earliest times an activity or event can occur are later than an imposed constraint. In this circumstance, the late dates calculated during the back pass are earlier than the early dates[17]. From a practical viewpoint this tells the scheduler the schedule logic needs modification or the constraint will not be met. Negative float can only be calculated in respect of Total Float (the lowest value that can be calculated for Free float is Zero).

Summary Activities

Summary activities[18] in a schedule can reasonably adopt the schedule dates of the last activity (or activities) they are summarising and so can the reported dates in a Work Package (WP). This is usually the latest early finish date (EF) and the latest late finish date (LF) of the activities being summarised – but these dates can be derived from different activities.

For example if two unrelated activities have the following calculated dates:

- Task X is critical and has an EF of 90 and LF of 90
- Task Y has 20 days float with an EF of 75 and a LF of 95

The summary activity or WP containing these two unconnected tasks would have an EF of 90 (it cannot finish until this date) and a LF of 95; it may not be finished until this date.

---

[16] For more on **RD-CPM** (the 'Relationship Diagramming Method (RDM) variation of the Critical Path Method') see:
http://www.mosaicprojects.com.au/WhitePapers/WP1035_RD-CPM.pdf

[17] For more on **CPM calculations** see: http://www.mosaicprojects.com.au/PDF/Schedule_Calculations.pdf

[18] For more on summary activities, hammocks and LOE tasks see:
http://www.mosaicprojects.com.au/Mag_Articles/P016_Hammocks_LOE_and_Summary_Activities.pdf

For more Scheduling Papers see: http://www.mosaicprojects.com.au/Planning.html#Roles

However, I would question if the summary activity of WP has 'total float' of 5 days. The proper calculation of TF is (LF – ES) – Dur. Summary activities (and WPs) don't have a set duration; the duration is derived from the timing of the underlying activities and can easily change at every update (unless the schedule is very simplistic).

This creates some interesting problems if you are using schedule levels[19] to keep network files to a sensible size and/or techniques such as 'rolling wave[20]' or schedule density[21].

My recommendations are:

- That more detailed logic always takes precedence and redundant logic at summary levels should be removed once there is more detailed information to be rolled up to the summary levels.
- Whilst there may be differences between early and late dates on summary activities (or in WPs) this is simply a reporting item – the difference is not 'float'.

Practical Considerations

The predominance of PDM is absolute, well over 95% of the software used by schedulers today cannot create an ADM schedule[22] and probably 99% of schedulers under the age of 40 have never seen or used an ADM schedule. What's needed to advance the practice of scheduling is a standardised way of dealing with calculation conflicts in PDM schedules; the problems are well known[23]. To date a standardised solution has not been achieved and consequently float in a PDM schedule is uncertain[24].

From a practical perspective this creates two issues of paramount importance:

- Resources levelling and resource smoothing are completely reliant on having access to accurate and understandable float values. All of the various floats including EFF and LFF and IF are used in creating the priority in the scheduling queue for a task to be scheduled where resources are in short supply. And the efficiency of resource levelling algorithms is enhanced when the choice to delay (split or stretch) an activity with independent float in preference to one with free float early is available[25]. The absence of these types of float in some forms of PDM based networks means the scheduling algorithms are likely to be less efficient.
- Contract management relies on clearly defining critical and non-critical activities and knowing how much flexibility (float) is reasonably available on the non-critical activities.

There are also two critical issues around the use of float:

---

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

[20] For more on **Rolling Wave** see: http://www.mosaicprojects.com.au/WhitePapers/WP1060_Rolling_Wave.pdf

[21] For more on **Schedule Density** see: http://www.mosaicprojects.com.au/WhitePapers/WP1016_Schedule_Density.pdf

[22] The Micro Planner range is one notable exception – the origins of this software was the ICL Pert mainframe software. See: http://www.microplanning.com.au/

[23] See, **Links, Lags & Ladders**: www.mosaicprojects.com.au/PDF/Links_Lags_Ladders.pdf

[24] The calculations suggested in our core paper **Schedule Calculations** are intended to offer a standard set of PDM calculations, we encourage the industry to make consistent use of these (or to agree an improved set of calculations) to remove the current inconsistencies. See: http://www.mosaicprojects.com.au/PDF/Schedule_Calculations.pdf

[25] Traditional CPM resource levelling algorithms are based on some form of decision table and the more sophisticated tools (particularly from the main frame era) allowed the planner to chose the sequence decisions would made in (by selecting which decision table to use) and set parameters for the processes to operate within. Most of these capabilities are embedded in Micro Planner X-Pert: http://www.microplanning.com.au/

- Once resource levelling has been done to create a resource optimised schedule, there can be no 'float' shifting any activity with its attendant resources can unbalance the resource loading for the whole schedule.
- Total float belongs to the whole path – not individual activities along the path. Because using total float on any one activity removes the same amount of float from all of its subsequent activities, only the core project management team should be allowed to consider using this float.

Where possible, we recommend changing the default settings in most scheduling tools to show Free Float in preference to the usual Total Float when displaying or printing bar charts. The normal effect is to maintain the differentiation between critical (usually shown red) and non-critical activities (usually shown grey), but the report only shows the 'dotted float bars' behind activates with Free Float. This means is a chain of 10 activities with 10 days float, instead of showing 10 float bars (one behind each activity) and 100 days of 'total float bar' – 9 activities are shown as non-critical, but with dependent successor tasks hat will be delayed if an earlier task is delayed, and the 10 days float belonging to the chain is shown as free float after the last activity.

Conclusions

The lack of defined calculations for most of the float values in a PDM schedule must reduce the overall value of the schedule model compared to more rigorous approaches. How important this reduction in schedule integrity is, is questionable. Certainly there has to be some loss of value, what's not determined is, is the loss of value generally significant?

If scheduling is a modelling process designed to affect the future behaviours of people working on the project (ie, persuade them to work to the plan), other factors may be more important[26]. However, from an analytical view point, any loss of accuracy is undesirable and this paper has clearly demonstrated PDM has less rigour in its float calculations than ADM.

However useful float is, it is critical to remember float is not real! It is a creation of the CPM modelling process. Float is useful for gaining insight and assisting in understanding 'what matters' but at the end of the day a project is completed by people doing all of the required work, not just the 'critical activities'. As my colleague Earl Glenwright, PE, PSP often reminds me, there is an Eastern Pennsylvania (Pennsylvania Dutch) saying that is very applicable to the misunderstanding and use of 'float'

"As you travel on thru life brother
Whatever be your goal,
Keep your eye upon the donut
And not upon the hole"

And so it is with 'float'. Practical schedulers keep their focus on working the plan, not the 'float'.

_____

---

[26] For more on this topic see: ***Scheduling in the Age of Complexity***:
www.mosaicprojects.com.au/Resources_Papers_089.html

Float

First published 2009; augmented and updated.

This paper is a reference in our PMI-SP and PTMC credential courses.
For more information on these courses see:
http://www.mosaicprojects.com.au/Training-Planning_One-on-One.html

The papers in this series:

- A Guide to Scheduling Good Practice: http://www.mosaicprojects.com.au/PDF/Good_Scheduling_Practice.pdf
- Attributes of a Scheduler: http://www.mosaicprojects.com.au/PDF/Attributes_of_a_Scheduler.pdf
- Dynamic Scheduling: http://www.mosaicprojects.com.au/PDF/Dynamic_Scheduling.pdf
- Links, Lags & Ladders: http://www.mosaicprojects.com.au/PDF/Links_Lags_Ladders.pdf
- Schedule Float: http://www.mosaicprojects.com.au/PDF/Schedule_Float.pdf
- Schedule Levels: http://www.mosaicprojects.com.au/PDF/Schedule_Levels.pdf
- Schedule Calculations: http://www.mosaicprojects.com.au/PDF/Schedule_Calculations.pdf

Additional information; see Mosaic's Scheduling Home page at: http://www.mosaicprojects.com.au/Planning.html