Core Scheduling Papers: #5

# 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:

- 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.

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[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

- 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).

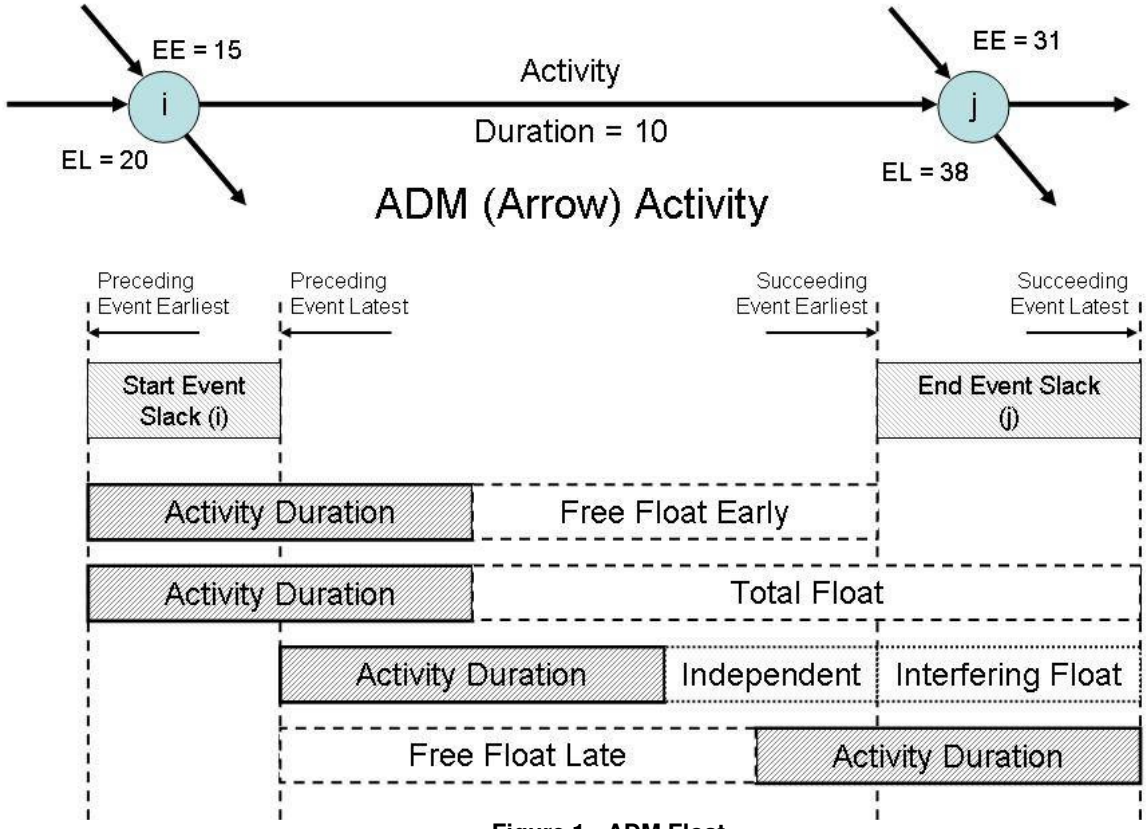


**Figure 1 - ADM Float**

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.

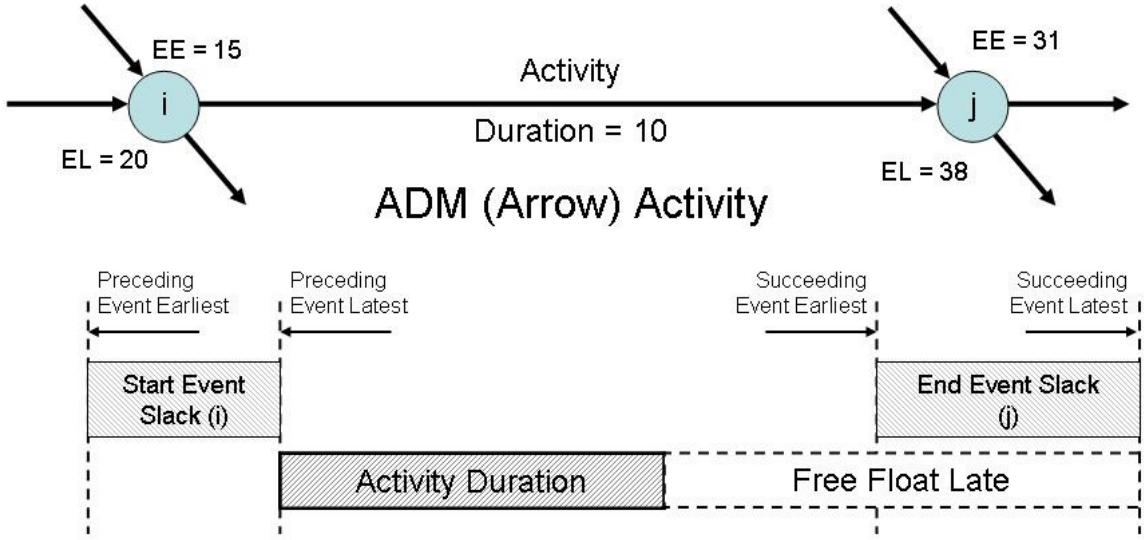


**Figure 2 – ICL Pert FFL**

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

### 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 then 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.

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

[7] The range of ICL Pert programs included 1500 Pert, 1900 Pert, and VME Pert; plus many ancillary tools.

## 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[8].

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.

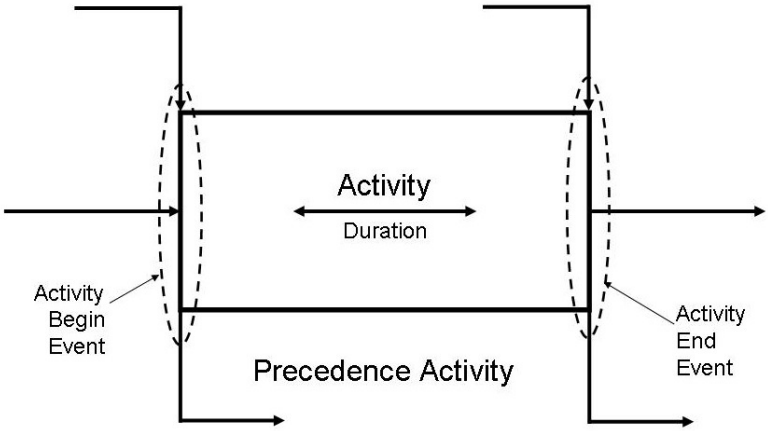


**Figure 3 - PDM Activity**

### PDM float Calculations

The only two 'floats' that can be reliably calculated in a PDM schedule 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 Early Starts of its successors; refer Figure 4.

Calculating the other floats, described in the ADM network above, for a PDM network depend on whether the activity is allowed to stretch, split or is schedule contiguously to meet the latest of the 'early start' conditions imposed by different link types (sometime causing 'lag drag'[9]).

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.

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.

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[10].

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

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

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

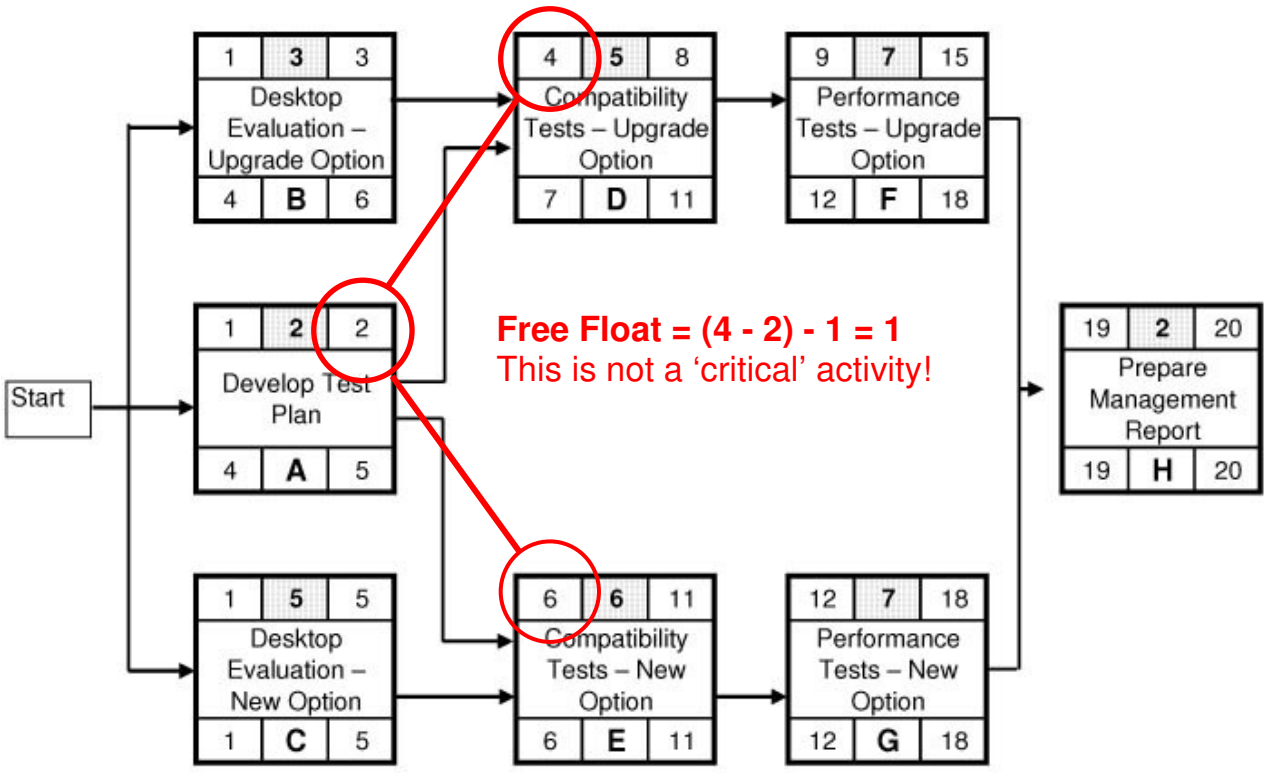


**Figure 4 - PDM Free Float Calculation**

The calculation shown in Figure 4 is the simplest option[11]. 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.

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.

## Practical Considerations

The predominance of PDM is absolute, well over 95% of the software used by schedulers today cannot create an ADM schedule[12] 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[13]. To date a standardised solution has not been achieved and consequently float in a PDM schedule is uncertain (with the exception of total float).

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

- Resources levelling and smoothing is completely reliant on having access to accurate and understandable float values. The absence of these means the scheduling algorithms are likely to be less efficient.

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

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

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

- Contract management relies on clearly defining critical and non-critical activities an knowing how much flexibility (float) is reasonably available on the non-critical activities.

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

- 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.

## 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[14]. 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'.

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### 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

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