Understanding the weight factors

Significance and influence on the S-curves

1. Recap on the S-curve construction

1.1. Processes and tasks sets

A process is any collection of tasks that can be assembled on the basis of some common characteristic.
E.g.: same contractor, same discipline, same area, same phase, same node of the project tree.

A process can be defined by the project tree. The tasks set is then assembled on the basis of the task's WBS (work breakdown structure).
One summary can define a process consisting of all the tasks that are contained in the summary. This is applicable to all summaries, whatever their level in the project tree.

A process can be defined by assembling a set of tasks on the basis of a common attribute. As stated already: executed by the same contractor, part of the same partial contract, belonging to the same area, belonging to the same discipline (piping, steel construction, cabling, etc.)

The process idea has much to do with the physics of the project. We need to keep in mind that the physics of the process prevail.

Whatever the nature of the project might be, we will always be dealing with physical, observable objects. A project is always about modifying real things or creating real things. These real objects, in whatever shape, colour or flavour they come, must be observable. Even if the project consists of a pure intellectual experiment, there must and will be some observable outcomes: sketches, notes, music notes, drawings, whatever. Without observable objects there can be no project.

A more complete development on these topics can be found here http://bit.ly/14JdnU8 , here http://bit.ly/1dADKI6 and here http://bit.ly/18IcAHU.

1.2. Progress of tasks

The timeline of the progress of a single task is assume to be linear.
The progress function is defined as follows:

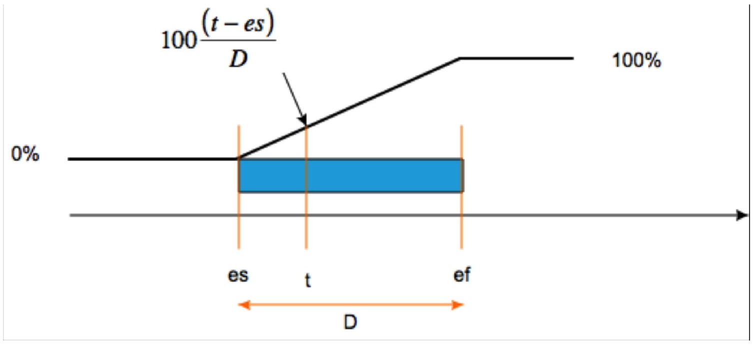
$$t \leq es \Rightarrow pct = 0$$

$$es < t < ef \Rightarrow pct = 100\frac{(t - es)}{D}$$

$$es \leq t \Rightarrow pct = 100$$

Whereby,

es: early start
ef: early finish
t: current date
pct: progress as %



1.3. Aggregated progress

1.3.1. The differential curve

We will now show how the differential curve is constructed for any given process.
The same procedure is applied to all processes.
The construction of the differential progress curve will be illustrated using the Gantt representation of the schedule.

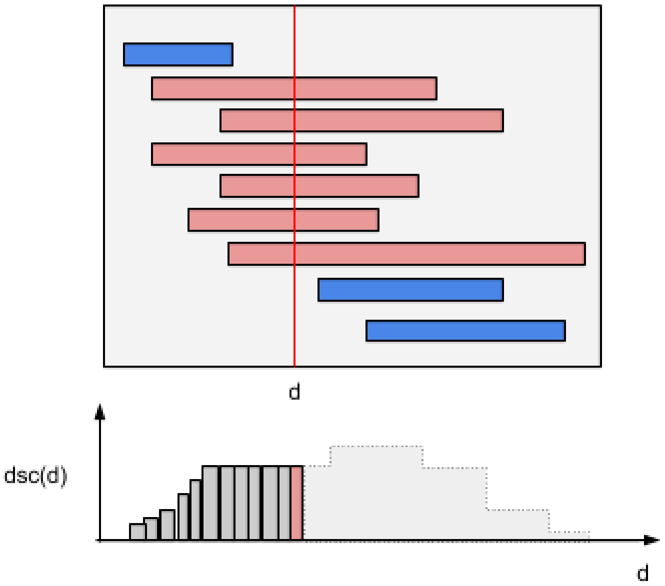
The weight factor of every task is known. By default it is its duration expressed in hours. Other values can be allocated:

- its financial value
- its labor content
- an abstract number of points
- a number of points according to well-established systems such as Kellog points used in piping jobs
- a risk “weight”

For every day located inside the schedule, i.e. in the closed interval {start, finish} of the given process, we sum the weight factors of the tasks that are active on that day.

$$s_d = \sum_{i=1}^{n} w_{i,}\ where\ i \in set\ of\ indexes\ of\ the\ tasks\ active\ on\ day\ d$$

When this is calculated for every day, we obtain the differential S-curve s(d)



The differential S-curve is the profile of the weighted activity of the process. It can also be viewed as the weighted activity distribution.

1.3.2. The integral curve

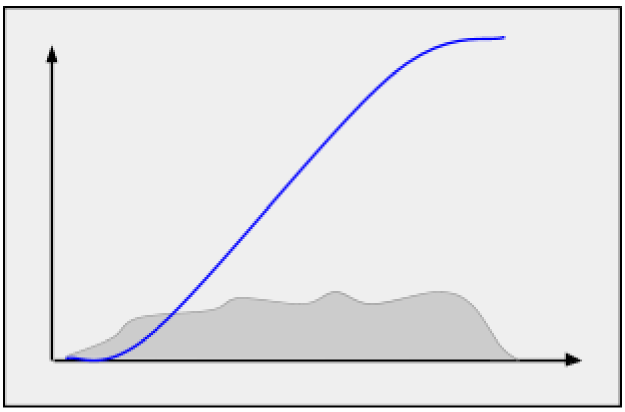
Taking the differential curve s(d) we now construct the integral curve by applying this procedure:

$$S_d = \sum_{i=1}^{D} s_d, \ where\ i\ \in range\ of\ day\ indexes\ of\ the\ process$$

Because we want to map the results in the range {0,100}, we will further normalise this equation as follows:

$$S_d = 100 \times \sum_{i=1}^{D} s_d \div \sum_{j=1}^{N} w_j, \ where\ j \in indexes\ set\ of\ all\ tasks\ in\ the\ process$$

The S(d) curve is the well-known S-curve, in our representation, the "Blue" curve. The picture below shows the integral curve, the S-curve in blue, and the differential curve in gray.



1.3.3. The track

We still consider the same process as for the construction of the S-curve.
When we register the progress of a process, we do that on the task level: for every task of the process, we enter its % complete (physical progress). This value is by definition the accumulated progress at the given status date (sd) for that task.
We now compute the progress value of the process, the aggregated progress, as follows:

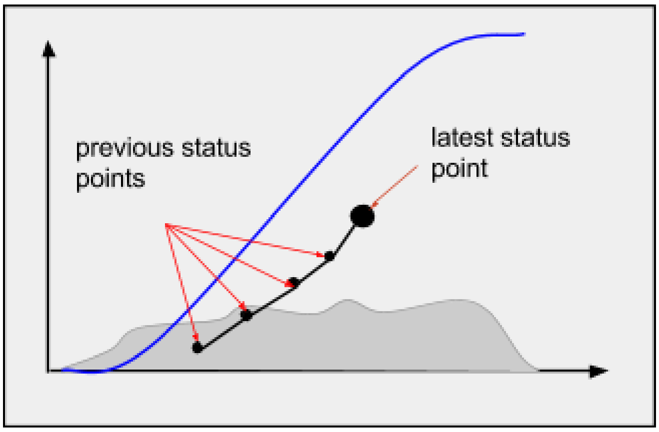
$$P_{ij} = 100 \times \sum_k p_{kj}\, w_k \div \sum_k w_k$$

Whereby

$$P_{i,j} = \text{Aggregated progress of process } i \text{ on status date } j$$
$$p_{k,j} = \text{the \% completion value of task } k \text{ at status date } j$$
$$w_k = \text{the weight factor of task } k \text{ in the process}$$

This formula is also normalized, so we map the values on the range {0,100} %.

Every time we compute a P_{ij} value, we obtain a new position point. All position points taken together form the track of the process. This is shown as the black dotted line in the next figure.



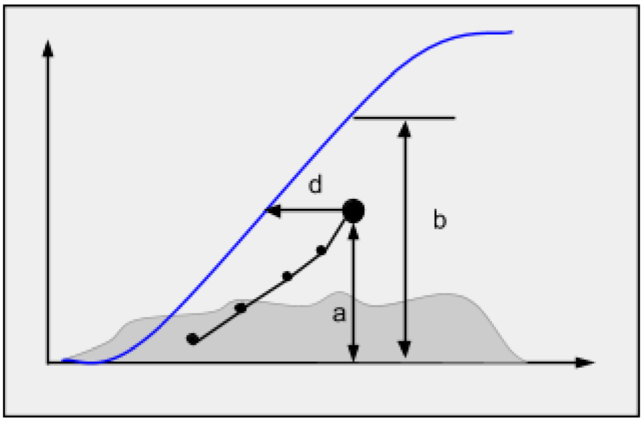
1.3.4. The Score

The position of a track point can be characterised by its score value. The score is defined as:

$$s = 100 \times (a - b) \div b$$

b: progress as per schedule
a: progress as per progress point

The score is negative when we have a delay and positive when we are ahead of schedule.
The more the score is negative, the large the “deficit” in performance.
The score is a dimensionless quantity and is therefore more significant than absolute values of progress.



The value of d represents the delay in days. It means this: the present progress value should have been reached d days ago; so we can conclude that we are d days late.

2. Influence of the wf profiles on the S-curves

2.1. Scope

The question is (1) if the profile of the wf values influences the shape of the s-curves (both scheduled and track), and (2) if the the score can be influenced by the same profiles.
By wf value profile we understand the wf values indexed over the tasks. Such profiles can be uniform - same value for all tasks (which is quite meaningless), random - this is the case when the tasks duration is taken as wf value - or have a specific shape, which we then install intentionally - eg. front load or back load.

The answer on (1) is yes. The answer on (2) is yes, but the score sign is never altered, ie. a delay stays a delay.

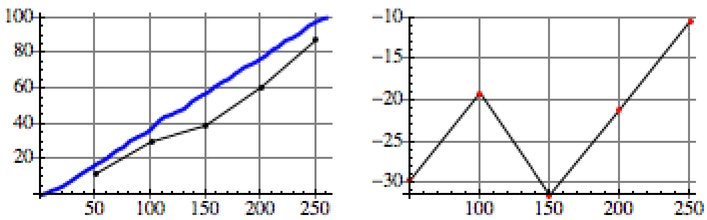
In the diagrams below we show two figures:

- On the left: the scheduled progress line (blue) and the track (black). Keep in mind that both lines are calculated with the same wf values.
- On the right: the score track

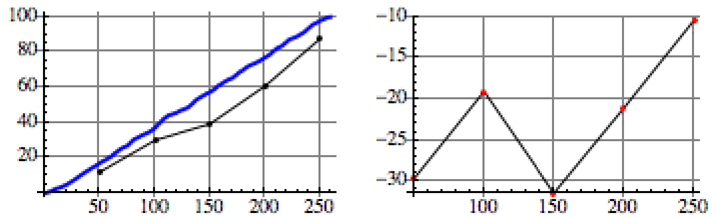
The diagrams have been calculated from a simulated schedule. The track (the observed progress line) has been constructed from a fixed set of task progress values. Only the wf values are modified between the cases.

2.2. Uniform wf distribution

The two diagrams have been calculated for two values of wf, whereby the wf values have a uniform profile. As one would expect: the diagrams are identical.



Case: Uniform wf profile at value 10

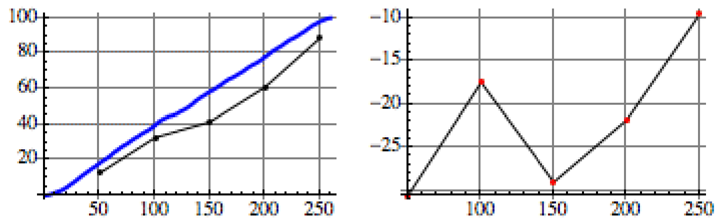


Case: Uniform wf profile at value 100

2.3. Duration as wf

In this case the task durations (expressed in hours) are used as wf. This is the default situation; these are the wf values that are used when nothing else has been defined

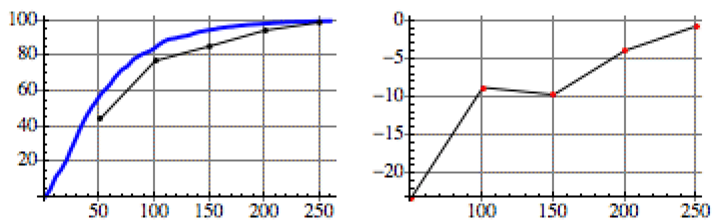
The task durations used in this simulation have effectively been generated randomly. We notice that the effect on the shape of the S-curves is limited; the score-track displays a little variance compared to the uniform case.



Case: wf = task duration

2.4. Front loaded wf profile

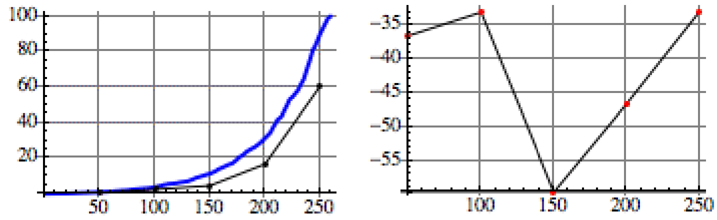
In this case we installed a pronounced front load wf profile. This means that the wf values are high for the early tasks and low for the later tasks. This simulates front loaded scheduling, which means that the bulk of the work is done over the first half of the duration.
The important feature here is the converging track: the track converges to the blue line in the last part of the process.
This is perfectly understandable: as the process nears finish, the balance of tasks to complete weighs less and less. The score will converge to zero on the negative side.



Case: wf profile is front loaded

2.5. Back loaded wf profile

In this case we installed a pronounced back load wf profile. This means that the wf values are low for the early tasks and high for the later tasks. This simulates back loaded scheduling, which means that the bulk of the work is done over the second half of the duration.
The important feature here is the diverging track: the track diverges from the blue line in the last part of the process.
This is perfectly understandable: as the process nears finish, the balance of tasks to complete weighs more and more. The score will stay largely negative.



Case: wf profile is back loaded

2.6. Conclusions

- wf profiles do influence the shape of the s-curves, both scheduled and observed.
- A delay stays a delay.
- In case of front load wf profile, the score naturally improves to the end of the process. This underlines the benefits of front loaded scheduling: delays become easy to correct; they tend to disappear naturally
- In case of a back load wf profile, the score remains largely negative. This underlines the dangers of back load scheduling: delays are difficult to recover.

3. Types of weight factors

3.1. Introduction

We must understand that the significance of the wf, their meaning, defines the significance of the S-curves.
If for example, the wf represents the labor content of the task, then the S-curve will represent the amount of labor "consumed" over time as a percentage of the total labor content of the monitored process.
So, if at any given point in time, a status of 25% is reached, then this means that 25% of the total labor content of the process has been "used", "produced" or "earned" in EVM speak, at that moment.

Now one has to bear in mind that this quantity has nothing to do with the real labor consumed, as would be known from a working time registration system. It is the fraction (25%) of the scheduled labor content. This value is an estimate that was set when the schedule was being constructed. This value can at best be regarded as an estimate of what a precise project accounting system should produce.

See it like this: the "labor content" weight factors are used to weigh the tasks against each other and to produce progress curves (the S-curves) that give a reasonable estimate of the labor resources consumed over time. By the same token, an image of the progress and progress rate based on estimated labor contents of the individual tasks will be produced.

The same reasoning, mutandis mutatis, can be applied to other types of wf. One type in particular is interesting: wf as the financial value of the individual task.

Why should we care about weight factors in general.
Let's go back to the basics: what purpose do the reports serve?
The answer in the DPC context is straightforward: to gain control over the monitored processes by observing their static and dynamic behaviour, and from these observations define a set of actions with the purpose of correcting and/or improving the overall performance; this is the feedback story.
We have seen from the analysis of the effects of the wf profiles on the shape of the S-curves, that such profiles do influence part of the results: they (the profiles) can modify the diverging/converging

of a given track, and in general they can modify the absolute value of the scores.
But they can't modify the sign of the score: remember, a delay stays a delay.
In other words, if we do not want to generate confusing reports, we better use wf profiles that mimic the real relative weight profiles as closely as possible.

3.2. Abstract weight

Abstract wf systems have no specific meaning. Their only purpose is to weigh tasks against each other. In other words to differentiate between important tasks (heavy - high wf) and less important tasks (light - low wf).

Such systems are very easy to implement. If task 'a' weighs 10 and task 'b' 100, the task 'b' will contribute 10 times more to the overall progress than task 'a'.

3.3. Duration

Using the task durations as wf is the most commonly used system. It is also the simplest: one has nothing more to do once the task durations have been set.

It is not a bad system. The idea that a task weighs more the longer it takes to complete is certainly not fundamentally flawed.
There are situations though when the system does introduce some errors: when a long task does not contain much work (eg. 'supervision'), it will mask the much shorter tasks, with eventually more labor content. This in turn will distort the view we will have on the behaviour of the monitored process.
The solution to that problem is very simple: just allocate a low value to that one task, or those few tasks.

3.4. Labor content

In this system, the values represent an estimate of the labor content of the task.

At this point it should also be remembered that we need to use one and only one type of wf system within any given process.

The labor content based system is probably the best we can define. There is indeed no better way to weigh tasks than through their labor content .
Unfortunately the labor content off all tasks is not always known at the time of schedule construction.

On the other hand, precise values of the labor content are not mandatory: we are not looking at project accountancy but at at operational dynamic behaviour. For that purpose estimates are sufficient.

A practical way for setting up labor based wf goes as follows: for every task

- take an estimate of the number of people involved (at 100%)
- multiply this number by the duration in days, then by 8

This procedure will generate labor content based wf values that will fit our purpose.

3.5. Financial value

In this system we have the wf representing the financial value of the task. By this procedure one builds what is also known as the "earned value base line".

The financial value must be the total value including equipment, material end labor cost.
The danger of this system is that it easily uncouples from the physical progress, the physics of the process. This is due to the presence of fixed cost components in the financial wf value, i.e. components that are not directly linked to the operational "physical" progress.
It is not because the value of 1000 tons of steel beams has been “earned” that the construction of the steel frame has progressed one jot.

So great care must taken not to fall into "good financial progress report" trap.

On the other hand, such system has the advantage of producing progress reports that can directly relate to "invoiceable" progress. This in turn can ease the financial followup of a project.

A recurrent difficulty is that the financial value of tasks is not always known. The reason is that the schedules are often constructed using WBS that are not congruent with the cost breakdown structure (CBS).
In other words, there is no direct link between a given budget item (CBS) and related task(s) (WBS).
The translation of the CBS into the WBS is often a tedious exercise. This is also the reason why "financial value based" wf system are not often used.

In section 4.3 we give an example of how the cost breakdown structure (CBS) can be mapped on the work breakdown structure (WBS).

3.6. Risk factor

An unusual wf system consists in setting the wf values to the task's "risk factor" (assuming that this can be quantified).

It is clear that such system is of no value as a mean to monitor the dynamic behaviour of a process.
There is though one interesting usage for this system: it is when risk-curves are correlated with progress curves obtained in the classical way. This is explained more thoroughly is this article: http://bit.ly/18MfiMC

4. Allocating wf values

The question now is, how practically does one allocate wf values to tasks. In the next sections we show two practical examples.
The third section deals with a method to create a wf system based on the financial value of the tasks.

4.1. Setting wf values in Smartsheet

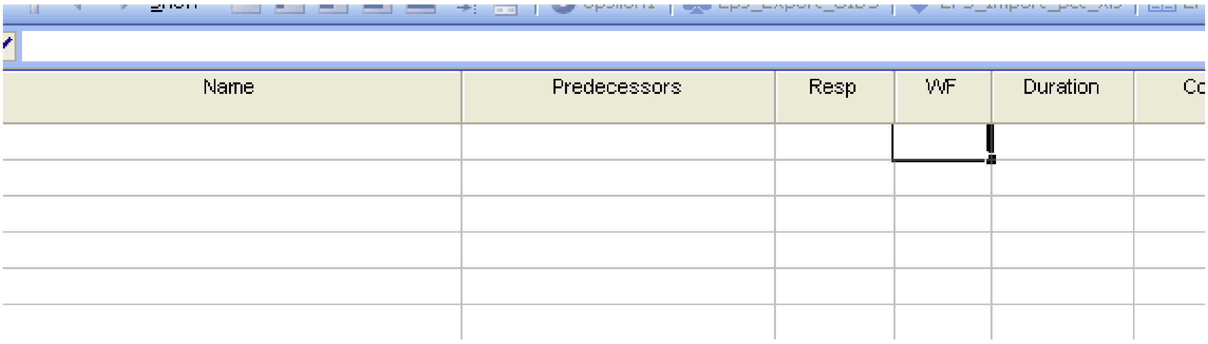
Task Name	Responsible	WF	Predecessors	Duratior	S D
*** Project Name (root) ***					

For the Smartsheet users we provide a template. In this template a column with name “WF” is

available. This is the column to contain the wf values. WF values must only be defined for the tasks, not for the summaries.
When the wf field is left blank or set to zero, the default wf value is taken. The default value is the task duration in hours.

Negative values and text values are rejected.

4.2. Setting wf values in MS Project



For the MS Project users we also provide a template. In this template a column with name “WF” is available. This is the column to contain the wf values. WF values must only be defined for the tasks, not for the summaries.
The default value for this column is zero. A zero value signals that the default wf value should be taken, which is the task duration in hours.

Negative values and text values are rejected.

4.3. Mapping the CBS on the WBS

In general we will have a CBS and a WBS that are different. It is not possible to have them overlapping perfectly (being congruent) because both are constructed with different objectives in mind:

- the CBS is for budget setup and control
- the WBS is for scheduling and process monitoring.

When we want to use financial value based wf systems, we need to map the WBS on the CBS. It is not a difficult task to do, but it is tedious.

For every atomic task in the WBS (not for the summaries) define these items:

$$b_j : \text{ budget item } j \text{ to which task } t_i \text{ belongs}$$
$$\alpha_{ij} : \text{ the fraction of budget item } b_j \text{ taken up by task } t_i$$

Whereby: $\sum_i \alpha_{ij} = 1$

We thus create the map

$$t_i \rightarrow \{b_j, \alpha_{ij}\}$$

If $B(b_j)$ is the value of budget item b_j, then the financial based weight factor for task t_i is:

$$wf_i = \alpha_i \times B(b_j)$$

This scheme assumes that any given task maps on one and only one budget item.