"Much Ado about Dates" Understanding P6 Date Information

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1. Introduction

Since its initial introduction in early 80's, Primavera Project Manager (P3™) scheduling software has been a popular tool used by schedulers, project managers and claims consultants. The construction industry relies heavily on this software to develop, maintain and analyze project schedules. In 1999, Primavera introduced an entirely new Critical Path Method (CPM) scheduling package designed for enterprise-wide project management which changed names almost yearly. P3 remained "P3" while this new enterprise-wide software is now called either P5 (short-hand for Primavera Project Manager™) or P6™ (for Enterprise Version 6.)

Besides a fundamental shift in the way that dates are conceptualized, Primavera Inc's newest and most powerful scheduling software, P6, has more kinds of useable dates than any other software in existence. The majority of P6 users are unaware of the underlying calculations for new date fields and their usage.

P3 users are frequently confused by the issue of dates when converting to P6. This is partly because the same company produces both P3 and P6 and partly due to the incorrect assumption that P3 must be an earlier version of the current P6 software. Date fields with similar names in both P3 and P6 behave differently in one than in the other. A plethora of new date fields in P6 create a steep learning curve. A lack of documentation regarding these features creates a potential for real confusion.

This paper discusses the underlying calculations for P6 date fields and their potential uses. It also identifies the issues related to them. For brevity, this paper assumes that the reader is familiar with the P3 date characteristics and deals mainly with differences that an experienced P3 user would understand or expect. Highlights of some of the P6 date issues discussed in this paper include:

- Schedulers are familiar with early and late dates. The whole purpose of CPM is to calculate the early and late dates so that the criticality of activities can be determined. P6 and P3 use fundamentally different method to calculate and store traditional CPM dates.

- In addition to the traditional CPM date fields, P6 contains numerous other date fields that are not included in traditional college courses on CPM scheduling.

- Planned start/finish dates are confusing to many P6 users. This is because planned dates are neither static like baseline dates nor dynamic like early and late dates once the activity has progressed. Planned dates might end up being your baseline dates, and yet they are not truly a baseline. Planned dates do not always display planned information. In some instances they display budgeted and current information as well. So the question becomes, how do the planned start/planned finish dates come into play for you as a project manager?

- Many P6 users are puzzled to see complete activities where early and late dates differ from actual dates. Does that mean P6 calculates early and late dates for complete activities? If so, total float for complete activities can be calculated. Is this as-built float? So how do the early/late dates come into play for you as a claims consultant?

- P6 introduced a new float field called remaining float which is dependant on resource leveling. So how does remaining float come into play for you as an earned value professional or as a scheduler?

Flexibility and abundance of date fields can be a benefit to the scheduler in developing the work plan if the scheduler is aware of the underlying calculations and uses them purposefully. Similarly, claims consultants must understand the P6 date fields so that they can analyze clients' schedules in their original format, without converting to P3.

2. The Date Fields

The first step in understanding P6 date fields is to realize the scope and variety of date fields. One logical way of categorizing the date fields is by functional hierarchy. Date fields can be categorized into 5 main groups:

1. Project Date Fields
2. WBS Date Fields
3. Activity Date Fields
4. Resource Date Fields
5. Relationship Date Fields

A list of the P6 date fields are shown below in Table 1.

Project & WBS Date Fields	
Anticipated Start	Anticipated Finish
Actual Start	Actual Finish
Planned Start	Finish Date
Forecast Start	Forecast Finish
	Must Finish By
Activity Date Fields	
Start	Finish
Early Start	Early Finish
Planned Start	Planned Finish
Remaining Early Start	Remaining Early Finish
Remaining Late Start	Remaining Late Finish
Actual Start	Actual Finish
External Early Start	External Late Finish
Baseline Start Dates	Baseline Finish Dates
Variance BL1 Start Date	Variance BL1 Finish Date
Primary & Secondary Constraint Dates	Expected Finish Date

Resource Date Fields	
Start	Finish
Actual Start	Actual Finish
Planned Start	Planned Finish
Remaining Early Start	Remaining Early Finish
Remaining Late Start	Remaining Late Finish
Relationship Date Fields	
Relationship Early Start	Relationship Early Finish
Relationship Late Start	Relationship Late Finish
Audit Date Fields (per record for Project/Activity/Step/Activity Code/Relationship/Expense)	
Date Created	Date Last Updated
	Date Deleted

Table 1 – Date Fields in P6

Activity and resource dates are the main focus of this paper. When we refer to an activity "date field," we mean that every activity in the schedule has a 'slot' available for storing the particular date that applies just to that activity. P6 has storage set aside to hold a unique date from every one of the above fields for every activity in the schedule.

A brief introduction to project & WBS dates is appropriate since project & WBS dates, such as the Planned Start and the Must Finish By, affect the activity-level calculations. Planned Start date field is the start date of the project. No early dates will be calculated before this date. Must Finish By date field is a date constraint placed on the project completion. Must Finish By Date determines the late finish of the first activity in the backward pass.

Very little is known for certain about Forecast Start and Finish dates. The documentation suggests that they play a part in resource leveling. They become the end points of the forward and backward resource leveling process. It is possible that this feature only applies to the web version of P6.

Finish date is the latest early finish date calculated when P6 last scheduled the project. Actual Start is the actual start date of the project, and it is inherited from the first started activity. Similarly, Actual Finish date is inherited from the last completed activity. Anticipated Start / Finish date fields are used during the project planning stage, and can be set at the Enterprise Project Structure (EPS), project, or WBS level. These dates are displayed at EPS level bars and columns when there are no activities. These dates remain as historical record when activities are added.

3. How Does P6 Calculate Date Fields?

One of the greatest differences between P3 and P6 software is how they deal with dates. Users of P3 decide upon the unit of measure before they create a new schedule. You can pick months, weeks, days, or hours. After the schedule is created, the chosen unit of measure is forever fixed and indivisible.

Most construction projects are scheduled in days. This unit of measure is normally appropriate for planning, estimating, and measurement. Appropriate unit granularity is enforced by an engineering assumption that all work begins at the beginning of the work day and all work finishes

at the end of the work day. P3 has no provision for measuring durations less than the chosen unit of measure.

The point here is that the engineers who designed P3 were forced to consider significant accuracy. You started with days and every mathematical calculation had to return whole number of days. As an example, if you were to status a 6-day activity as 30% complete, that would mean that you had 4 days remaining, not the 4.2 days that the mathematical calculation would suggest. Engineers would say that if we plan our work using whole days and measure it in whole days, then it is false accuracy to say we can predict anything with better accuracy than a full day's duration.

Users of P6 face an entirely different philosophy about the measurement of duration and time. All dates are stored in the database as a complex number that describes the date, hours, minutes, and even seconds. Users of P6 can approximate the look of a schedule calculated in days by setting their user preference to only display whole days without hours. When displaying durations, you can also have P6 round the current duration to the nearest whole number. This does not mean that your dates and durations are now being measured in whole days; only that it is displayed that way.

Because the engineers that designed P6 used a method of storage that allowed for fractional dates and fractional days (down to the second,) they did not feel constrained the way the P3 engineers were. They were free to have durations down to the second and compute early start and finish dates down to the second. P6 user can plan in units of days, enter only durations in whole units of days and still will quite often get calculated results that are expressed in hours, minutes, and seconds. In all of our investigations, we have never seen any indication of adjustments to calculations designed to ensure significant accuracy in any of the P6 calculations.

So what is the unit of measure in P6? The Primavera literature says that the schedule is calculated in hours. If you look at the calendar setups, you will notice that you can input the work/no working hours per day accurate to the nearest ½ hour. If the calendars use ½ hours, then perhaps this is the unit of measure. The fact that you can enter durations and dates down to the single minute must mean that P6 at least considers time intervals to the minute, so we are left back where we started asking ourselves, what is the unit of measure in P6?

To verify the smallest unit of measure (and thus the unit of measure for P6) we set P6 to display activity duration in hours with two decimal places (the highest accuracy display available.) When we enter 0.01 hours (0.6 minutes,) P6 automatically converts this into 0.02 hours (roughly 1 minute). We then compute the schedule and get the results shown in Figure 1.

Activity ID	Activity Name	Original Duration	Remaining Duration	Total Float	Start	Finish
B100	Activity 1	0.02	0.02	0.00	02-Apr-08 08:00	02-Apr-08 08:01
B110	Activity 2	0.03	0.03	0.00	02-Apr-08 08:01	02-Apr-08 08:03
B120	Activity 3	0.02	0.02	0.00	02-Apr-08 08:03	02-Apr-08 08:04
B130	Activity 4	0.02	0.02	0.00	02-Apr-08 08:04	02-Apr-08 08:05
C1000	Activity 5	0.02	0.02	0.02	02-Apr-08 08:00	02-Apr-08 08:01
C1010	Activity 6	0.02	0.02	0.02	02-Apr-08 08:01	02-Apr-08 08:02

Figure 1 – P6 Unit of Measure

Activity 1 starts at 08:00 and ends at 08:01. Activity 2 starts at 08:01 and ends at 08:03. Activity 3 starts at 08:03 and ends at 08:04. Clearly, P6 computes schedules at least to the minute (if not lower.)

So now that we understand the real unit of measure of P6, how does the new date structure affect the scheduler working in days as the unit of measure? P6 has a simple mechanism for converting days into hours and back again.

P6 converts the data based on the "Hours per Time Period" settings (either the Admin Preference or User Preference screen as shown in Figure 2). If the Admin Preference option - "Allow users to specify the number of work hours for each time period" - is selected, then each user can define their own Hours/day conversion factor. This results in each user displaying a different duration. If the Admin Preference option - "Allow users to specify the number of work hours for each time period" - is not selected, the Hours per Time Period settings defined in the Admin Preferences, are used for the conversion.

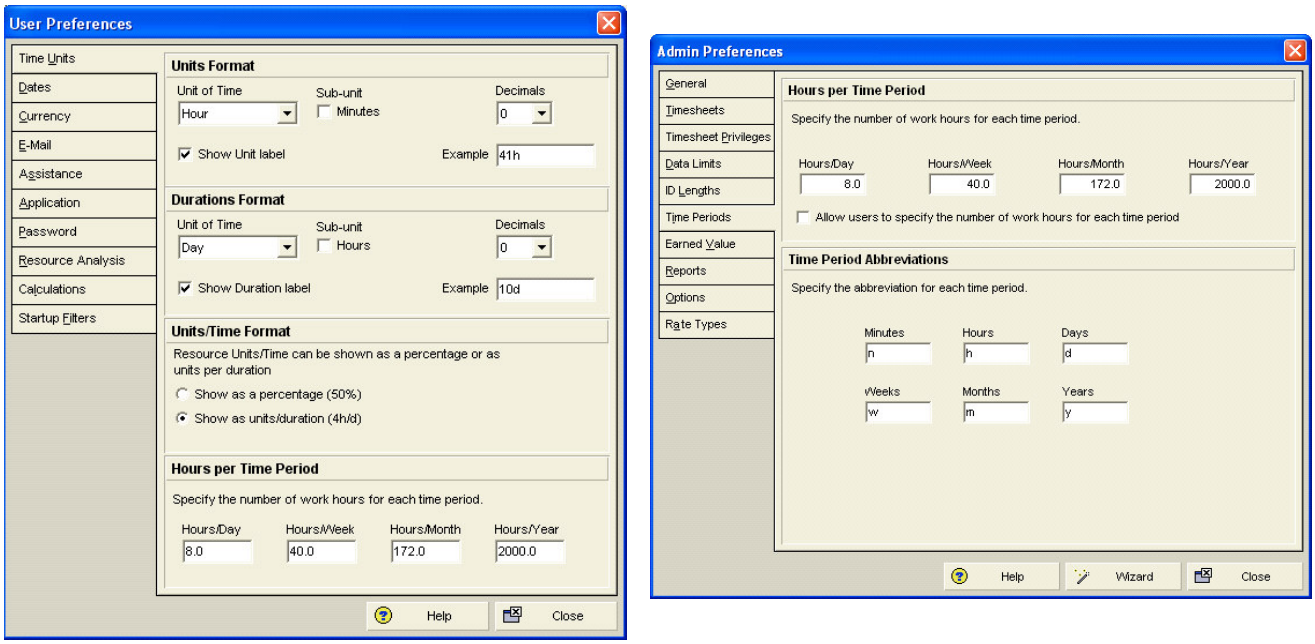

Figure 2 – Admin and User Preferences for Time Periods

The fact that a single conversion factor is used for all projects and for all activities does not take into account that various projects may operate different work schedules and different shift schedules. In addition, various activities in the same schedule may work on dissimilar work schedules.

Changing the conversion factor to meet current needs does not solve the problem. The user might enter the duration in days and that duration might vary based on either the conversion settings or calendars. As shown in Figure 3 if the duration format is in days, and user enters duration of 10 days with a calendar of 8 hrs/day, P6 will convert this duration to 80 hours.

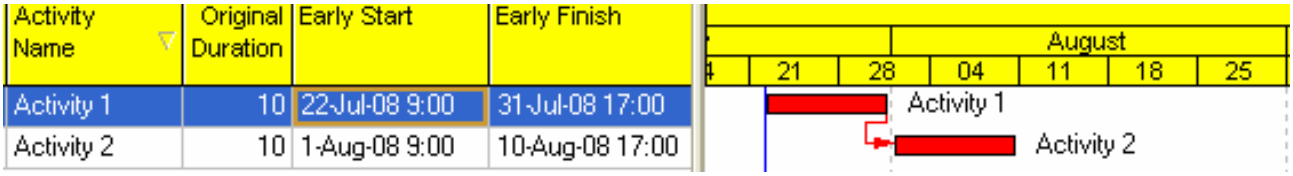

Figure 3 – Activity with 8 hour/day Calendar

If the user changes that calendar to a 10 hrs/day, the original duration will still display 10 days. However the duration will calculate to be 8 days when it is calculated as the difference of the start and finish dates as shown in Figure 4. A similar issue is also inherent in float calculations.

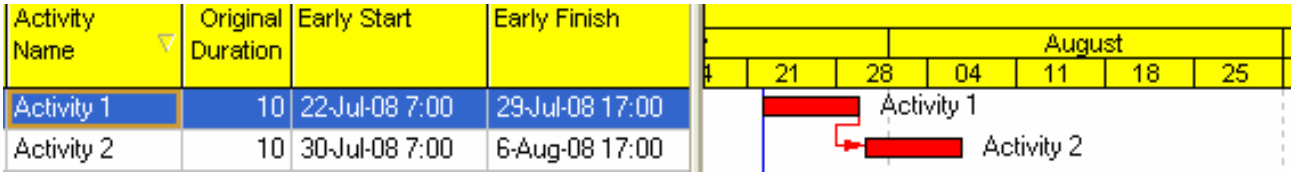

Figure 4 – Activity with 10 hour/day Calendar

This issue is also exhibited in many other software packages like Microsoft Project™, SureTrak™ and Contractor™ (which is just a limited-function copy of P6.)

With P3, the data date was the beginning of the first available working time unit and the finish was the end of the time unit. If the data date was 01AUG08 then the data date was the beginning of that day. Similarly if an activity finished on the 01AUG08, it was the end of that day. Because unstarted daily activities begin in the morning and always finish at the end of the day, the CPM calculation rule for the earliest start of the successor activity requires that we add "1" to the work day number of the finish of the predecessor when computing the start of the successor [1]. This might not be the case with P6. Let's look at the example shown in Figure 5. When both activities are on the same calendar, Activity 2 starts the day after Activity 1 finishes. As shown in the bottom section of Figure 5, Activity 1 is on a 9:00 to 17:00 calendar and Activity 2 is on an 8:00 to 16:00 calendar. In this case, Activity 2 starts the same day Activity 1 finishes.

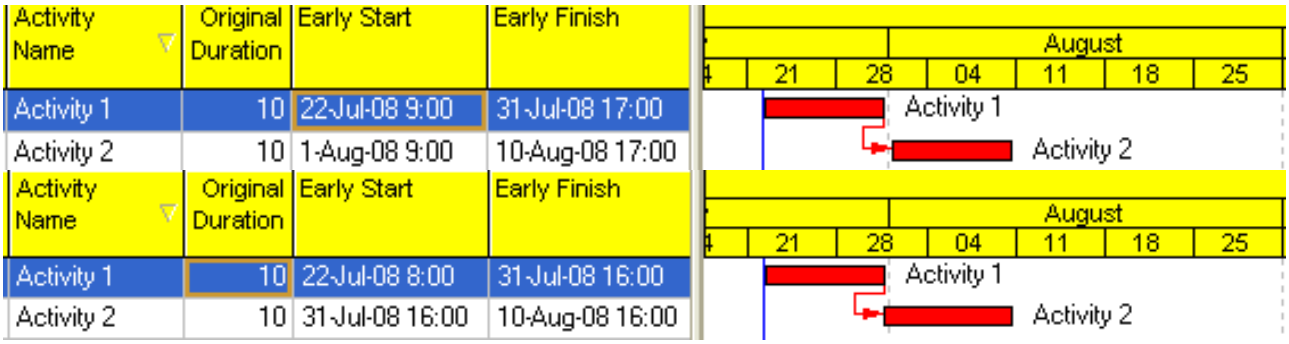

Figure 5 - Effects of Calendars

Another issue that P3 users must deal with is the fundamental difference in defining the correlation between time and duration. With P3, a 1-hour duration activity might start at 08:00 and end at 08:59; that is, activities start at the beginning of a period (in this case an hour) and end at the end of the time period. P6 uses the format employed by Microsoft Project scheduling software. For P6, a 1-hour activity might start at 08:00 and end at 09:00. By saying that the activity ends at 09:00, we really mean that it ends at 08:59:59. With P6, one does not need to

add “1” to time difference calculations, nor do you need to add “1” to compute the start of successor activities when dealing with Finish-to-Start relationships.

3.1. Early Start/Finish Dates

CPM rules dictate how early and late dates are calculated based on durations, calendars, constraints, relationships, and resources. This paper does not explain these calculations in detail, as we are focusing on issues that make the calculation and identification of dates special in P6. For detailed explanation of CPM calculations a book such as CPM in Construction Management by O’Brien and Plotnick [2] can be consulted.

Unfortunately, no available publication explains what really happens to the CPM when activities have actual status. To our knowledge, P6 is unique in the transparency of displaying all internal date calculations. This transparency has caused some consternation in the ‘World of Scheduling Experts’ who thought that they understood everything possible about their craft.

Simply put; every activity in the schedule is always considered when computing a CPM, even those that are statused as complete. Unless overridden by a constraint, all activities without a predecessor are scheduled (with consideration to their calendars) to begin on the current data date (early start) and their remaining durations are used to compute their early finish. This rule even applies to completed activities with a remaining duration of zero.

Immediate successors of the activities whose early dates were just evaluated are considered in like kind with completed activities all ‘piling-up’ on the data date like a bunch of milestones. This process continues until we finally uncover an activity with a remaining duration greater than zero (i.e. an uncompleted activity.) From here on in, the CPM proceeds as most experts normally appreciate. This process allows us to consider the delaying effects of uncompleted work due to out-of-sequence progress under the Retained Logic CPM calculation rule.

The P6 Early Start, Early Finish, Late Start, and Late Finish (Early/Late Start/Finish) columns are presented differently from their counterparts in Microsoft Project™ or P3. After the CPM calculations are complete, Microsoft Project blanks out all calculated date entries for completed activities. P3 actually deletes the calculated dates for completed activities and replaces those computed dates with the established actual dates. This substitution has led scheduling experts to conclude that the actual dates were not used in computing the current CPM schedule dates. Beginning with their Version 5.0 software release, P6 took a third tact and dares to show calculated dates, even for completed activities.

Figure 6 below shows a P6 schedule displaying the Actual Date columns as well as the Early Start, Early Finish, Late Start, and Late Finish columns for activities that are completed.

Activity ID	Activity Name	Original Duration	Remaining Duration	Actual Start	Actual Finish	Early Start	Early Finish	Late Start	Late Finish
0277X-12	PREP - Fle...	40.00	0.00	03-Apr-06 08:00	14-Jun-06 17:00	04-Dec-06 00:00	04-Dec-06 00:00	11-May-07 08:00	11-May-07 08:00
0277X-14	APPROVE ...	15.00	0.00	15-Jun-06 08:00	29-Jun-06 17:00	04-Dec-06 00:00	04-Dec-06 00:00	11-May-07 08:00	11-May-07 08:00
0277X-16	PROCURE ...	60.00	0.00	30-Jun-06 08:00	29-Sep-06 17:00	04-Dec-06 00:00	04-Dec-06 00:00	11-May-07 08:00	11-May-07 08:00
0277X-19	REQ by - Fl...	0.00	0.00		30-Sep-06 08:00				

Figure 6 - Early/Late Start/Finish Dates

Notice in the above example that Activity 0277X-12 actually started on 03APR06 but had an early start of 04DEC08. You would be correct to guess that the data date used for that calculation was

04DEC06. Also note that the late start of 11MAY07 indicates that this completed activity has float!

There are several interesting ramifications arising from the way P6 displays the Early/Late Start/Finish columns. If you have early and late dates, then you should be able to subtract the early date from the late date and calculate total float. The initial Version 5.0 of P6 did calculate and display this float for completed activities as well as uncompleted ones. This was the last straw for scheduling experts and Primavera quickly issued Version 5, Service Pack 1 to blank out the float column for completed activities. Just like the moral of many of the science fiction movies back in the 1950's, this was information that, "Man was not meant to know."

The quick of you will shortly ask, "If this means that P6 can display the float of completed activities, then is this float the "As-Built Float?" Unfortunately, computing the As-Built Float of an activity is not that simple.

Experts call the daily float value of an activity while it was on-going or active, the "As-Built Float." A planned activity might have been on the critical path (with a float of zero) on the first day of the project but that float value may change over time as conditions change during the course of the project. Only the actual float value of the activity while it was actively being executed can be called the As-Built Float. The float value generated after the activity is complete only reflects the current float value of the path it is on and the remaining work and not its As-Built Float.

Getting back to our issue of P6 showing calculated dates for completed activities; one wonders how we are ever going to be able to show this information to clients without needing to issue a summons on the authors of this paper. Primavera has foreseen this conundrum and has provided the Start and Finish column for your use. These columns display the calculated early dates for uncompleted work and the actual dates for the others, much like how P3 does. Figure 7 shows the same information as Figure 6, only with the Start and Finish columns displayed.

Activity ID	Activity Name	Original Duration	Remaining Duration	Actual Start	Actual Finish	Early Start	Early Finish	Late Start	Late Finish	Start	Finish
0277X-12	PREP - Fle...	40.00	0.00	03-Apr-06 08:00	14-Jun-06 17:00	04-Dec-06 00:00	04-Dec-06 00:00	11-May-07 08:00	11-May-07 08:00	03-Apr-06 08:00 A	14-Jun-06 17:00 A
0277X-14	APPROVE ...	15.00	0.00	15-Jun-06 08:00	29-Jun-06 17:00	04-Dec-06 00:00	04-Dec-06 00:00	11-May-07 08:00	11-May-07 08:00	15-Jun-06 08:00 A	29-Jun-06 17:00 A
0277X-16	PROCURE ...	60.00	0.00	30-Jun-06 08:00	29-Sep-06 17:00	04-Dec-06 00:00	04-Dec-06 00:00	11-May-07 08:00	11-May-07 08:00	30-Jun-06 08:00 A	29-Sep-06 17:00 A
0277X-19	REQ by - Fl...	0.00	0.00		30-Sep-06 08:00						30-Sep-06 08:00 A

Figure 7 - Start and Finish Dates

To use a physical example that you can follow along with, imagine the following four activities shown in series in Figure 8. We have entered the out-of-sequence status but have not recalculated the schedule.

Activity ID	Activity Name	Original Duration	Remaining Duration	Actual Start	Actual Finish	Early Start	Early Finish	Start	Finish
B100	Activity 1	10.00	0.00	03-Mar-08 08:00	14-Mar-08 17:00			03-Mar-08 08:00 A	14-Mar-08 17:00 A
B110	Activity 2	10.00	5.00	17-Mar-08 08:00				17-Mar-08 08:00 A	08-Apr-08 17:00
B120	Activity 3	10.00	0.00	17-Mar-08 08:00	26-Mar-08 17:00			17-Mar-08 08:00 A	26-Mar-08 17:00 A
B130	Activity 4	10.00	5.00	27-Mar-08 08:00				27-Mar-08 08:00 A	08-Apr-08 17:00

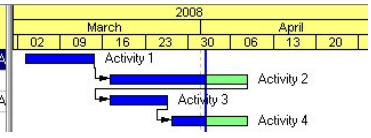

Figure 8 - Out-of-sequence Progress before CPM Calculation

When we ask P6 to re-compute the schedule (using the Retained Logic rule) P6 only looks at the activity remaining durations and begins calculating the schedule from the data date of 02APR08. Figure 9 shows us just how simple this process is,

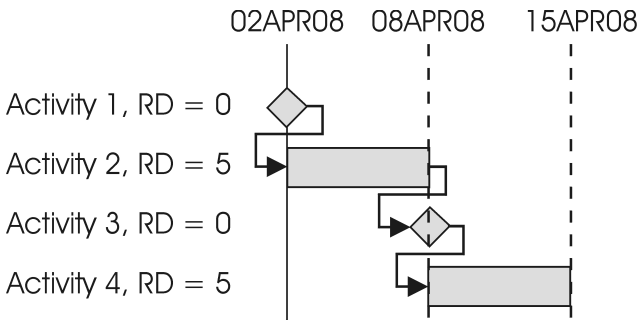

Figure 9 – CPM Calculation

All of the CPM Early/Late Start/Finish dates are noted in the assigned columns. After the schedule has been recalculated, P6 then returns to the schedule and 'fixes-up' everything so that Mr. Gantt would be pleased, plotting the actual date bars instead of the CPM dates, necking the area between the actual date bar and the new planned work but leaving anything in the planned state alone as shown below in Figure 10.

Activity ID	Activity Name	Original Duration	Remaining Duration	Actual Start	Actual Finish	Early Start	Early Finish	Start	Finish
B100	Activity 1	10.00	0.00	03-Mar-08 08:00	14-Mar-08 17:00	02-Apr-08 00:00	02-Apr-08 00:00	03-Mar-08 08:00 A	14-Mar-08 17:00 A
B110	Activity 2	10.00	5.00	17-Mar-08 08:00		02-Apr-08 08:00	08-Apr-08 17:00	17-Mar-08 08:00 A	08-Apr-08 17:00
B120	Activity 3	10.00	0.00	17-Mar-08 08:00	26-Mar-08 17:00	08-Apr-08 17:00	08-Apr-08 17:00	17-Mar-08 08:00 A	26-Mar-08 17:00 A
B130	Activity 4	10.00	5.00	27-Mar-08 08:00		09-Apr-08 08:00	15-Apr-08 17:00	27-Mar-08 08:00 A	15-Apr-08 17:00

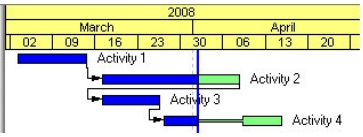

Figure 10 – Displaying CPM Calculation

Notice how the early start date for Activity B120 in Figure 10 is 08APR08, 6 days later than the current data date. The Start date is listed as 17MAR08, the actual start date.

You may notice that we display hours when displaying dates in all of our examples. We recommend that all P6 users do this, even though it is contrary to normal inclination when working in days. The reason for this is what we refer to as, the "Default Time Issue."

If an actual start or finish date is entered without the time being displayed, then the software will use 00:00 as the default time. The result of this entry has the following undesired effects:

- One day activities become zero duration as the start and finish time are set to the same date and time.
- A late finish constraint is set to the start of a day in effect giving one day less than it is intended to have as the constraint time is set to 00:00 at the start of a day and not say 17:00 at the end of the day.

3.2. Suspend and Resume Dates

Suspend and resume function in P6 is handled differently than with P3. A P3 activity is suspended at the end of the day but a P6 activity is suspended on the exact minute and hour specified (which is usually at the beginning of the specified day.) P6 requires that the activity have an actual start date before a suspend date can be entered. The functionality of suspend and resume date applies only to task dependent and resource dependent activities.

P6 calculates an actual duration for all activities based on the amount of non-suspended time. The amount of time that an activity's progress is suspended is generally deducted from the total duration. Units and costs are not spread over the period of suspension.

If the suspend/resume functionality is used then the early start is set equal to the resume date. The early finish is calculated using the resume date and the remaining duration as shown in Figure 11 below.

Activity Name	Start	Early Start	Remaining Early Start	Suspend Date	Resume Date
Activity 1	1-Jul-08 A	20-Jul-08	20-Jul-08	15-Jul-08	20-Jul-08
Activity 2	29-Jul-08	29-Jul-08	29-Jul-08		

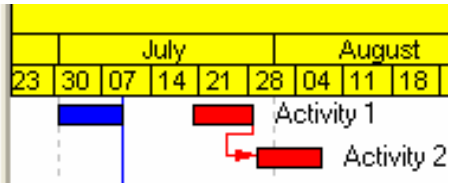

Figure 11 – Suspend Resume – Early Start/Finish Date

If the suspend date is entered without a resume date then, P6 ignores the suspend date. P6 sets the early start to the data date shown in Figure 12 below.

Activity Name	Start	Early Start	Remaining Early Start	Suspend Date	Resume Date
Activity 1	1-Jul-08 A	10-Jul-08	10-Jul-08	15-Jul-08	
Activity 2	19-Jul-08	19-Jul-08	19-Jul-08		

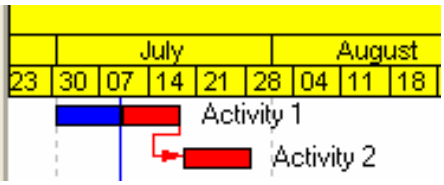

Figure 12 – Suspend without Resume - Early Start/Finish Date

3.3. Start/Finish Dates

Start and finish dates work similar to Microsoft Project. They represent the early dates when activities have no progress as displayed in Figure 13. If there is no progress on the activity, then start date is equal to the early start and finish date is equal to the early finish. The user can manually input a start date but schedule calculations will generally overwrite the user input.

Activity Name	Early Start	Start	Remaining Early Start	Planned Start
Activity 1	1-Jul-08	1-Jul-08	1-Jul-08	1-Jul-08
Activity 2	11-Jul-08	11-Jul-08	11-Jul-08	11-Jul-08

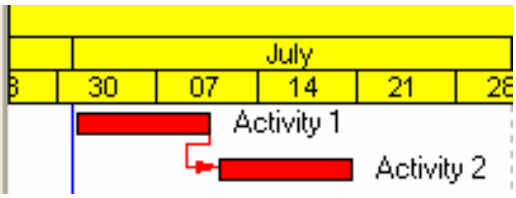

Figure 13 – No progress Activity - Start/Finish Date

When the activity is in progress, start is equal to the actual start and finish will remain equal to early finish as shown in Figure 14. Again, the user can manually enter a start date and user input will overwrite actual date.

Activity Name	Start	Actual Start	Remaining Early Start	Planned Start	Early Start
Activity 1	1-Jul-08 A	1-Jul-08		1-Jul-08	20-Jul-08
Activity 2	11-Jul-08 A	11-Jul-08	20-Jul-08	11-Jul-08	20-Jul-08

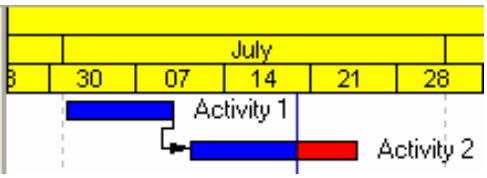

Figure 14 – Activity in Progress - Start/Finish Date

When the activity is complete, start and finish dates will be equal to the actual start and finish dates. User can manually enter a start or finish date, which will overwrite actual dates.

3.4. Planned Start/Finish Dates

Of all the date fields available in P6, probably the most interesting and controversial ones are planned dates. The majority of P6 users are unaware of the planned date calculations and how they are used. To be fair, an almost total lack of documentation does not help this situation. The only reliable reference that we found was Paul Harris' book on P6[3].

What makes planned dates really controversial is that they are used in many calculations that affect your schedule, yet their purpose is clouded. Before we start looking at the underlying calculations and their effects, we need to understand the following aspects of the planned dates:

1. Once the activity notes progress, planned dates are neither static like baseline dates nor dynamic like early and late dates.
2. Planned dates might end-up being your baseline dates if your project does not have a baseline assigned. Yet they are not truly a baseline for the reason stated above.
3. Planned dates do not always display planned information. In some instances they are used to display Budgeted and Current information as well.

Planned date calculations are complex but basically if an activity is complete or in progress they are set to equal the Actual dates. If an activity is unstarted then they are set to the early start and early finish. However this simple view has many anomalies.

If there is no progress on the activity the planned start date is set to the early start. Planned finish is calculated by adding the original duration to the planned start as shown in Figure 15 below. Early start and the planned start are not directly linked. If you change the planned start date manually start date will change but early start will not change. Schedule CPM calculation will overwrite the user input with the calculated early start date. There is no warning to the user that their input will be overwritten.

Figure 15 – No Progress Activity – Planned Start/Finish Date

The user can input a planned finish to overwrite the calculated planned finish. This change will also automatically change the original duration of the activity and there is no warning to the user.

If the activity is in progress, then planned start is set equal to actual start. Planned finish is calculated by adding the original duration to the planned start as shown in Figure 16 below. The user can input a planned finish to overwrite the calculated planned finish. Once again, this change will also automatically change the original duration of the activity and there is no warning to the user.

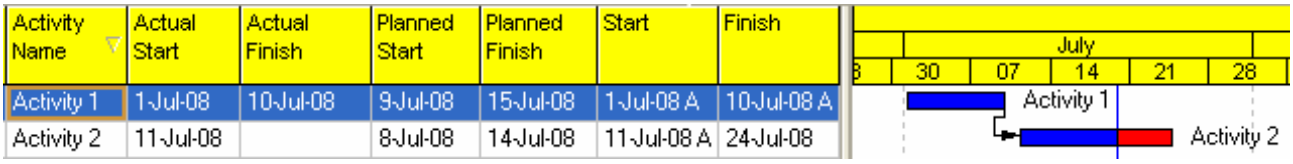

Figure 16 – Activity in Progress – Planned Start/Finish Date

The user can manually input a planned start and CPM schedule calculation will not overwrite this manual entry. There is no warning to the user on this. Basically the user can change the planned dates as desired without fear of the CPM schedule calculation overwriting the planned start or finish. If there is no baseline assigned, then the planned dates are used for calculating the variances.

Planned dates are used by many of the popular features of P6 such as [4]:

1. Progress Spotlight uses the planned dates. This is different from what one expects after using P3, SureTrak or Microsoft Project with update progress. Actual dates are changed to planned dates without any warning. To overcome this problem many schedulers run a Global Change to set the planned dates equal to the start and finish dates before running the automatic update feature.
2. When a baseline has not been assigned, planned dates are used to display a Project or User Primary Baseline bar. This is because planned dates are represented as bars when nothing is selected in the Assign Baselines form.
3. Planned dates are also used in the Activity Usage Profile to show the budgeted values and as the baseline values when no baseline has been set. Once a baseline has been assigned then baseline dates are used.
4. Planned dates are also used in the Activity Usage Profile to show the earned value curves when no baseline has been assigned. Once a baseline has been set, then baseline values are used for displaying the earned value curves.

Planned dates are often accidentally used when sharing layouts created by other people for other schedules. “Layouts” are a formal package of settings used to define what is displayed on the screen. To make communicating schedule issues easier, multiple users often share the same settings, or “Layout.” Thus when one user assigns a Primary User Baseline and a second user applies this layout but they have not assigned a User Baseline then the "Planned Dates" are used as a baseline.

So how do the planned start/planned finish dates come into play for you? These are not static like the baseline, nor are they dynamic like early dates. They are involved if you use Apply Actuals or Update Progress. The user can change the planned dates as desired. If there is no baseline assigned, then the planned dates are used for calculating the variances. Planned dates also have the potential to overwrite your actual start/actual finish with the planned start/planned finish dates. It is a highly suspect feature that automatically overwrites actual dates. Once done, everything looks like it occurred according to the original baseline plan.

3.5. Remaining Early Start/Finish Dates

Remaining early start date is basically the earliest date the activity in-progress can start or continue after the data date. If there is no out-of-sequence progress or no resource leveling then the remaining early start should be the data date (or the earliest date after that for that activity’s

calendar.) Effects of Out-of-Sequence Progress calculation options and resource leveling are discussed in subsequent sections.

If the Activity has no progress then remaining early dates are set equal to the early dates as shown in Figure 17 below.

Activity Name	Early Start	Start	Remaining Early Start	Planned Start
Activity 1	1-Jul-08	1-Jul-08	1-Jul-08	1-Jul-08
Activity 2	11-Jul-08	11-Jul-08	11-Jul-08	11-Jul-08

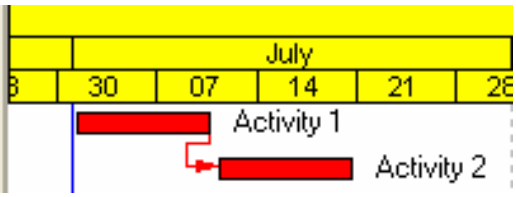

Figure 17 – No Progress Activity – Remaining Start/Finish Date

If progress follows as expected, then remaining early start will equal the data date. Remaining early finish will be calculated by adding the remaining duration to remaining early start. The user can manually adjust the remaining early finish but this will adjust the remaining duration without warning the user. User can't enter a remaining finish that is earlier than remaining early start.

Activity Name	Actual Start	Actual Finish	Remaining Early Start	Remaining Early Finish	Remaining Late Start	Remaining Late Finish
Activity 1	1-Jul-08	10-Jul-08				
Activity 2	11-Jul-08		20-Jul-08	24-Jul-08	20-Jul-08	24-Jul-08

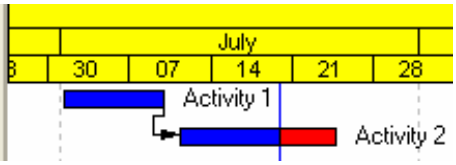

Figure 18 – Activity in Progress – Remaining Start/Finish Date

Once the activity is complete, remaining early start and finish are blanked out as shown in Figure 18 above.

There is also a new float field called remaining float. Remaining float is calculated as the difference between late finish and remaining early finish. Therefore as shown in Figure 19, remaining float will be equal to total float when the activity is unstarted. The user can manually change the remaining early finish and this would change the remaining duration. When the schedule is calculated using the new remaining duration, remaining float will equal total float.

Activity Name	Original Duration	Early Start	Early Finish	Total Float	Remaining Float	Remaining Early Start	Remaining Early Finish
Activity 1	10	26-Dec-08 8:00	8-Jan-09 17:00	0	0	26-Dec-08 8:00	8-Jan-09 17:00
Activity 2	10	26-Dec-08 8:00	8-Jan-09 17:00	0	0	26-Dec-08 8:00	8-Jan-09 17:00

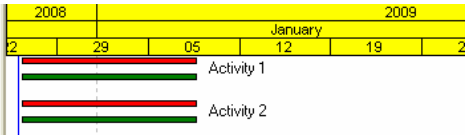

Figure 19 – Remaining Float before Resource Leveling

If resource leveling is used, then the remaining early finish might be different than early finish date. In this case, remaining float will have a different value than total float. In other words, remaining float is a resource-dependent float. Figure 20 demonstrates this by displaying early bars in green and remaining bars in red.

Activity Name	Original Duration	Early Start	Early Finish	Total Float	Remaining Float	Remaining Early Start	Remaining Early Finish
Activity 1	10	26-Dec-08 8:00	8-Jan-09 17:00	0	0	26-Dec-08 8:00	8-Jan-09 17:00
Activity 2	10	26-Dec-08 8:00	8-Jan-09 17:00	0	-10	9-Jan-09 8:00	22-Jan-09 17:00

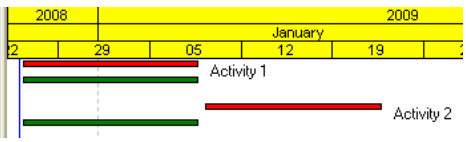

Figure 20 – Remaining Float after Resource Leveling

Since total float assumes that all resources are available, then the ratio of total float to remaining float might be of interest to the scheduler. As the ratio increases it means that the activity is more sensitive to resource availability. For example after leveling, Activity 1 has a remaining float of 5 and total float of 10 days. Activity 2 has a remaining float of 1 and total float of 10 days. One could conclude that the Activity 2 is more sensitive to resource availability than Activity 1.

3.6. Baseline Dates

According to P6 terminology, a baseline schedule is a complete copy of a project plan that can be compared to the current schedule to evaluate progress. P6 allows an unlimited number of baselines per project, depending upon administrative preference settings. Only up to three baselines can be assigned per project for comparison purposes. Unlike P3, P6 baselines do not exist as separate projects that the user can access unless the baseline schedule is 'unloaded" from primary schedule.

The user can assign primary, secondary, and tertiary baselines. If a baseline is not selected, the current project is used by default. This means that planned dates are used as BL1 dates.

Variance calculation in P3 is the difference between the current schedule and the target. Therefore a positive variance means delay. On the other hand P6 help states that the variance is calculated by the following formula:

Variance BL1 Start Date = BL1 Start - Start

However P6, calculates the variance similar to P3, not like the formula given in the P6 help. Positive variance means delay. However this does not necessarily mean delay to the project completion since the Start Dates display the Early Dates. Figure 21 shows an example of calculated baseline variance. P6 also can display Variance –Start and Variance –Finish Date fields. These fields use the Primary User Baseline data.

Activity Name	Start	Finish	BL1 Start	BL1 Finish	Planned Start	Planned Finish	Variance - BL1 Start	Variance - BL1 Finish
Activity 1	1-Jul-08 A	10-Jul-08 A	9-Jul-08	15-Jul-08	9-Jul-08	15-Jul-08	-8	-6
Activity 2	11-Jul-08 A	24-Jul-08	8-Jul-08	14-Jul-08	8-Jul-08	14-Jul-08	3	10

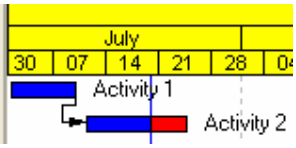

Figure 21 – Baseline Variance

3.7. External Start/Finish Dates

Otherwise independent schedules can be 'linked' by assigning a relationship from one activity in one schedule to another activity in the second schedule. It is dangerous to export a single schedule when schedules are linked to other schedules with such relationships, as these relationships are 'lost.'

In cases like these where the inter-schedule relationships are lost, P6 does its best to maintain proper timing by internally constraining the appropriate early/late dates of the activities missing their inter-project relationships. This causes the schedule to mimic the effects of the relationship at the time of the export. The imposed constraints will not show up under the task's constraint boxes, as these are internally imposed. The only indication of an imposed constraint will be an

asterisk printed to the right of the date in the Start or Finish column. These constraint dates will only be visible in the External Dates columns, if displayed.

To force P6 to ignore such external constraints, the scheduling options tab has a setting for -"Ignore relationships to and from other projects". This can also fix extreme negative float values. You can also remove the external constraints entirely from your schedule by showing the External Early Start and External Late Finish columns; remove the external dates shown, and then recalculating the schedule.

4. What else affects the Date Fields?

4.1. Resource Loading and Leveling

If the schedule is resource loaded, the date calculations get even more complicated. One of the most direct effects of the resource loading is recalculation of the duration based on resources. P6 calculates Resource Units per Activity by multiplying the Resource Units per time period and the duration of the activity. The duration type of the activity determines which variables change if the user changes any of the other variables.

P6 has a very large number of duration type options. There are 4 activity duration types in P6 namely; Fixed Unit/Time, Fixed Duration and Units/Time, Fixed Unit and Fixed Duration & Units. The choice of duration type determines how the durations will be calculated. Fixed Duration & Units and Fixed Duration & Unit/Time duration types will not affect the duration. If the other duration types are used, P6 will adjust the duration based on either Unit/Time or Resource Unit.

Resources can be defined as, "Driving Activity Dates." If such a resource is assigned to an activity, then the activity will not begin until the start of the resource shift, regardless of what activity type is assigned. This will override the normal CPM early start date and can cause a great amount of confusion trying to explain the scheduling calculation.

Activities set to "Resource Driven" will use the resource calendar instead of the designated activity calendar for calculations computing the activity's dates. Resource calendars are a third type of calendar used in addition to Global and Project.

Resource leveling is another area that affects the date calculations. There are 4 commonly used methods of resource leveling, constraining activities based on resource availability, using preferential logic, manually adjusting activity timing, and Automatic Resource Leveling.

Automatic Resource Leveling can be optionally performed without user intervention after every CPM calculation, so it is wise to note when this option is set. Automatic Resource Leveling is performed in two basic methods; forward (early dates) and backward (late dates.) Forward leveling schedules the early dates (forward pass) of the project. This can delay the project. Backward leveling schedules the late dates (backward pass) of the project. Essentially, backward leveling a project will tell you when you should have started the project.

P3 allows the user to select the forward or backward leveling, but not both. P6 has the option to run forward and backward at the same time. If the user selects Preserve Scheduled Early and Late Dates checkbox, P6 only forward-levels the schedule, which means that the early dates of activities from the start to the finish of the project are scheduled. You can review the leveled

early dates in the Remaining Start/Finish columns and the Start and Finish columns. When the schedule is leveled forward and backward (by clearing the checkbox to preserve scheduled early and late dates), the project's early and late start/finish dates are updated.

P6 has a very interesting resource leveling option that allows you to only adjust activities within the limits of their available float. Using this option, the resource leveling process will not delay the project, even if resources are not available. If the user selects 'level resources only within activity float' option then the leveling process will not generate negative float but may not completely level the schedule. The activities will only be delayed until all float is consumed. This option will also automatically select 'preserve scheduled early and late dates' option.

P3 and P6 differ slightly in how they handle the outcome of resource leveling. Whenever an activity in P3 is moved after computing the schedule (either manually by dragging or by resource leveling,) the total float for that activity is automatically adjusted. Free float is not adjusted in this manner. On the other hand, P6 does not automatically adjust float after manually moving the activity or resource leveling. Both total float and free float remain at the original CPM-calculated setting. Neither of these methods of handling float will accurately reflect the correct resource-leveled float, so the differences here are minor.

There are multiple of important issues to consider when using resource leveling:

1. There is no indicator or other test to determine if resource leveling has been accomplished.
2. Multiple leveling methods such a preferential logic and constraints should not be used simultaneously with automatic leveling without careful consideration.
3. The leveling is extremely complicated considering the effects of progress, activity types, driving resources, resource calendars. Therefore, the user should level as few resources at the same time as possible.
4. A reasonable P6 resource leveling report may be produced at the time of the leveling, but this report is inferior to the one automatically produced during a P3 resource leveling run. In particular, the P6 leveling report does not indicate what resource delayed an activity and what levels were available. It is very difficult or impossible to verify the appropriateness of the leveling technique using a P6 leveling report.

4.2. CPM Calculation Options

P6 has more schedule calculation options than P3 and most of them affect the date calculations. Some of these options appear to be the same as P3 and some are new. This paper will focus on the calculation options defined in the General Tab shown in Figure 22. We will only discuss the differences from P3.

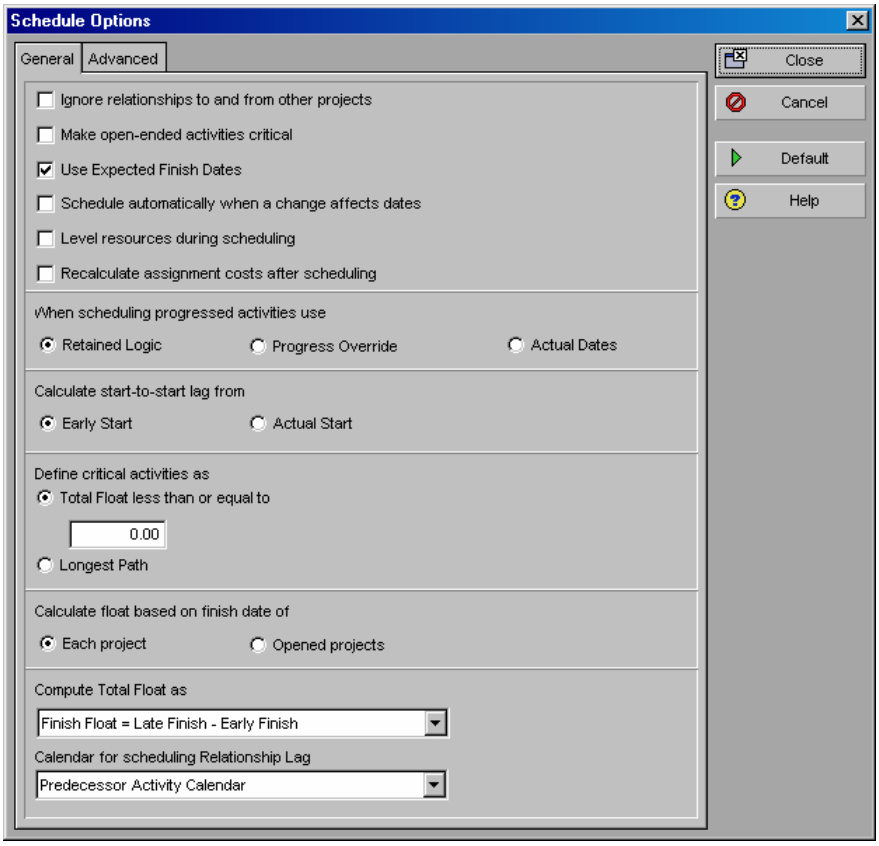

Figure 22 – P6.2 Schedule Calculation Options

The Advanced Tab currently is only involved calculating multiple float paths. In the process of doing this, P6 calculates the early and late start and finish dates for the relationships between activities just as if they were activities themselves. These relationship dates can be viewed on either the Relationship or the Predecessors Tabs by right-clicking on the column headers, clicking on customize, and then expanding the Multiple Float Paths section.

You can elect to have P6 ignore relationships to and from other projects. If this option is selected, P6 computes the schedule without regard to any logical timing in any other dependent schedule. There is no indication of whether the current schedule actually has any inter-project relationships. If this Option is selected, backups of this single schedule will also not include any internal constraints.

Just like P3, P6 recalculates the duration of activities with expected finish dates as the difference between their calculated early start dates and the assigned expected finish date. With P6, you can define Expected Finish constraints and still not use them. This option is checked by default.

You can elect to have P6 automatically level the activities for resource usage each time the project is scheduled. This can be a nearly 'invisible' operation, as resource leveling reports (if produced) are not automatically displayed. Schedule analysis should always begin with checking to see if this option is selected. Be sure to also note if you elect to Schedule automatically when a change affects dates, as you will also level your schedule every time you move from one activity to the next.

Out-of-sequence progress is not uncommon in construction schedules. P3 offered two methods of handling out-of-sequence progress. P6 introduces a third method for handling out-of-sequence progress. We will review all three types.

If the Retained Logic option is selected, P6 does not schedule the remaining duration of a progressed activity until all of its predecessors are complete. Remaining early start of the out-of-sequence successor (Activity 2) is generally [5] set to the early finish of predecessor (Activity 1) +1 as shown in Figure 23.

Activity Name	Total Float	Early Start	Early Finish	Late Start	Late Finish	Actual Start	Remaining Early Start
Activity 1	0	10-Jul-08	18-Jul-08	10-Jul-08	18-Jul-08	1-Jul-08	10-Jul-08
Activity 2	0	19-Jul-08	28-Jul-08	19-Jul-08	28-Jul-08	8-Jul-08	19-Jul-08

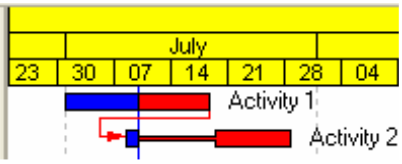

Figure 23 – Retained Logic

On the other hand if the Progress Override option is selected, P6 ignores network logic and allows the activity that has begun out-of-sequence to progress without waiting for the predecessor activity to complete. In this case, remaining early start equals the data date and the early finish is calculated by adding the remaining duration to the remaining early start as shown in Figure 24.

Activity Name	Total Float	Early Start	Early Finish	Late Start	Late Finish	Actual Start	Remaining Early Start
Activity 1	1	10-Jul-08	18-Jul-08	11-Jul-08	19-Jul-08	1-Jul-08	10-Jul-08
Activity 2	0	10-Jul-08	19-Jul-08	10-Jul-08	19-Jul-08	8-Jul-08	10-Jul-08

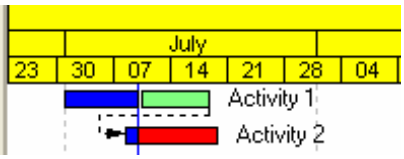

Figure 24 – Progress Override

It is important to note that not only did the out-of-sequence Activity 2 continue progressing on the data date, but that Activity 1 is no longer a critical activity. Even though P6 displays the relationship between the two activities on the screen in the barchart and activity details, this relationship is completely ignored during CPM calculations and treated as if it were deleted. Just like P3, Progress Override is applied to every type of relationship other than the Finish-to-finish (FF) relationship. In the example above, Activity 1 now does not have any successor activities. The P3 Progress Override calculation method produces the same results.

P6 has a new calculation option called, “Actual Dates.” If the Actual Dates option is selected, then the predecessor’s late finish is set to the time unit before the actual start of the out-of-sequence successor. This assignment has the potential of creating negative float.

For Actual Dates calculations, the Early Start of the out of sequence successor (Activity 2) is generally set to the Early Finish of predecessor (Activity 1) or +1 day, as shown in Figure 25.

Activity Name	Total Float	Early Start	Early Finish	Late Start	Late Finish	Actual Start	Remaining Early Start
Activity 1	-11	10-Jul-08	18-Jul-08	29-Jun-08	7-Jul-08	1-Jul-08	10-Jul-08
Activity 2	0	19-Jul-08	28-Jul-08	19-Jul-08	28-Jul-08	8-Jul-08	19-Jul-08

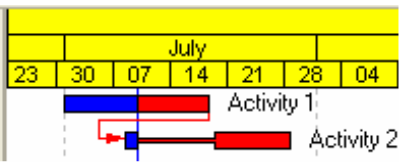

Figure 25 – Actual Dates

The Late finish of the predecessor (Activity 1) is set to the day before the actual start of the out-of-sequence successor (Activity 2). Activity 1 should have been completed on 07JUL08 so that

Activity 2 can start on 08JUL08. This logic is flawed since Activity 2 already started; it is evident that Activity 1 finish was not necessary. Although there are no constraints, the schedule calculates a negative float.

If Actual Dates option is selected the Start to Start Lag calculation option is disabled. The Start to Start lag is calculated just like using Retained Logic and Actual Start option.

In general, using Actual Dates option will cause the CPM to behave like Retained Logic if the out-of-sequence activity has started but not finished and to behave like the Progress Override option if the out-of-sequence activity has finished.

New to P6, Service Pack 2 (P6.2) is the option to calculate the total float based on the finish date of each project in a collection of schedules or on all opened schedules. Previously, when a project containing multiple schedules was opened, the CPM would begin calculating the late early and finish dates based upon the early finish last activity in each schedule. This meant that each schedule calculated the critical path independently even if they were tied together in a network of relationships. The older method fails to identify the single critical path for a project of multiple schedules. The down-side of the new option is that other then viewing the scheduling log, there is no indication as to which option was used when later reviewing the results of a CPM computation.

P6 definitely differs from P3 in that you can define the calendar for scheduling relationship lag. P3 always uses the predecessor activity's calendar when computing the lag of relationships. P6 user has 4 options when designating a calendar to calculate the lag between predecessors and successors. This one setting is used for all relationships. The default setting used to be the successor activity's calendar until Version 4 of P6, when the predecessor activity's calendar was used as the default in deference to P3. The lag can be calculated based on

- Successor Activity Calendar
- Predecessor Activity Calendar;
- 24 Hour Calendar
- Project Default Calendar - the calendar selected as Default for New Activities on the Defaults tab of Project Details

Regardless of the relationship lag setting, P6 uses the successor's calendar when determining whether a Finish-to-Finish relationship is a part of the longest path. This fact often causes the P6 longest path to be discontinuous if different calendars are used.

5. What does this mean to schedulers?

P6 is the most complex and flexible scheduling software to date. Flexibility of P6 can be a benefit but it might be intimidating to a scheduler expecting P3's relative simplicity. Every P6 scheduler should clearly understand the software's method of calculation to use this powerful tool at its full capacity. This paper covers only a small portion of the functionality of P6. A brief summary of some of the important points are listed below:

1) Each schedule is calculated and updated to the minute. Without diligence on the scheduler's part, this can lead to situations where the successor activity begins on the same date as the predecessor finishes.

2) If the durations are entered in time units other than hours, then they are automatically converted to hours using a single, set conversion factor. Later these durations are re-converted back to days using the currently existing conversion factor. This factor is used for all calendars and may be changed later, invalidating the earlier conversions. Many schedules enter durations in hour, even when scheduling in days.
3) Schedulers should always show time as well as dates when entering actuals, even when working in days. When times are not shown, P6 defaults to entering 00:00 in the time portion of the date field.
4) In P3, zero-duration activities end on the day before they start. In P6, they generally end on the same time or a minute after that start. In the past, finish milestones have started one minute after the start of the workday (this was reportedly fixed in Version 6.2.) Sometimes, unrestrained activities are scheduled to begin many minutes into the workday instead of on 08:00.
5) Planned dates are neither static like baseline dates nor dynamic like early and late dates once the activity has progress.
6) Planned dates might end up being wrongly used as your baseline dates if your project does not have a baseline assigned.
7) Planned dates do not always display planned information. In some instances they are used to display Budgeted and Current information as well.
8) If using the update progress feature, P6 might replace your actual dates with the planned dates. We recommend that you use Global Change to set the planned dates equal to the start and finish dates if running the automatic update feature.
9) Planned dates are also used in the Activity Usage Profile to show the Budgeted values and as the baseline values when no baseline has been set. Baseline dates are used once a baseline has been assigned.
10) Planned dates are also used in the Activity Usage Profile to show the earned value curves when no baseline has been assigned. Once a baseline has been set, then the baseline values are used for displaying the earned value curves.
11) Early start, early finish, late start, and late finish dates are based upon computing the entire schedule starting from the current data date. This means that completed activities will show early and late start/finish dates that are not equal to their actual start/finish dates.
12) Early start and finish dates are not blanked-out or replaced with actual dates when actual dates exist. Early start shows the newest calculated early start date (using the current data date) for activities even with actual dates.
13) Start/Finish dates are early dates, corrected for actual dates.
14) Variance fields compare the start date (early start) rather than the late dates of the baseline to the actual dates. Therefore positive variance does not necessarily mean delay to the project completion, it may just consume float.
15) Manual input of planned dates will be overwritten by schedule calculation unless the activity is in progress or complete.
16) During export, the external relationships might be lost. Compare the external early start and finish date with the early start and finish dates after the project import.
17) 'S' curves and reports are taken from early planned dates. You must manually transfer the late planned dates into planned in order to derive the late 'S' curve.
18) Resource Leveling populates the remaining early/late fields. You can set an option switch to also occupy the start and finish Fields with the leveled dates, if you wish.
19) Actual dates can be created in P6 using the auto-complete option. P6 now requires the entry of an actual date when statusing an actual start or actual finish (an improvement over P3.) You cannot enter an actual finish without an actual start.

20) By default, the standard Gantt chart display shows activity bars reflecting the start dates, not the early dates. This can be overridden but seldom is.

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References:

[1] "**How to Befuddle a College Professor (Without Really Trying)**," by Ron Winter, PSP copyright AACE International Cost Engineering Journal 45, 10 (2003): 8-10
[2] "**CPM in Construction Management, Sixth Edition**" by O'Brien and Plotnick, copyright 2005 by McGraw-Hill
[3] "**Project Planning and Control using Primavera P6**," by Paul Eastwood Harris, copyright 2008 by Eastwood Harris Pty Ltd.
[4] From Planning Planet web blog by Paul Harris, Building Works, Victoria , Australia, www.planningplanet.com
[5] In the text above we use the term, "generally" to indicate that the CPM calculation produces the described result if the update status is annotated as occurring at the end of the workday. The issue of measuring daily events and setting the correct time of day values (as well as issues using different activity calendars) produces logically different results that distracts from the point trying to be made.

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