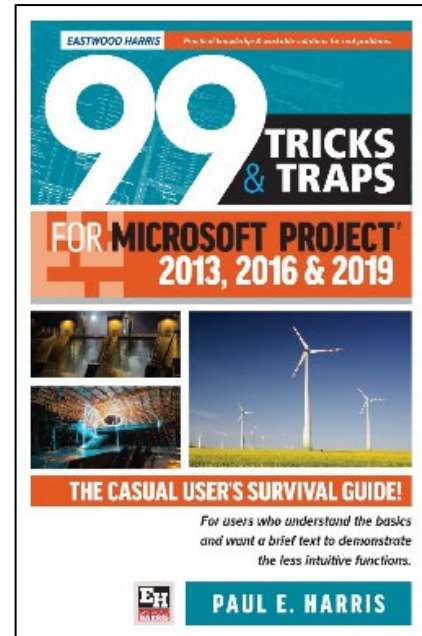# MICROSOFT PROJECT CRITICAL PATH CALCULATIONS

1   Introduction

Many building and construction contracts specify that a delay may only be claimed when it impacts activities on the **Critical Path** but in turn leave it up to the contractor to decide what scheduling options they may use in their scheduling software, thus allowing the contractor to determine how the **Critical Path** is calculated.

Therefore an understanding how the Microoosoft Project **Options** may assist a contractor to set up their programs to put more activities on the **Critical Path** and to be able to substantiate more claims than a program with the Microsoft Project default **Options** is an important subject.
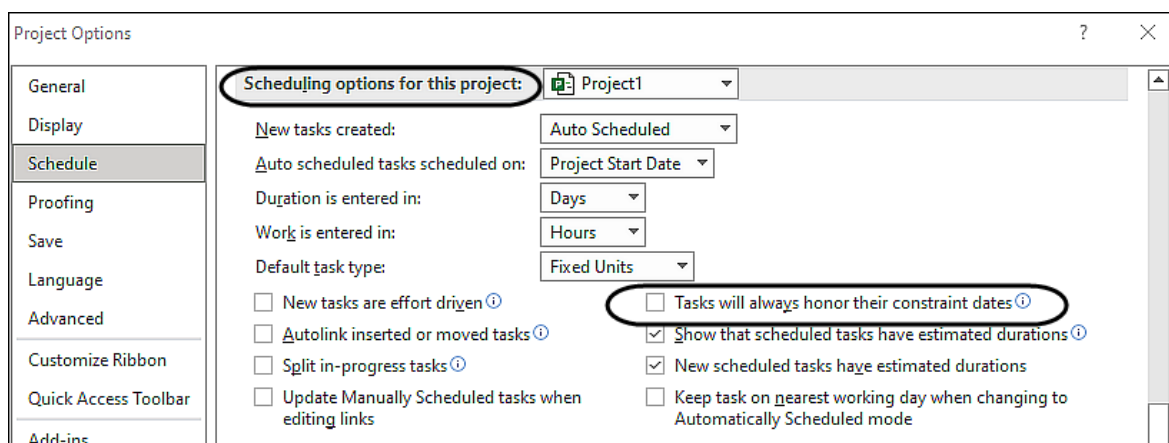
2   Aim

The aim of this paper is to explain how the Microsoft Project default **Options** affect the calculation of the **Critical Path** of a Microsoft Project schedule and identify which options may be useful for contractors to increase the number of client delays they may be able to substantiate with their schedule.

3   Understanding Microsoft Project Schedule Options that define the Critical Path

The **File**, **Schedule**, **Options** form has the following options that determine the calculation of **Critical** activities:

- The **Schedule** tab, **Scheduling Options for this project:** heading, **Tasks will always honor their constraint dates**:

- **The Advanced** tab**, Calculation options for this project:**
  - ➢ **Calculate multiple critical paths** and
  - ➢ **Tasks are critical if slack is less than or equal to** plus a user defined value in whole days:
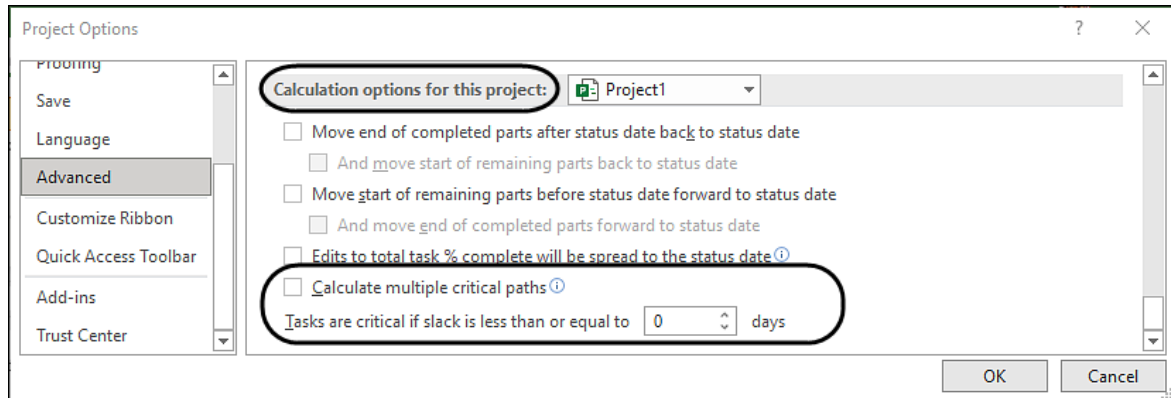
NOTE: The calculation of the **Longest Path** is not an inbuilt option in Microsoft Project that is found in other products such as Primavera P6 and Elecosoft Powerproject.

4   Methodology

I have taken a section form my books where I applied a constraint to the Finish Milestone earlier than the calculated finish date and:

- Scheduled with **Tasks will always honor their constraint dates**: checked, then

- Scheduled with **Tasks will always honor their constraint dates**: unchecked,

I then created a small schedule with three chains of activities:

- Most have been assigned no calendar and adopt the Standard 5 day per week and 8 hour per day calendar and

- Some have been assigned a 7 day per week and 8 hour per day. These could represent, for example, curing of concrete.

- **Calculate multiple critical paths** - unchecked.
  - ➢ **Tasks are critical if slack is less than or equal to**:
    - o 0 day
    - o 1 day and
    - o 2 days
- **Calculate multiple critical paths** - checked.
  - ➢ **Tasks are critical if slack is less than or equal to:**
    - o 0 day
    - o 1 day and
    - o 2 days
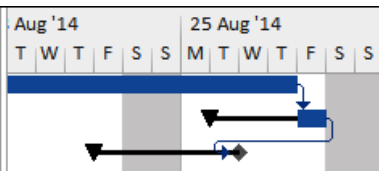
5   Tasks will always honour their constraint dates

This option will make all constraints override relationships. For example, a task with a **Must Start On** constraint, which is prior to a predecessor's Finish Date, will have an Early Start on the constraint date and not the scheduled date. (This is similar to converting all Primavera software **Must Start On** constraints to **Mandatory** constraints.) When checked, the **Total Slack** may not calculate as the difference between Late Start and Early Start.

Examine the following two examples with the option box checked and unchecked:

➢ **Tasks will always honor their constraint dates** option box checked.

Start	Finish	Late Finish	Total Slack	Constraint Date	Constraint Type		
12 Aug	28 Aug	25 Aug	-3 days	NA	As Soon As Possible		
29 Aug	29 Aug	26 Aug	-3 days	NA	As Soon As Possible		
26 Aug	26 Aug	26 Aug	-3 days	26 Aug	Finish No Later Than		

⚠️ The third task starts before the predecessor finishes and the Total Slack of the second task is calculated at –3 days, which is not the difference between the early and late dates. Thus the Total Float calculation is also incorrect.

➢ **Tasks will always honor their constraint dates** option box NOT checked.

Start	Finish	Late Finish	Total Slack	Constraint Date	Constraint Type		
12 Aug	28 Aug	25 Aug	-3 days	NA	As Soon As Possible		
29 Aug	29 Aug	26 Aug	-3 days	NA	As Soon As Possible		
29 Aug	29 Aug	26 Aug	-3 days	26 Aug	Finish No Later Than		

Tasks will always honor their constraint dates option box should never be used.

⚠️ It is suggested that this option is **NEVER** switched on, unless you are very experienced, as the schedule may appear to be achievable when it is not.
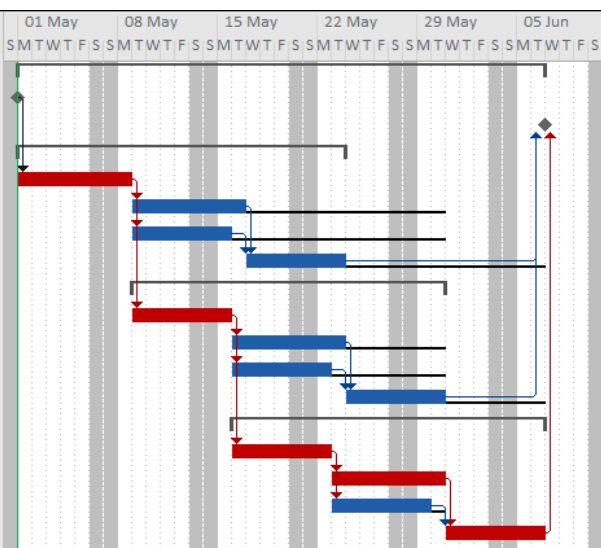
6   Calculate multiple critical paths unchecked

6.1   *Tasks are critical if slack is less than or equal to 0 days*

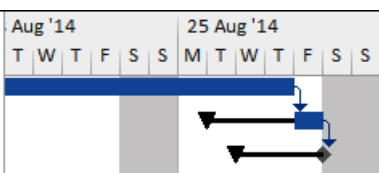This is the **Default Setting** for Microsoft Project:

In the picture below the **Critical Path** and logic is clear:

	ⓘ	Task Name	Task Calendar	Dur	Total Slack	
1		◢ **Project Summary**	**None**	**27d**	**0d**	
2		Start Milestone	None	0d	0d	
3		Finish Milestone	None	0d	0d	
4		◢ **Deliverable 1**	**None**	**17d**	**0d**	
5		A	None	6d	0d	
6	📋	B	7 days/week	8d	14d	
7		C	None	5d	11d	
8		D	None	5d	10d	
9		◢ **Deliverable 2**	**None**	**16d**	**0d**	
10		A	None	5d	0d	
11	📋	B	7 days/week	8d	7d	
12		C	None	5d	6d	
13		D	None	5d	5d	
14		◢ **Deliverable 3**	**None**	**16d**	**0d**	
15		A	None	5d	0d	
16	📋	B	7 days/week	8d	0d	
17		C	None	5d	1d	
18		D	None	5d	0d	

Issue: None of the activities, except the first, under Deliverable 1 or Deliverable 2 are on the Critical Path and a delay to any of these may not be claimed when the contract requires the delay to be substantiated against the Critical Path.

Now the duration of Task 5 has been changed to 5d and the Critical Paths changes from Task 16 to Task 17 because 16 is on a 7 day per week calendar:

	ⓘ	Task Name	Task Calendar	Dur	Total Slack
1		◢ **Project Summary**	**None**	**25d**	**0d**
2		**Start Milestone**	None	0d	0d
3		**Finish Milestone**	None	0d	0d
4		◢ **Deliverable 1**	**None**	**15d**	**0d**
5		A	None	5d	0d
6	📑	B	7 days/week	8d	15d
7		C	None	5d	10d
8		D	None	5d	10d
9		◢ **Deliverable 2**	**None**	**15d**	**0d**
10		A	None	5d	0d
11	📑	B	7 days/week	8d	8d
12		C	None	5d	5d
13		D	None	5d	5d
14		◢ **Deliverable 3**	**None**	**15d**	**0d**
15		A	None	5d	0d
16	📑	B	7 days/week	8d	1d
17		C	None	5d	0d
18		D	None	5d	0d
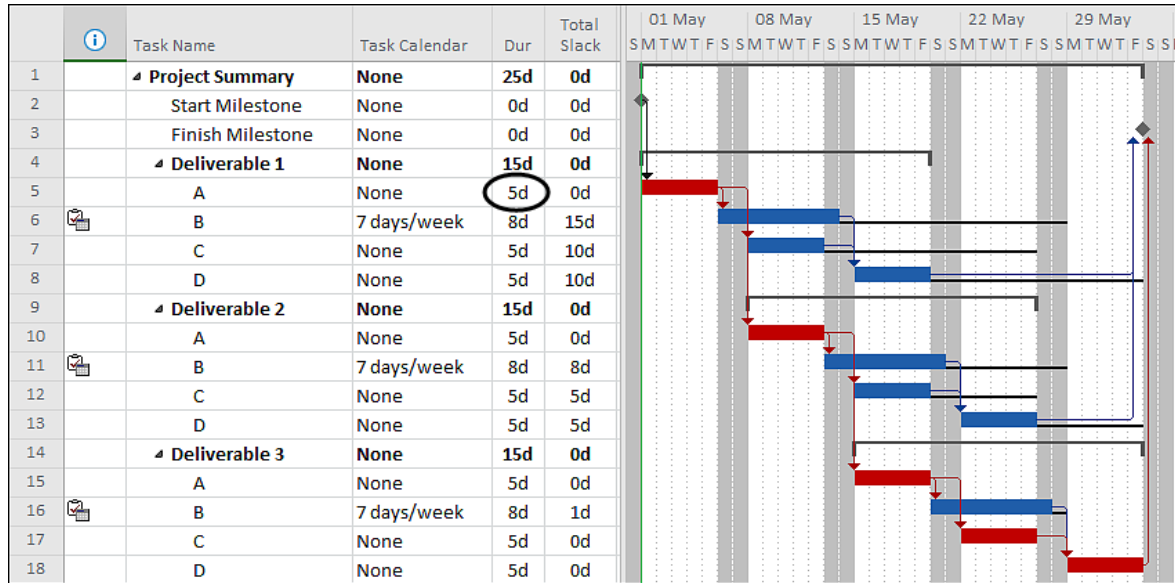
Now the duration of Task 5 has been changed to 4d and the Critical Path has disappeared:

	ⓘ	Task Name	Task Calendar	Dur	Total Slack
1		◢ **Project Summary**	**None**	**25d**	**0d**
2		**Start Milestone**	None	0d	1d
3		**Finish Milestone**	None	0d	0d
4		◢ **Deliverable 1**	**None**	**15d**	**1d**
5		A	None	4d	1d
6	📑	B	7 days/week	8d	16d
7		C	None	5d	11d
8		D	None	5d	10d
9		◢ **Deliverable 2**	**None**	**16d**	**1d**
10		A	None	5d	1d
11	📑	B	7 days/week	8d	9d
12		C	None	5d	6d
13		D	None	5d	5d
14		◢ **Deliverable 3**	**None**	**16d**	**0d**
15		A	None	5d	1d
16	📑	B	7 days/week	8d	2d
17		C	None	5d	1d
18		D	None	5d	0d

This is a typical issue with schedule that have calendars with different working days per week.

6.2   Tasks are critical if slack is less than or equal 1 day

To demonstrate the way Microsoft Project calculates I have changed the duration of Task 17 to 4 days.

When Task 5 is 6 days this results in a single Critical Path:

When Task 5 is changed to 5 days this results in two activities on parallel Critical Paths:

When Task 5 is changed to 4 days then this results in the Critical Path disappearing for the two activities that are in parallel because they both have 2 days Total Float which is greater than the setting **Tasks are critical if slack is less than or equal** 1 day:

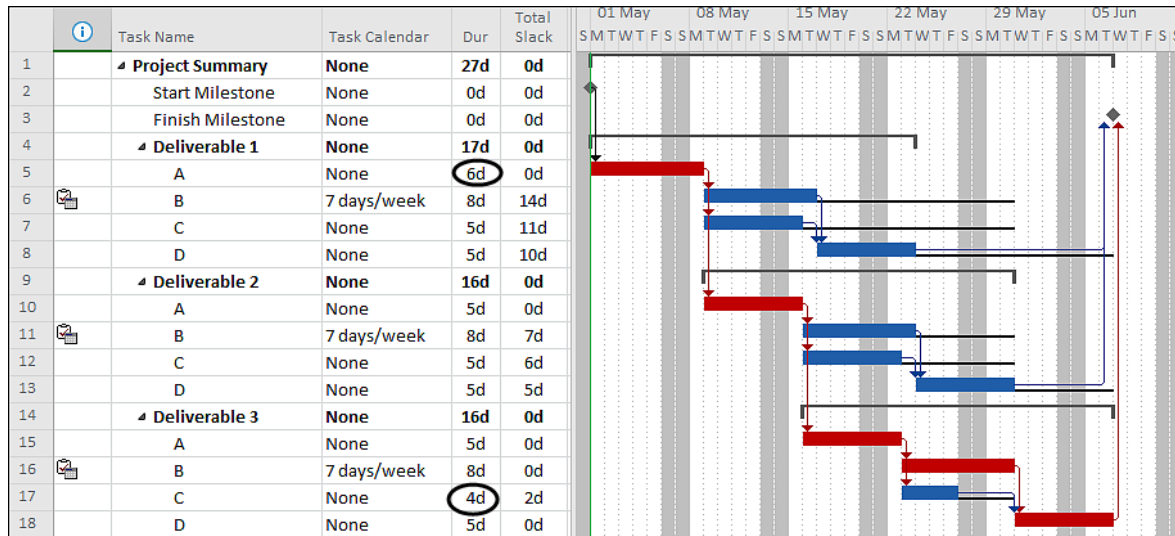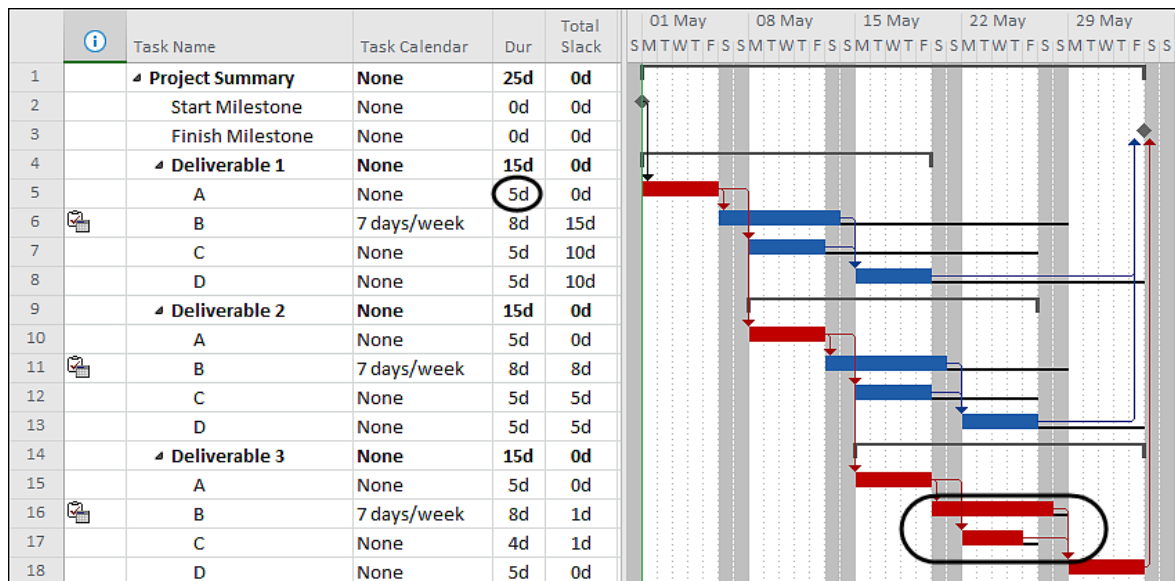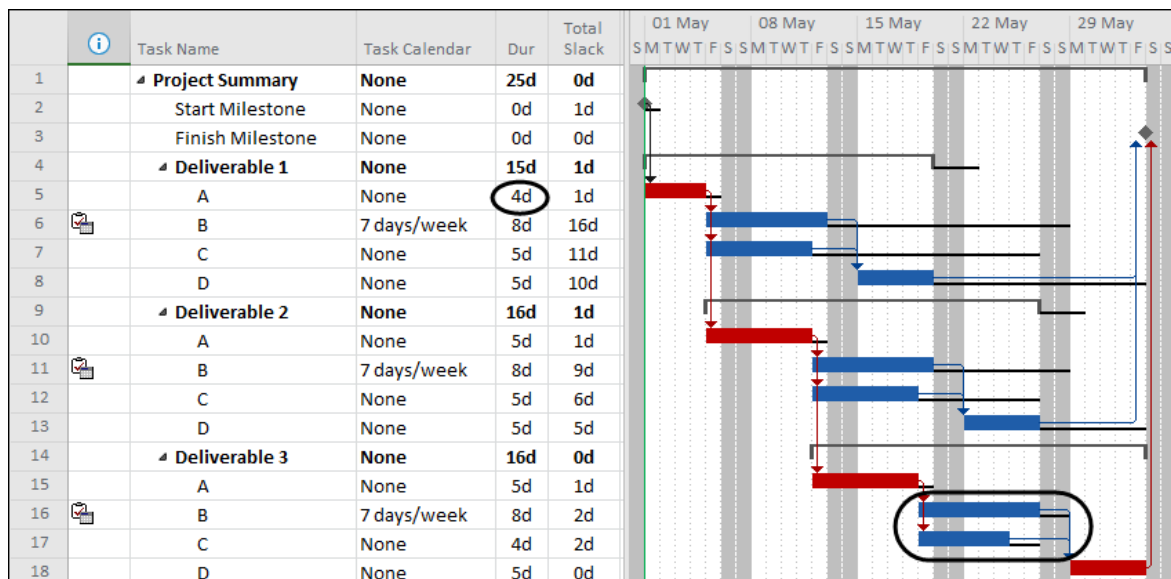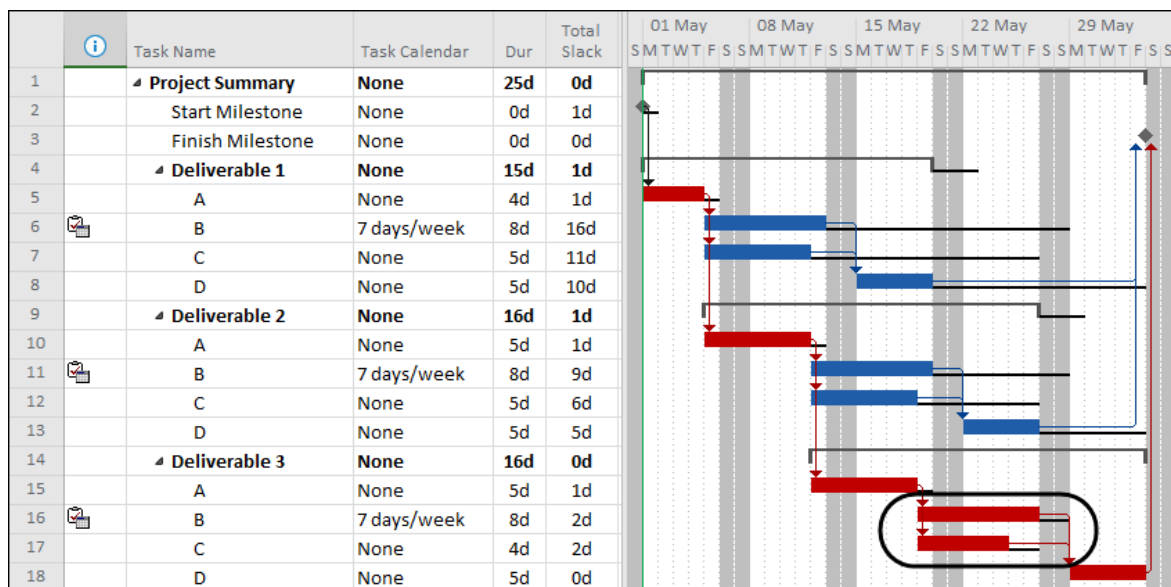|	(i)	Task Name	Task Calendar	Dur	Total Slack	Gantt
1		◢ **Project Summary**	**None**	**25d**	**0d**	
2		Start Milestone	None	0d	1d	
3		Finish Milestone	None	0d	0d	
4		◢ **Deliverable 1**	**None**	**15d**	**1d**	
5		A	None	4d	1d	
6	📋	B	7 days/week	8d	16d	
7		C	None	5d	11d	
8		D	None	5d	10d	
9		◢ **Deliverable 2**	**None**	**16d**	**1d**	
10		A	None	5d	1d	
11	📋	B	7 days/week	8d	9d	
12		C	None	5d	6d	
13		D	None	5d	5d	
14		◢ **Deliverable 3**	**None**	**16d**	**0d**	
15		A	None	5d	1d	
16	📋	B	7 days/week	8d	2d	
17		C	None	4d	2d	
18		D	None	5d	0d	

6.3   Tasks are critical if slack is less than or equal 2 days

When the **Tasks are critical if slack is less than or equal** 2 days we always receive a continuous chain of activities on the Critical Path and always 2 activities in parallel:

	(i)	Task Name	Task Calendar	Dur	Total Slack	Gantt
1		◢ **Project Summary**	**None**	**25d**	**0d**	
2		Start Milestone	None	0d	1d	
3		Finish Milestone	None	0d	0d	
4		◢ **Deliverable 1**	**None**	**15d**	**1d**	
5		A	None	4d	1d	
6	📋	B	7 days/week	8d	16d	
7		C	None	5d	11d	
8		D	None	5d	10d	
9		◢ **Deliverable 2**	**None**	**16d**	**1d**	
10		A	None	5d	1d	
11	📋	B	7 days/week	8d	9d	
12		C	None	5d	6d	
13		D	None	5d	5d	
14		◢ **Deliverable 3**	**None**	**16d**	**0d**	
15		A	None	5d	1d	
16	📋	B	7 days/week	8d	2d	
17		C	None	4d	2d	
18		D	None	5d	0d	

Comment: This option of using **Tasks are critical if slack is less than or equal** 2 days, when there is a 2 day difference in calendar working days will maintain a continuous Critical Path when there are no public holidays. This may not work over holidays like Easter and Christmas when the difference between the number of working days per week of calendars in excess of two days.

7   Total Float less than or equal to checked

To make Microsoft Project calculate Multiple Critical Paths some logic has to be removed. The picture below has a **Closed Network** and all activities are tied into the Finish Milestone Task 3and only one Critical Path is calculated:

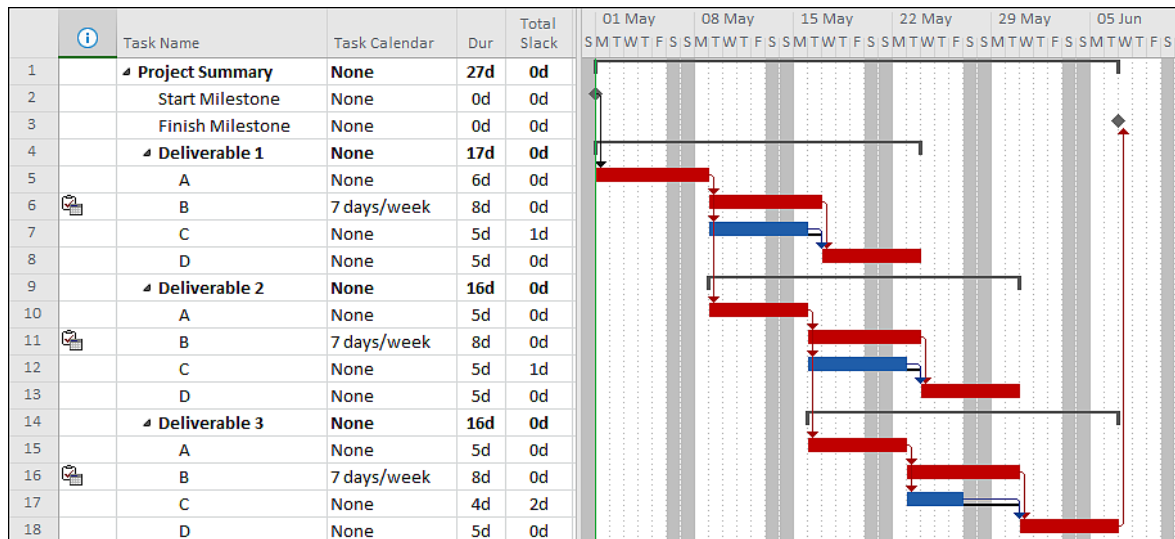|	ⓘ	Task Name	Task Calendar	Dur	Total Slack	Gantt
1		▲ **Project Summary**	**None**	**27d**	**0d**	
2		Start Milestone	None	0d	0d	
3		Finish Milestone	None	0d	0d	
4		▲ **Deliverable 1**	**None**	**17d**	**0d**	
5		A	None	6d	0d	
6	☑	B	7 days/week	8d	14d	
7		C	None	5d	11d	
8		D	None	5d	10d	
9		▲ **Deliverable 2**	**None**	**16d**	**0d**	
10		A	None	5d	0d	
11	☑	B	7 days/week	8d	7d	
12		C	None	5d	6d	
13		D	None	5d	5d	
14		▲ **Deliverable 3**	**None**	**16d**	**0d**	
15		A	None	5d	0d	
16	☑	B	7 days/week	8d	0d	
17		C	None	4d	2d	
18		D	None	5d	0d	

7.1   Tasks are critical if slack is less than or equal 0 days

After the successors are removed from Tasks 8 and 13 then the schedule calculates with Multiple Critical Paths because activities without successors have their **Total Float** set to Zero:

	ⓘ	Task Name	Task Calendar	Dur	Total Slack	Gantt
1		▲ **Project Summary**	**None**	**27d**	**0d**	
2		Start Milestone	None	0d	0d	
3		Finish Milestone	None	0d	0d	
4		▲ **Deliverable 1**	**None**	**17d**	**0d**	
5		A	None	6d	0d	
6	☑	B	7 days/week	8d	0d	
7		C	None	5d	1d	
8		D	None	5d	0d	
9		▲ **Deliverable 2**	**None**	**16d**	**0d**	
10		A	None	5d	0d	
11	☑	B	7 days/week	8d	0d	
12		C	None	5d	1d	
13		D	None	5d	0d	
14		▲ **Deliverable 3**	**None**	**16d**	**0d**	
15		A	None	5d	0d	
16	☑	B	7 days/week	8d	0d	
17		C	None	4d	2d	
18		D	None	5d	0d	

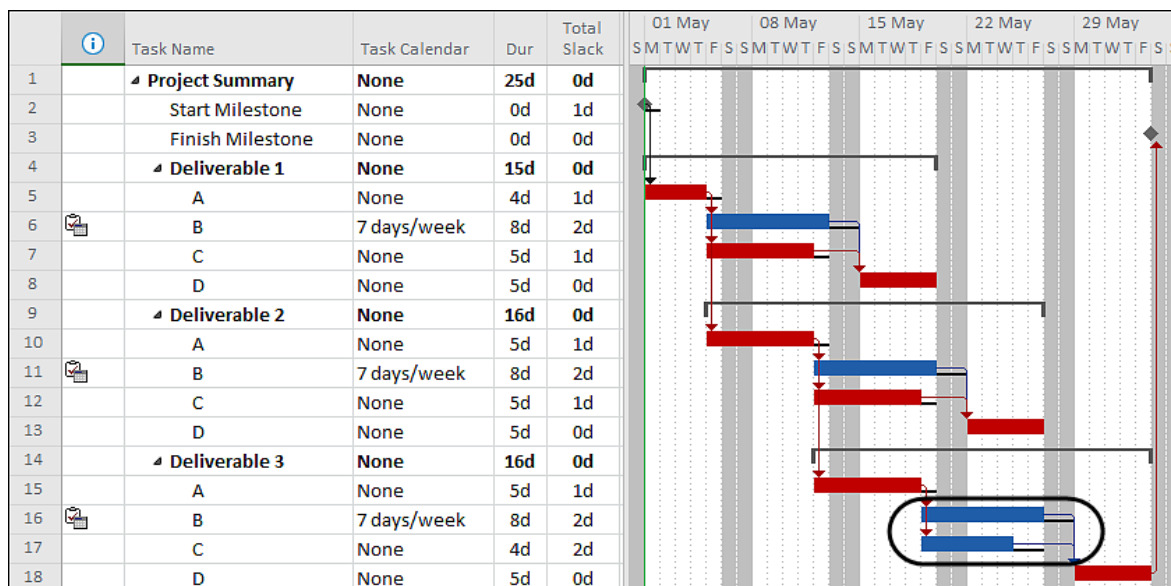But again, we end with more issues of the Critical Path disappearing when we change the duration of Task 5 to 4 days:

	ⓘ	Task Name	Task Calendar	Dur	Total Slack	Gantt
1		⊿ Project Summary	None	25d	0d	
2		Start Milestone	None	0d	1d	
3		Finish Milestone	None	0d	0d	
4		⊿ Deliverable 1	None	15d	0d	
5		A	None	4d	1d	
6		B	7 days/week	8d	2d	
7		C	None	5d	1d	
8		D	None	5d	0d	
9		⊿ Deliverable 2	None	16d	0d	
10		A	None	5d	1d	
11		B	7 days/week	8d	2d	
12		C	None	5d	1d	
13		D	None	5d	0d	
14		⊿ Deliverable 3	None	16d	0d	
15		A	None	5d	1d	
16		B	7 days/week	8d	2d	
17		C	None	4d	2d	
18		D	None	5d	0d	

7.2   Tasks are critical if slack is less than or equal 1 day

Again, we have issues with a non-continuous Critical Path:

	ⓘ	Task Name	Task Calendar	Dur	Total Slack	Gantt
1		⊿ Project Summary	None	25d	0d	
2		Start Milestone	None	0d	1d	
3		Finish Milestone	None	0d	0d	
4		⊿ Deliverable 1	None	15d	0d	
5		A	None	4d	1d	
6		B	7 days/week	8d	2d	
7		C	None	5d	1d	
8		D	None	5d	0d	
9		⊿ Deliverable 2	None	16d	0d	
10		A	None	5d	1d	
11		B	7 days/week	8d	2d	
12		C	None	5d	1d	
13		D	None	5d	0d	
14		⊿ Deliverable 3	None	16d	0d	
15		A	None	5d	1d	
16		B	7 days/week	8d	2d	
17		C	None	4d	2d	
18		D	None	5d	0d	

7.3   Tasks are critical if slack is less than or equal 2 days

Now everything is Critical in this schedule, which probably does not give the client confidence in your schedule and they will look more closely at the program.

	ⓘ	Task Name	Task Calendar	Dur	Total Slack
1		⊿ **Project Summary**	**None**	**25d**	**0d**
2		Start Milestone	None	0d	1d
3		Finish Milestone	None	0d	0d
4		⊿ **Deliverable 1**	**None**	**15d**	**0d**
5		A	None	4d	1d
6	📅	B	7 days/week	8d	2d
7		C	None	5d	1d
8		D	None	5d	0d
9		⊿ **Deliverable 2**	**None**	**16d**	**0d**
10		A	None	5d	1d
11	📅	B	7 days/week	8d	2d
12		C	None	5d	1d
13		D	None	5d	0d
14		⊿ **Deliverable 3**	**None**	**16d**	**0d**
15		A	None	5d	1d
16	📅	B	7 days/week	8d	2d
17		C	None	4d	2d
18		D	None	5d	0d

8   Discussion on Contract Terms and Conditions

The option **Tasks will always honor their constraint dates** should never be used as the resulting program may not calculate a proper critical path as the schedule may appear to be achievable when it is not.

In the situation when:

- The contractor wishes to identify a single Critical Path from the start to finish of the project,
- There are multiple calendars in the program and
- The contractor is not interested in claiming delays for activities that are not on the Critical Path.

Then P6 **Longest Path** which is not available in Microsoft Project but is a better solution, but when using Microsoft Project the contractor should consider the following settings:

- **Calculate multiple critical paths** unchecked, and
- **Tasks are critical if slack is less than or equal** set to:
  - ➢ **1 day** if they have calendars with 5 and 6 days per week and
  - ➢ **2 days** if they have calendars with 5, 6 and 7 days per week

On the other hand, it is unreasonable for a client not to allow costs for activities that have been delayed by the client when the contractor has either:

- High standby costs for equipment that may not be utilized during the delay. This would occur in a projects, such as a wind farm erection, and the client does not deliver equipment on time and the contractor has cranes sitting on high standby rates, or
- When a contractor has committed to start date to a subcontractor and will incur delay costs for the subcontractor that may not be claimed from the client through the contract.

Often contracts do not allow a claim for cost for tasks that are delayed by the client unless they are on the critical path. What are the subcontractor options in this situation:

- One option is to negotiate a change to the contract so costs for delayed activities NOT on the critical path that are delayed by the client may be claimed.

- The contractor could start litigation which will incur further costs.
- Once subcontracts have been signed with fixed start dates then a **Start On Constraint** could be assigned to the activity to make it critical.
- Another option is to put in logic into the contract program that is not logical to force high-cost activities that could be delayed by the customer on to the critical path. This is not advisable as this is easily found by inspection of the program.
- Some contractors use **Pacing**, which is the process of increasing the duration of activities to force them onto the critical path. Again, this is not advisable as this is easily found by inspection of the program.
- Also, in the situation where there are separate independent chains of events that are not logically linked then the option of using **Calculate multiple critical paths** may be considered. Some notes on this process are:
  - ➢ If the contract specifically states that the schedule must have a **Closed Network** then this option may result in the schedule not being accepted by the client because a Closed Network stops a Multiple Critical Path from Calculating.
  - ➢ When there are multiple calendars with different number of working days per week then the option of **Calculate multiple critical paths** say 1 or 2 days may need to be used to put more tasks onto the critical path, but again this may then result in the schedule not being accepted by the client.

Paul E Harris

Director Eastwood Harris Pty Ltd

14 October 2021