

# Project Scheduling with Microsoft Project

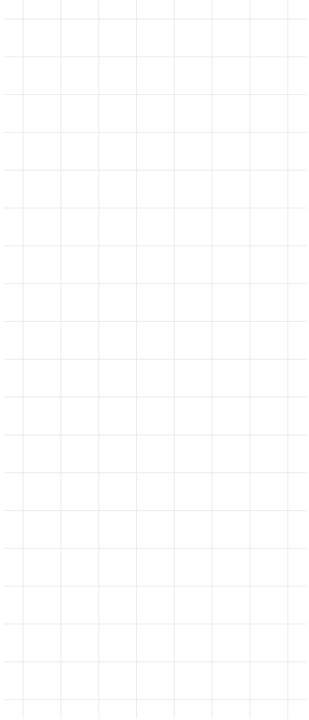
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### Prerequisite to Project Scheduling

- ➔ **Project scoping** → agreeing upon the **boundaries** and the **deliverable(s)** of the project ⇨ Project Roadmap
- ➔ **Project planning** → identifying the **set of activities** to carry out to perform the project ⇨ Work Breakdown Structure (WBS)
- ➔ **Project costing** → estimating and assigning **resources** to the project activities ⇨ Budget Document + RACI matrix

- ➔ **Project scheduling** → sequencing the activities, calculating dates, floats and critical path(s), levelling/smoothing resources, baselineing the result ⇨ **Coordination Schedule / Gantt Chart**



## Typology

### 2 types of **project schedules**

#### Master Schedule

~ Summary Schedule  
Masterplan  
*Calendrier directeur*



**Strategic level**  
The whole project  
Intuitive approach

One page/slide  
Can be in the **Project Roadmap**

#### Coordination Schedule

~ **"PERT"**, Gantt chart  
Activity network  
*Calendrier de coordination*



**Tactical level**  
One or a few phases  
Analytical approach

Several pages  
Can be in the **PMP**

## Project **Planning** for Complex Systems Projects

### 1 Identifying the project activities

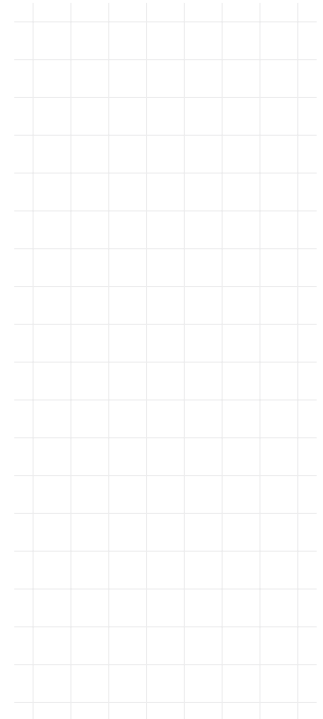
- 1.1 Describing the final deliverable(s) in a **PBS**
- 1.2 Deriving the **WBS top nodes** from the PBS
- 1.3 Preparing and populating the **WBS matrix**
- 1.4 Generating the **list of activities** from the WBS matrix

### 2 Estimating and assigning resources

- 2.1 Identifying the resources that are available in a **RBS**
- 2.2 Estimating the resources that are required (**workload**)
- 2.3 Assigning resources to activity in a **RACI matrix**

## Project Scheduling for Complex Systems Projects

- 3 Sequencing and scheduling the activities
  - 3.1 Estimating the **duration** for each activity
  - 3.2 Deriving the **technical constraints** between activities
  - 3.3 Perhaps, getting rid of **loops** → DSM (Design Structure Matrix)
  - 3.4 If needed, defining **temporal constraints** and **calendars**
  - 3.5 Calculating earliest/latest start/finish **dates, floats** and **critical path(s)** → PDM (Precedence Diagramming Method)
  - 3.6 If needed, calculating (earliest) start/finish dates considering **resource constraints** → RCPS
  - 3.7 Analysing the resulting schedule, inserting **buffers**, and freezing a **baseline** in view of following up progress



### The CanNet Pilot Project



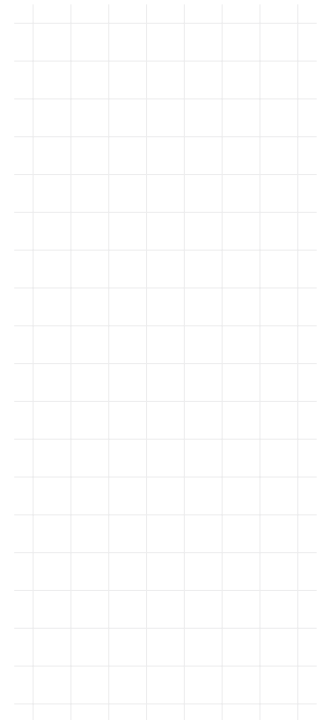
#### The project context (1)

- OrgaDairy is an industrial dairy that makes yogurts
- OrgaDairy factory houses a lot of tanks (homogenization, fermentation)
- The process shall be carefully monitored (**regular samplings**), the tanks shall also be carefully cleaned, rinsed and controlled after each batch

the **initial situation**, i.e. problem ①

- Until now, this monitoring is carried out very manually: many time-consuming rides between the factory lab and the many tanks
- To improve the monitoring process and to comply with evolving rules, OrgaDairy executive management decided to invest in an **enhanced sampling system** which shall be in operation in less than one year

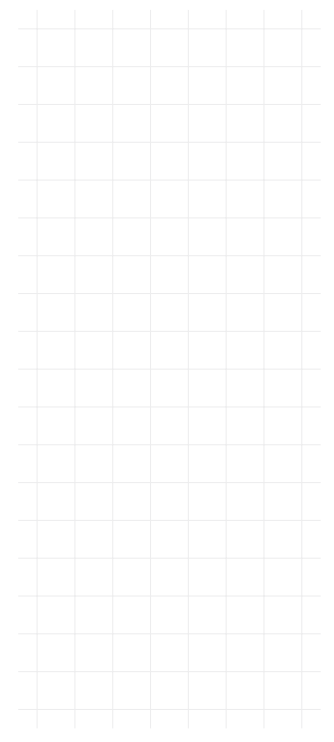
the **project objectives** ②



## The CanNet Pilot Project

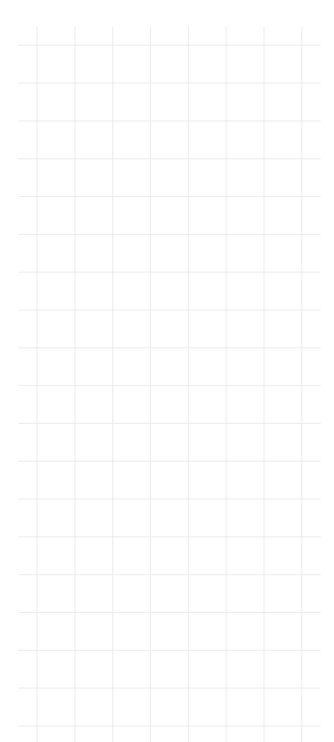
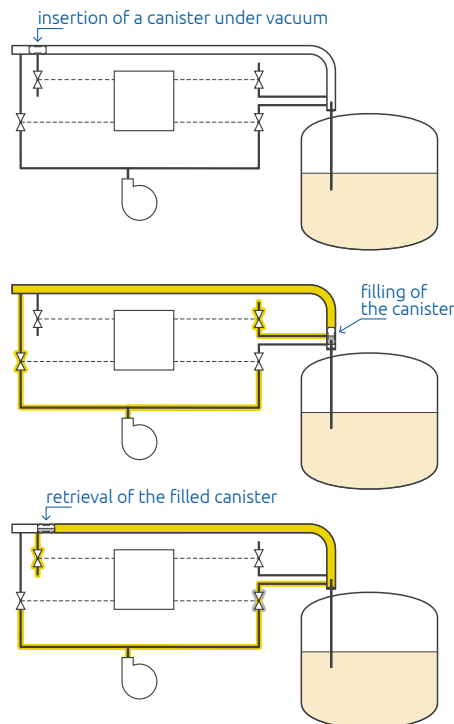
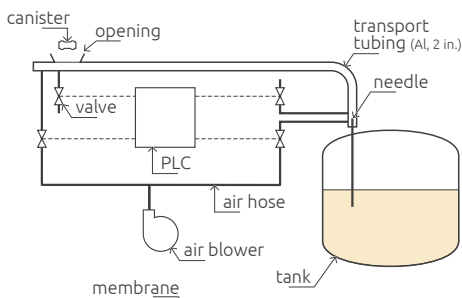
### The project context (2)

- A few possible solutions were considered during the initialize phase some possible solutions ③
- The one that was preferred consists of installing a **pneumatic tube transport system (PTTS)** to propel **canisters** between the factory lab and the many tanks the preferred solution ④
- Its feasibility was demonstrated during the study phase CDR
- The initiative is named **CanNet (canister network) Project** and Mr. Ayrton, senior plant engineer, was appointed project manager 4.2
- The project is made of **three major phases:** 4.3
  - ⇒ A study phase (already completed)
  - ⇒ A pilot project → PTTS between the factory lab and three tanks
  - ⇒ A full deployment project throughout the entire factory



## The CanNet Pilot Project

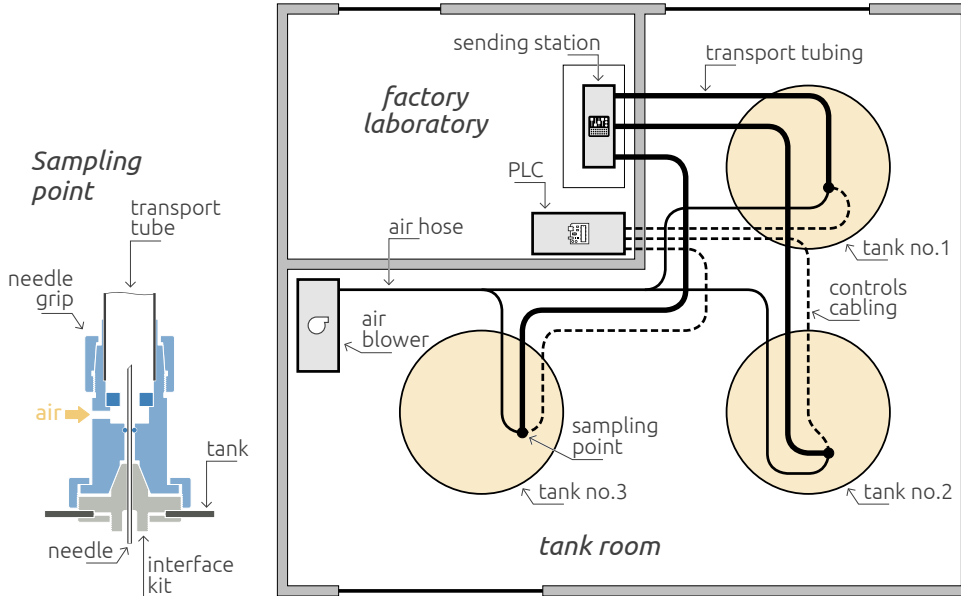
### The process





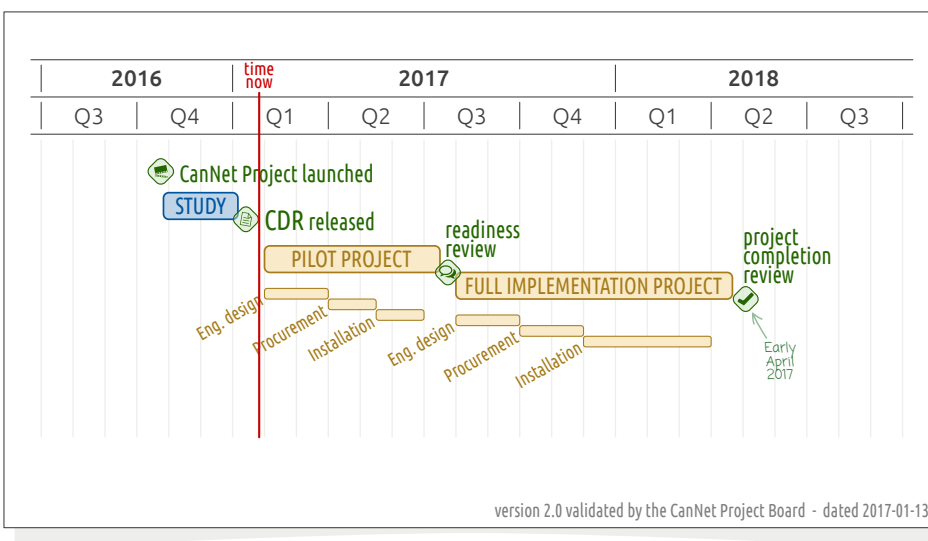
The CanNet Pilot Project

The layout



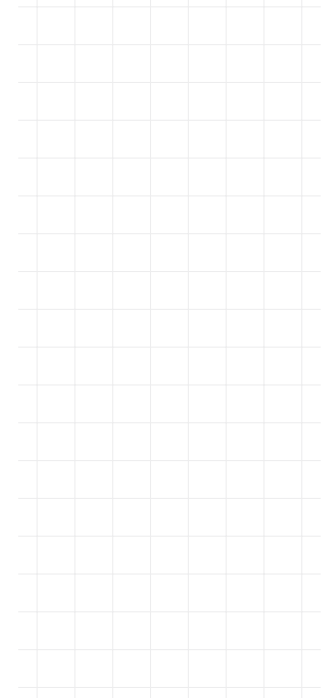
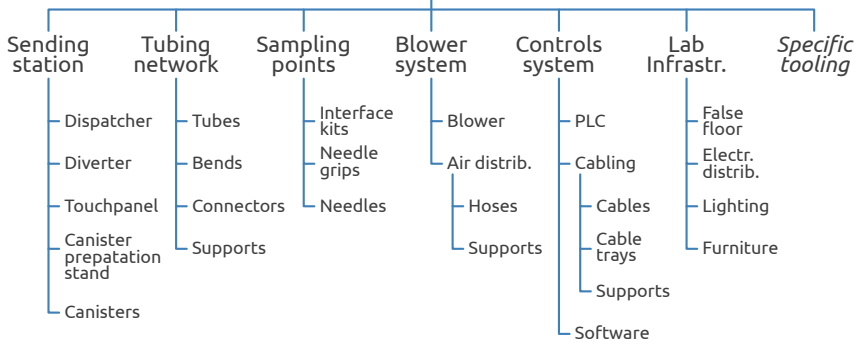
The CanNet Pilot Project

The project master schedule

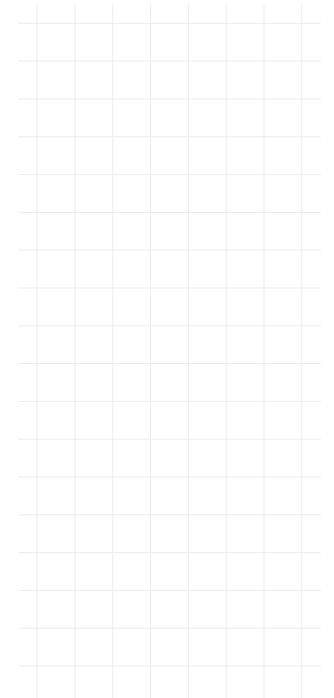


## Product Breakdown Structure (PBS)

### OrgaDairy PTTS Pneumatic Tube Transport System

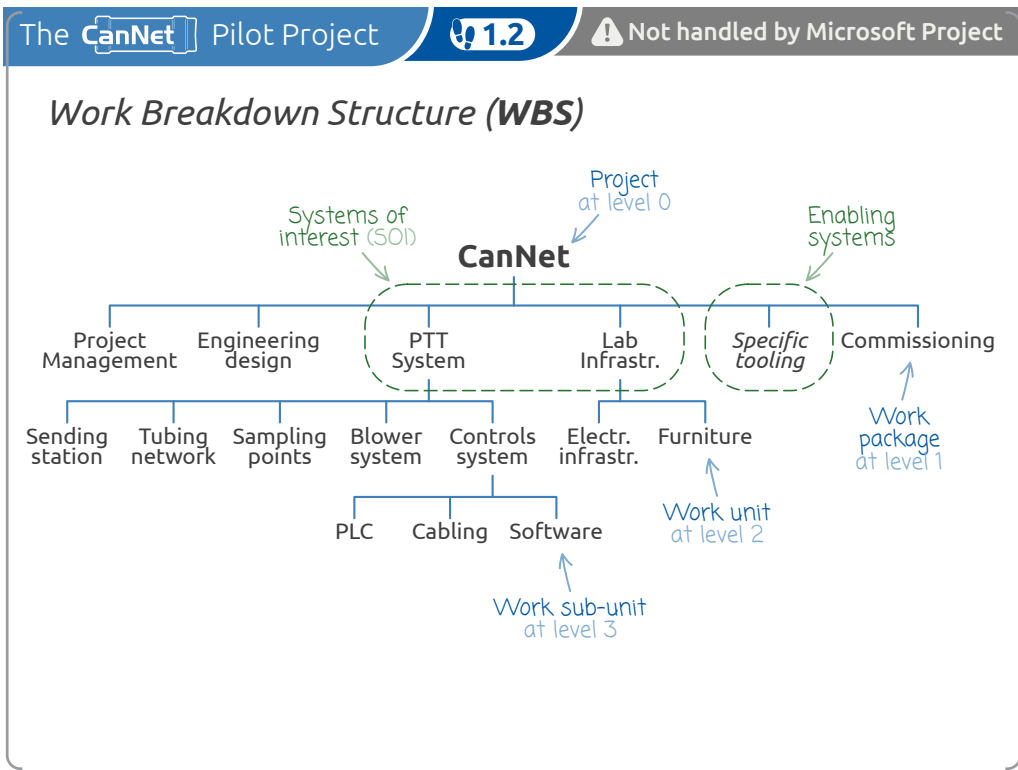


The screenshot shows the PTTS hierarchy in an Excel spreadsheet. The 'Data' menu is open, highlighting the 'Group and Outline' option. A 'Settings' dialog box is also shown, with the 'Direction' section containing options for 'Summary rows below detail' and 'Summary columns to right of detail'. A yellow arrow points to the 'untick' instruction, which refers to unchecking the 'Summary rows below detail' option in the Settings dialog.



The **CanNet** Pilot Project **1.2** **!** Not handled by Microsoft Project

The image shows two screenshots of Microsoft Project software. The left screenshot displays a detailed Work Breakdown Structure (WBS) for a project named 'PTTS'. The WBS is organized into a hierarchical tree structure with tasks such as 'Sending station', 'Tubing network', 'Blower system', 'Controls system', 'Cabling', 'Software', 'Lab infrastructure', and 'Furniture'. The right screenshot shows a simplified WBS for a project named 'CanNet'. The tasks are 'Project management', 'Engineering design', 'PTT System', 'Sending station', 'Tubing network', 'Sampling points', 'Blower system', 'Controls system', 'PLC', 'Cabling', 'Software', 'Lab infrastructure', 'Electr. infrastr.', 'Furniture', 'Specific tooling', and 'Commissioning'. Green arrows and text annotations connect the two views, indicating that the 'CanNet' structure is a simplified version of the 'PTTS' structure. Annotations include 'becomes', 'simplified', and 'added'.



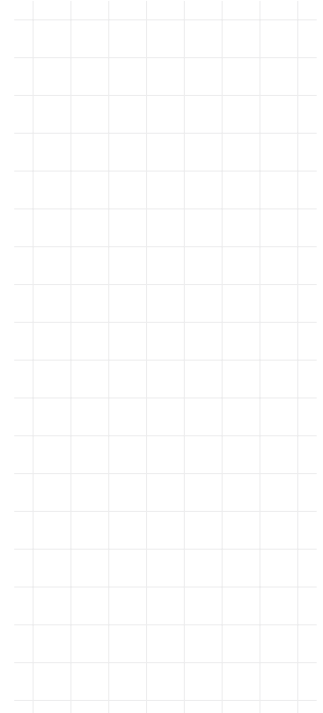
## The CanNet Pilot Project

### The generic activities

suited to OrgaDairy improvement projects



- Manage the project
- Perform the system-level design
- Perform detailed design
- Get rid of IP/patenting issues
- Write technical specification
- Prepare tendering docts
- Award contract/place order
- Develop/parametrize software
- Test/validate software
- Prepare construction/installation
- Prepare commissioning/acceptance
- Construct/install
- Commission/perform acceptance



## The CanNet Pilot Project

1.3

⚠ Not handled by Microsoft Project

**to run the VBA macro**

**the generic activities**

**WBS**

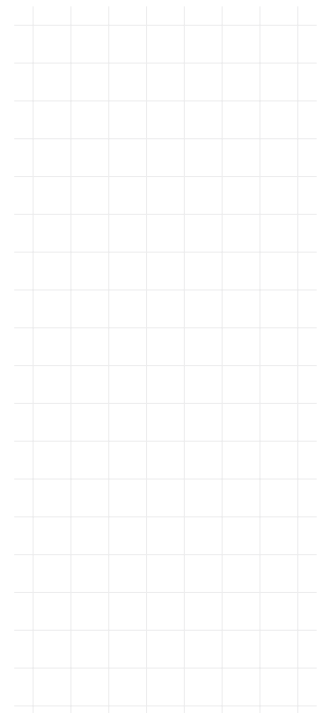
One detailed design activity for the PTTIS

number of activities of a certain type

Number of activities

WBS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Project Management																		
Engineering design																		
PTT System	1	1	1	2				1	1									
Sending station																		1
Tubing network																		3
Sampling points																		1
Blower system																		1
Controls system																		1
PLC																		
Cabling																		1
Software							1	1										
Lab infrastructure		1																
Electr. infrastr.				1	1	2												1
Furniture				1	1	2												1
Specific tooling					1	2												
Commissioning																		1
																		<b>Σ</b>
																		<b>34</b>

- To run the macro:
1. Put a '>' in col. A (e.g. cell A20)
  2. Select cells for which activities will be generated (e.g. H2:T17)
  3. Click the button



## Activity ≈ Work Unit ≈ Work Package

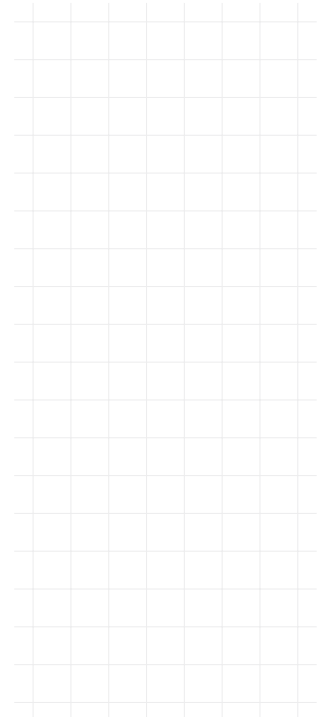
An activity is an elementary action that:

- consumes **time**
- consumes **resources**
- has a **start** and a **finish** dates
- is assignable to **one person**
- produces **deliverable(s)**
- is **measurable** (to assess its progress)

### Activity ≠ Deliverable

To avoid confusion, clever professional practices and several textbooks suggest to label activities as follow:

Action verb (infinitive tense) + Substantive

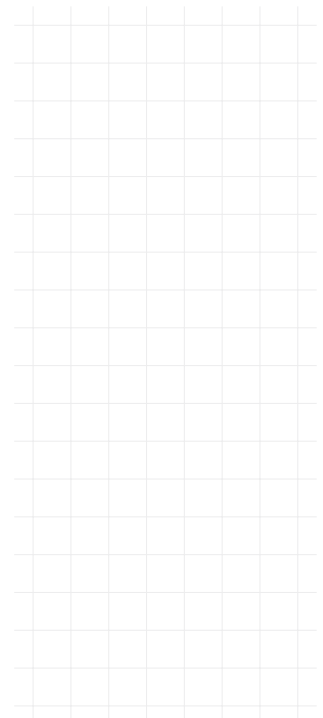


## How many activities on a schedule?

What should be the size of a project's **Activity Portfolio**?

- No definitive answer!
- That depends of the size and complexity of the project
- But more than **300 or 400 activities\*** is known to be difficult to handle
- **100 activities\*** sounds reasonable for a project spanning over one year

\* Activities + remaining planned activities



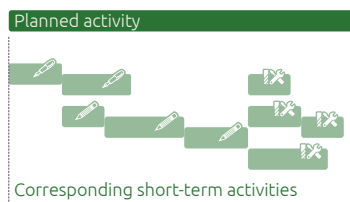
## Activity vs. Planned Activity

The **ANSI #748** project management standard for reporting distinguishes two types of activities:

- ➔ **Activities** (work units) → short/medium term
- ➔ **Planned activities** (planned units) → longer term

Planned activities are defined more roughly than short/medium term activities

As the project progresses, planned activities arrive on a shorter term and are split up in short/medium term activities



The **CanNet** Pilot Project
**1.4**
⚠ Not handled by Microsoft Project

raw list  
of activities

To run the macro:

1. Put a '>' in col. A (e.g. cell A20)
2. Select cells for which activities will be generated (e.g. H2:T17)
3. Click the button

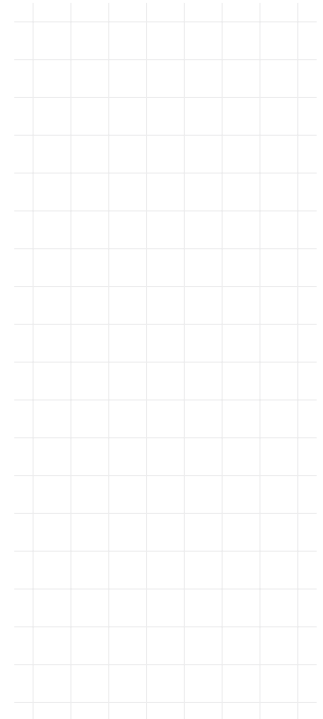
Activities listed as from row marked '>' downward

4. Adjust the labels\*
5. Copy-paste the list into the project scheduling software

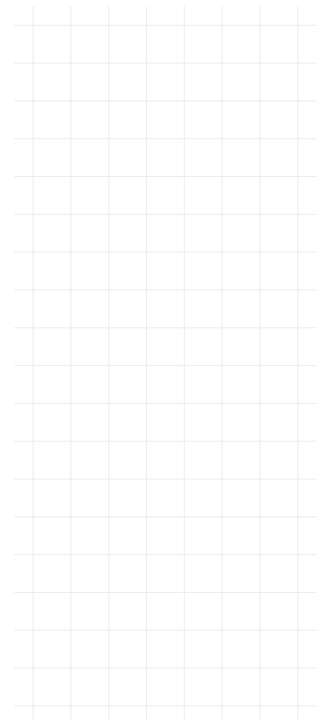
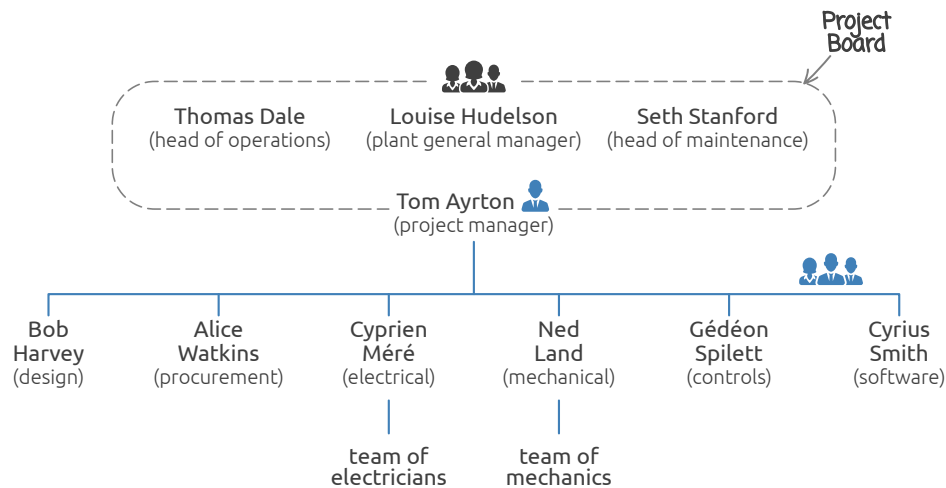
List of activities (LoA) with adjusted labels

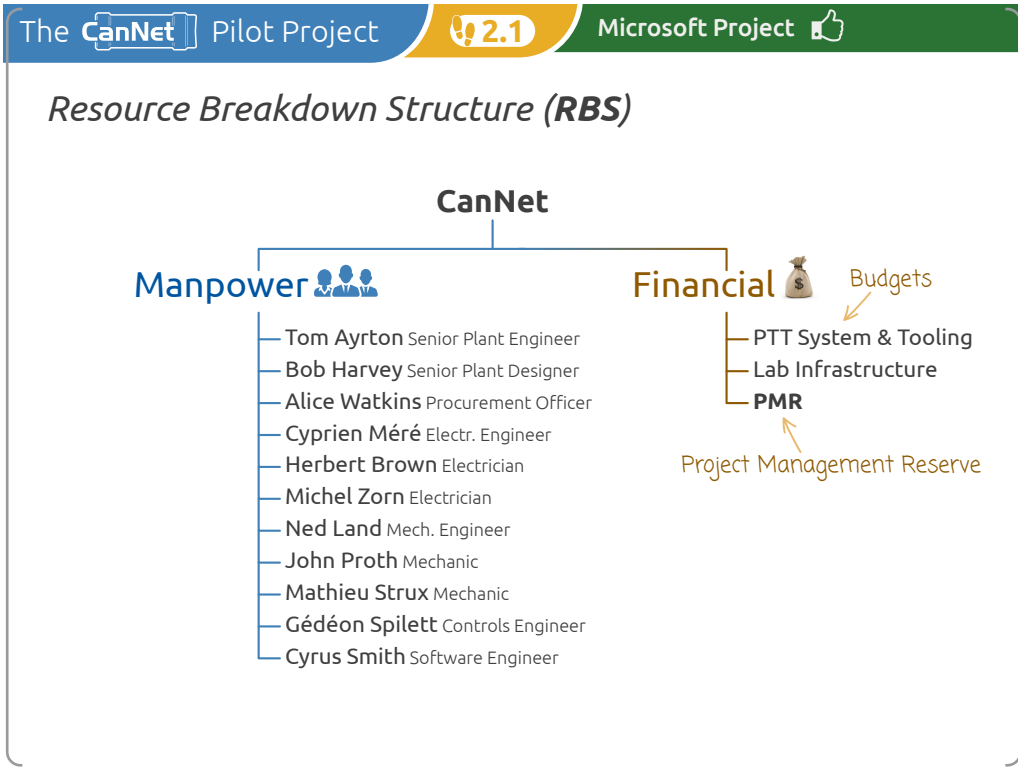
- Manage the CanNet project
- Set the project management framework
- Perform detailed design of the PTT system
- Write technical specification for the PTT system
- Prepare tendering docs for the PTT system
- Send invitations to tender for the PTT system
- Open tenders and place order for the PTT system
- Perform the installation design
- Prepare installation of the PTT system
- Prepare commissioning of the PTT system
- Install the tank #1 sampling point assembly
- Install the tank #2 sampling point assembly
- Install the tank #3 sampling point assembly
- Lay down the tubing network
- Install the blower and lay down the air hoses
- Pull and connect controls cabling
- Install the PLC and sending station in the lab

- Parametrize software for the PTT system
- Test and validate software for the PTT system
- Perform detailed design of the lab arrangement
- Write technical specification for the electr. infrastr.
- Prepare tendering docs for the electr. infrastr.
- Send invitations to tender for the electr. infrastr.
- Open tenders and place order for the electr. infrastr.
- Install the electr. infrastr. In the lab
- Write technical specification for the lab's furniture
- Prepare tendering docs for the lab's furniture
- Send invitations to tender for the lab's furniture
- Open tenders and place order for the lab's furniture
- Arrange the furniture in the lab
- Prepare tendering docs for the specific tooling
- Send invitations to tender for the specific tooling
- Open tenders and place order for the specific tooling
- Debug and commission the pilot PTT system



Organisational Breakdown Structure (OBS)





The **CanNet** Pilot Project **2.3** Not handled by Microsoft Project

### RACI matrix

list of activities

CanNet	Tom Ayrton / Senior Plant Engineer	Bob Harvey / Senior Plant Designer	Alice Watkins / Proc. Officer	Cyprien Méré / Electr. Engineer	Herbert Brown / Electrician	Michel Zorn / Electrician	Ned Land / Mech. Engineer	John Proth / Mechanic	Mathieu Strux / Mechanic	Gédéon Spilett / Controls Engineer	Cyrus Smith / Software Engineer	PTT System / Engineer	Lab Infrastr. / Budget	Project Management Reserve
1														
2	X	X	X					X						R
3	X													
4	I	X	I	I				I		I	I			
5	I	I	I			X				I	I			
6	I		X											
7	I		X											
8	F	I	X	I			X			I	I		R	
9	I	X	I	I				I						
10	I					X								
11	I		X		X				X	X				
12	I					F	X	X	I					
13	I					F	X	X	I					
14	I					F	X	X	I					
15	I					F	X	X	I					
16	I					F	X	X	I					
17	I					F	X	X	I					
18	I				F	X	X			X				
19	I									I	X			
20	I										I	X		
21	I	X	I	I										
22	I	I	I	X										

**Legend**

- Executes: X
- Follows up: F
- Is informed: I
- Provide help: H
- Is required: R
- Is responsible: X, F



The CanNet Pilot Project **2.3** ⚠ Not handled by Microsoft Project

**Human Resources**

- Tom Ayrton | Senior Plant Engineer
- Bob Harvey | Senior Plant Designer
- Alice Watkins | Proc. Officer
- Cyprien Méré | Electr. Engineer
- Herbert Brown | Electrician
- Michel Zorn | Mech. Engineer
- Ned Land | Mech. Engineer
- John Froth | Mechanic
- Mathieu Struk | Mechanic
- Gédéon Spilet | Controls Engineer
- Cyrus Smith | Software Engineer

**Financial Resources**

- PTT System | Budget
- Lab Infrastr. | Budget
- Project Management Reserve

Activity	F	I	X	X	I	I	R
Open tenders and place order for the lab's furniture							
Arrange the furniture in the lab							
Prepare tendering docs for the specific tooling							
Send invitations to tender for the specific tooling							
Open tenders and place order for the specific tooling							
Debug and commission the pilot PTT system							

← list of activities & resources

## Activity

An activity is an elementary action that:

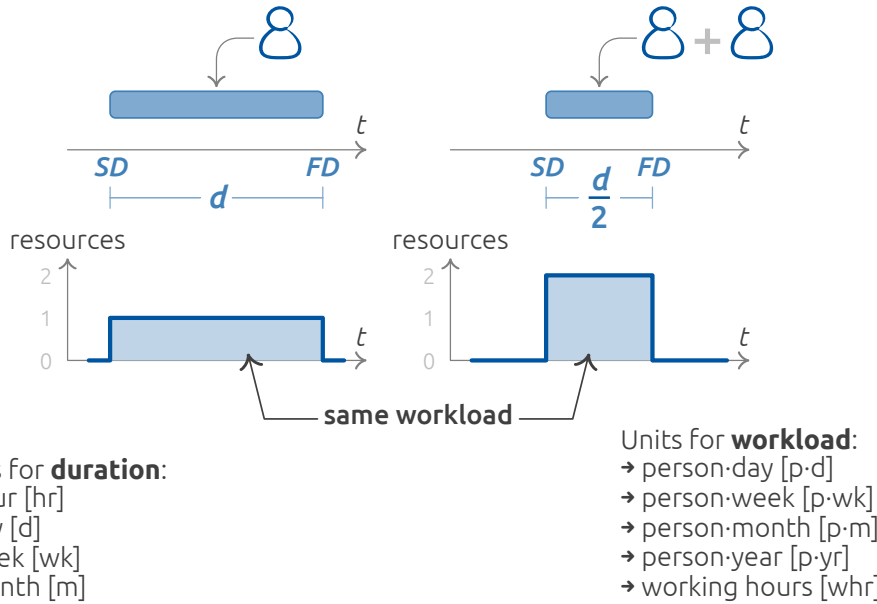
➔ consumes **time** *yes, but within certain limits!*

What is then the maximum duration for an activity?

- ➔ No definitive answer!
- ➔ No more than **5%** to **10%** of the project duration
- ➔ No more than **13 weeks** (long lead projects)
- ➔ Some so-called **Level-of-Effort** activities are allowed **one** such or up to **1%** of the activities **ANSI #748**

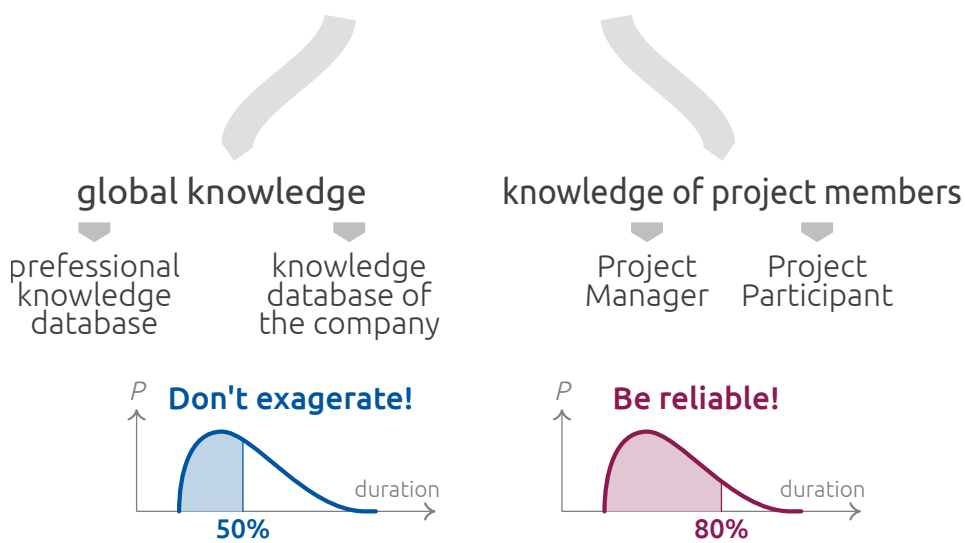
## Estimating Activity Duration

Workload Histogram



## Estimating Activity Duration

### Sources of Estimates

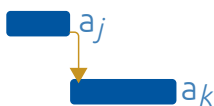


List of activities (LoA) + duration estimates [weeks]

<b>PM</b>	Manage the CanNet project	LoE	<b>PSW</b>	Parametrize software for the PTT system	4
<b>PMF</b>	Set the project management framework	1	<b>TSW</b>	Test and validate software for the PTT system	2
<b>DDP</b>	Perform detailed design of the PTT system	5	<b>DDL</b>	Perform detailed design of the lab arrangement	2
<b>TSP</b>	Write technical specification for the PTT system	2	<b>TSE</b>	Write technical specification for the electr. infrastr.	1
<b>TDP</b>	Prepare tendering docts for the PTT system	1	<b>TDE</b>	Prepare tendering docts for the electr. infrastr.	1
<b>ITP</b>	Send invitations to tender for the PTT system	0+ε*	<b>ITE</b>	Send invitations to tender for the electr. infrastr.	0+ε*
<b>POP</b>	Open tenders and place order for the PTT system	1	<b>POE</b>	Open tenders and place order for the electr. infrastr.	0.5
<b>IDP</b>	Perform the installation design	1.5	<b>Elec</b>	Install the electr. infrastr. In the lab	2
<b>IPP</b>	Prepare installation of the PTT system	2	<b>TSF</b>	Write technical specification for the lab's furniture	0.5
<b>CPP</b>	Prepare commissioning of the PTT system	2	<b>TDF</b>	Prepare tendering docts for the lab's furniture	0.5
<b>Tk1</b>	Install the tank #1 sampling point assembly	0.5	<b>ITF</b>	Send invitations to tender for the lab's furniture	0+ε*
<b>Tk2</b>	Install the tank #2 sampling point assembly	0.5	<b>POF</b>	Open tenders and place order for the lab's furniture	0.5
<b>Tk3</b>	Install the tank #3 sampling point assembly	0.5	<b>Furn</b>	Arrange the furniture in the lab	1
<b>Tub</b>	Lay down the tubing network	2	<b>TDT</b>	Prepare tendering docts for the specific tooling	0.5
<b>Blw</b>	Install the blower and lay down the air hoses	1	<b>ITT</b>	Send invitations to tender for the specific tooling	0+ε*
<b>Ctrl</b>	Pull and connect controls cabling	1	<b>POT</b>	Open tenders and place order for the specific tooling	0.5
<b>Lab</b>	Install the PLC and sending station in the lab	2	<b>Com</b>	Debug and commission the pilot PTT system	1

\* ca. one hour, but once converted in weeks, dur = 0+ε = 0 wk

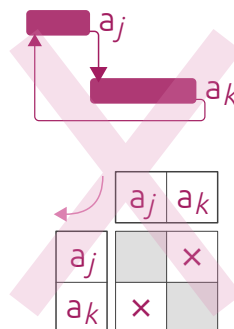
Technical Constraints



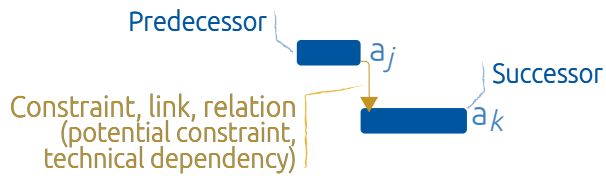
	$a_j$	$a_k$
$a_j$		
$a_k$	x	

Precedence Matrix

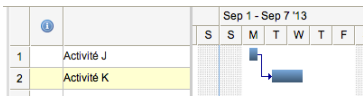
ATTENTION  
The activity net shall be free of loops!



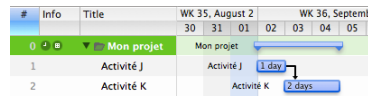
## Technical Constraints → Finish–Start



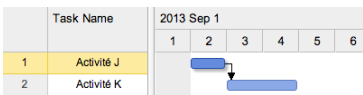
Finish–start constraint in **Ganttter.com**



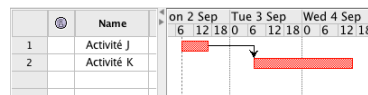
Finish–start constraint in **Merlin**



Finish–start constraint in **Gantic.com**

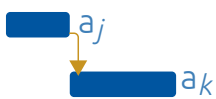


Finish–start constraint in **OpenProj**



## Technical Constraints

finish-start



start-start



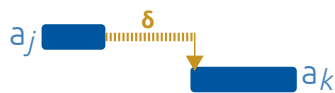
finish–finish



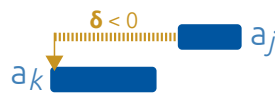
start–finish



positive lag



negative lag

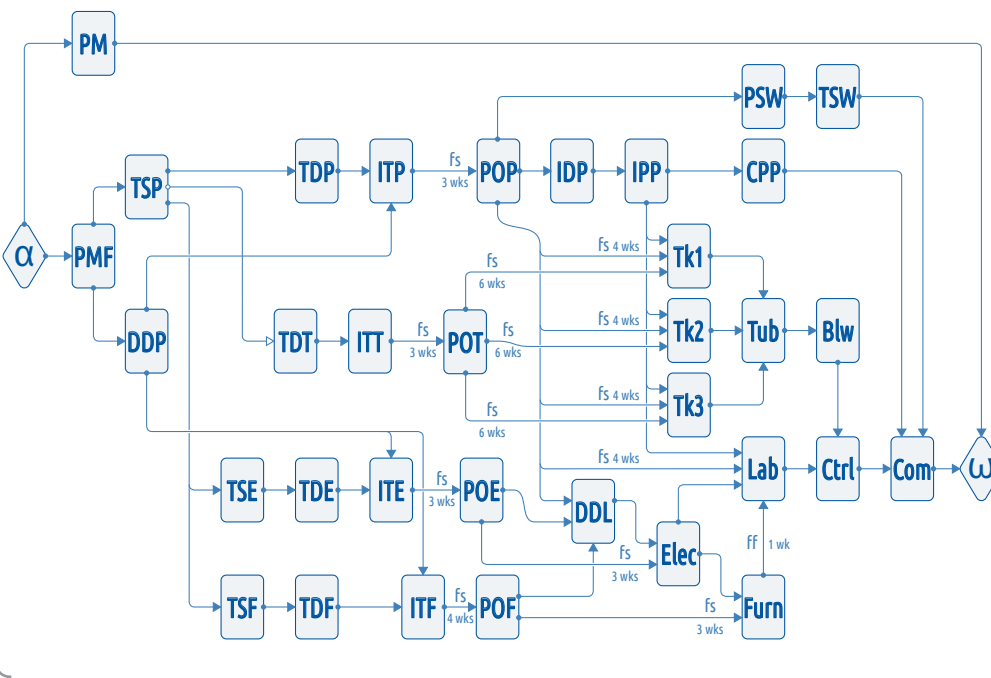


List of activities (LoA) + duration estimates [weeks] + predecessors

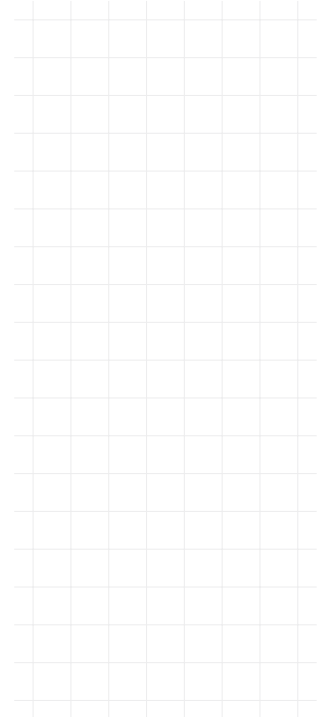
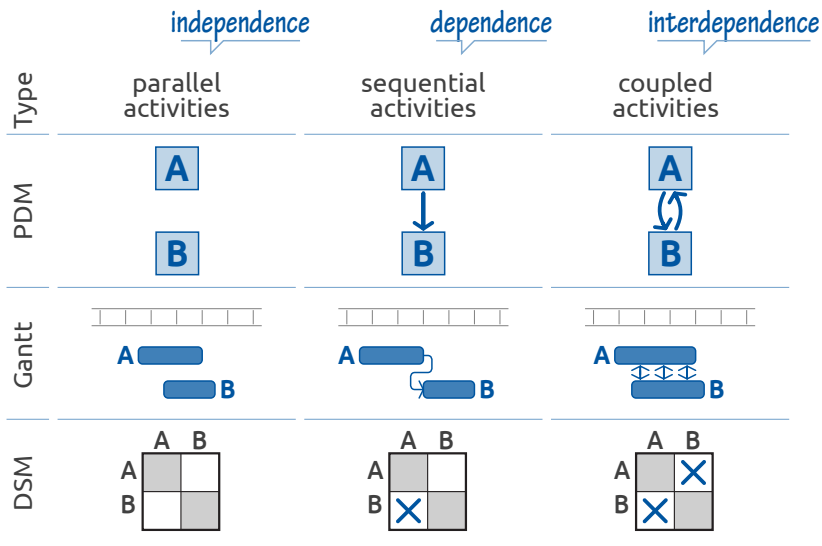
α ← project start node

Activity	Predecessors	LoE	Activity	Duration
PM	α		PSW	POP
PMF	α	1	TSW	PSW
DDP	sPMF	5	DDL	POP, POE, POF
TSP	PMF	2	TSE	TSP
TDP	TSP	1	TDE	TSE
ITP	DDP, TDP	0	ITE	DDP, TDE
POP	ITP fs+3 wks	1	POE	ITE fs+3 wks
IDP	POP	1.5	Elec	DDL, POE fs+3 wks
IPP	IDP	2	TSF	TSP
CPP	IPP	2	TDF	TSF
Tk1	POP fs+4 wks, IPP, POT fs+6 wks	0.5	ITF	DDP, TDF
Tk2	POP fs+4 wks, IPP, POT fs+6 wks	0.5	POF	ITF fs+4 wks
Tk3	POP fs+4 wks, IPP, POT fs+6 wks	0.5	Furn	Elec, POF fs+3 wks
Tub	Tk1, Tk2, Tk3	2	TDT	TSP
Blw	Tub	1	ITT	TDP
Ctrl	Blw, Lab	1	POT	ITT fs+3 wks
Lab	POP fs+4 wks, IPP, Elec, Furn ff+1 wk	2	Com	Ctrl, TSW, CPP
			ω	PM, Com

ω ← project finish node

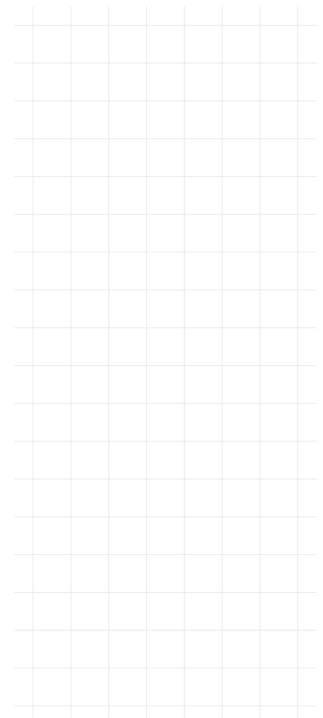
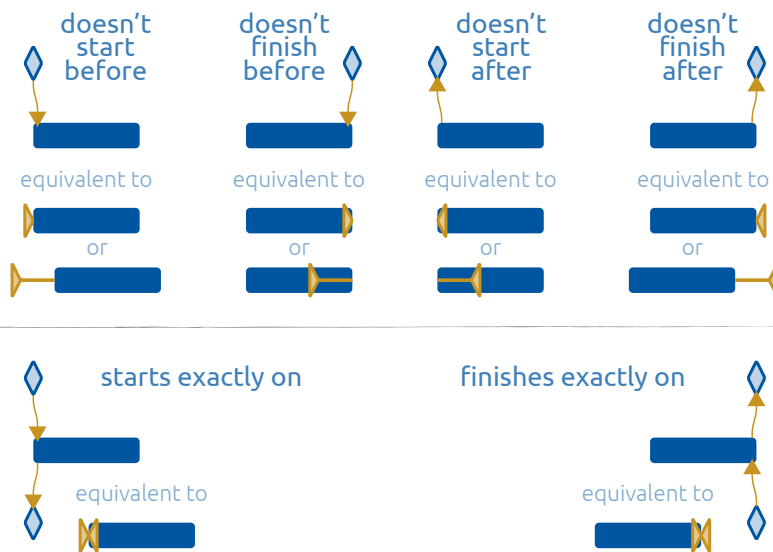


## Design Structure Matrix



## PDM Scheduling

Six possible temporal constraints



## Calendars

The Gregorian Calendar and the calendar handling issue

- one year = 12 months, 365 or 366 days, ca. 52 weeks ↗ every 409 years in average
- one month = from 28 to 31 days, slightly more than four weeks
- one week = seven days, but five working days
- one day = 24 hours, but 7 or 8 working hours
- one hour = 60 minutes and one minute = 60 seconds

! ISO 8601:2004 *Representation of dates and times* → YYYY-MM-DDTHH:MM:SS



## PDM Scheduling

- A given **set of activities**:  $A = \{ a_1, a_2, \dots, a_n \}$
- For each activity, a **duration** is estimated:  $a_i \rightarrow DUR_i$
- Some activities are interdependent by means of **technical constraints**
- ? **Earliest start (ES<sub>i</sub>)** and **earliest finish (EF<sub>i</sub>)** dates
- ? **Latest start (LS<sub>i</sub>)** and **latest finish (LF<sub>i</sub>)** dates
- ? **Total float (TF<sub>i</sub>)**, **free floats (FF<sub>i</sub>)** and **critical path(s)**
- While minimizing the project duration

## PDM Scheduling

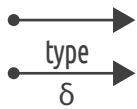
"a PDM convention"

<b>ID</b>	<b>DUR</b>
<b>ES</b>	<b>LS</b>
<b>EF</b>	<b>LF</b>
<b>FF</b>	<b>TT</b>

**ID** Activity ID  
**DUR<sub>ID</sub>** Estimated duration  
**ES<sub>ID</sub>** Earliest start date  
**EF<sub>ID</sub>** Earliest finish date  
**LS<sub>ID</sub>** Latest start date  
**LF<sub>ID</sub>** Latest finish date  
**FF<sub>ID</sub>** Free float (slack)  
**TT<sub>ID</sub>** Total float (slack)

<b>α</b>	<b>ω</b>
<b>E<sub>α</sub></b>	<b>E<sub>ω</sub></b>

**α, ω** Project start and finish nodes  
**E<sub>α</sub>** Project fixed start date ← given!  
**E<sub>ω</sub> (L<sub>ω</sub>)** Project earliest finish date



Technical constraint: default type = finish–start  
 Technical constraint: type (fs, ff, ss, sf) and lag δ

## PDM Scheduling

Calculations in three steps

- 1 Calculation of the **earliest dates** by propagation (**forward pass**) from left to right

The CPM algorithm

**E<sub>α</sub>** ← Project start date  
 Order {**a<sub>j</sub>**} so that **a<sub>i</sub>** < **a<sub>k</sub>**  $\forall i < k$   
 For **j**=1 to |{**a<sub>j</sub>**}| repeat:  

$$ES_j \leftarrow \begin{cases} E_\alpha & \text{if } \Gamma_j^{-1} = \emptyset \\ \max_{k \in \Gamma_j^{-1}} \{ ES_k + DUR_k \} & \text{otherwise} \end{cases}$$

- 2 Calculation of the **latest dates** by propagation (**backward pass**) from right to left

**L<sub>ω</sub>** ← **E<sub>ω</sub>**  
 For **j**=|{**a<sub>j</sub>**}| to 1 repeat:  

$$LF_j \leftarrow \begin{cases} L_\omega & \text{if } \Gamma_j = \emptyset \\ \min_{k \in \Gamma_j} \{ LF_k - DUR_k \} & \text{otherwise} \end{cases}$$

- 3 Calculation of the **total floats** and **free floats**

**TF<sub>j</sub>** ← **LF<sub>j</sub>** – **EF<sub>j</sub>**  
**FF<sub>j</sub>** ←  $\min_{k \in \Gamma_j} \{ ES_k \} - EF_j$



## PDM Scheduling

The real PDM algorithm!

$E_\alpha \leftarrow$  Project start date

Order  $\{a_j\}$  so that  $a_i \prec a_k \forall i < k$

For  $j=1$  to  $|\{a_j\}|$  repeat:

$$ES_j \leftarrow \begin{cases} E_\alpha & \text{if } \Gamma_j^{-1} = \emptyset \\ \max_{k \in \Gamma_j^{-1}} \{ \bullet \} & \text{otherwise} \end{cases}$$

$ES_k + DUR_k + LAG_{kj}$  if  $\sigma_{kj} = "FS"$

$ES_k + LAG_{kj}$  if  $\sigma_{kj} = "SS"$

$ES_k - DUR_j + LAG_{kj}$  if  $\sigma_{kj} = "SF"$

$ES_k + DUR_k - DUR_j + LAG_{kj}$  if  $\sigma_{kj} = "FF"$

$L_\omega \leftarrow E_\omega$

For  $j = |\{a_j\}|$  to 1 repeat:

$$LF_j \leftarrow \begin{cases} L_\omega & \text{if } \Gamma_j = \emptyset \\ \min_{k \in \Gamma_j} \{ \bullet \} & \text{otherwise} \end{cases}$$

$LF_k - DUR_k - LAG_{kj}$  if  $\sigma_{jk} = "FS"$

$LF_k - DUR_k + DUR_j - LAG_{kj}$  if  $\sigma_{jk} = "SS"$

$LF_k + DUR_j - LAG_{kj}$  if  $\sigma_{jk} = "SF"$

$LF_k - LAG_{kj}$  if  $\sigma_{jk} = "FF"$

$TF_j \leftarrow LF_j - EF_j$

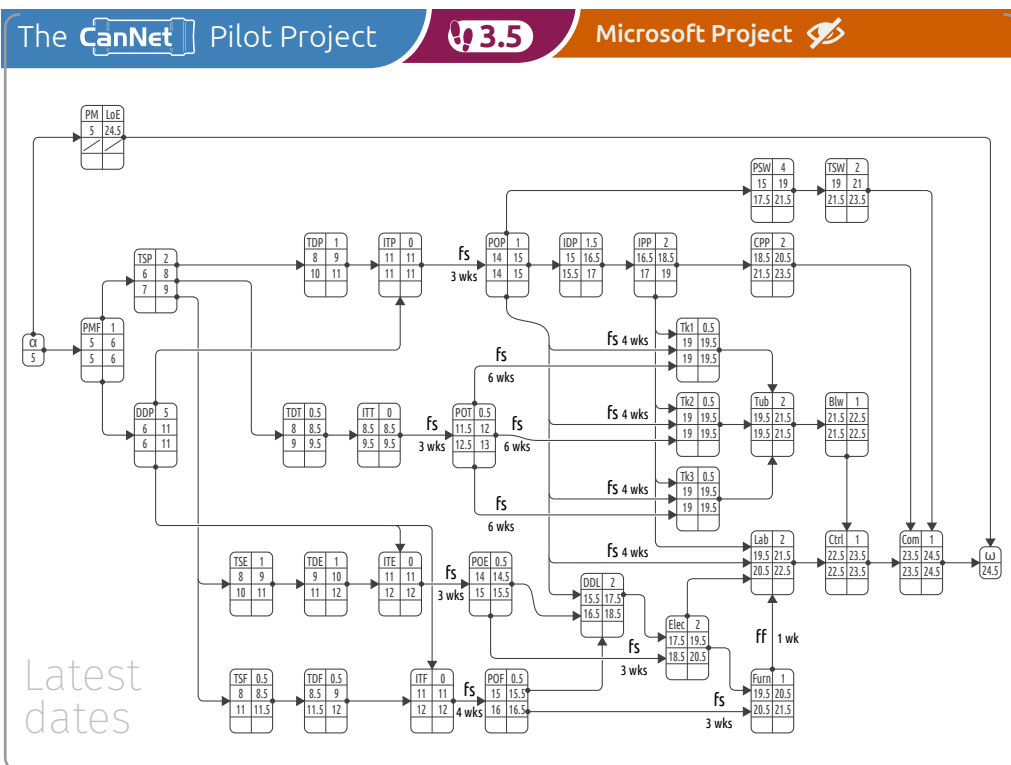
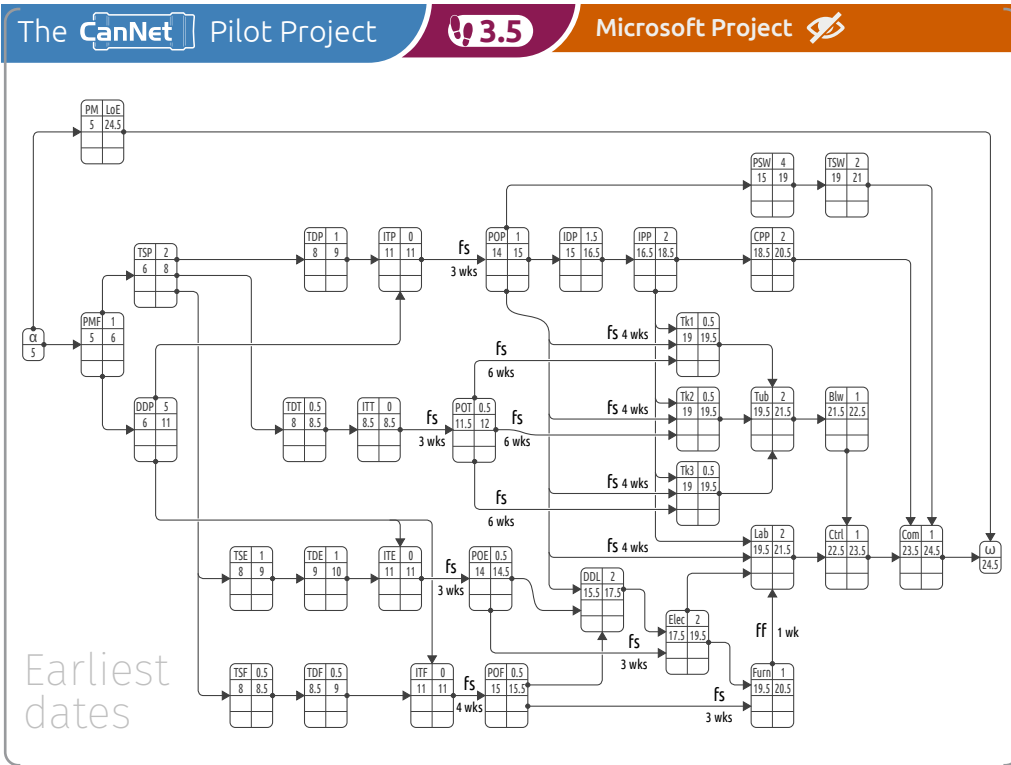
$FF_j \leftarrow \min_{k \in \Gamma_j} \{ ES_k \} - EF_j$

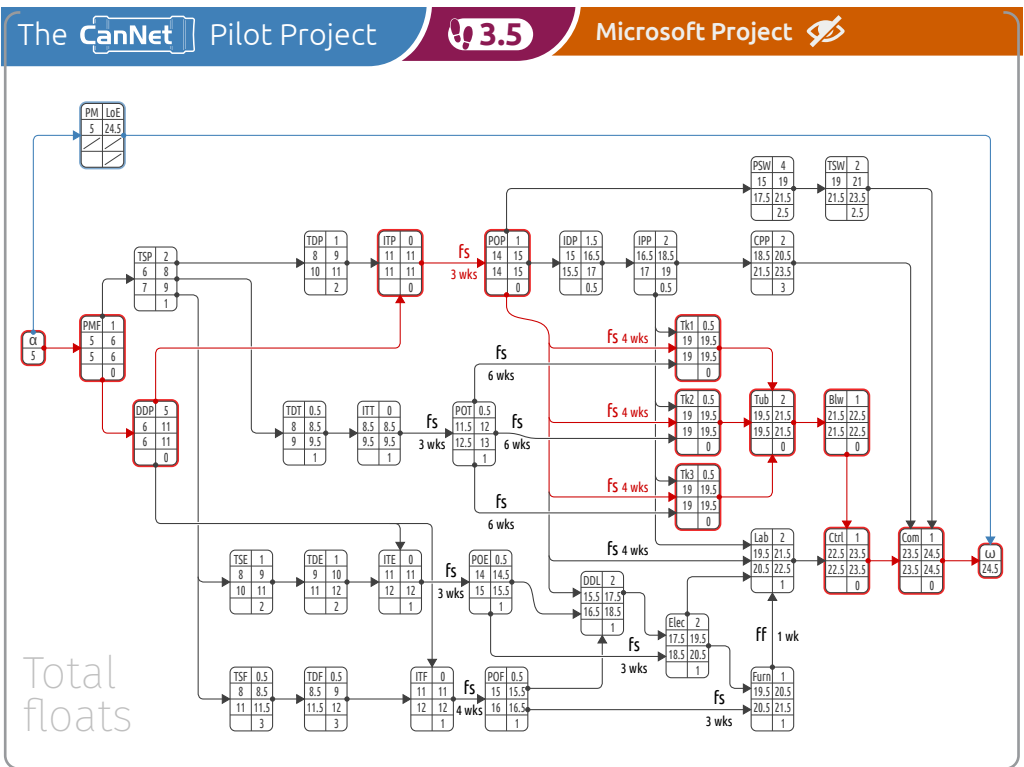
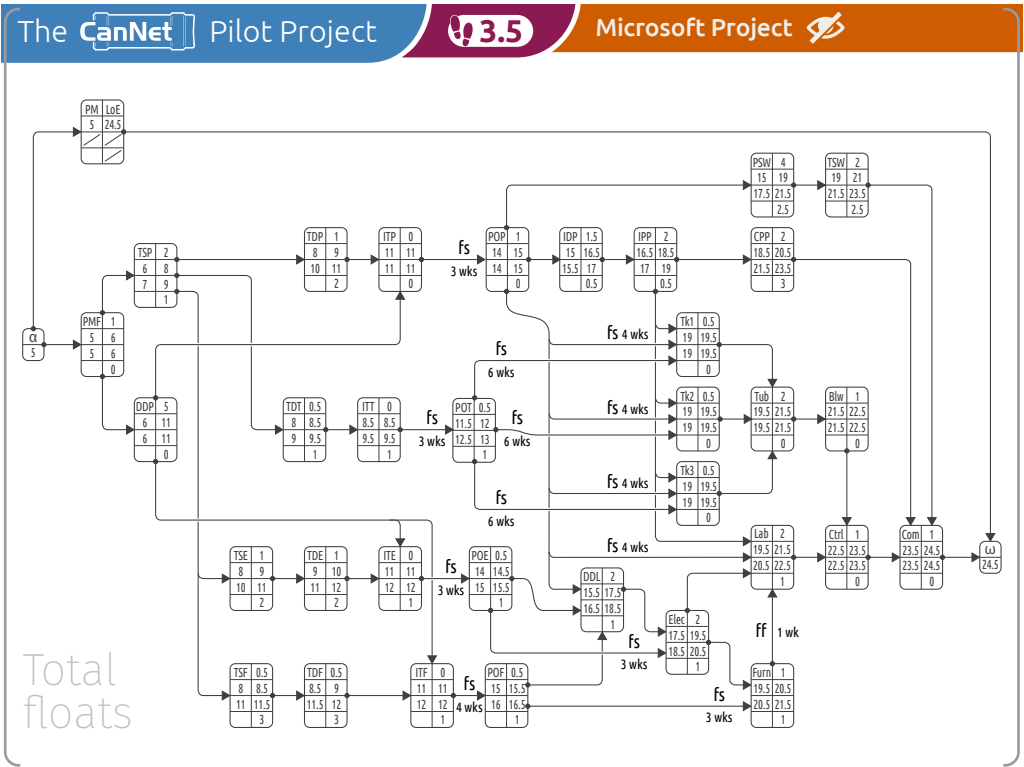
## PDM Scheduling

Floats and Critical Path(s)

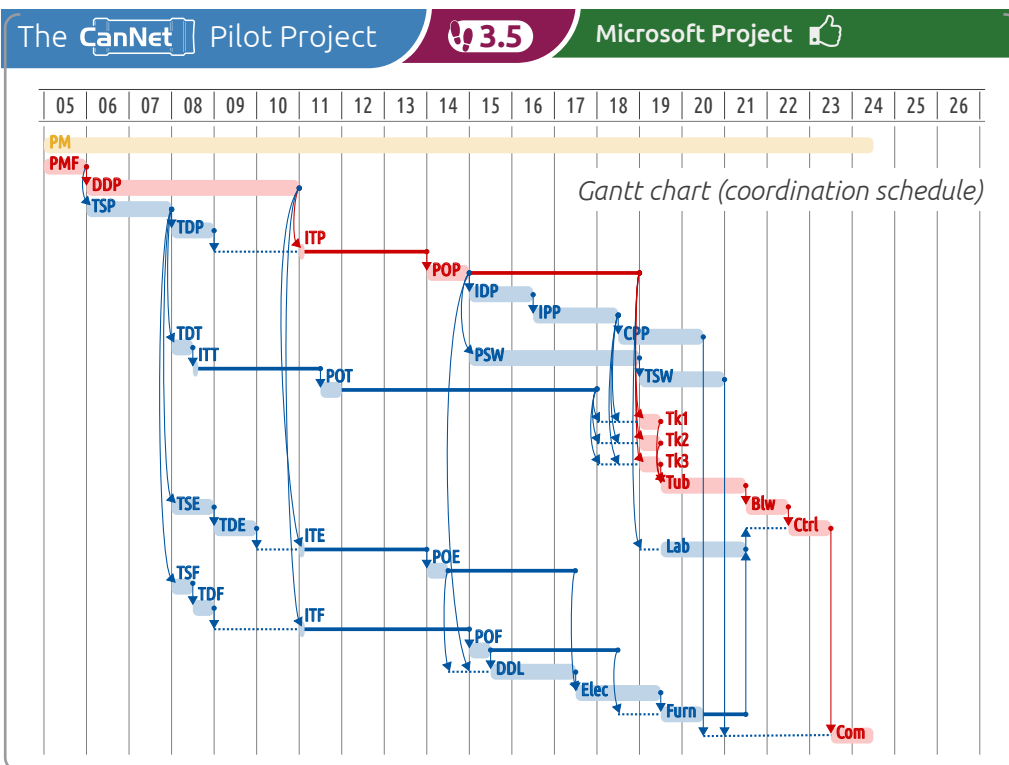
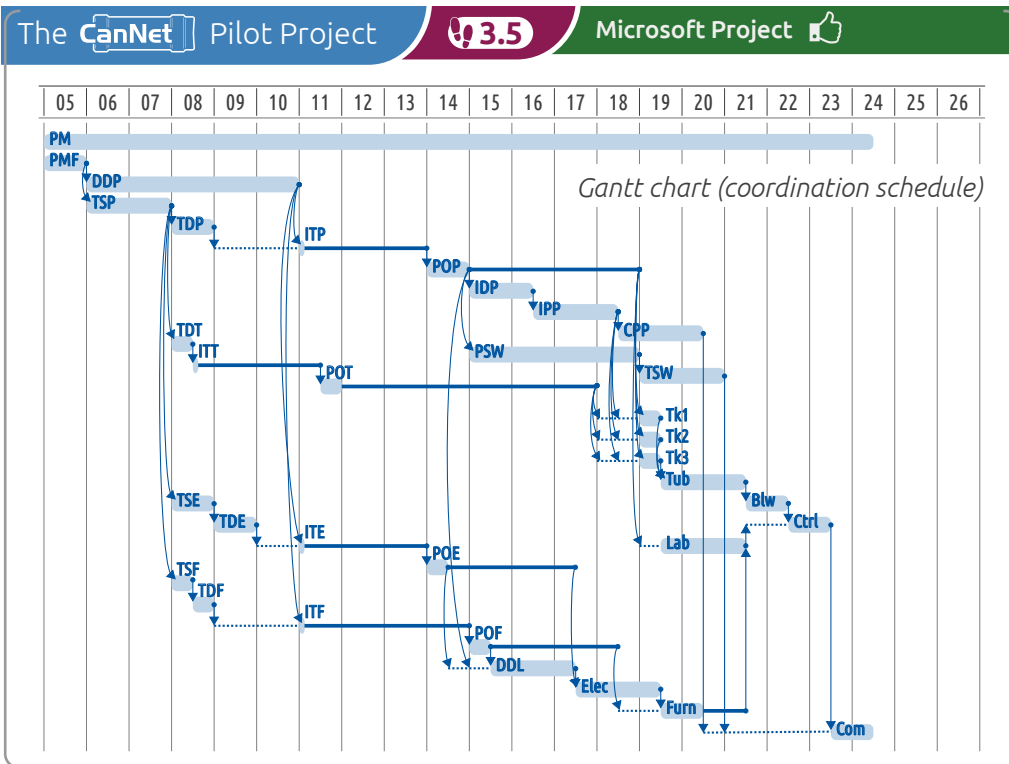
- ⇒ So called **total floats**, **free floats** and **critical paths** are obtained from PDM calculations
- ⇒ **Free float** <sup>Free slack in Microsoft Project</sup> = the amount of time that an activity can be delayed from its earliest start date without causing a delay to **the earliest dates of subsequent activities**
- ⇒ **Total float** <sup>Total slack in Microsoft Project</sup> = the amount of time that an activity can be delayed from its early start date without causing a delay to **the project finish date**
- ⇒ If  $TF_{ID} = 0$  then necessarily  $FF_{ID} = 0$ !
- ⇒ **Critical path** = the sequence of activities which add up to the **longest overall duration**, i.e. which makes the project duration
- ⇒ **Critical activity** = an activity that belongs to a critical path ( $TF_{ID} = 0$ )



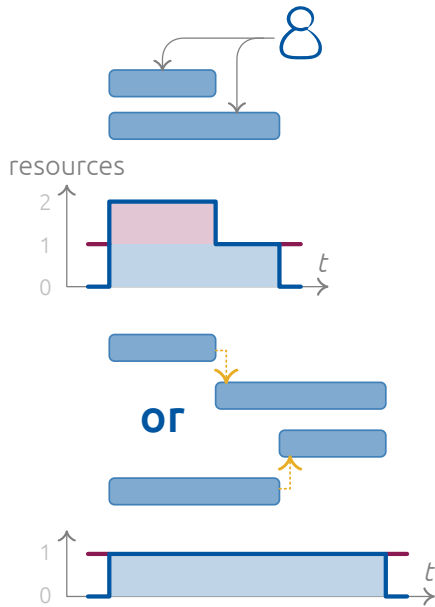








## Resource-Constrained Scheduling

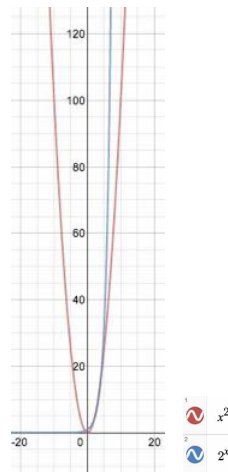


2 activities	1 resource	→	2 combinations
3 activities	1 resource	→	6 combinations
4 activities	1 resource	→	24 combinations
5 activities	1 resource	→	120 combinations
			720 combinations
			5040 combinations
			40320 combinations
			362880 combinations
			3628800 combinations

## Resource-Constrained Scheduling

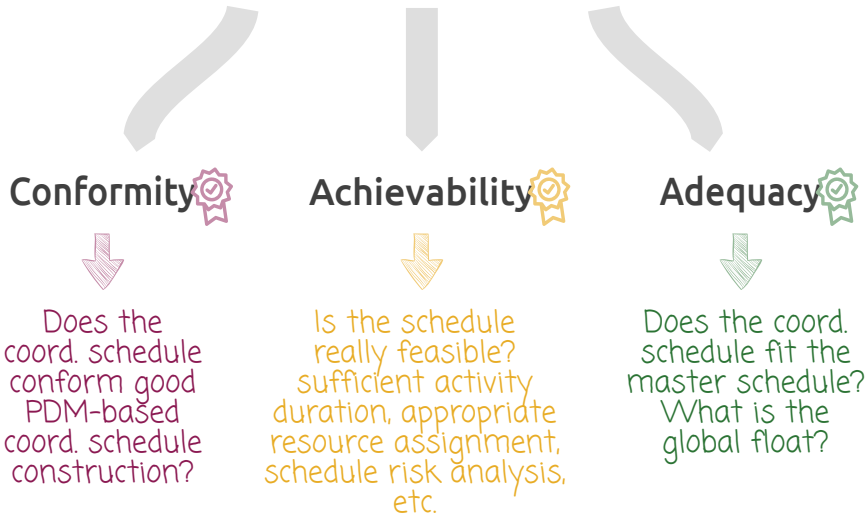
In algorithmics, there are two types of problems:

- Those which complexity grows **polynomially** with the quantity of data to handle →  $O(q) \sim q^c$
- Those which complexity grows **exponentially** with the quantity of data to handle →  $O(q) \sim c^q$
- PDM algorithm → **polynomial** growth algorithm
- Exact solution for the RC-PSP → **exponential** growth algorithm
- Sufficiently good solution for the RC-PSP → **optimization heuristics**  
E.g. → priority-rule-based optimization algorithms



## Schedule Analysis

*Three aspects to look at prior to freeze the coord. schedule baseline*



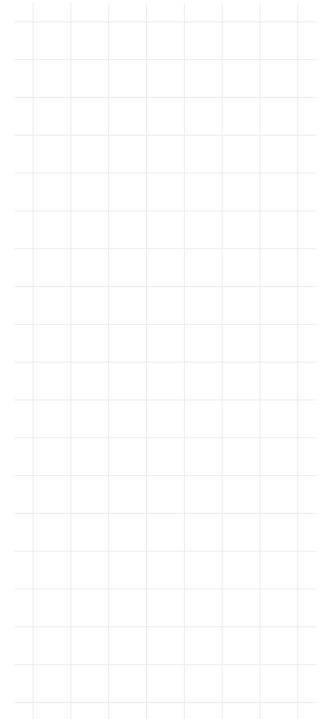
## Schedule Analysis | Conformity

- ➔ Size → # activities < 400
- ➔ Task labelling → action verbs + substantives
- ➔ Activity duration < 10% of project duration
- ➔ Activity typology → # LoE activities < min( 1 ; 1% of # activities )
- ➔ PDM logic
  - ➔ # activities with no predecessor = 0
  - ➔ # activities with no successor = 0
  - ➔ # FS constraints / # constraints > 80%



## Schedule Analysis | Achievability

- General agreement w.r.t. activity duration
- General agreement w.r.t. activity sequencing
- Schedule criticality → # critical activities < 0.3 × # activities

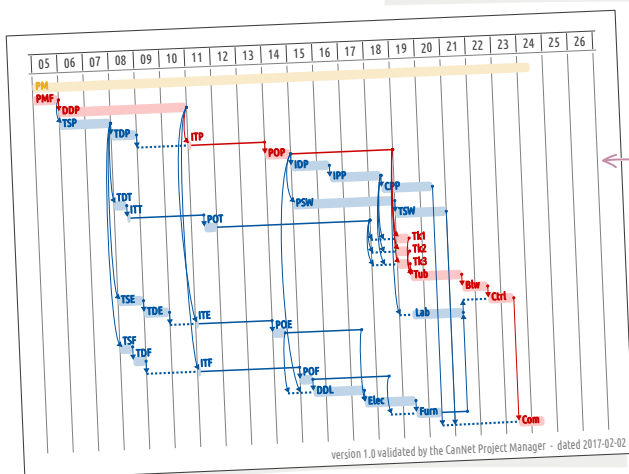
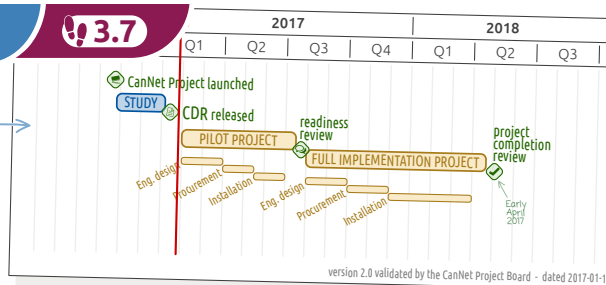


### The CanNet Pilot Project

3.7

#### Project Master Schedule

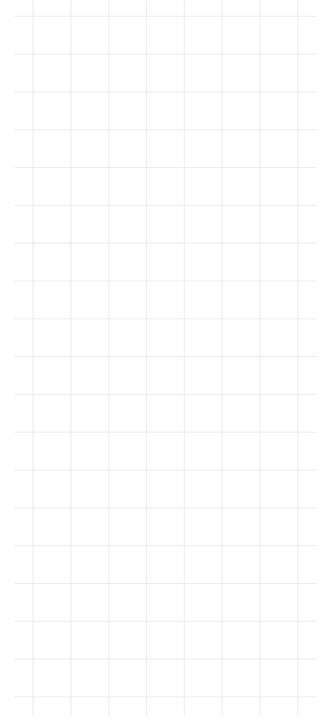
Pilot Project makespan: from end January (Monday of week 05) to mid-July (Friday of week 28)

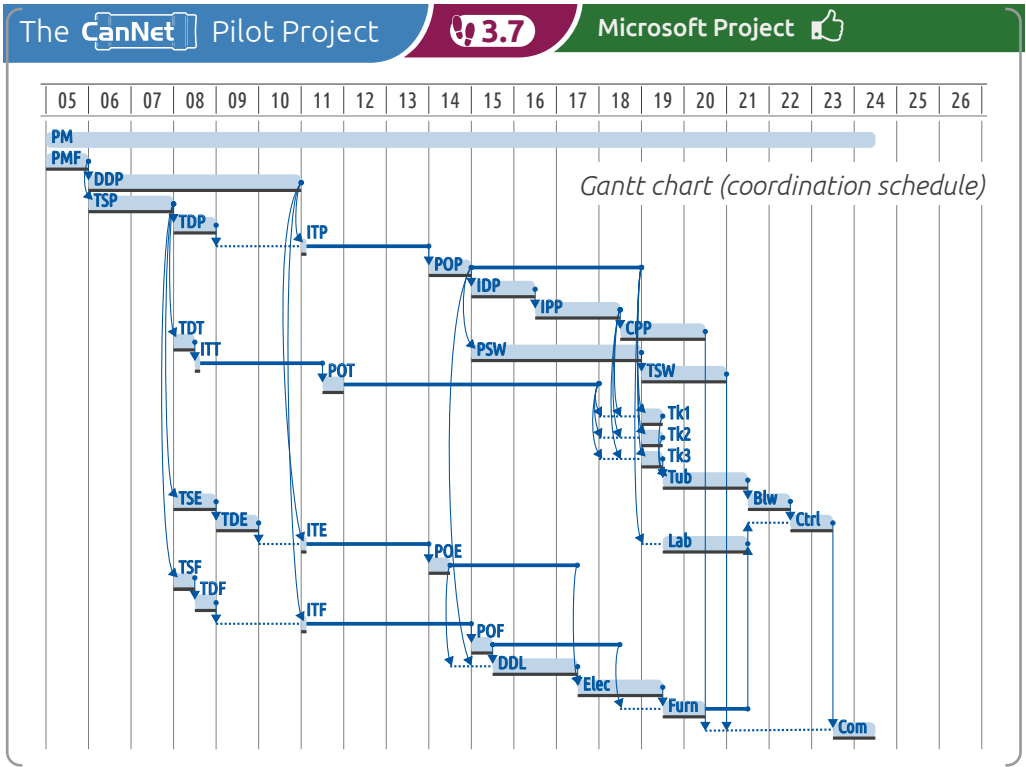


#### Coordination Schedule

Pilot Project makespan: from early week 05 to mid week 24

$$\text{Float} = 29 - 24.5 = 4.5 \text{ wks}$$

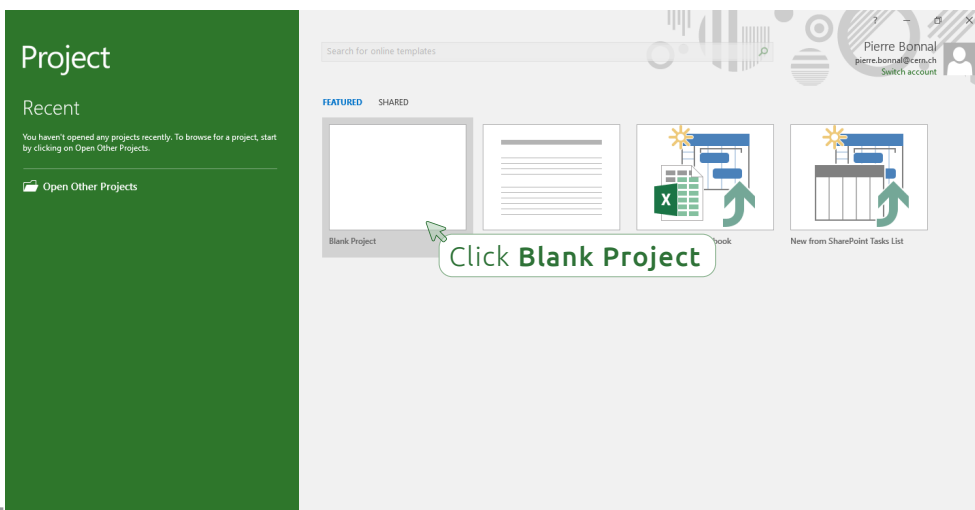




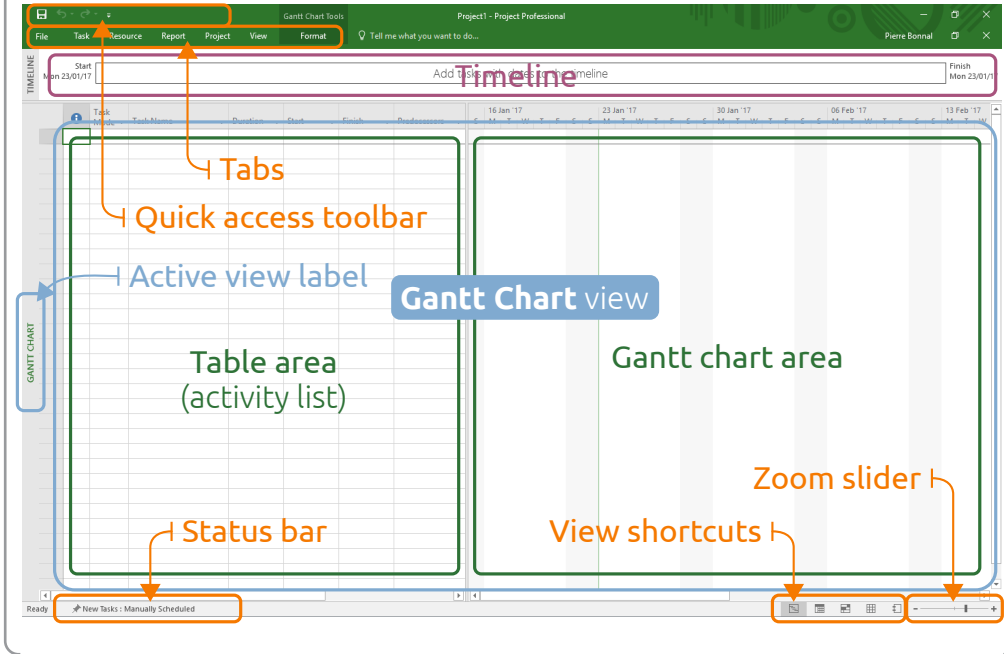
## Launching the software

**Windows 10** ▶ Start Menu ▶ Microsoft Office ▶ Microsoft Project

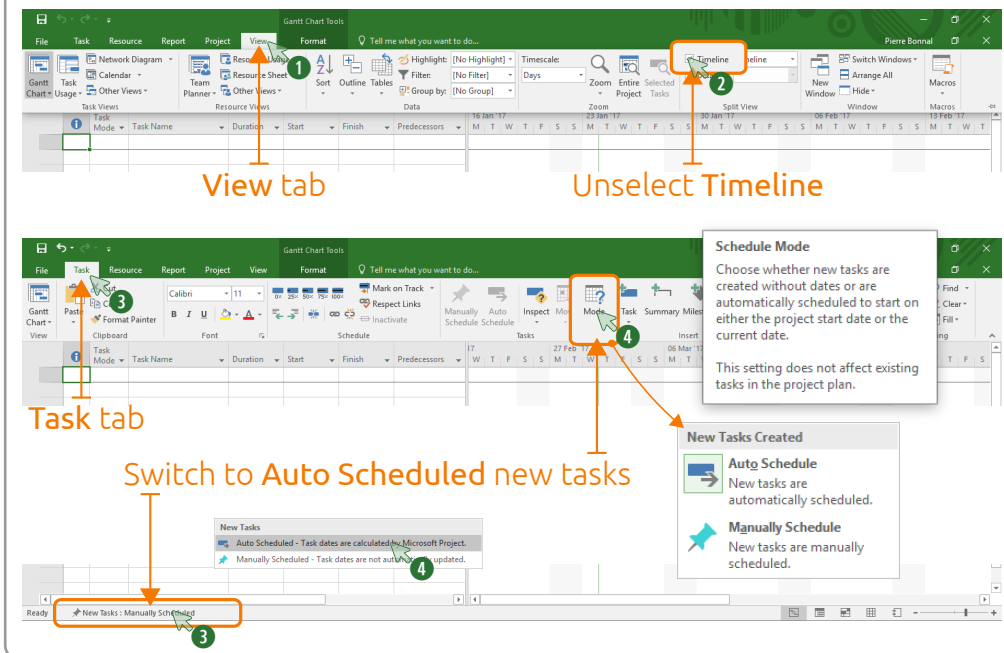
**Mac OS X** ▶ Launchpad ▶ Windows 10 Applications ▶ Microsoft Project



## Getting familiar with Microsoft Project's interface



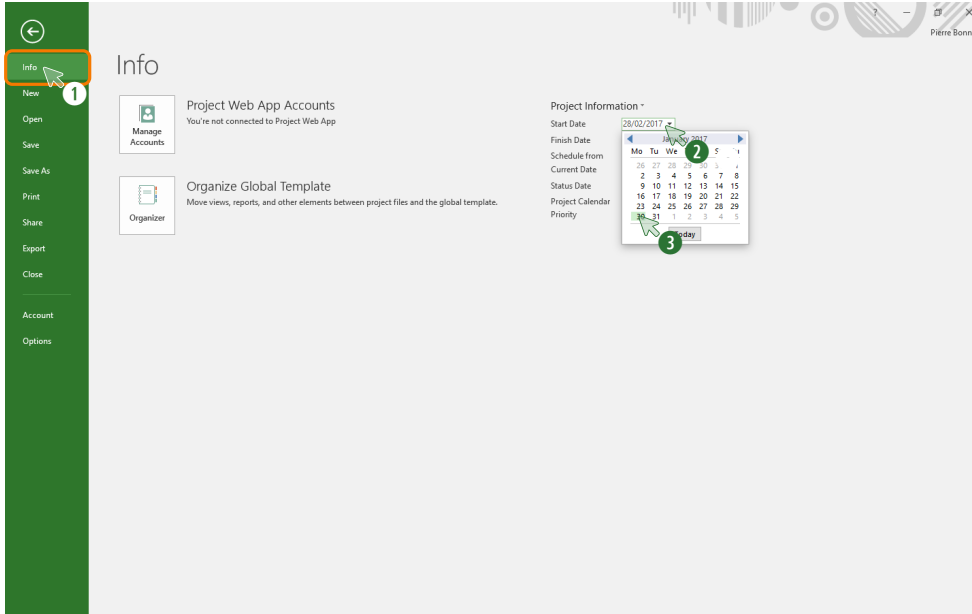
## Setting up a proper scheduling configuration



## Setting the project start date

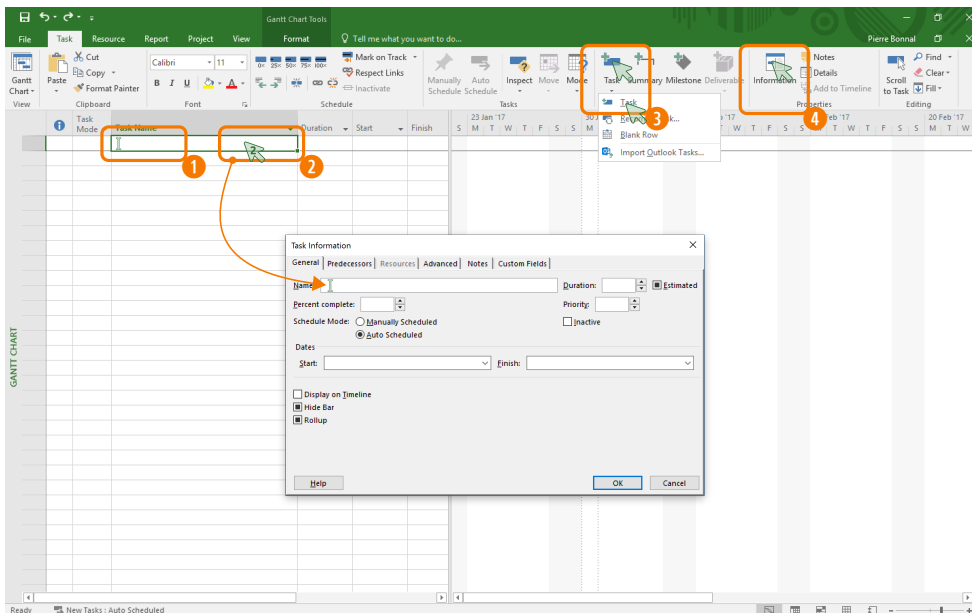
The project start date is a temporal constraint

! 3.4



## Entering and editing activity labels

! 1.4



## Adapting the Gantt view timescale

1.4

**It's up to you**

February 2017						
Su	Mo	Tu	We	Th	Fr	Sa
29	30	31	01	02	03	04
						05
						06

## Entering and updating activity duration

3.1

**type: to get:**

- m or min minutes
- h or hr hours
- d or day days
- w or wk weeks
- mo months

**1 year = 12 months**  
**1 year = 48 weeks**  
**1 week = 5 days**  
**1 day = 8 hours**  
**1 hour = 60 minutes**

## Defining technical constraints



The screenshot shows the Microsoft Project interface with a Gantt chart. A task named 'Perform detailed design of the PTT system' is selected. A dialog box titled 'Task Dependency' is open, showing the relationship between 'Set the project management framework' and 'Perform detailed design of the PTT system'. The dependency type is set to 'Finish-to-Start (FS)' with a lag of 0 days. A 'Task Information' dialog box is also visible, showing details for the selected task.

### Modifying a link

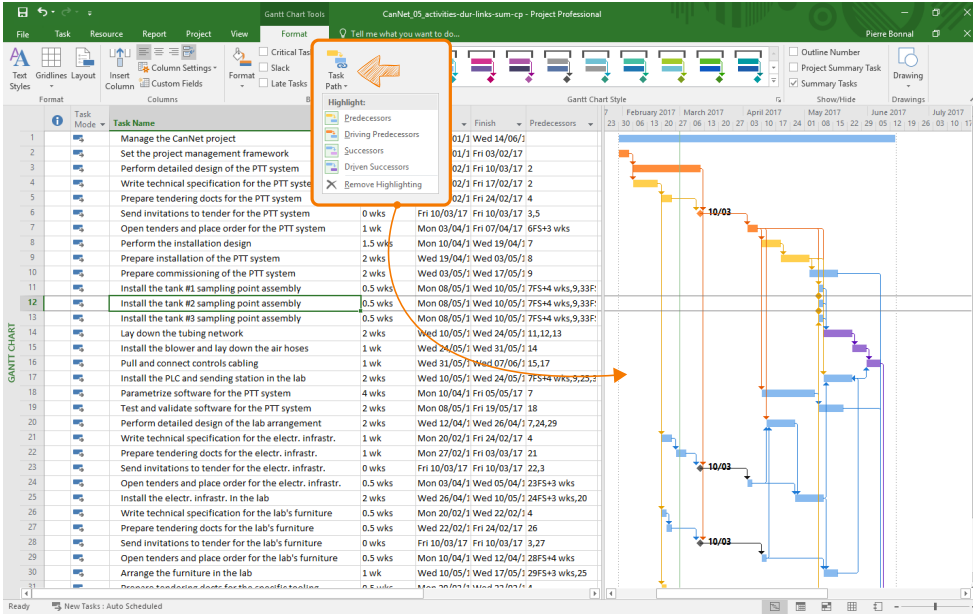
A diagram illustrating the modification of a task link. A mouse cursor is shown clicking on a link between two task bars in the Gantt chart. A 'Task Dependency' dialog box is shown below, with the 'Type' dropdown menu open, highlighting 'Finish-to-Start (FS)'. The 'Lag' is set to '0d'.

## Analysing the resulting schedule (before RCPS)

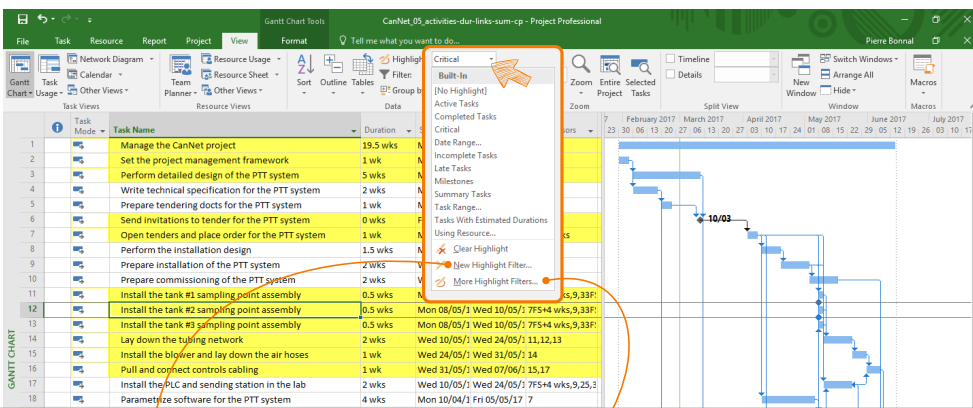


The screenshot shows the Microsoft Project interface with a detailed Gantt chart. The task list on the left includes tasks such as 'Manage the CanNet project', 'Set the project management framework', 'Perform detailed design of the PTT system', and 'Write technical specification for the PTT system'. The Gantt chart shows the duration and dependencies of these tasks, with a critical path highlighted in red. The 'Task Information' dialog box is also visible, showing details for the selected task.

## Analysing the resulting schedule (before RCPS)



## Analysing the resulting schedule (before RCPS)



More Filters

Filter:  Task  Resource

- Active Tasks
- Completed Milestones
- Completed Tasks
- Cost Greater Than...
- Cost Overbudget
- Created After...
- Critical
- Date Range...
- In Progress Tasks
- Incomplete Tasks
- Late Milestones
- Late Tasks
- Late/Overbudget Tasks Assigned To...

Buttons: Highlight, Apply, Cancel

Filter Definition

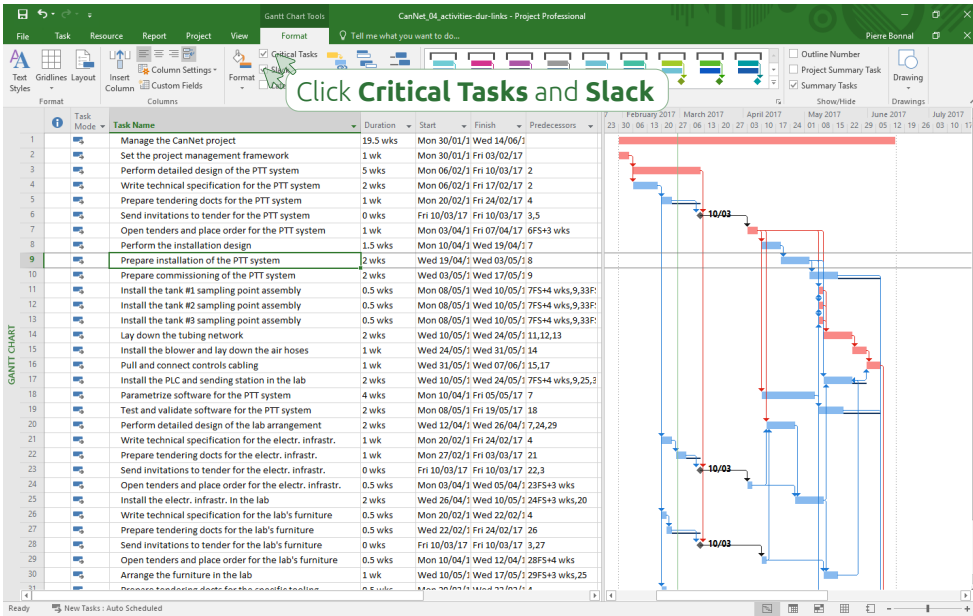
Name: Filter1

Filter:

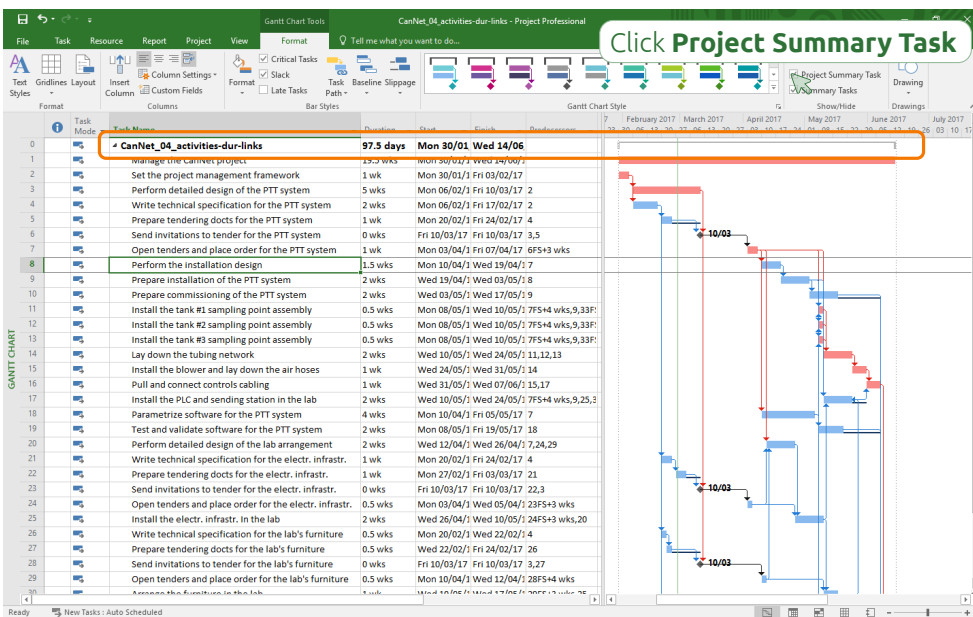
And/Or	Field Name	Test	Value(s)

Buttons: Cfg Row, Copy Row, Paste Row, Insert Row, Delete Row, Apply, Save, Cancel

## Analysing the resulting schedule (before RCPS)

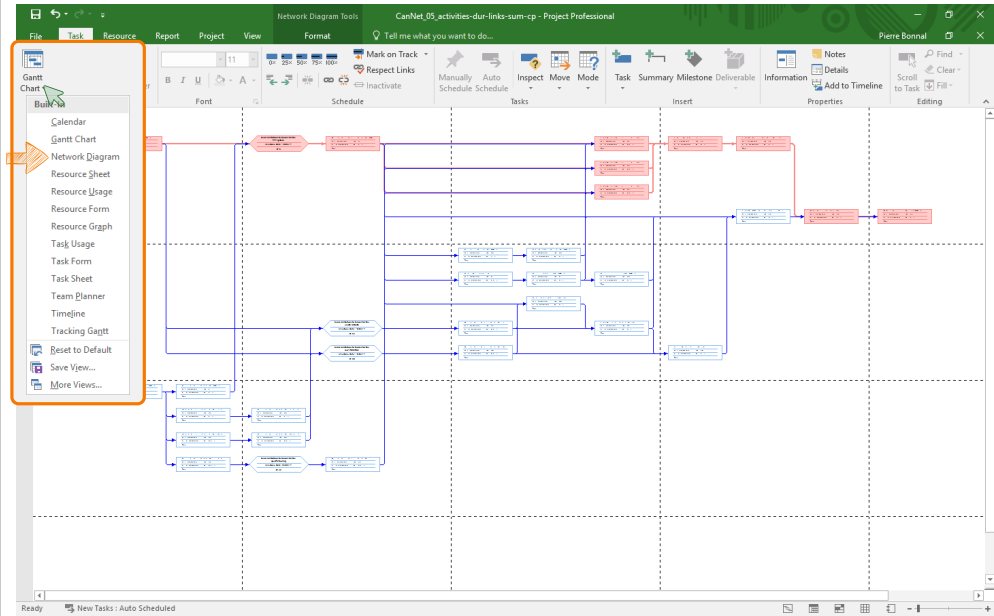


## Analysing the resulting schedule (before RCPS)

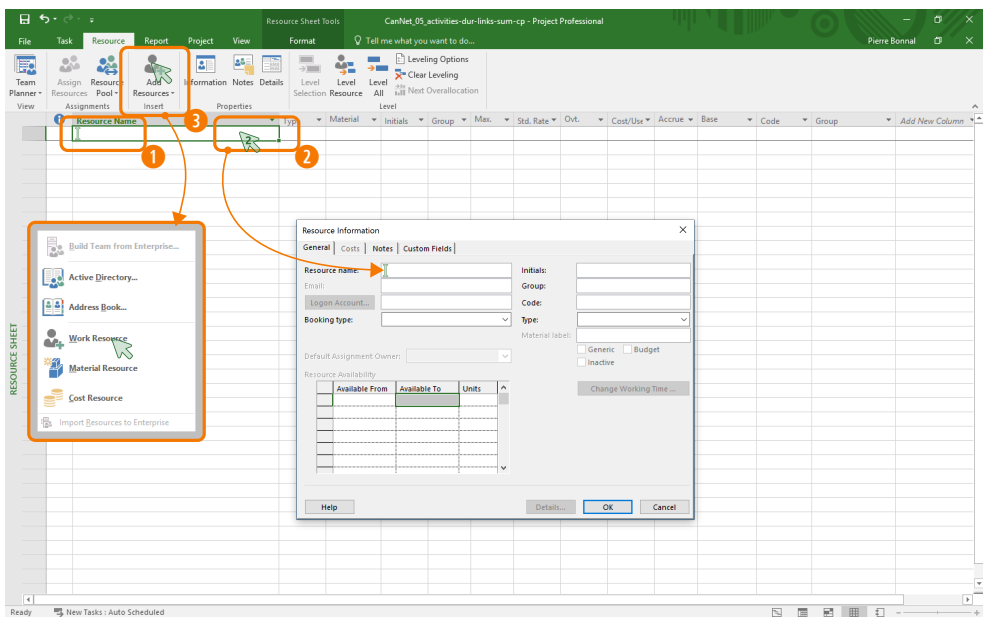




## Analysing the resulting schedule (before RCPS)



## Entering and editing resources



## Entering and editing resources

2.1

The screenshot shows the Resource Sheet in Microsoft Project. A dropdown menu for the 'Type' column is open, showing options: Work, Material, and Cost. A red box highlights the 'Material' option. A green callout box with a warning icon contains the following text:

<b>Work</b>	People & machines	Time dependent
<b>Material</b>	Consumables	Time independent
<b>Cost</b>	Financial means	Time independent

## Assigning resources to activities

2.3

The screenshot shows the Gantt Chart in Microsoft Project. A task named 'Set the project management framework' is selected. The 'Resources' list on the right shows a list of resources with checkboxes. Two dialog boxes are shown:

- Assign Resources**: Shows a list of resources with columns for Resource Name, R/D, Units, and Cost. The 'Assign' button is highlighted.
- Task Information**: Shows the 'Resources' tab for the selected task. The 'Resources' list is populated with the selected resources, including columns for Name, Assignment Owner, Units, and Cost.

Numbered callouts (1, 2, 3, 4) indicate the sequence of actions: 1. Selecting a resource in the list, 2. Clicking the 'Assign' button, 3. Clicking the 'Assign Resources' button in the ribbon, and 4. Clicking the 'Resources' button in the ribbon.

## Assigning resources to activities

2.3

The screenshot shows the Microsoft Project interface with the 'Resource Initials' column highlighted. A macro named 'CanNet' is displayed, containing a list of tasks and their durations. The tasks are:

Task Name	Duration
Manage the CanNet project	19.5 wks
Set the project management framework	1 wk
Perform detailed design of the PTT system	5 wks
Write technical specification for the PTT system	2 wks
Prepare tendering docs for the PTT system	1 wk
Send invitations to tender for the PTT system	0 wks
Open tenders and place order for the PTT system	1 wk
Perform the installation design	1.5 wks
Prepare commissioning of the PTT system	2 wks
Install the tank #1 sampling point assembly	0.5 wks
Install the tank #2 sampling point assembly	0.5 wks
Install the tank #3 sampling point assembly	0.5 wks
Lay down the tubing network	2 wks
Install the blower and lay down the air hoses	1 wk
Pull and connect controls cabling	1 wk
Install the PLC and sending station in the lab	2 wks
Parametrize software for the PTT system	4 wks
Test and validate software for the PTT system	2 wks
Perform detailed design of the lab arrangement	2 wks
Write technical specification for the electr. infrastr.	1 wk
Prepare tendering docs for the electr. infrastr.	1 wk
Send invitations to tender for the electr. infrastr.	0 wks
Open tenders and place order for the electr. infrastr.	0.5 wks
Install the electr. infrastr. in the lab	2 wks
Write technical specification for the lab's furniture	0.5 wks
Prepare tendering docs for the lab's furniture	0.5 wks
Send invitations to tender for the lab's furniture	0 wks
Open tenders and place order for the lab's furniture	0.5 wks
Arrange the furniture in the lab	1 wk
Prepare tendering docs for the specific tools	0.5 wks

Annotations in the image include: 'Run macro' pointing to the 'CanNet' macro, 'Paste' pointing to the 'Resource Initials' column, 'Select range' pointing to the task list, and 'Select range + copy' pointing to the task list.

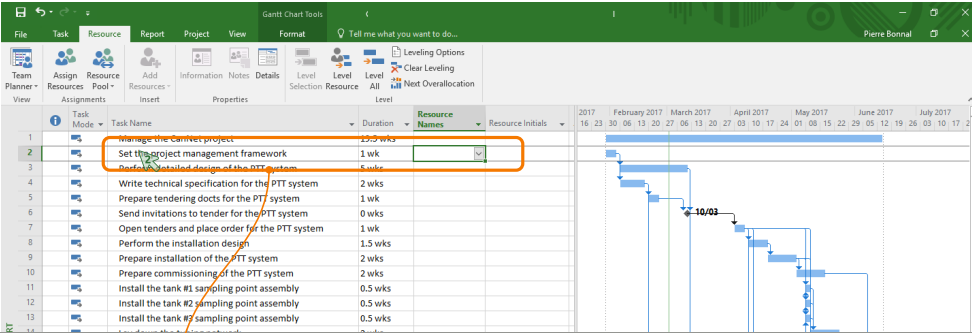
## Assigning resources to activities

2.3

The screenshot shows the Microsoft Project interface with the 'Resource Graph' view selected. The graph displays resource usage over time for 'Tom Ayrton | Senior Plant Engineer' and 'Bob Harvey | Senior Plant Designer'. The graph shows that Tom Ayrton is overallocated (red bars) and Bob Harvey is allocated (blue bars). A legend indicates: Overallocated (red), Allocated (blue), Proposed (purple). Annotations include 'Click once' pointing to the 'Resource Graph' view and 'Resource Graph view' pointing to the graph itself.

## Before leveling

3.6



Task Information

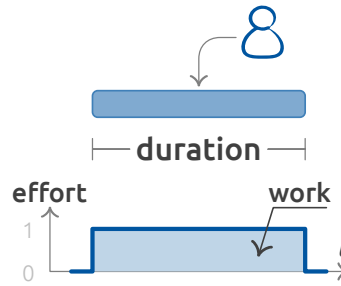
Name: Set the project management framework | Duration: 1 wk | Estimated

Constraint type: As Soon As Possible | Constraint date: NA

Task type: Fixed Units

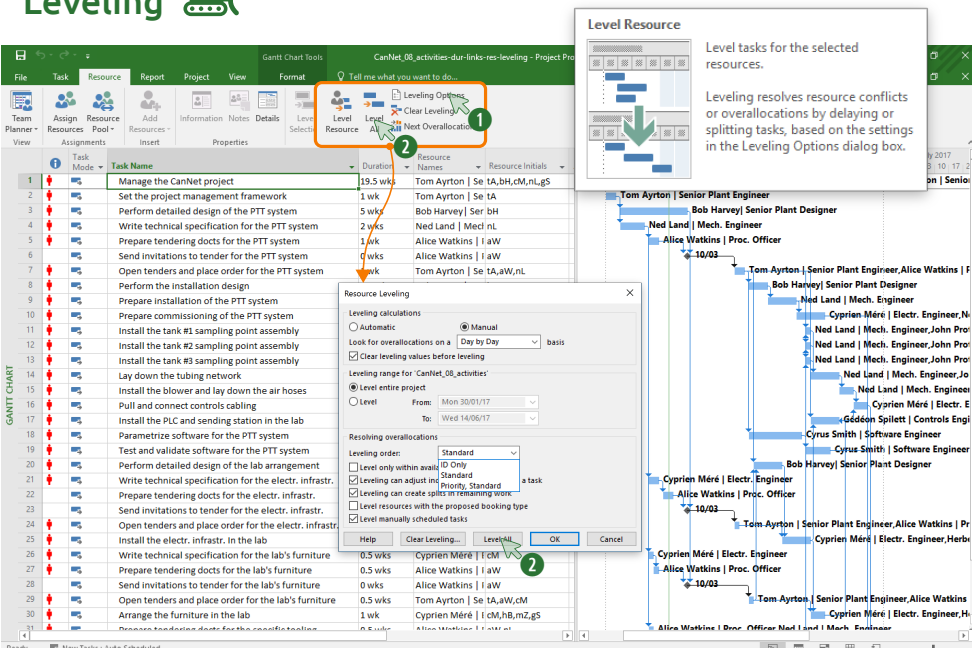
Calendar: Fixed Units

WBS code: Fixed Work

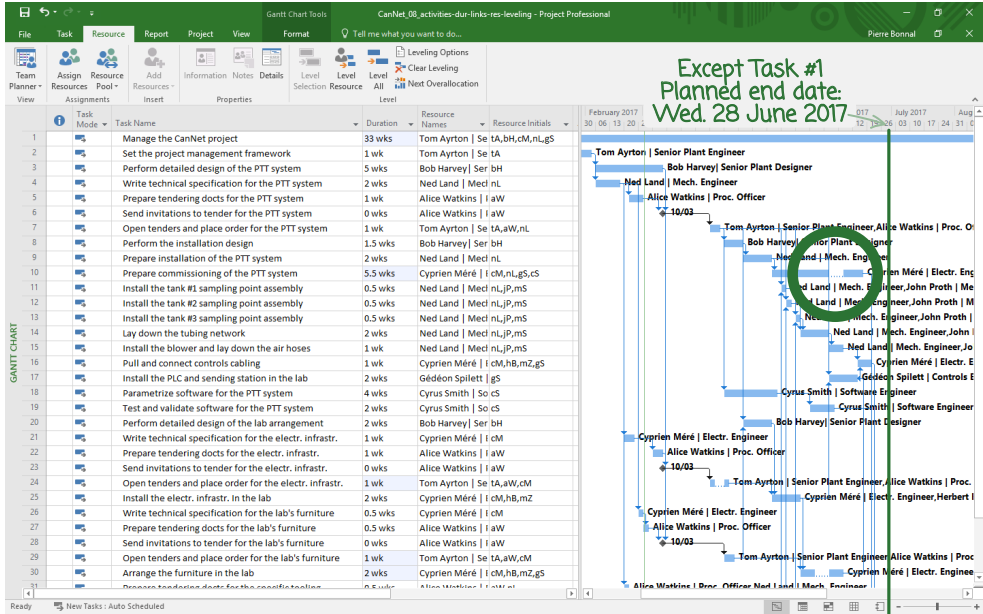


## Leveling

3.6



# Schedule analysis

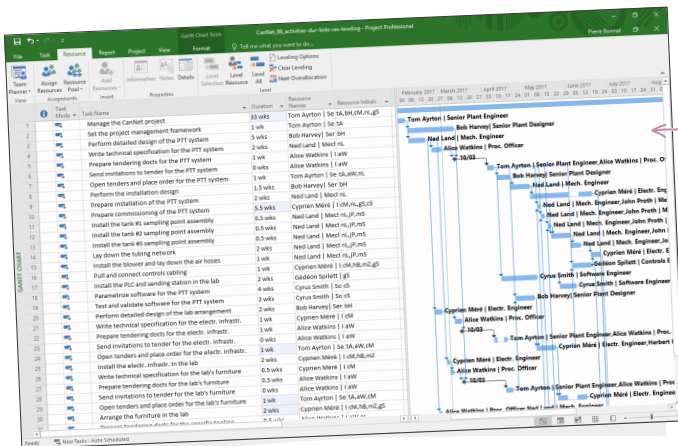
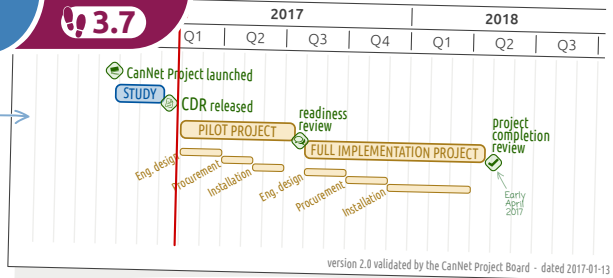


## The CanNet Pilot Project



### Project Master Schedule

Pilot Project makespan: from end January (Monday of week 05) to mid-July (Friday of week 28)



### Coordination Schedule

Pilot Project makespan: from early week 05 to mid week 26

$$\text{Float} = 29 - 26.5 = 2.5 \text{ wks}$$



# Baselining



**Set Baseline**  
Take a snapshot of your schedule that includes information about tasks, resources, and assignments.  
Compare multiple baselines to see how your project has changed over time.

The screenshot shows the Microsoft Project interface. The 'Set Baseline' dialog box is open, with the 'Set Baseline' radio button selected. The 'Set interim plan' section is also visible. The Gantt chart shows a project schedule with tasks and resources. A callout box highlights the 'Set Baseline' button in the ribbon. A callout box highlights the 'Set Baseline' dialog box. A callout box highlights the 'Set Baseline' button in the ribbon. A callout box highlights the 'Set Baseline' dialog box.