

# CONSTRUCTION SCHEDULING

PhD. Eng. Jerzy Rosłon, ACIOB, PSMB, IPMA  
**Institute of Building Engineering**

**Schedule** - planned dates of **activities** and planned **milestones** of the schedule (significant events in the project, e.g. end of a stage, acceptance).

**Scheduling** - finding such start dates for all activities that meet the constraints related to the relationships between them and the availability of resources, with the simultaneous optimization of the objective function (it may be, for example, minimizing the duration of the project or maximizing NPV).

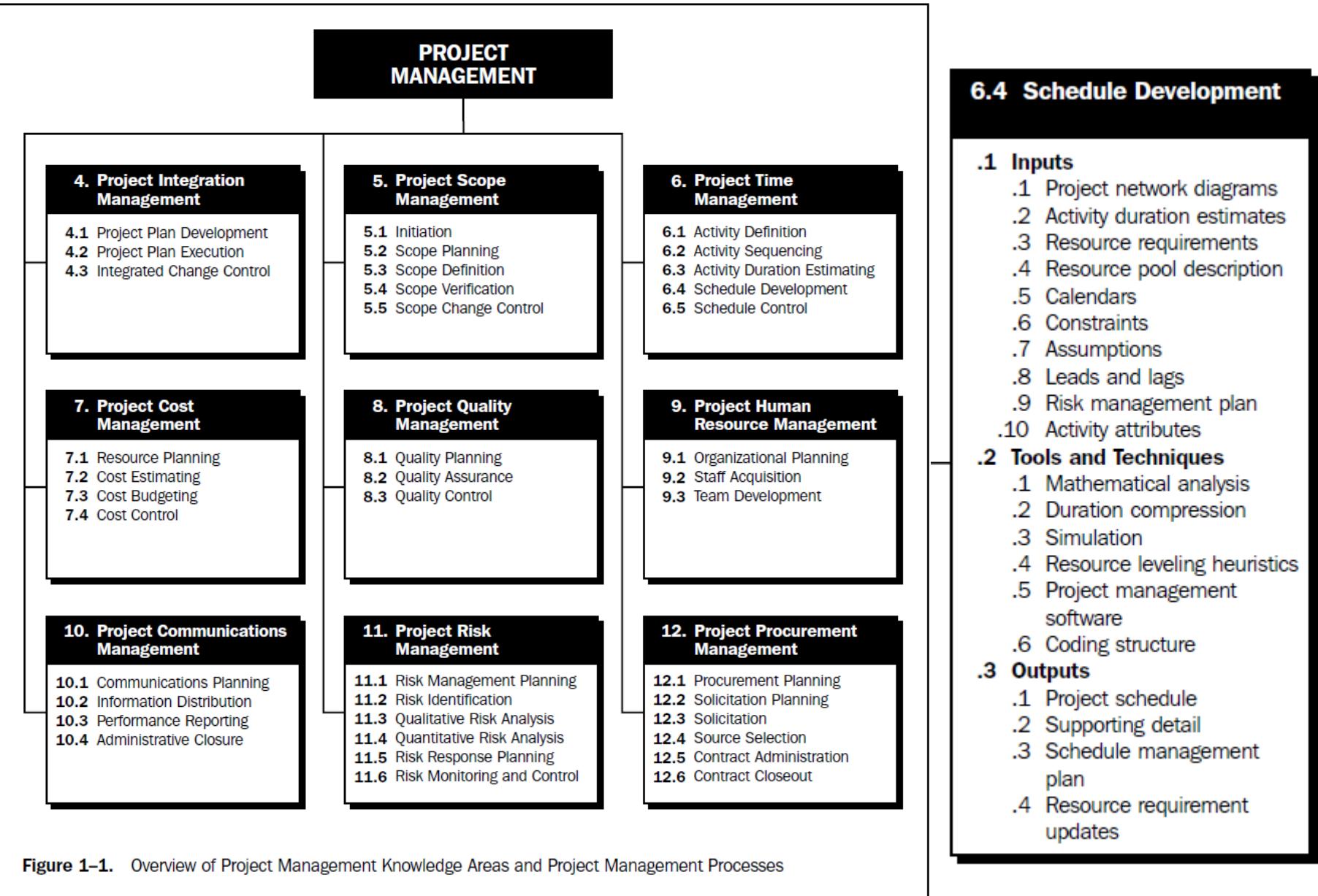
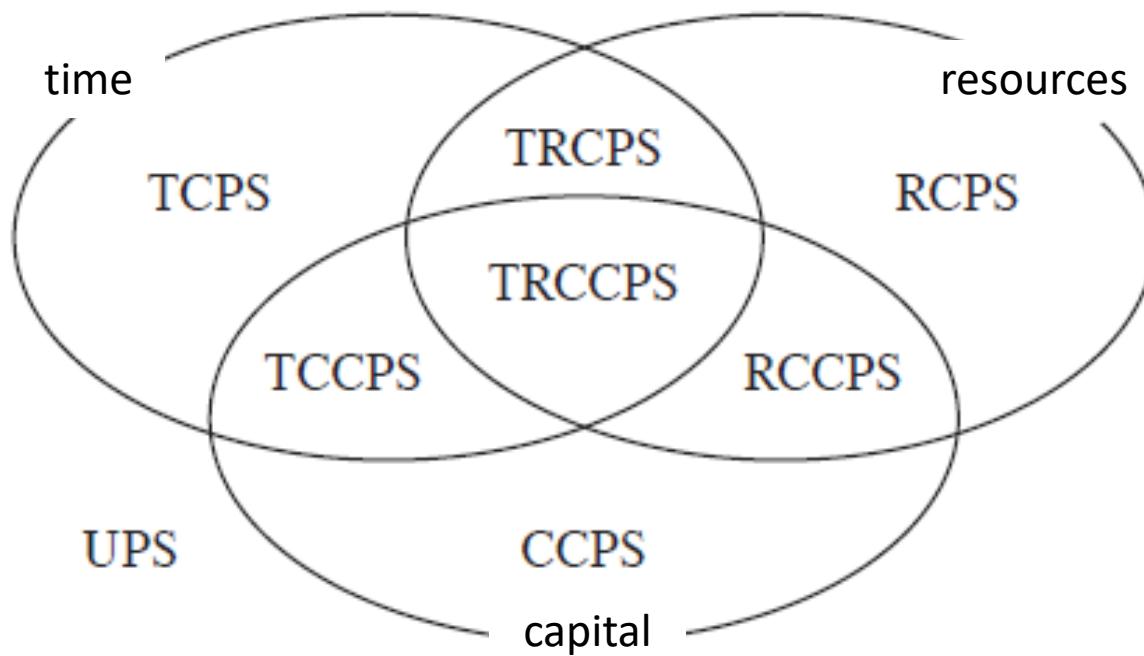


Figure 1–1. Overview of Project Management Knowledge Areas and Project Management Processes

Project Management Institute. (2004). A Guide to the Project Management Body of Knowledge, Third Edition, PMI, USA.



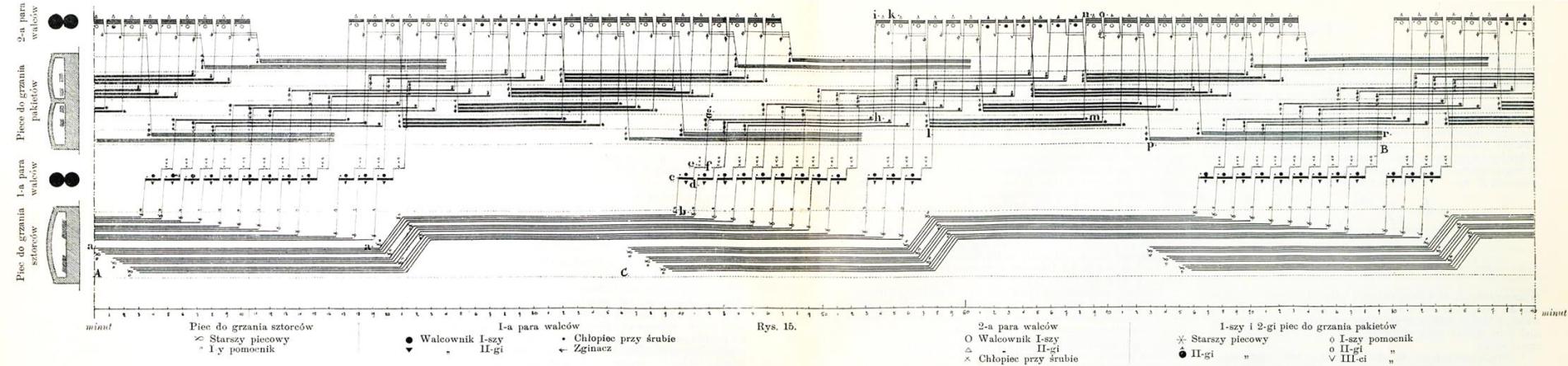
- UPS - *unconstrained project scheduling*
- TCPS - *time constrained project scheduling*
- RCPS - *resource constrained project scheduling*
- CCPS - *capital constrained project scheduling*
- TRCPS - *time and resource constrained project scheduling*
- TCCPS - *time and capital constrained project scheduling*
- RCCPS - *resource and capital constrained project scheduling*
- TRCCPS - *time, resource and capital constrained project scheduling*

Kostrubiec, A. (2003). Harmonogramowanie realizacji projektów-przegląd modeli. W: Inżynieria zarządzania przedsięwzięciami. Red. L. Zawadzka. Gdańsk, 2003.

other examples:

- Deterministic vs. Non-deterministic
- Master project schedule vs. Milestone schedule / summary schedule vs. Detailed project schedule
- *Multi-Mode Resource-Constrained Project Scheduling* - **MRCPS**,
- *Multi-Mode Resource-Constrained Time-Cost Trade-off*,  
**MRC-TCT** or **RC-TCT**),
- *Time, Resource & Capital Constrained Project Scheduling Problem* - **TRCCPSP**,
- **P-MRCPSP** - *preemptive scheduling*,
- *MRCPSP with Discounted Cash Flows* – **MRCPSPDCF**,  
.....and many, many more....

# Karol Adamiecki and Henry Gantt



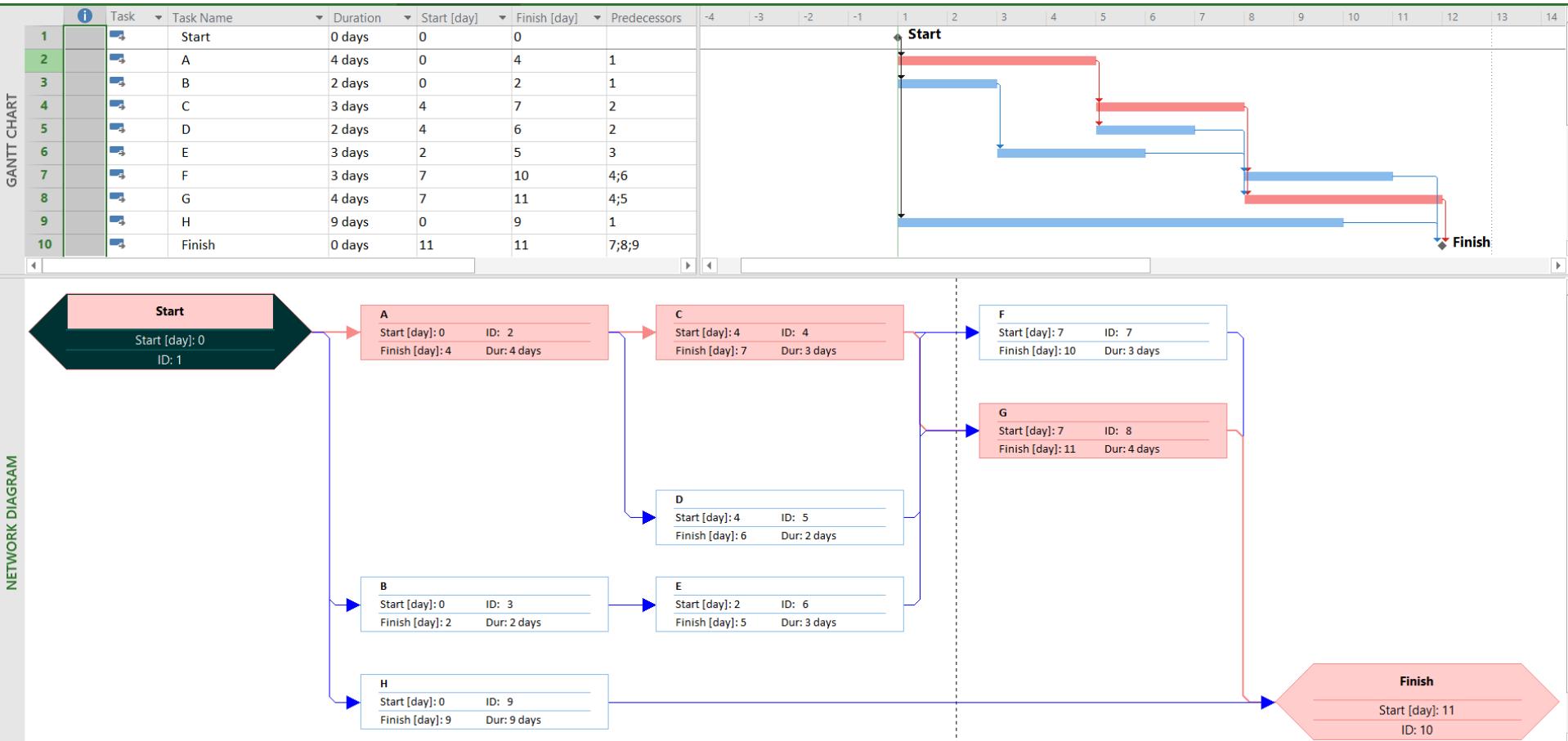
Karol Adamiecki, 1909, Metoda wykreślna organizowania pracy zbiorowej w walcowniach, w: Przegląd Techniczny 19 (47)

SYMBOL	DEPARTMENT OR MACH. CLASS	% OF CAPACITY USED ON Day TURN	TOTAL EXPENSE OF IDLENESS	DETAILS OF IDLENESS EXPENSE DUE TO				
				LACK OF WORK	LACK OF HELP	LACK OF AND POOR MATERIAL	REPAIRS	POOR PLANNING
	Spinning	18 10	18 70					
	Winding	118 14		103 74			15 00	
	Doubling	10 61	10 61					
	Twisting	17 95	17 95					
	Quilling	20 67	10 67	10 00				
	Warping	390 75			390 75			
	Weaving	915 25	75 00		840 25			
	Finishing	210 72			210 72			
	Inspecting	49 70		10 70	39 00			
	Shipping	216 17	66 00		150 17			
	Total	1969 26	198 93	124 44	1630 89			

Crank Handles	Order Number	January					February					March									
		14	17	21	24	28	31	4	7	11	14	18	21	25	28	3	6	10	13	17	20
No. 14-F-Spec.	90 59031		-	1	2	3		4	5	6	7										
No. 12-F-Spec.	60 59032		-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	5			
No. 14-F	100 59043		-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	5			
No. 8-F-Spec	10 59063		-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	5			
No. 10-F-Spec.	10 59064		-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	5			
No. 8-F-Spec.	100 59065		-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	5			
No. 14-F-Spec.	100 59067			-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	5		

<https://www.onepager.com/community/blog/a-brief-history-of-the-gantt-chart/>

# Network vs. Gantt chart



# MS Project

**Training Project Schedule - Project Professional**

Rosłon Jerzy

**TIMELINE**

Start Mon 16-01-04 00:00 Pre Construction Mon 16-02-01 09:00 - Tue 17-01-24 17:00

Material Procurement Mon 16-01-18 09:00 - Fri 16-04-22 17:00

Finish Wed 17-03-29 17:00

**GANTT CHART TOOLS**

**FORMAT**

**Task Mode**

**Task Name**

**Duration**

**Start**

**Finish**

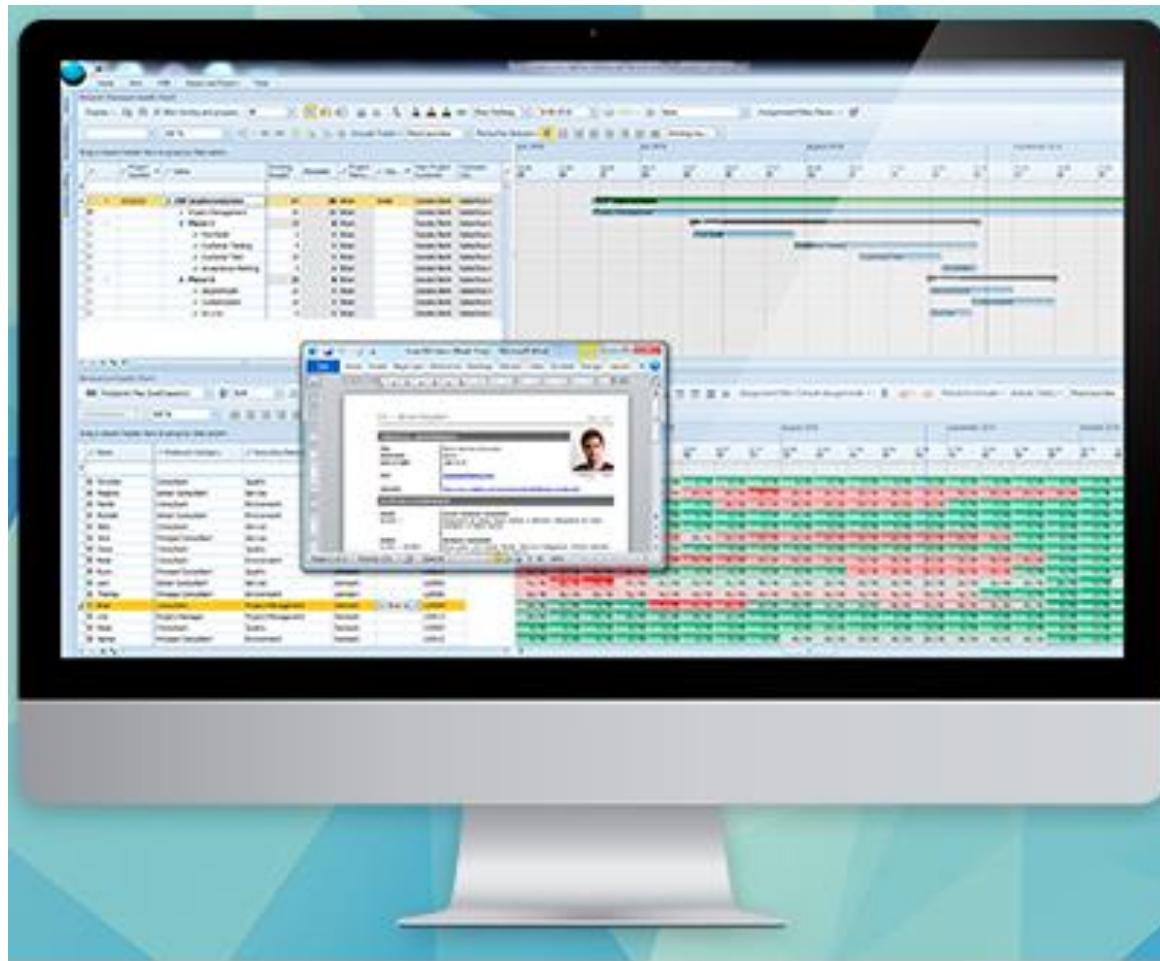
**Predecessors**

**GANTT CHART**

01-04

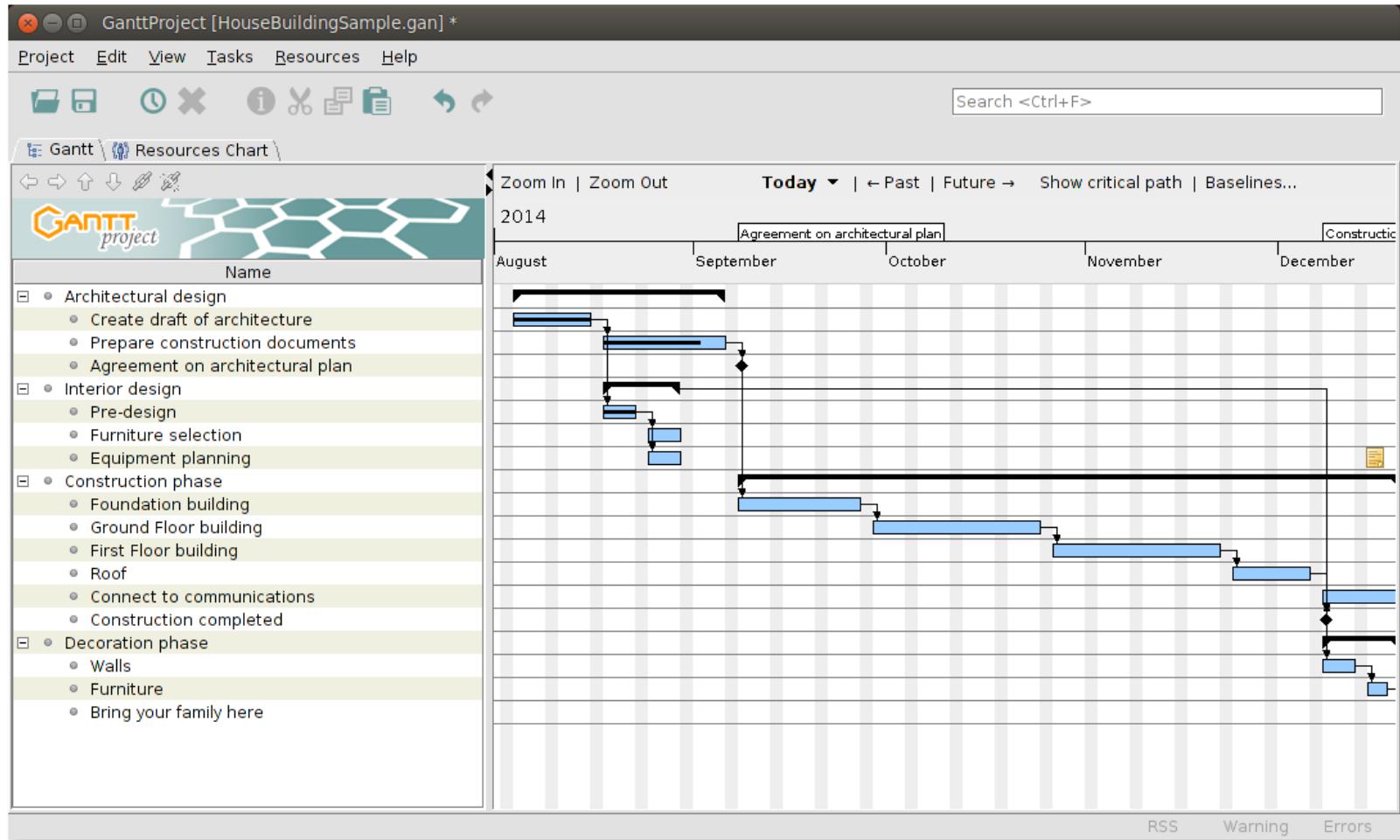
Task	Start	Finish
Office Building, Core & Shell	Mon 16-01-04	Wed 17-03-29
Pre Construction	Mon 16-01-04	Fri 16-01-29
Notice to Proceed	Mon 16-01-04	(Mon 16-01-04)
Building Permit	Mon 16-01-04	(Fri 16-01-29) 17 3
Award Subcontractors	Mon 16-01-04	(Fri 16-01-25) 5FS+5 days
Perimeter Fence	Mon 16-01-25	(Wed 16-01-27) 6FS-1 day
Temporary Hard Standing	Wed 16-01-27	(Wed 16-01-27) 6FS-1 day
Field Office	Thu 16-01-28	(Fri 16-01-29) 17 7
Material Procurement	Mon 16-01-18	Fri 16-04-22
Structural Steel	Mon 16-01-18	(Fri 16-04-15) 17 5
Glass Curtain Wall	Mon 16-01-18	(Fri 16-04-08) 17 5
Elevator	Mon 16-01-18	(Fri 16-04-15) 17 5
MEP Equipment	Mon 16-01-18	(Fri 16-04-22) 17 5
Construction	Mon 16-02-01	Tue 17-01-24
Site Construction	Mon 16-02-01	Tue 17-01-10
Foundation Excavation	Mon 16-02-01	(Fri 16-02-05) 17 4
Structural Piles	Mon 16-02-08	(Fri 16-03-04) 17 16
Site Utilities	Mon 16-02-01	(Fri 16-03-25) 17 4
Backfill / Compact Foundation Excavation	Mon 16-03-21	(Fri 16-03-25) 17 26
Crushed Gravel, Ground Floor	Mon 16-06-13	(Fri 16-06-17) 53;27
Road / Parking Lot Preparation	Wed 16-11-23	(Tue 16-12-20) 1 43;82
Road / Parking Lot Pavement	Wed 16-12-21	(Wed 16-12-28) 21
Site Improvements	Wed 16-11-23	(Tue 16-12-27) 1 82
Site Plantings	Wed 16-12-28	(Tue 17-01-10) 1 23
Concrete	Mon 16-03-07	Thu 16-07-07
Pile Caps	Mon 16-03-07	(Fri 16-03-18) 17 17
Grade Beams	Mon 16-03-28	(Fri 16-04-08) 17 19;26
Slab on Grade	Mon 16-06-20	(Wed 16-06-22) 20
Slab on Deck, 1st Floor	Thu 16-06-23	Tue 16-07-05
Slab on Deck, 1st Floor, Area 1	Thu 16-06-23	Tue 16-06-28
Slab on Deck, 1st Floor, Area 1A	Thu 16-06-23	Thu 16-06-23
Slab on Deck, 1st Floor, Area 1B	Fri 16-06-24	Fri 16-06-24
Slab on Deck, 1st Floor, Area 1C	Mon 16-06-27	(Mon 16-06-27) 32
Slab on Deck, 1st Floor, Area 1D	Tue 16-06-28	Tue 16-06-28
Slab on Deck, 1st Floor, Area 2	Wed 16-06-29	Thu 16-06-30
Slab on Deck, 1st Floor, Area 2A	Wed 16-06-29	Wed 16-06-29
Slab on Deck, 1st Floor, Area 2B	Thu 16-06-30	Thu 16-06-30
Slab on Deck, 1st Floor, Area 3	Fri 16-07-01	Tue 16-07-05

# Maconomy People Planner



<https://www.deltek.com/en/products/project-erp/maconomy/modules/people-planner>

# GanttProject

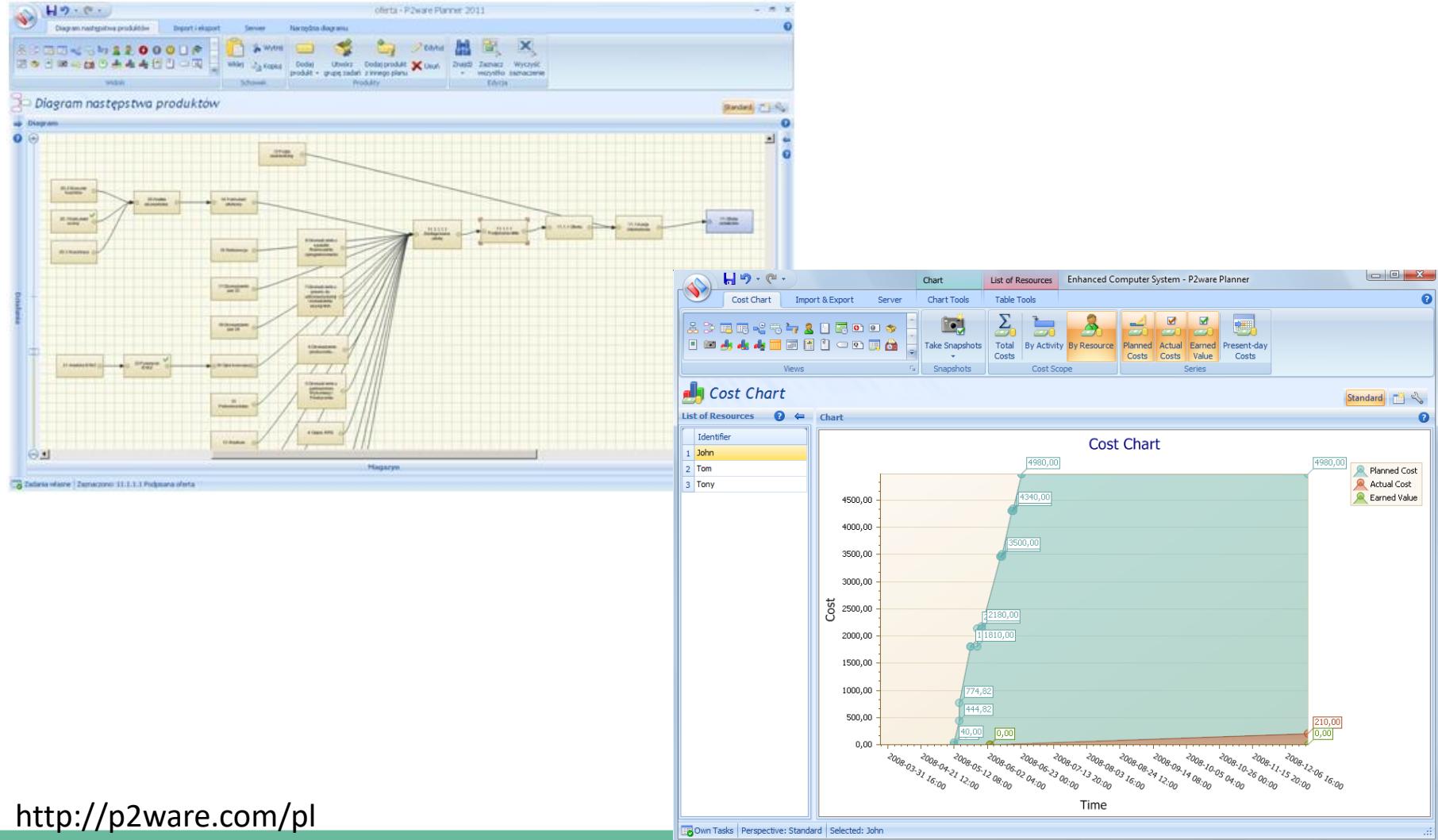


<http://www.ganttproject.biz/>

Construction Project Management

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# P2ware Planner Suite



<http://p2ware.com/pl>

# Construction Project Management

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# Open Project

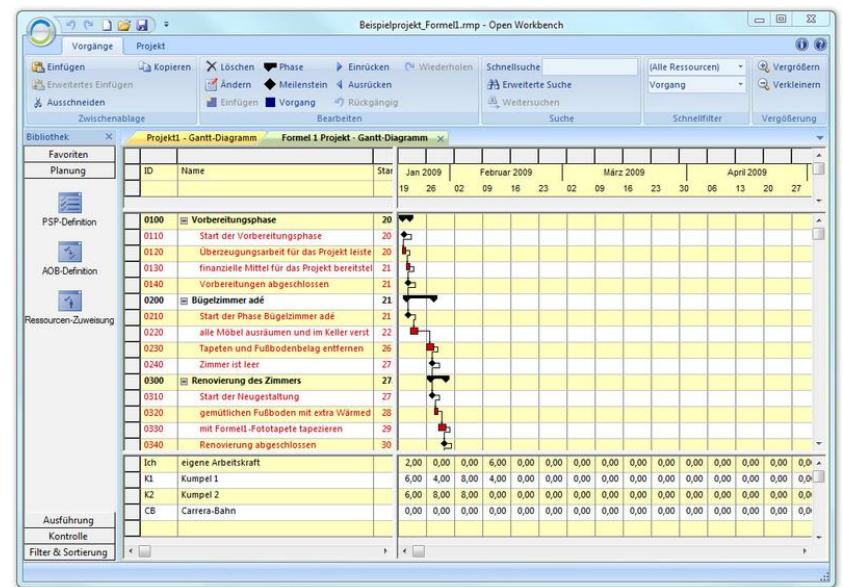
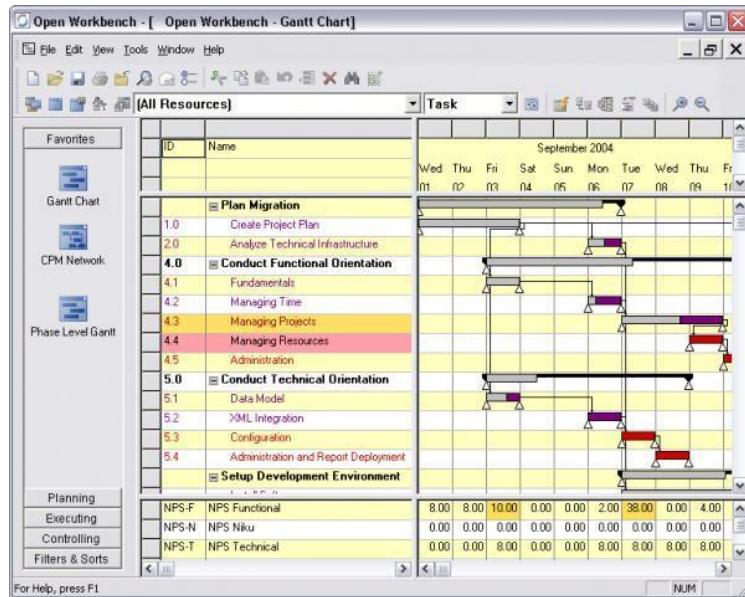
Timeline report

Task	Status	Assignee	Type
Identify website scope	Closed	John Doe	Phase
Determine objective of website	Closed	John Doe	Task
Create personas	Closed	John Doe	Task
Create website concept	Scheduled	Claire Gulian	Phase
Develop navigation concept	Specified	Peter Nielsen	Task
Create wireframes	In progress	Peter Nielsen	Task
Website concept ready	Scheduled	John Doe	Milestone
Choose hosting provider	New	John Doe	Task
Select template or custom design	In progress	John Doe	Task
Implement website layout and content	New	Peter Nielsen	Task
Go Live	Scheduled	Peter Nielsen	Milestone

Sprint 1

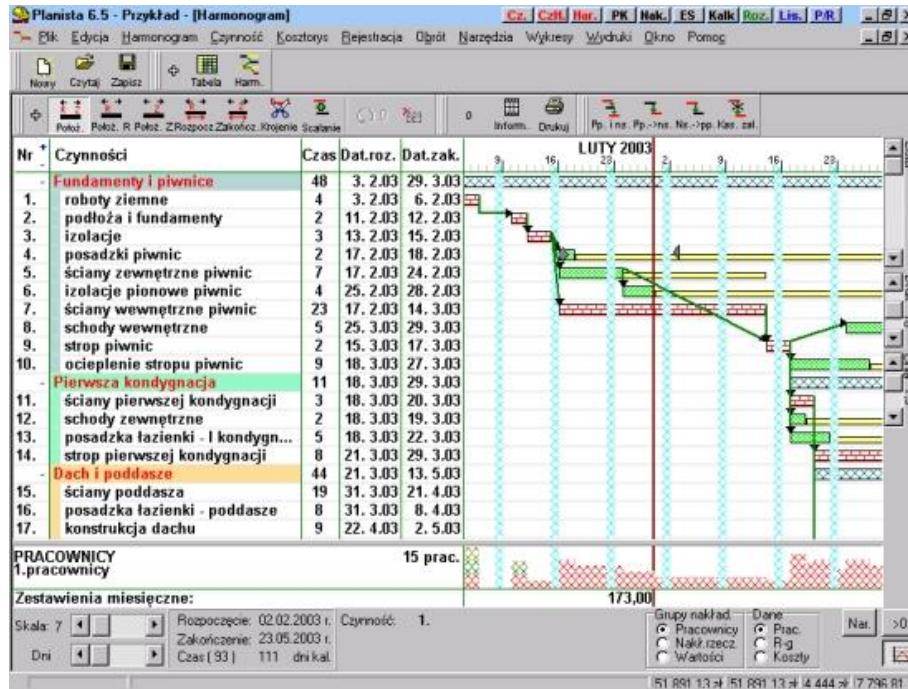
Story	New	In progress	On hold	Rejected	Closed
Sprint impediments	+ 37	No access to test environment			
Contact form	25	+ 34	Christoph Zierz		23
Cookie warning	24	+ 33	Christoph Zierz		
PDF Export	18	+ 31	John Doe		
Newsletter registration form	26	+ 30	Peter Nielsen		38
Style the form	21	Christoph Zierz			
Write tests	22	Christoph Zierz			
Integrate export library	25	John Doe			
Text integration with...	38	Peter Nielsen			

# Open Workbench



[https://en.wikipedia.org/wiki/Open\\_Workbench](https://en.wikipedia.org/wiki/Open_Workbench)

# Planista



# Primavera

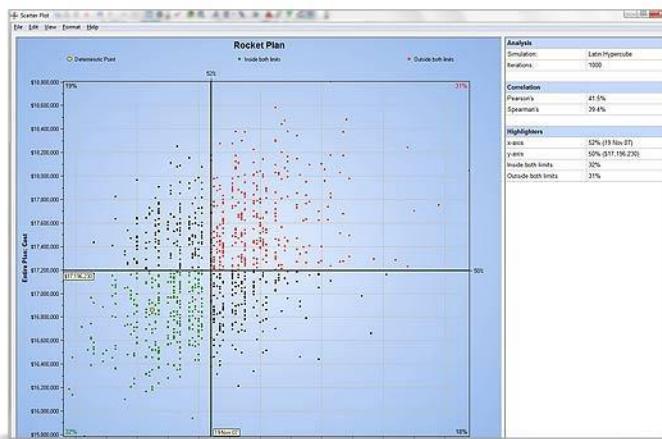
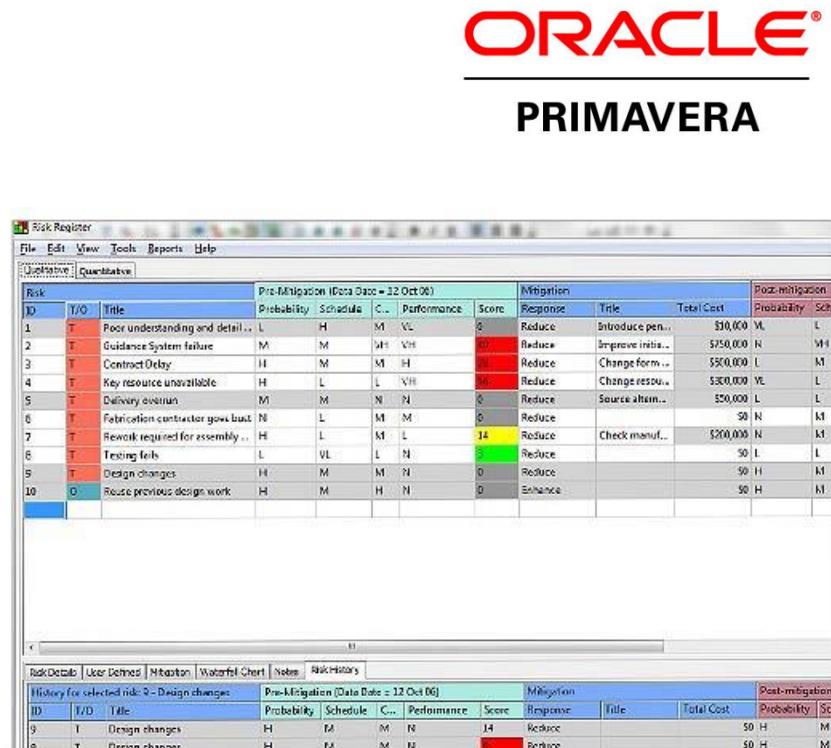
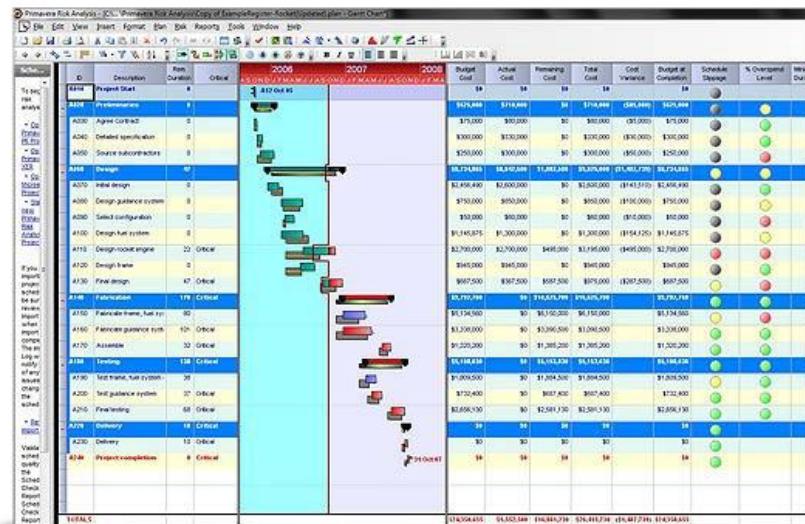
**ORACLE**  
**PRIMAVERA**

The screenshot displays the Oracle Primavera P6 software interface, which includes several windows:

- Top Left Window:** A Gantt chart titled "Project Gantt Chart" showing tasks across years 2010 to 2014. Projects listed include "Alliance Portal Int", "Cash Flow Bt Proj", "GIS Interface Proj", "Lead Qualification I", "Logistics Reengineer", "Nexus Project", "Online Invoice Gen", "Order Fulfillment R", "Order Management", and "Performance".
- Top Right Window:** A pie chart titled "Budget by PM" showing resource allocation. The segments represent Mary Jones (21.75%), Thomas Chen (57.00%), Bob Thomas (6.00%), Jorge Cortes (2.400,000), and Chris Pell (14%).
- Bottom Left Window:** A detailed Gantt chart for "HwyNorth (Phase 2 - Northbound)" under the "Facilities Division". It shows tasks like "Harbour Pointe Assisted Living Center", "Lincoln Hospital Project Trauma Ward", "Recovery Plan Lincoln Hospital Project", "Edison Area High School Renovation", "Container stat. Manufacturing & Dist", "Office Building Addition", and "Contracted Backlog (Not Started)".
- Bottom Right Window:** A Gantt chart titled "EC00501. Haidong Corporate Park" showing tasks such as "Design and Engineer", "Review and Approve Design", "Review Technical Data on Heat Pump", "Start Office Building Addition Project", "Found. Foundation", "Excavation", "Form/Pour Concrete Footing", "Install Underground Electric Conduit", "Install Underground Water Lines", and "Site Preparation".

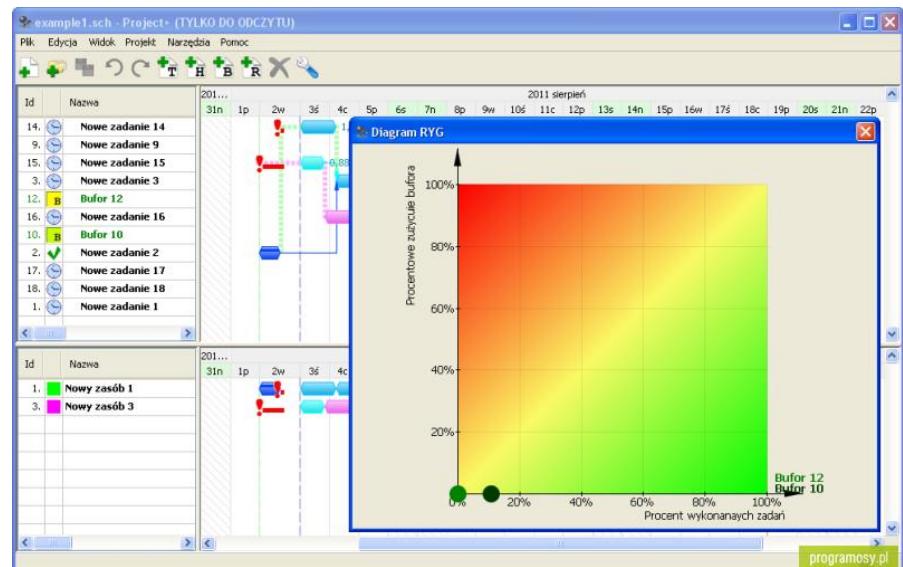
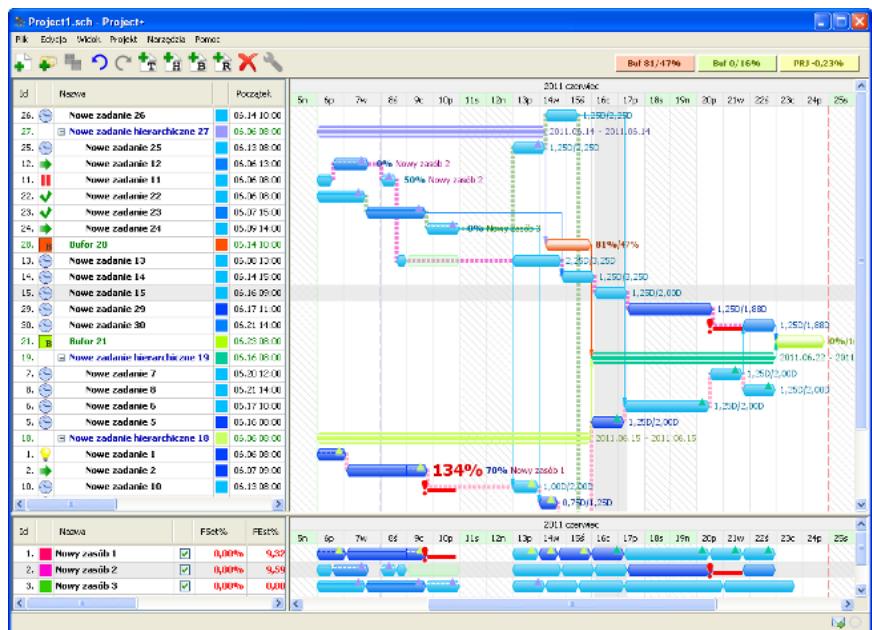
<https://www.oracle.com/pl/applications/primavera/index.html>

# Pertmaster - Oracle's Primavera Risk Analysis



<https://www.oracle.com/pl/applications/primavera/index.html>

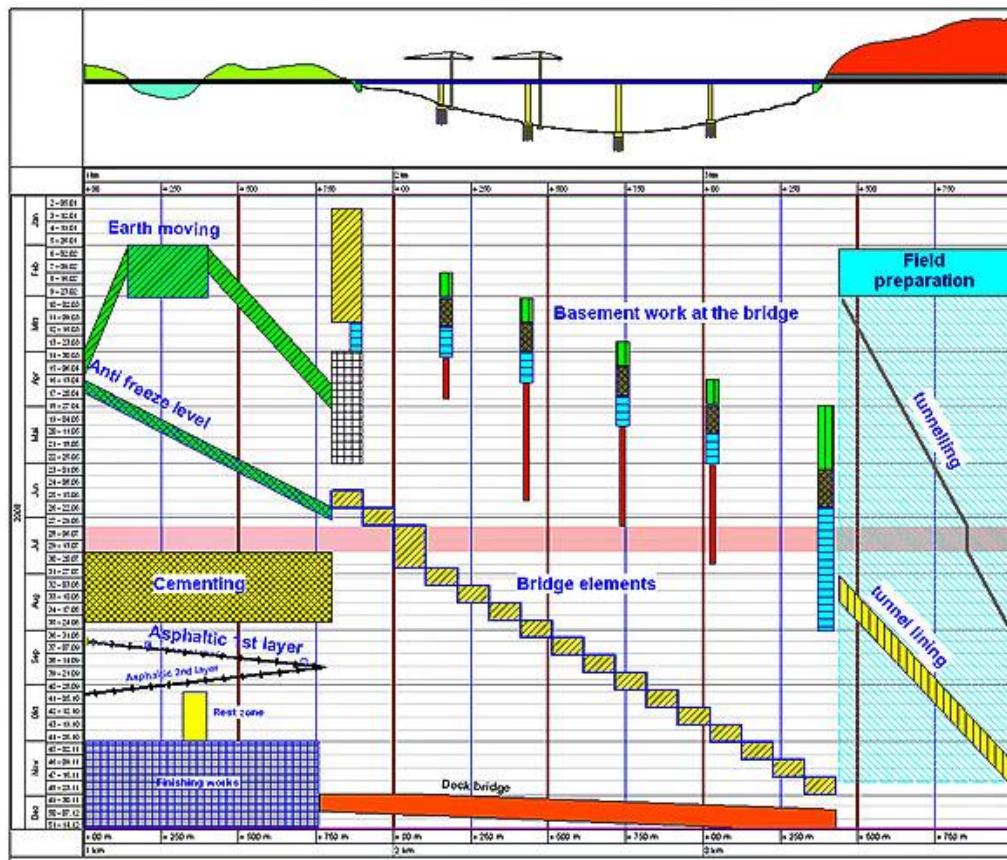
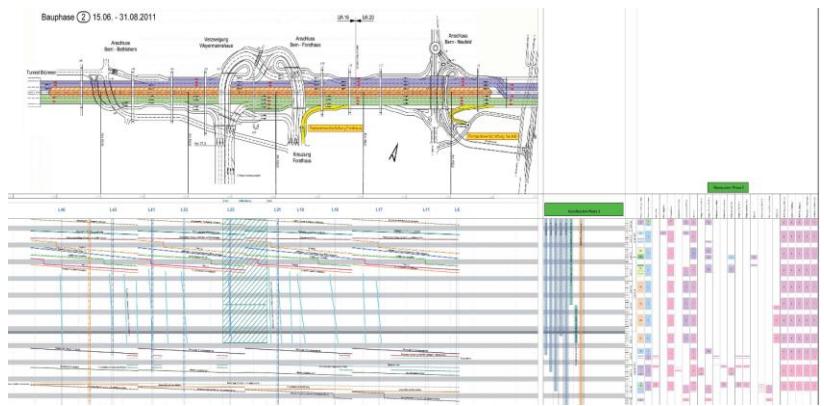
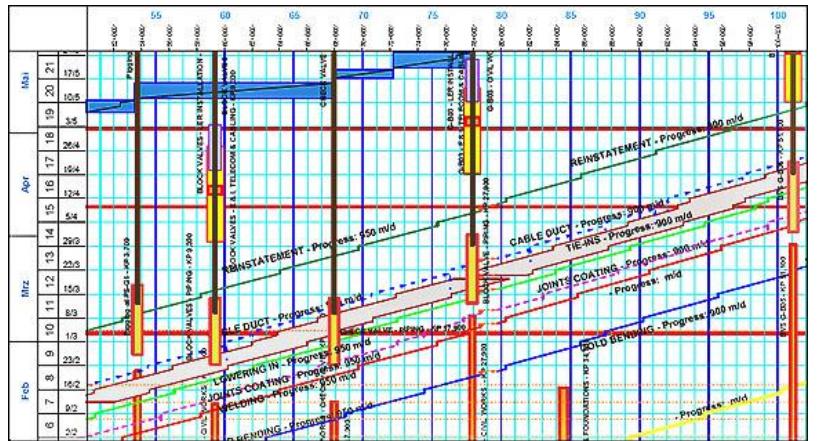
# Project+



<http://ccpmsoft.home.pl/pl/pobierz-program/35-pobierz-program>

# Tilos

**Tilos**



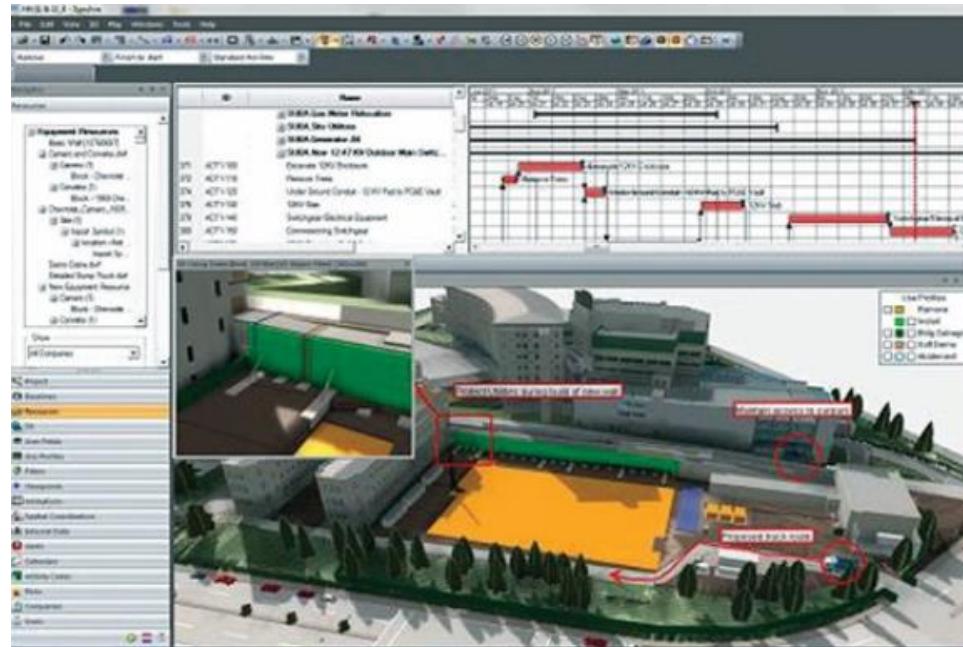
<http://www.tilos.org>

# Construction Project Management

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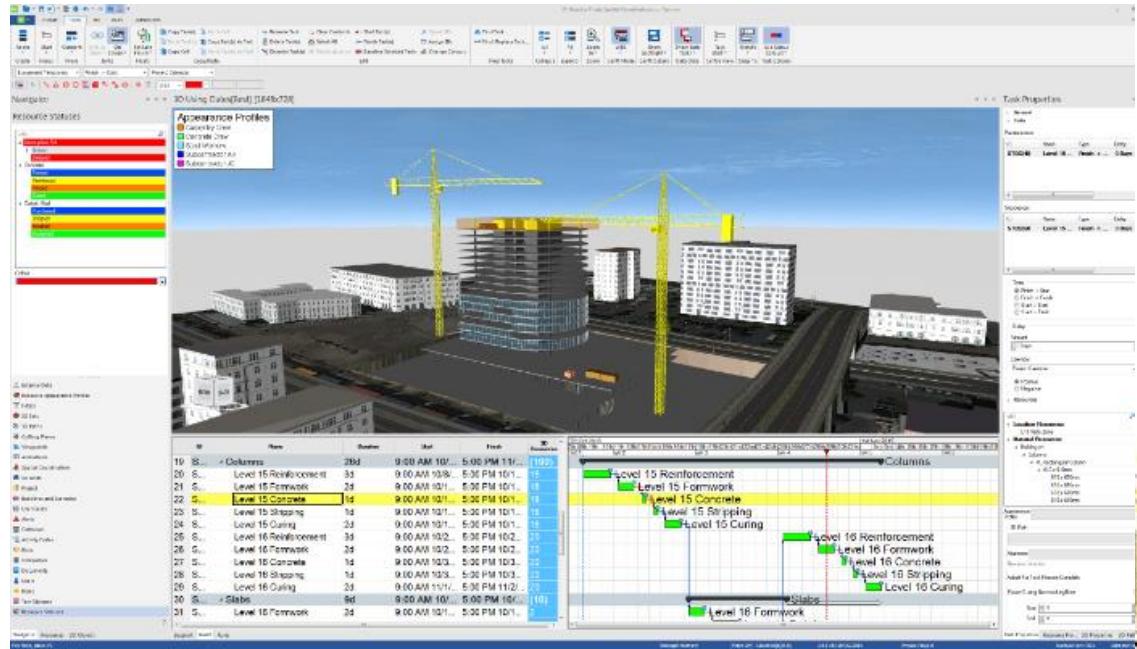
# TIME – BIM 4D

- In BIM the 3D models are complemented by 4th dimension – Time
- The model can include whole life cycle of a project
- BIM 4D allows for importing of schedules from other applications, and for rendering visualizations of the construction works
- It also allows for: better supply coordination, analysis od different implementation variants, monitoring, delays reporting



<https://synchro ltd.com/>

# Synchro Pro



<https://synchrotd.com/synchro-pro/>

## Further reading:

- Project Management Institute. (2004). A Guide to the Project Management Body of Knowledge, Third Edition, PMI, USA.
- CLOEMC - Construction Manager's Library - [www.cloemcv.il.pw.edu.pl](http://www.cloemcv.il.pw.edu.pl)
- Neumann, K., Schwindt, C., Zimmermann, J. (2012). Project scheduling with time windows and scarce resources: temporal and resource-constrained project scheduling with regular and nonregular objective functions. Springer Science & Business Media.
- Sprecher, A., Kolisch, R., & Drexl, A. (1993). Semi-active, active and non-delay schedules for the resource-constrained project scheduling problem (No. 307). Manuskripte aus den Instituten für Betriebswirtschaftslehre der Universität Kiel.
- Kostrubiec, A. (2003). Harmonogramowanie realizacji projektów-przegląd modeli. W: Inżynieria zarządzania przedsięwzięciami. Red. L. Zawadzka. Gdańsk, 2003.
- Google scholar

# Basics of MS Project - Review

**GANTT CHART TOOLS**

Training Project Schedule - Project Professional

FILE TASK RESOURCE REPORT PROJECT VIEW FORMAT

Cut Copy Paste Format Painter Calibri 11 Mark on Track Respect Links Manually Schedule Auto Schedule Inspect Move Mode Task Summary Milestone Deliverable Information Notes Details Add to Timeline Find Clear Scroll to Task Fill

Gantt Chart View Clipboard Font Schedule Tasks Insert Properties Editing

Start Mon 16-01-04 00:00 Pre Construction Mon 16-02-01 09:00 - Tue 17-01-24 17:00

Material Procurement Mon 16-01-18 09:00 - Fri 16-04-22 17:00

Finish Wed 17-03-29 09:00 - Wed 17-03-29 17:00

TIMELINE

Project Completion

Mon 16-01-04 00:00 S M T W T F S 26 15 Nov 30 16 Jan 04 16 Feb 08 16 Mar 14 16 Apr 18 16 May 23 16 Jun 27 16 Aug 01 16 Sep 05 16 Oct 10 16 Nov 14 16 Dec 19 17 Jan 23 17 Feb 07 17 Apr 03

Mon 16-01-04 00:00

Task Mode Task Name Duration Start Finish Predecessors

1 Office Building, Core & Shell 323 days Mon 16-01-04 Fri 17-03-29

2 Pre Construction 20 days Mon 16-01-04 Fri 16-01-29 17

3 Notice to Proceed 0 days Mon 16-01-04 ( Mon 16-01-04 )

4 Building Permit 20 days Mon 16-01-04 ( Fri 16-01-29 17 3

5 Award Subcontractors 10 days Mon 16-01-04 ( Fri 16-01-25 17 3

6 Perimeter Fence 3 days Mon 16-01-25 ( Wed 16-01-27 : 5FS+5 days

7 Temporary Hard Standing 1 day Wed 16-01-27 ( Wed 16-01-27 : 6FS-1 day

8 Field Office 2 days Thu 16-01-28 0 Fri 16-01-29 17 7

9 Material Procurement 70 days Mon 16-01-18 Fri 16-04-22 17

10 Structural Steel 65 days Mon 16-01-18 Fri 16-04-15 17 5

11 Glass Curtain Wall 60 days Mon 16-01-18 Fri 16-04-08 17 5

12 Elevator 65 days Mon 16-01-18 Fri 16-04-15 17 5

13 MEP Equipment 70 days Mon 16-01-18 ( Fri 16-04-22 17 5

14 Construction 257 days Mon 16-02-01 Tue 17-01-24 1

15 Site Construction 247 days Mon 16-02-01 Tue 17-01-10 1

16 Foundation Excavation 5 days Mon 16-02-01 ( Fri 16-02-05 17 4

17 Structural Piles 20 days Mon 16-02-08 ( Fri 16-03-04 17 16

18 Site Utilities 40 days Mon 16-02-01 ( Fri 16-03-25 17 4

19 Backfill / Compact Foundation Excavation 5 days Mon 16-03-21 ( Fri 16-03-25 17 26

20 Crushed Gravel, Ground Floor 5 days Mon 16-06-13 ( Fri 16-06-17 17 52;27

21 Road / Parking Lot Preparation 20 days Wed 16-11-23 ( Tue 16-12-20 1 43;82

22 Road / Parking Lot Pavement 6 days Wed 16-12-21 ( Wed 16-12-28 : 21

23 Site Improvements 25 days Wed 16-11-23 ( Tue 16-12-27 1 82

24 Site Plantings 10 days Wed 16-12-28 ( Tue 17-01-10 1 23

25 Concrete 89 days Mon 16-03-07 ( Thu 16-07-07 1

26 Pile Caps 10 days Mon 16-03-07 ( Fri 16-03-18 17 17

27 Grade Beams 10 days Mon 16-03-28 ( Fri 16-04-08 17 19;26

28 Slab on Grade 3 days Mon 16-06-20 ( Wed 16-06-22 : 20

29 Slab on Deck, 1st Floor 9 days Thu 16-06-23 0 Tue 16-07-05 1

30 Slab on Deck, 1st Floor, Area 1 4 days Thu 16-06-23 0 Tue 16-06-28 1

31 Slab on Deck, 1st Floor, Area 1A 1 day Thu 16-06-23 0 Thu 16-06-23 1 28

32 Slab on Deck, 1st Floor, Area 1B 1 day Fri 16-06-24 09 Fri 16-06-24 17 31

33 Slab on Deck, 1st Floor, Area 1C 1 day Mon 16-06-27 ( Mon 16-06-27 : 32

34 Slab on Deck, 1st Floor, Area 1D 1 day Tue 16-06-28 0 Tue 16-06-28 1 33

35 Slab on Deck, 1st Floor, Area 2 2 days Wed 16-06-29 ( Thu 16-06-30 1

36 Slab on Deck, 1st Floor, Area 2A 1 day Wed 16-06-29 ( Wed 16-06-29 : 34

37 Slab on Deck, 1st Floor, Area 2B 1 day Thu 16-06-30 0 Thu 16-06-30 1 36

38 Slab on Deck, 1st Floor, Area 3 3 days Fri 16-07-01 09 Tue 16-07-05 1 35

GANTT CHART

READY NEW TASKS : AUTO SCHEDULED

## Project Options

?

X

- General
- Display
- Schedule
- Proofing
- Save
- Language
- Advanced
- Customize Ribbon
- Quick Access Toolbar
- Add-ins
- Trust Center



Change options related to scheduling, calendars, and calculations.

**Calendar options for this project:**

Project1

Week starts on: Monday

Fiscal year starts in: January

Use starting year for FY numbering

Default start time: 08:00

Default end time: 17:00

Hours per day: 8

Hours per week: 40

Days per month: 20

These times are assigned to tasks when you enter a start or finish date without specifying a time. If you change this setting, consider matching the project calendar using the Change Working Time command on the Project tab in the ribbon.

**Schedule**

Show scheduling messages

Show assignment units as a: Percentage

**Scheduling options for this project:**

Project1

New tasks created:

Manually Scheduled

Auto scheduled tasks scheduled on:

Project Start Date

Duration is entered in:

Days

Work is entered in:

Hours

Default task type:

Fixed Units

New tasks are effort driven

Tasks will always honor their constraint dates

Autolink inserted or moved tasks

Show that scheduled tasks have estimated durations

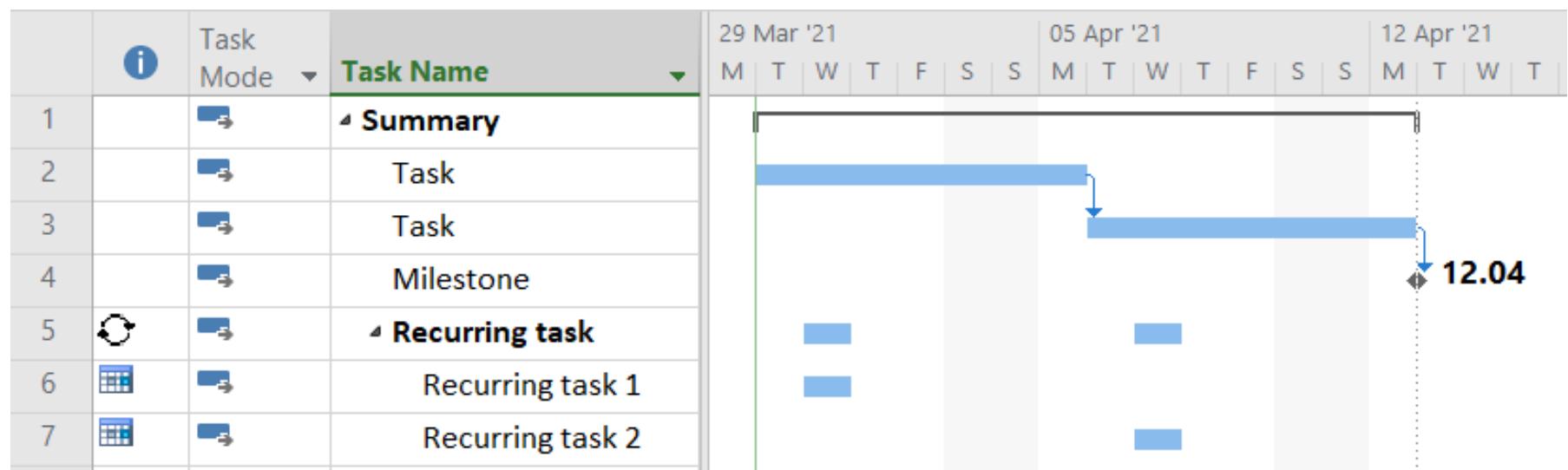
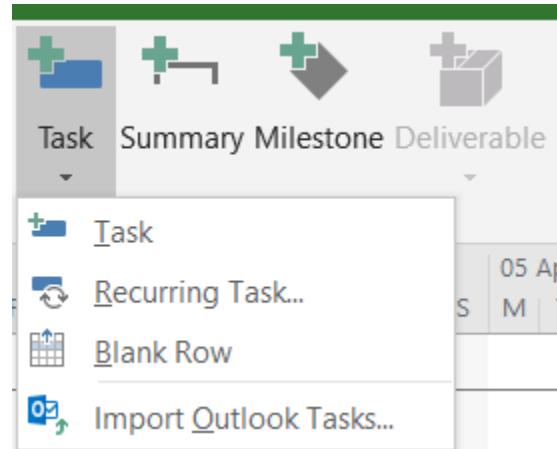
Split in-progress tasks

New scheduled tasks have estimated durations

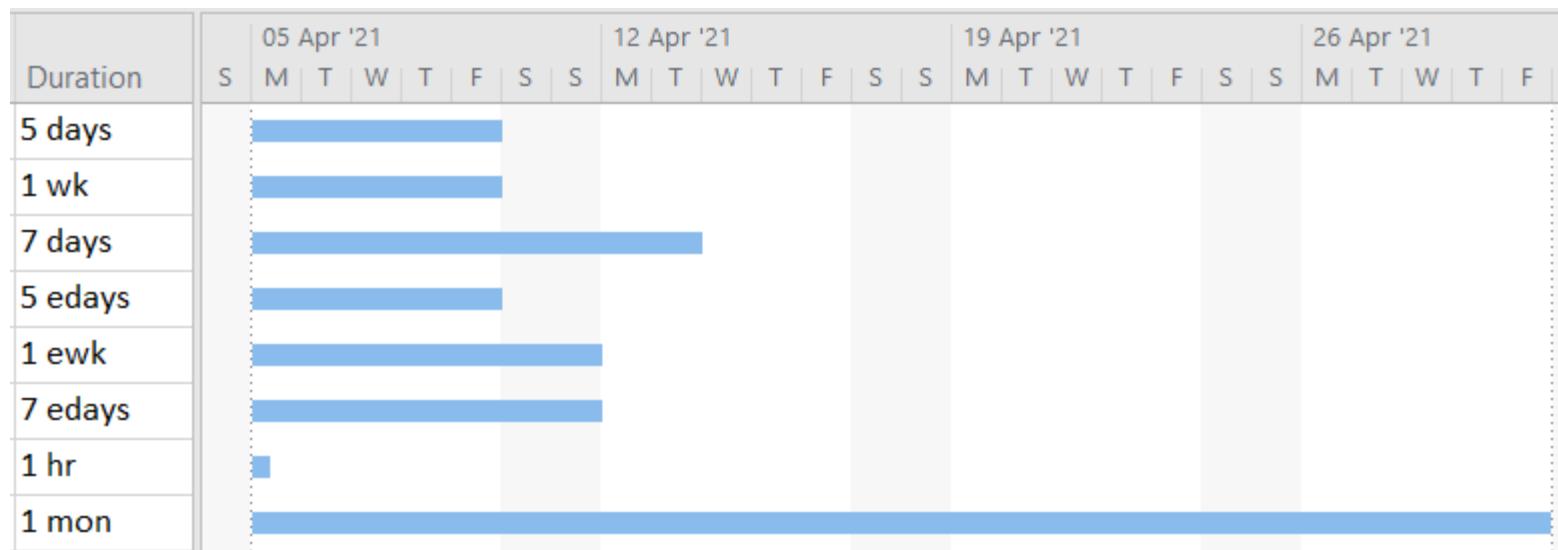
OK

Cancel

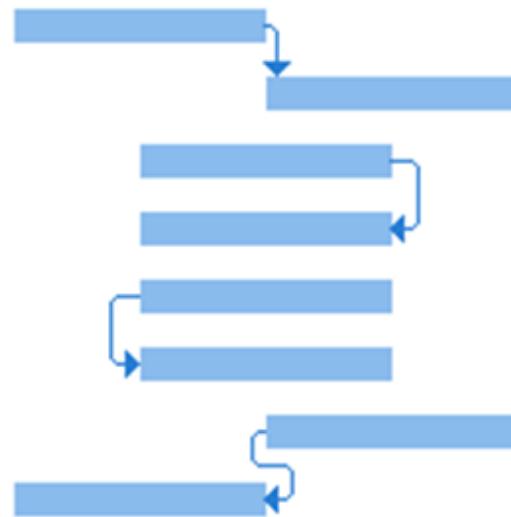
# Tasks



# Duration



# Precedence relationships



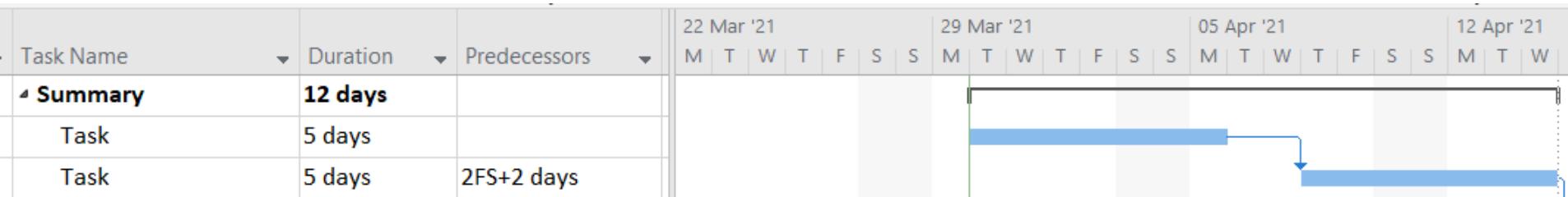
*Finish-to-Start, FS*

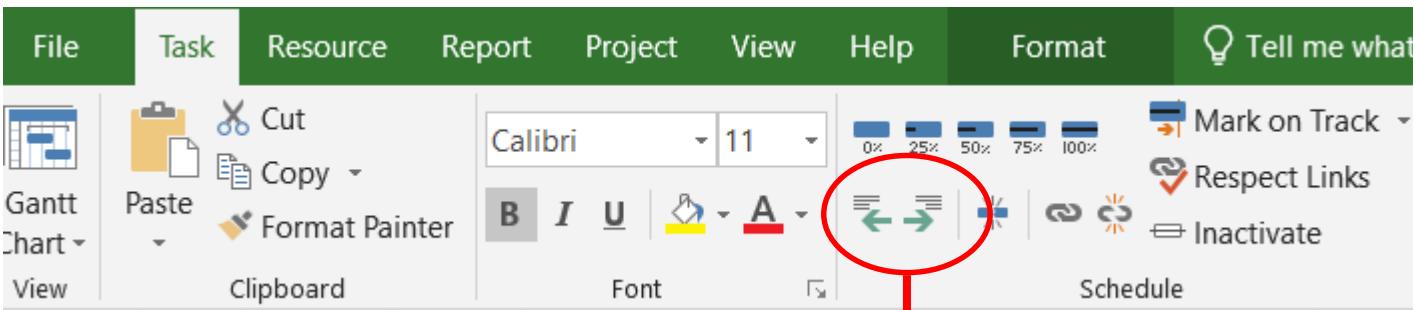
*Finish-to-Finish, FF*

*Start-to-Start, SS*

*Start-to-Finish, SF*

+ lead/lag





# WBS

2.4	MEP Equipment
3	▫ Construction
3.1	▫ Site Construction
3.1.1	Foundation Excavation
3.1.2	Structural Piles
3.1.3	Site Utilities
3.1.4	Backfill / Compact Foundation Excavation
3.1.5	Crushed Gravel, Ground Floor
3.1.6	Road / Parking Lot Preparation
3.1.7	Road / Parking Lot Pavement
3.1.8	Site Improvements
3.1.9	Site Plantings
3.2	▫ Concrete
3.2.1	Pile Caps

File Task Resource Report Project View Help Format Tell me what you want to do

Text Gridlines Layout Insert Column Column Settings Custom Fields Format Path Bar Styles Gantt Chart Style Show/Hide

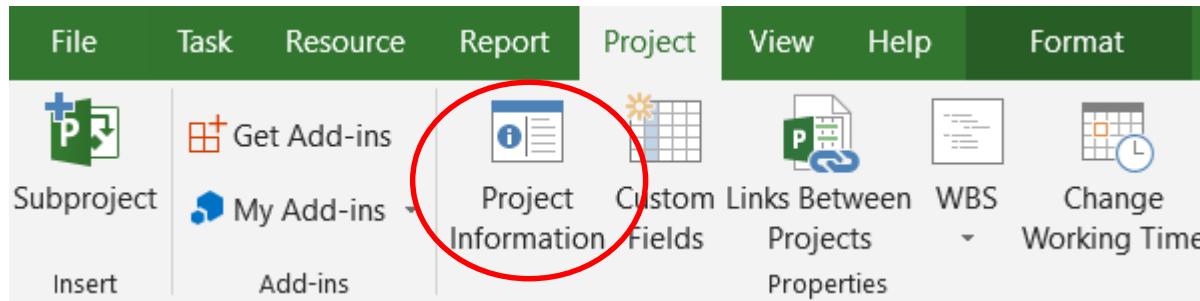
Outline Number  
 Project Summary Task  
 Summary Tasks  
Show/Hide

**WBS**

**1.3 Construction**

- **1.3.1 Site Construction**
  - 1.3.1.1 Foundation Excavation
  - 1.3.1.2 Structural Piles
  - 1.3.1.3 Site Utilities
  - 1.3.1.4 Backfill / Compact Foundation Excavation
  - 1.3.1.5 Crushed Gravel, Ground Floor
  - 1.3.1.6 Road / Parking Lot Preparation
  - 1.3.1.7 Road / Parking Lot Pavement
  - 1.3.1.8 Site Improvements
  - 1.3.1.9 Site Plantings
- **1.3.2 Concrete**
  - 1.3.2.1 Pile Caps
  - 1.3.2.2 Grade Beams

# Project information

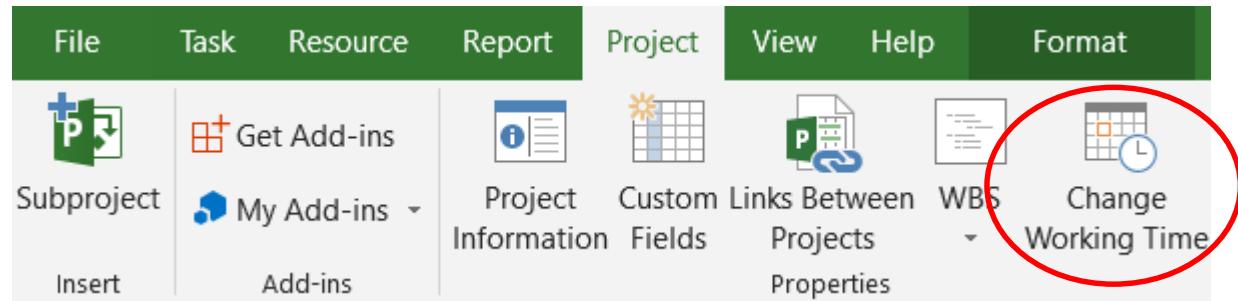


Project Information for 'Project2'

Start date:	Mon 05.04.21	Current date:	Tue 30.03.21
Finish date:	Fri 30.04.21	Status date:	NA
Schedule from:	Project Start Date	Calendar:	Standard
All tasks begin as soon as possible.		Priority:	500
Enterprise Custom Fields			
Department:			
	Custom Field Name	Value	

Help Statistics... OK Cancel

# Calendar



## Change Working Time

For calendar: Standard (Project Calendar) [Create New Calendar ...](#)

Calendar 'Standard' is a base calendar.

**Legend:**

- Working
- Nonworking
- 31 Edited working hours
- 31 On this calendar: Exception day
- 31 Nondefault work week

Click on a day to see its working times: March 2021

M	T	W	Th	F	S	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

30 March 2021 is nonworking.

Based on:  
Exception 'Exception 1' on calendar 'Standard'.

**Details for 'Exception 1'**

Set working times for these exceptions

Nonworking

Working times:

From	To

Recurrence pattern

Daily | Every  days

Weekly

Monthly

Yearly

Range of recurrence

Start: Tue 30.03.21 | End after:  occurrences

End by: Tue 30.03.21

Exceptions Work Weeks

	Name	Start	Finish	
1	Exception 1	30.03.2021	30.03.2021	<a href="#">Details...</a>
				<a href="#">Delete</a>

# Task

- In response to the ongoing changes on the market,  
a construction design firm plans to modernize  
one of the computer labs and software
- Prepare a schedule based on the provided data
- File: 6\_2\_Task\_-\_Design\_company\_-  
\_computer\_office\_modernization.docx
- Please send your schedules to:  
[projekty.ipb@gmail.com](mailto:projekty.ipb@gmail.com)