

Projektin etenemisen seuranta ja tuloksen arvo
laskenta
(Earned Value Management, EVM, Earned Value
Analysis, EVA)

Matti Haukka 23.4.2021
Suomen Projektii-Instituutti Oy

Project Institute Finland Ltd
Adapro
est.1990

We help our Customers to **improve their results**
by using modern Project Management
discipline in most efficient way.

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Project Institute Finland Ltd

Established	1990	Personnel	12 people
Revenue	1,5 M€ (2019)	Network	17 people, 12 companies
Operations in 16 countries			

ABC Project Management Models > 100 delivered, used in over 70 countries

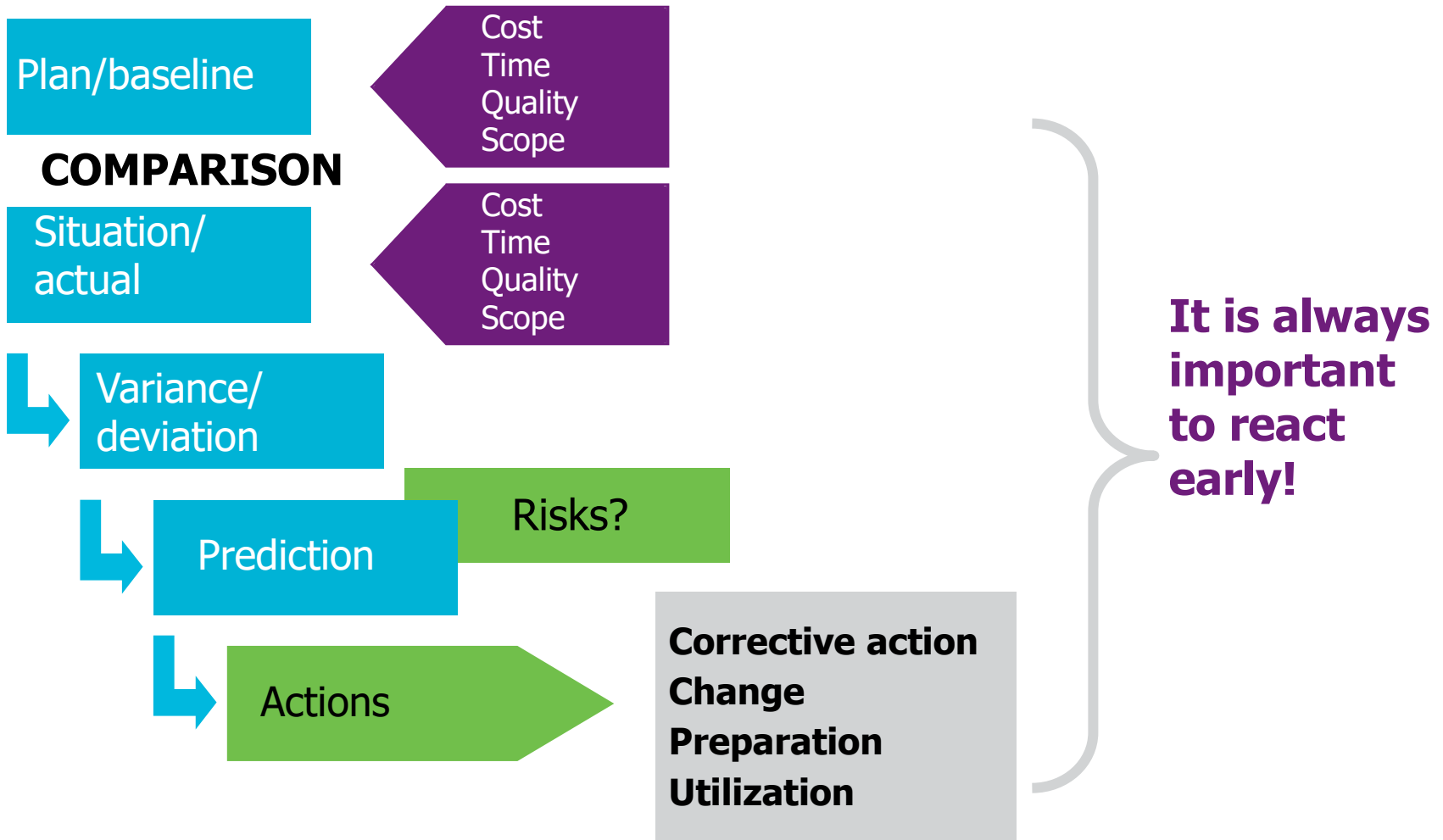


Content of the presentation:



- Introduction to EVM and backgrounds
- EVM terms and basic theory
- Estimating the percent complete
- Forecasting and Estimate at Completion
- Case Example (Aurora Australis)
- Implementing EVM methodology



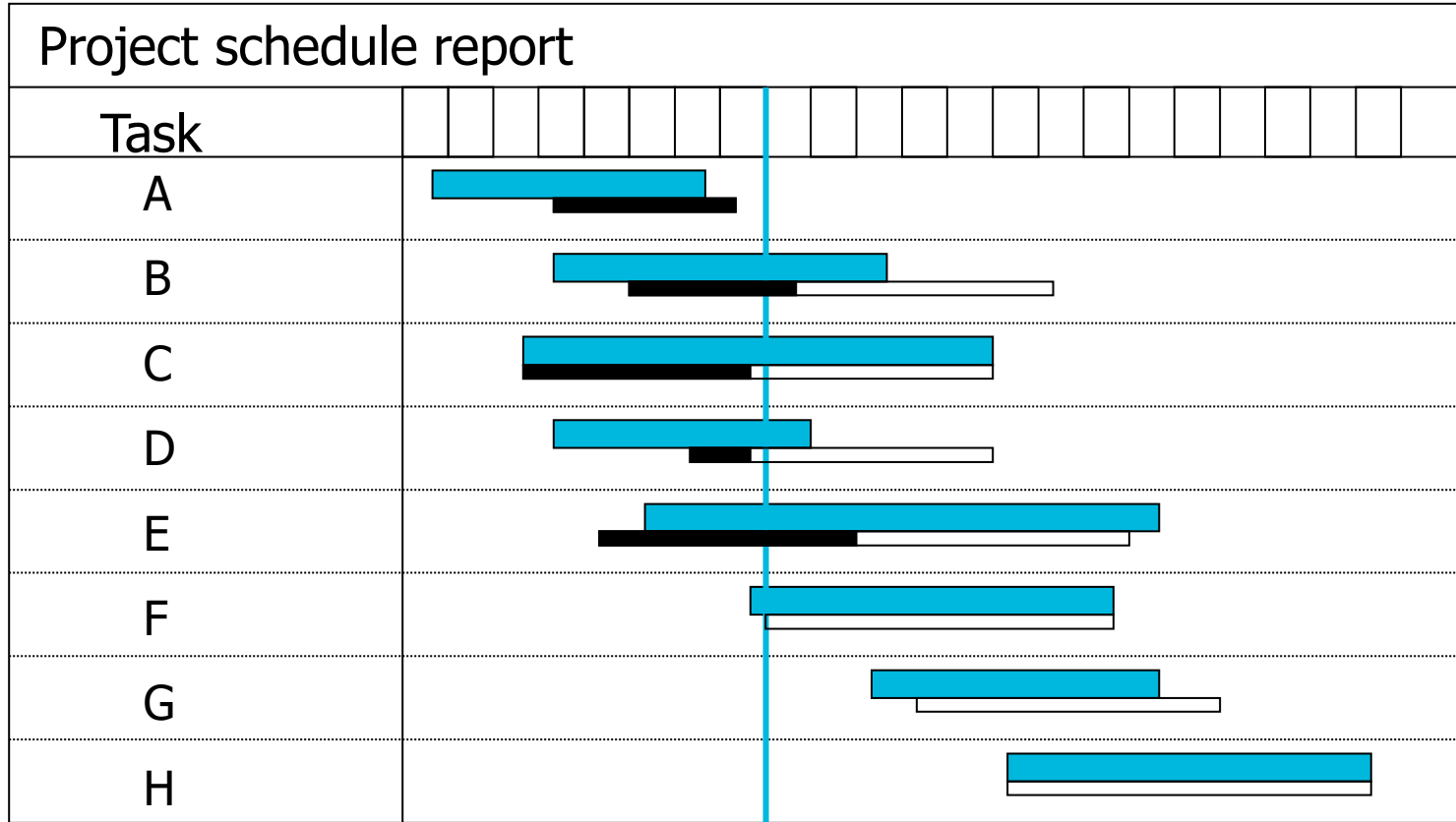
Monitoring and Controlling



Cost Control methods of different types of projects

Origin of cost		Control method
<p>Mainly own or external work</p> <ul style="list-style-type: none">• typical delivery project (software application, design work, installation work) or internal project.• Internal projects (e.g. volume product development) are not always cost critical regarding to project budget		<p>Schedule and cost control should be combined</p> <ul style="list-style-type: none">• E.g. Earned Value - method
<p>Mainly external procurements</p> <ul style="list-style-type: none">• E.g. industry production investments		<p>Follow-up of committed costs and comparison to budget is essential to control cost!</p>

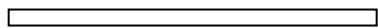
Schedule Control



Planned schedule



Actual start and percent complete/actual end

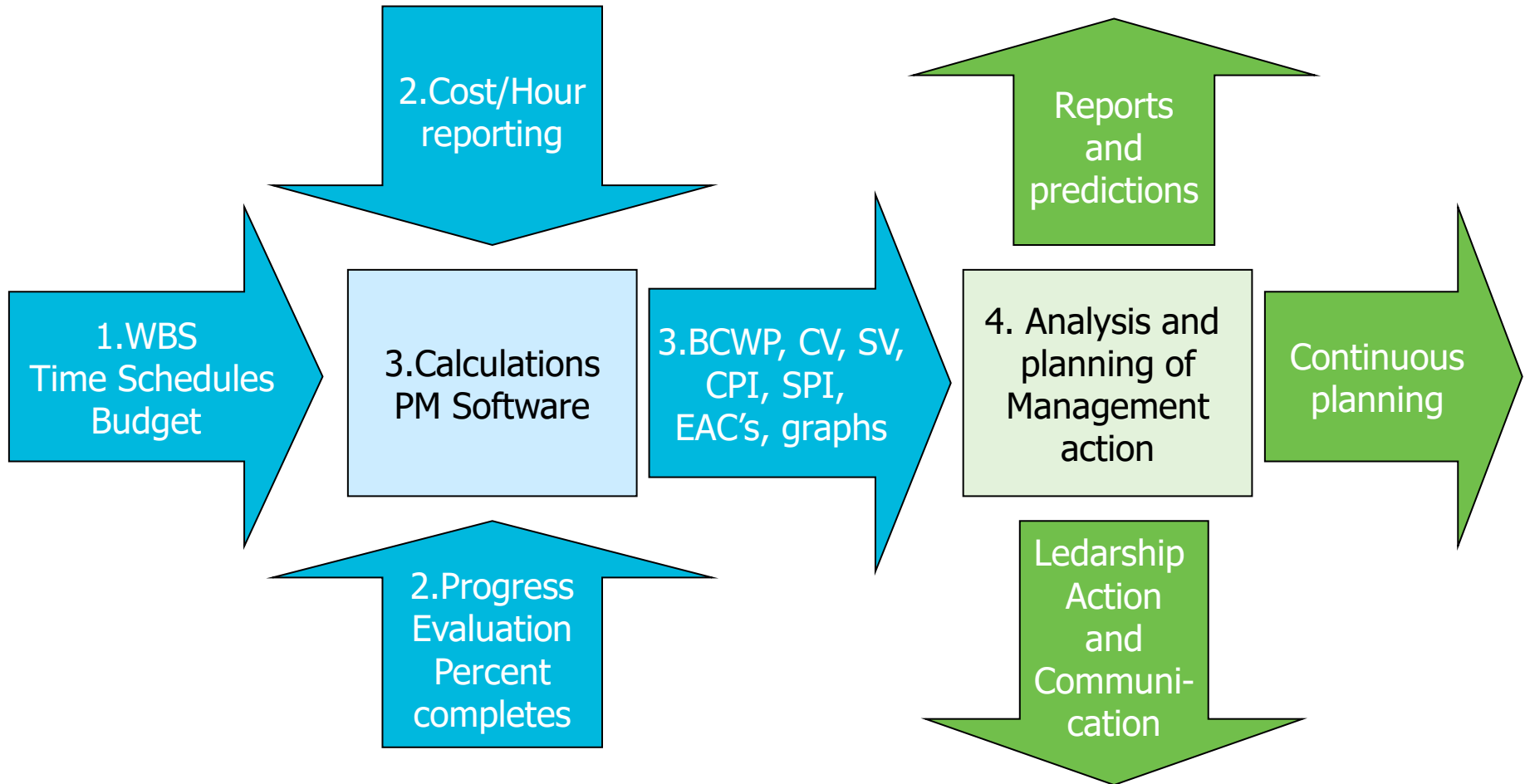


Forecasted time to completion of task at reporting moment

Earned Value Management

is a technique for measuring project progress in an objective manner. EVM has the ability to **combine measurements of scope, schedule, and cost in a single integrated system**. When properly applied, EVM provides an early warning of performance problems.

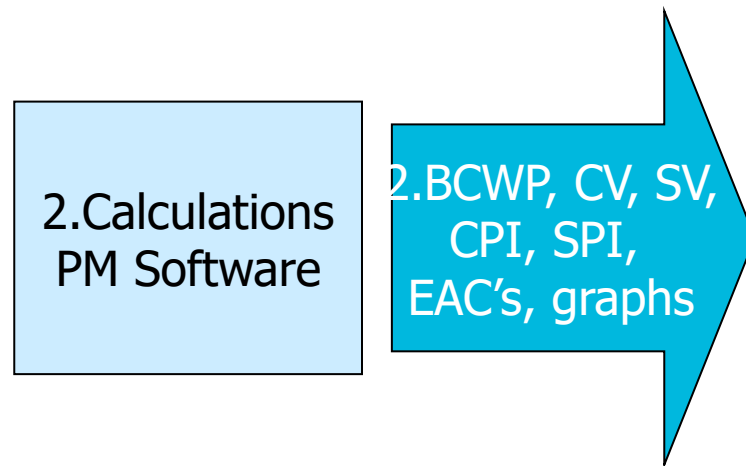
EVA process



Earned Value Analysis

1. WBS, Budget and Time Schedules
2. Status analysis
 - The analysis is only as good as the data
3. Calculations
 - Understanding the terms and their meanings
 - Use excel or PM Softwares
4. Conclusions and management action
 - Some basic rules can be applied
 - Essence of experience

EVA calculations



Basic EVM elements and terms

BAC Budget at Completion

Budjetti /kokonaisbudjetti

The total planned value (budget) for the project

EAC Estimate at Completion

Kokonaiskustannusennuste

The expected total cost of a project, a schedule activity or WBS component when the defined scope of work will be completed.

Three "Cornerstones" :

ACWP AC, Actual Cost (hours) of Work Performed

Toteuma / toteutuneet kustannukset

Total costs actually incurred and recorded in accomplishing work performed during given time period for a a schedule activity or WBS component

BCWS Budgeted Cost (hours) of Work Scheduled, Planned Value (PV)

Suunniteltu arvo

The authorized budget assigned to the scheduled work to be accomplished for a schedule activity or WBS component

BCWP Budgeted Cost of Work Performed, Earned Value (EV), How much the achieved progress was planned to cost?

Ansaittu arvo

The value of work performed expressed in terms of the approved budget assigned to that work for a schedule activity or WBS component

Basic EVA elements and terms

SV	Schedule Variance	A measure of schedule performance on a project ($SV = BCWP$ minus $BCWS$)
CV	Cost Variance	A measure of cost performance on a project ($SV = BCWP$ minus AC)
SPI	Schedule Performance Index	A measure of schedule efficiency on a project ($SPI = BCWP$ divided by $BCWS$)
CPI	Cost Performance Index	A measure of cost efficiency on a project ($CPI = BCWP$ divided by AC)
ETC	Estimate to Completion	The expected cost needed to complete all the remaining work for a project, a schedule activity or WBS component .

Lyhenteet ja termit

BCWP (EV) = ansaittu arvo (tuloksen arvo) = **Valmiusaste X budjetti**

BCWS (PV) = suunniteltu arvo

ACWP (AC) = toteutuneet kustannukset (toteuma)

BAC = kokonaisbudjetti

EAC = kokonaiskustannusennuste

CV = kustannuspoikkeama (kustannusero) = **BCWP - ACWP**

SV = aikataulupoikkeama (aikatauluero) = **BCWP - BCWS**

CPI = kustannustehokkuusindeksi = **BCWP / ACWP**

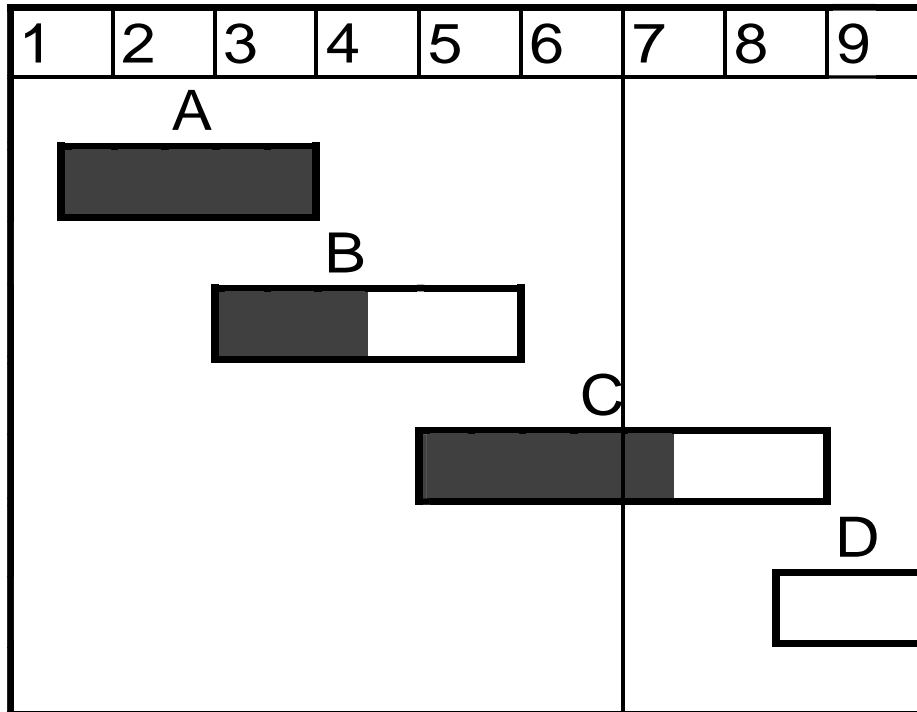
SPI = aikataulutehokkuusindeksi = **BCWP / BCWS**

VAC = poikkeama lopussa = **BAC - EAC**

ETC = jäljellä olevan työ kustannusennuste

Example: Project ABCD

Example 2. Project ABCD (a)



Percent complete:

A = 100%

B = 50%

C = 55%

What is the situation?

Partly delayed, partly ahead of schedule?

A clear conclusion cannot be made!

Example 2. Project ABCD (b)

1	2	3	4	5	6	7	8	9	Budg.	Actual	Plann.
									100	90	100
									150	110	150
									200	100	100
									50	0	0
									500	300	350

Planned Value = 350
Actual Costs = 300

Costs = 50 less than planned (?)

Looks good?

Example 2. Project ABCD (c)

1	2	3	4	5	6	7	8	9	BAC	ACWP	BCWS	BCWP	CV	SV
									100	90	100	100	10	0
									150	110	150	75	-35	-75
									200	100	100	110	10	10
									50	0	0	0	0	0
									500	300	350	285	-15	-65

Planned Value (BCWS) = 350

Actual Cost = 300

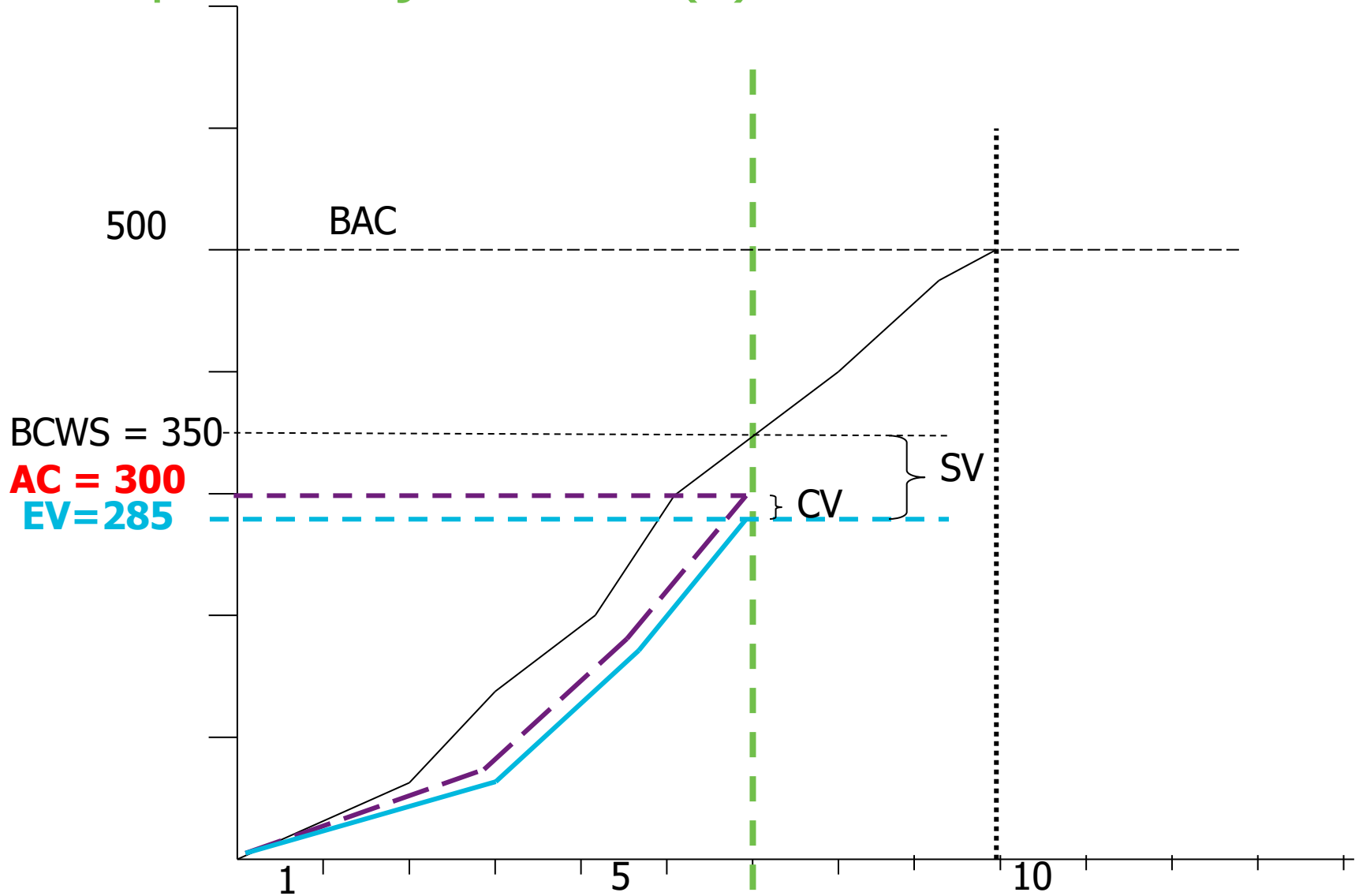
Earned Value (BCWP) = 285

Schedule Variance (BCWP-BCWS) = -65

Cost Variance (BCWP-ACWP) = -15

Report: Project will be delayed and costs over budgeted!

Example 2. Project ABCD (d)



EVM and Forecasting: Project ABCD

Project ABCD Case 3

BCWS BCWP

1	2	3	4	5	6	7	8	9	BAC	AC	PV	EV	CV	SV
									100	100	100	100	0	
									150	110	150	75	-35	-75
									200	100	100	110	10	10
									50	0	0	0	0	0
									500	300	350	285	-15	-65

Miten laskisit kokonaiskustannusennusteen?
(EAC)?

Planned Value = 350

Actual Cost = 300

Earned Value = 285

Schedule Variance (BCWP-BCWS) = -65

Cost Variance (BCWP-ACWP) = -15

Project will be delayed and costs over budgeted!

Project ABCD

Cost Performance Index , CPI

$$= \text{BCWP} / \text{ACWP} = 285/300 = 0,95$$

Schedule Performance Index , SPI

$$= \text{BCWP} / \text{BCWS} = 285/350 = 0,81$$

BCWS = PV

BCWP = EV

ACWP = AC

Project ABCD

Estimate at Completion (1)

Cost:

$$\begin{aligned} \text{EAC (1)} &= \text{ACWP} + (\text{BAC} - \text{BCWP}) \\ &= 300 + (500 - 285) = 515 \end{aligned}$$

Or

$$\text{EAC (1)} = \text{BAC} - \text{CV} = 500 - (-15) = 515$$

Project ABCD

Estimate at Completion (2)

$$\begin{aligned} \text{EAC (2)} &= \text{BAC} / \text{CPI} = \text{BAC} \times \text{ACWP} / \text{BCWP} \\ &= 500 / 0,95 = 526 \end{aligned}$$

Future cost performance is believed to be the same as all past cost performance.

or

$$\text{EAC} = \text{ACWP} + ((\text{BAC}-\text{BCWP}) / ((\text{BCWPI}+\text{BCWPj}+\text{BCWPk}) / (\text{ACWPI}+\text{ACWPj}+\text{ACWPk})))$$

Future cost performance is believed to be the same as the last three measurement periods.

Project ABCD

Estimate at Completion (2)

EAC (2)

Same results calculated alternatively

Percent Complete of the Project WWW
= **BCWP** / BAC = 57 %

To achieve the Percent Complete 57 % we used 300 h
How much should we use to get the whole project completed?

57% / **300 h** = 100 % / X

X (EAC) = 526 h

Project ABCD

Estimate at Completion (3)

EAC (3)

%	BAC	AC	BCWS	BCWP	CV	SV	EAC (3)
100	100	90	100	100	10	0	90
50	150	110	150	75	-35	-75	220
55	200	100	100	110	10	10	182
0	50	0	0	0	0	0	50
	500	300	350	285	-15	-65	542

Project ABCD

Estimate at Completion (4)

$$\begin{aligned} \text{EAC (4)} &= \text{ACWP} + ((\text{BAC} - \text{BCWP}) / (\text{CPI} * \text{SPI})) \\ &= 300 + (500 - 285) / 0,95 * 0,81 &= 579 \end{aligned}$$

Future Cost Performance will be influenced additionally by past Schedule Performance

The use of different forecasting methods

1. The uncompleted work will be done according to the original plan (CPI = 1 for the rest of the work) (1)
 - Can be used, if problems and past inefficiency has already gained
 - Past and future tasks are totally independent what it comes to their CPI
2. Trend analysis according to EVA principles (2)
 - Will be used, if future cost performance is believed to be the same as all past cost performance
3. Analysing the ETC of single tasks using trend analysis (3)
 - If the activity is not started, its EAC = BAC
 - EAC of the whole project is the sum of EAC of single activities
 - AC of single activities must be reported

Time Estimate to Completion

It is important to note that EVM method can generate a fairly rough time estimate and must always be compared with the status reflected with other methods such as **critical path method**.

It is possible that EVM could show no schedule variance and yet the project is still behind the schedule, if only the critical path is behind the schedule.

Project ABCD

Time Estimate to Completion

(1) The future SPI is believed to be as originally planned

=> Total duration $9 + 1$ weeks = 10 weeks

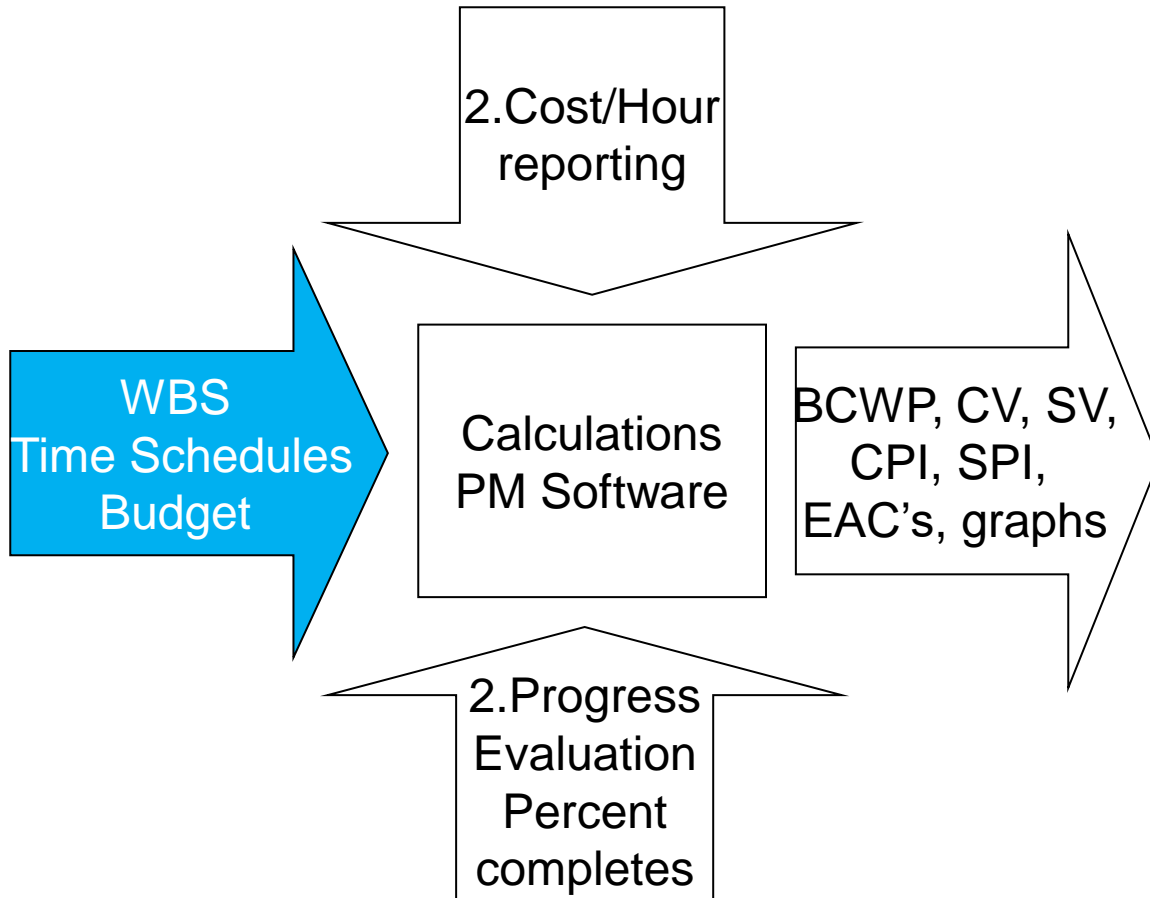
(2) Planned duration / SPI

= $9 / 0,81 = 11$ weeks (??)

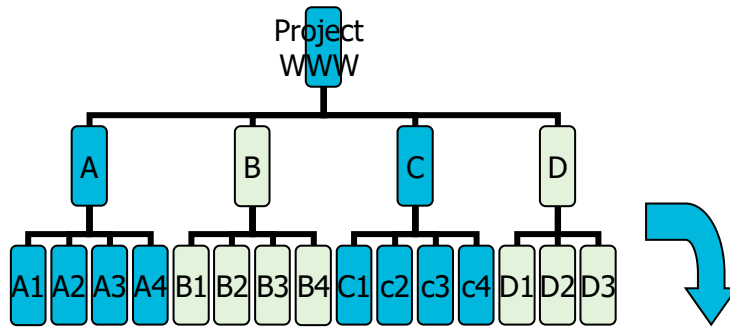
EVM in Practice

This is the theory, but what is the challenge in reality?

Input of EVA process



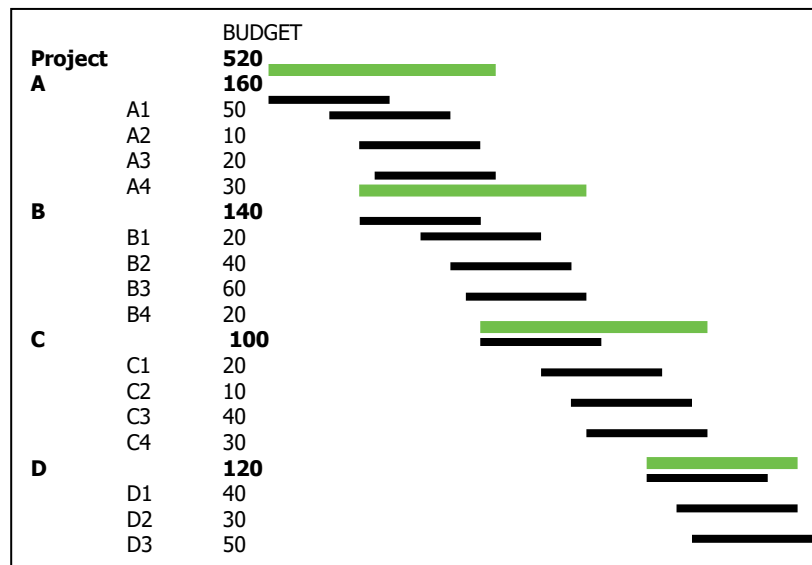
EVA process



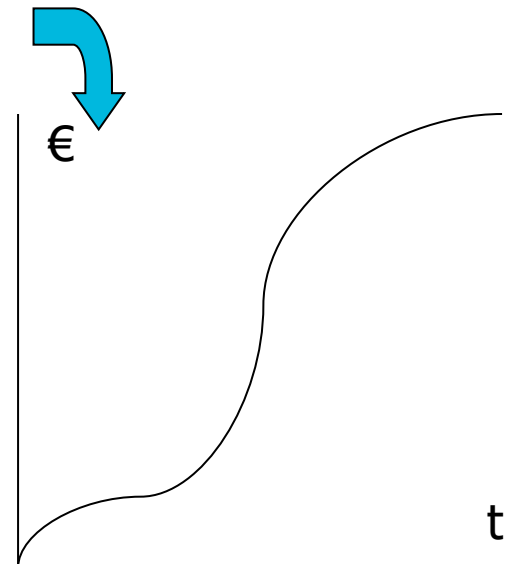
The planning requirements of Earned Value analysis

- **WBS according to 100% rule**

1.WBS
Time Schedules
Budget

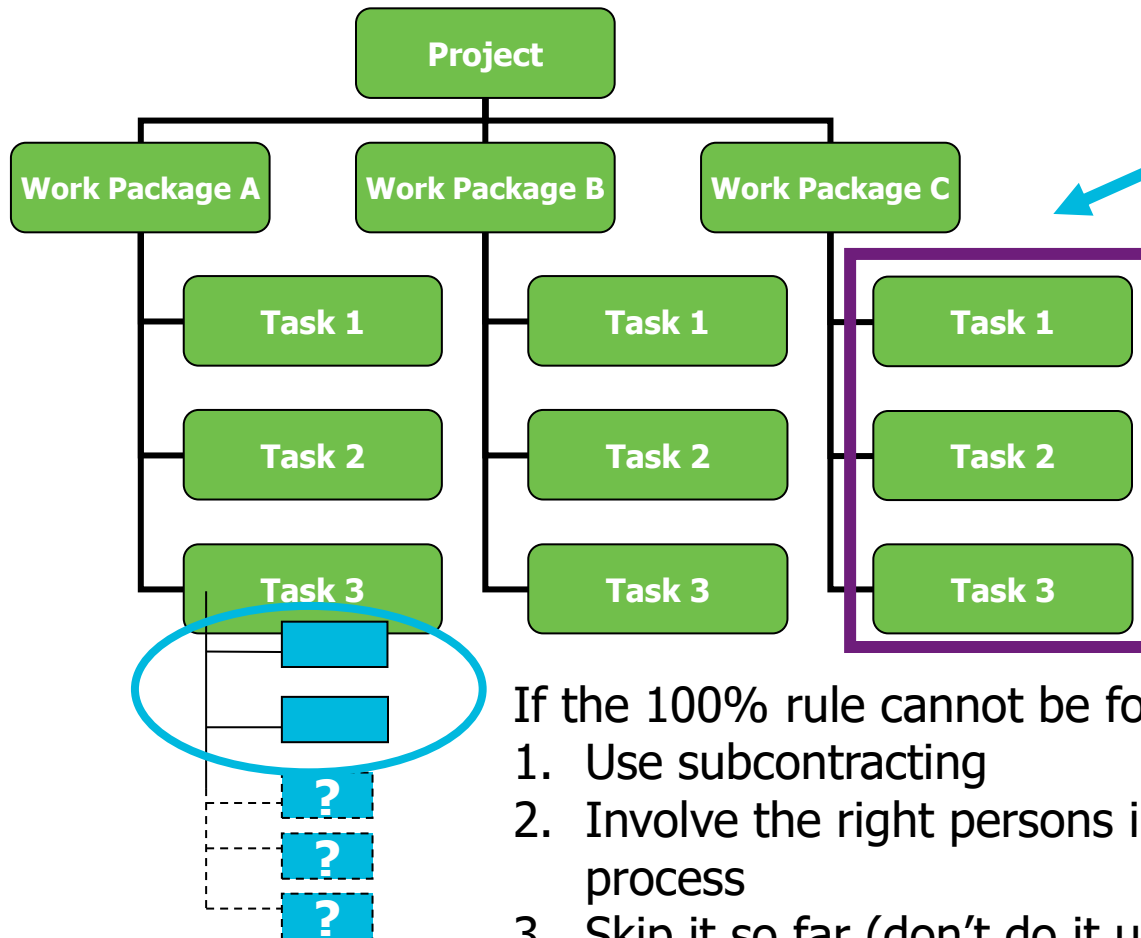


- Time phased budget



- Budget which has been divided in such elements, where you can estimate the percents complete reliably enough

WBS: The 100% rule



Elements of lower level must cover 100% of the content of higher level

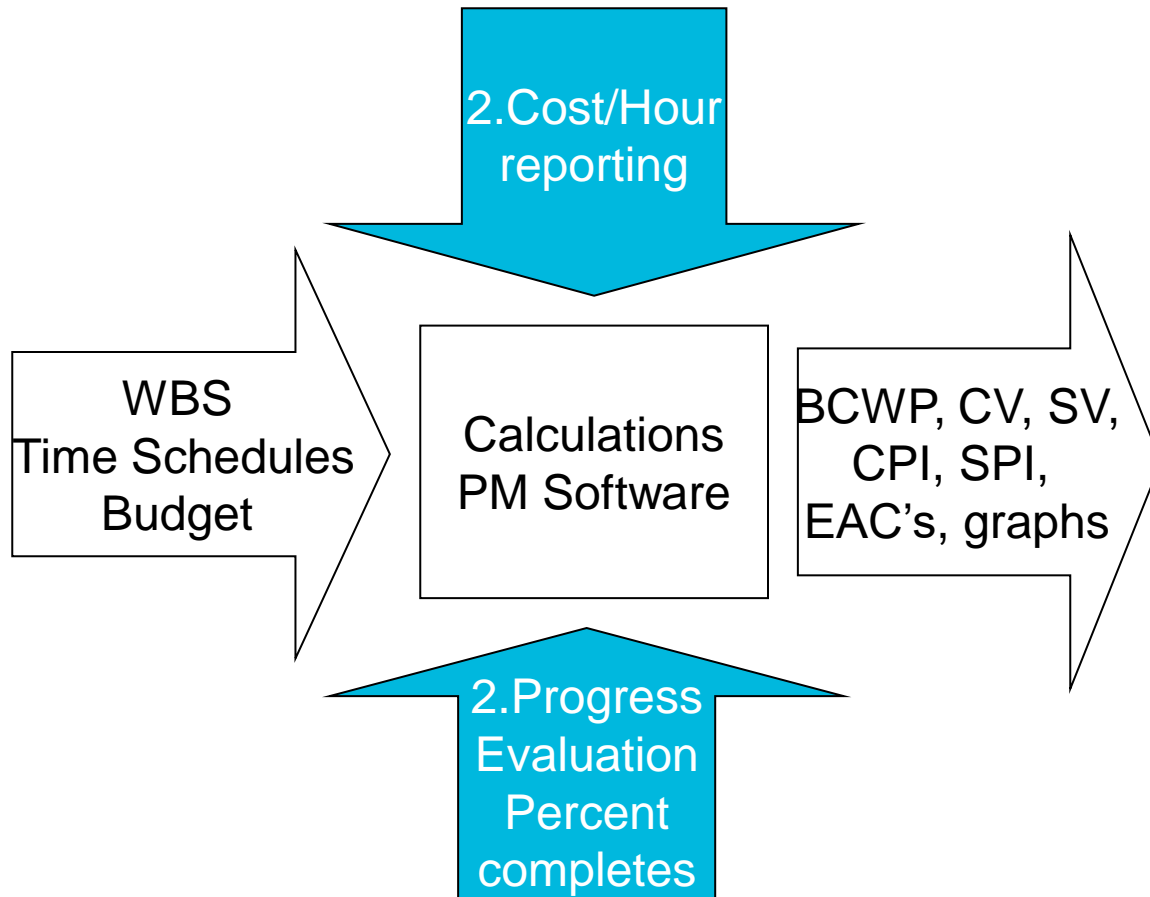
If the 100% rule cannot be followed

1. Use subcontracting
2. Involve the right persons in WBS process
3. Skip it so far (don't do it until you are able to follow the rule)

Input of EVA process

Cost /hour reporting

Estimation of % completes



The information needed to do Earned Value Analysis:

- Follow up of actual hours/costs
- **Estimation of percent completes of single activities**

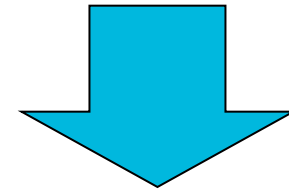
Estimating the Percent Complete (1)

- The use of Earned Value –method is based on how many percent of the task is complete!
- However, it is often easier and even more important to estimate time or work to completion.
- This estimation, however, usually gives quite accurate level of percent complete if actual work hours are known.

Estimating the Percent Complete (1)

Actual work hours 120 h

Estimation of the remaining work hours 40 h



Estimation of the percent complete 75 %

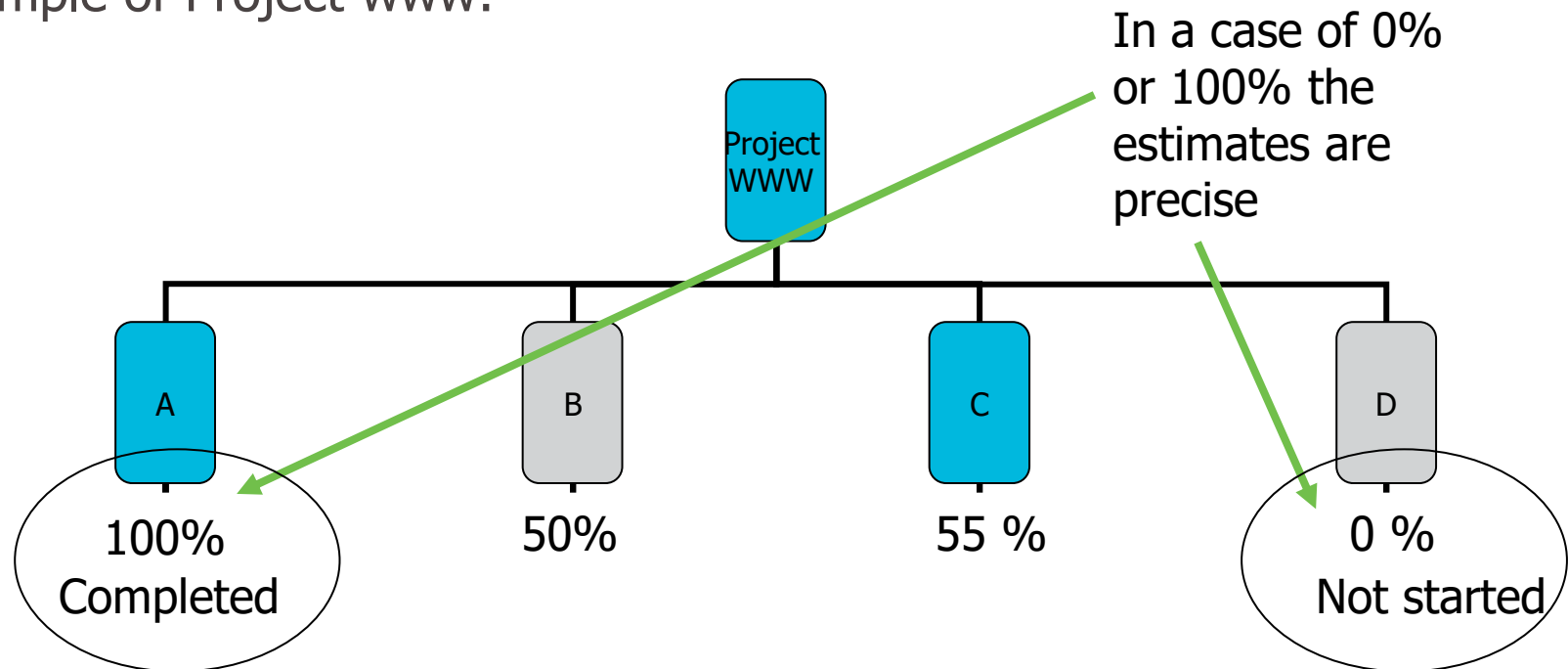
This evaluation can be done with **certain preconditions!**

Note: If the original budget has been 40 h, then the earned value is 30 h!

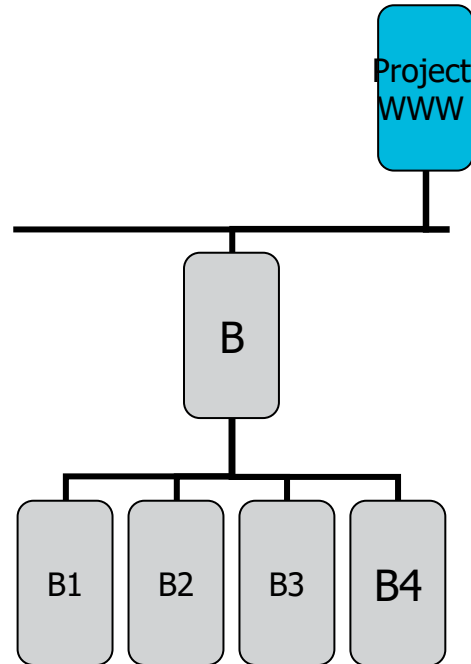
Estimating the Percent Complete (2)

To get more precise estimates, you must have more detailed WBS

Example of Project www:



WBS of Project ABCD



	%	BAC	BCWP
B1	100	30	30
B2	50	40	20
B3	50	20	10
B4	25	60	15
B	50	150	75

Budget is divided to the lower level of WBS and Percent Completes of this level elements (B1, B2, B3, B4) are estimated

Percent Complete B = $EV/BAC = 75/150 = 50 \%$

Estimate at Completion EAC (3)

	%	BAC	BCWP
B1	100	30	30
B2	50	40	20
B3	50	20	10
B4	25	60	15
B	50	150	75

teht.

	%	BAC	AC	BCWS	BCWP	CV	SV	EAC (3)
A	100	100	90	100	100	10	0	90
B	50	150	110	150	75	-35	-75	220
C	55	200	100	100	110	10	10	182
D	0	50	0	0	0	0	0	50
		500	300	350	285	-15	-65	542

WBS of Project ABCD

Budget is divided to the lower level of WBS and Percent Completes of this level elements are estimated

$$\text{Percent Complete B} = \text{BCWP} / \text{BAC} = 75 / 150 = 50 \%$$

If you use only 0 % or 100 % estimates here, the error will still be significant. But using steps of 25%, you will probably have a status report which is reliable enough.

	%	BAC	BCWP
B1	100	30	30
B2	50	40	20
B3	50	20	10
B4	25	60	15
B	50	150	75

Estimating the Percent Complete (2)

Percent Complete Technique

- Simple and easy, but can be the most subjective
- Do not try to be too accurate, try to be realistic:
 - Milestones e.g.:
 - 0% not started
 - 25% started
 - 50% “almost finished”
 - 75% “finished”
 - 100% approved result

Or: (?)
0% not started or started
100 % completed

Estimating the Percent Complete (3)

- Fixed Formula

- 0/100

- 25/75

- 50/50

- 50/50 means: 50% of work is credited as complete for the measurement period in which work begins , regardless of how much work has actually been completed

- Most effectively used on small, short duration tasks

Estimating the Percent Complete (4)

- Weighted Milestone

- Divides the work to be completed into segments, each ending with an observable milestone
- Is actually almost the same as having more accurate WBS
- Suitable for longer duration tasks having intermediate, tangible outcomes

Estimating the Percent Complete (5)

- Apportioned Effort

- The BCWP or Percent Complete is determined based on the BCWP of the reference base activity or the BCWP of the rest of the project
- e.g. Percent Complete of Project Management
- Using EVM you have estimated the Percent Complete of the project to be 25%. You have budgeted 1000 hours for PM activities. BCWP of Project Management is then 250 h.

Estimating the Percent Complete (6)

- Level of Effort (LOE)
 - The Planned Value is automatically credited as the BCWP
 - E.g. Project Management activities can be measured this way as well
 - Note: LOE tasks has no Schedule Variance



Case: Aurora Australis

Case: Aurora Australis

- Project was implemented 1987 – 1990
- The objective was to build a new Antarctic Research Vessel. The old vessel (Nella Dan) destroyed after collision with an ice.
- In the beginning Wärtsilä Marine was offering to build the vessel in Finland
- However Australian authorities wanted the vessel to be built in Australia

Case: Aurora Australis

- Australian shipyards didn't have technical competence and know how to design and build this kind of special vessel (research vessel and ice breaker)
- Carrington Slipways was selected to build and deliver the vessel
- The precondition was however that Wärtsilä Marine should be the main designer of the vessel

Case: Aurora Australis

- Wärtsilä Marine delivered almost entire design of the Vessel vastasi (contract value was app. 20 MFIM)
- Additionally WM procured a significant amount of equipment, material and machines (e.g. Ice strengthened steel)
- WM was also giving technical and Project Management consultation for the shipyard.
- The responsible business unit was Wärtsilä Marine Contracting and the design work was carried out by Wärtsilä Marine Engineering

Case: Aurora Australis

- EVM was the was selected to be the most important management method in the project
- EVM was used to manage the time schedules and especially to forecast costs.
- Design work was sold using fixed price contract. The EAC of the project was correctly forecasted quite early.
- We were able to have EV reports using several viewpoints: The entire project, design department, design/ship area, steel blocks/units)

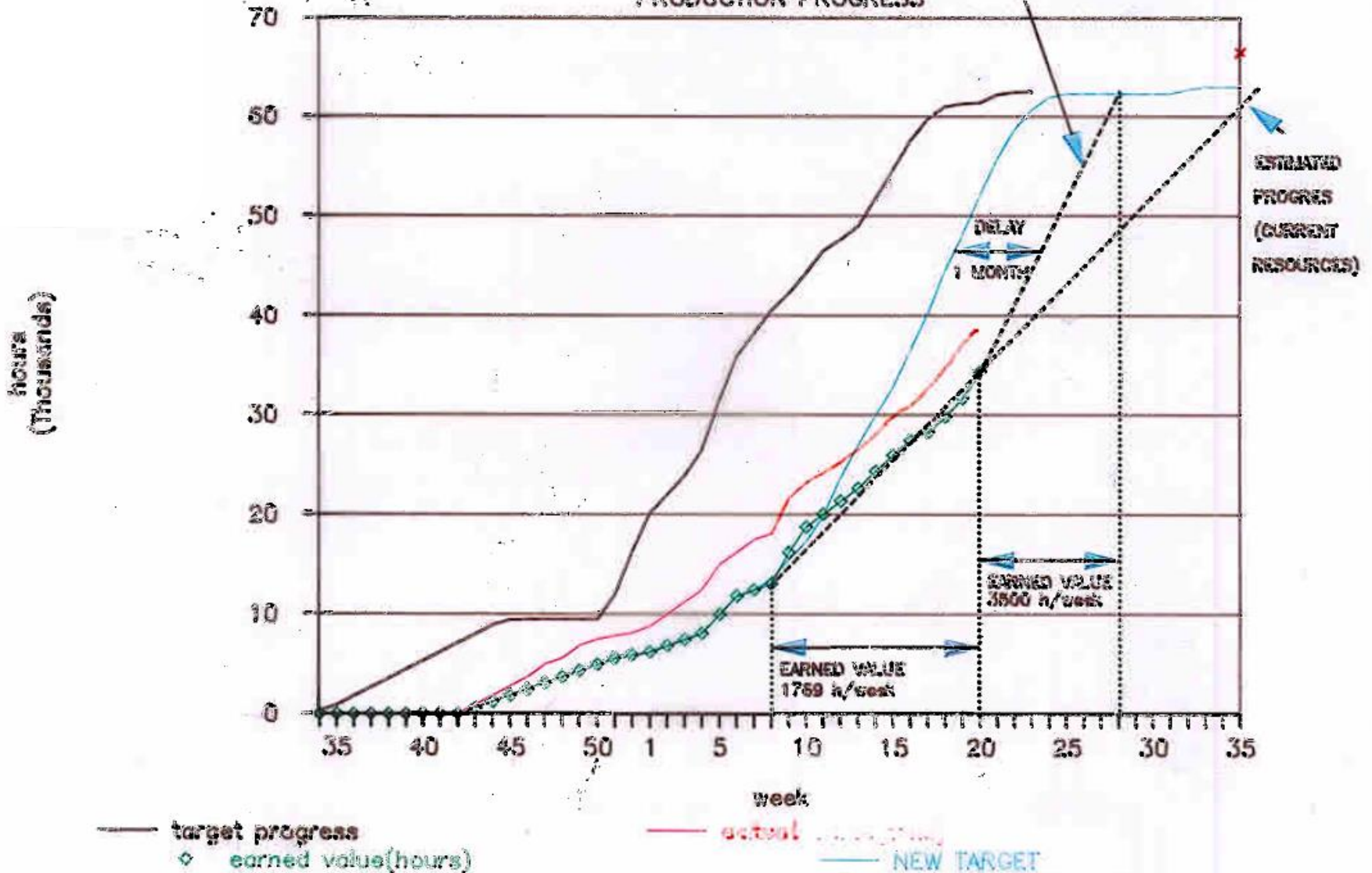
Case: Aurora Australis

- EVM was also used to monitor and control the building phase
- Wärtsilä Marine was consulting PM, including time schedule planning and control
- We were able to have EV reports using several viewpoints: The entire project or building phase

SUPER UNIT ERECTION

CATCH UP
IN EIGHT WEEKS
(1 MONTH DELAY TO BE FIXED)

PRODUCTION PROGRESS



CONCLUSION:

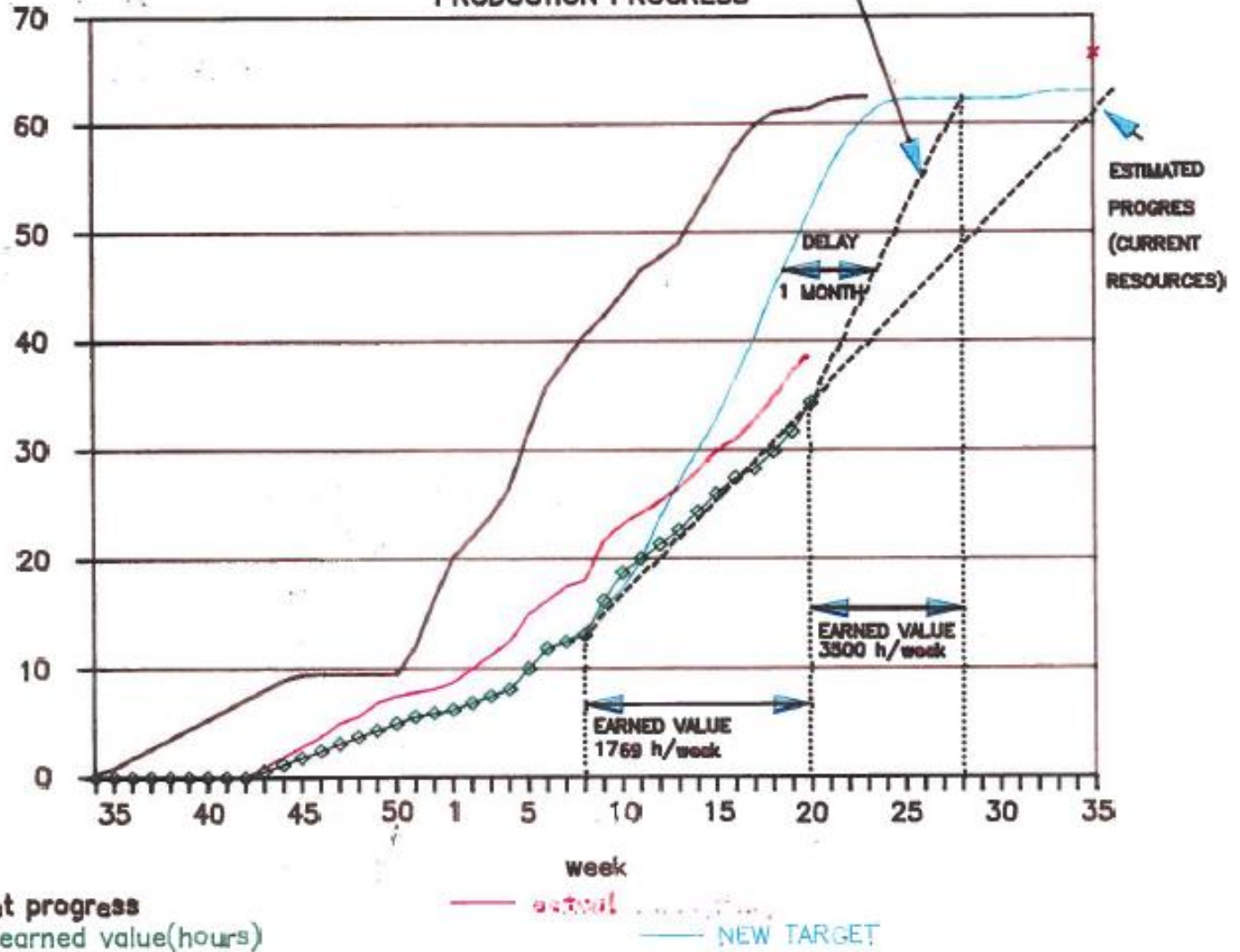
MANPOWER REOURCES
HAVE TO BE DOUBLED
TOTALLY 105 MEN IS
NEEDED IN BERTH
WITHIN EIGHT
WEEK PERIOD .

hours
(Thousands)

SUPER UNIT ERECTION

CATCH UP
IN EIGHT WEEKS
(1 MONTH DELAY TO BE FIXED)

PRODUCTION PROGRESS



Implementing EVM

Why EVM becomes more important?

- Need of measurable controlling methods
- Need of better forecasting
- Need of transparent and reliable project reporting

However EVM can not be applied if general Project Management maturity is not high enough

The use of EVM improves your Project Management in all fields, improving especially the quality of project planning

Why EVM becomes more important?

EVM can play a crucial role in answering management questions that are critical to the success of every project, such as:

- Are we ahead of or behind schedule?
- How efficiently are we using our time?
- **When is the project likely to be completed?**
- Are currently under or over our budget?
- How efficiently are we using our resources?
- What is the remaining work likely to cost?
- What is the entire project likely to cost?
- **How much will we be under or over budget at the end?**

PMI: Practice Standard for EVM

Why EVM becomes more important?

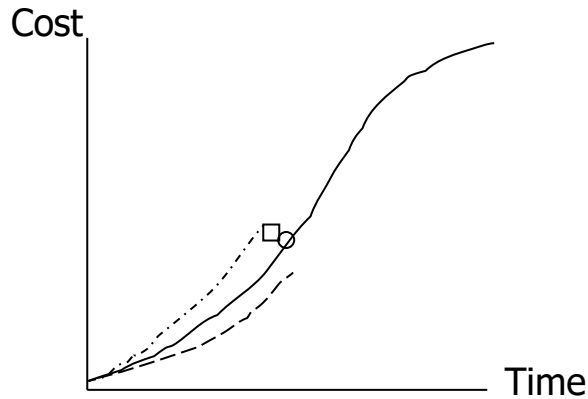
The project manager can use the EVM methodology to help identify:

- Where problems are occurring?
- Whether the problems are critical or not?
- What it will take to get project on track?

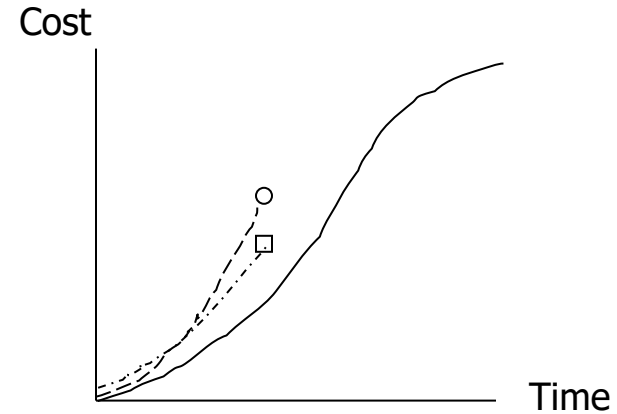
Earned Value method

- Is suitable for projects where critical or major (schedule or costs) part of project work is own work
- Is suitable also for controlling other parties (e.g. suppliers) and anticipating problems
- Trend observation helps to find causes for problems (forecasting and corrective activities)
- In projects, where fixed price procurements form a critical part of the project, the use of Earned Value –method is more difficult
- Requires effective follow-up system and WBS that is accurate enough
- Reveals easily and clearly the lack resources

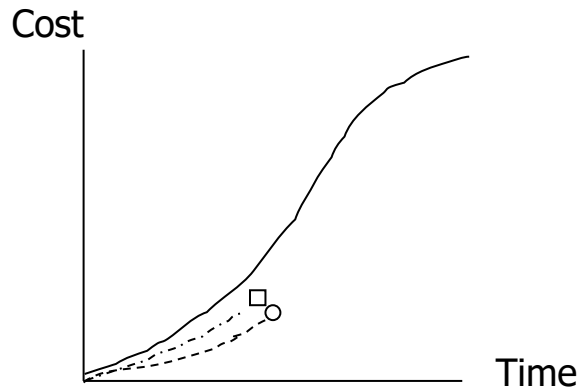
Monitoring Costs and Time Using S-curves



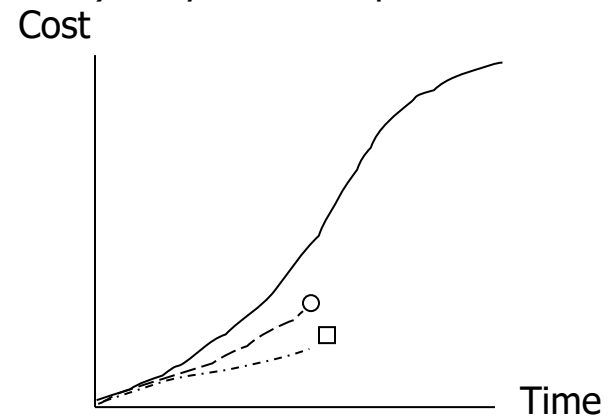
a) Early and underspent



b) Early and overspent



c) Late and underspent



d) Late and overspent

—————	Planned cost of work scheduled (Baseline)	-----□	Planned cost of work complete (Earned value)
-----○	Actual cost of work complete (Accrual)		

Source: Turner

Benefits

Project forecasting

- One key benefit of EVA is that it provides a solid basis to create project forecast only after $\sim 20\%$ of the budgeted total cost is accumulated
- The detailed technique to create the forecast must be based on rational decision by the project manager and the project owner, otherwise the results may be faulty

Earned Value method

The knowledge needed to use Earned Value method

- The philosophy of the method
- Formula: $\text{Earned value} = \% \times \text{budget}$, the other information can be concluded with common sense
- You may use the table only, but the graphical report is better and more illustrative.
- No need of other formulas (of course you may use some formulas to calculate some indexes and explain the theory)

Earned Value method

The information needed to do Earned Value analysis

- Budget which has been divided in such elements, where you can estimate the percents complete reliably enough
- Time phased budget
- Follow-up of actual hours/costs
- Estimation of percent completes of single activities

Tuloksen arvo -menetelmä

Kokemuksia Tuloksen arvo -menetelmän käytöstä:

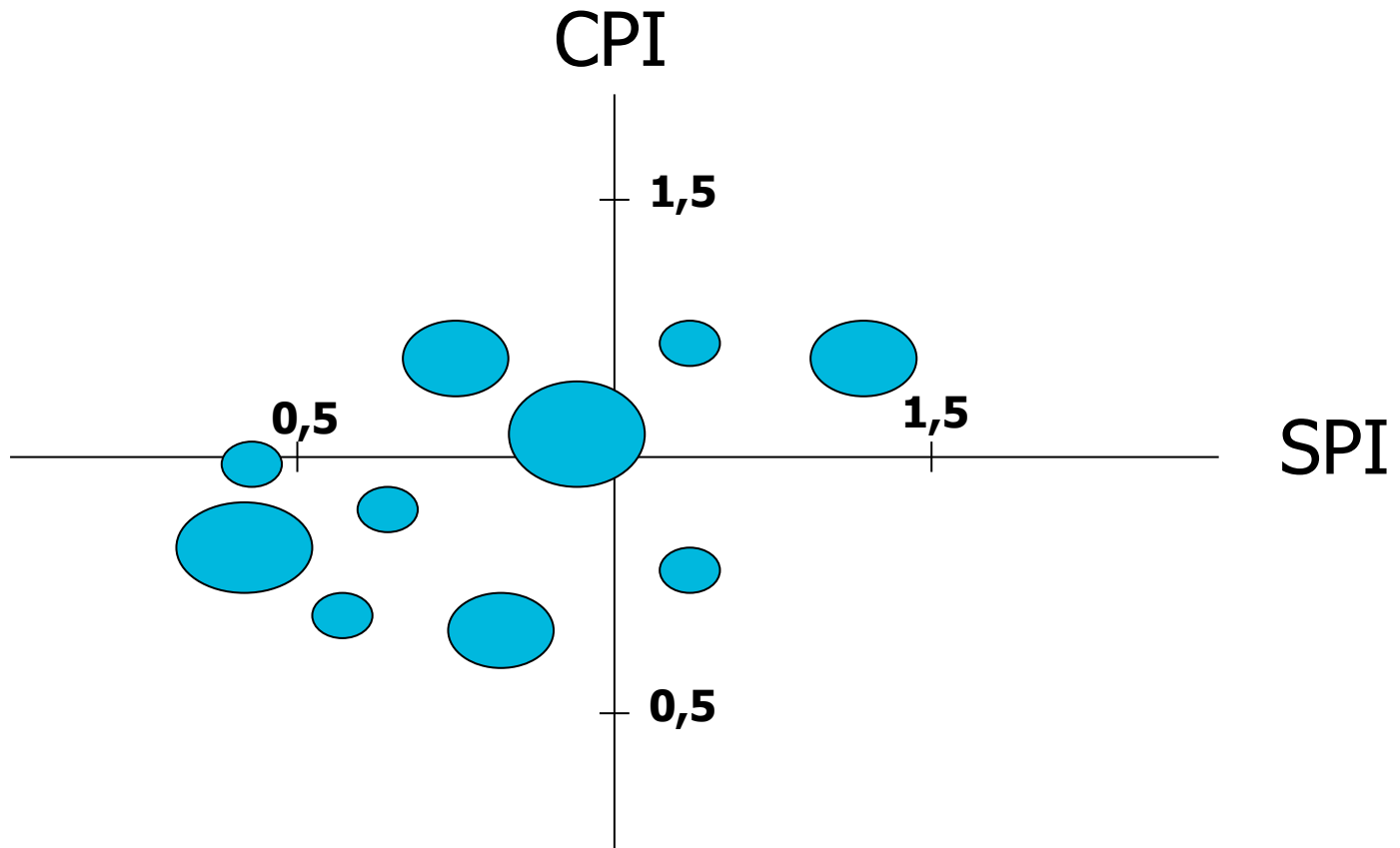
- *” Kokonaisuutena harppaus ”selittely”hallinnasta systemaattiseen toimintatapaan. Organisaatio on oppinut käyttämään (vaatii aikaa ja koulutusta) ”*
- *” Looginen ja kiistaton”*
- *” Raportointitavoissa eroja ihmisten välillä ”*
- *” Hyvä trendin näyttäjä ja usein myös hälyttäjä”*

Pertti Rinta-Panttila/Kvaerner Masa Yards 1994

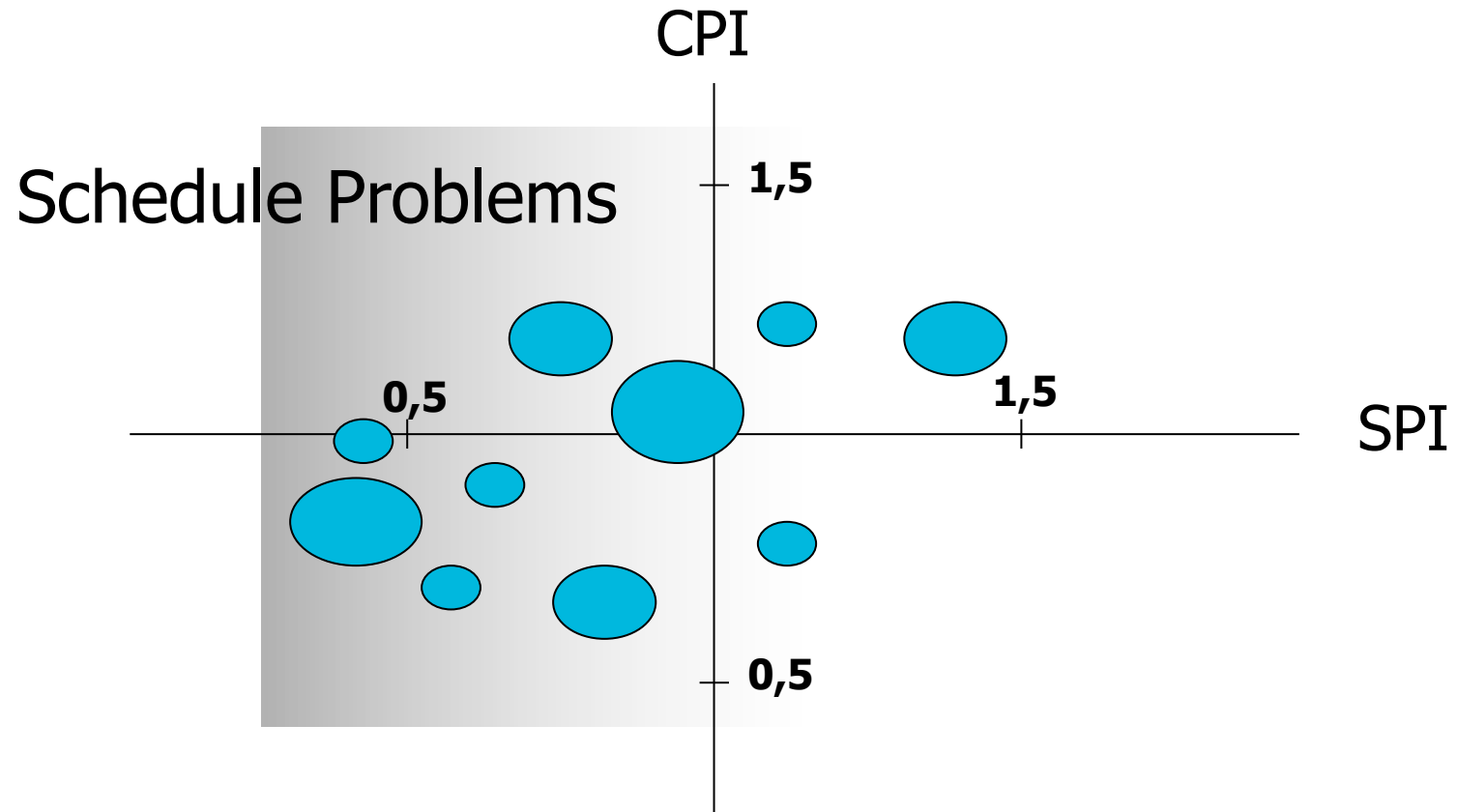
Earned Value method

- EVM can be an excellent method for forecasting and steering the whole company's business
- In this case EVM is used in all projects and thus a realistic estimation can be received to an incomplete project portfolio
- Incomplete projects can also be documented to the accounting system with accurate estimates

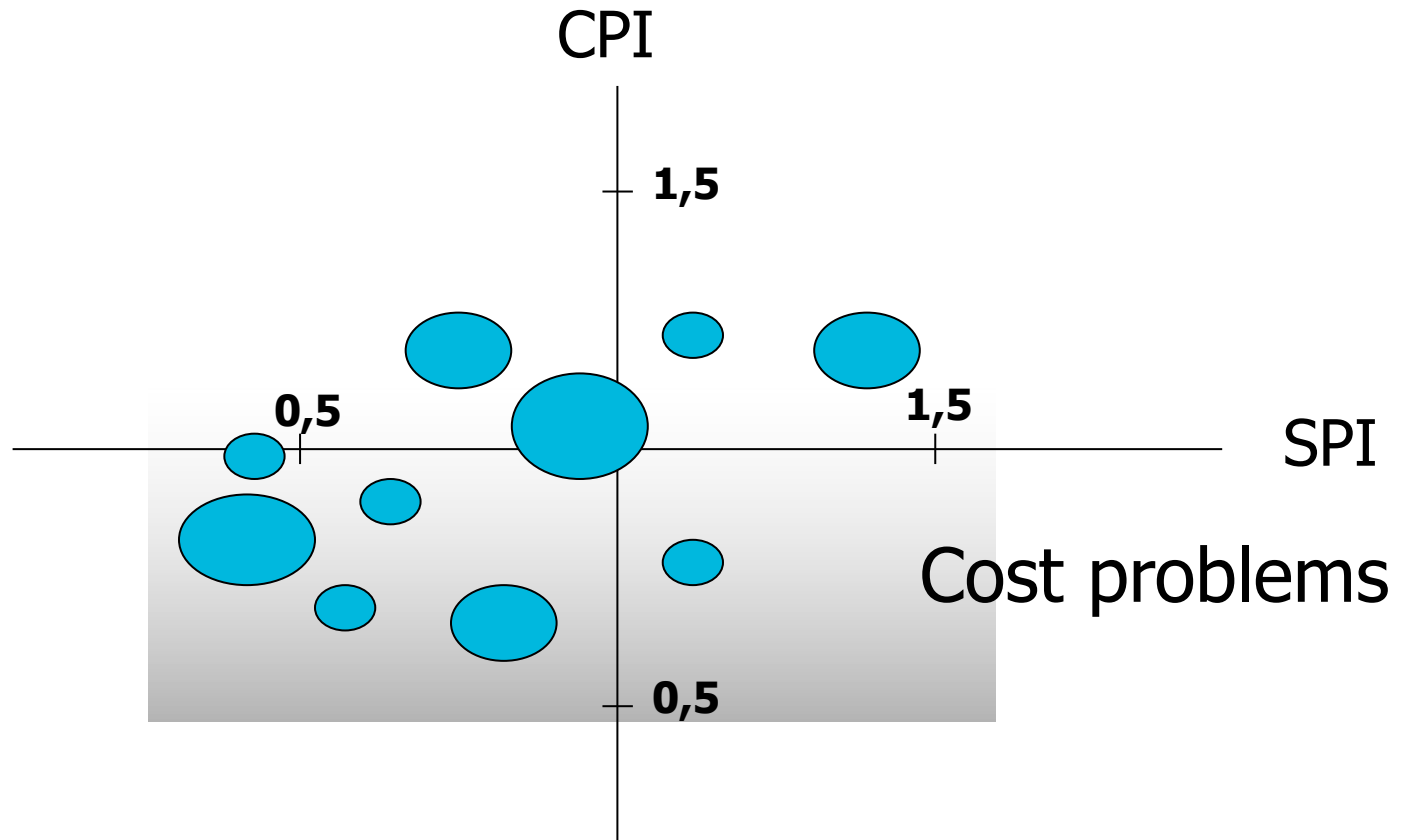
Evaluating the status of Project Portfolio using the EV method



Evaluating the status of Project Portfolio using the EV method



Evaluating the status of Project Portfolio using the EV method



Answers to management questions:

- Are we ahead of or behind schedule? SV
- How efficiently are we using our time? SPI
- When is the project likely to be completed? EACt
- Are currently under or over our budget? CV
- How efficiently are we using our resources? CPI
- What is the remaining work likely to cost? ETC
- What is the entire project likely to cost? EAC
- How much will we be under or over budget at the end? VAC

PMI: Practice Standard for EVM

Simple exercise Quiz/poll vaihtoehdot 4 kpl

ACWP = 50 h

	Budget	Pct complete
Task 1	30h	33%
Task 2	60h	67%
Task 3	<u>20h</u>	25%
	110 h	

Calculate EAC assuming that each task will be completed having the same cost performance as so far

Simple exercise

ACWP = 50 h

	Budget	Pct complete	EV
Task 1	30h	33%	10h
Task 2	60h	67%	40h
Task 3	<u>20h</u>	25%	<u>5 h</u>
	110 h		55 h

CPI = BCWP / ACWP = 55 / 50 = 1,1 EAC = BAC / CPI = 110 / 1,1 = 100

% complete of the project = EV / Budget 55 / 110 = 50%
50 h is used for 50% , **100 h is used for 100 %**



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"OH, YEAH? WELL MY DAD'S EARNED VALUE IS BIGGER THAN YOUR DADS!"