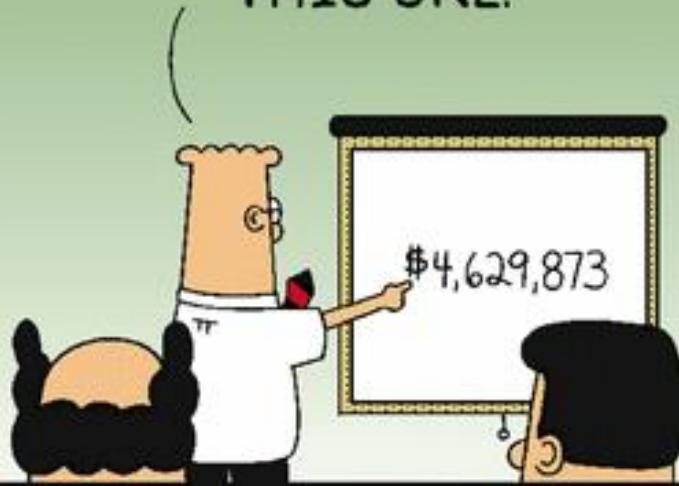


Estimating

I DIDN'T HAVE ANY
ACCURATE NUMBERS
SO I JUST MADE UP
THIS ONE.



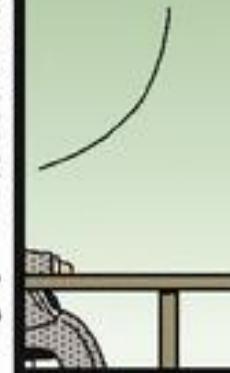
www.dilbert.com scottadams@aol.com

STUDIES HAVE SHOWN
THAT ACCURATE
NUMBERS AREN'T ANY
MORE USEFUL THAN THE
ONES YOU MAKE UP.



5808 © 2008 Scott Adams, Inc./Dist. by UFS, Inc.

HOW
MANY
STUDIES
SHOWED
THAT?



EIGHTY—
SEVEN.



Recap

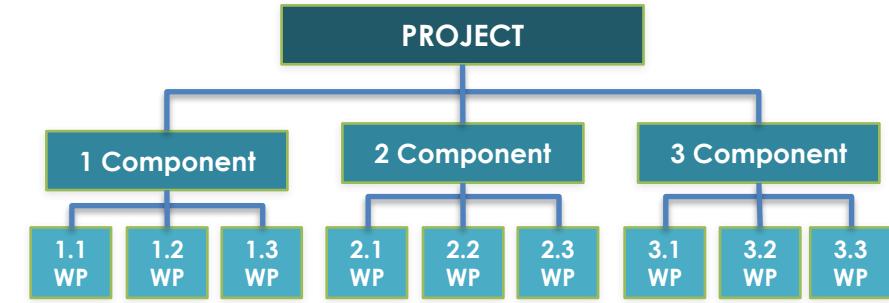
Start-up / Initiation:

- **PMBOK®**: Project Charter
- **PRINCE2®**: Project Brief, PID, PPD, Business Case...



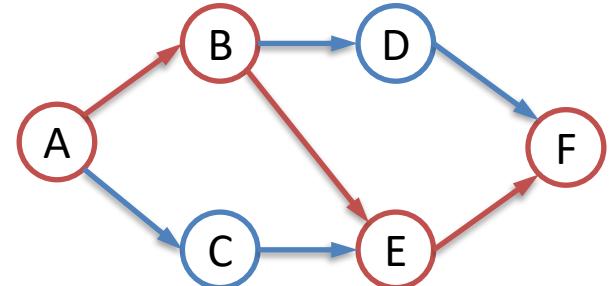
PMBOK® vs PRINCE2®

	PMBOK Guide®	PRINCE2®
What is it	Framework	Methodology
Focus	Activities	Deliverables ("Products")
Driver	Customer requirements	Business Case
Process 'groups'	5	7
Knowledge areas	10	7
Steps	49	40



Scope & Time Management:

- WBS
- Gantt, PND
- CPM, PERT





This session is being recorded.



WARWICK

CS352 Project Management for Computer Scientists

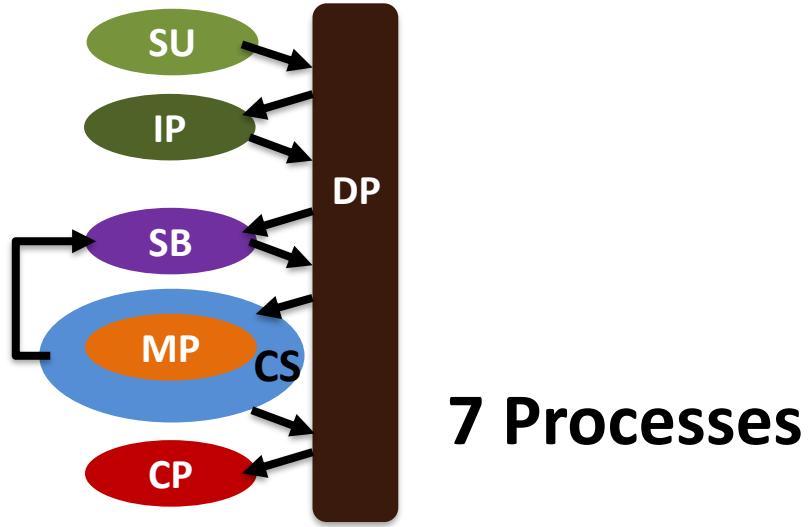
5. Budgeting and Forecasting



interact at:

warwick.ac.uk/pm4cs/5

Dr. Ian Saunders



PRINCE2® Recap



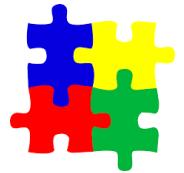
7 Principles



Structured Roles



Post your answers:
warwick.ac.uk/pm4cs/5



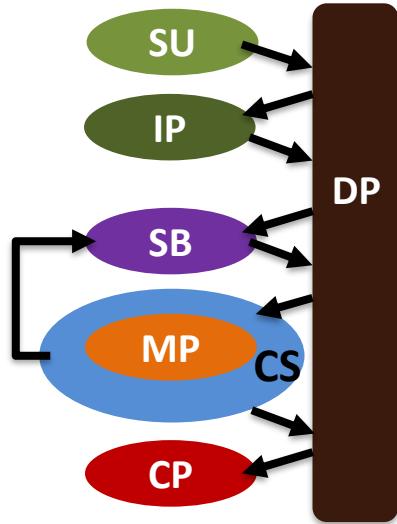
7 Themes



“Management Products”



What are the 7 PRINCE2 principles? (submit one word for each)



7 Processes



Structured Roles



7 Themes



“Management Products”

PRINCE2® Recap



7 Principles

1. Continuous business justification
2. Learn from experience
3. Defined Roles and responsibilities
4. Manage by stages
5. Manage by exception
6. Focus on products
7. Tailor to suit the environment

Quiz!

PRINCE2®



warwick.ac.uk/pm4cs/5



Who is on the Project Board / represented by the Board?

Vote for up to 3 choices

1. Business Executive
2. Project Manager
3. Developers
4. Users
5. Customers
6. Suppliers
7. Stakeholders

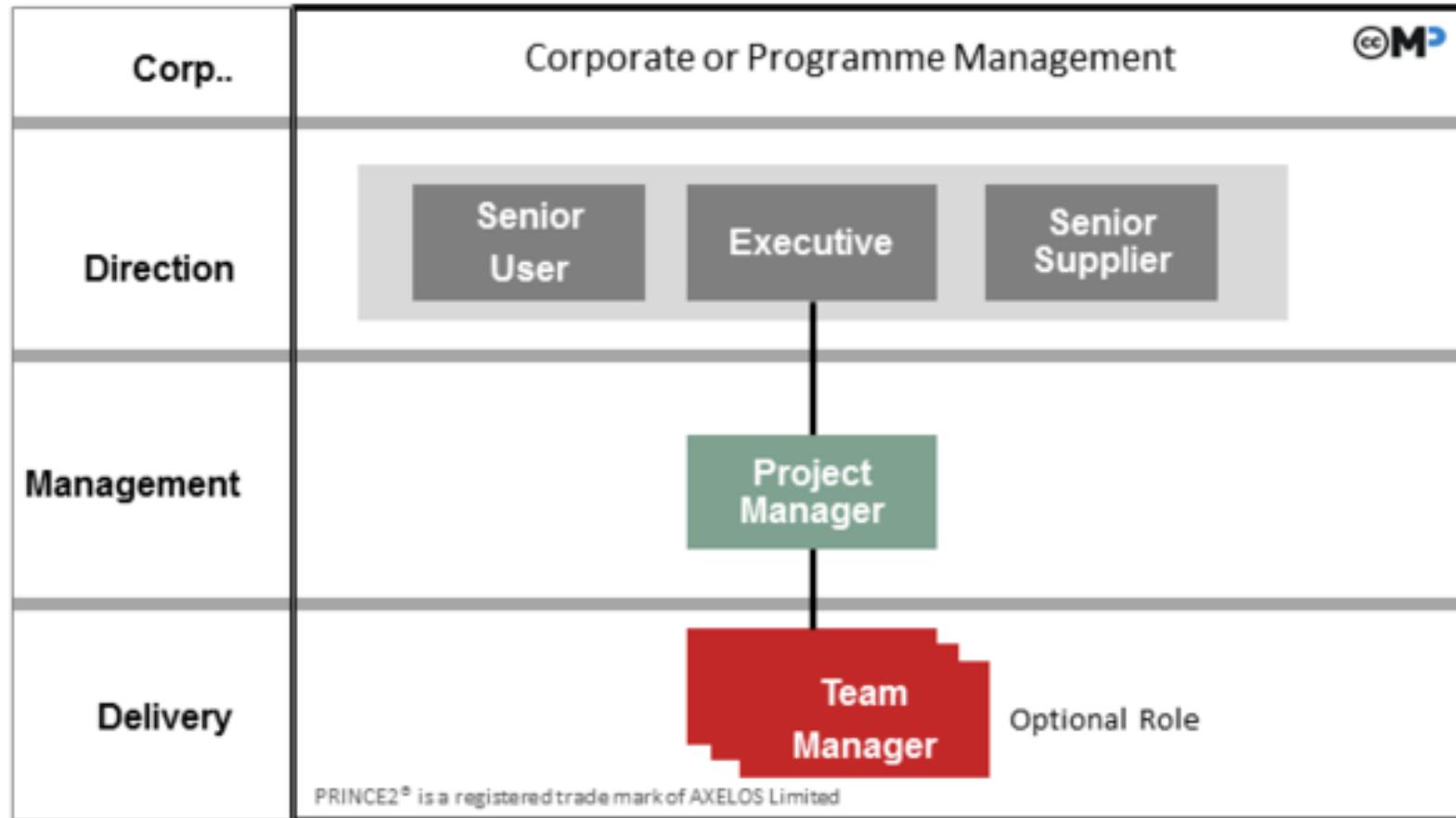


Who is on the Project Board / represented by the Board?

Vote for up to 3 choices

- 1 Business Executive
- 2 Project Manager
- 3 Developers
- 4 Users
- 5 Customers
- 6 Suppliers
- 7 Stakeholders

The Project Board





Starting Up a project is triggered by which of the following?

- 1 Business Case
- 2 Outline Business Case
- 3 Project Charter
- 4 Project Mandate
- 5 Project Executive
- 6 Senior Management
- 7 Corporate Strategy

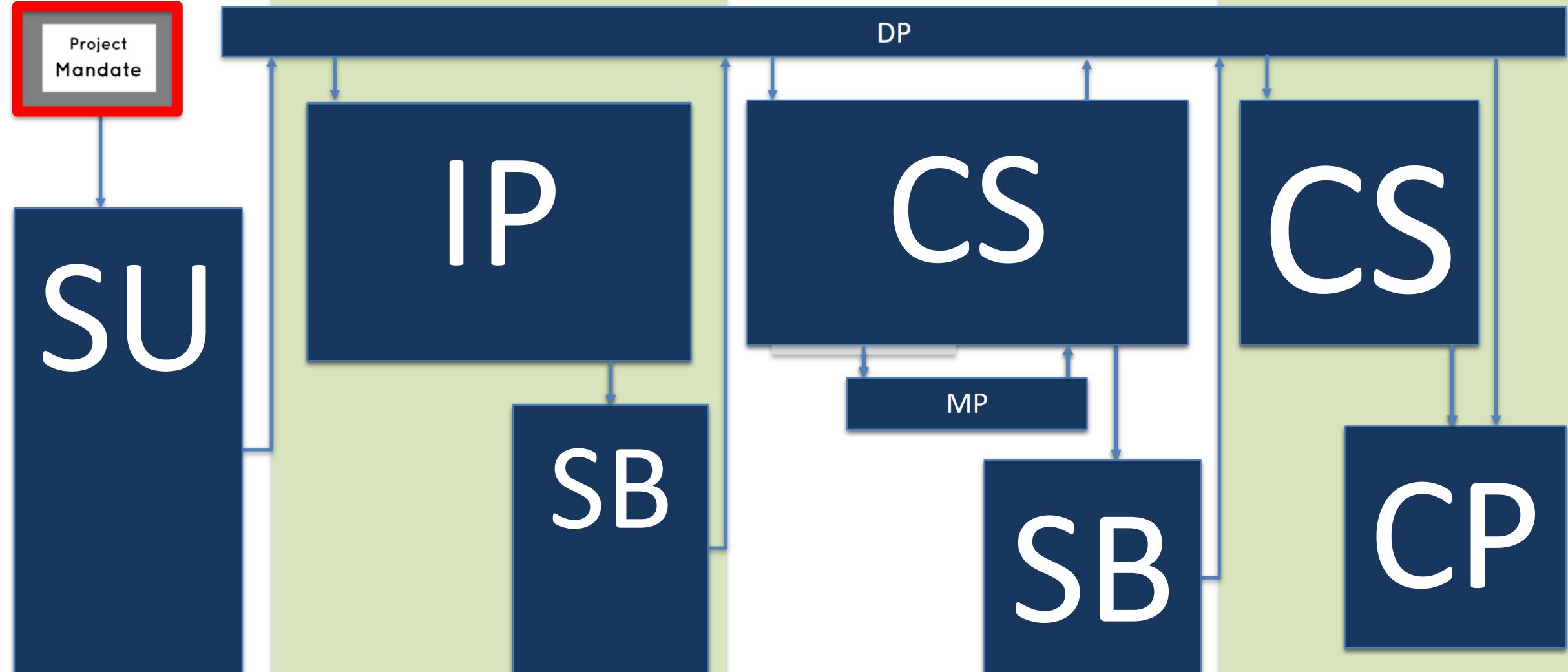
Start Up

Initiation Stage

Execution Stage

Closing Stage

(there could be more than one of these)



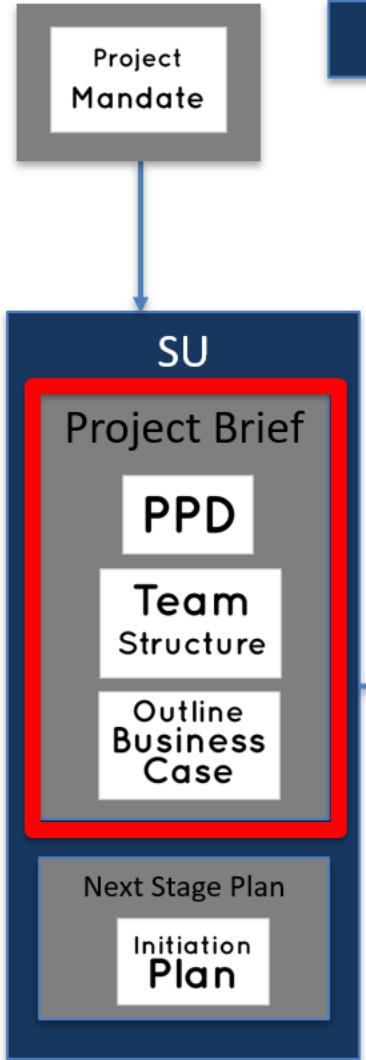
Logs

Registers

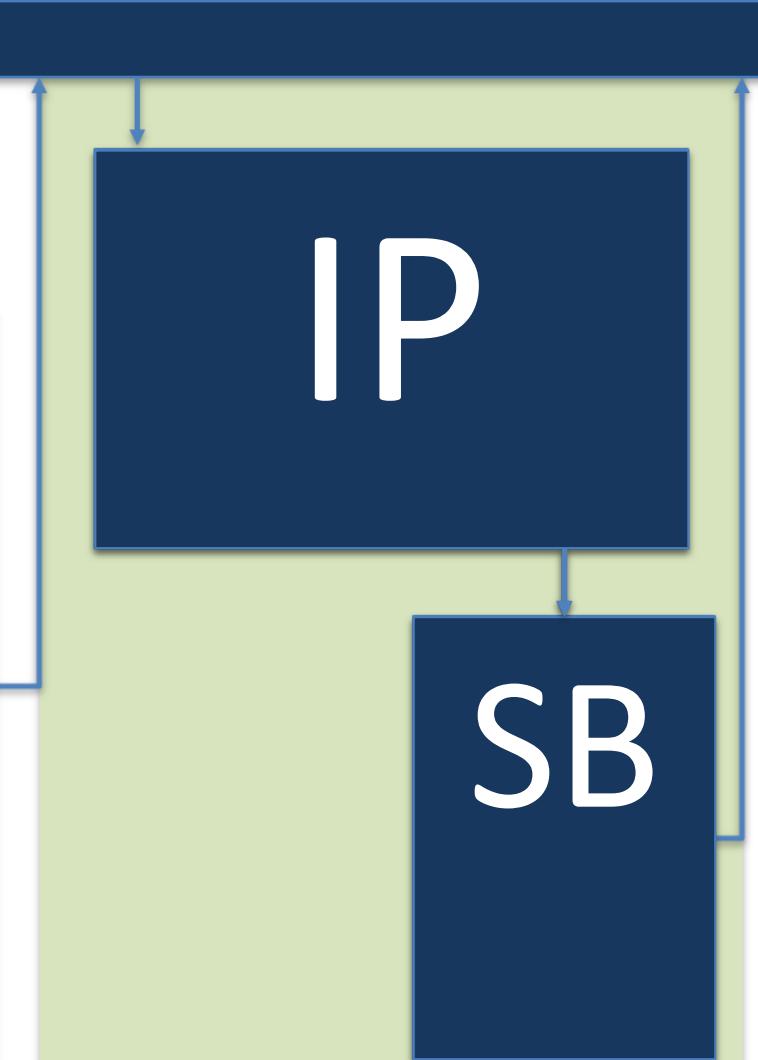
Which of the following is NOT an objective of Initiating a Project?

- 1 Understanding the roles and responsibilities of the Project Management Team
- 2 Understand how progress will be monitored and controlled
- 3 Understand how quality required will be achieved
- 4 Understanding the scope of what is to be done and the products to be delivered

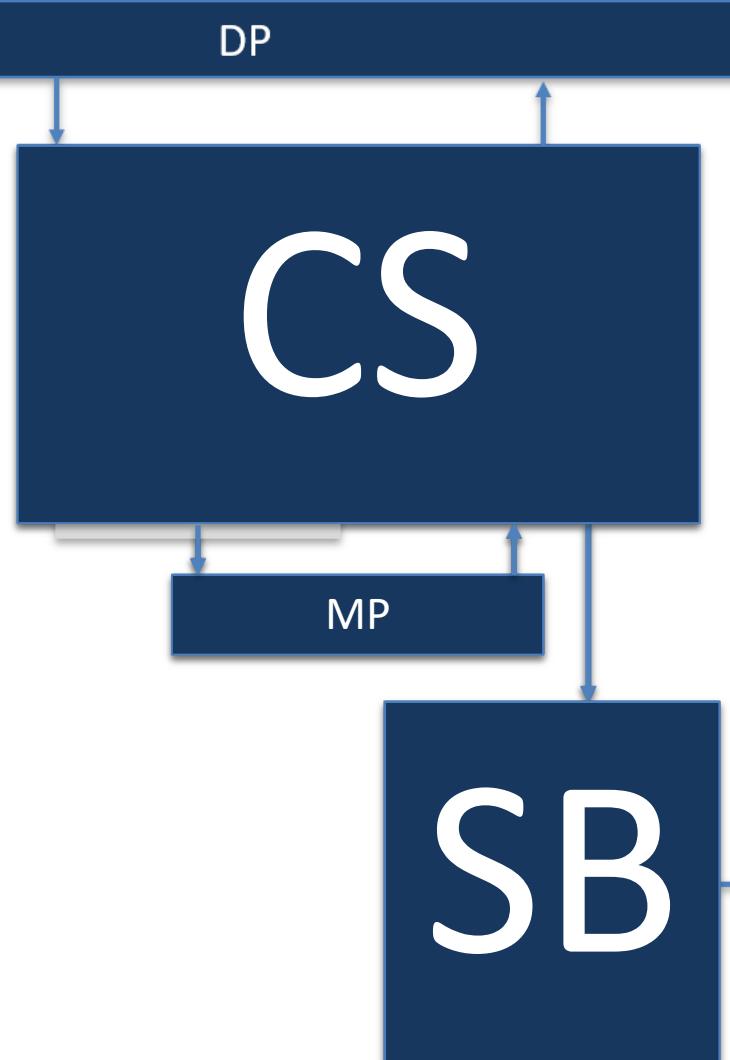
Start Up



Initiation Stage

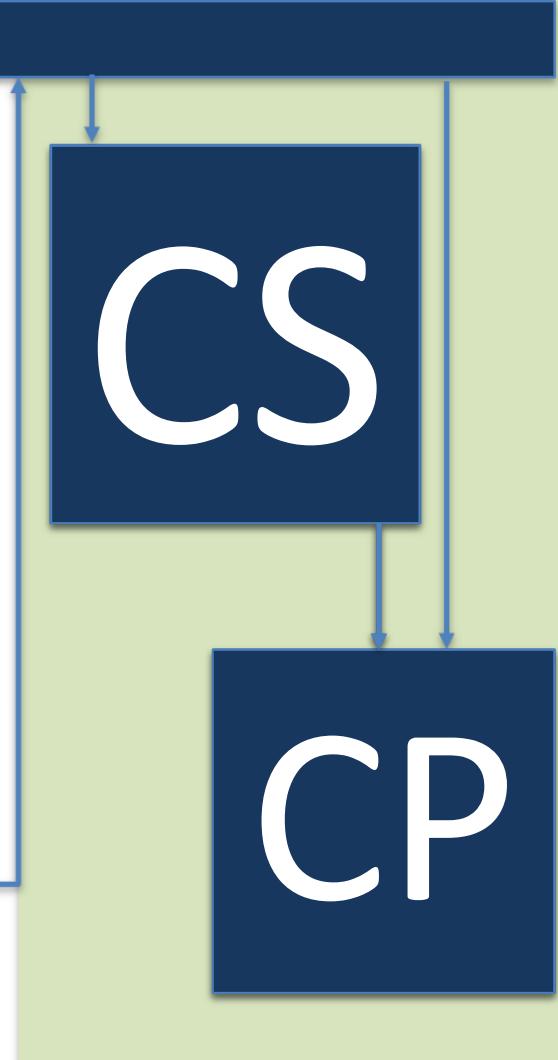


Execution Stage (there could be more than one of these)



...

Closing Stage



Logs

Registers



Which other management product is created when the Business Case is updated during Initiating a Project?

- 1 Benefits Review Plan
- 2 Issue Register
- 3 Risk Register
- 4 Initiation Plan

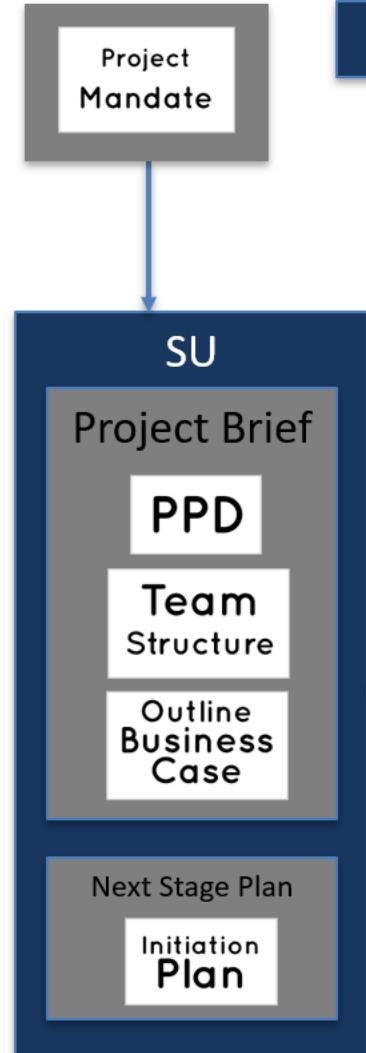
Start Up

Initiation Stage

Execution Stage

Closing Stage

(there could be more than one of these)

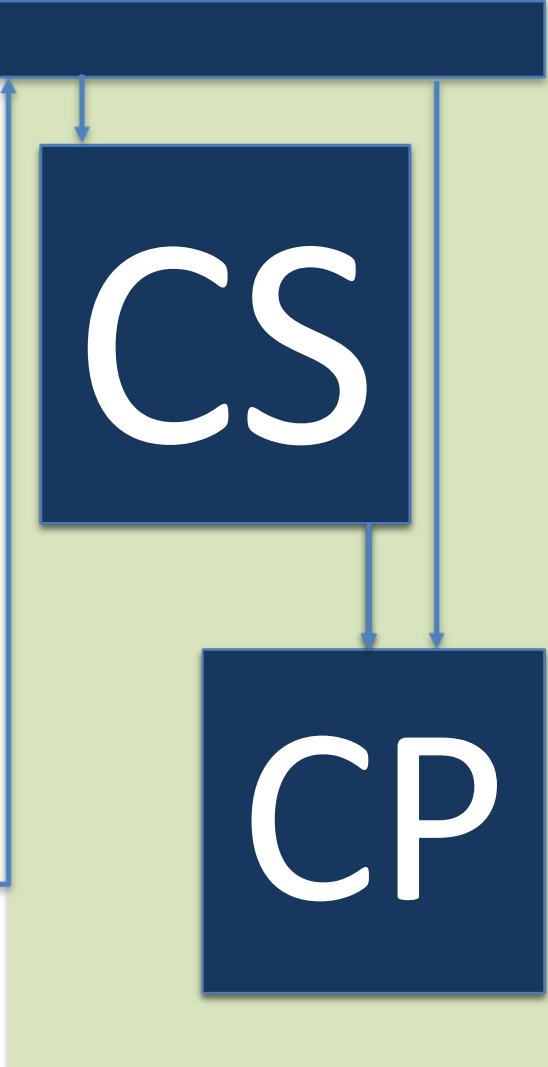
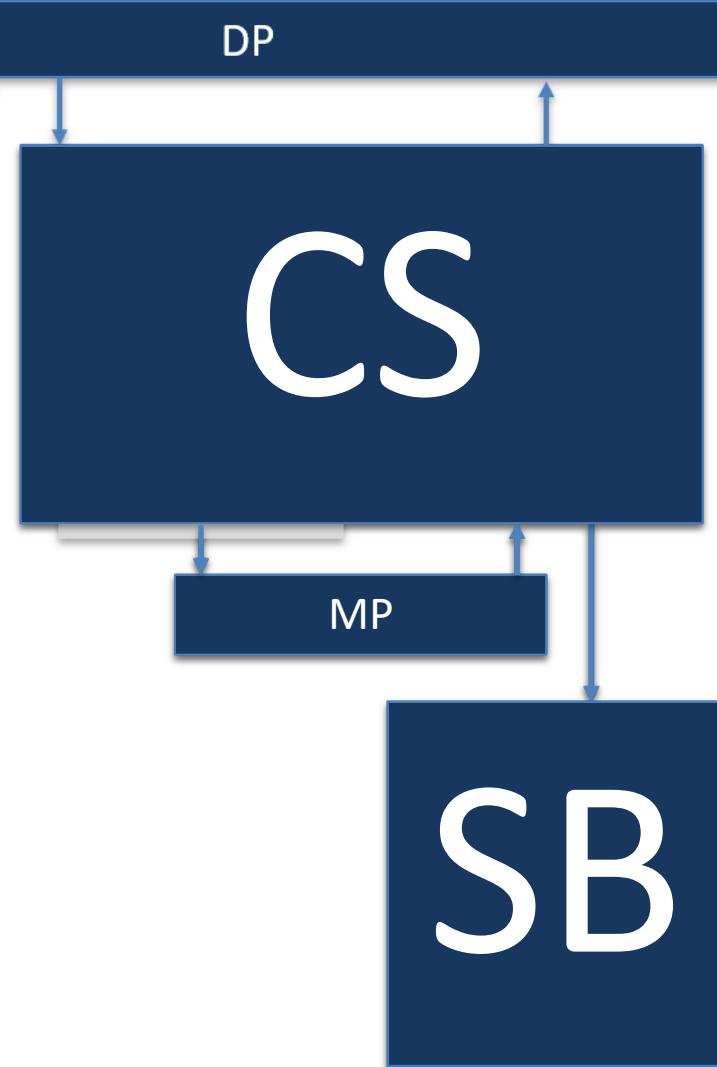
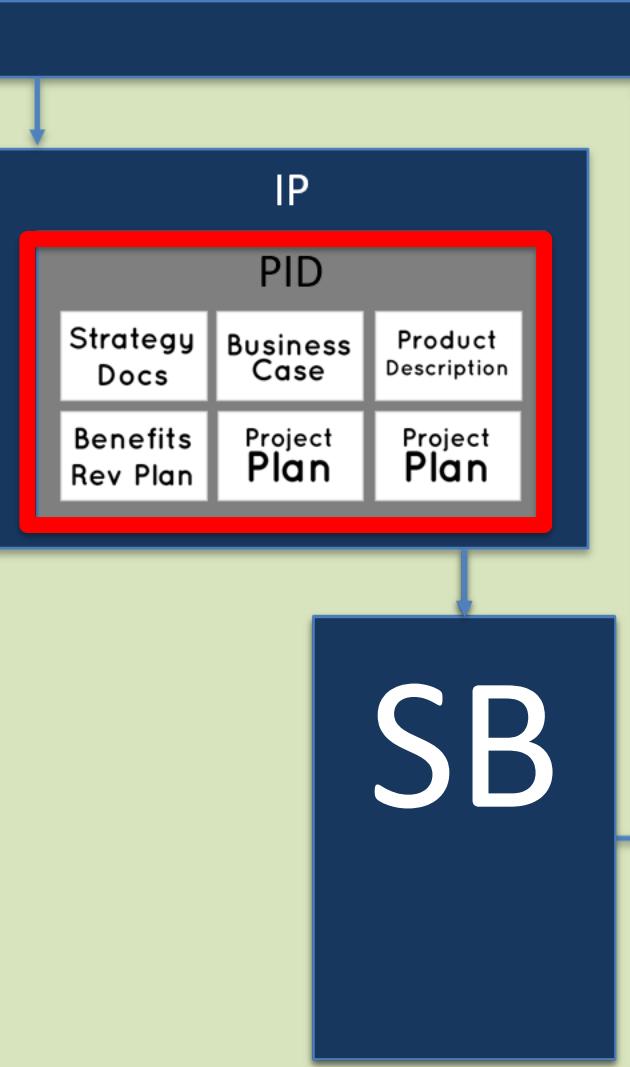


Registers

Risk Register

Issue Register

Quality Register



Logs



When updating the project plan as part of Managing a Stage Boundary, what else might be updated?

- 1 Project Management Team
- 2 Exception Plan
- 3 Project Initiation Documentation
- 4 Business Case

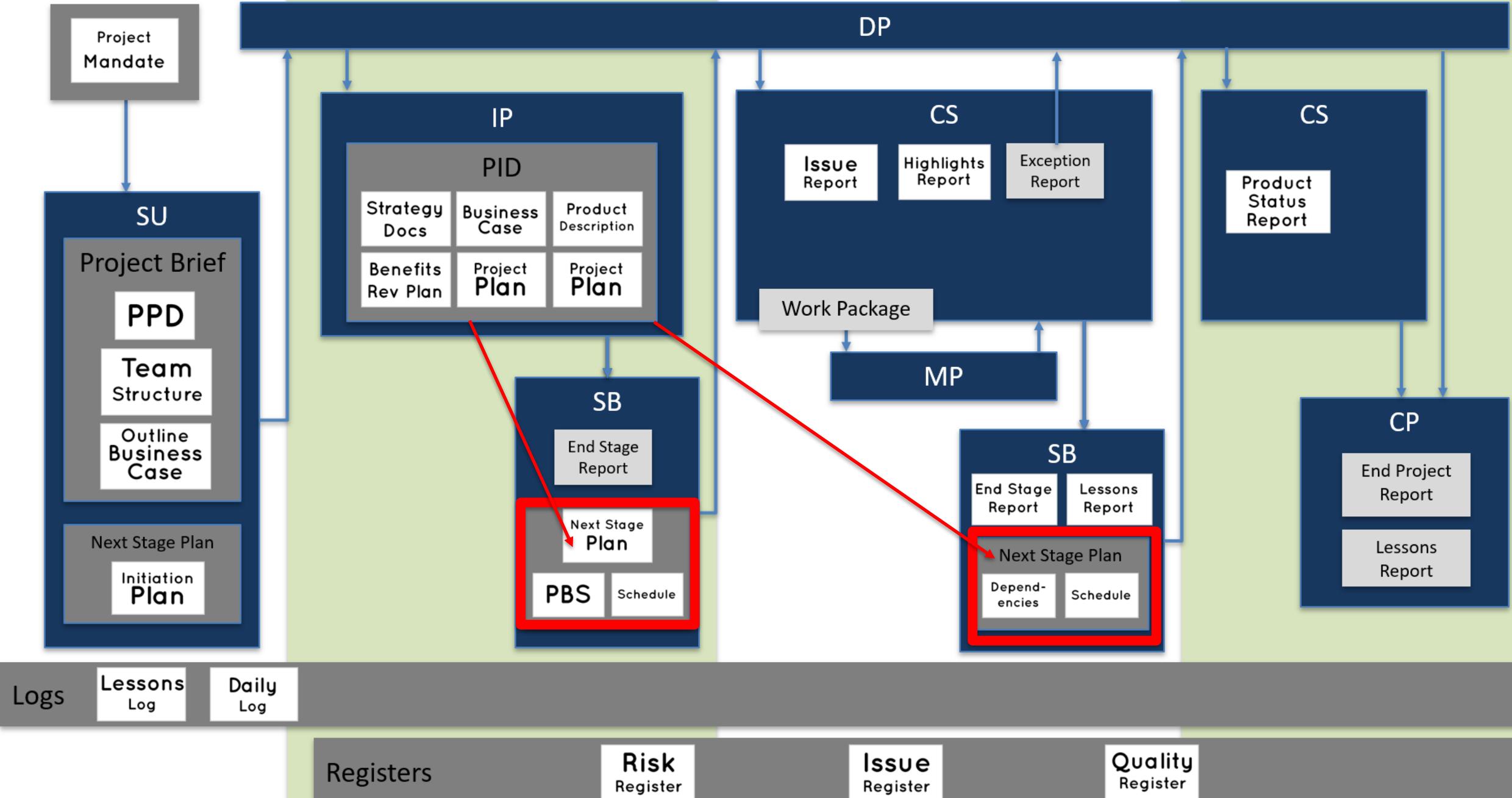
Start Up

Initiation Stage

Execution Stage

(there could be more than one of these)

Closing Stage





Leaderboard



Position	Participants	Score

PRINCE2® Recap

Opponents say

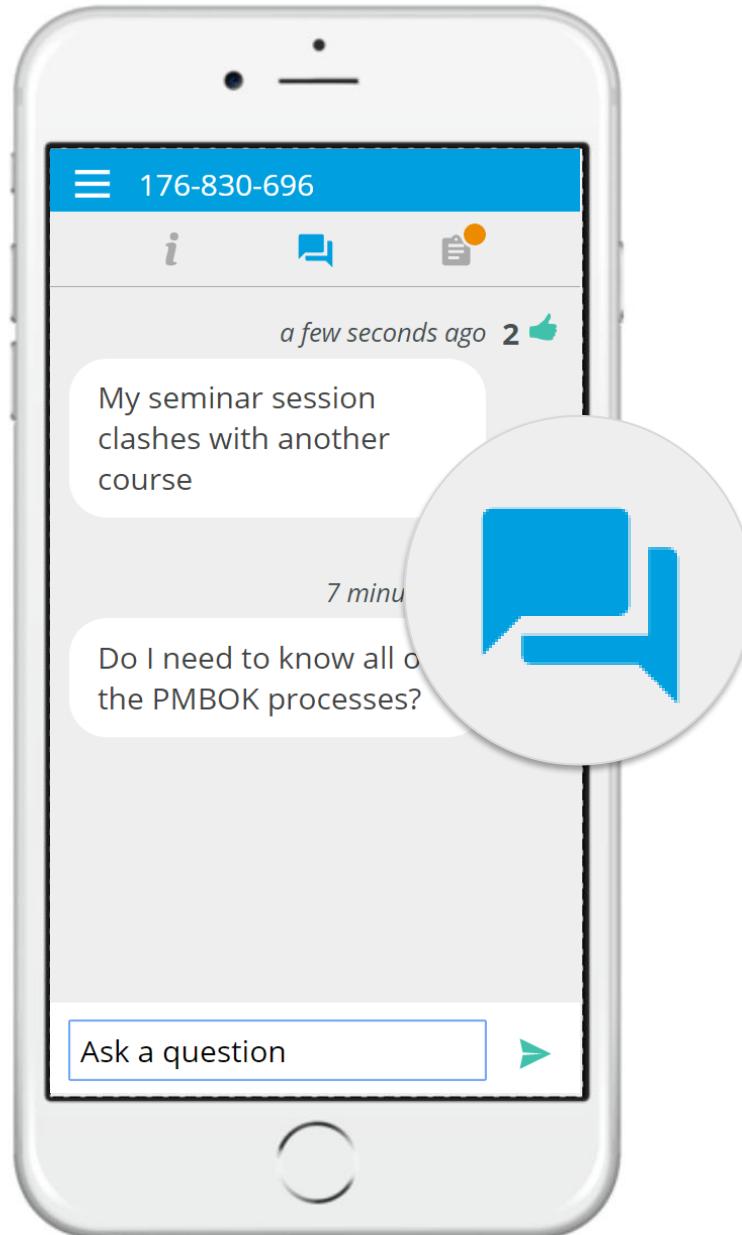
- Only for large projects
- Mountains of paperwork
- Bureaucratic

Proponents say

- Fully scalable, *tailored*
- Audit trail useful, *learn, reduce risk, progress*
- Maintains control, by *exception*

Not a silver bullet:

- Do we even **need** the project? (Space pen *vs* pencil)
- Is the **board** right? (authority *vs* relation to end-user)
- Managing powerful **egos** (how to overrule?)



Ask a question at any time!
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Today



Budgeting

Creating a project budget
Estimating activity costs
(and why it is hard)



Monitoring

Measuring Performance:
Planned vs Earned Value

Earned Value Analysis
(EVA) to compute efficiency



Forecasting

EVA to predict the future



Success

Case studies and lessons learned

Defining success and Key Performance Indicators (KPIs)

Today



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Defining success and Key Performance Indicators (KPIs)

a Budget (*noun*)

- An **estimate**, over a specified **period**, of:
 - **costs** (expenditure)
 - **revenues** (income)
 - **resources**

to Budget (*verb*)

- To **plan** expenditure
- To **allocate** resources to cover future spending



	Initiating	Planning	Executing	Controlling	Closing
Integration	Develop Project Charter	Develop Project Management Plan	Direct and Manage Project Work Manage Project Knowledge	Monitor and Control Project Work Perform Integrated Change Control	Close Project or Phase
Scope		Plan Scope Management Collect Requirements Define Scope Create WBS		Validate Scope Control Scope	
Time		Plan Schedule Management Define Activities Sequence Activities Estimate Activity Durations Develop Schedule		Control Schedule	
Cost		Plan Cost Management Estimate Costs Determine Budget		Control Costs	
Quality		Plan Quality Management	Manage Quality	Control Quality	
HR/Resources		Plan Resource Management Estimate Activity Resources	Acquired Resources Develop Team Manage Team	Control Resources	
Communication		Plan Communications Management	Manage Communications	Monitor Communications	
Risk		Plan Risk Management Identify Risks Perform Qualitative Risk Analysis Perform Quantitative Risk Analysis Plan Risk Responses	Implement Risk Responses	Monitor Risks	
Procurement		Plan Procurement Management	Conduct Procurements	Control Procurements	Close Procurements
Stakeholder	Identify Stakeholders	Plan Stakeholder Engagement	Manage Stakeholder Engagement	Monitor Stakeholder Engagement	

Planning and Controlling Costs

Project Cost Management

Plan Cost Management

- How will costs be managed?

Estimate Costs

- Approximate cost of activities

Determine Budget

- Aggregated value – *cost baseline*

Control Costs

- Monitor activity status, update baseline, manage changes.

	Planning	Controlling
Integration	Develop Project Management Plan	Monitor and Control Project Work Perform Integrated Change Control
Scope	Plan Scope Management Collect Requirements Define Scope Create WBS	Validate Scope Control Scope
Time	Plan Schedule Management Define Activities Sequence Activities Estimate Activity Durations Develop Schedule	Control Schedule
Cost	Plan Cost Management Estimate Costs Determine Budget	Control Costs
Quality	Plan Quality Management	Control Quality
HR/Resources	Plan Resource Management Estimate Activity Resources	Control Resources
Communication	Plan Communications Management	Monitor Communications
Risk	Plan Risk Management Identify Risks Perform Qualitative Risk Analysis Perform Quantitative Risk Analysis Plan Risk Responses	Monitor Risks
Procurement	Plan Procurement Management	Control Procurements
Stakeholder	Plan Stakeholder Engagement	Monitor Stakeholder Engagement



Creating a Project Budget

Relies on understanding scope, schedule and resources.

Characteristics of a good budget: Planned, Structured, Controlled

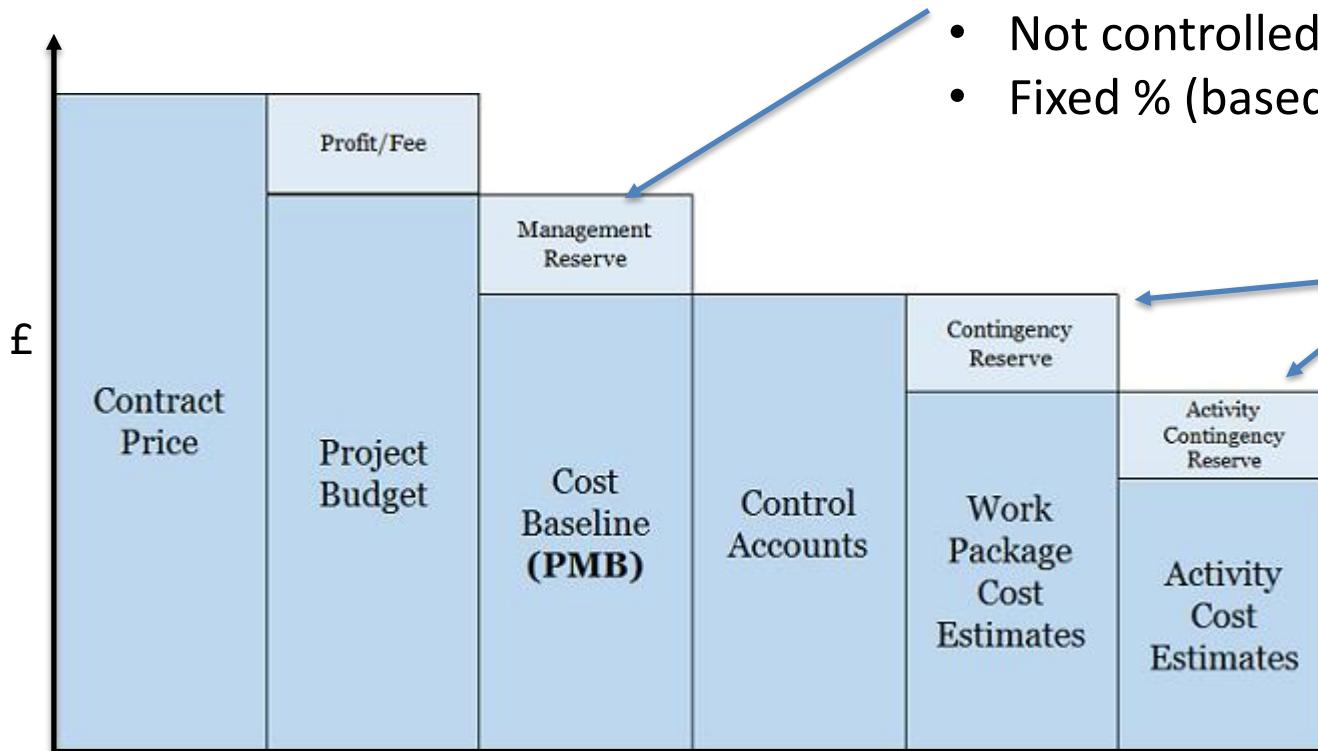
Inputs

- Project Management Plan
- Project Charter / Brief
- Environmental Factors and Organizational Assets

Outputs

- 1 **Cost Management Plan** – how the organization will manage **cost variance**.
- 2 **Activity estimates** – **estimate** of cost for each **activity**
- 3 **Cost baseline** – the initial **budget**

Reserves



Management reserve

- For **unidentified** risks
- Not controlled by PM
- Fixed % (based on risk appetite of business)

Contingency reserve

- To handle **identified** risks
- Controlled by PM
- Estimated, based on perceived risk

Cost per X

Typical costs: Human Resources, Equipment, Material, Venue hire ...

Usually of three types:

1. **Cost per time unit** (hour/day/week/month/year): this is typically used to budget human resources.
2. **Cost per use**: for instance, the use of a venue for a meeting; the cost of a cleaning service after the party.
3. **Cost per material consumption**: for instance, the food and the beverages provided at a conference; the bricks to build a house.

Estimating Activity Costs

Analogous – How much it cost last time (adjusted to this project)

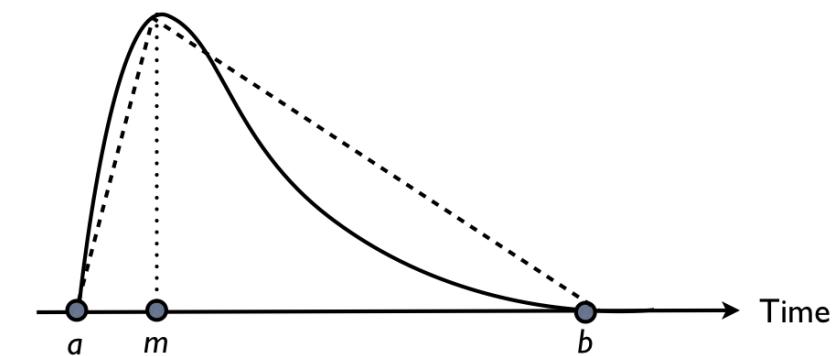
Parametric – As above, but with a statistical model

Team-based – by the people doing the work

Three Point – m mean, a min, b max

$$t_{\text{triangular}} = (a + m + b)/3$$

$$t_{\text{beta}} = (a + 4m + b)/6$$

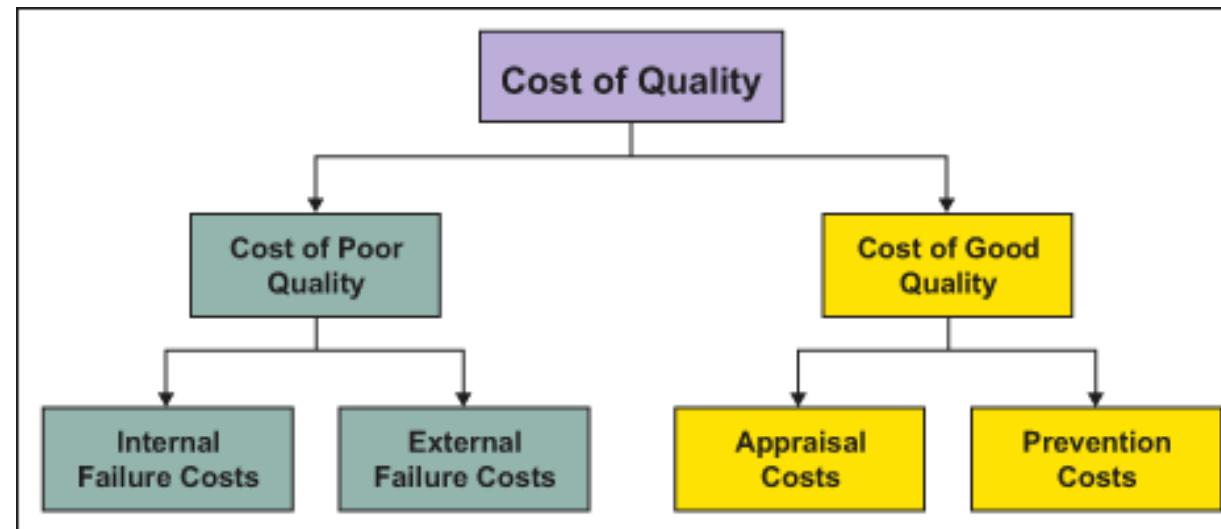


- Very useful to also have a measure of **uncertainty**

Estimating Activity Costs 2

Vendor Bids – compare competitive bids from vendors

Cost of (Poor) Quality – compare for different quality levels



isixsigma.com

The self-driving taxi business-case

Some rough calculations:

- Car lease: £2000/month
- Fuel costs: £1000/month
 - EV 3 miles / kWh, Electricity 30p/kWh, => 10p/mile.
 - 25mph for 50% of the day => 300 miles per day => £30/day => £1000/month
- Income: Assume 10,000 minutes of paid journeys per month
 - 43800 minutes in a month
 - Driven 25% of the time, running 24/7
- Break-even at $\text{£}3000/10,000\text{m} = \text{£}0.30/\text{minute}$
- Uber (with driver): currently approx. £1/minute



Budgeting Activity

- Project: Build an autonomous taxi service.
- Question: how much will it cost?

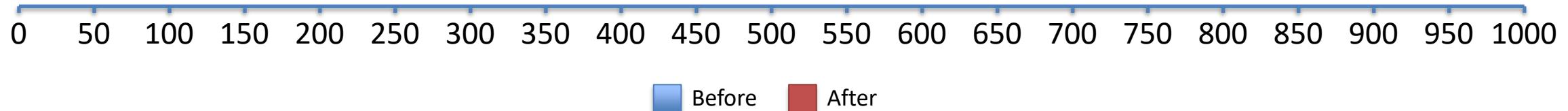




1. Initial Guess - R&D Budget (in £million)

2. Discuss with your neighbour, then estimate
R&D Budget again (in £million)

Results - R&D Budget (in £million)



The Competition

- Waymo (Alphabet)



Google spent £1.1bn on Waymo between 2009 and 2015

Running Cruise costs GM about \$2 billion a year



- Cruise (GM)

- Zoox (Amazon)

Amazon acquired Zoox for \$1.2 bn in 2020



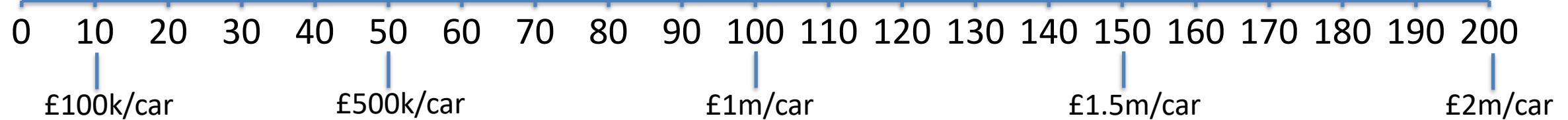
Lidar sensor:

- 2015: £75k
- 2020: £100
- Musk: Fool's Errand

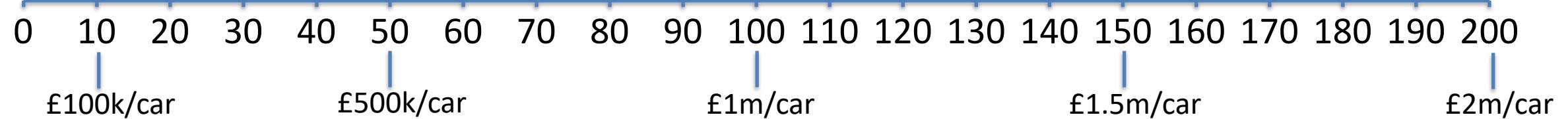


How much to build a fleet of 100 cars? (in £ million)

Please enter a value between 0 and 200.

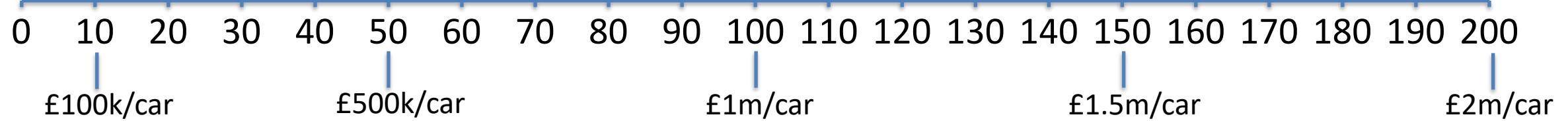


MINIMUM to build a fleet of 100 cars? (in £ million)

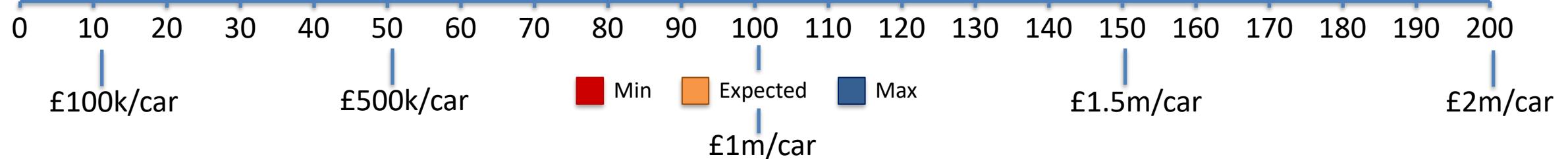




MAXIMUM to build a fleet of 100 cars? (in £ million)



Initial Estimate to build a fleet of 100 cars? (£ million)



Work Breakdown Structure for Self-Driving Taxi

Management

Project Initiation

- 1.1 Define Project Scope
- 1.2 Identify Stakeholders
- 1.3 Establish Project Goals and Objectives
- 1.4 Develop Project Charter

Project Planning

- 2.1 Create Project Plan
- 2.2 Resource Planning
- 2.3 Define Project Metrics and Key Performance Indicators (KPIs)

Hardware and Software

Vehicle Hardware and Sensors

- 3.1 Sensor Selection and Procurement
- 3.2 Install Sensors on Vehicles

Software Development

- 4.1 Perception and Sensor Fusion
- 4.2 Mapping and Localization
- 4.3 Control and Planning
- 4.4 User Interface and Passenger Interaction

Connectivity

- 5.1 Vehicle-to-Vehicle (V2V) Communication
- 5.2 Vehicle-to-Infrastructure (V2I) Communication
- 5.3 Internet Connectivity

Deployment

Testing and Safety

- 6.1 Simulation Testing
- 6.2 Closed-Course Testing
- 6.3 On-Road Testing
- 6.4 Safety Systems

Regulatory Compliance

- 7.1 Ensure Compliance with Local and National Regulations
- 7.2 Obtain Necessary Permits and Approvals

Fleet Deployment

- 8.1 Vehicle Manufacturing or Retrofitting
- 8.2 Maintenance and Service Centres
- 8.3 Fleet Management Software

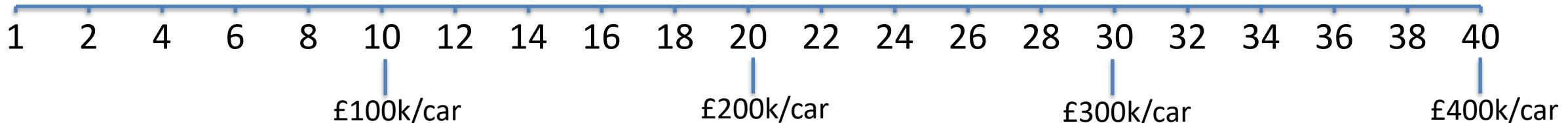
Development cost? (not manufacture) (in £million)

Software Development

- 4.1 Perception and Sensor Fusion
- 4.2 Mapping and Localization
- 4.3 Control and Planning
- 4.4 User Interface and Passenger Interaction

Connectivity

- 5.1 Vehicle-to-Vehicle (V2V) Communication
- 5.2 Vehicle-to-Infrastructure (V2I) Communication
- 5.3 Internet Connectivity



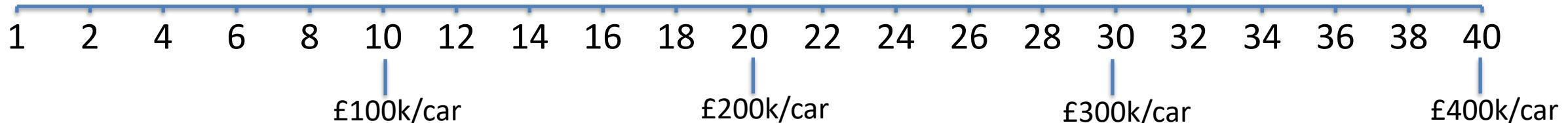
Management costs? (in £ million)

Project Initiation

- 1.1 Define Project Scope
- 1.2 Identify Stakeholders
- 1.3 Establish Project Goals and Objectives
- 1.4 Develop Project Charter

Project Planning

- 2.1 Create Project Plan
- 2.2 Resource Planning
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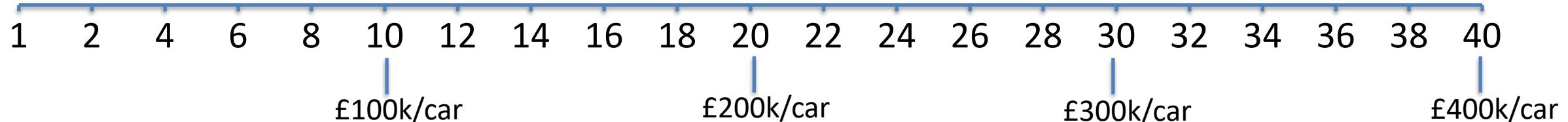
Testing, safety and compliance cost (in £ million)

Testing and Safety

- 6.1 Simulation Testing
- 6.2 Closed-Course Testing
- 6.3 On-Road Testing
- 6.4 Safety Systems

Regulatory Compliance

- 7.1 Ensure Compliance with Local and National Regulations
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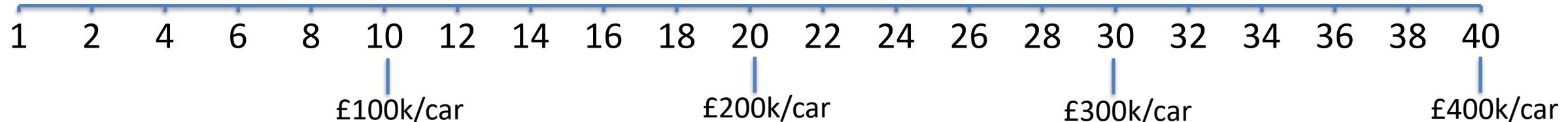
Manufacture/build/deploy cost for 100 cars? (£ million)

Vehicle Hardware and Sensors

- 3.1 Sensor Selection and Procurement
- 3.2 Install Sensors on Vehicles

Fleet Deployment

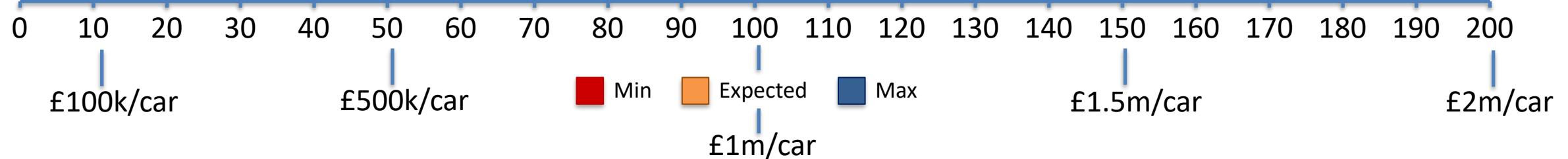
- 8.1 Vehicle Manufacturing or Retrofitting
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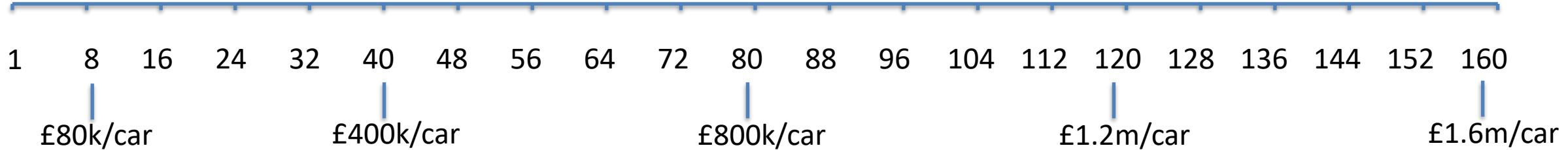
The answer (?)

- £250k/car (back when Lidar sensors cost £100k!)
- £150k/car (Estimate by Waymo 2021)
- £100k/car (RBC Capital Markets, 2023)
- £30k/car (eventually! by 2030? 2040?)

Initial Estimate to build a fleet of 100 cars? (£ million)



Revised Estimate for 100 cars (in £million)



Lessons Learned?

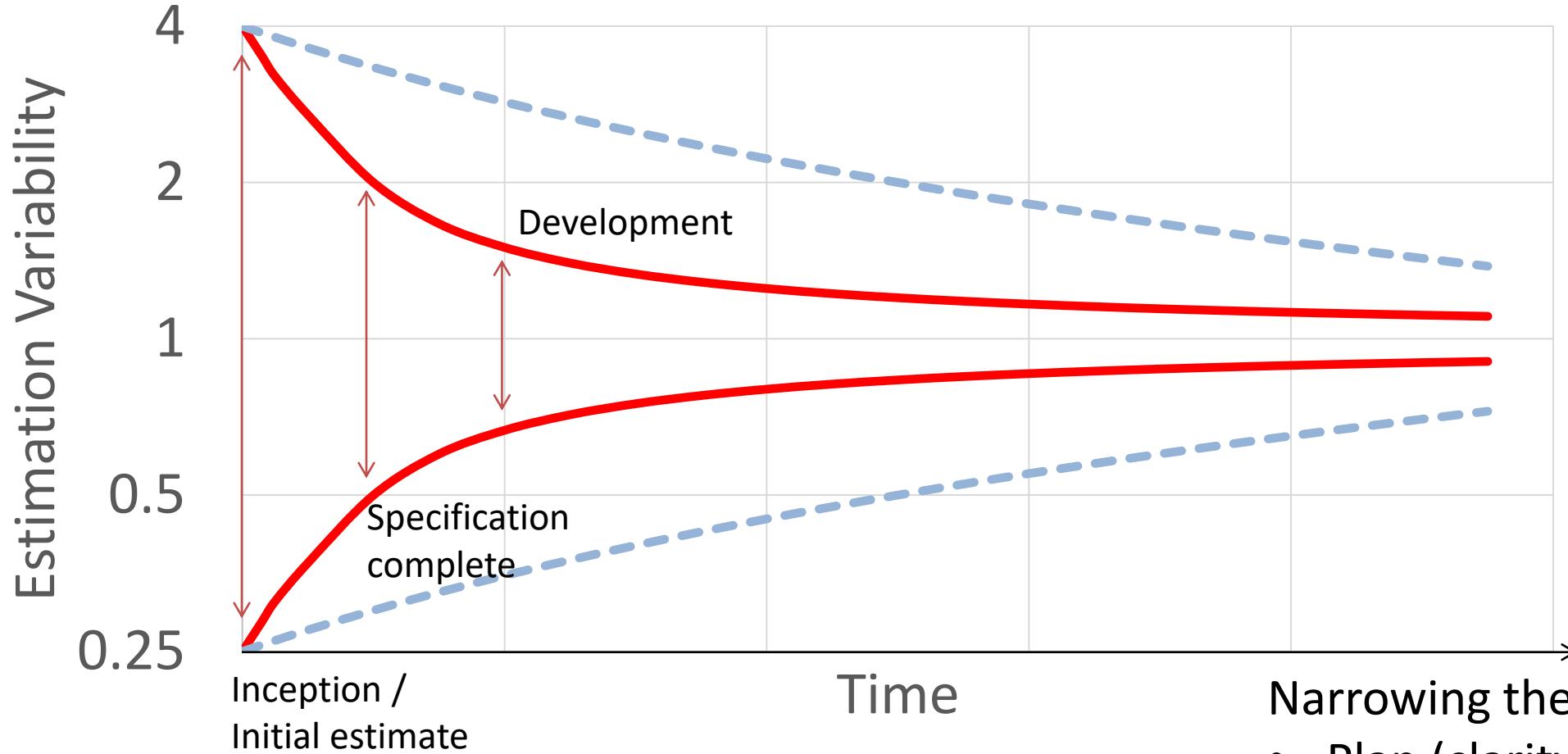
Hypotheses:

- Team-estimation (neighbour) - improves accuracy?
- 3-point estimation (min/max) - bounds uncertainty?
- WBS - improves accuracy?

Discussion/Conclusions:

- Do we know what we don't know?
- Convergence on 'true' answer?
- People are generally rubbish at estimating?

Cone of Uncertainty



- Narrowing the cone:
- Plan (clarity of definition)
 - Iterate (feedback, learning)

Today



Budgeting

Creating a project budget
Estimating activity costs
(and why it is hard)



Monitoring

Measuring Performance:
Planned vs Earned Value

Earned Value Analysis
(EVA) to compute efficiency



Forecasting

EVA to predict the future



Success

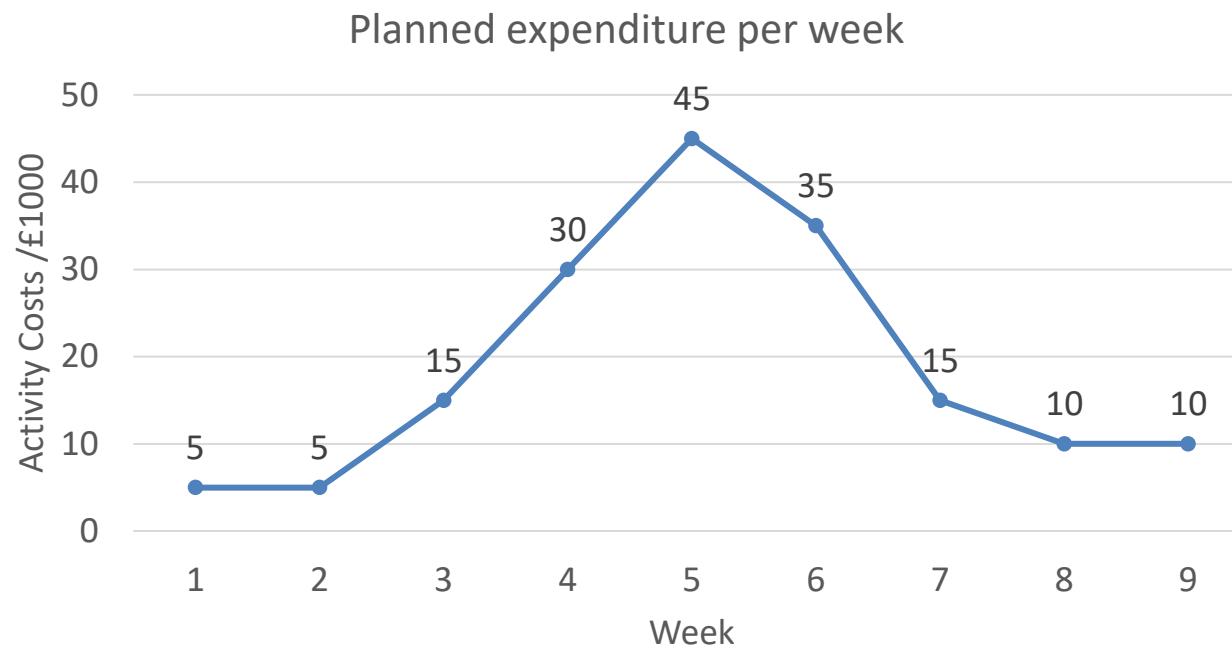
Case studies and lessons learned

Defining success and Key Performance Indicators (KPIs)

Cash Flow

- Cash is not always as liquid as we think
- Important to know not only *how much* but *when*:
 - Staggered funds
 - Invoice periods
 - Consideration for *slack* in schedule.
- Cash can be **scheduled** like any resource

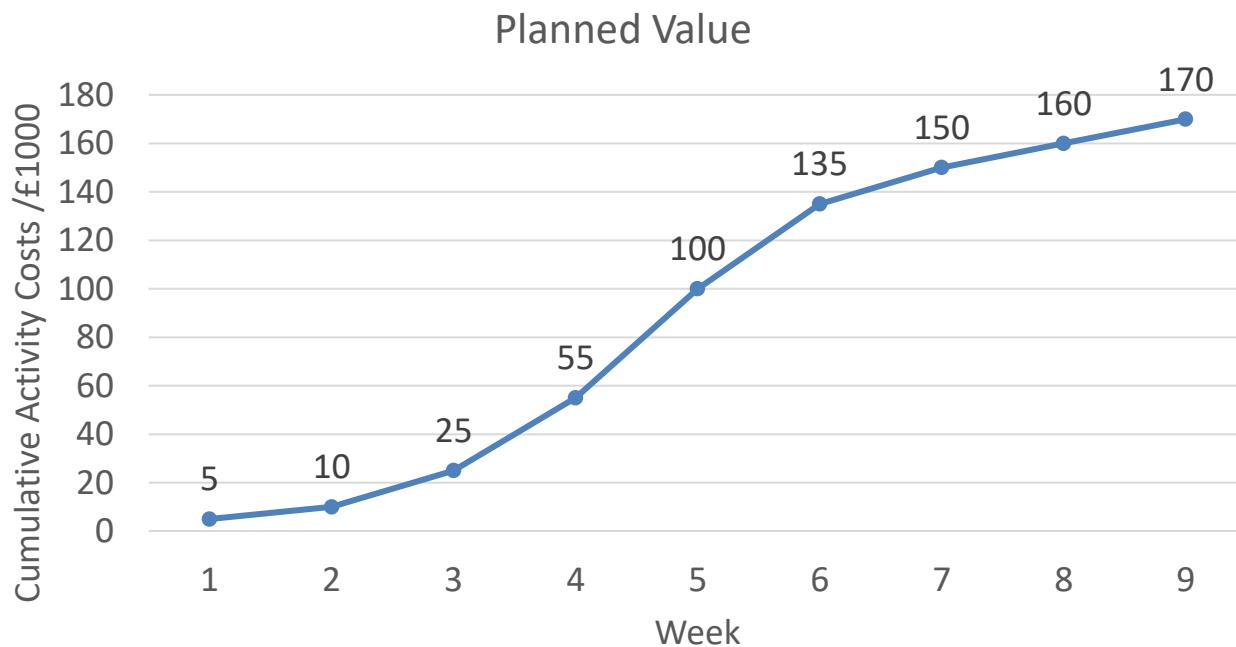
Cash Flow



We can anticipate cash flow issues by summing the daily/weekly/monthly planned activity costs. Then, either:

- Ensure resources are in place to cover anticipated expenditure
- Reschedule activities to smooth out spikes

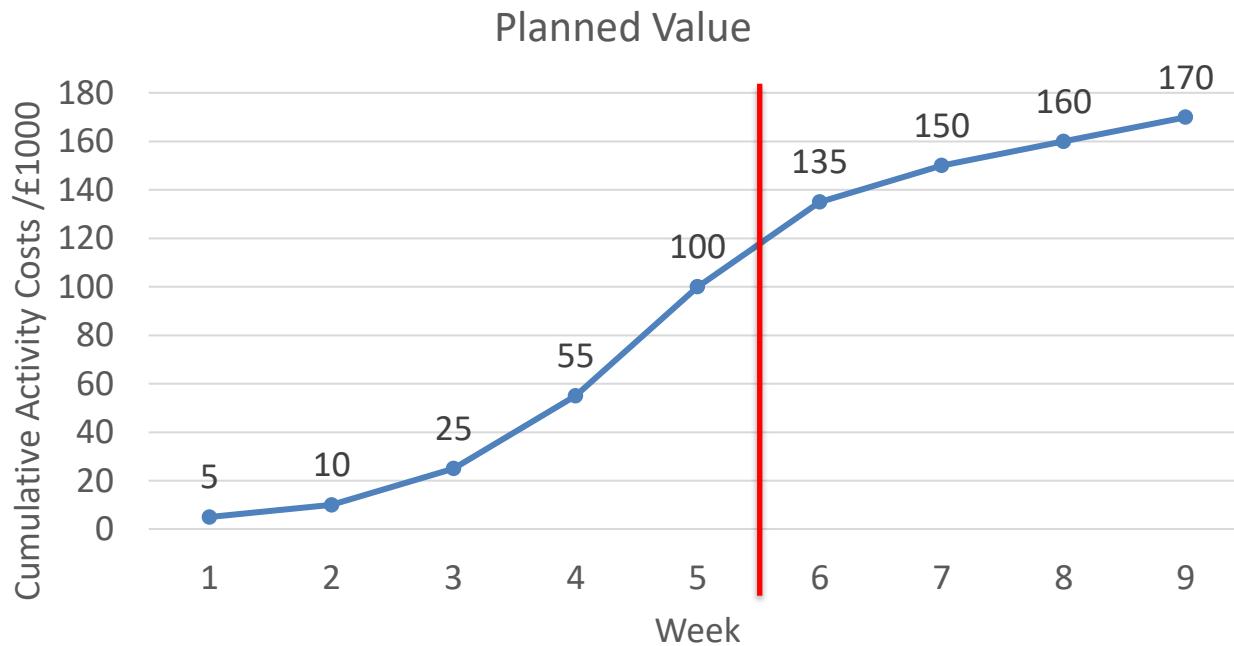
Cash Flow



We can also build a **cumulative plot** of planned expenditure over the life of the project.

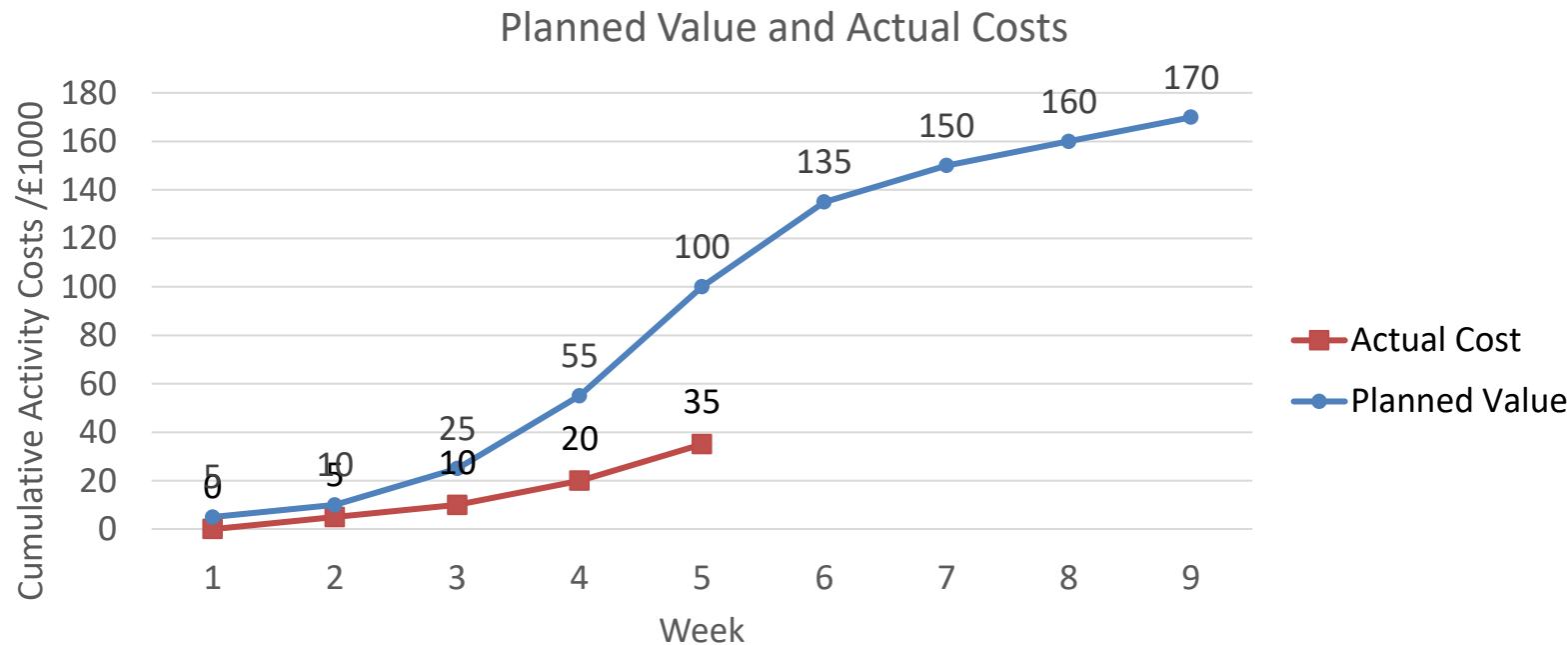
Performance Measurement Baseline (PMB) of a Work Package or Project – a time-phased plan of costs (budget) against which actual performance can be measured.

Planned Value (PV)



Planned Value (PV) of a Work Package or Project - how much of the (authorised) budget has been **assigned** to the work at a given point in time?

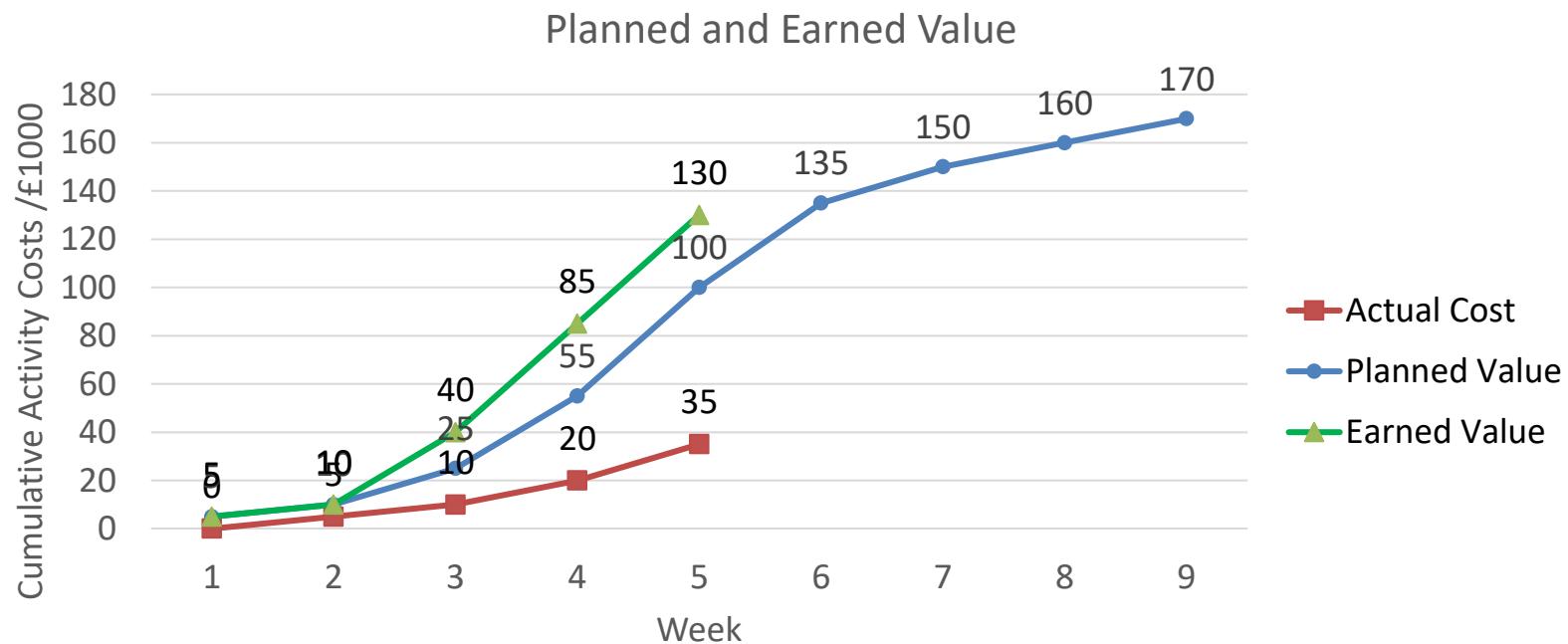
Actual Cost (AC)



Actual Cost (AC) of a Work Package or Project - how much of the (authorised) budget has been **spent** on the work at a given point in time?

But: are we **under budget** or just **running late**?

Earned Value (EV)



What we want is a measure that lets us compare the **budget** to the **work done** (a measure of progress).

Earned Value (EV) of a Work Package - how much of the **planned value** has been achieved by doing the work so far?



3

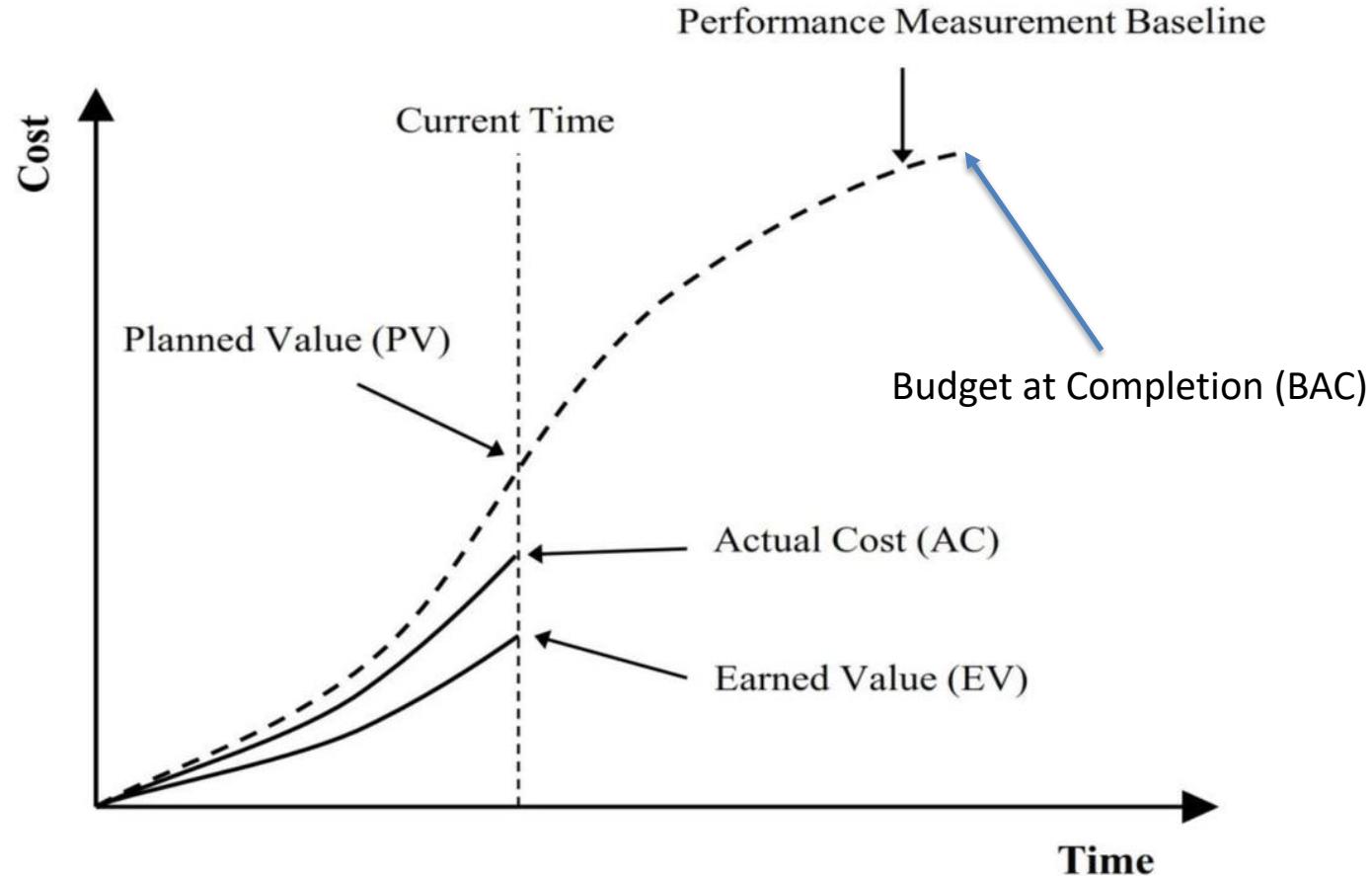
Performance Measurement Baseline (PMB)

Activity estimates →

Planned expenditure for project

PMB: a formal plan against which actual performance can be measured.

S-curve: Reflects phases of projects – initiate, plan, execute, close.



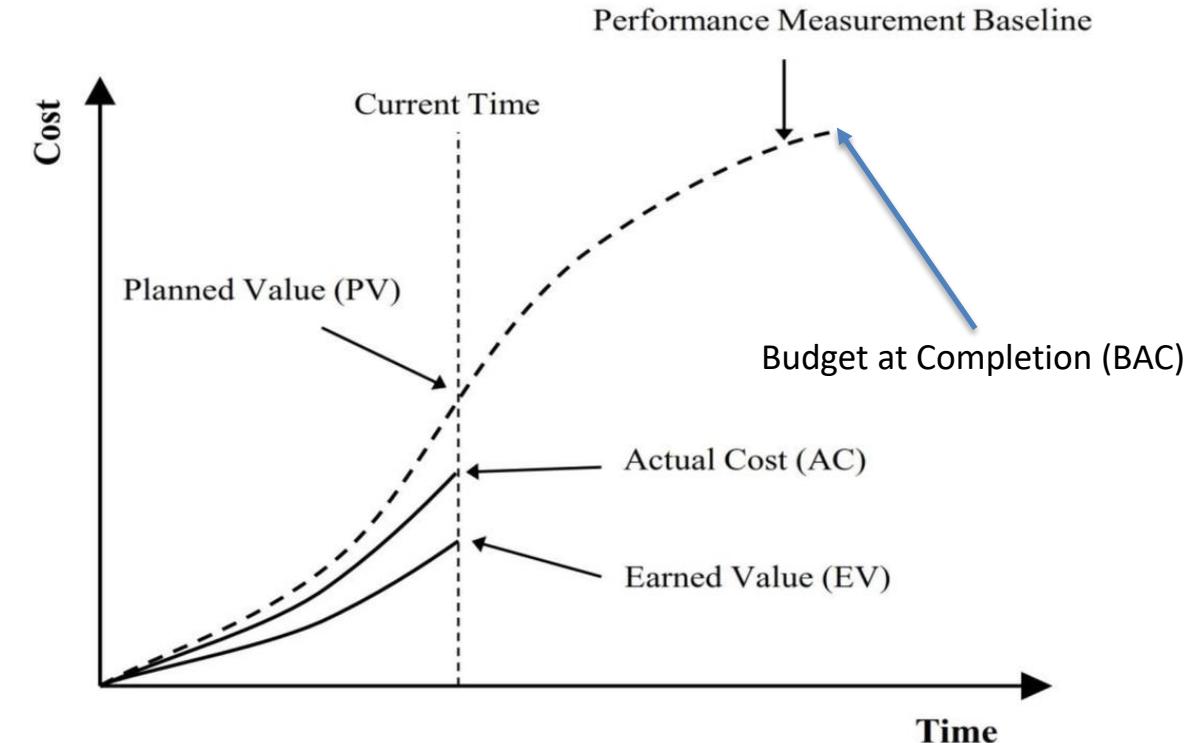
Earned Value (EV)

Planned Value (PV) – budget at each point in time

Budget at Completion (BAC) – total planned value

Actual Cost (AC) – how much we actually spent

Earned Value (EV) – the “value” of the work completed to date



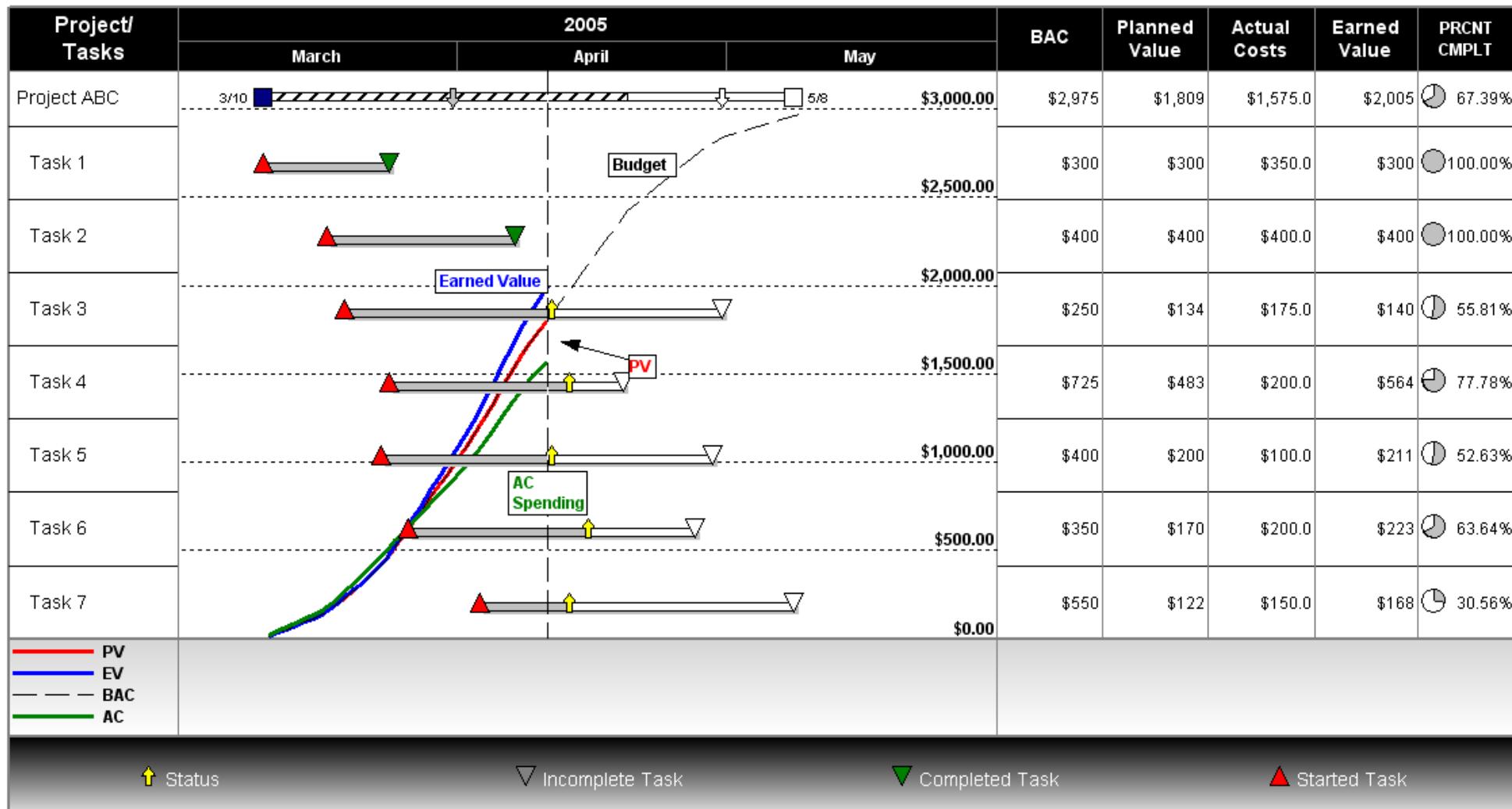
Earned value is an indicator of *progress*.

Written as a ‘cost’ (*i.e. relative to the planned value*) we can compare the numbers.

Combine with Gantt Chart

Earned Value Calculations

Earned Value = Budget x % Complete
 Planned Value = Total Budget x % duration to the current date



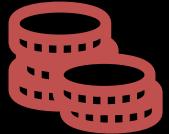
↑ Status

▽ Incomplete Task

▼ Completed Task

▲ Started Task

Today



Budgeting

Creating a project budget
Estimating activity costs
(and why it is hard)



Monitoring

Measuring Performance:
Planned vs Earned Value
Earned Value Analysis
(EVA) to compute efficiency



Forecasting

EVA to predict the future



Success

Defining success and Key
Performance Indicators
(KPIs)

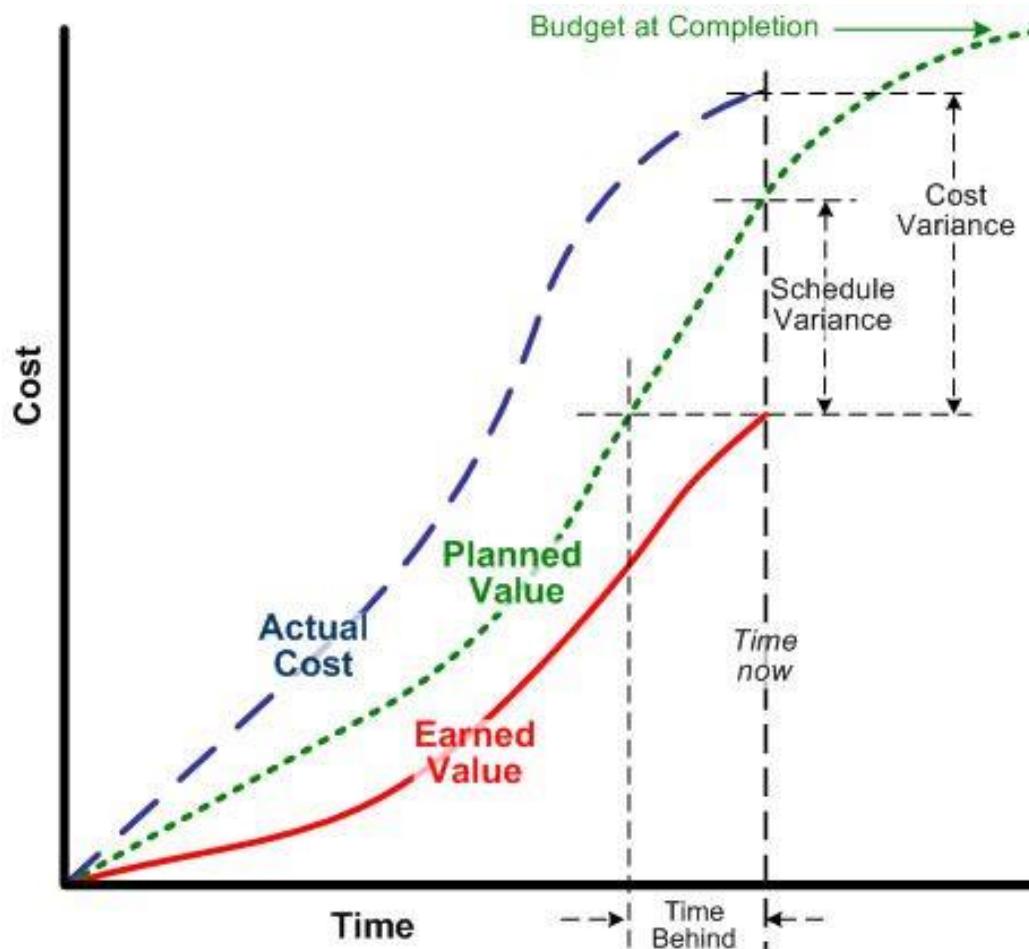
Earned Value Analysis (EVA)

You cannot control that which you cannot measure!

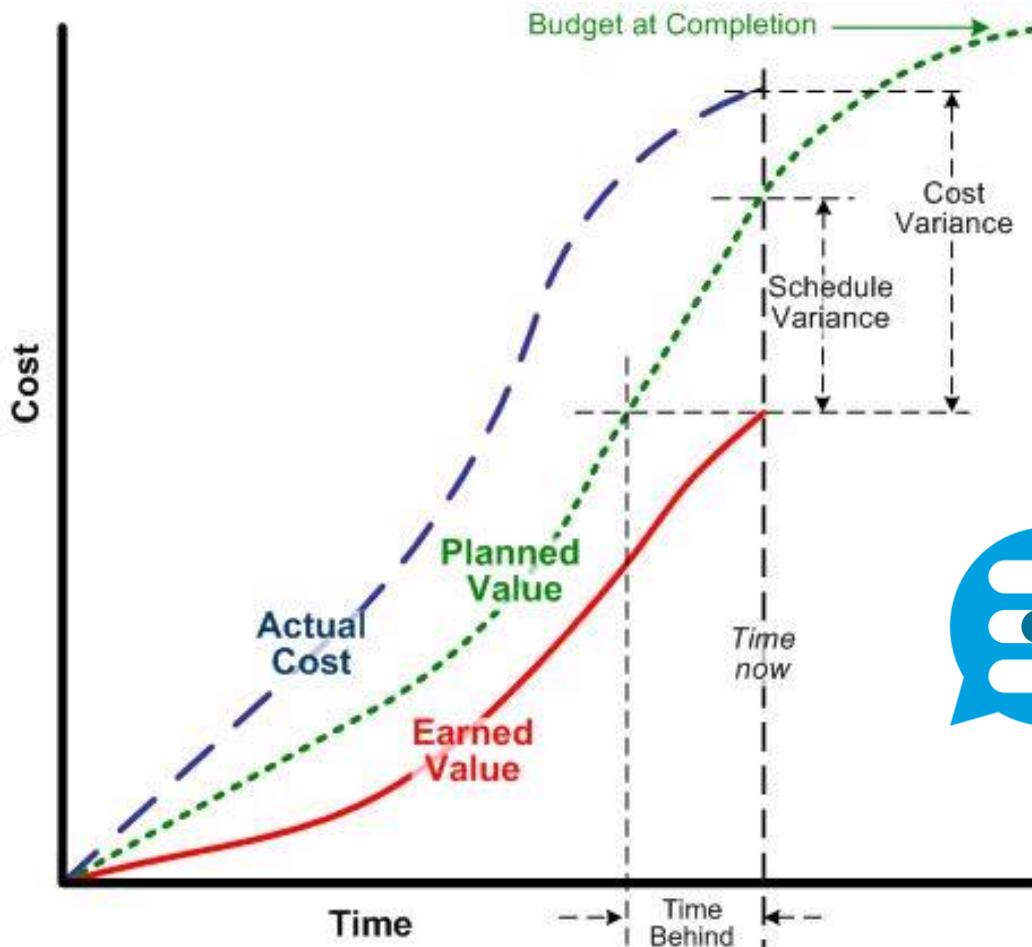
These variables give an instantaneous picture of project at a certain **moment in time**

Variable	Description	Calculation
Budget at Completion (BAC)	Total Budgeted Cost of Work	Budget
Planned Value (PV)	Budgeted Cost of Work Scheduled	$BAC \times \%Scheduled$
Actual Cost (AC)	Actual Cost of Work Performed	Measured
Earned Value (EV)	Budgeted Cost of Work Performed	$BAC \times \%Done$
Schedule Variance (SV)	On schedule?	$EV - PV$
Cost Variance (CV)	Within budget?	$EV - AC$
Schedule Performance Index (SPI)	Working quickly?	$EV \div PV$
Cost Performance Index (CPI)	Working cost-effectively?	$EV \div AC$
Cost Schedule Index (CSI)	Overall efficiency (time and money)	$SPI \times CPI$

Curve Interpretation



Curve Interpretation



Quiz

warwick.ac.uk/pm4cs/5

Project Status

Vote for up to 4 choices

1. CV<0

2. CV>0

3. SV<0

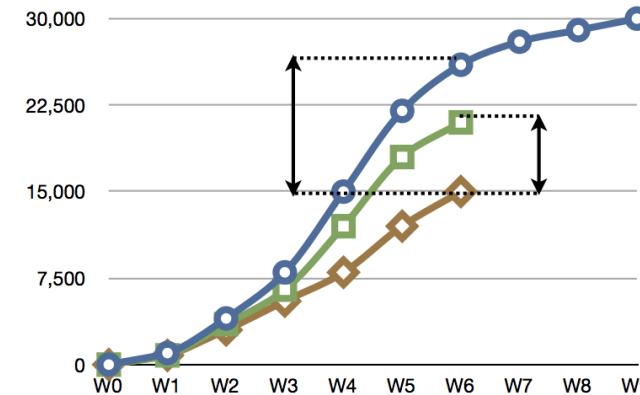
4. SV>0

5. overbudget

6. underbudget

7. ahead-of-schedule

8. delayed



Project Status

Vote for up to 4 choices

1. CV<0

2. CV>0

3. SV<0

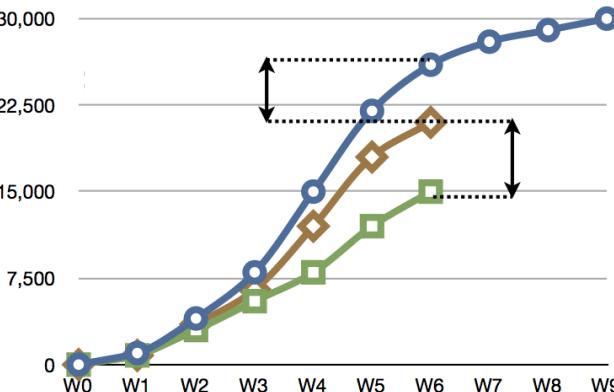
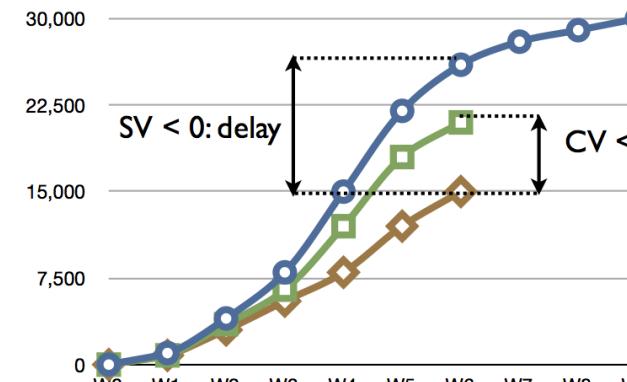
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5. overbudget

6. underbudget

7. ahead-of-schedule

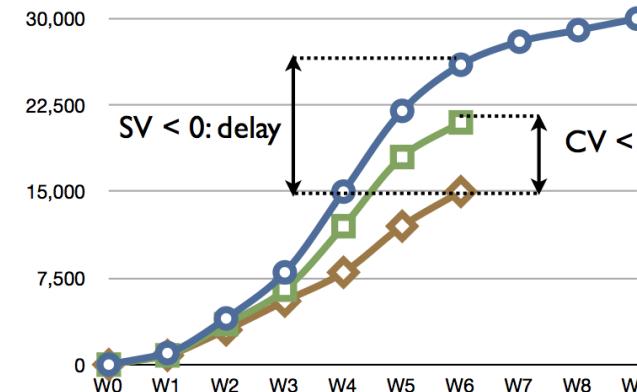
8. delayed



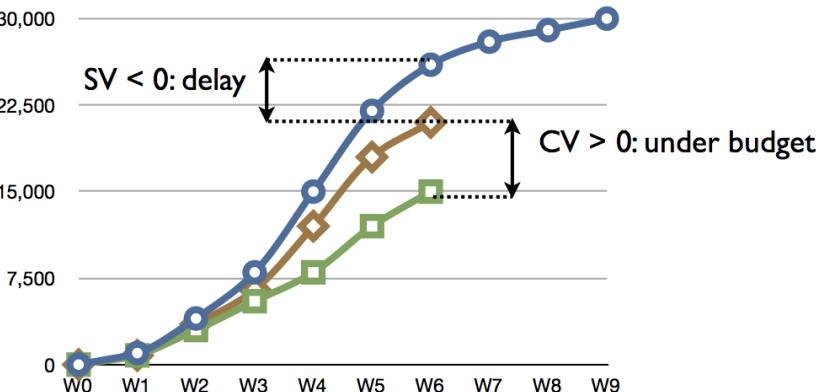
Project Status

Vote for up to 4 choices

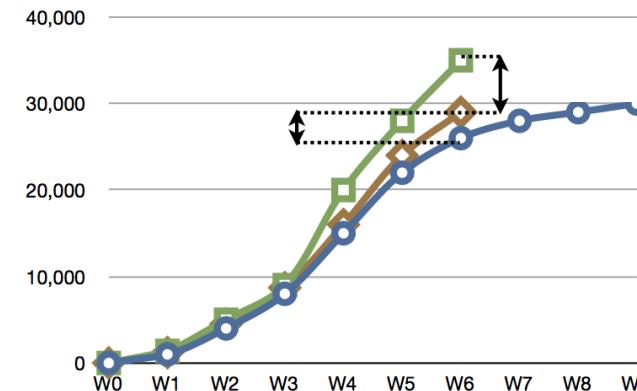
1. CV<0



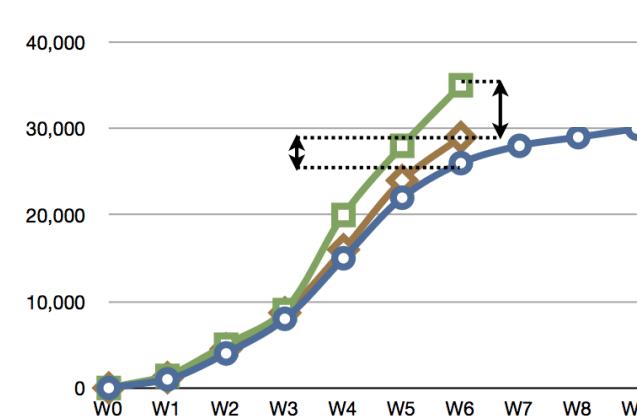
2. CV>0



3. SV<0



4. SV>0



5. overbudget

6. underbudget

7. ahead-of-schedule

8. delayed

○ Planned Value (PV)

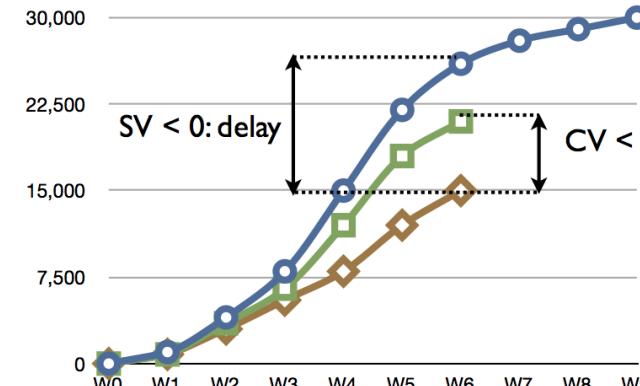
□ Actual Cost (AC)

◆ Earned Value (EV)

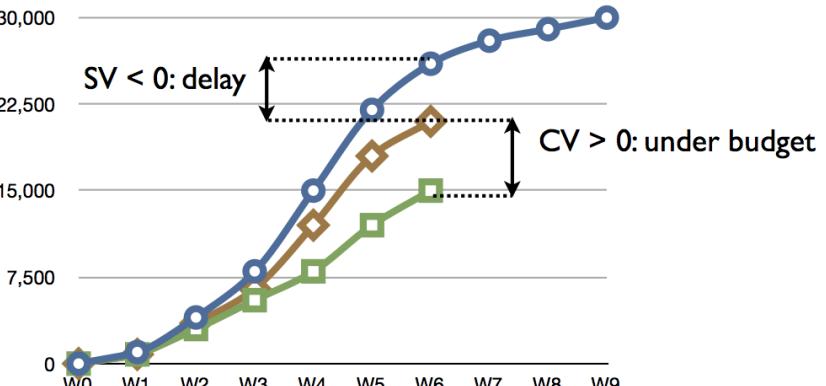
Project Status

Vote for up to 4 choices

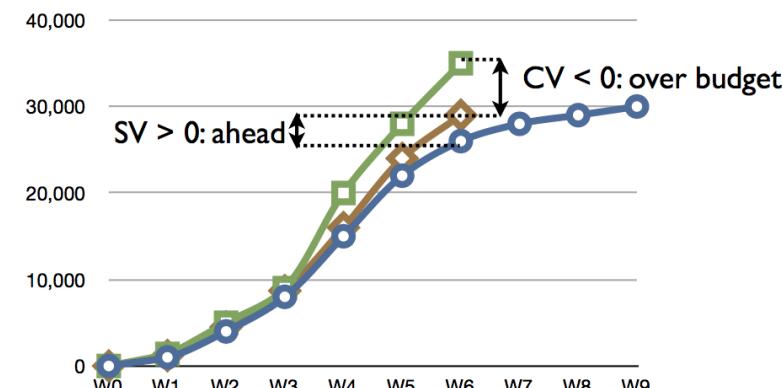
1. CV<0



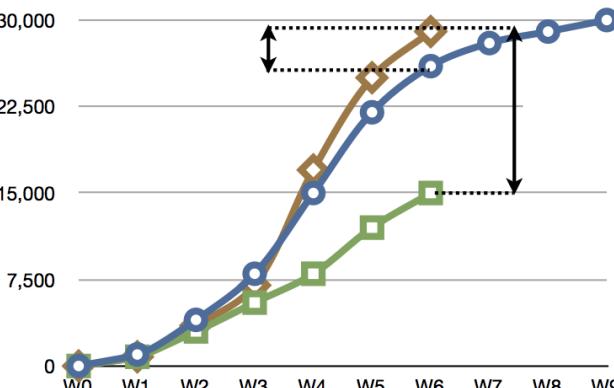
2. CV>0



3. SV<0



4. SV>0



5. overbudget

6. underbudget

7. ahead-of-schedule

8. delayed

○ Planned Value (PV)

□ Actual Cost (AC)

◆ Earned Value (EV)

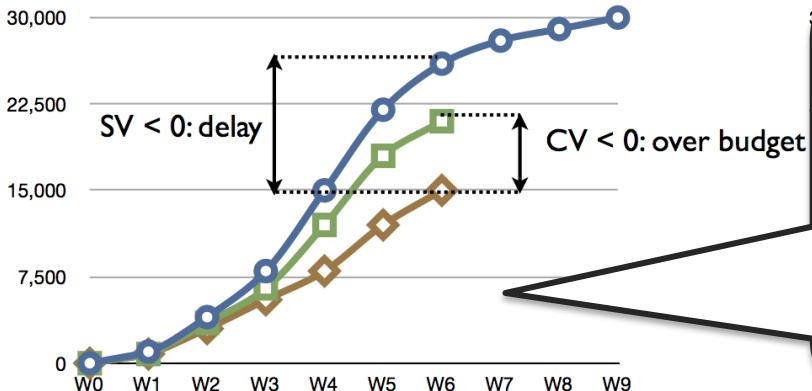


Leaderboard

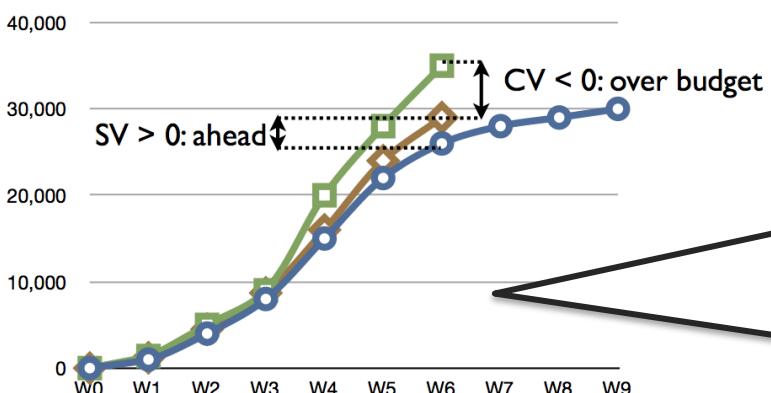


Position	Participants	Score

Curve Interpretation



“The work is £11,000 late”



“We’re ahead of schedule by £4,000”

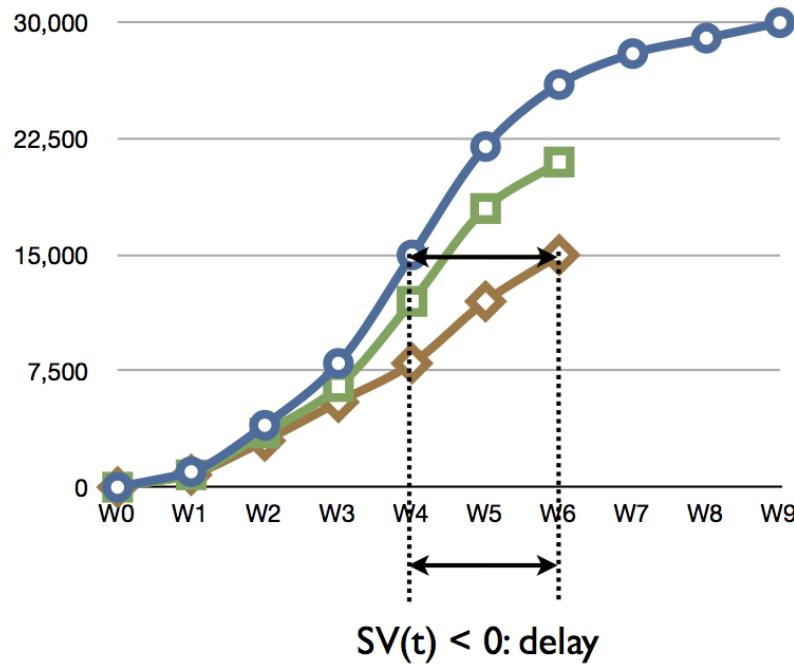
○ Planned Value (PV)

□ Actual Cost (AC)

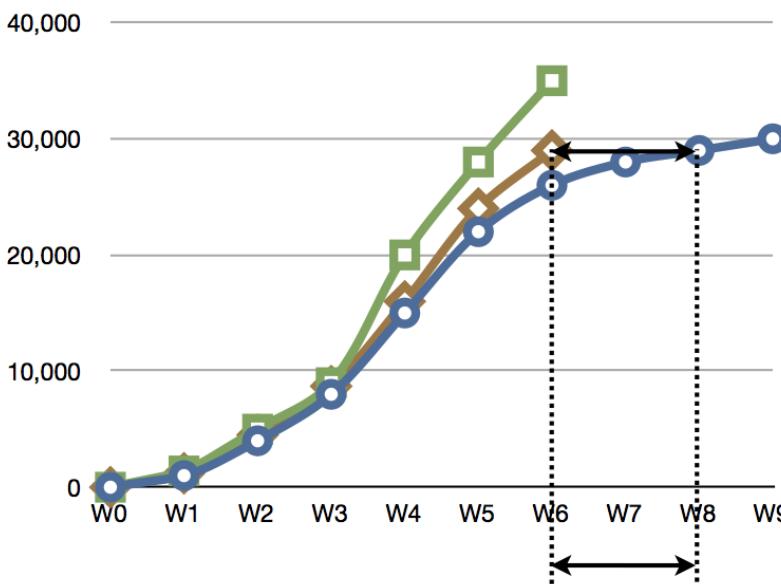
◆ Earned Value (EV)

$SV(t)$

Read the graph horizontally to express in **time units** instead of **cost units**!



$SV(t) > 0$: ahead of schedule



● Planned Value (PV) □ Actual Cost (AC) ♦ Earned Value (EV)

Homework

https://warwick.ac.uk/pmcs/resources/eva_homework.xlsx

WP	Budget	Actual % Done	Planned % Done	Actual Cost (AC)	Earned Value (EV)	Planned Value (PV)	Schedule Variance (SV)	Cost Variance (CV)	Schedule Perf. Index (SPI)	Cost Perf. Index (CPI)	Cost Schedule Index (CSI)
A	£30,225	93%	100%	£30,458							
B	£30,720	84%	100%	£23,055							
C	£15,300	83%	100%	£6,999							
D	£44,828	85%	83%	£37,571							
E	£10,409	75%	70%	£7,817							
F	£8,890	98%	100%	£6,138							
G	£3,458	90%	100%	£2,736							
H	£51,092	10%	20%	£8,347							
I	£1,404	44%	30%	£432							
J	£1,258	25%	30%	£756							
K	£10,373	60%	60%	£2,904							
L	£4,531	11%	15%	£72							
M	£59,186	0%	0%	£0							

Test! Which WP is the:

- **Best** performer in terms of **schedule**
- **Best** performer in terms of **budget**
- **Worst** performer in terms of **schedule**
- **Worst** performer in terms of **budget**

Example

WP	Budget	Actual % Done	Planned % Done	Actual Cost (AC)	Earned Value (EV)	Planned Value (PV)	Schedule Variance (SV)	Cost Variance (CV)	Schedule Perf. Index (SPI)	Cost Perf. Index (CPI)	Cost Schedule Index (CSI)
E	£10,409	75%	70%	£7,817							

Ahead of schedule

Underbudget ??

Example

WP	Budget	Actual % Done	Planned % Done	Actual Cost (AC)	Earned Value (EV)	Planned Value (PV)	Schedule Variance (SV)	Cost Variance (CV)	Schedule Perf. Index (SPI)	Cost Perf. Index (CPI)	Cost Schedule Index (CSI)
E	£10,409	75%	70%	£7,817	£7,807						

$$EV = PV \times \% \text{Done}$$

Overspending?

Example

WP	Budget	Actual % Done	Planned % Done	Actual Cost (AC)	Earned Value (EV)	Planned Value (PV)	Schedule Variance (SV)	Cost Variance (CV)	Schedule Perf. Index (SPI)	Cost Perf. Index (CPI)	Cost Schedule Index (CSI)
E	£10,409	75%	70%	£7,817	£7,807	£7,286					

$$PV = BAC \times \% \text{ Scheduled}$$

Ahead of schedule?

Example

WP	Budget	Actual % Done	Planned % Done	Actual Cost (AC)	Earned Value (EV)	Planned Value (PV)	Schedule Variance (SV)	Cost Variance (CV)	Schedule Perf. Index (SPI)	Cost Perf. Index (CPI)	Cost Schedule Index (CSI)
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$$SV = EV - PV$$

$$CV = EV - AC$$

- Ahead of schedule
- Spent slightly more than planned

Example

WP	Budget	Actual % Done	Planned % Done	Actual Cost (AC)	Earned Value (EV)	Planned Value (PV)	Schedule Variance (SV)	Cost Variance (CV)	Schedule Perf. Index (SPI)	Cost Perf. Index (CPI)	Cost Schedule Index (CSI)
	£10,409	75%	70%	£7,817	£7,807	£7,286	£520	-£10	1.07	0.999	1.07
						Schedule Performance Index (SPI) Cost Performance Index (CPI) Cost Schedule Index (CSI)					
						$EV \div PV$ $EV \div AC$ $SPI \times CPI$					

- Ahead of schedule
- Spent slightly more than planned
- SPI = 1.07 shows good **time efficiency**
- CPI = 0.999 shows our spend is (almost) **on plan**

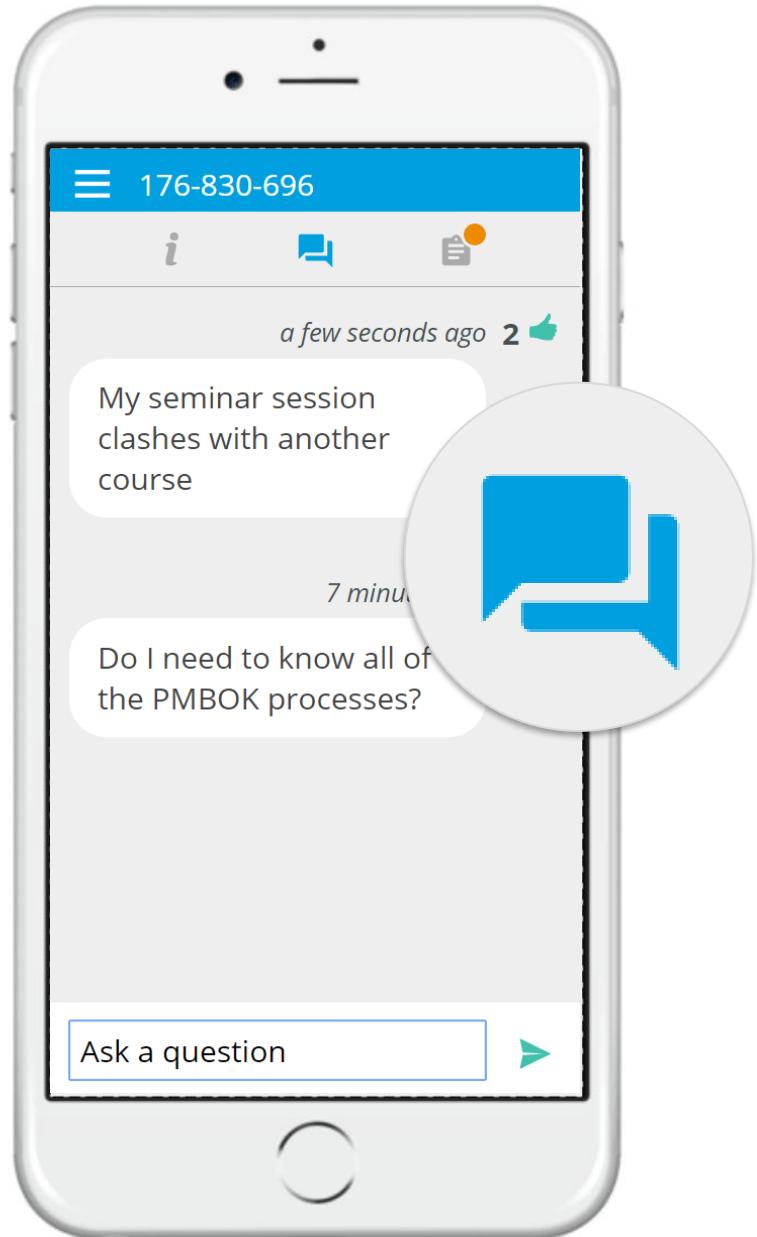
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- **Worst** performer in terms of **schedule**
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Q&A after the break
warwick.ac.uk/pm4cs/5

Today



Budgeting

Creating a project budget
Estimating activity costs
(and why it is hard)



Monitoring

Measuring Performance:
Planned vs Earned Value

Earned Value Analysis
(EVA) to compute efficiency



Forecasting

EVA to predict the future



Success

Case studies and lessons learned

Defining success and Key Performance Indicators (KPIs)

Forecasting Example

		Actual % Done	Planned % Done	Actual Cost (AC)	Earned Value (EV)	Planned Value (PV)	Schedule Variance (SV)	Cost Variance (CV)	Schedule Perf. Index (SPI)	Cost Perf. Index (CPI)	Cost Schedule Index (CSI)
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- *Will the work package be on time and on budget?*

Forecasting Example

WP	Budget	Actual % Done	Planned % Done	Actual Cost (AC)	Earned Value (EV)	Planned Value (PV)	Schedule Variance (SV)	Cost Variance (CV)	Schedule Perf. Index (SPI)	Cost Perf. Index (CPI)	Cost Schedule Index (CSI)
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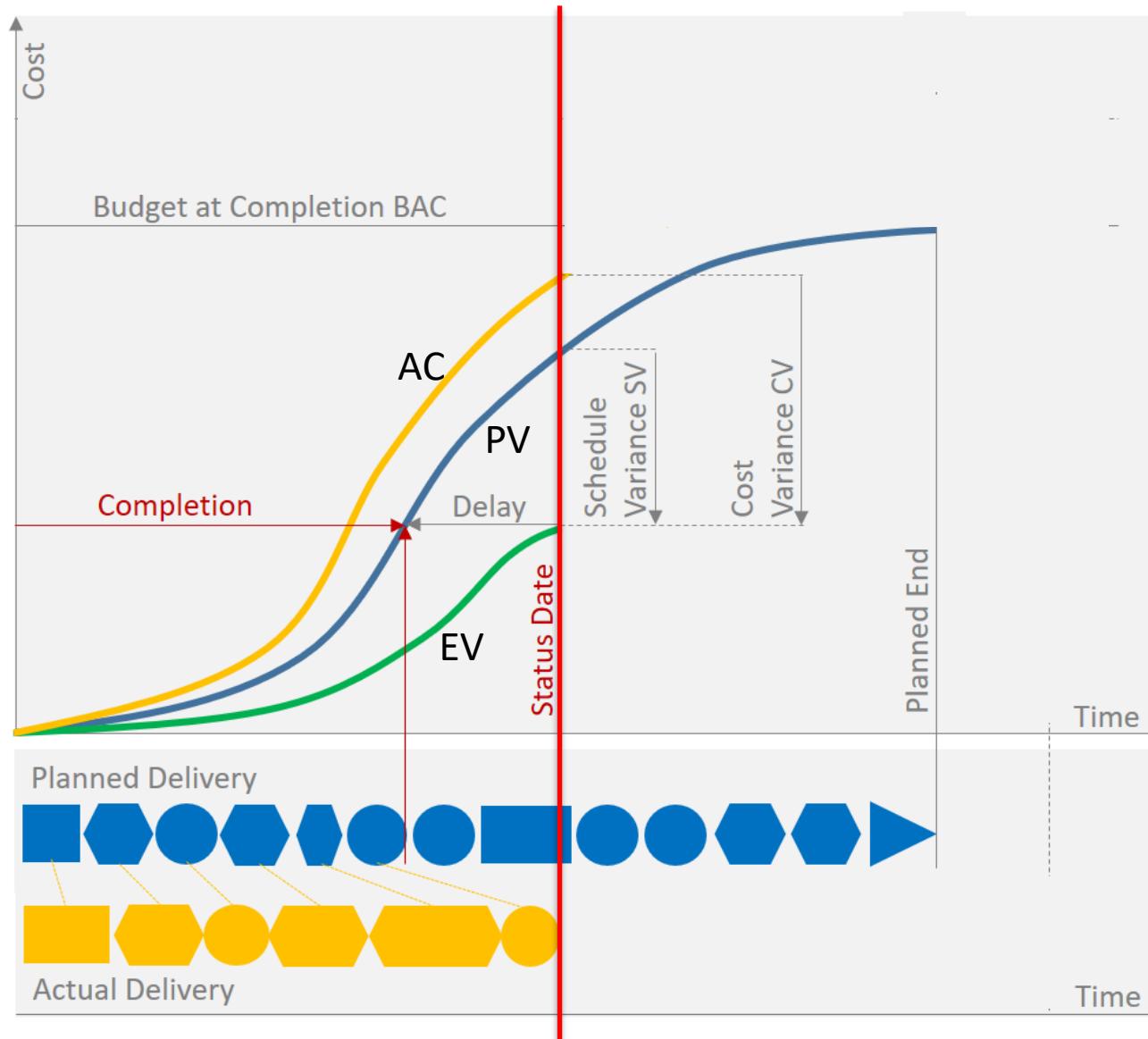
- *Will the work package be on time and on budget?*
- Forecasting assumptions:
 - Constant rate of work?
 - Constant rate of resource consumption (cash)?

Forecasting Example

WP	Budget	Actual % Done	Planned % Done	Actual Cost (AC)	Earned Value (EV)	Planned Value (PV)	Schedule Variance (SV)	Cost Variance (CV)	Schedule Perf. Index (SPI)	Cost Perf. Index (CPI)	Cost Schedule Index (CSI)
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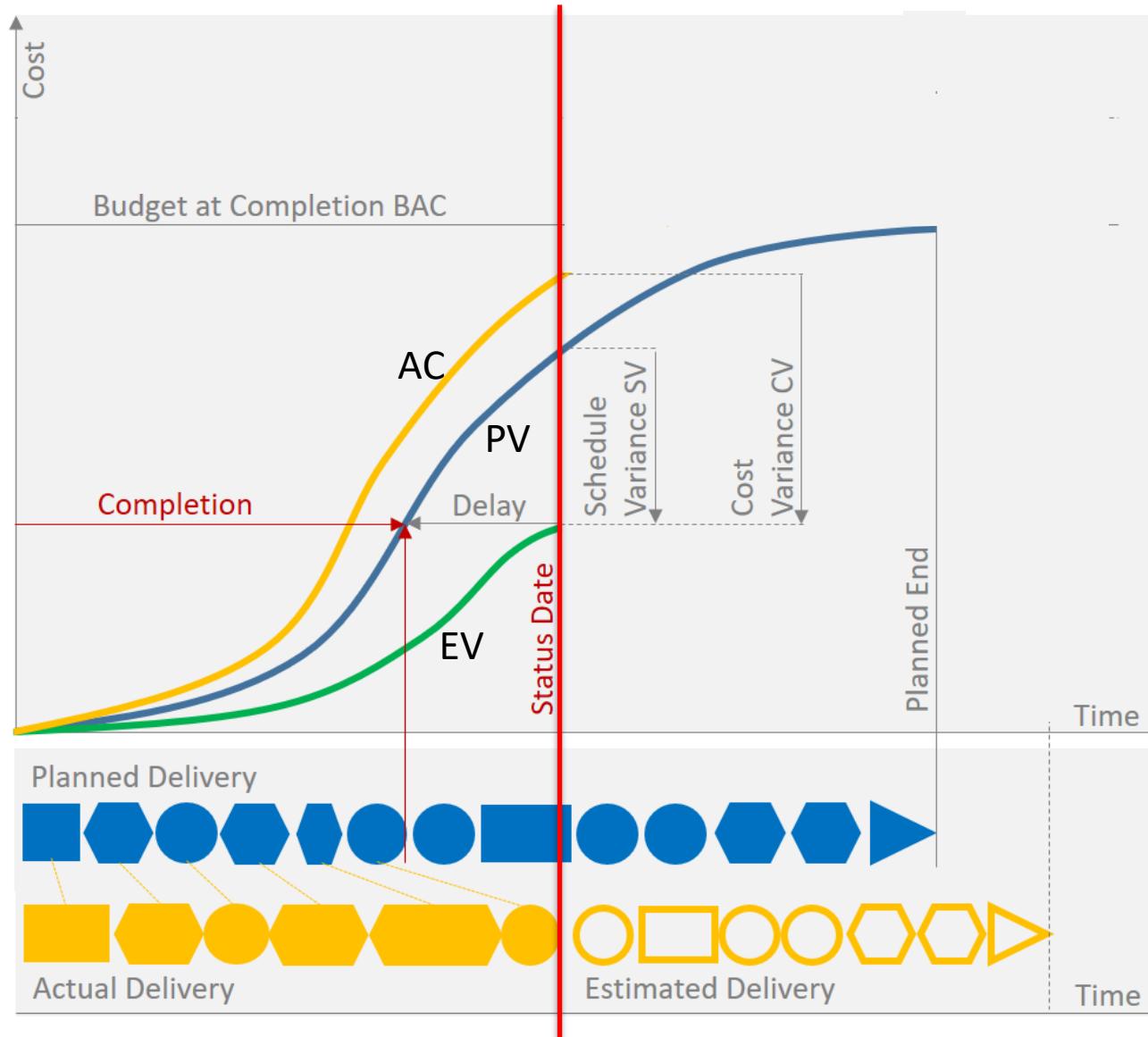
- *Will the work package be on time and on budget?*
- Forecasting assumptions:
 - Constant rate of work?
 - Constant rate of resource consumption (cash)?
- How is **%Done** measured?
 - What if we have tackled the really easy bits first?

Forecasting



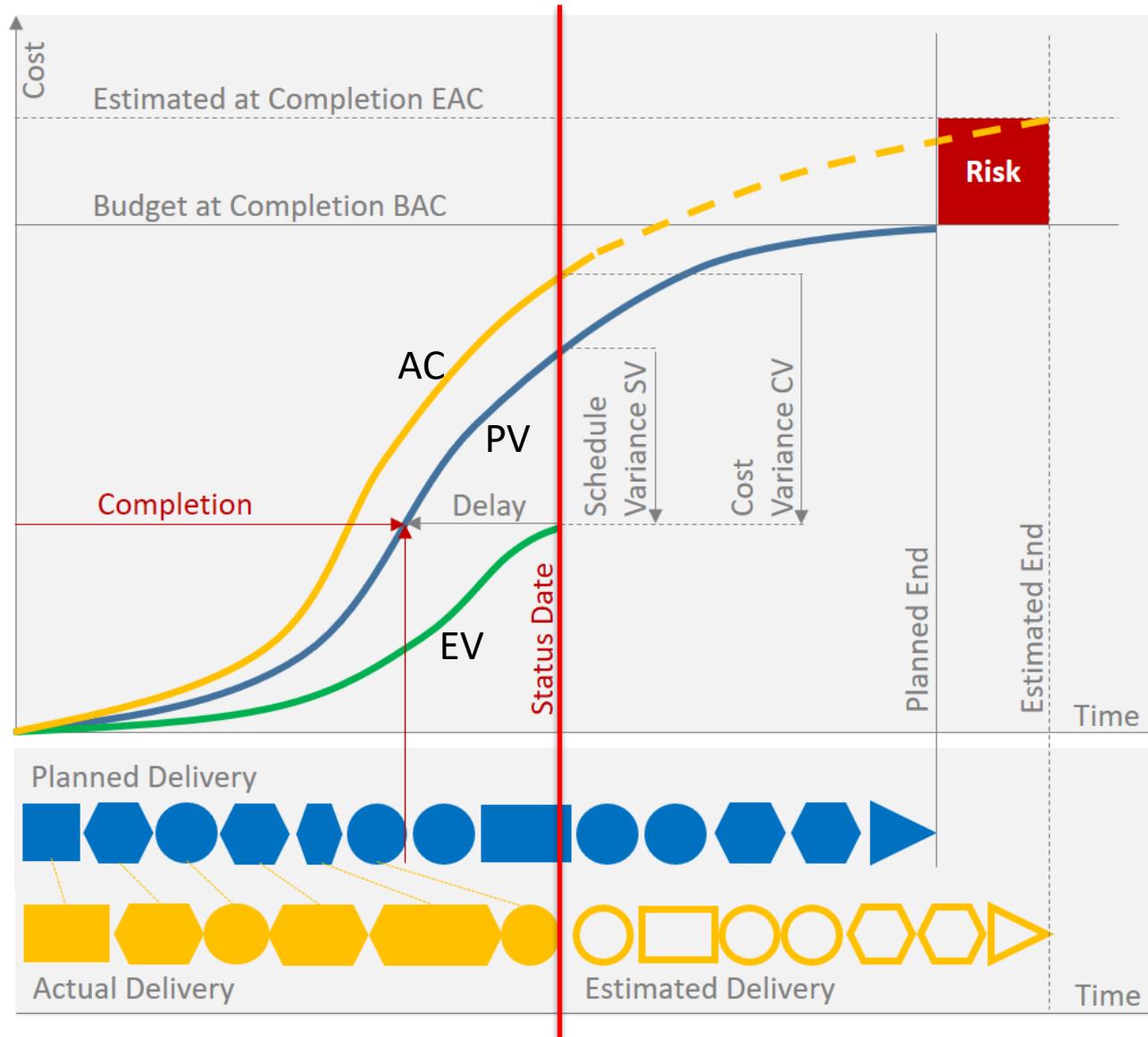
- We want to:
 - Estimate end date
 - Estimate project cost
- How?
 - Sum remaining activities?
 - Extrapolate AC curve?
 - Assumptions?

Forecasting



- We want to:
 - Estimate end date
 - Estimate project cost
- How?
 - Sum remaining activities?
 - Extrapolate AC curve?
 - Assumptions?

Forecasting

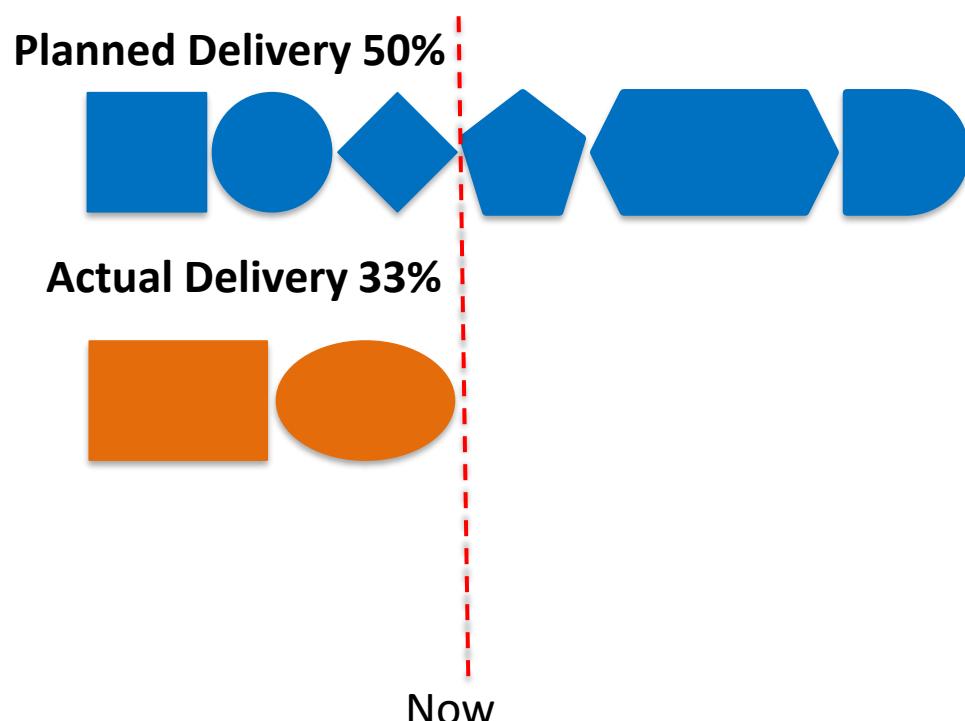


- We want to:
 - Estimate end date
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 - Sum remaining activities?
 - Extrapolate AC curve?
 - Assumptions?

Forecasting Assumptions

Estimate at Completion (EAC) – estimated final total cost of the project

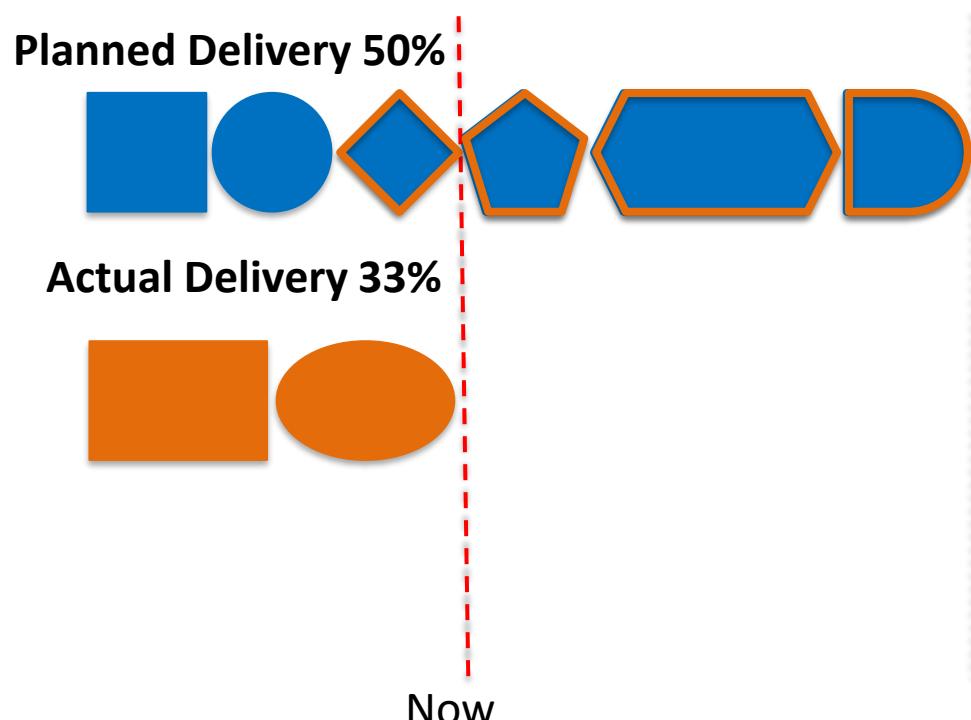
1. Trust original estimate, i.e. assume remaining work will take as long as we had originally planned
2. Assume performance (cost-efficiency) to date is a good indication of how rest of project will perform
3. Assume both cost **and** schedule-efficiency are good indication of how rest of project will perform



Forecasting Assumptions

Estimate at Completion (EAC) – estimated final total cost of the project

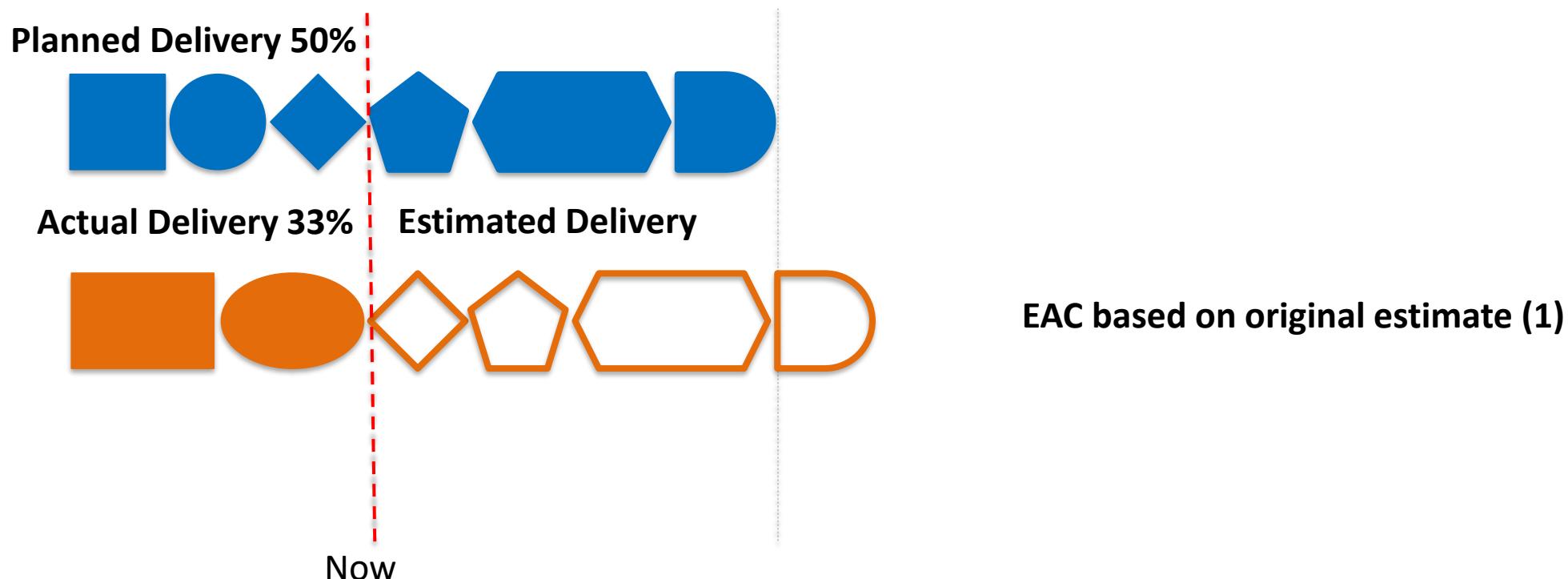
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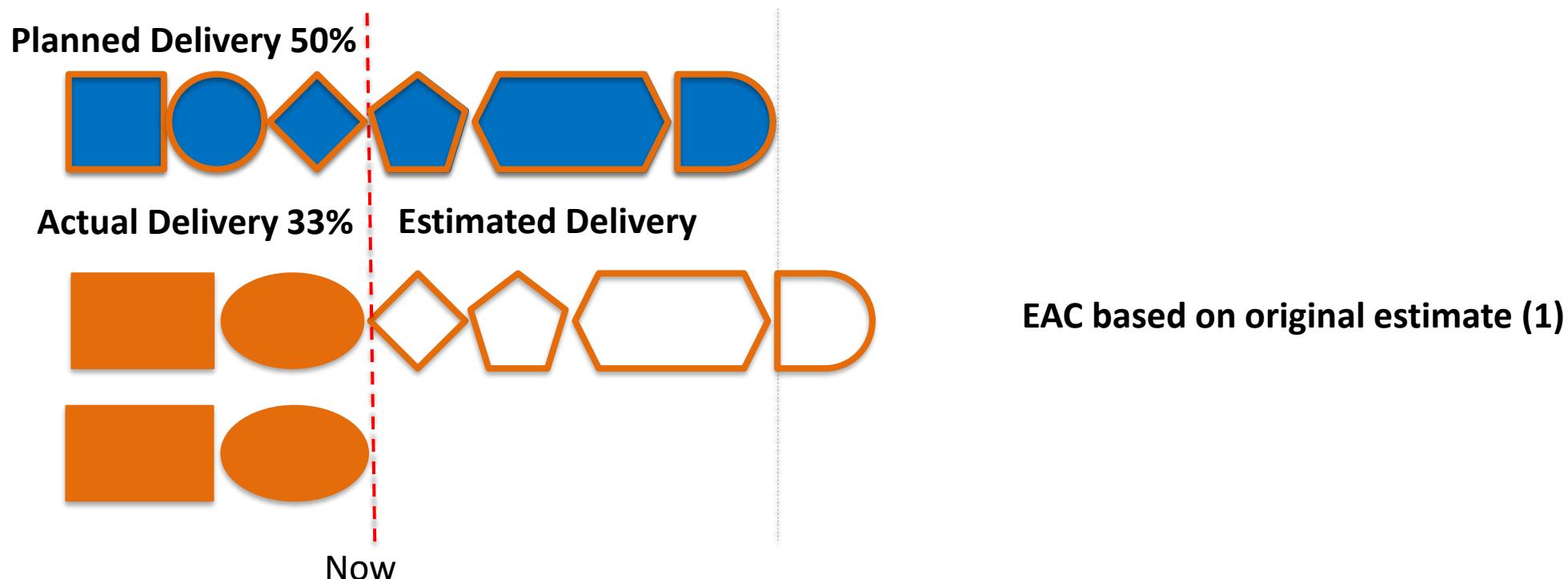
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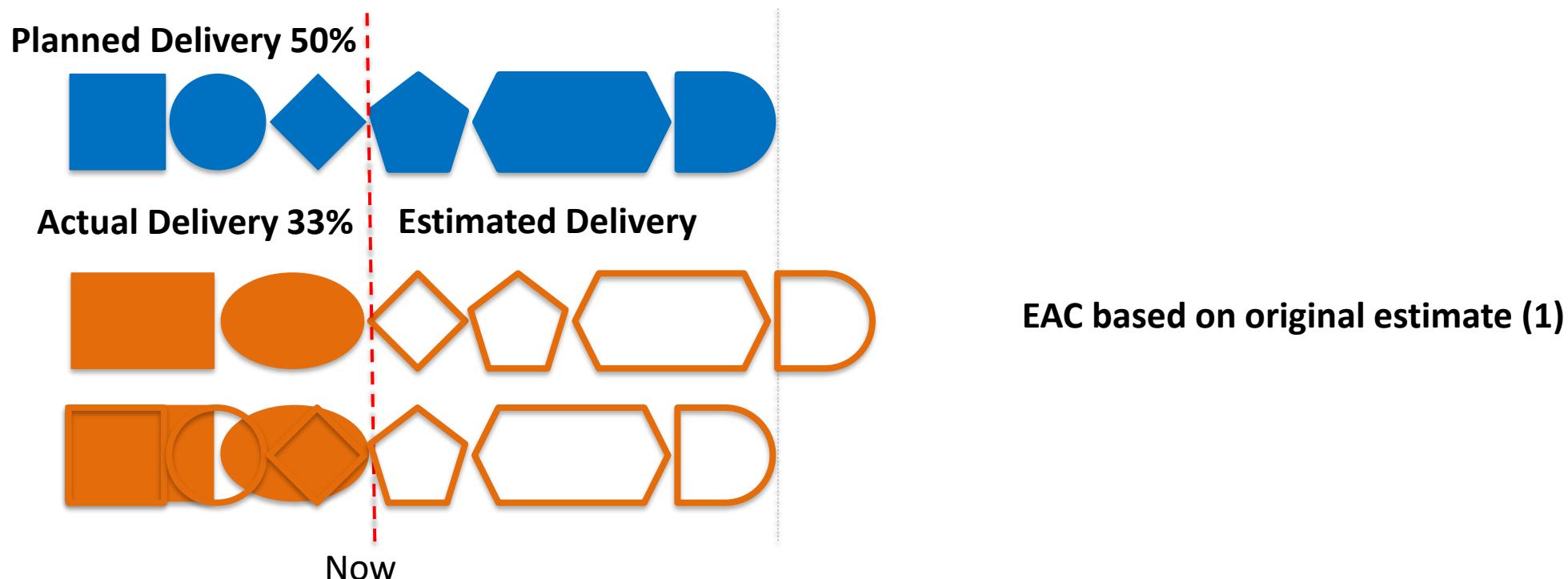
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Forecasting Assumptions

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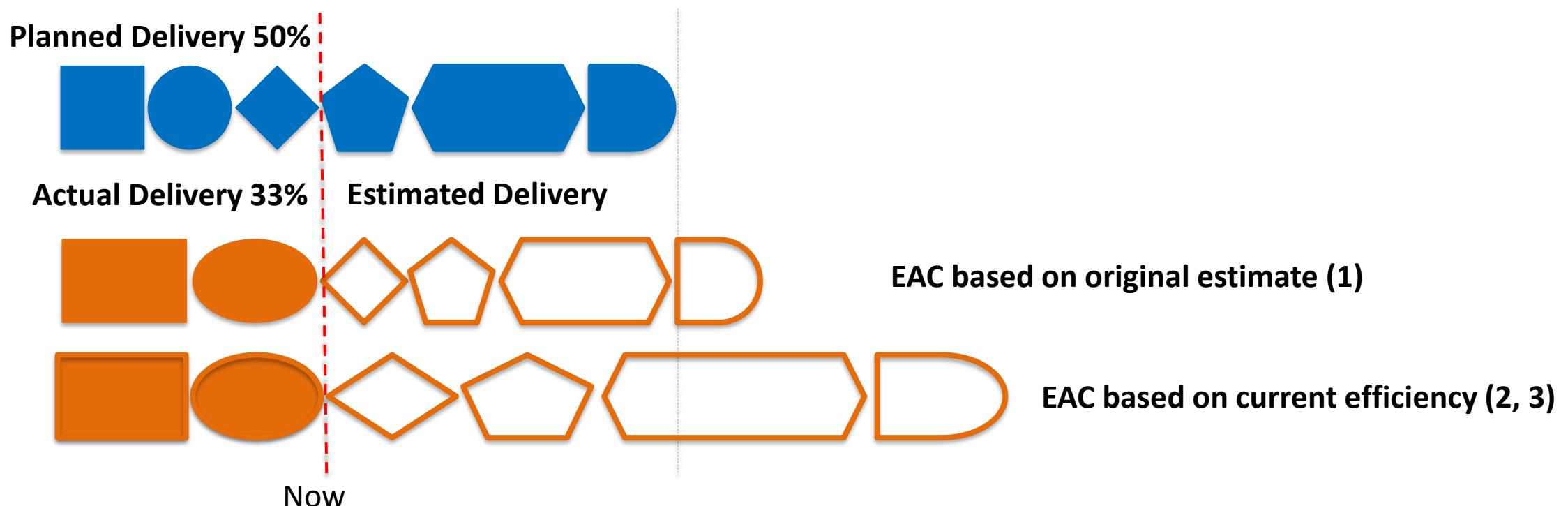
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Forecasting Assumptions

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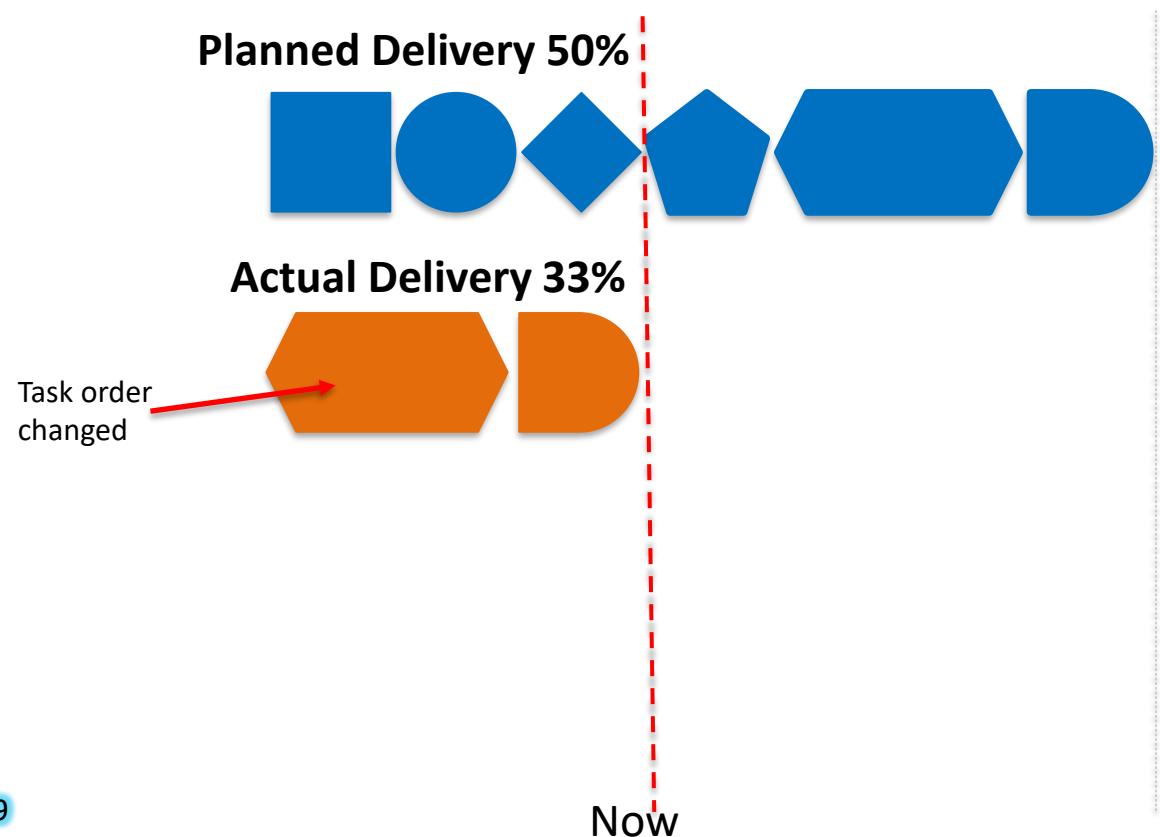
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Forecasting Assumptions

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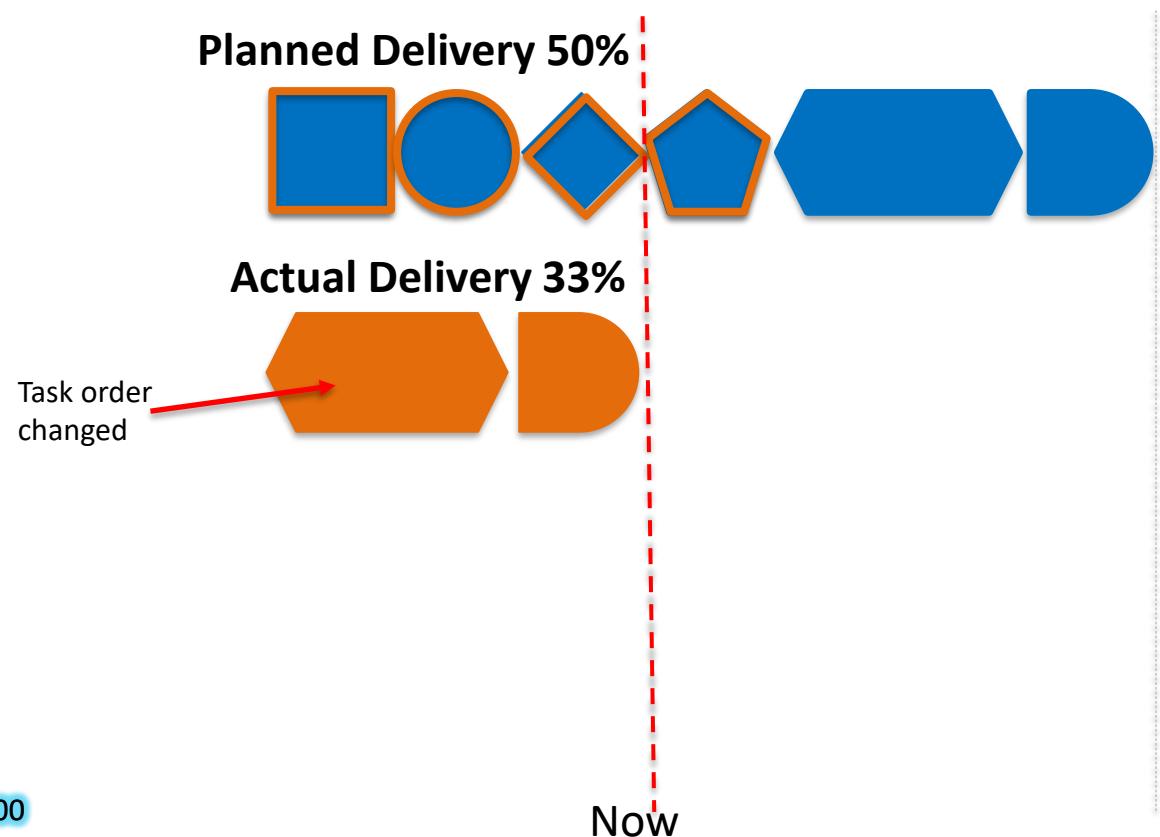
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Forecasting Assumptions

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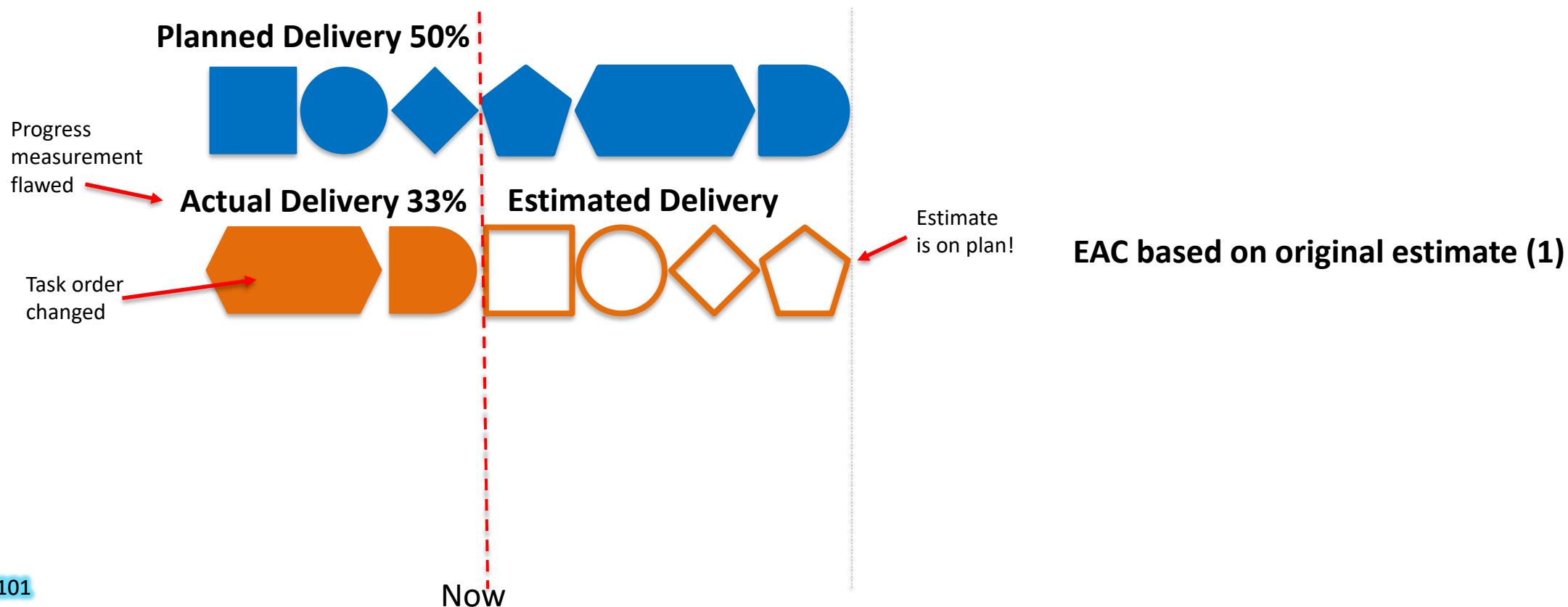
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Forecasting Assumptions

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Forecasting Assumptions – More Metrics

Estimate at Completion (EAC) – estimated final total cost of the project

1. Trust original estimate, i.e. assume remaining work will take as long as we had originally planned
2. Assume performance (cost-efficiency) to date is a good indication of how rest of project will perform
3. Assume both cost **and** schedule-efficiency are good indication of how rest of project will perform

Estimate to Complete (ETC) – how much will we need to spend to **finish** the work?

Variance at Completion (VAC) – The expected overspend (or cost savings)

To-Complete Performance Index (TCPI) – The future **cost efficiency** required

Forecasting Assumptions – More Metrics

Estimate at Completion (EAC) – estimated final total cost of the project

1. Trust original estimate, i.e. assume remaining work will take as long as we had originally planned
2. Assume performance (cost-efficiency) to date is a good indication of how rest of project will perform
3. Assume both cost **and** schedule-efficiency are good indication of how rest of project will perform

Estimate to Complete (ETC) – how much will we need to spend to **finish** the work?

1. Difference between estimate at completion and actual spend to date
2. Bottom-up, when original estimation fundamentally flawed;

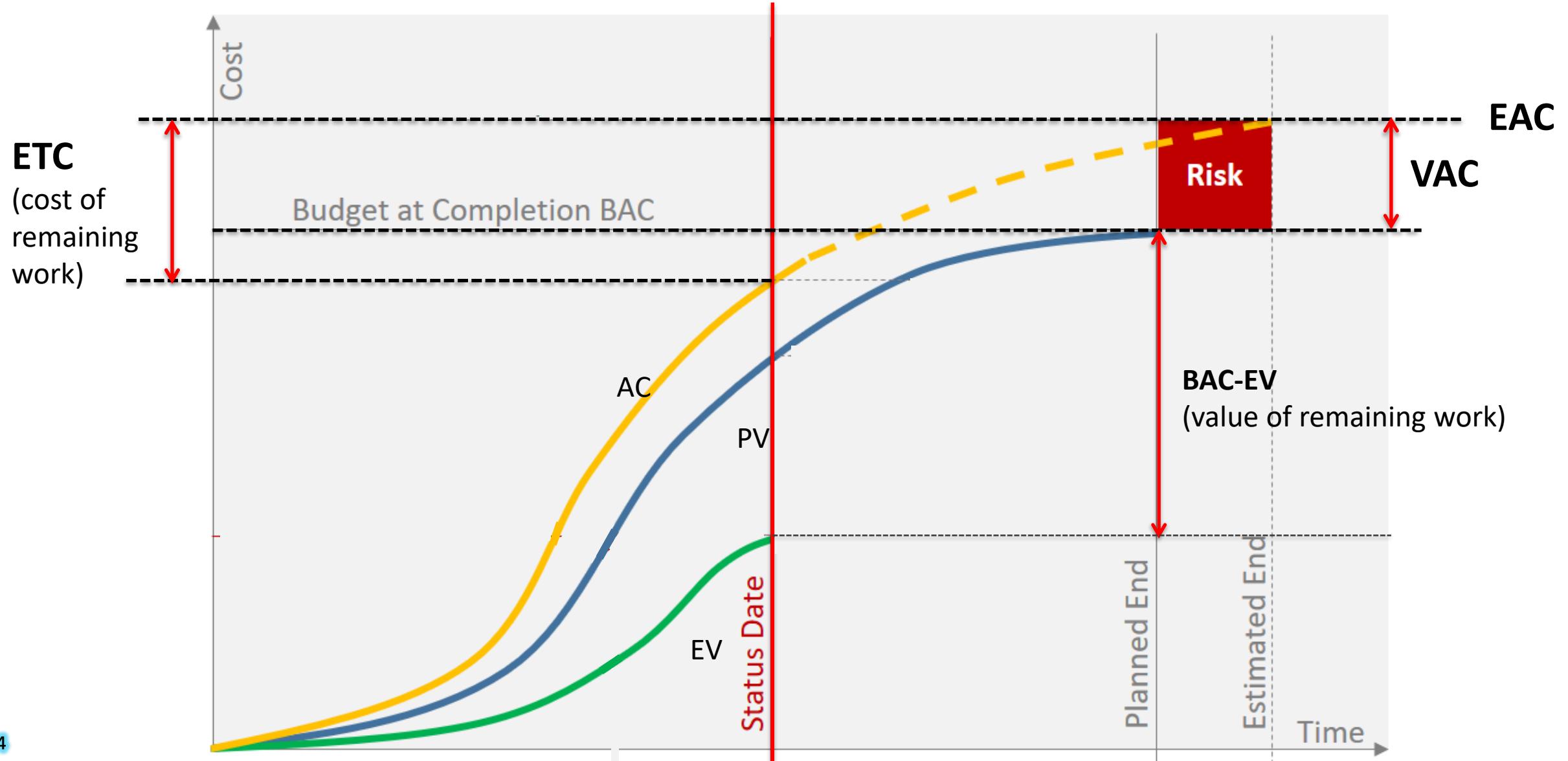
Variance at Completion (VAC) – The expected overspend (or cost savings)

1. The difference between what the project was originally expected to cost, versus what it is currently estimated to cost.

To-Complete Performance Index (TCPI) – The future **cost efficiency** required

1. To achieve the **original** budget
2. To achieve the **estimated** budget

Forecasting Assumptions – More Metrics



Forecasting with EVA

These variables extrapolate our earlier computations to the completion date.

Variable	Description	Calculation
Estimate at completion (EAC)	Est. cost based on progress to date	$BAC \div CPI$
	Est. cost based on original estimation	$AC + (BAC - EV)$
	Est. cost based on overall efficiency (progress and spend)	$AC + (BAC - EV) \div CSI$
Estimate to complete (ETC)	Est. Remaining Cost of Work	$EAC - AC$
Variance at Completion (VAC)	Deviation from budget	$BAC - EAC$
To-Complete Performance Index (TCPI-EAC)	The cost efficiency required to achieve the EAC	$(BAC - EV) \div (EAC - AC)$
To-Complete Performance Index (TCPI-BAC)	The cost efficiency required to achieve the BAC	$(BAC - EV) \div (BAC - AC)$

Forecasting Example

		Actual % Done	Planned % Done	Actual Cost (AC)	Earned Value (EV)	Planned Value (PV)	Schedule Variance (SV)	Cost Variance (CV)	Schedule Perf. Index (SPI)	Cost Perf. Index (CPI)	Cost Schedule Index (CSI)
WP	Budget										
E	£10,409	75%	70%	£7,817	£7,807	£7,286	£520	-£10	1.07	0.999	1.07

	based on		
	CPI	original	CSI
Estimate at completion (EAC)			
Estimate to complete (ETC)			
Variance at Completion (VAC)			
To-Complete Performance Index (TCPI-EAC)			

Forecasting Example

	WP Budget	Actual % Done	Planned % Done	Actual Cost (AC)	Earned Value (EV)	Planned Value (PV)	Schedule Variance (SV)	Cost Variance (CV)	Schedule Perf. Index (SPI)	Cost Perf. Index (CPI)	Cost Schedule Index (CSI)
E	£10,409	75%	70%	£7,817	£7,807	£7,286	£520	-£10	1.07	0.999	1.07

Original budget

EAC

keep original estimation	AC + (BAC – EV)

	based on		
	CPI	original	CSI
Estimate at completion (EAC)		£10,419	
Estimate to complete (ETC)			
Variance at Completion (VAC)			
To-Complete Performance Index (TCPI-EAC)			

Consequence: We retain the existing £10 overspend

Forecasting Example

WP	Budget	Actual % Done	Planned % Done	Actual Cost (AC)	Earned Value (EV)	Planned Value (PV)	Schedule Variance (SV)	Cost Variance (CV)	Schedule Perf. Index (SPI)	Cost Perf. Index (CPI)	Cost Schedule Index (CSI)
E	£10,409	75%	70%	£7,817	£7,807	£7,286	£520	-£10	1.07	0.999	1.07

Original budget

EAC

based on cost efficiency

keep original estimation

$BAC \div CPI$

$AC + (BAC - EV)$

	CPI	original	CSI
Estimate at completion (EAC)	£10,423	£10,419	
Estimate to complete (ETC)			
Variance at Completion (VAC)			
To-Complete Performance Index (TCPI-EAC)			

Consequence: We continue at the same cost-inefficiency. The final overspend is higher.

Forecasting Example

WP	Budget	Actual % Done	Planned % Done	Actual Cost (AC)	Earned Value (EV)	Planned Value (PV)	Schedule Variance (SV)	Cost Variance (CV)	Schedule Perf. Index (SPI)	Cost Perf. Index (CPI)	Cost Schedule Index (CSI)
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Original budget

EAC

based on cost efficiency

keep original estimation

based on overall efficiency

$BAC \div CPI$

$AC + (BAC - EV)$

$AC + (BAC - EV) \div CSI$

	CPI	original	CSI
Estimate at completion (EAC)	£10,423	£10,419	£10,249
Estimate to complete (ETC)			
Variance at Completion (VAC)			
To-Complete Performance Index (TCPI-EAC)			

Consequence: The remaining work can be done at the same **overall** efficiency. We finish the work sooner and so spend less.

Forecasting Example

WP	Budget	Actual % Done	Planned % Done	Actual Cost (AC)	Earned Value (EV)	Planned Value (PV)	Schedule Variance (SV)	Cost Variance (CV)	Schedule Perf. Index (SPI)	Cost Perf. Index (CPI)	Cost Schedule Index (CSI)
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	based on		
	CPI	original	CSI
Estimate at completion (EAC)	£10,423	£10,419	£10,249
Estimate to complete (ETC)	£2,606	£2,602	£2,432
Variance at Completion (VAC)	-£14	-£10	£160
To-Complete Performance Index (TCPI-EAC)			

 EAC – AC
 BAC – EAC

Forecasting Example

WP	Budget	Actual % Done	Planned % Done	Actual Cost (AC)	Earned Value (EV)	Planned Value (PV)	Schedule Variance (SV)	Cost Variance (CV)	Schedule Perf. Index (SPI)	Cost Perf. Index (CPI)	Cost Schedule Index (CSI)
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To-Complete Performance Index (TCPI-EAC)	0.999	1.000	1.07

 EAC – AC
 BAC – EAC
 (BAC – EV) ÷ (EAC – AC)

Look Familiar?

More Homework

Add the remaining columns!

https://warwick.ac.uk/pmcs/resources/eva_homework.xlsx

WP	Budget	Actual % Done	Planned % Done	Actual Cost (AC)	Earned Value (EV)	Planned Value (PV)	Schedule Variance (SV)	Cost Variance (CV)	Sched Perf. Index (SPI)	Cost Perf. Index (CPI)	Cost Index (CSI)	To-Complete Performance Index (TCPI-BAC)	Estimate at completion (EAC) based on CPI	Estimate to complete (ETC)	Variance at Completion (VAC)	To-Complete Performance Index (TCPI-EAC)
	£30,225	93%	100%	£30,458												
A	£30,720	84%	100%	£23,055												
B	£15,300	83%	100%	£6,999												
C	£44,828	85%	83%	£37,571												
E	£10,409	75%	70%	£7,817	£7,807	£7,286	£520	-£10	1.07	0.999	1.07	1.004	£10,423	£2,606	-£14	0.999
F	£8,890	98%	100%	£6,138												
G	£3,458	90%	100%	£2,736												
H	£51,092	10%	20%	£8,347												
I	£1,404	44%	30%	£432												
J	£1,258	25%	30%	£756												
K	£10,373	60%	60%	£2,904												
L	£4,531	11%	15%	£72												
M	£59,186	0%	0%	£0												

Recap so far



Budgeting

Creating a project budget
Estimating activity costs
(and why it is hard)



Monitoring

Measuring Performance:
Planned vs Earned Value

Earned Value Analysis
(EVA) to compute efficiency



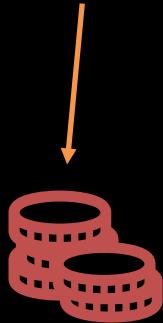
Forecasting

EVA to predict the future

Recap so far

Estimate activity durations

Combine to get PMB / Planned Value



Budgeting

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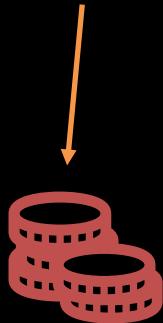
EVA to predict the future

Start with: Planned Value, Earned Value, Actual Expenditure
Compute: Variance, Efficiency

Recap so far

Estimate activity durations

Combine to get PMB / Planned Value



Budgeting

Creating a project budget

Estimating activity costs
(and why it is hard)



Monitoring

Measuring Performance:
Planned vs Earned Value

Earned Value Analysis
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Start with: Planned Value, Earned Value, Actual Expenditure
Compute: Variance, Efficiency

Extrapolate expenditure (based on measured efficiency)
Predict overspend and delays



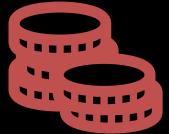
Forecasting

EVA to predict the future

Why???

(Clue: last week's seminar)

Today



Budgeting

Creating a project budget
Estimating activity costs
(and why it is hard)



Monitoring

Measuring Performance:
Planned vs Earned Value
Earned Value Analysis
(EVA) to compute efficiency



Forecasting

EVA to predict the future



Success

Defining success and Key
Performance Indicators
(KPIs)

Why Projects Fail

1. The requirements list was incomplete.
2. The stakeholders were not involved.
3. There weren't enough resources to complete the project.
4. The expectations for what could reasonably be created during the project were too high.
5. The support from above wasn't strong enough.
6. The requirements for the project kept changing.
7. The project wasn't well planned.
8. There was no longer a need for the project.
9. There wasn't enough management involved.
10. Those involved did not have the skills required to complete the project.

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What does success look like?



Mersey Gateway: Fireworks launch for new £600m bridge

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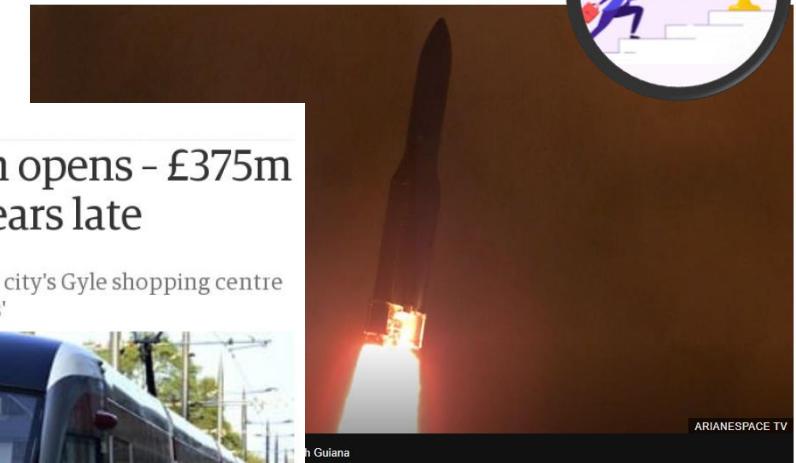
NEWS

Home UK World Business Politics Tech Science Health Family & Education Entertainment & Arts More Science & Environment

Europe's Ariane-5 rocket makes 100th flight

By Jonathan Amos
BBC Science Correspondent

© 26 September 2018



Edinburgh The Observer

Edinburgh's tram system opens - £375m over budget and three years late

Edinburgh people cheer as first service leaves city's Gyle shopping centre amid admissions project had been a 'shambles'

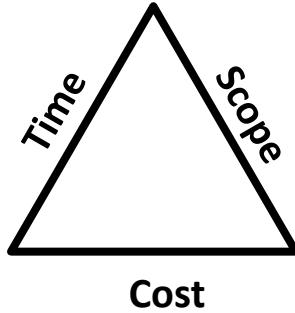


The first passenger-carrying tram ran on Edinburgh's Princes Street at the weekend. Photograph: Rex

Measuring Project Success

Common Objectives:

- **Budget** targets
- **Schedule** targets
- **Scope** targets



***But:** No point delivering on time/within budget if no actual **benefits**!*

Equally important:

- A high **quality** product is implemented
- The product is **utilized**.
- **Business** objectives are achieved
- Resources used effectively
- Team is able to **support** solution in future
- Participants have **pride** of ownership
- Adhered **standards** and best practice.
- Methods in place to **evaluate benefit realization**.

Key Performance Indicators (KPIs)

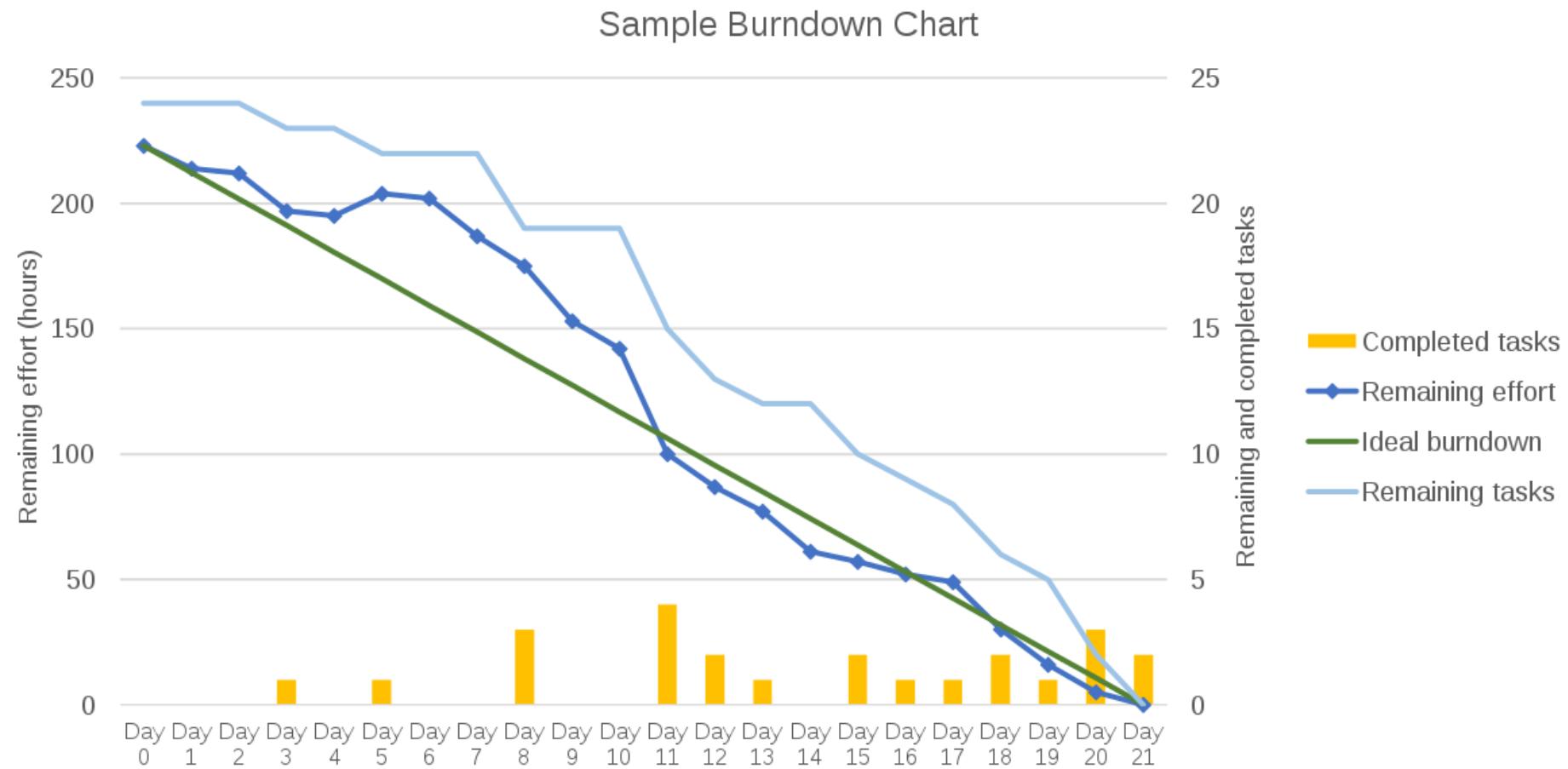
- High-level **indicators**
 - Simple, measurable **metrics**
 - Correlated to stakeholder **objectives**
 - Agreed between PM and stakeholders
- Metrics of **success**
 - Which are the critical metrics such that the project will be viewed as a success by all of the stakeholders?
- Measure of **progress**
 - Continually measured to track progress towards goals



Key Performance Indicators (KPIs)

- Scope
 - % tasks complete
 - To-do list size
 - No of scope review meetings
- Timeliness
 - % tasks on time
 - Time spent on schedule
 - No of schedule revisions
- Budget
 - % tasks on budget
 - Budget variance (Actual vs planned cost)
 - Budget creation time
 - No of budget revisions
- Quality
 - Customer satisfaction ratings
 - Number of bugs or errors
 - Customer complaints
- Efficiency / Effectiveness
 - Resource utilisation %
 - Missed milestones
 - Rate of returns
- Project
 - Return on Investment (ROI)
 - Operating margins
 - Time to achieve value
 - Cost of management
 - % projects complete
 - % projects over budget

Agile: Burndown Chart



Source: Wikipedia

Enterprise resource planning (ERP)

- Business Analytics
- Central database with interfaces to every part of the company
 - E.g. stock control, production line, sales, marketing, finance, HR, customer service
 - Tracks metrics in real time
- Data-driven management
 - Visualise metrics on a dashboard
 - Quickly spot issues
 - Manage the management



Data Driven Project Management

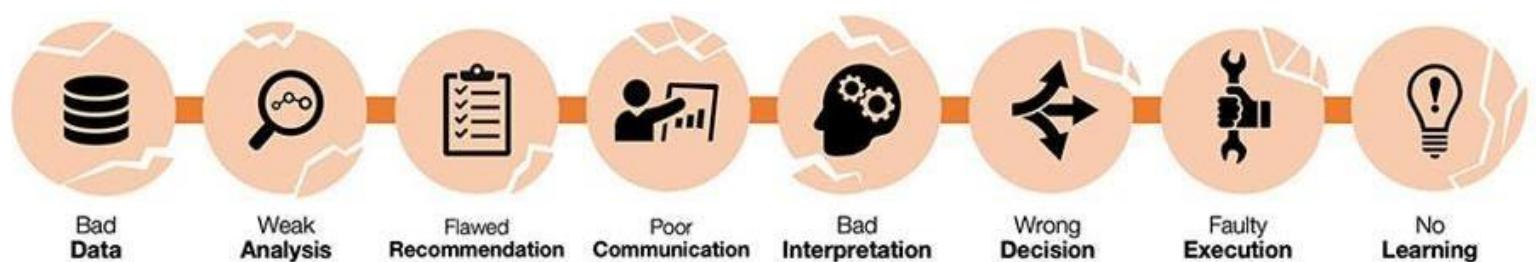


Pros

- Metrics tell us if we are hitting targets/milestones, getting better or worse
- Early identification of issues
- Informed decision making
- proactive management
- Reduces the subjective bias of intuition or guesswork

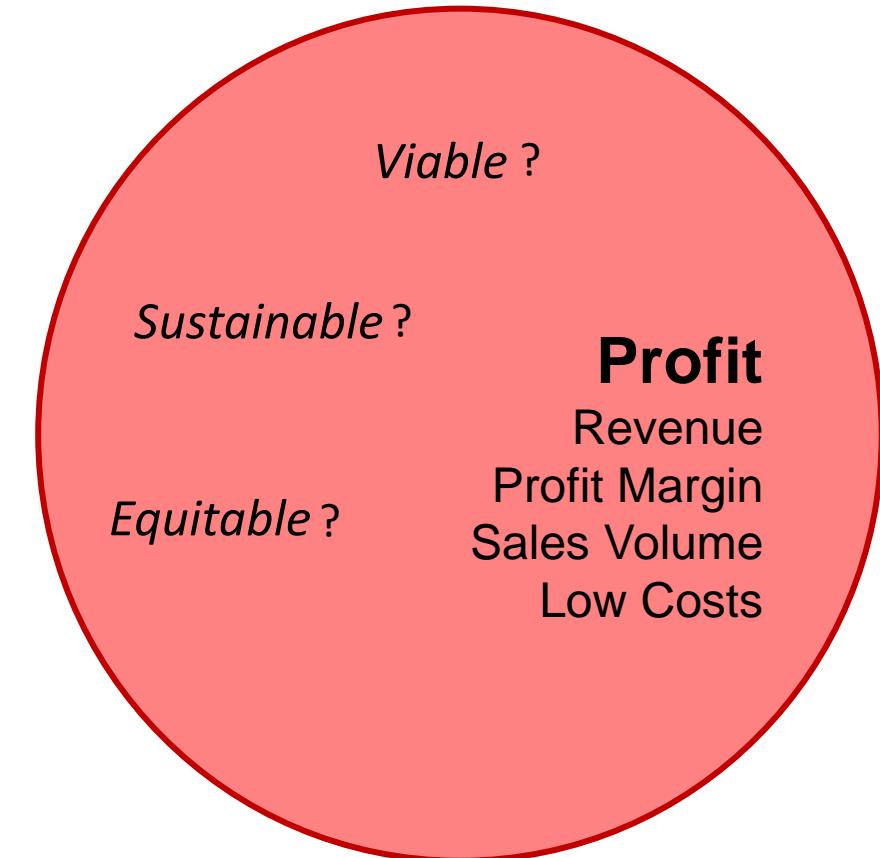
Cons

- Project environments are short and susceptible to changing metrics
- Wrong metrics decision only as good as the data
- Lack of skills - poor analysis or proposed solution
- Oversimplification
- Misinterpretation



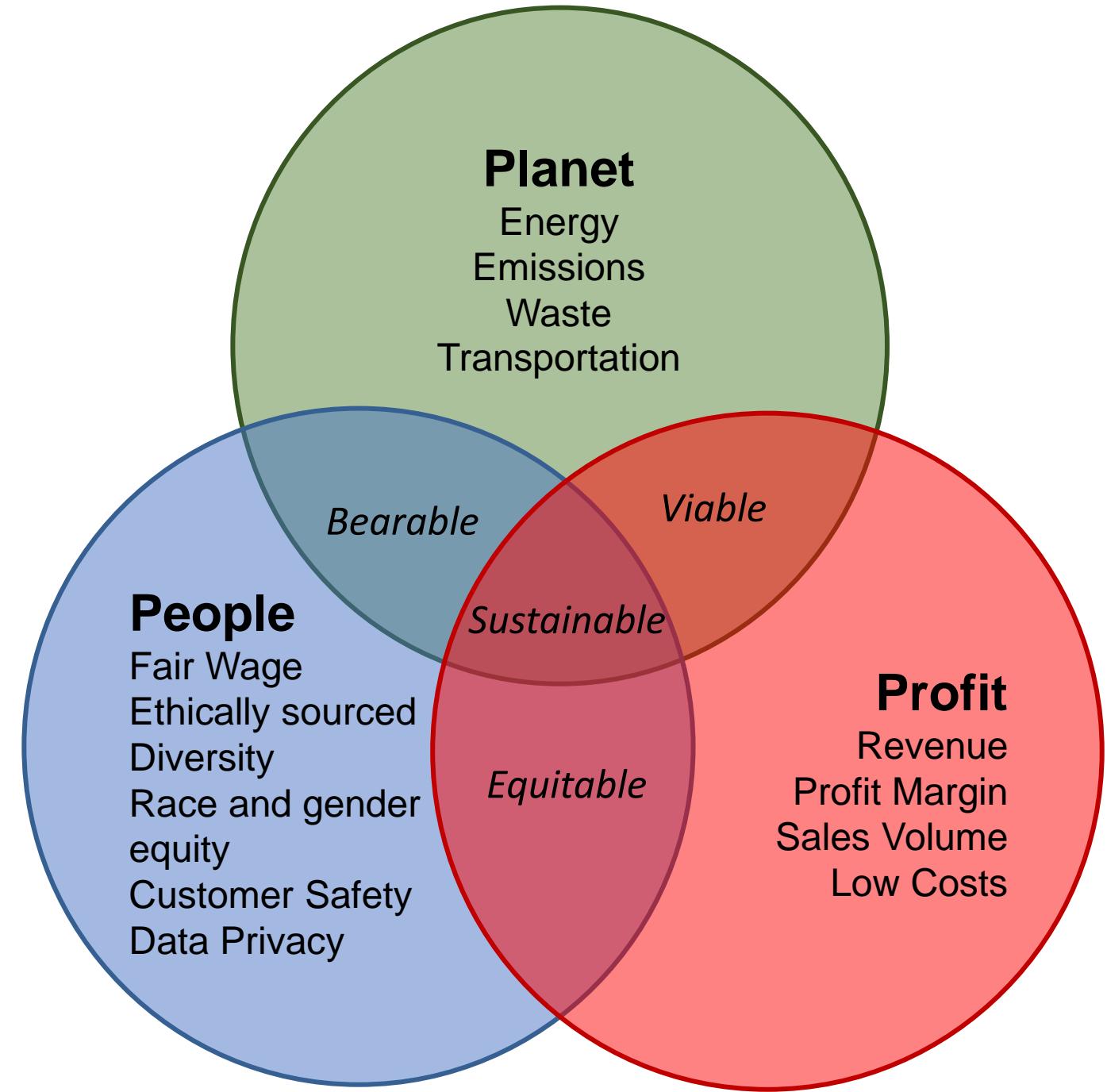
Bottom Line

- Profit is necessary to survival.
- Survival at any cost?
 - fair and equitable practices;
 - happy employees, suppliers, and stakeholders?
 - viable or feasible, given limited availability of resources?
 - Pure profit-focus is short sighted and unsustainable.



Triple Bottom Line

- What you measure is what you get – it's the incentive; the thing that employees and organisations optimised for.
- Measuring the “triple bottom line” requires a little bit of creativity compared to traditional accounting!





HS2 KPIs

Vote for up to 2 choices

1. £ spent / customer-journey-hours saved
2. Schedule Variance (SV)
3. Miles of track built / £ spent
4. Estimate at Completion (EAC)

HS2 KPIs

- 13 KPIs, including:
 - Progress relative to plan (SV)
 - Projected programme costs (EAC)
 - % of technical requirements met
 - Health and safety index
 - % of workforce who are apprentices
 - % of staff who are women, BAME, disabled
 - Community engagement index

Summary

- Estimation is hard!
- So, try to **control**:
 - Set **limits** – budget, schedule, scope...
 - Monitor KPIs, to track **performance**
 - Measure **progress** and react quickly
 - Even better, **forecast** – react before it happens!
- Why? For future **benefits**:
 - Profit, growth, brand awareness, customer satisfaction
 - profit.

Week	Lectures		Seminars			Individual Report		
	Topic	Guest	Case Study	Exercises	Submission	Chapter	Submission	Marking
1	Specification			Specification				
2	Initiation		Selection		Pitch			
3	Scope / Time			Scope/Time				
4	PRINCE2	PRINCE2	Initiation			Ch.1 Initiation		
5	Budgeting			Budgeting			Self-assess	
6	Lean/Agile 1	Waterfall / Agile	Planning			Ch.2 Planning		
7	Lean/Agile 2	Lean		Scrum/Kanban			Ch.1-2	
8	Risk	Risk / Finance	Monitoring			Ch.3 Execution		Review Ch.1-2
9	Teamwork	Large Projects	Prepare Presentation	Risk				
10	Revision				Presentation	Ch.4 Monitoring		
11							Ch.1-4	
Term 2								Review Ch. 1-4

Individual Report

Chapter 1

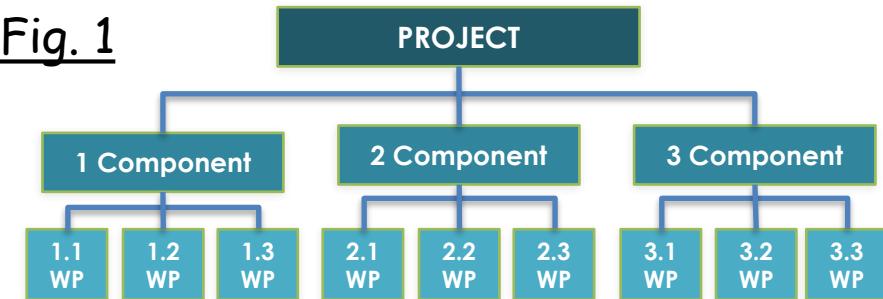
warwick.ac.uk/pmcs/assignments/chapter1

Seminars only scratch the surface:

- Expand on seminar work with your team, or work independently
- Is your Business Case convincing enough?
- Will the project deliver value to the stakeholders?
- Complete Self-Assessment

Essay Components

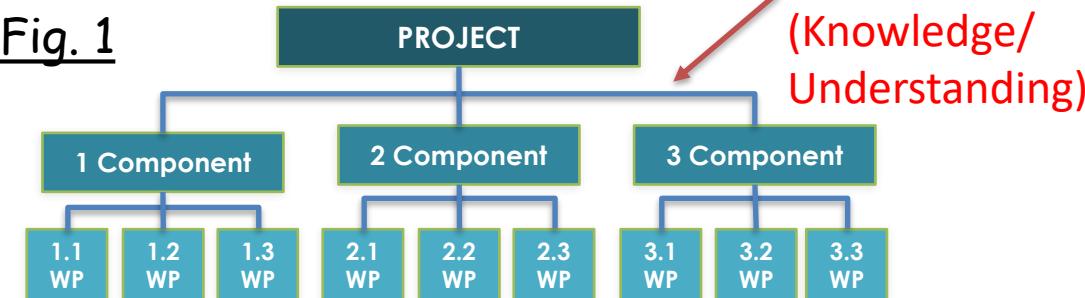
Fig. 1



1. Fig. 1 Shows the WBS
2. This is broken down hierarchically into strict deliverables, and constitutes the scope.
3. To ensure that the scope aligned with the objectives, deliverables were grouped by objective.
4. We limited scope to reduce cost, as the PM must make a trade-off to balance cost, time and scope/quality [1].
5. However, this is problematic, as the iron triangle omits 'risk' ...
6. Further research [2] suggests that we should also have considered ...
7. ... on reflection, we should have modified objective 1 and expanded the scope.

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Application
(Knowledge/
Understanding)

Knowledge

Understanding

Evidence

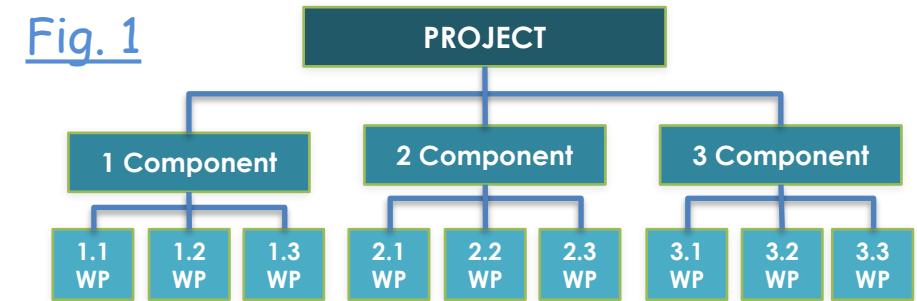
Analysis

Critical Analysis

Reflection

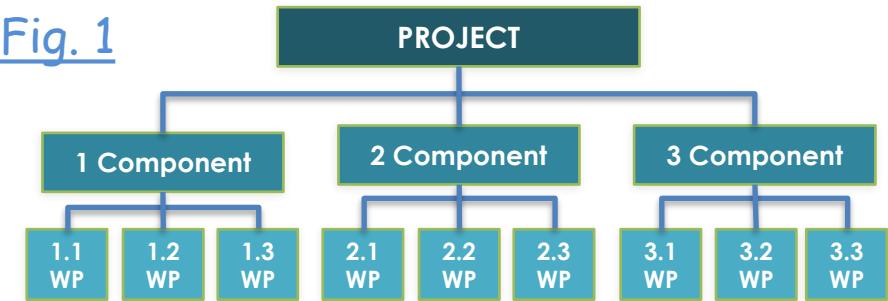
Essay Components

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Essay Components

Fig. 1



1. Fig. 1 Shows the WBS

Knowledge/Understanding

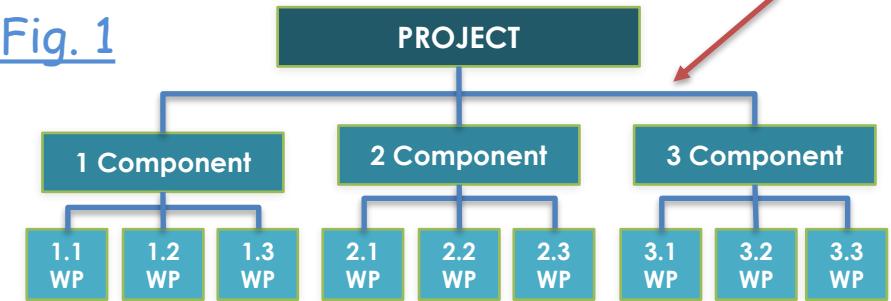
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Does the submission correctly apply appropriate project management methods and methodologies?

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- **1 = Poor.** e.g. Significant errors or omissions
- **2 = Average.** e.g. Recalls taught concepts accurately
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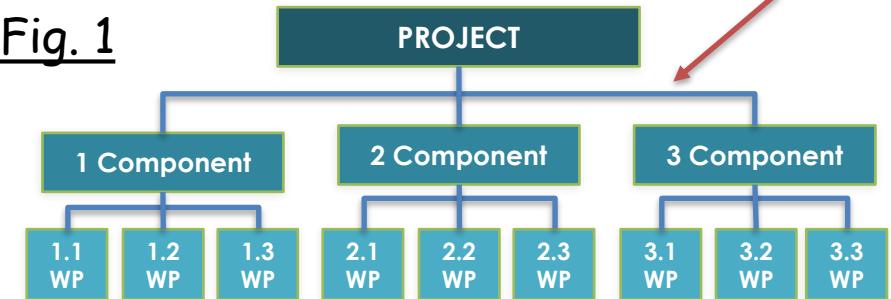
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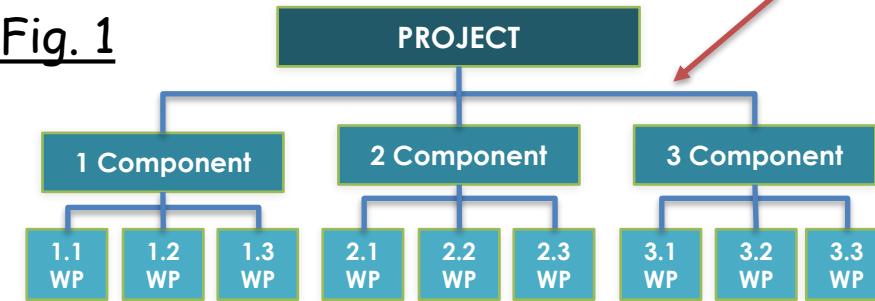
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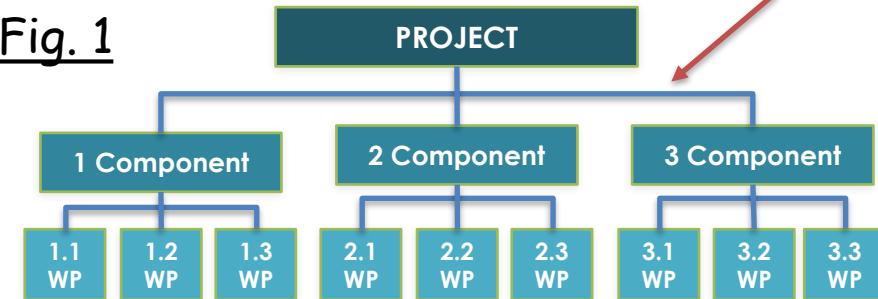
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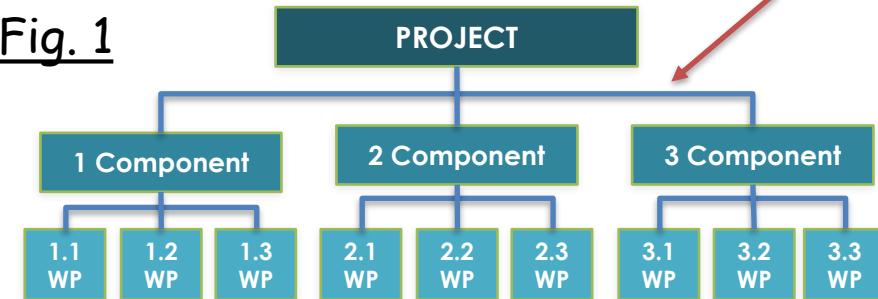
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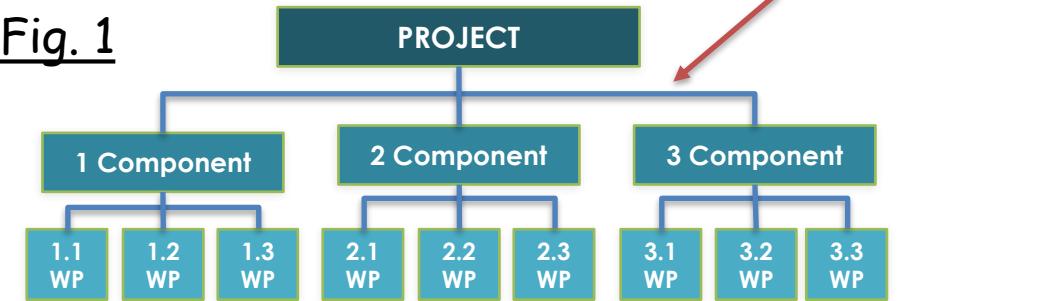
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Depth of Analysis

Are sources evaluated critically to construct well-reasoned balanced arguments?

- **0 = Very Poor.** e.g. No analysis

- **1 = Poor.** e.g. Mainly descriptive

- **2 = Average.** e.g. Some analysis and justification

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Use of Evidence

Is the work evidence-informed, making effective use of examples and references?

0 = Very Poor. e.g. Uninformed, arguments unsupported

1 = Poor. e.g. Limited use of evidence

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Are sources evaluated critically to construct well-reasoned balanced arguments?

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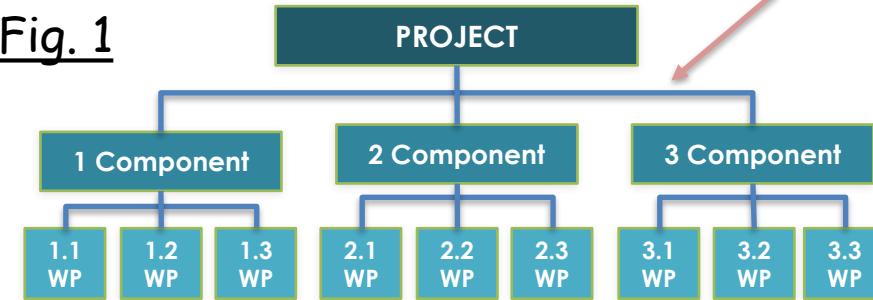
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Essay Components

Fig. 1



1. Fig. 1 Shows the WBS

2. This is broken down hierarchically into strict deliverables

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Does the submission show good communication skills? Consider things such as a logical structure, audience awareness and engaging delivery.

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Application

Knowledge

Understanding

Evidence

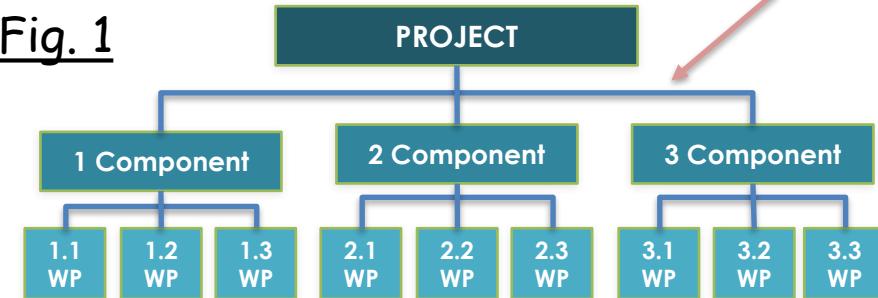
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Evidence + Analysis

Reflection + Evaluation

20-point Mark Scale

Class	Scale	Mark	Descriptor
First	Excellent 1st	100	Work of original and exceptional quality which in the examiners' judgement merits special recognition by the award of the highest possible mark.
		94	Exceptional work of the highest quality, demonstrating excellent knowledge and understanding, analysis, organisation, accuracy, relevance, presentation and appropriate skills. At final-year level: work may achieve or be close to publishable standard.
		88	Very high quality work demonstrating excellent knowledge and understanding, analysis, organisation, accuracy, relevance, presentation and appropriate skills. Work which may extend existing debates or interpretations.
		82	
		78	
		74	
Upper Second (2.1)	High 2.1	68	High quality work demonstrating good knowledge and understanding, analysis, organisation, accuracy, relevance, presentation and appropriate skills.
	Mid 2.1	65	
	Low 2.1	62	
Lower Second	High 2.2	58	Competent work, demonstrating reasonable knowledge and understanding, some analysis, organisation, accuracy, relevance, presentation and appropriate skills.
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	Low 2.2	52	
Third	High 3rd	48	Work of limited quality, demonstrating some relevant knowledge and understanding.

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Self Assessment Tool (beta)

WARWICK Dashboard This Module ▾ Help ▾ More ▾

10 Revision Presentation Presentation Ch.4 Monitoring Ch.1

11

Term 2

▼ Individual Report - Submission and Peer Assessment

In addition to the team-based activities in this module, you will need to produce an **Individual Report**. You will work on this in your own time (independently of your team).

You will submit this report (including an interim submission) to Moodle. You are also required to mark the work of your peers and provide constructive feedback. See the [assignments](#) page for more details. You should also be aware of the [deadlines and penalties](#).

 [Self-Assessment \(Ch. 1\)](#)

[How to mark the essay](#)

[Consent Form - you must complete this before you can submit your essay](#)

[Interim Essay Submission and Peer Marking \(Ch.1-2\)](#)

[Interim Essay Results \(Ch. 1-2\)](#)

[Final Essay Submission and Peer Marking \(Ch.1-4\)](#)

[Final Essay Results \(Ch. 1-4\)](#)

Self-Assessment

Stakeholders: Yes

Have you conducted a stakeholder analysis?

The more stakeholders you can identify early on and the more you can tailor your communication to win approval and support from the various types of stakeholders, the more likely your project is to succeed [1]. Read [1] for more information.

Reflect:

- Think about the constraints, compromises and requirements for each stakeholder.
- Are all stakeholder interests suitably represented in your project design?
- Do some stakeholders matter more than others?

[1] <https://www.productplan.com/glossary/stakeholder-analysis/>

Advice

Further reading

Stakeholder Analysis

 [Stakeholder Analysis: ...](#)

Videos

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https://warwick.ac.uk/pmcs/resources/eva_homework.xlsx