SESA6085 – Advanced Aerospace Engineering Management

Lecture 17

2024-2025

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A Recap

- In the previous lecture we tackled project risk management
  - PUMP
  - Focus on quantification of uncertainty (inc. elicitation) & its use in decision making
- We assumed, for the main, that the project plan itself was a static entity
  - Our calculations of uncertainty assumed that one activity flows into another etc.
- This is often not the case!
- Project plans can themselves be dynamic and an appropriate response to uncertainty may be an adjustment of the plan
  - Scheduling!

Scheduling & Resource Management

Scheduling – Past Encounters

- Scheduling and its related concepts should (hopefully) not be new to you
- You will have had several lectures on this in FEEG2006 covering:
  - Network analysis
  - Scheduling
  - Resource planning
  - Crashing etc.
  - Uncertainty
- Hopefully, you are using these approaches in your GDPs
- Don’t worry we will recap these concepts today and go a bit further

Precedence Tables

- A precedence table is a very simple tabular representation listing activities and their pre-requisite activities
  - This is the basic starting point to generate a network representation
  - In order to define the network, precedence must be established

Activity	Pre-requisite
A	-
B	A
C	B
D	B
E	C & D

Activity B depends on A

Activities C & D both depend on B

Activity E depends on C & D being completed

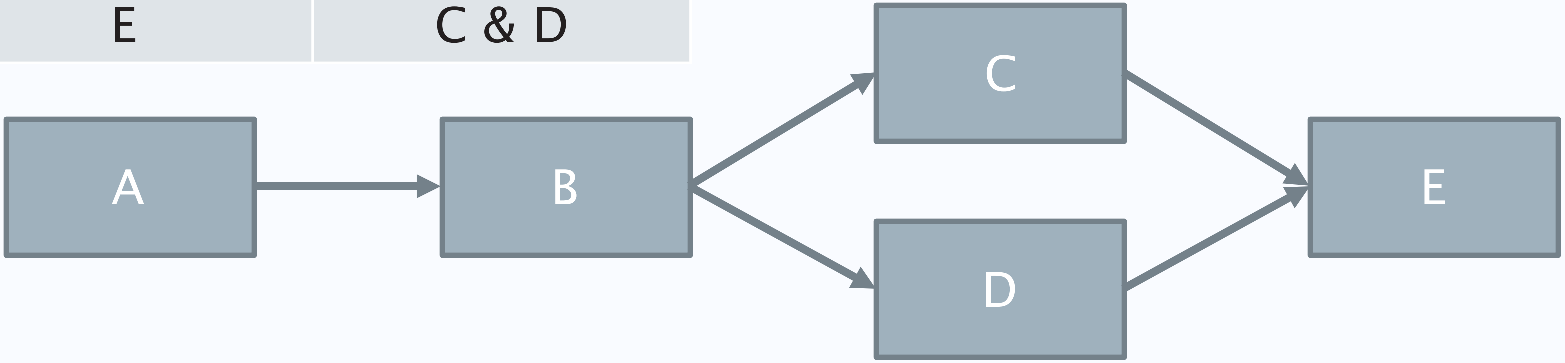
Activity Network Diagrams

- The activity network is an important project planning tool
- It clearly illustrates the interdependence of all tasks and work packages
  - The impact of issues downstream can be clearly seen
- It illustrates communication flows
- It indicates times associated with tasks and helps with overall planning
- It helps to identify critical activities – those that must be completed on time
  - Also identifies those with "wiggle" room
- It helps to determine overall completion times and activity start/end times

Activity-on-Node Network

- The activity-on-node network representation for our previous precedence table is therefore

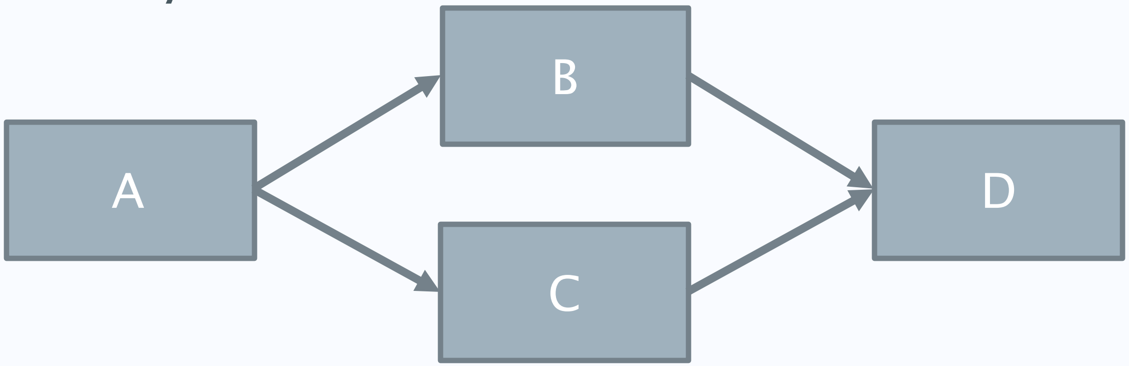
Activity	Pre-requisite
A	-
B	A
C	B
D	B
E	C & D



Network Terminology

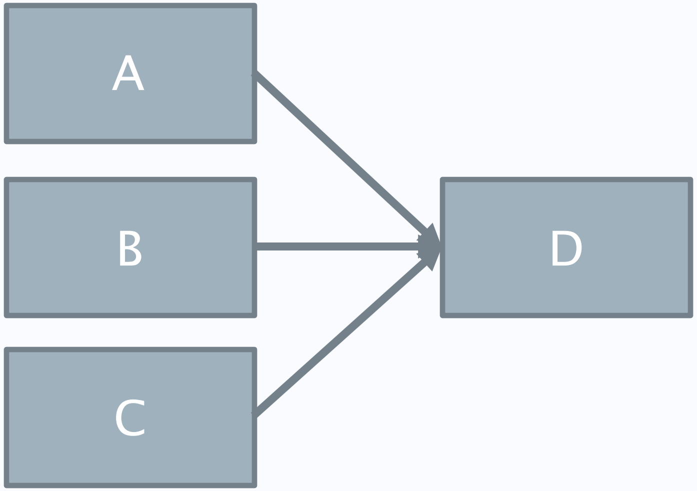
- Serial activities – one activity flows into the next

- Parallel/concurrent activities – activities occurring simultaneously

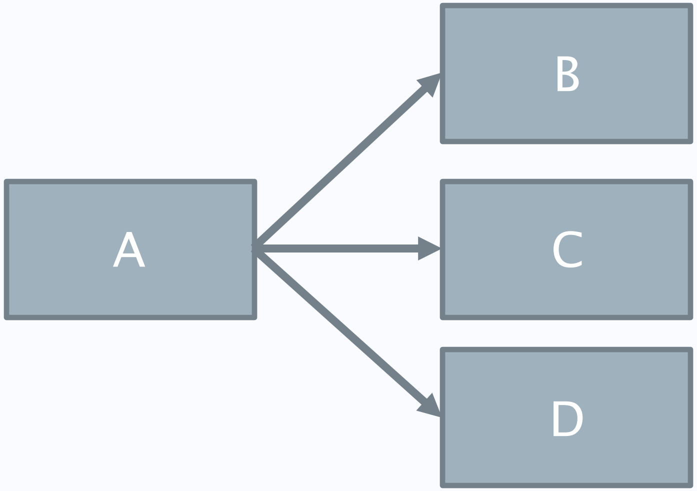


Network Terminology

- Merge activity – an activity with ≥2 predecessors
- Burst activity – an activity with ≥2 successors



Merge Activity “D”



Burst Activity “A”

Network Terminology

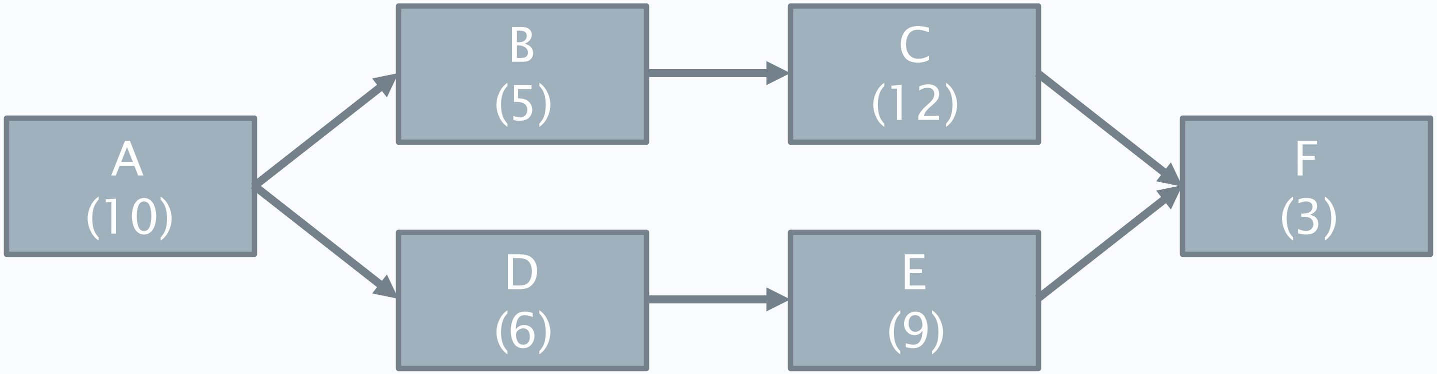
- There are other terms used in the definition of such networks including:
  - Laddering – overlapping sequential tasks
  - Hammock activities
  - Different forms of lag between activities
- These are summarised in the module textbook and in the FEEG2006 lectures for those who are interested
  - We don’t need to go beyond basic network definition here

Duration Estimation

- Deterministic
  - Each activity has a fixed duration
  - Total project duration is defined as the longest path from the start to the end
  - This is the critical path – associated activities are critical
  - Non-critical activities may be delayed to some extent without impacting the total duration
- Stochastic
  - Durations are now defined by a PDF – recall our PUMP processes
  - PDFs could be derived from data or elicitation of experts
  - Total project duration is now a PDF with an expected value etc.
  - The critical path may no longer be fixed in its definition
  - MC analysis starts to play a role

Duration Estimation – Deterministic Example

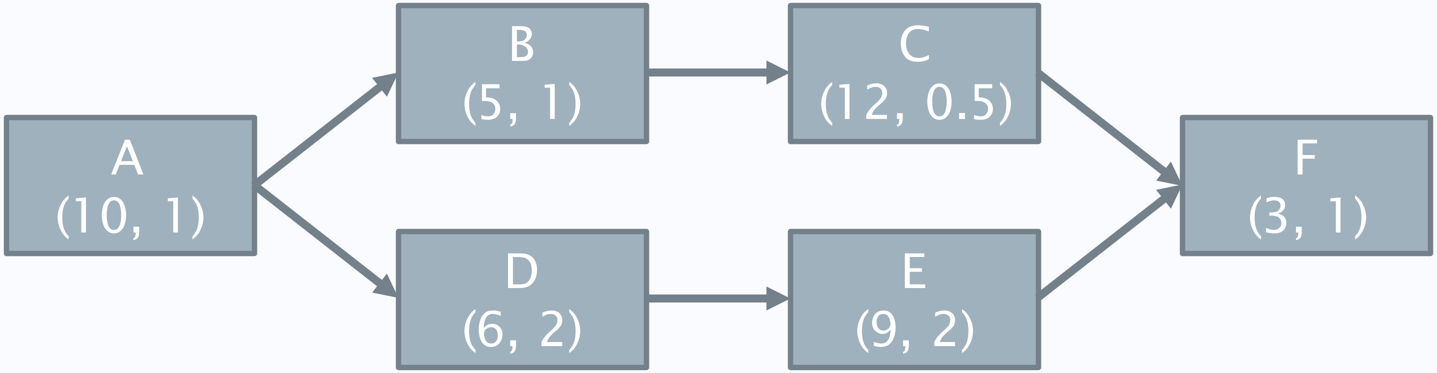
- Consider the following activity network with the given times...



- We have two paths – via activity B or D giving total durations of 30 or 28 respectively
  - The path "A" > "B" > "C" > "F" is, therefore, the critical path
  - "A", "B", "C" & "F" are the critical activities
  - The alternative path "A" > "D" > "E" > "F", offers 2 units of "wiggle" room

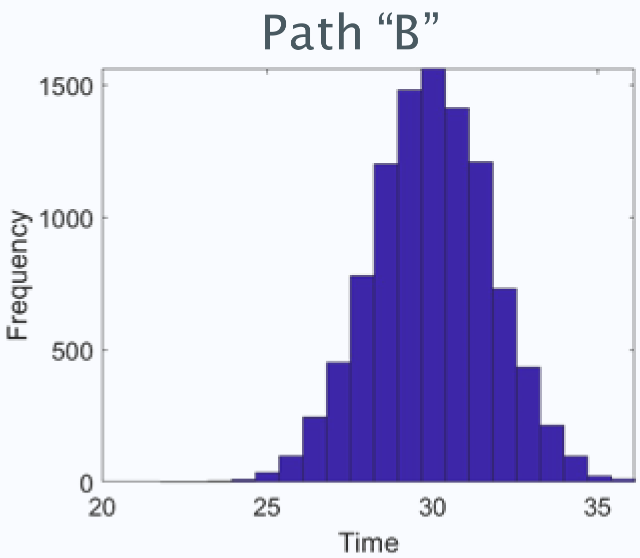
Duration Estimation – Stochastic Example

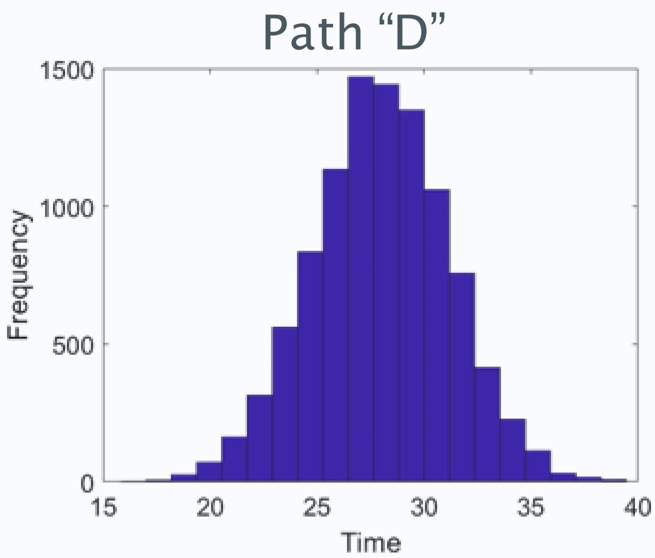
- Consider the same activity network but now with durations estimated via a normal distribution with given mean and standard deviation



- We can use Monte Carlo analysis to investigate the total time
  - Randomly define a duration for each activity based on their associated distribution
  - Determine the total project time for each random sample

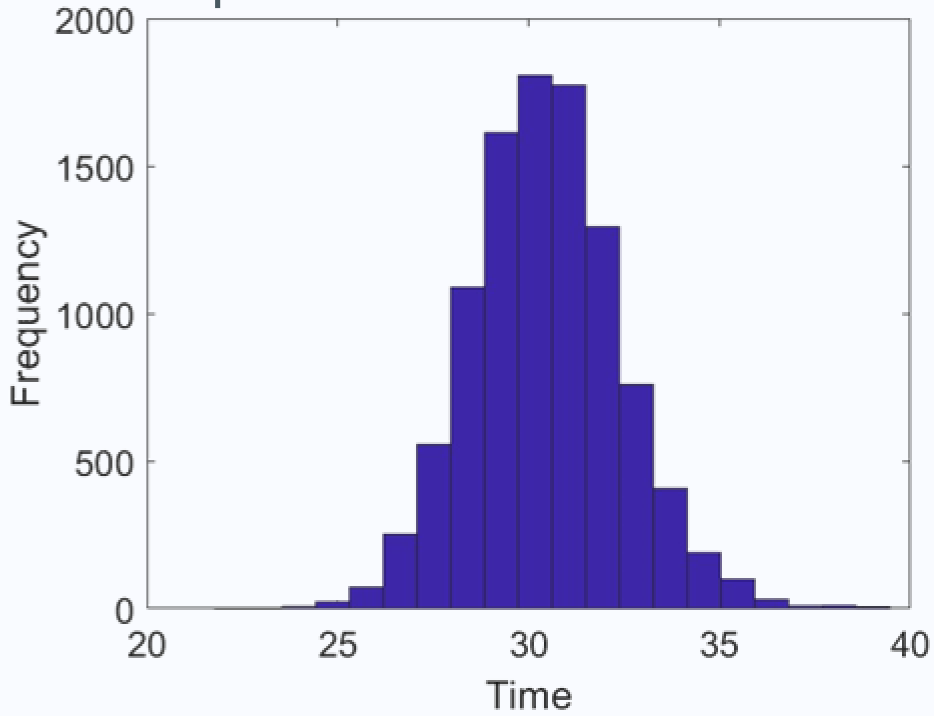
Duration Estimation – Stochastic Example





Duration Estimation – Stochastic Example

- The overall project duration is therefore the maximum of either path "B" or "D"



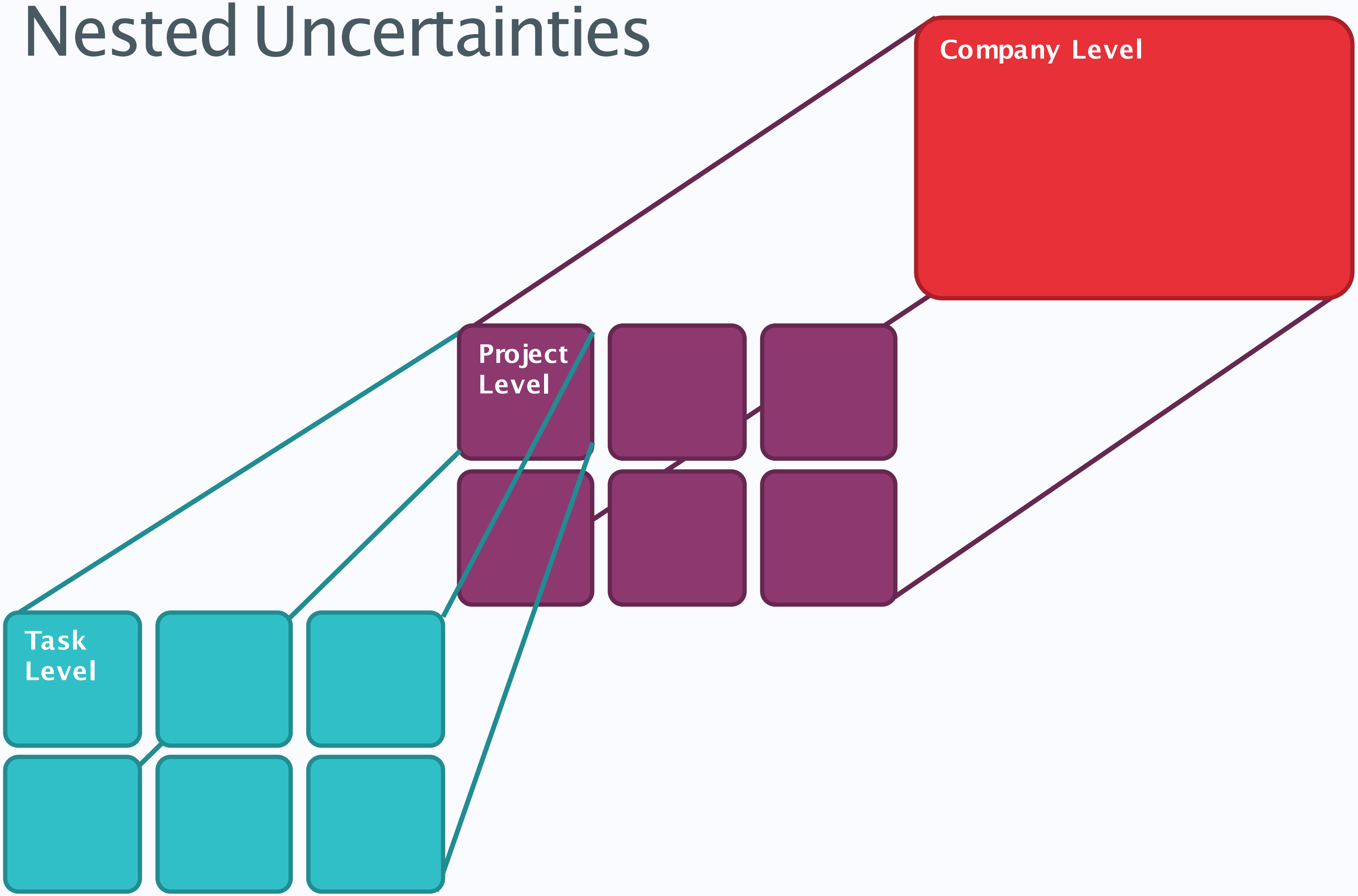
- Expected duration ≈ 30.46
- 5th percentile ≈ 27.41
- 95th percentile ≈ 33.76

- Path "B" is only the critical path 74.1% of the time
  - Modifying path "D" carries a risk that it impacts the total duration

Returning to Project Uncertainty

- Let's put this into the context of our previous two lectures
- Determining duration is perhaps a sub-step of quantifying uncertainty
  - Dependent on what the objective(s) of the PUMP are
  - The question we may wish to ask is "What is the probability of overrunning our target project completion time of 32 days?"
- In this case the MC again comes to our rescue
  - ≈19.9%
- From an uncertainty management point of view we can then decide if this is acceptable or not and make adjustments to minimize this uncertainty

Nested Uncertainties



Accelerating Projects

Reducing The Critical Path

- Depending on the discussions surrounding our previous estimate of the overrun probability it may be necessary to attempt to reduce the length of the critical path
- There are number of common approaches for doing this

1. Eliminate tasks on the critical path
   - Tasks can be eliminated if unnecessary or moved to noncritical paths with the slack to accommodate them
2. Re-plan serial paths to be in parallel
3. Overlap sequential tasks i.e. laddering
4. Shorten the duration of critical path tasks
   - Needs to be carefully considered – links to resourcing

Reducing The Critical Path

5. Shorten early tasks
   – There is less uncertainty with early (ongoing) tasks meaning they can be shortened with more confidence as to the impact
6. Shorten the longest tasks
   – Less likely shortening longer tasks leads to scheduling problems – cuts are more easily absorbed
7. Shorten the easiest tasks
   – Durations for easy tasks may be inflated
8. Shorten tasks that cost the least to speed up

- Whichever the method careful consideration to the impact of the change and related assumptions should be given

Crashing Projects

- The process of accelerating a project is referred to as crashing
- This directly relates to resource commitment
  - The more we can commit the faster the project can be pushed
- Potential reasons to crash include
  - An initially too aggressive schedule – crashing is inevitable
  - Demand for earlier completion due to changing market needs
  - The project has slipped behind schedule
  - Contractual situation provides an incentive not to slip delivery

Accelerating Projects

- There are a number of options which can be considered when attempting to accelerate a project
  - Resource constraints may naturally constrain things

1. Improve the productivity of existing project resources
   - Finding more efficient ways of working e.g. eliminating barriers to productivity (bureaucracy etc.)
   - Perhaps better done between projects rather than in the middle of one
2. Change the working method
   - Altering the technology and type of resources employed

Accelerating Projects

3. Compromise quality and/or reduce project scope
   - Sacrifice some of the original project specifications to speed up completion
   - Cheaper materials, fewer oversight/testing steps etc. – often not really an option e.g. construction
   - Removal of features – more manageable option
4. Fast-track the project
   - Parallelisation of critical path activities (see previous points)

Accelerating Projects

5. Use of overtime
   - Easy way of increasing productivity (in theory)
   - However, drawbacks include, cost (impacting overall project budget), if used continuously it can have a detrimental impact on productivity
6. Add resources to the project team
   - Including additional people in a team can reduce the total time a task takes
   - Improvements in communication/coordination can also help

- For all of these options its important to consider the trade-offs between cost and time

Brooks's Law

- Former IBM executive Fred Brooks
- Adding resources to ongoing activities only delays them further
- The additional time/training needed to bring someone new up to speed can negate any potential benefit
- Resources should instead be added to activities which are yet to start

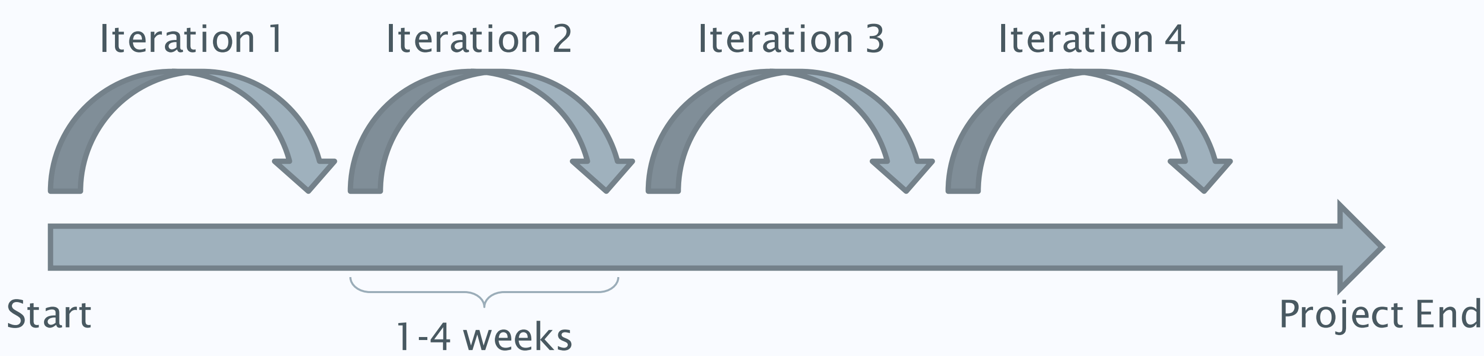
Agile Planning

Agile Project Management?

- A highly structured approach to planning may not be appropriate for all types of projects
- This is particularly true in IT-related projects
  - The end result of a project may be difficult to visualise due to changes and the evolution in customer demands
  - Following the original plan no longer makes sense – can lead to the customer crying “this is not what I meant” at the project’s conclusion
- An agile approach to project management helps organisations react quickly to opportunities
  - Recall the lecture on PUMP

Agile Project Management

- Agile PM approaches the project like a rolling wave
  - Continuous plan-execute-evaluate cycles across the project
  - Each wave creates "incremental value" by steadily developing sub-features or elements of the overall project
  - Deliberately short lengths e.g. 1-4 weeks – long enough to create value that a customer can evaluate but short enough to remain responsive
  - Following each "sprint" a review is held to evaluate and agree the next set of deliverables



Problems With Agile

- There are, however, potential issues with an agile approach
  - Collaboration through the scrum team can be time-consuming requiring a commitment from all involved
  - Evolving requirements can lead to scope creep – a never-ending series of requested changes
  - Difficult to predict what the product will look like at the end and therefore make an effective business case
  - Testing is performed throughout the project – this adds costs as in a non-agile approach these are only required at the end
  - Applying it to the wrong project i.e. one with a high level of predictability can lead to increased costs

Agile & You

- Consider your experiences, you will most certainly have worked in an agile manner and are most likely doing so now
- Individual project
  - Research-like activity
  - Perhaps unknown and evolving outcomes and requirements
  - Weekly meeting between you and your supervisor(s) to review progress and define goals for the coming “sprint”
- Group design project
  - Perhaps unknown and evolving outcomes and requirements
  - Weekly meeting between your groups and your supervisor(s) to review progress and define goals for the coming “sprint”

Resource Management

Resource Management

- We've looked at activity diagrams and how projects can be accelerated and made agile
- The reality is very different as the constraints or limitations that a project operates under get in the way
- Resource is the number one such constraint
  - Cash/budget, people, etc.
- Resource planning is critical to making those carefully laid plans actually work!

Resource Constraints

- The most common resource constraint is people
  - The simplest approach to shortening a project involves as much parallelisation as possible
  - But this assumes we have the people to do the work!
  - If we don't have the people we resort to asking them to multi-task which can have a detrimental effect on productivity
- Budgetary constraints – a hangover from the initial costing
- Physical constraints can be an issue
  - Environmental or contractual issues
  - Materials
  - Technical constraints e.g. access to specialised equipment or skills

Optimal Scheduling

- When including resource constraints determining an optimal project schedule can suddenly become very challenging
  - Shortest possible development time with as many tasks in parallel as possible
  - But we face an inevitable problem finding the resources for this be it people, money, materials etc.
- Of course, we can complicate this even further by introducing uncertainties into our project plan along with their implications
  - Uncertainty durations may result in penalties for overruns etc.
- We can even further complicate matters by attempting to define an optimal schedule across all projects within an organisation

Resource Loading Charts

- Introduced in FEEG2006 they can be used to visualise and reallocate resources to keep the chart as “flat” as possible
  - Being careful to observe precedences

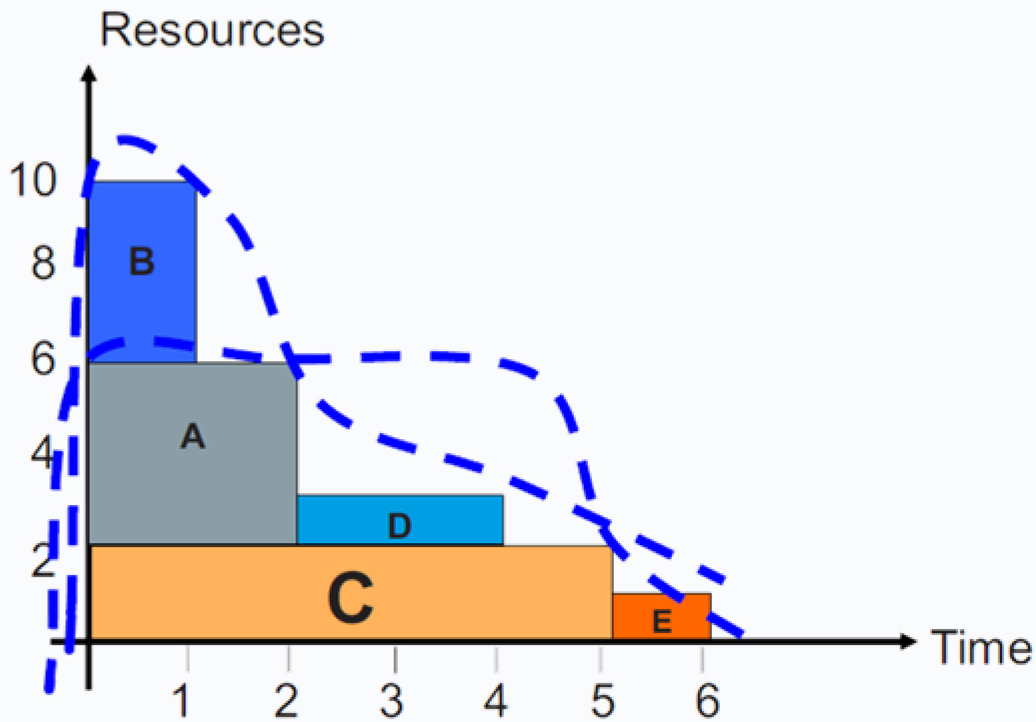


Image taken from FEEG2006 notes

Optimal Scheduling

- Optimal scheduling is effectively a combinatorial problem
  - Find the combinations of activities which e.g.
    - Minimise total project time
    - Minimise utilisation of a resource e.g. cost
    - Minimise slippage
  - Satisfying the desired precedences and other resource limitations
- Computers are very good at solving these types of problems
- Specialist software can deal with the above across multiple projects and in the presence of uncertainties
- Of course, the complexity of this increases by an order of magnitude when uncertainty is included!

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