ESD.36 System Project Management

Lecture 12

Strategic Project Management

Instructor(s)

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October 18, 2012
Today’s Agenda

• Strategic Project Management
  • Example 1: Project Preparation
  • Example 2: Project Planning
  • Example 3: Project Execution
Enterprise has chosen what product or system to develop

Doing the Right Job

Doing the Job Right

Next Project

Project Completion

Project Preparation

Project Planning

Project Monitoring

Project Adaptation

Project Learning

System Project Management
ESD.36 Framework
What is corporate strategy as it applies to projects and the project portfolio, versus “strategy” as it applies to an individual project?
Corporate Strategy for the Project

- Determining the fit of the project to business objectives (the “mission” – doing the right job)
  - features / scope of end product
  - schedule milestones (time to market)
  - delivered quality (defects)
  - resources & budget (development cost)

And the mix/timing of “projects” necessary to achieve corporate strategy

*Operationally, “projects” implement corporate strategy.*
Strategic *Project* Management

- Understanding how project “design” decisions affect project performance ...
  - Scope/schedule/ ... (i.e., mission feasibility)
  - Organization, process, ...
  - Buffers, phase overlap, ...
  - Staffing strategies, schedule slip, ...
  - ...
- ... and how they affect other current projects (portfolio issues), and future projects.
- Learning from past projects.

*Operationally, “day-to-day project decisions” implement project strategy.*
Example: Strategic/Tactical vs Operational Staffing Decisions

**Strategic/Tactical**
- Hire experienced staff rather than inexperienced
- Start with all of staff you need or gradually build
- How much training for inexperienced staff
- ....

**Operational**
- Who specifically and with what experience
- How many, and/or at what ramp up
- When, what programs, etc.
System Project Management
ESD.36 Framework

Doing the Right Job

Strategic Project Management

Enterprise has chosen what product or system to develop.

Project Preparation

Project Planning

Project Monitoring

Project Adaptation

Project Learning

Doing the Job Right

Corporate Strategy

Next Project

Project Completion
DISCUSSION?
What is SD useful for?

- Conceptualization of project dynamics and the issues/tradeoffs involved in strategic management of projects
- Quantification of above ...
  - Heuristics
  - Specific forecasts and decision guidance
- Project-to-project learning
1. A feasible plan is essential, including:

- Estimates of rework, undiscovered rework, and delays in discovering that rework
- Estimates of productivity loss dealing with rework
- Adequate buffers and reserves for rework
- [Rework increases with project uncertainty and complexity]
2. A feasible plan recognizes the “iron triangle”; there will be multiple “feasible” plans depending on priorities.

3. Tradeoffs in the plan can often be improved by changes in project structure and organization to reduce rework and delays in discovering rework.
4. Attempts to achieve an infeasible plan via project control actions lead to “vicious circle” side effects which increase project cost and duration.

- On complex projects, these costs usually exceed the “direct” costs of infeasibility.

5. Project “changes,” and risks which materialize, are fundamentally the same as an infeasible plan. (Lecture 13)
6. Project managers need buffers and/or flexibility (e.g., slip schedule, cut scope, ship with “bugs”) to respond to changes and uncertainties. These have costs that need to be evaluated; the importance of different tradeoffs differs by project. (Lecture 13)

7. The costs of project control can be minimized by understanding the sources of the vicious circles. The timing, magnitude, and duration of different controls affects performance.
SD Perspective: Typical project dynamics result in schedule &/or budget overrun ...

What can we do to avoid/minimize the *dynamics* ...

... in project preparation and planning?

... in project execution and adaptation?
How Does It Get Started?

Other Risks

Uncertainty & Complexity

Productivity

Effort
Applied

Fraction Correct and Complete

Scope Growth

Infeasible Plan

Changes

These are characteristics of "complex" (vs. "simple") projects
Example Project

- **Scope** = 1000 Tasks
- **Scheduled Completion Date** = 30 (Month)
- **Staff** = 40 (Implied budget of 1200 person-months, including **200 tasks estimated rework**)
- **Normal Quality** = 0.85
- **Productivity** = 1 task/month/person

**Note:** Infeasible Plan
Project Behavior

Cost = 1570 person-months, Finish 39.25

Total Tasks = 1570

How do we change & manage the project to improve its performance?
Today’s Agenda

• Strategic Project Management

• Example 1: Project Preparation
  Developing a Consistent Plan

• Example 2: Project Planning

• Example 3: Project Execution
A Consistent (Feasible) Project Avoids the Dynamics

“SD Class 3” Model With:

- Scope = 1000 (tasks)
- Scheduled Completion Date = 35 (month) [versus 30 in Class 3 model]
- Delivered Quality > 99%
- Normal Fraction Correct = 0.85
- Staff = 50 (people) [Versus 40 staff; Implying a budget of 1750 person-months, versus 1200 person-months]
- Estimated Rework = 750 tasks [versus 200]
A Consistent Project Avoids the Dynamics

Plan fully accounts for **rework tasks**, Schedule and staffing plan reflect **rework cycle**
Normal design evolution accounted for in plan

Effect of Experience

Productivity

Fraction Correct and Complete

Effect of Undiscovered Rework
Infeasible projects initiate the dynamics when management responds …

Trying to achieve inconsistent objectives can lead to disaster …
What do we expect?

**Other Risks**

- Productivity
- Effort Applied
- Fraction Correct and Complete

**Uncertainty & Complexity**

- Scope Growth
- Time Expectation: Feasible Plan
- Infeasible plan

Scope Work to Do

Rework to Do

Original Work to Do

Rework Generation

Project Staffing

Expectation:
But when management reacts...
Trying to achieve infeasible plan ...

Effect of Experience on Fraction Correct

0 6 12 18 24 30 36 42 48 54 60

Time (Month)

Effect of Experience on Fraction Correct : SD4 Infeasible Plan Control
Effect of Experience on Fraction Correct : SD4 Infeasible Plan No Control
Effect of Experience on Fraction Correct : SD4 Feasible Plan1
Which snowballs via “errors on errors” feedback ...

Effect of Undiscovered Rework on Fraction Correct

Effect of Undiscovered Rework on Fraction Correct: SD4 Infeasible Plan Control
Effect of Undiscovered Rework on Fraction Correct: SD4 Infeasible Plan No Control
Effect of Undiscovered Rework on Fraction Correct: SD4 Feasible Plan 1

Effect of “Errors on Errors”
With end result worse (schedule/cost) than if project budgeted higher at start!

<table>
<thead>
<tr>
<th>Test</th>
<th>Finish</th>
<th>Cost(person-mos)</th>
</tr>
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<tbody>
<tr>
<td>Infeasible Plan Targets</td>
<td>30</td>
<td>1200</td>
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<tr>
<td>Infeasible, No Control</td>
<td>39.25</td>
<td>1570</td>
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<td>Infeasible, with control</td>
<td>36.25</td>
<td>2148</td>
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<td>Feasible Plan 1</td>
<td>33.75</td>
<td>1615</td>
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<tr>
<td>Feasible Plan 2</td>
<td>30.125</td>
<td>1650</td>
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</table>

Best choice depends on corporate strategy.

Note: Feasible Plan 1 (Initial Staff 50, Schedule 35, Budget 1750); Feasible Plan 2 (Initial Staff 60, Schedule 30, Budget 1800)
There are alternative feasible plans that reflect project priorities.
Survey Question 1

Does your organization plan for rework in establishing project budgets and baselines?

1. Yes, we explicitly try to estimate the expected amount of rework
2. Yes, but only by adding a “management reserve”
3. No
Survey Question

Do you feel that on the typical project in your organization, budget and schedule are ...

1. More than is needed __________

2. Tight, but manageable __________

3. Insufficient enough that the vicious circles are significant __________
Why Won’t We Develop a Realistic Plan?

Then why add resources when situation realized?
Getting a Feasible Plan

- Use a model
- Use data from prior projects (learning!), and calibration, to estimate:
  - Normal Productivity
  - Normal Fraction Correct and Complete
  - Time to Discover Rework
  - Total rework and undiscovered rework profile
  - Strength of effects ...

- Include buffers and have a sound project control plan (see example 3)
1. A feasible plan is essential, including:
   - Estimates of rework, undiscovered rework, and delays in discovering that rework
   - Estimates of productivity loss dealing with rework
   - Adequate buffers and reserves for rework
   - [Rework increases with project uncertainty and complexity]

2. A feasible plan recognizes the “iron triangle”; there will be multiple “feasible” plans depending on priorities.

4. Attempts to achieve an infeasible plan via project control actions lead to “vicious circle” side effects which increase project cost and duration.
2. A feasible plan recognizes the “iron triangle”; there will be multiple “feasible” plans depending on priorities.

3. Tradeoffs in the plan can often be improved by changes in project structure and organization to reduce rework and delays in discovering rework.
Today’s Agenda

• Strategic Project Management
• Example 1: Project Preparation

Deciding on the Process Model

• Example 2: Project Planning
• Example 3: Project Execution
What Increases Cost & Schedule?

Uncertainty that reduces fraction complete and correct.

- Technical complexity
- Uncertainty about customer requirements
Strategic Project Planning

What changes in process, organization, etc. might help deal with technical or customer uncertainties?

- Increase planned design iterations?
- Autonomous (dedicated) integrated product team vs. functional?
- Waterfall vs. d/b/t iterative vs. spiral vs. ...?
- More phase overlap and concurrency?

*How do we assess what process model is right for our project?*
How do we assess what process model is right for our project?

Determining Impact on Dynamics:
1. Model project with current processes, policies, ...
2. Specify **direct** impacts of alternatives on --
   - Scope (added tasks)
   - Productivity
   - Fraction correct and complete
   - Rework discovery
   - Strength of productivity and FCC effects
   - ...

[Secondary impacts assessed via simulation]
3. Simulate and compare performance
4. Test sensitivity to uncertain assumptions
### Requirements

- **Scope**: 100 Tasks
- **Staff**: 6
- **Productivity**: 2 tasks/month/person
- **Duration**: 8.33 months (no rework)
- **NFCC**: 0.75

### Design

- **Scope**: 1000 tasks
- **Staff**: 25
- **Productivity**: 4 tasks/month/person
- **Duration**: 10 months (no rework)
- **NFCC**: 0.7

### Build/Test

- **Scope**: 1000 tasks
- **Staff**: 40
- **Productivity**: 1 tasks/month/person
- **Duration**: 25 months (no rework)
- **NFCC**: 0.95

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**Assumptions:**

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Design</th>
<th>Build/Test</th>
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<tbody>
<tr>
<td>Scope = 100 Tasks</td>
<td>Scope = 1000 tasks</td>
<td>Scope = 1000 tasks</td>
</tr>
<tr>
<td>Staff = 6</td>
<td>Staff = 25</td>
<td>Staff = 40</td>
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<tr>
<td>Productivity = 2 tasks/month/person</td>
<td>Productivity = 4 tasks/month/person</td>
<td>Productivity = 1 tasks/month/person</td>
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<tr>
<td>Duration = 8.33 months (no rework)</td>
<td>Duration = 10 months (no rework)</td>
<td>Duration = 25 months (no rework)</td>
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<tr>
<td>NFCC = 0.75</td>
<td>NFCC = 0.7</td>
<td>NFCC = 0.95</td>
</tr>
</tbody>
</table>
Rework Discovery Assumptions (similar to CityCar HW#3)

- 60% of rework discoverable in design
- One design planned iteration & limited design review
- Fraction of Rework Discovered in First Iteration = 30%
- Fraction of Rework Discovered in Later Design Iterations = 70% two iterations, 95% three iterations (note: derivable via DSM and signal flow graph simulation?)
- Tasks repeated per iteration = 25%
- Build starts when design is 70% reported complete
Simulation results for current processes...

**No rework finish**

**Design**

**Build/Test**

**Requirements**

**Work Done**

**Project Staff**

**Total**

**Build/Test**

**Design**

**Requirements**

**Design “done”**
Can we improve performance by shifting more rework discovery to design?

**Design "done"**

**Design Original Work to Do**
- Design Undiscovered Rework
- Design Rework to Do
- Design Work Done

**Fraction Design Rework Discovered**
- 1
- 0.75
- 0.5
- 0.25
- 0

**Discovery by design**

**Discovery by build**
1. Classical “Quality” or design misexecution from people or technical coupling. Discoverable by further design work such as iteration, review.


3. Knock-on Rework Work done “correctly” but ultimately needing rework. Discoverable by both.
Example: Planned Design Iterations

1. Add iteration tasks

2. Which discover more rework in design

Rework discovered in Design

Rework discovered in Build/Test
Increasing design iterations ... 

... increases design original work, but reduces downstream rework.
... pushes more rework discovery into design

Fraction of Design Rework Discovered Over Time

Fraction Design Rework Discovered : Three P Four S V5 BNFCC 0pt95 Sens 0pt75 Middle One Three New5
Fraction Design Rework Discovered : Three P Four S V5 BNFCC 0pt95 Sens 0pt75 Middle One Two New5
Fraction Design Rework Discovered : Three P Four S V5 BNFCC 0pt95 Sens 0pt75 Middle One Iter New5
Three iterations discovers all the “discoverable” rework

Derivable via DSM and signal flow graph simulation?
Increasing rework discovered in design reduces rework left for build ...
Improving build “quality” and reducing build rework

Build/Test Fraction Correct and Complete

Cumulative Build Rework

-13.1%

-26.6%
With the “Base Case” Assumptions …

<table>
<thead>
<tr>
<th>&quot;Middle&quot; Project</th>
<th>&quot;New5 Results&quot;</th>
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<tr>
<td></td>
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<td>Design</td>
<td>Build</td>
<td>Total</td>
<td>Finish</td>
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<tr>
<td>Test</td>
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<td>Effort</td>
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<td>-13.1%</td>
<td>444.45</td>
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<td>1887</td>
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<tr>
<td>Three Iterations, Start 70%</td>
<td>311.86</td>
<td>-26.6%</td>
<td>516</td>
<td>1321</td>
<td>1904</td>
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</table>

While build effort is reduced with more design iterations …

... the increasing design cost indicates two iterations are “optimal”.

What assumptions impact this tradeoff?
Assumptions

- Fraction of design tasks that need to be repeated per iteration
- Relative cost of build/test versus design
- When build starts (overlap with design)
The benefits of design iteration increase the higher build cost

Cumulative Effort (Person-Months)

<table>
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<th>Build Cost Multiplier</th>
<th>0.5</th>
<th>1</th>
<th>1.25</th>
<th>1.5</th>
<th>1.75</th>
<th>2</th>
<th>3</th>
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<tr>
<td>One Iteration</td>
<td>1187</td>
<td>1903</td>
<td>2261</td>
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<td>2234</td>
<td>2565</td>
<td>2895</td>
<td>3225</td>
<td>4546</td>
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Increasing Build Cost
Build is starting before design rework is fully discovered.

**One Iteration**

*Effect of Design Undiscovered Rework on Fraction Correct*

- Delaying build with one iteration will have less benefit because build needed to discover rework.

**Three Iterations**

*Effect of Design Undiscovered Rework on Fraction Correct*

- Iterations 2 & 3 occurring months 18-24
## Benefits of delaying build start

<table>
<thead>
<tr>
<th>&quot;Middle&quot; Project</th>
<th>&quot;New5 Results&quot;</th>
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<tbody>
<tr>
<td></td>
<td>Cum</td>
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<tr>
<td>Test</td>
<td>Build Rework</td>
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<td>425.16</td>
</tr>
<tr>
<td>Two Iterations</td>
<td>369.38</td>
</tr>
<tr>
<td>Three Iterations, Start 70%</td>
<td>311.86</td>
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<tr>
<td>Three Iterations, Start 60%</td>
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<td>Three Iterations, Start 80%</td>
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<td>Three Iterations, Start 90%</td>
<td>271.99</td>
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<tr>
<td>Two Iteration, Start 60%</td>
<td>386.26</td>
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<tr>
<td>Two Iteration, Start 70%</td>
<td>369.4</td>
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<tr>
<td>Two Iteration, Start 80%</td>
<td>359</td>
</tr>
<tr>
<td>Two Iteration, Start 90%</td>
<td>348.72</td>
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</table>

*Three iterations, start at 90% "optimal" cost, but finish is later.*
Other Factors Affection Desirability of More Planned Iterations

- Normal amount of rework
- Amount of rework discoverable in design (vs in build/test)
- Additional rework discovered per iteration
- ...

...
## Developing Heuristics by Project Type

<table>
<thead>
<tr>
<th>Parameter</th>
<th>“Novel”</th>
<th>“Repeat”</th>
<th>“Mature”</th>
</tr>
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<tbody>
<tr>
<td>Normal FCC</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
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<td>Frac Discoverable in Design</td>
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<td># Iterations</td>
<td>1</td>
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<td>2</td>
</tr>
<tr>
<td>Build Start</td>
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</table>

*Use simulation to develop heuristics by project type.*
Summary

1. Under almost all situations, two design iterations are most cost effective. The benefits of multiple iterations increases the more design rework that can be discovered by design. Hence, multiple iterations makes more sense for “Repeat” and “Middle” projects than for “Novel” projects.

2. The start of build should be delayed until the design effort has executed all of the planned iterations.

3. The benefits of additional design iteration increases the higher build/test costs are relative to design costs.
Revised Network/Gantt showing planned design iterations

Added design iteration tasks ... ... to reduce unplanned iterations
3. Tradeoffs in the plan can often be improved by changes in project structure and organization to reduce rework and delays in discovering rework.

- See textbook Chapter SD4 for other examples.
Today’s Agenda

• Strategic Project Management
• Example 1: Project Preparation
• Example 2: Project Planning
• Example 3: Project Execution

Deciding on Project Controls
6. Project managers need buffers and/or flexibility (e.g., slip schedule, cut scope, ship with “bugs”) to respond to changes and uncertainties. These have costs that need to be evaluated; the importance of different tradeoffs differs by project. (Lecture 13)

7. The costs of project control can be minimized by understanding the sources of the vicious circles. The timing, magnitude, and duration of different controls affects performance.
Strategic Control Issues

- Incorporating rework estimates in planning and progress monitoring (see Chapter SD4.4).
- How much to rely on “work intensity” vs. overtime vs. adding staff?
- Should you slip the schedule? Early or late?
- Should you pay extra for experience when adding staff?
- How much training (delay in adding staff, but higher productivity and quality)?

A Strategic View – Deciding in advance the best way to handle problems if they arise
Project Resource Control

- You’ve misplanned, either because you don’t include rework estimates or because this particular project has unusually high levels ....

- Or
  - Scope growth occurred on the project
  - Other risks/problems materialized

*What do you do?*

*(note – these are “permanent” impacts, not temporary delays on isolated parts)*
“So the best thing to do is to do nothing, right?”

No – the costs of project control can be minimized by understanding the sources of the vicious circles. The timing, magnitude, and duration of different controls affects performance.
## What do you do? 2012

### What You Do at 30%

<table>
<thead>
<tr>
<th></th>
<th>First</th>
<th>Second</th>
<th>Third</th>
<th>Fourth</th>
<th>Fifth</th>
<th>Sixth</th>
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<tbody>
<tr>
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<td>17.1%</td>
<td>11.6%</td>
<td>14.3%</td>
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<tr>
<td>Longer Hours</td>
<td>31.9%</td>
<td>23.9%</td>
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<td>16.3%</td>
<td>7.1%</td>
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<tr>
<td>Intensity</td>
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<td>19.5%</td>
<td>23.3%</td>
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<td>Slip</td>
<td>17.0%</td>
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<td>19.5%</td>
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### What You Do at 65%

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<tr>
<td>Add People</td>
<td>16.7%</td>
<td>50.0%</td>
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<td>9.5%</td>
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<td>9.5%</td>
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<td>0.0%</td>
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<tr>
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<td>8.3%</td>
<td>26.7%</td>
<td>21.4%</td>
<td>22.2%</td>
<td>0.0%</td>
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<tr>
<td>Slip</td>
<td>8.3%</td>
<td>10.4%</td>
<td>15.6%</td>
<td>38.1%</td>
<td>24.4%</td>
<td>50.0%</td>
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<tr>
<td>Cut Scope</td>
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<td>2.1%</td>
<td>8.9%</td>
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<td>Other</td>
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<td>0.0%</td>
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<td>Total</td>
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</tbody>
</table>
% Specifying 1\textsuperscript{st} or 2\textsuperscript{nd} Choice

2011

<table>
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<tr>
<th>What You Do?</th>
<th>At 30%</th>
<th>At 65%</th>
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<tr>
<td>Add People</td>
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<tr>
<td>Intensity</td>
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<td>19.4%</td>
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<tr>
<td>Slip</td>
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<tr>
<td>Cut Scope</td>
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<tr>
<td>Other</td>
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2012

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<th>What You Do?</th>
<th>At 30%</th>
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<tbody>
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<td>31.2%</td>
<td>33.3%</td>
</tr>
<tr>
<td>Longer Hours</td>
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<td>32.3%</td>
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<tr>
<td>Intensity</td>
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<tr>
<td>Slip</td>
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<tr>
<td>Cut Scope</td>
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<td>Other</td>
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</tr>
<tr>
<td>Total</td>
<td>100.0%</td>
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</tbody>
</table>
Brooks’ Law


Homework 5 Analysis: Under what conditions is this true.
Qualitative model representation

[Diagram with labeled nodes and arrows indicating relationships such as Original Work to Do, Original Rework to Do, and Work Done, with additional nodes for undesired states like Undiscovered Rework, Infeasible Plan, and Scope Growth. Arrows and labels indicate directions and effects such as Effort Applied, Fraction Correct and Complete, Productivity, and Effort Needed.]
1. Project control is driven by estimates of how much effort is left ...

2. Estimates are based on work to do and productivity ( undiscovered rework?)
How many people do I need to get the job done on time?

Staff Required = \( \frac{\text{Estimated Effort Remaining (Person-Months)}}{\text{Time Remaining}} \) [People]
How many people do I need to get the job done on time?

When Can I finish with the current staff?

Indicated Completion Date = Time + \((\text{Estimated Effort Remaining}/\text{Staff})\) [Month]
Project Control

Based on Staff Required and Indicated Completion Date, three options:

1. Add Staff
2. Explicitly Slip Schedule
3. Exert “Schedule Pressure” (Work Intensity and Extra Hours)
Actions Determined By ...

"Willingness to Use Intensity & Extra Hours (0-1)"

"Willingness to Slip (0-1)"

"Willingness to Hire (0-1)"
Testing Brook’s Law?

\[ \text{Effect} = \frac{(\text{New Staff} \times \text{Relative Experience} + \text{Experienced Staff})}{\text{Staff Level}} \]

What uncertainties would you test sensitivity to?
Options

- Add Staff
- Work OT
- Increase “intensity”
- Slip Schedule
- Some Combination
Discussion – Resource Controls

- Relative impact on fraction correct (and productivity)
- Relative delays
- Can work intensity be sustained?
- Limits – greater for OT than WI?
Step Change in Overtime – Impact on ...
Step Change in Staff—Impact on ...

Equivalent Staff

FCC/PDY

Net Output
Change in Work Intensity – Impact on...

Equivalent Staff

FCC/PDY

Net Output
What should you do when a project gets behind schedule?

- When in the project should you use overtime (and/or for how long)?
- When do you?
- When in the project should you hire?
- When do you?
- Does it ever pay to work more “intensely” (cut corners, etc.)?
- Do you?
- When should you use buffers & slack? Slip Schedule? (as soon as recognized, or try to make up schedule?)
7. The costs of project control can be minimized by understanding the sources of the vicious circles. The timing, magnitude, and duration of different controls affects performance.

- Lowest direct cost strategy – slip schedule
- If need to meet schedule, lowest cost strategy depends on ...
  - When during project problem recognized
  - Limits of different resources
  - Size and timing of secondary impacts of control
- May not always be able to achieve the schedule by adding more resources, but it will always cost you more.
Next SD Class:

Case Examples of ...

- Change management & disputes
- Risk management
- Project-to-Project Learning

Multi-project dynamics
Resources Needed
Step Change in Overtime – Impact on...

Equivalent Staff

FCC/PDY

Net Output
Step Change in Staff—Impact on ...

Equivalent Staff

FCC/PDY

Net Output
Change in Work Intensity – Impact on...

Equivalent Staff

FCC/PDY

Net Output