Dynamics of Project Performance

System Dynamics and Project Management

Lecture #19, SD Class 7 & 8? (11/6/00)
Typical project dynamics ...

... Result in schedule &/or budget overrun
What can we do to avoid/minimize in …

- … project preparation (design) √
- … project planning √ – except overlap/concurrency
- … risk management
- … change management
- … execution and adaptation
Strategic Process & Organization Issues

- Waterfall vs. spiral vs. adaptive vs. …?
- Autonomous (dedicated) integrated product team vs. functional?
- System vs. modules?
- How much phase overlap and concurrency?
- How much to subcontract, make vs. buy?

*How do we assess what is right for our project?*
What are the pros and cons of above alternatives *in the context of the model framework*?

- Direct impacts of alternatives (one-off vs. dynamic) --
  - Scope
  - productivity
  - quality
  - rework discovery
  - strength of productivity and quality effects
  - ...

- Secondary impacts (assessed via simulation)
How do we know these values?

- First time, you don’t ==> make educated guesses. Remember --
  - Better than mental models alone
  - Can do sensitivities – e.g., how bad would the scope increase have to be before Spiral was not helpful for this type of project
- Once project finishes, can get a good estimate of the impact for use in future planning
General Conclusions re. Process and Teaming

- An iterative development process and/or integrated product team can improve performance if project conditions would otherwise cause significant undiscovered rework.
- The benefits of these approaches increase with the uncertainty (risk) in the development, i.e., the amount of potential rework.
- Cautions -- alternatives may …
  - … not help for truly “exogenous” changes
  - … involve additional scope, or
  - … involve short-term implementation costs (for new processes/tools/structures) which may negate the benefits of the alternatives.
Topics

- Planning – A look at issues in overlap and concurrency
- A System Dynamics View of Risk Management
- A Systems Dynamics View of Change Management and Dispute Resolution
- A System Dynamics View of Execution and Adaptation
Strategic Process & Organization Issues

- Waterfall vs. spiral vs. adaptive vs. …?
- Autonomous (dedicated) integrated product team vs. functional?
- System vs. modules?
- How much phase overlap and concurrency?
- How much to subcontract, make vs. buy?

How do we assess what is right for our project?
Reducing Project Duration, *The Plan* ...

Traditional project

Overlap phases

Compress each phase

- ESD.36J SPM

Massachusetts Institute of Technology

Copyright © 2003
James M. Lyneis
## Phase Overlap & Concurrency: More Overlap ...

<table>
<thead>
<tr>
<th><strong>Pros</strong></th>
<th><strong>Cons</strong></th>
</tr>
</thead>
</table>

Phase Overlap & Concurrency: More Overlap ...

Pros
- Speed development by starting downstream phases before upstream finished
- ...

Cons
- Requires more resources at peak overlap
- Executing downstream work before upstream is ready reduces productivity
- Executing downstream work with partial or incorrect information creates potential quality problems
- ....
Reducing Project Duration, *The Pitfalls* ...

**Traditional Projects Rarely Meet Plan Because of Rework**

<table>
<thead>
<tr>
<th>Traditional project</th>
<th>Planned Duration</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>Rework</td>
<td>Phase 2</td>
</tr>
<tr>
<td></td>
<td>Rework</td>
<td></td>
</tr>
</tbody>
</table>

- Overlap phases
  - Phase 1
  - Phase 2

- Compress each phase
  - Phase 1
  - Phase 2
And simply overlapping phases often creates more rework because incompleteness and undiscovered errors in upstream work cause errors in downstream work.

Traditional project

Overlap phases

Compress each phase

Planned Duration

Phase 1

Phase 2

Rework

More Rework?
Reducing Project Duration, The Pitfalls …

Traditional project:
- Phase 1
- Rework
- Phase 2
- Rework

Overlap phases:
- Phase
- Rework
- Phase

Compress each phase:
- Phase 1
- Max Rework
- Phase 2
- Max Rework

And we all know what dynamics simply reducing schedules can create!
Alternatively -- Reduce Unplanned Rework!

Traditional project

Overlap phases

Compress each phase

Reduce Rework

Phase 1

Rework

Phase 2

More Rework?

Phase 1

More Rework?

Phase 2

More Rework?

Phase 1

Rework

Phase 2

Rework

Copyright © 2003

Massachusetts Institute of Technology

James M. Lyneis
This is not to say that overlap or compression, if carefully planned, cannot be done …

- DSM, ICE approaches as methods for effectively planning concurrency/overlap?
- Critical chain approaches to remove padding?
- … other thoughts?
Note that staffing strategies, concurrency, and process (iteration) models are interrelated ...

Conventional staffing practices force development efforts into phases that become dominated by specific functions.

… as iteration, teaming, and/or concurrency require a more level staffing

Dedicated staffing forces overlapping and cross-functional interaction.

Conclusions re. Phase Overlap

- Quality as well as “availability” is critical in determining the readiness of starting downstream work phases.
- In many cases, it may be better to devote staff to finding and fixing errors than starting downstream phases.
- If downstream progress is necessary to discovery upstream rework, careful planning and monitoring are needed to minimize the adverse consequences of progressing downstream with low quality upstream information.

continued ...
Conclusions re. Phase Overlap (cont.)

- Increased phase overlap requires greater upstream and downstream communication to facilitate starting downstream work with partial information, and avoiding/finding upstream rework ==> teams that may lower productivity, but increase quality and reduce rework discovery time

- ...

- ...
Topics

- Planning – A look at issues in overlap and concurrency
- A System Dynamics View of Risk Management
- A Systems Dynamics View of Change Management and Dispute Resolution
- A System Dynamics View of Execution and Adaptation
Decomposition of Risk Management
(from Professor Warmkessel)

Risk Management

- Risk Identification
- Risk Assessment
- Risk Mitigation
- Risk Tracking & Handling
For Certain Risks, SD Can Help …

Risk Management

- Risk Identification
  Identify Risks & Quantify Range of Direct Impacts
- Risk Assessment
- Risk Mitigation
- Risk Tracking & Handling
For Certain Risks, SD Can Help …

Risk Identification
- Identify Risks & Quantify Range of Direct Impacts

Risk Assessment
- Assess Total Impact of Risks Alone & In Combination

Risk Mitigation

Risk Tracking & Handling

Risk Management
For Certain Risks, SD Can Help …

Risk Management

- Risk Identification: Identify Risks & Quantify Range of Direct Impacts
- Risk Assessment: Assess Total Impact of Risks Alone & In Combination
- Risk Mitigation: Design Effective Mitigation, Including What To Monitor
- Risk Tracking & Handling
Examples of Risks

- Technology – E.g., uncertain technology, technology leap
- Functionality – E.g., uncertain customer requirements
- Programmatic --
  - Availability and quality of information from others (suppliers, other projects, platforms)
  - Availability of staff or other resources
For Certain Risks, SD Can Help …

Risk Management

- Risk Identification
  - Identify Risks & Quantify Range of Direct Impacts

- Risk Assessment
  - Assess Total Impact of Risks Alone & In Combination

- Risk Mitigation
  - Design Effective Mitigation, Including What To Monitor

- Risk Tracking & Handling
Risk Identification and Quantification -- Learning from Prior Projects

- Model prior project(s)
- Quantify all deviations to project vis a vis original plan and input as time series or parametric changes
  - Estimate *direct* impacts
  - Fine tune quantification via calibration to actual data
- Add to “data base” of sources and magnitude of changes to original plans
Specify “Direct Impacts” In Terms Of ...

- Changes in scope
- Changes in quality
- Effects on productivity and quality
- Effects on staffing

... via changes to normal parameters or via time series inputs

Indirect and total impacts are determined by the model
Example – Automotive Development

Based on a simulation model, major sources of risk ranked in terms of impact on schedule and delivered quality (Analysis of 11 projects):

1. Late information and/or changes
2. Resource availability
   - Slow ramp up, lower peak, forced ramp down to meet budget
   - Inadequate skills mix
3. New processes, missing enablers, or new materials
4. Organization &/or geographic changes
5. Aggressive program assumptions
   - Compressed timing, inadequate budget, lean allowance for prototypes
For Certain Risks, SD Can Help …

Risk Management

- Risk Identification
  - Identify Risks & Quantify Range of Direct Impacts

- Risk Assessment
  - Assess Total Impact of Risks Alone & In Combination

- Risk Mitigation
  - Design Effective Mitigation, Including What To Monitor

- Risk Tracking & Handling
Risk Assessment

- Set up model to represent plan (if possible)
- Using prior project data base, determine possible risks and range of impact
- Test individually and in combination

The numbers may not be accurate, but the thought process coupled with sensitivity analysis improves risk management.
For Example: The “Class6” Base Case

Experience on prior projects indicates significant risk of late rework with the clarification of customer needs:

- Uncertain customer requirements cause quality problems early in the project
  - normal quality = .95
  - all other parameters as in Homework1 Model
- Assume waterfall model with functional organization structure
The Base Case Overruns ...

Graph for Staff Level

Completion: Month 38.875 (30 planned)
Cost: 263 Person-months (115 plan)

Time (Month)

Staff Level : Class6 Waterfall
Staff Level : Class6 Plan

People

People
For Certain Risks, SD Can Help …

Risk Management

Risk Identification
- Identify Risks & Quantify Range of Direct Impacts

Risk Assessment
- Assess Total Impact of Risks Alone & In Combination

Risk Mitigation
- Design Effective Mitigation, Including What To Monitor

Risk Tracking & Handling
Risk Mitigation

- Determine possible methods of mitigation for risks likely to impact this project
- Assess cost-benefit, *including indirect impacts via reduced productivity and increased rework*
- Implement up front, or monitor and implement pre-defined action plan
For Example, Mitigating Risk From Uncertain Customer Requirements: Strategic Process & Organization Issues

- Waterfall vs. spiral vs. adaptive vs. …?
- Autonomous (dedicated) integrated product team vs. functional?
- System vs. modules?
- How much phase overlap and concurrency?
- [How much to subcontract, make vs. buy?]
Automotive Development: Risk Mitigation Actions

- “Disciplined” Product Development:
  - Contain workscope by maximizing reuse
  - Focus on quality rather than early milestones
  - Minimize late changes
  - Accelerate rework discovery

- Staffing:
  - Get planned resources on time (“fight”, external, …)
  - Minimize sustained overtime
  - Additional and accelerated training
  - Colocation
ESD.36J  System & Project Management

A Case Example: The Peace Shield Air Defense System

Copyright © 2003
James M. Lyneis
The Peace Shield Program

- **Hughes (now part of Raytheon):** A major US aerospace company that regularly develops large-scale air defense systems

- **The problem:** Frequent budget overruns resulted in lengthy claim disputes between Hughes and their customers; this contract was won competitively after being taken from another contractor in trouble

- **System dynamics model was used for:**
  - Bid support and risk assessment;
  - On-going project management
  - Post-project benchmarking and policy assessment
Bid Support and Risk Assessment

- Adapted model of prior CCS development
- Assessed risks associated with critical assumptions
  - amount of code from prior project that does not require change and could be used as is ("liftability")
  - availability of experienced staff
  - vendor delays
  - ...
- Estimated likely competitor bid
“Liftability” – How much “work really done” and how much “undiscovered rework” in the “lifted” code?

“Base Case”:

- Work To Be Done: 80%
- Work Really Done: 20%
- Known Rework
- Undiscovered Rework
- Rework Discovery
- Progress
Liftability Most Critical and Uncertain...

Man-Months

Total Development Man-Months

Total Development Man-Months

- Peace Shield Base
- 100% of lift usable as is
- 60% of lift usable as is
- 40% of lift usable as is
- 20% of lift usable as is
- 0% of lift usable as is

- Software
- System Engineering
- Test
- PMO

9/23/03 - ESD.36J SPM

Massachusetts Institute of Technology

Copyright © 2003

James M. Lyneis
Competitor inexperience in this type of project likely to result in unrealistically low bid

- Submit a low bid, but still profitable if managed aggressively
- Carefully define work scope assumptions
- Aggressively manage program to control costs, including early emphasis on rework discovery, use of experienced staff, and management of customer expectations
… concentrate early program efforts on flushing out as-yet- undiscovered rework in the lifted work, rather than steeply ramping up staff to accomplish new work
Project Planning: Based on Model Analyses, Adopt New Process and Organization …

- Implementation of a “teaming” structure and other improved processes (*including worse before better impacts*)
  - Upstream and downstream staff involved in design and review for all phases
  - Customer participation in design reviews
- Implementation of a new staffing strategy for software engineering and coding
  - Delay start of downstream phase
  - Delay roll-off of staff from phase and assign to rework discovery
“In my 26 years in acquisition, this [Peace Shield Weapon System] is the most successful program I’ve ever been involved with, and the leadership of the U.S. Air Force agrees.”

Darleen Druyun

Program Manager

March-April 1996
Post-project benchmarking ...

Staff Levels

Cumulative Effort

Past Program

Peace Shield

Copyright © 2003
James M. Lyneis
What caused the differences between Peace Shield and Past Program?

- Differences in work scope?
- External Conditions?
- Management policies and processes?

And how can a company learn from these differences, and therefore

- Bid better?
- Plan better?
- Manage better?
The same model accurately replicated Peace Shield ...

Data and Plans in mid-1993

Simulated
... and the Past Program with management policy & risk (external) changes only
Programs overlayed highlight difference …
Major external differences

Peace Shield --

- Lower scope and fewer changes
- Fewer vendor delays & hardware problems
- Better hiring conditions (less delay)

(Some of these are sources of risk)
Removing external sources of difference from the past program ...
Removing external sources of difference from the past program...
Management differences

Peace Shield --

- Adopted teaming structure including customer involvement in design reviews
- Different staffing strategy by phase of work
Delayed Roll-off of Staff and Later Start of Downstream Phases on Peace Shield

Start of S/W Coding

Past C&C Shield
Peace Shield

S/W Design Complete
Peace Shield: Reduce Overlap and Unplanned Rework!

Past Project: Overlap phases

Peace Shield: Reduce duration by reducing rework in upstream phases

Copyright © 2003 James M. Lyneis
Teaming, Delayed Roll-off of Staff, and Customer involvement in Design Reviews Contributed to Shorter Rework Discovery Times on Peace Shield

Rework Discovery Delay (Months)

<table>
<thead>
<tr>
<th>Program Year</th>
<th>Past Program</th>
<th>Peace Shield</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>18</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>14</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>10</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>11</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>13</td>
<td>0</td>
<td>20</td>
</tr>
</tbody>
</table>

Copyright © 2003
James M. Lyneis
Removing management differences ...

Cumulative Effort


0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800

Past Program

Past Program

Peace Shield

Peace Shield

External Differences Removed

Copyright © 2003
James M. Lyneis
Where Did The Cost Improvement Come From?

- **Policies & Processes 56%**
  - Teaming & Other Improvements: 13%
  - More Experienced People: 24%
  - Different Staffing Policies: 19%

- **External Conditions 44%**
  - Scope Differences & Fewer Customer Changes: 22%
  - Fewer Vendor & Hardware Problems: 19%
  - Better Hiring Conditions: 3%
Topics

• Planning – A look at issues in overlap and concurrency
• A System Dynamics View of Risk Management
• A Systems Dynamics View of Change Management and Dispute Resolution
• A System Dynamics View of Execution and Adaptation
What are differences between “changes” and “quality” problems?

- Changes represent truly unknowable, uncontrollable, exogenous impacts (often can be compensated for)
  - competitor introduces a new feature
  - ...

- “Quality” problems can be anticipated and dealt with in the design and management of the project
  - buffers, prototypes, process, ...
Changes can impact a project in a number of *direct* ways:

- Added work scope
- Added hours, without changes in “scope”
- Work obsoleted
- Work made uncertain because of possible changes
- Late/deficient information or equipment
- Diversion of management time

*How much, when, how long*
Mid-Project Changes Are Costly -- Many Projects Experience Delay and Disruption Ratios of 3-5

Source: Pugh-Roberts Associates
Estimating Impact & Mitigation

- What is the total cost and schedule impact of the change, if mitigating actions are not taken?
- What actions will reduce the extent of the disruption --
  - Schedule relief? Slipping interim milestones?
  - Additional budget?
  - Management actions (overtime, hiring, ...)?
- Should the change be made, and how should we be compensated (if possible)?
Impact Increases the Later the Change ...

<table>
<thead>
<tr>
<th>Test</th>
<th>Finish</th>
<th>Cost(person-mos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan</td>
<td>30.5</td>
<td>119.33</td>
</tr>
<tr>
<td>Changes, 20% @ Month 5</td>
<td>31.625</td>
<td>143.25 (+20%)</td>
</tr>
<tr>
<td>Changes, 20% @ Month 10</td>
<td>32.2</td>
<td>152.35 (+28%)</td>
</tr>
<tr>
<td>Changes, 20% @ Month 15</td>
<td>32.875</td>
<td>161.73 (+36%)</td>
</tr>
</tbody>
</table>
... and the Larger the Change

<table>
<thead>
<tr>
<th>Test</th>
<th>Finish</th>
<th>Cost (person-mos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan</td>
<td>30.5</td>
<td>119.33</td>
</tr>
<tr>
<td>Changes, 10% @ Month 15</td>
<td>31.69</td>
<td>138.35 (+16%, 1.6X)</td>
</tr>
<tr>
<td>Changes, 20% @ Month 15</td>
<td>32.875</td>
<td>161.73 (+36%, 1.8X)</td>
</tr>
<tr>
<td>Changes, 30% @ Month 15</td>
<td>34.1</td>
<td>186.6 (+56%, 1.9X)</td>
</tr>
</tbody>
</table>
Cost impact can be mitigated ...

Graph for Staff Level

- Changes
- Changes, Slip Schedule
- Plan

Time (Month)
<table>
<thead>
<tr>
<th>Test</th>
<th>Finish</th>
<th>Cost(person-mos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan</td>
<td>30.5</td>
<td>119.33</td>
</tr>
<tr>
<td>Changes</td>
<td>32.875</td>
<td>161.73 (+36%)</td>
</tr>
<tr>
<td>Changes, Slip Schedule</td>
<td>34.2</td>
<td>139.78 (+17%)</td>
</tr>
</tbody>
</table>
ESD.36J  System & Project Management

Delay and Disruption Disputes
Delay and disruption

Schedule and cost growth resulting from the effects of unplanned changes or unanticipated problems.
How SD in Project Management got started: Ingalls Shipbuilding vs. US Navy

- Firm fixed price contract structure
- $500 million cost overrun on the programs (Ingalls and Navy agreed on $150 direct cost – the rest?)
  - Navy – bad management
  - Ingalls – D&D
- Ingalls sues Navy claiming design changes caused delay and disruption

The big question: ‘How would the program have performed absent customer-responsible events & conditions?’
One simple, extreme solution

The first thing we do, 
let’s kill all the lawyers …

William Shakespeare
Henry VI, Part 2, IV. ii.
All changes from plan (both customer and company) are specified in terms of their *direct* impacts on the project:

- Added work scope
- Added hours, without changes in “scope”
- Work obsoleted
- Work made uncertain because of possible changes
- Late/deficient information or equipment
- Diversion of management time

*How much, when, how long*
Answering the big question is a three-step process

- **Step 1:** Use the program simulation model to re-create history with the customer-responsible events & conditions included.

- **Step 2:** Remove the customer-responsible events & conditions and re-simulate the program.

- **Step 3:** Analyze the differences between the two program simulations – they comprise and explain the total customer-responsible cost & schedule growth.
Step 1: Re-creating program history (including customer claim items)

Program Labor

- Total
- Design
- Fab, Assy, Inst'n
- Flight Test
- Mgmt. & Support

Dashed lines are Aircraft Program data

Equivalent People (hundreds)

TIME

9/23/03 - ESD.36J SPM

Copyright © 2003
James M. Lyneis
Step 2: Remove customer claim items and resimulate

Customer-Responsible Events & Conditions

Simulation Model

Total Program Labor (Equiv. People)
- As-Built
- Data
- Absent Customer Items

Company Actions
Step 3: The claim is the difference between the simulations...

![Graph showing program cumulative labor hours with As Built, Data, and Absent Customer Items lines.]

**Program Cumulative Labor Hours**

- **As Built**
- **Data**
- **Absent Customer Items**

Labour Hours (millions)

Budget hours

Actual

Cust.-driven labor growth

It would have needed...
Actual vs. Would-Have for Ingalls

Annual Staffing (Person Years)


LHA Program Staffing

Actual History
Would-Have Been
...which includes the added delay and disruption costs stemming from customer changes.

US Navy initially acknowledged only the direct costs their changes caused – a small portion of the total $500M budget overrun.

Original Budget
- Cost of Unanticipated Delay & Disruption from Customer Changes: $300M
- Direct Cost of Customer Changes: $147M
- Overruns caused by Ingalls: $53M

Full Impact of Unplanned Events & Conditions: $447M
Ingalls was even able to quantify specific sources of cost growth.

% Impact on Cost Growth for the LHA Program

- Reduced Drawing Quality: 6%
- Inadequate Skill Level: 3%
- Loss of Learning: 3%
- Out-of-Sequence Work: 29%
- Delayed/Reduced Quality of Prior Construction: 14%
- Other Labor Impacts: 22%
- Excessive Schedule Pressure: 23%

Source: Analysis of Delay and Disruption in the LHA and DD Programs, June 1978, table 5.5 (after p134).
The Navy’s starting position

“If you think you’re going to get 10 cents from us with this black box hocus-pocus simulation model, you’re nuts.”

But after a review by MIT System Dynamics Professors …
Case settled out of court for $447 million

Model-generated analysis was the basis for $200-300 million of the claim.

Since the beginning ...

- More than 30 contract disputes
  - In excess of $4 billion in dispute, with average recovery of 75% vs. 40% with traditional methods
  - All disputes have settled out of court, avoiding lengthy litigation
- More than 75 proactive applications
  - In excess of $25 million in consulting fees
  - Conservatively saved clients $5 billion on cost and schedule performance
Why has system dynamics been so successful?

- Transparent and logical cause-effect structure
  - Facilitates discussion with adversaries
  - Focuses discussion on assumptions, rather than outcomes

- Highly validated model --
  - Accurate re-creation of project history (essential for allocating costs to causes)
  - Concurrence of project managers that structure and behavior are right
  - Use of models for managing other projects
  - Reasonableness of behavior under a wide range of conditions
Why has system dynamics been so successful? (cont.)

“What-if …” capability --
- What “would-have” happened
- Project future consequences
- Demonstrate management reasonableness and impact mitigation
Topics

• Planning – A look at issues in overlap and concurrency

• A System Dynamics View of Risk Management

• A Systems Dynamics View of Change Management and Dispute Resolution

• A System Dynamics View of Execution and Adaptation
Selected Issues in Execution & Adaptation

- Managing Risks and Changes:
- Schedule adjustments
- Staffing strategies

A Strategic View – Deciding in advance the best way to handle problems if they arise
In the face of a projected schedule overrun, is it better to slip as soon as you know it or wait and see if corrective actions will help?
Graph for Staff Level

Staff Level: Class 7x Base
Staff Level: Class 7x Slip Late
Staff Level: Class 7x Slip Early

No Slip
Slip Late
Slip Early (and all along)
Graph for Cumulative Effort Expended

Cumulative Effort Expended : Class7x Base
Cumulative Effort Expended : Class7x Slip Late
Cumulative Effort Expended : Class7x Slip Early
Conclusions

- If project priorities favor cost over schedule, it’s better to slip the schedule early rather than wait until the damage is done. [Note: if rework creation is high enough, not slipping early can make the project finish later!]
- Use buffers early.
ESD.36J  System & Project Management

Staffing Strategies
Selected Staffing Issues

- Should staff be added to a late project (Homework 4 question)?
  - Unless new staff are 100% productive from day 1, adding staff increases cost;
  - And, can make project later if the quality hit is large enough
- Should you start with the expected full team, or staff up gradually?