ESD.36 System Project Management

Lecture 12

Strategic Project Management

Instructor(s)

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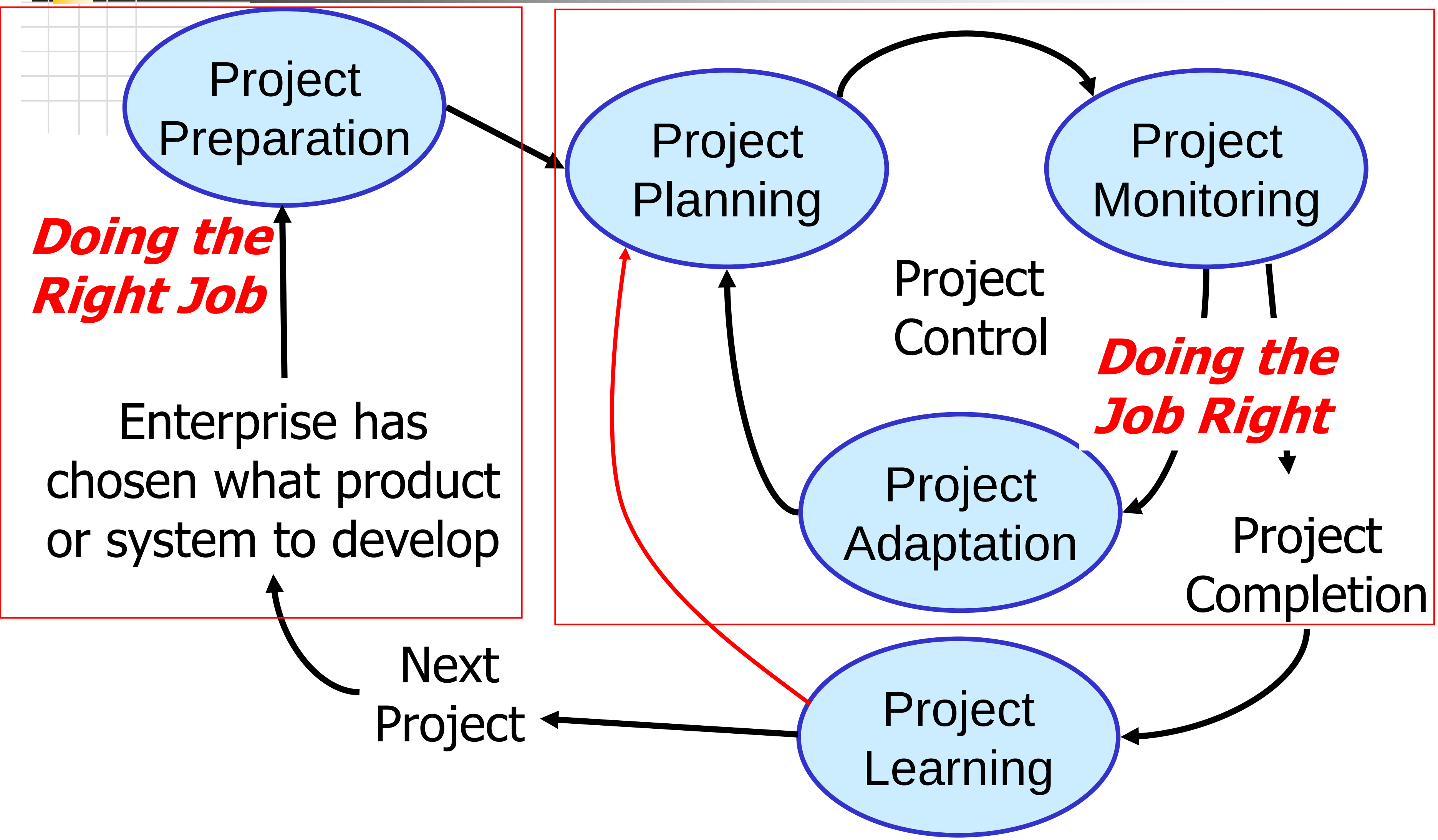
October 18, 2012

Today's Agenda

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

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

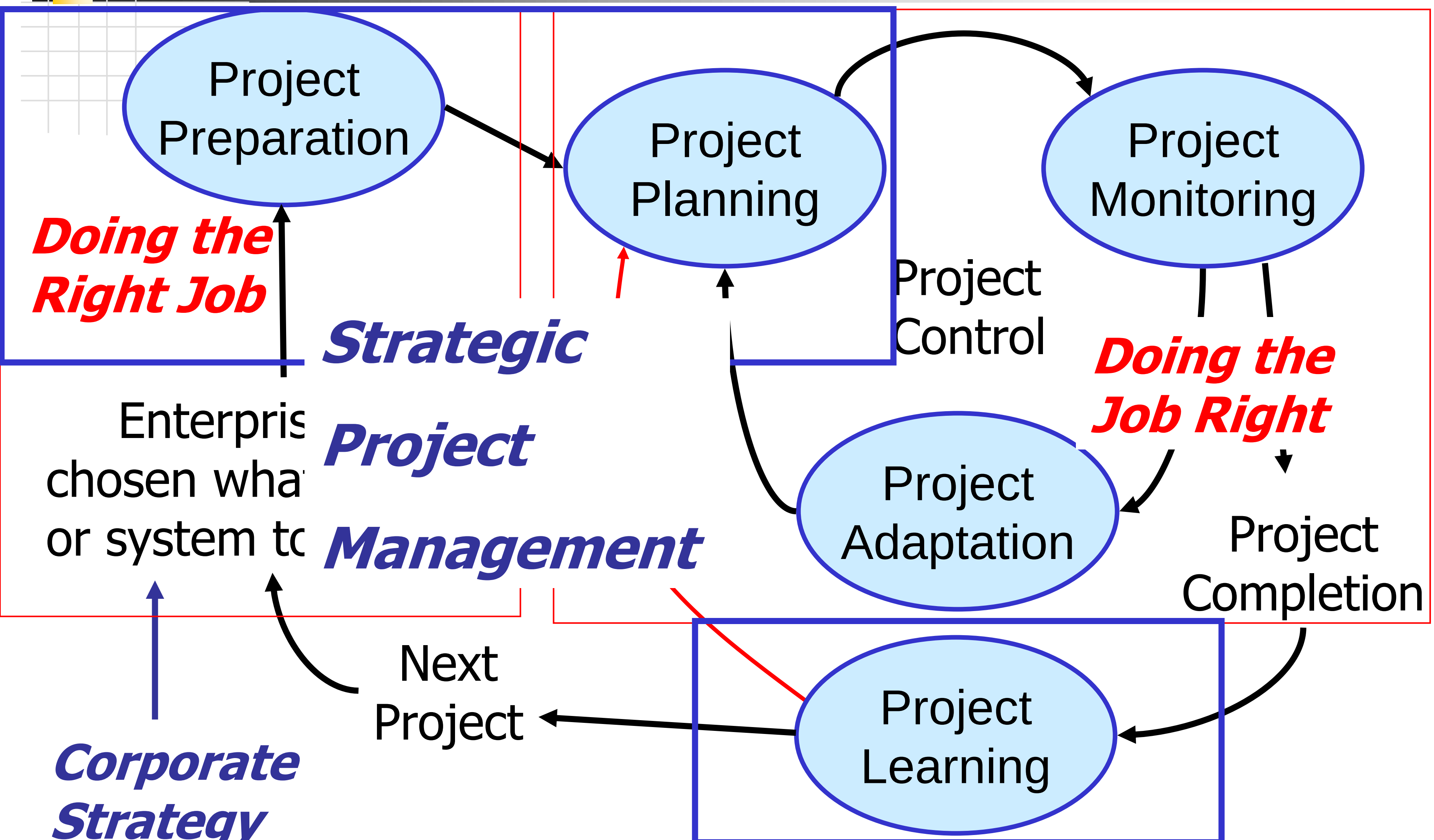
Strategic/Tactical

- 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



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

SD Qualitative Insights -1

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]

SD Qualitative Insights – 2

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.

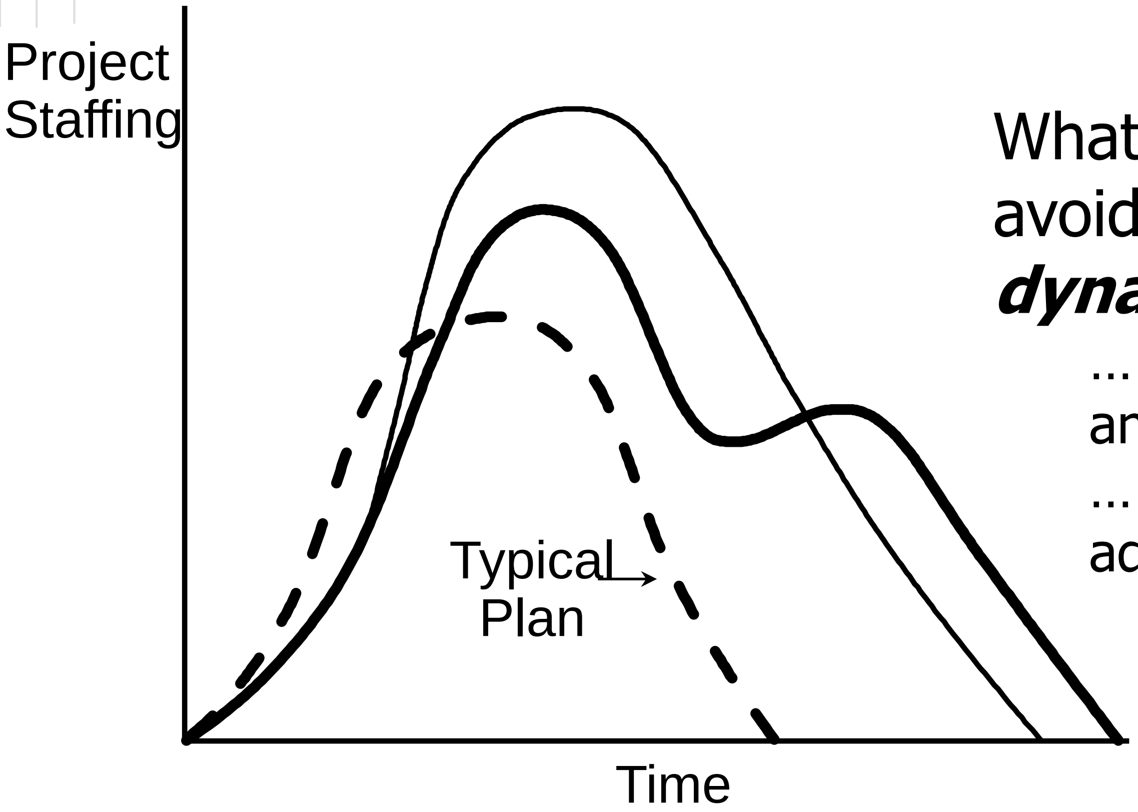
SD Qualitative Insights – 3

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)*

SD Qualitative Insights – 4

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 ...

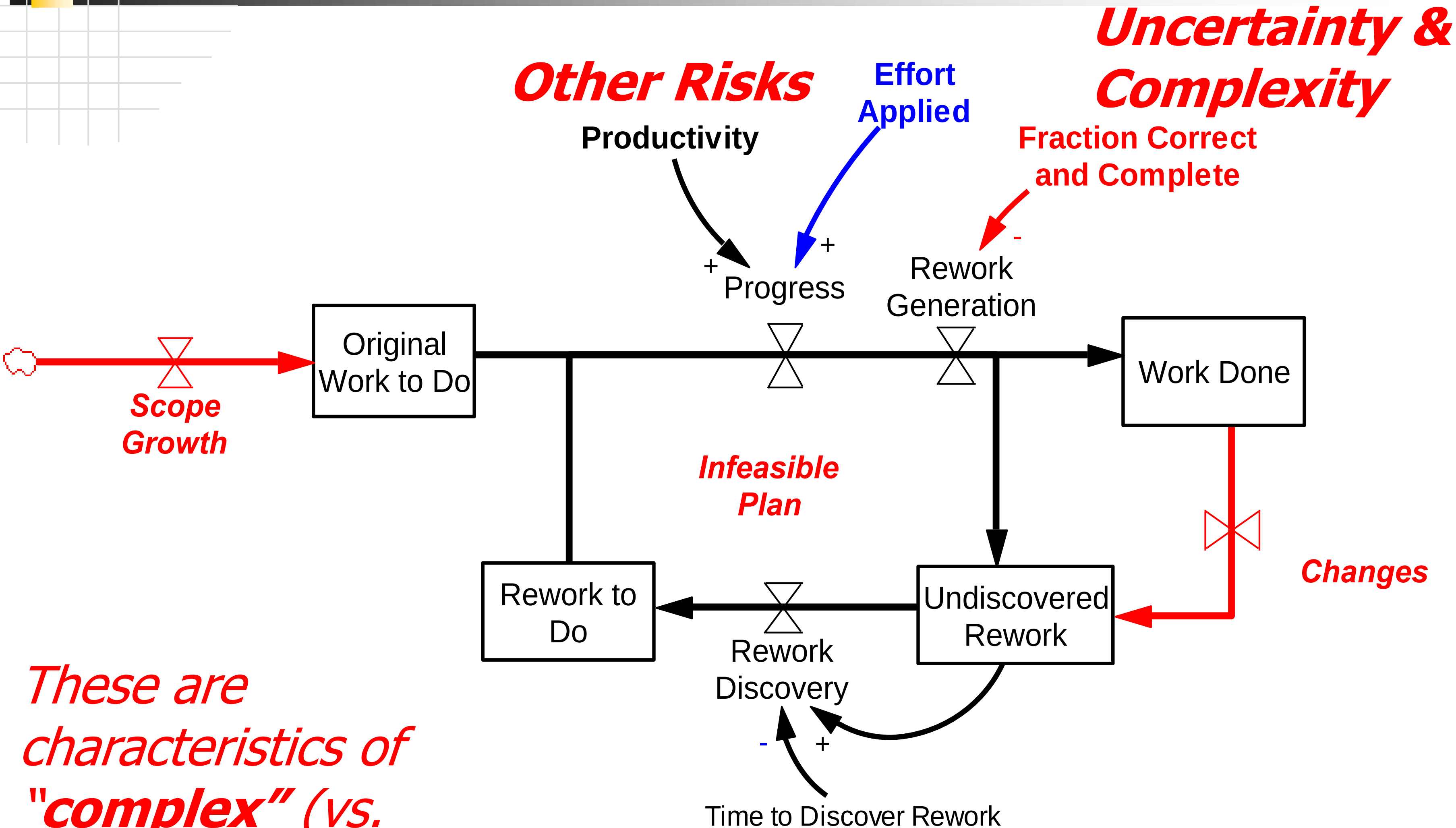


What can we do to avoid/minimize the ***dynamics*** ...

... in project preparation and planning?

... in project execution and adaptation?

How Does It Get Started?



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

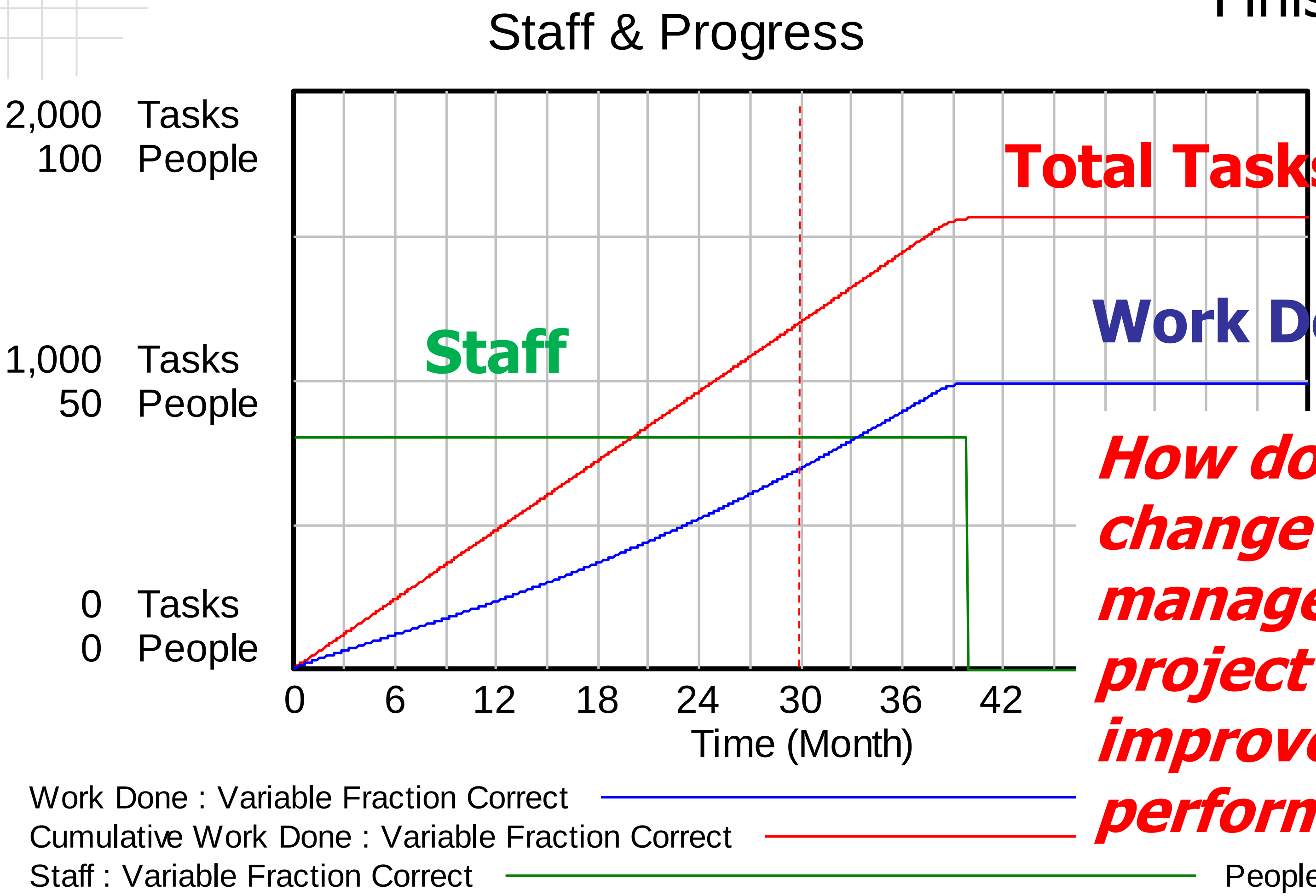
Example Project

- 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



How do we change & manage the project to improve its performance?

Today's Agenda

- Strategic Project Management
- Example 1: Project Preparation

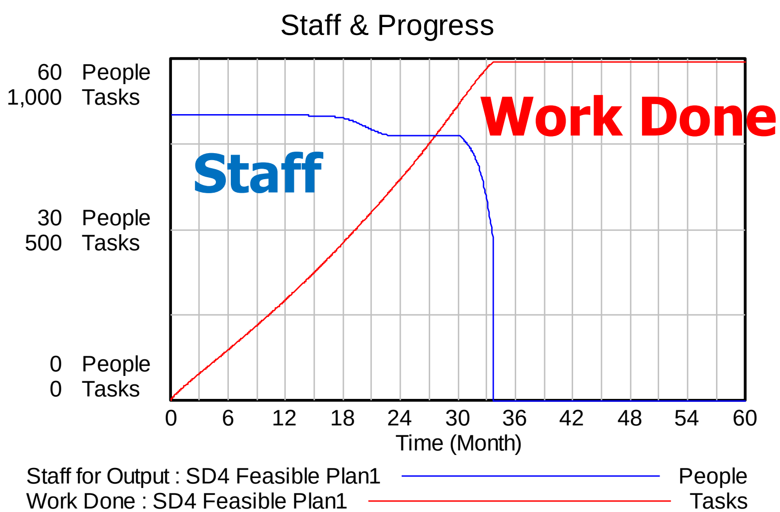
  Developing a Consistent Plan
- Example 2: Project Planning
- Example 3: Project Execution

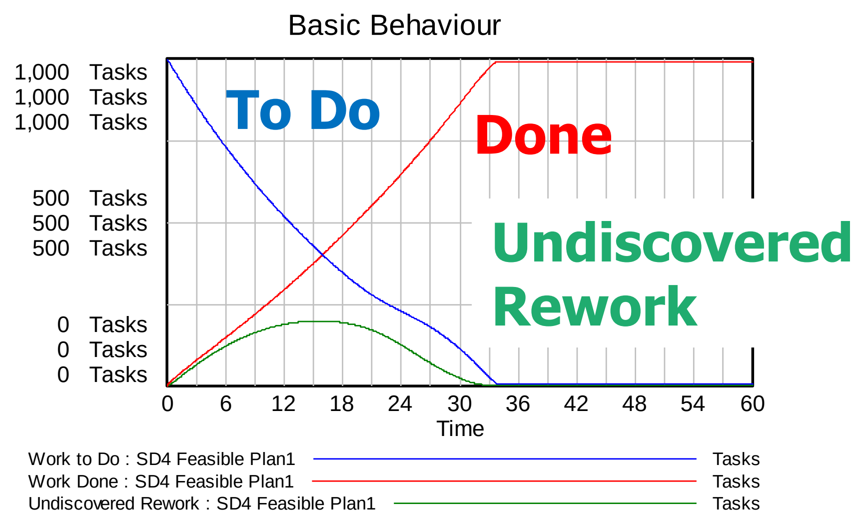
A Consistent (Feasible) Project Avoids the Dynamics

"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]

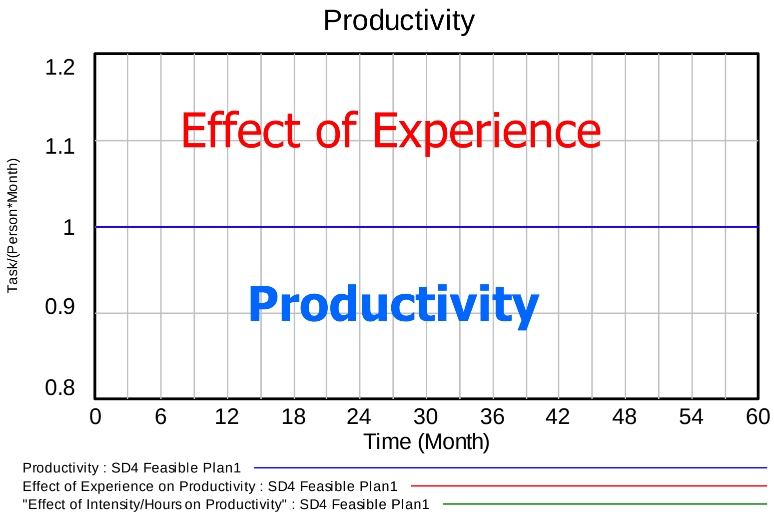
A Consistent Project Avoids the Dynamics

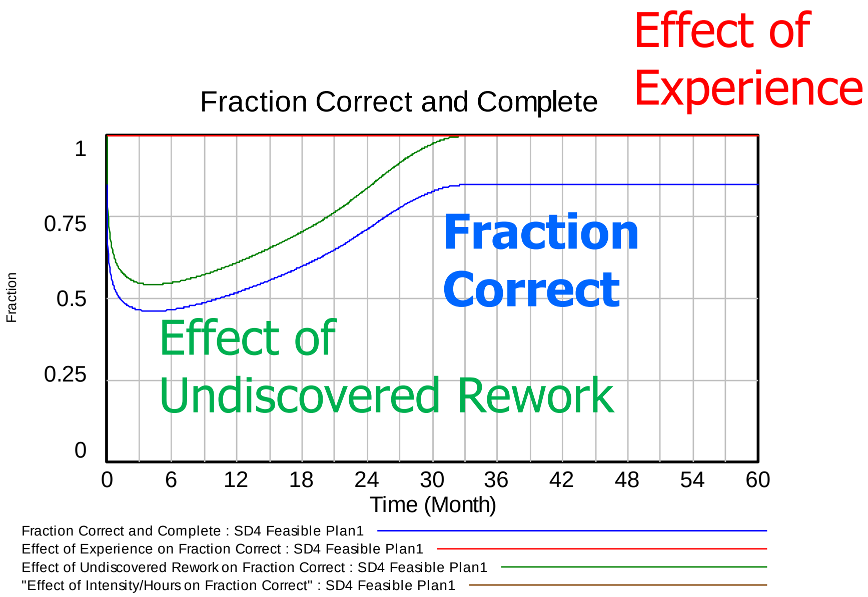




Plan fully accounts for ***rework tasks***;
Schedule and staffing plan reflect ***rework cycle***

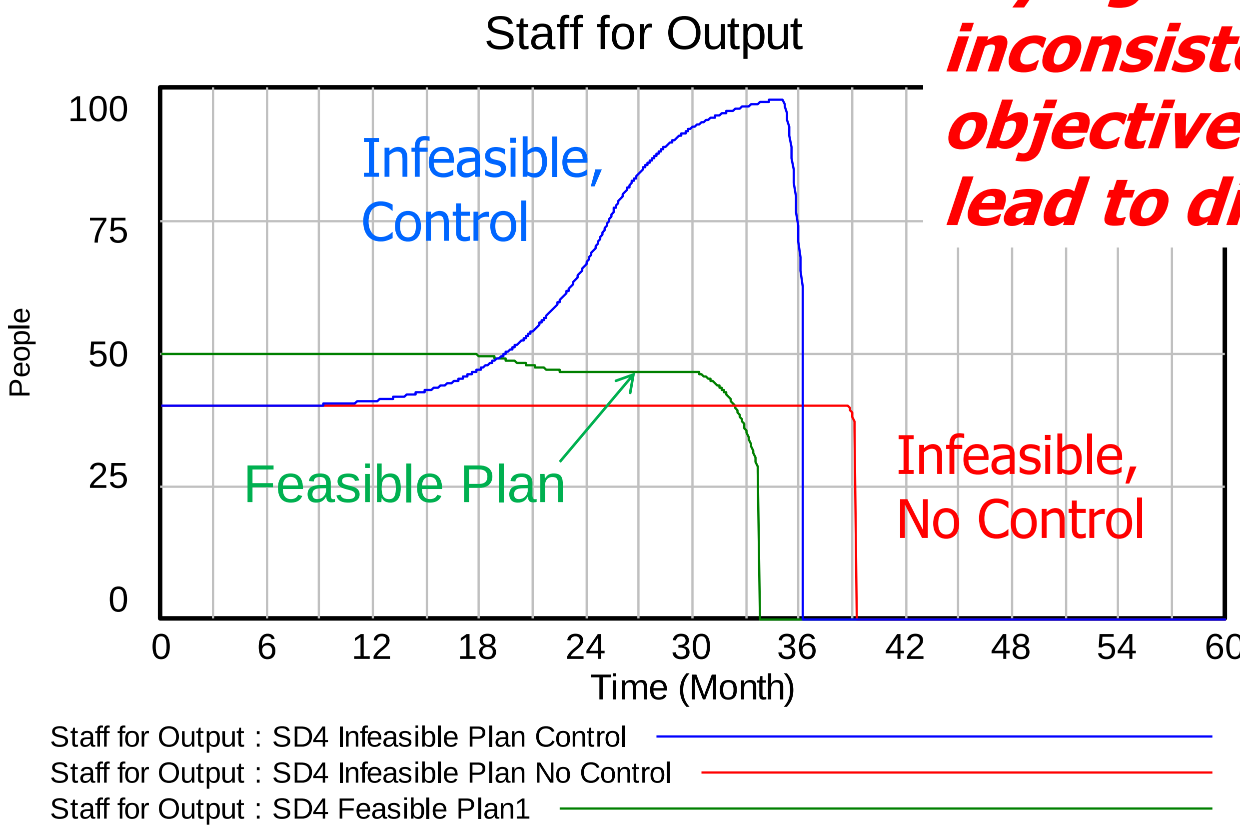
Normal design evolution accounted for in plan



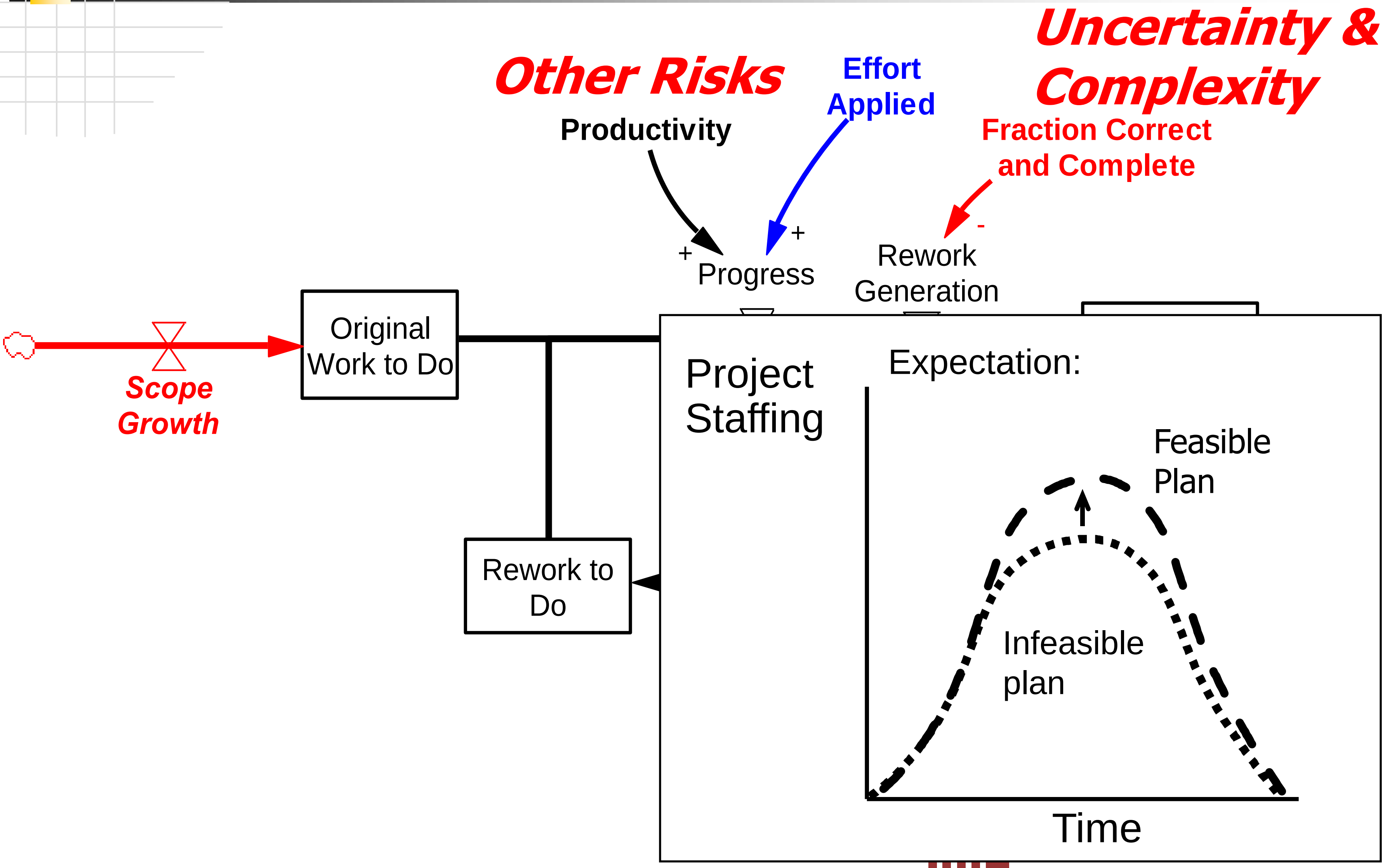


Infeasible projects initiate the dynamics when management responds …

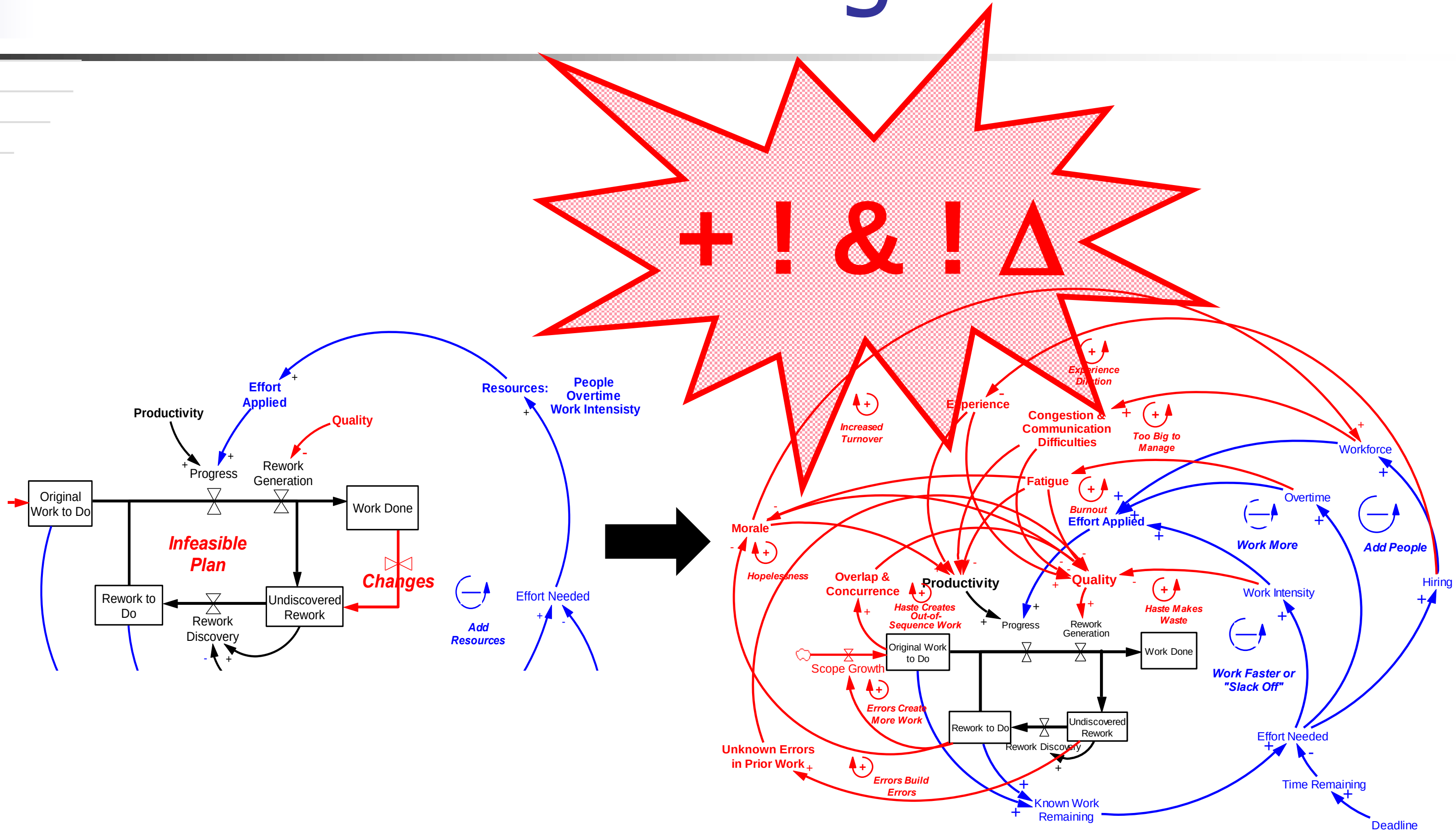
Trying to achieve inconsistent objectives can lead to disaster …



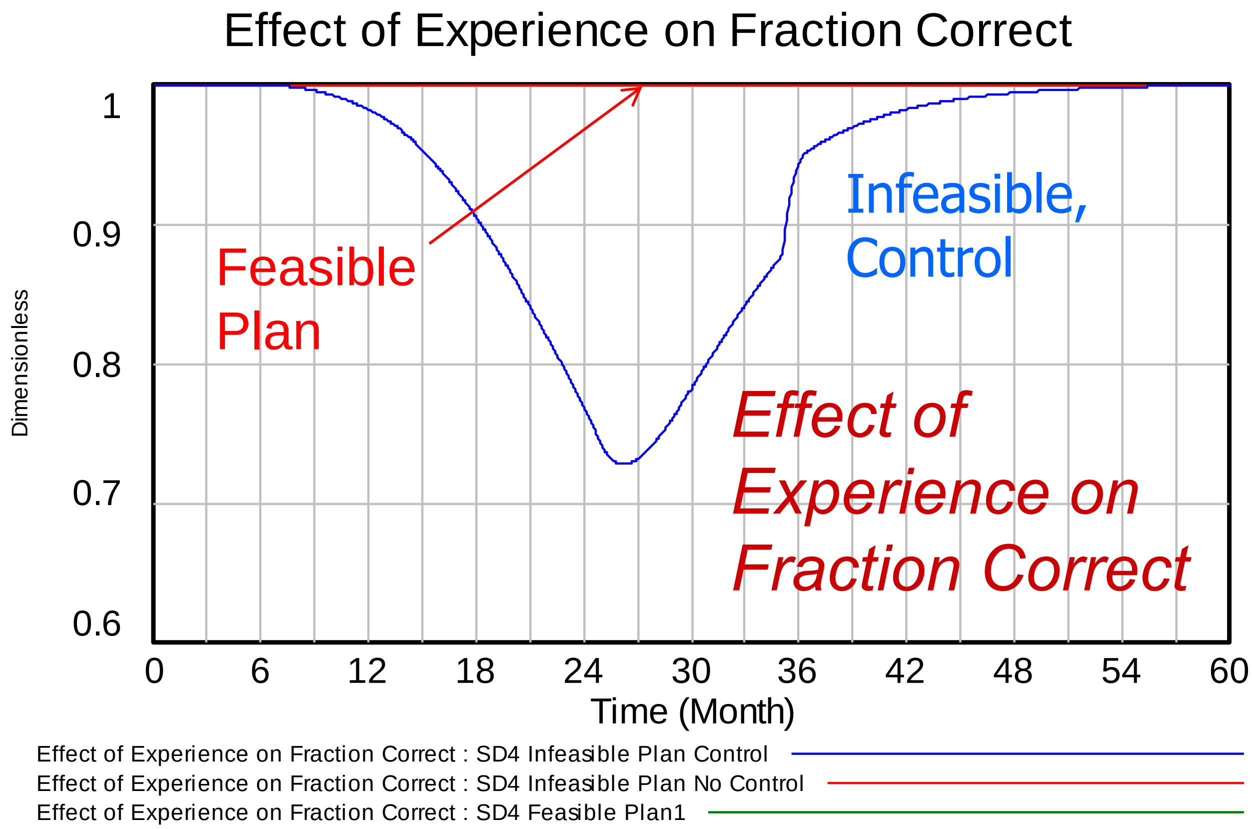
What do we expect?



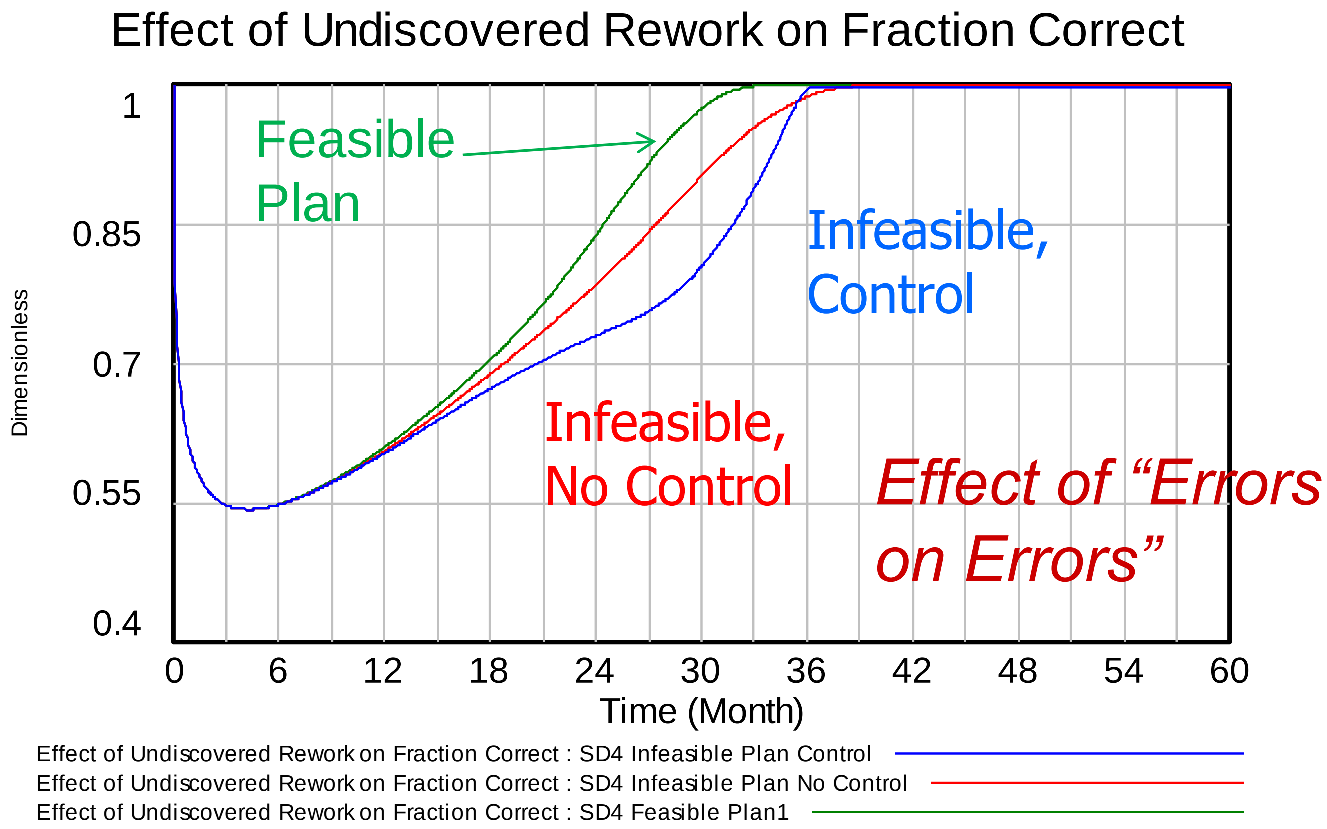
But when management reacts



Trying to achieve infeasible plan …



Which snowballs via "errors on errors" feedback ...



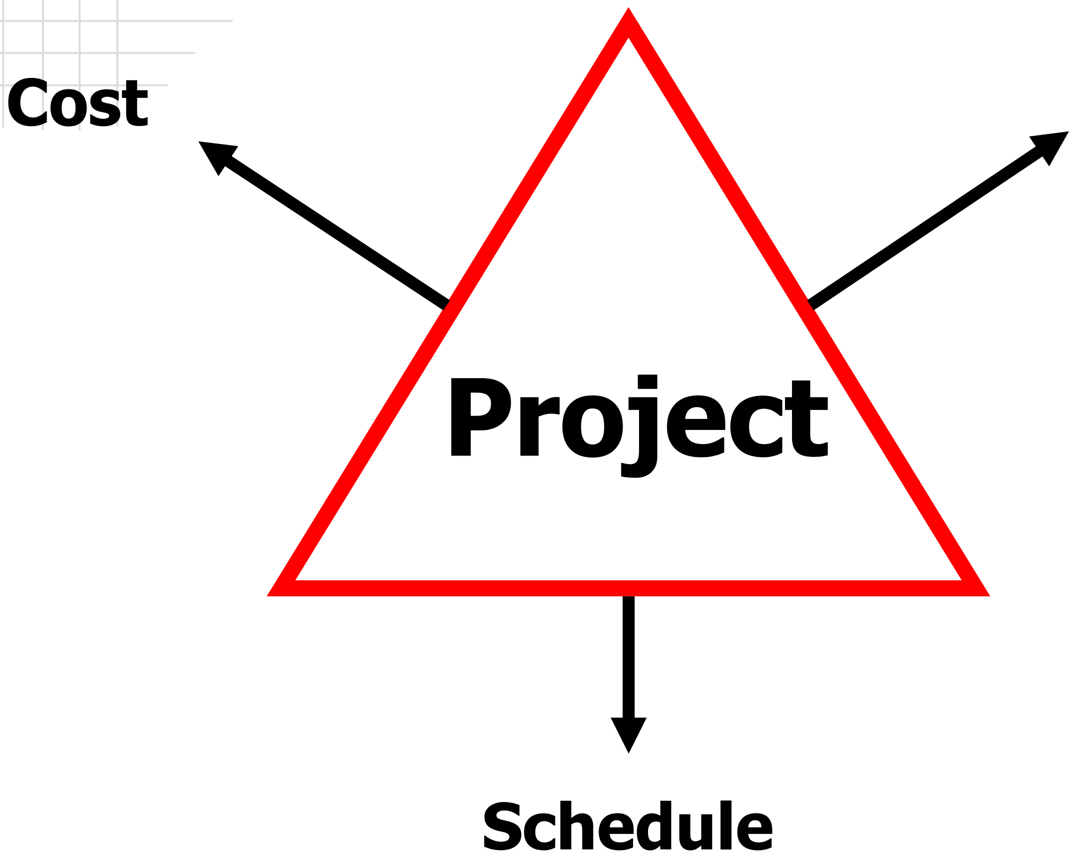
With end result worse (schedule/cost) than if project budgeted higher at start!

Test	Finish	Cost(person-mos)
Infeasible Plan Targets	*30*	*1200*
Infeasible, No Control	39.25	1570
Infeasible, with control)	**36.25**	**2148**
Feasible Plan 1	33.75	1615
Feasible Plan 2	30.125	1650

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)

The "Iron Triangle"



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)

SD Qualitative Insights Review

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.

SD Qualitative Insights – 2

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
- Example 2: Project Planning

  Deciding on the Process Model
- 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 out project?

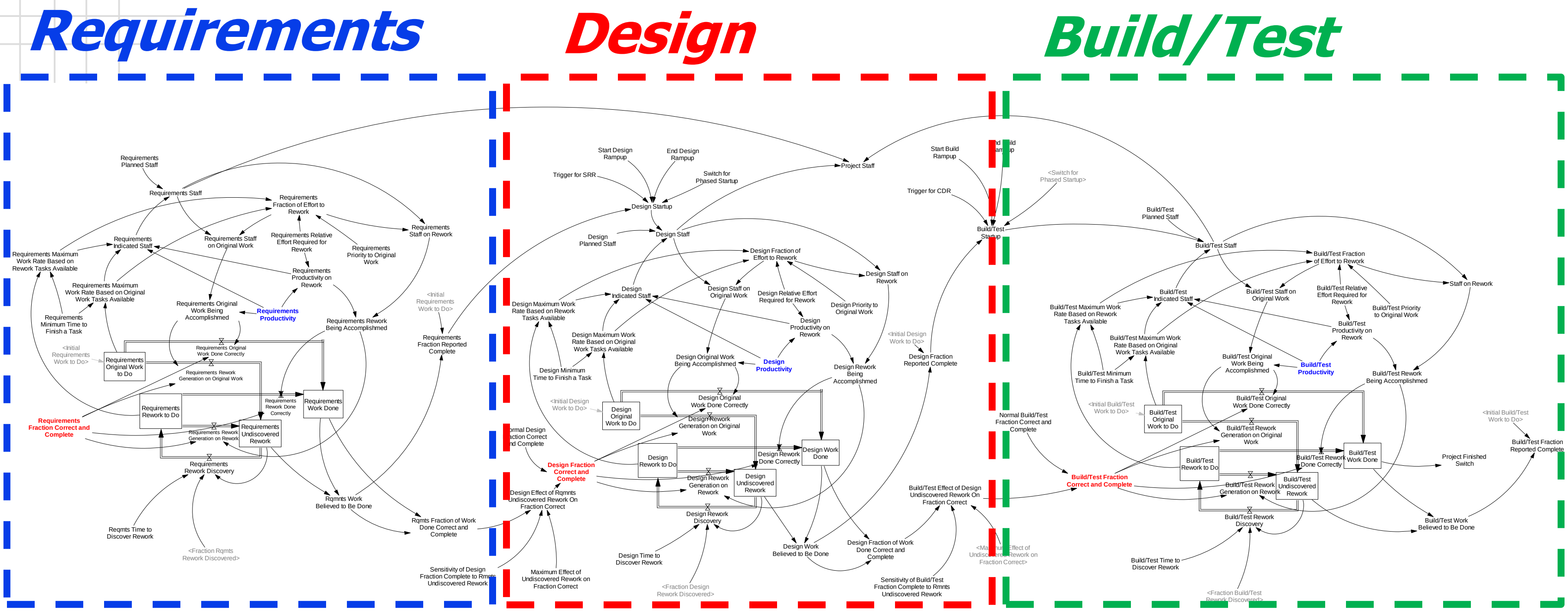
How do we assess what process model is right for our project?

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

Example: Three-Phase Model (from Lecture 7)



Assumptions:

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

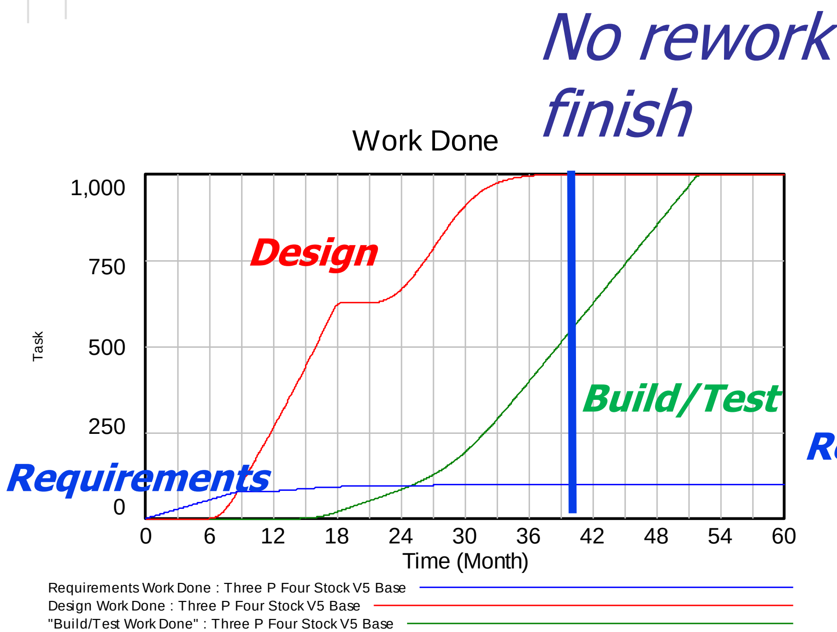
Design
- Scope = 1000 tasks
- Staff = 25
- Productivity = 4 tasks/month/person
- Duration = 10 months (no rework)
- NFCC=0.7

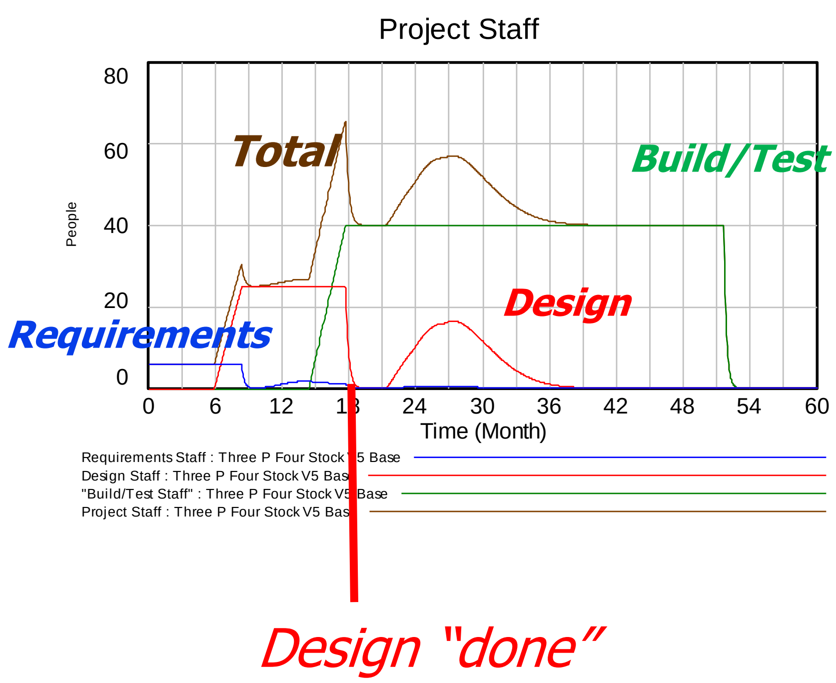
Build/Test
- Scope = 1000 tasks
- Staff = 40
- Productivity = 1 tasks/month/person
- Duration = 25 months (no rework)
- NFCC= 0.95

Rework Discovery Assumptions (similar to *CityCar* HW#3)

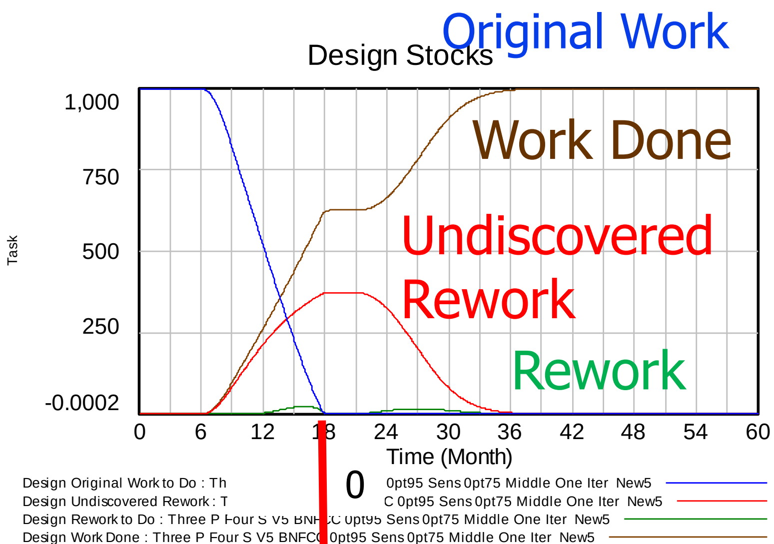
- 60% of rework discoverable in design
- One design planned iteration & limited design review
- ➔ Fraction of Rework Discovered in First Iteration = 30%
- Fraction of Rework Discovered in Later Design Iterations = 70% two iterations, 95% three iterations (note: derivable via DSM and signal flow graph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

Simulation results for current processes …

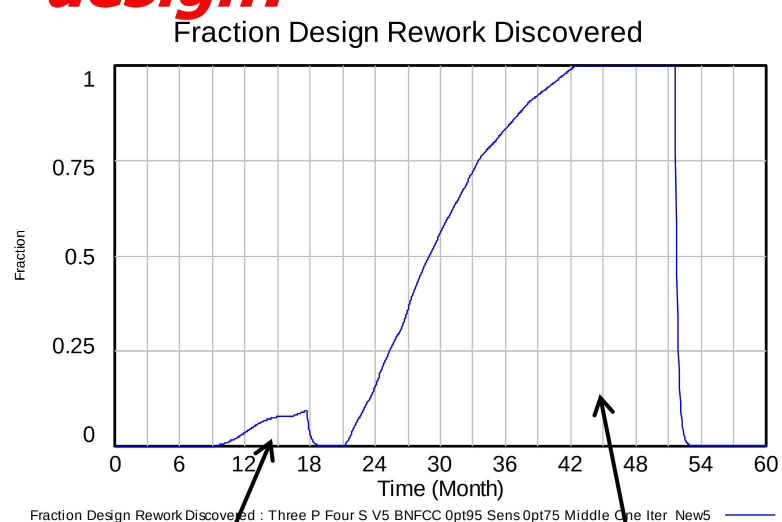




Can we improve performance by shifting more rework discovery to design?



Design "done"



Discovery by design

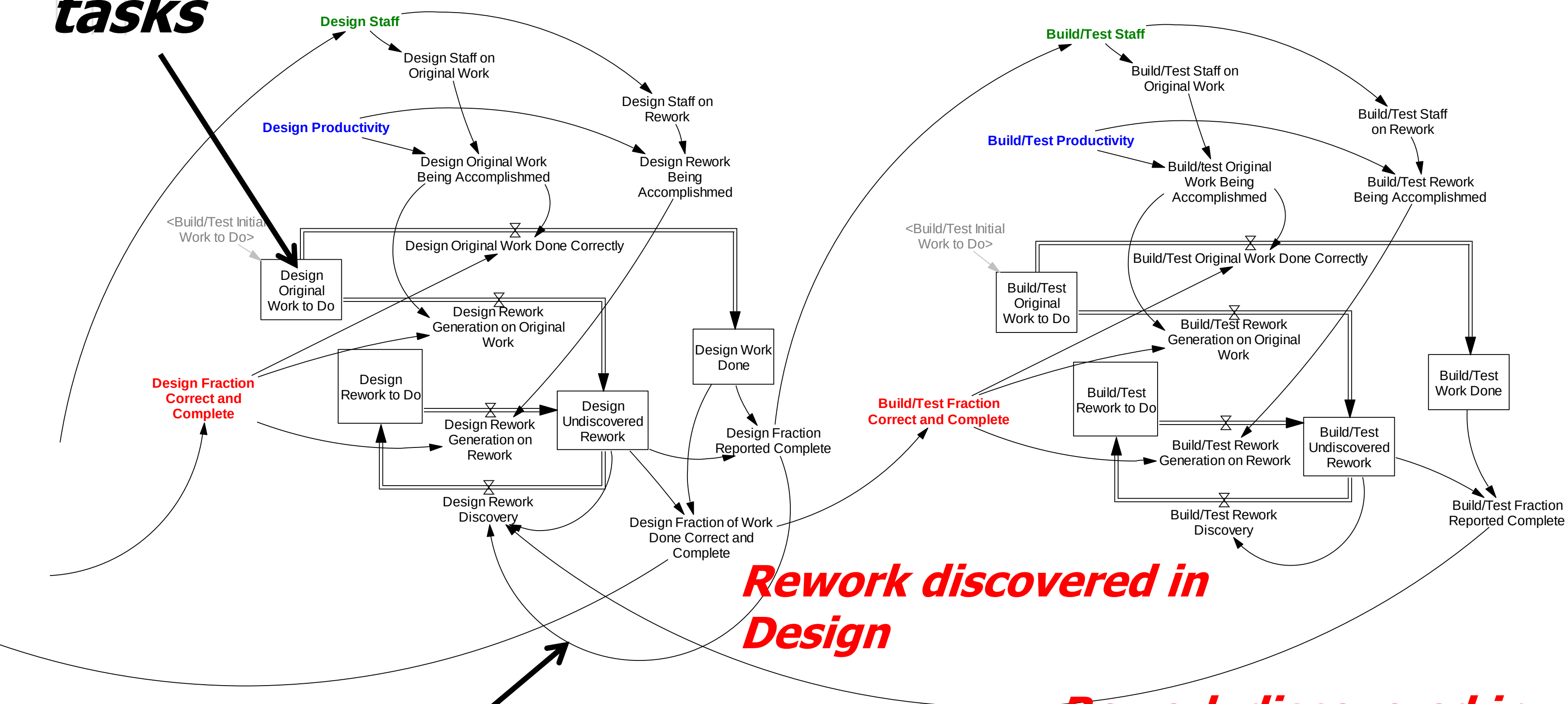
Discovery by build

Sources of Rework – Categories (from Lecture 7)

1. Classical "Quality" or design misexecution from people or technical coupling. *Discoverable by further design work such as iteration, review.*
2. Technical complexity/novelty; customer uncertainty. *Discoverable by build/test work, including d/b/t iterations.*
3. Knock-on Rework Work done "correctly" but ultimately needing rework. *Discoverable by both.*

Example: Planned Design Iterations

1. Add iteration tasks



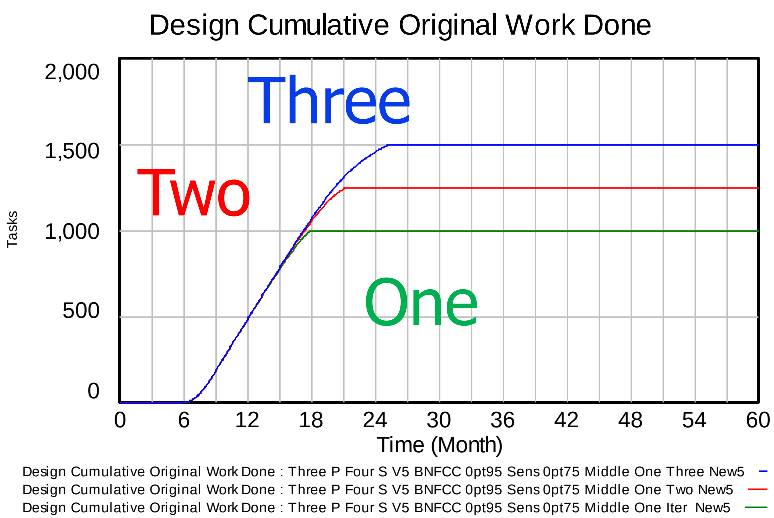
Rework discovered in Design

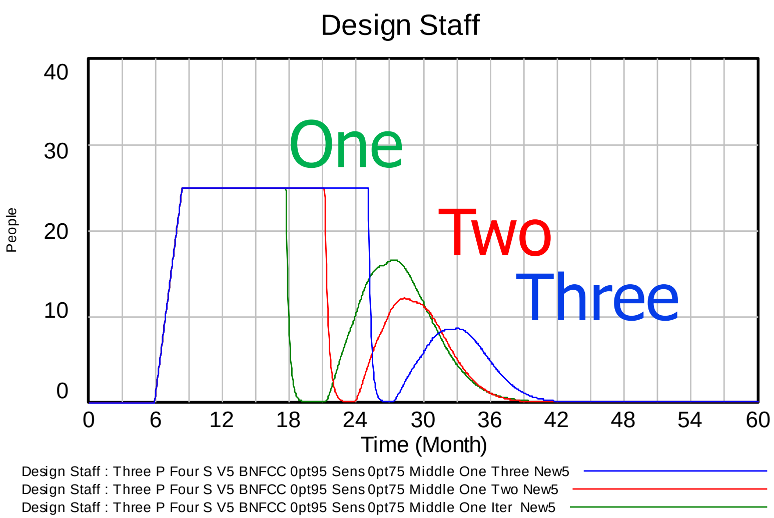
2. Which discover more rework in design

Rework discovered in Build/Test

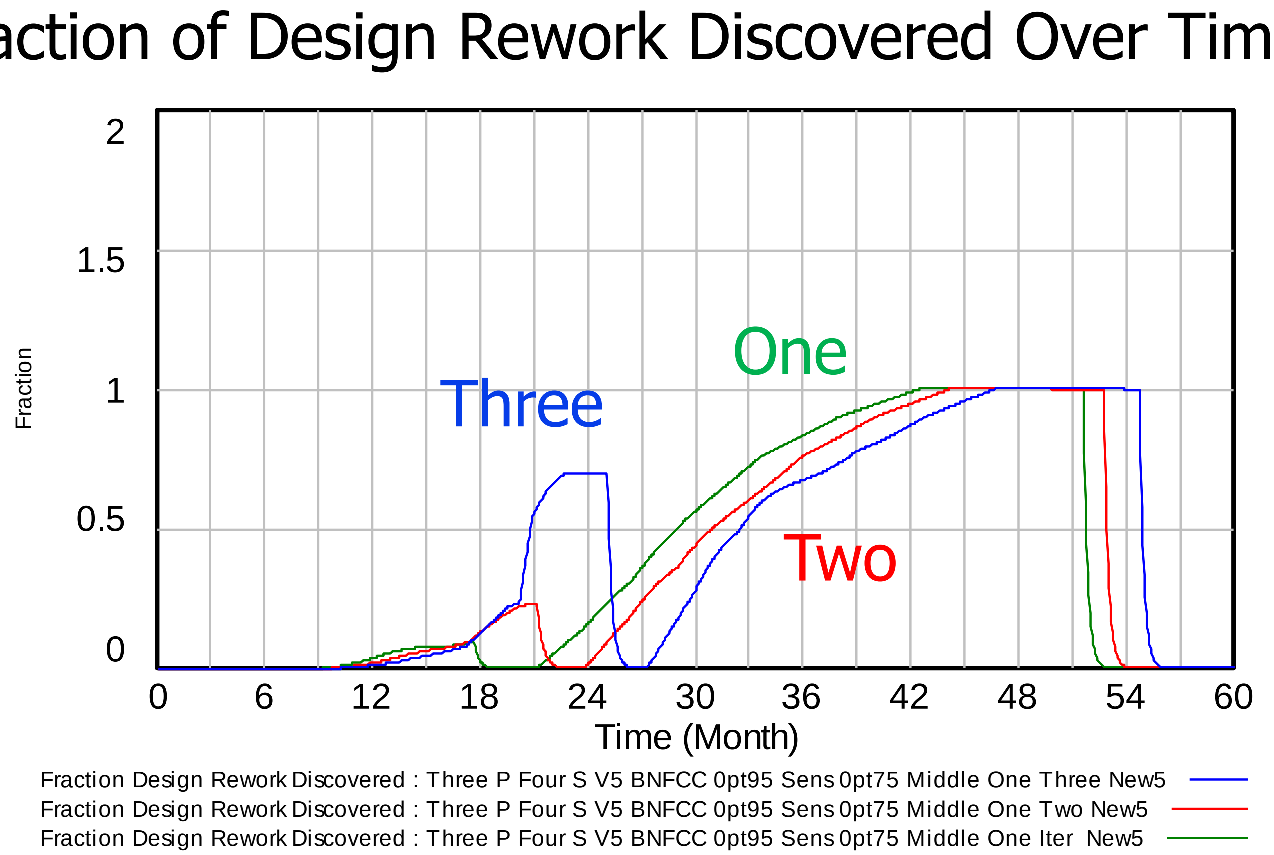
Increasing design iterations …

… increases design original work, but reduces downstream rework.



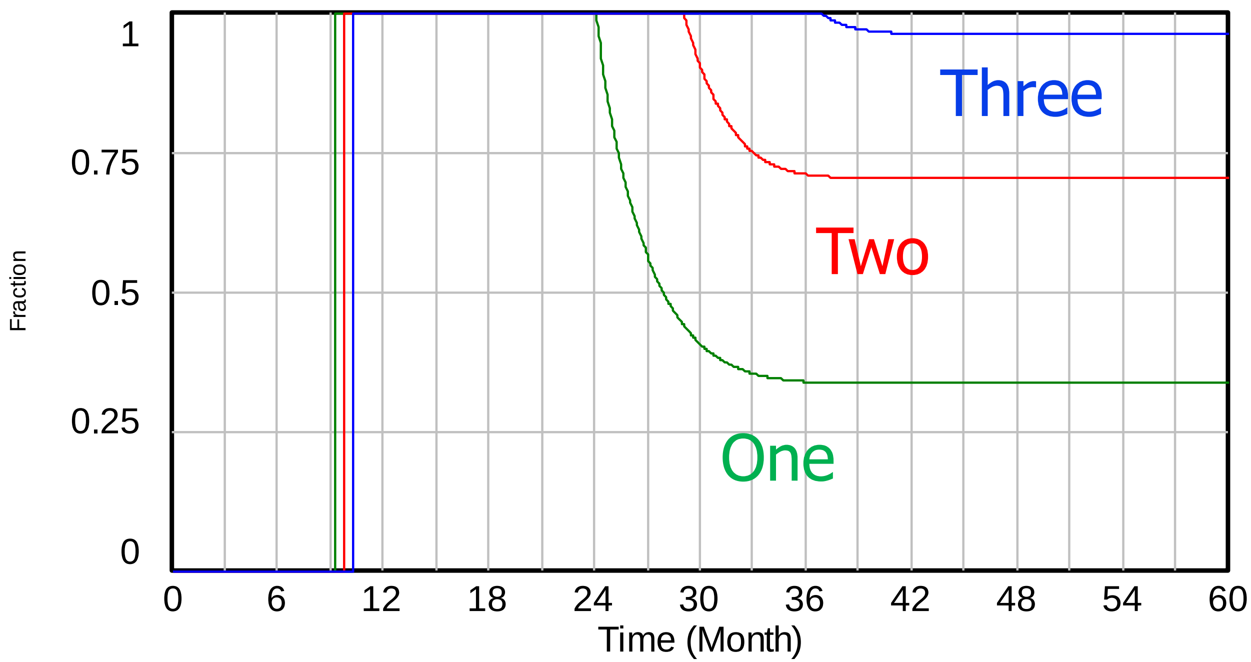


... pushes more rework discovery into design



Three iterations discovers all the "discoverable" rework

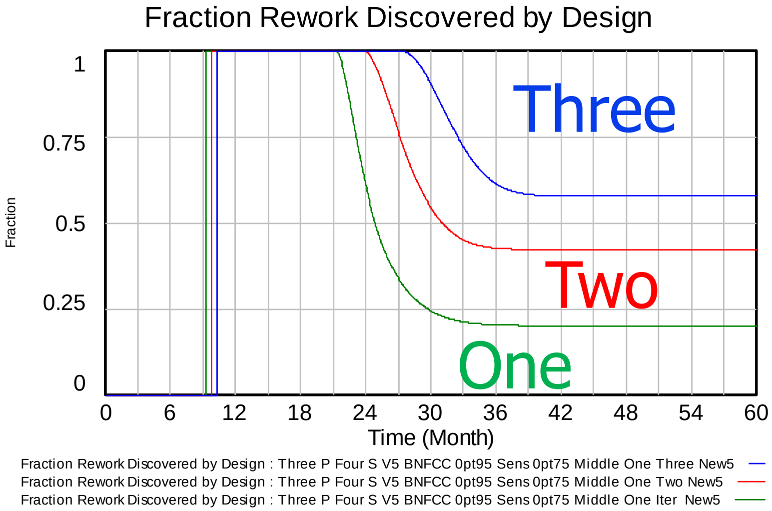
Fraction Rework Discovered by Design as Fraction of Max

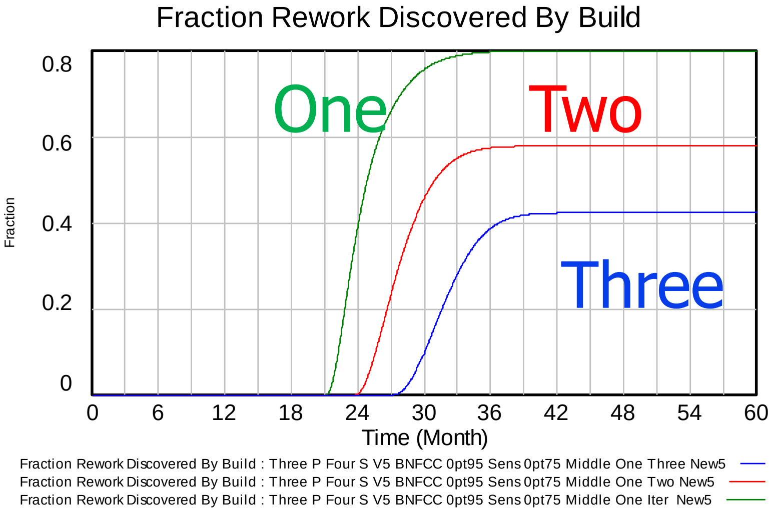


Fraction Rework Discovered by Design as Fraction of Max : Three P Four S V5 BNFCC 0pt95 Sens 0pt75 Middle One Three New5
Fraction Rework Discovered by Design as Fraction of Max : Three P Four S V5 BNFCC 0pt95 Sens 0pt75 Middle One Two New5
Fraction Rework Discovered by Design as Fraction of Max : Three P Four S V5 BNFCC 0pt95 Sens 0pt75 Middle One Iter New5

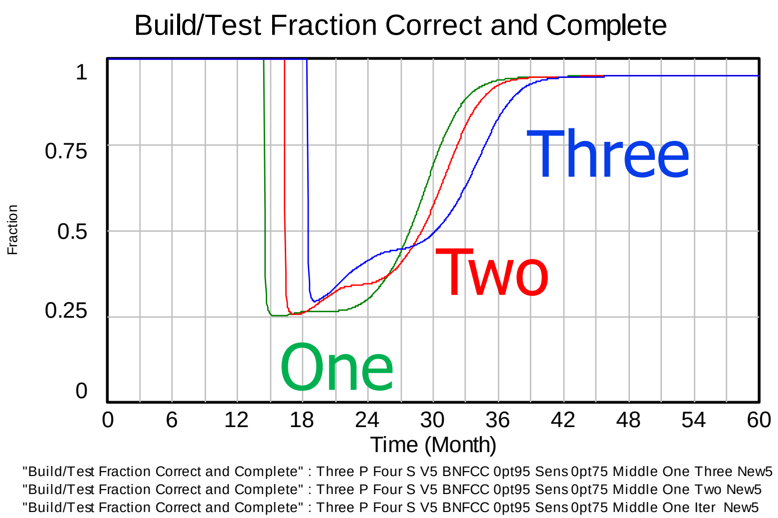
Derivable via DSM and signal flow graph simulation?

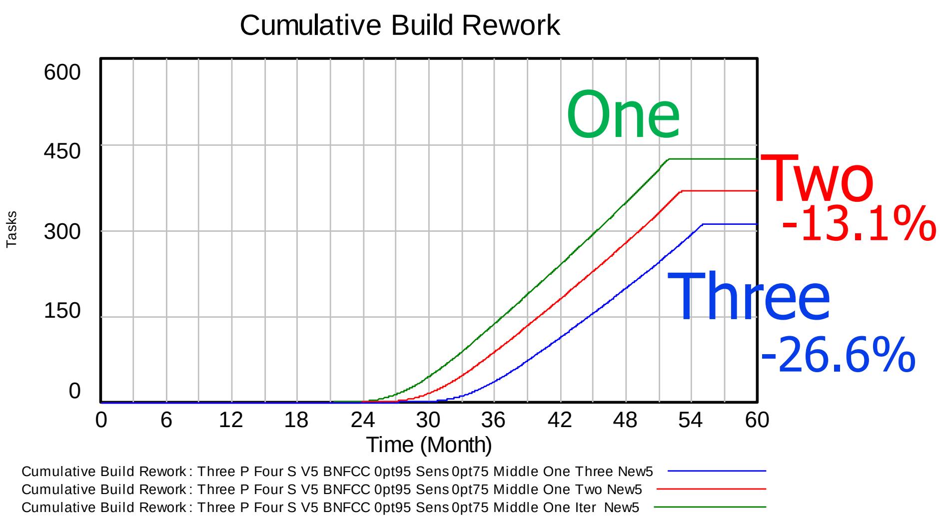
Increasing rework discovered in design reduces rework left for build …





Improving build "quality" and reducing build rework





With the “Base Case” Assumptions …

"Middle" Project	*"New5 Results"*					
	Cum		Design	Build	Total	
Test	Build Rework		Effort	Effort	Effort	Finish
One Iteration	425.16		404.4	1432	1903	51.6875
Two Iterations	369.38	-13.1%	444.45	1376	1887	52.875
Three Iterations, Start 70%	311.86	-26.6%	516	1321	1904	54.8125

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)

			Build Cost Multiplier											
	0.5		1		1.25		1.5		1.75		2		3	
One Iteration	1187		1903		2261		2619		2977		3335		4767	
Two Iterationss	1199	1.01%	1887	-0.84%	2231	-1.33%	2575	-1.68%	2919	-1.95%	3263	-2.16%	4639	-2.69%
Three Iterations	1243.5	4.76%	1904	0.05%	2234	-1.18%	2565	-2.08%	2895	-2.76%	3225	-3.30%	4546	-4.64%

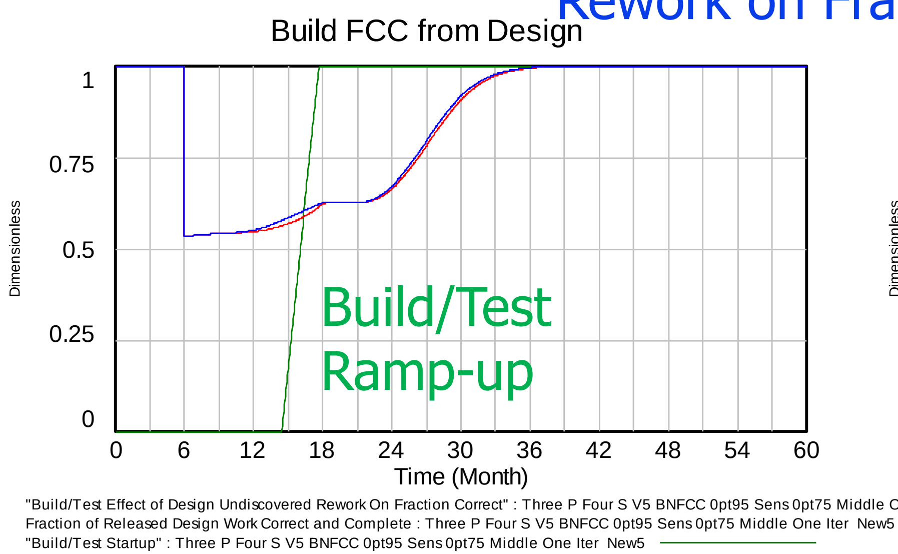
Increasing Build Cost

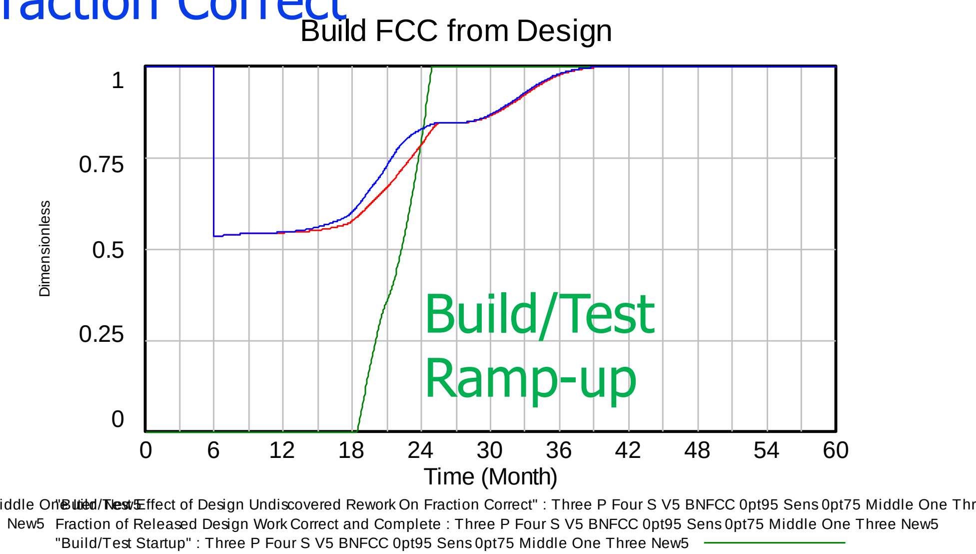
Build is starting before design rework is fully discovered

One Iteration

Three Iterations

Effect of Design Undiscovered Rework on Fraction Correct





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

Iterations 2 & 3 occurring months 18-24

Benefits of delaying build start

"Middle" Project	*"New5 Results"*						
	Cum		Design	Build	Total		
Test	Build Rework		Effort	Effort	Effort		Finish
One Iteration	425.16		404.4	1432	1903		51.6875
Two Iterations	369.38	-13.1%	444.45	1376	1887	-0.84%	52.875
Three Iterations, Start 70%	311.86	-26.6%	516	1321	1904	0.05%	54.8125
Three Iterations, Start 60%	337.67	-20.6%	516	1353	1935	1.68%	53.5
Three Iterations, Start 70%	311.86	-26.6%	516	1321	1904	0.05%	54.8125
Three Iterations, Start 80%	285.49	-32.9%	516	1291	1874	-1.52%	55.4375
Three Iterations, Start 90%	271.99	-36.0%	516	1275	1857	-2.42%	56
Two Iteration, Start 60%	386.26	-9.1%	444.45	1396	1907	0.21%	51.125
Two Iteration, Start 70%	369.4	-13.1%	444.45	1376	1887	-0.84%	52.875
Two Iteration, Start 80%	359	-15.6%	444.45	1364	1875	-1.47%	53.4375
Two Iteration, Start 90%	348.72	-18.0%	444.45	1353	1864	-2.05%	54.0625

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

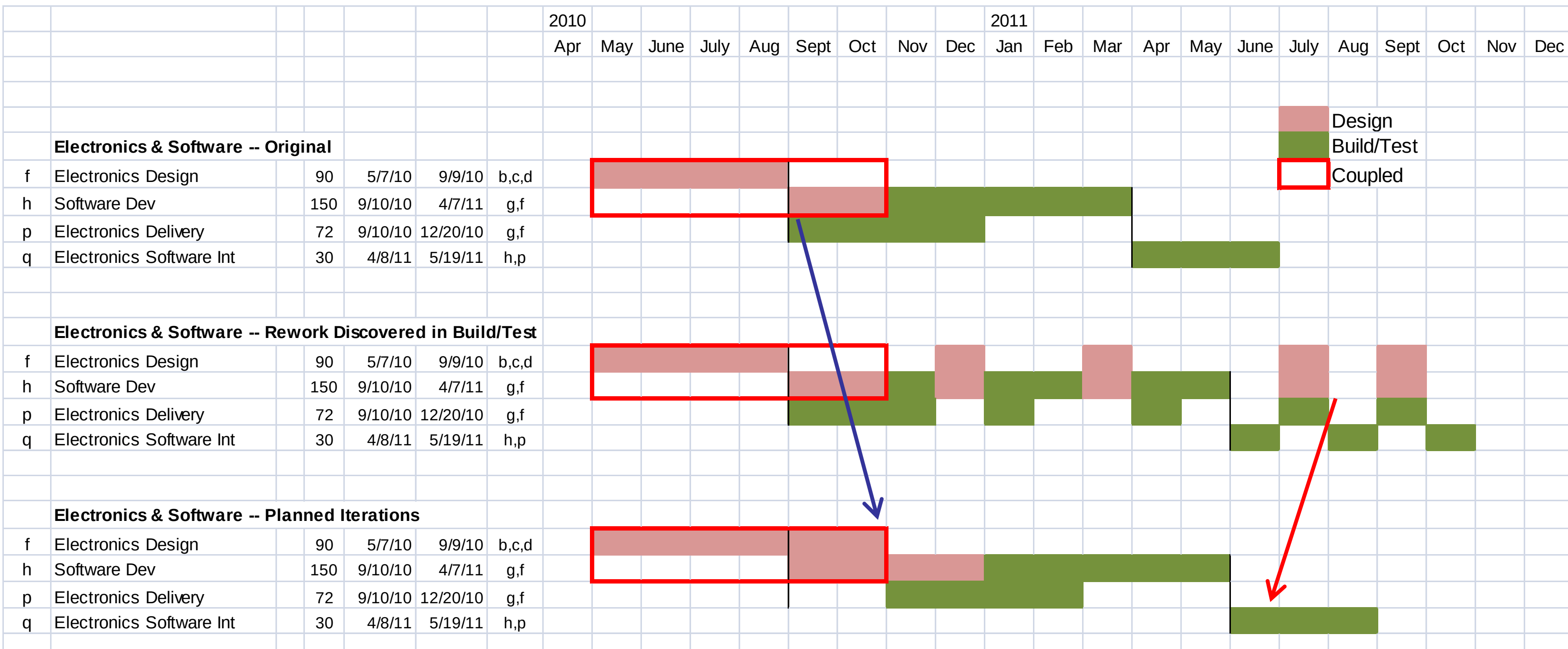
Parameter	"Novel"	"Repeat"	"Mature"
Normal FCC	0.6	0.7	0.8
Frac Discoverable in Design	0.3	*(examples)* 0.6	0.9
Frac Discoverable First Iteration	Depends on product & organization:		
Frac Discoverable Later Iterations	analyze projects, use DSM & signal flow graph simulation to		
Tasks Repeated	estimate.		
# Iterations	*1*	*3*	*2*
Build Start	*When planned iterations done.*		

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

SD Qualitative Insights – 2

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

SD Qualitative Insights – 4

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

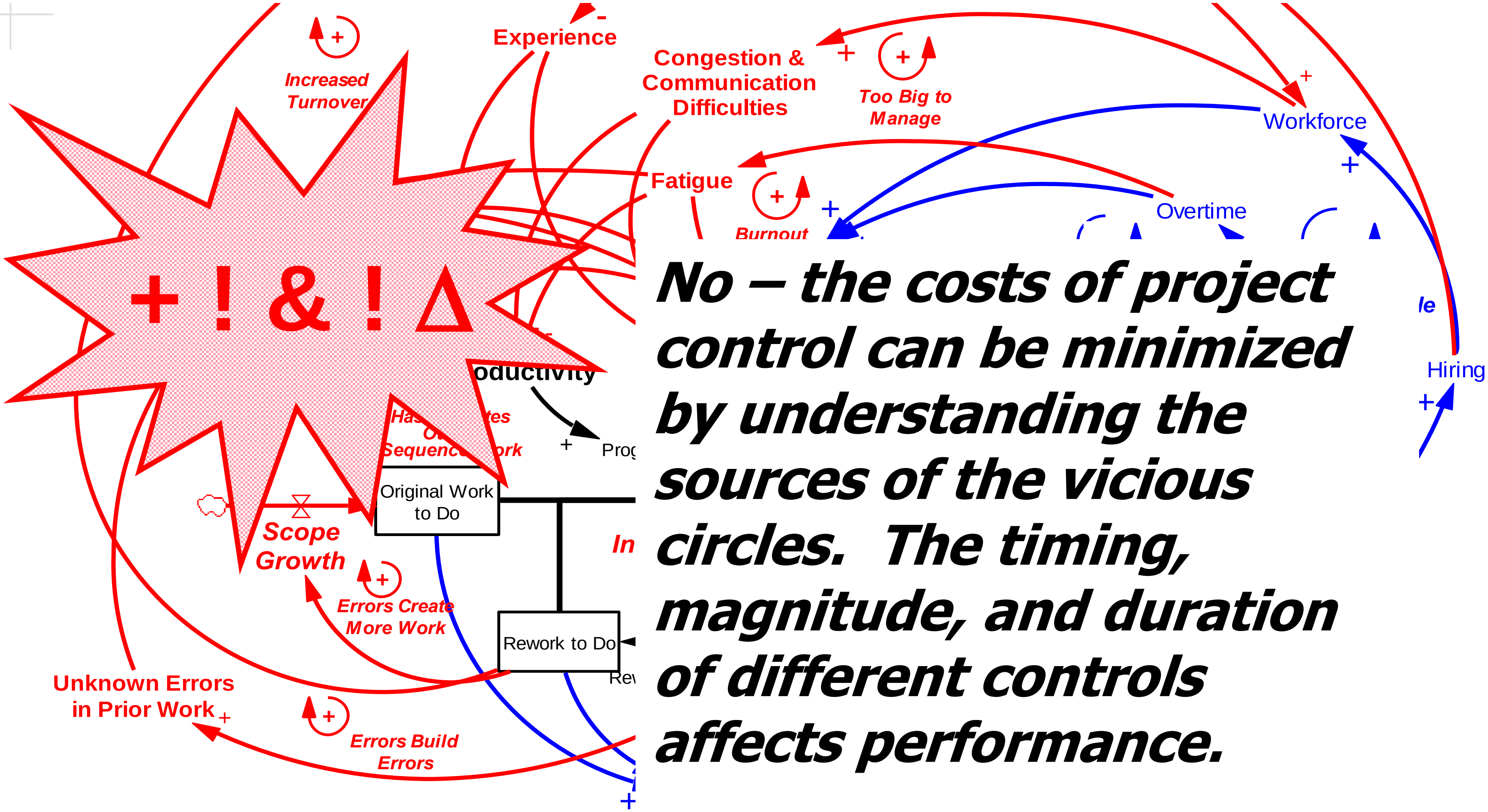
- You've misplanned, either because you don't include rework estimates or because this particular project has unusually high levels ….
- Or
  - Scope growth occurred on the project
  - Other risks/problems materialized

What do you do?

(note – these are "permanent" impacts, not temporary delays on isolated parts)

Project Control

"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%						
	First	**Second**	**Third**	**Fourth**	**Fifth**	**Sixth**
Add People	10.6%	52.2%	17.1%	11.6%	14.3%	25.0%
Longer Hours	31.9%	23.9%	26.8%	16.3%	7.1%	0.0%
Intensity	25.5%	13.0%	19.5%	23.3%	21.4%	0.0%
Slip	17.0%	8.7%	19.5%	23.3%	26.2%	25.0%
Cut Scope	14.9%	2.2%	17.1%	25.6%	31.0%	50.0%
Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

What You Do at 65%						
	First	**Second**	**Third**	**Fourth**	**Fifth**	**Sixth**
Add People	16.7%	50.0%	31.1%	9.5%	8.9%	25.0%
Longer Hours	35.4%	29.2%	17.8%	9.5%	13.3%	0.0%
Intensity	16.7%	8.3%	26.7%	21.4%	22.2%	0.0%
Slip	8.3%	10.4%	15.6%	38.1%	24.4%	50.0%
Cut Scope	22.9%	2.1%	8.9%	21.4%	31.1%	25.0%
Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

% Specifying 1st or 2nd Choice

2011

What You Do?		
	At 30%	***At 65%***
Add People	40.8%	34.7%
Longer Hours	24.3%	23.5%
Intensity	21.4%	19.4%
Slip	5.8%	11.2%
Cut Scope	7.8%	11.2%
Other	0.0%	0.0%
Total	100.0%	100.0%

2012

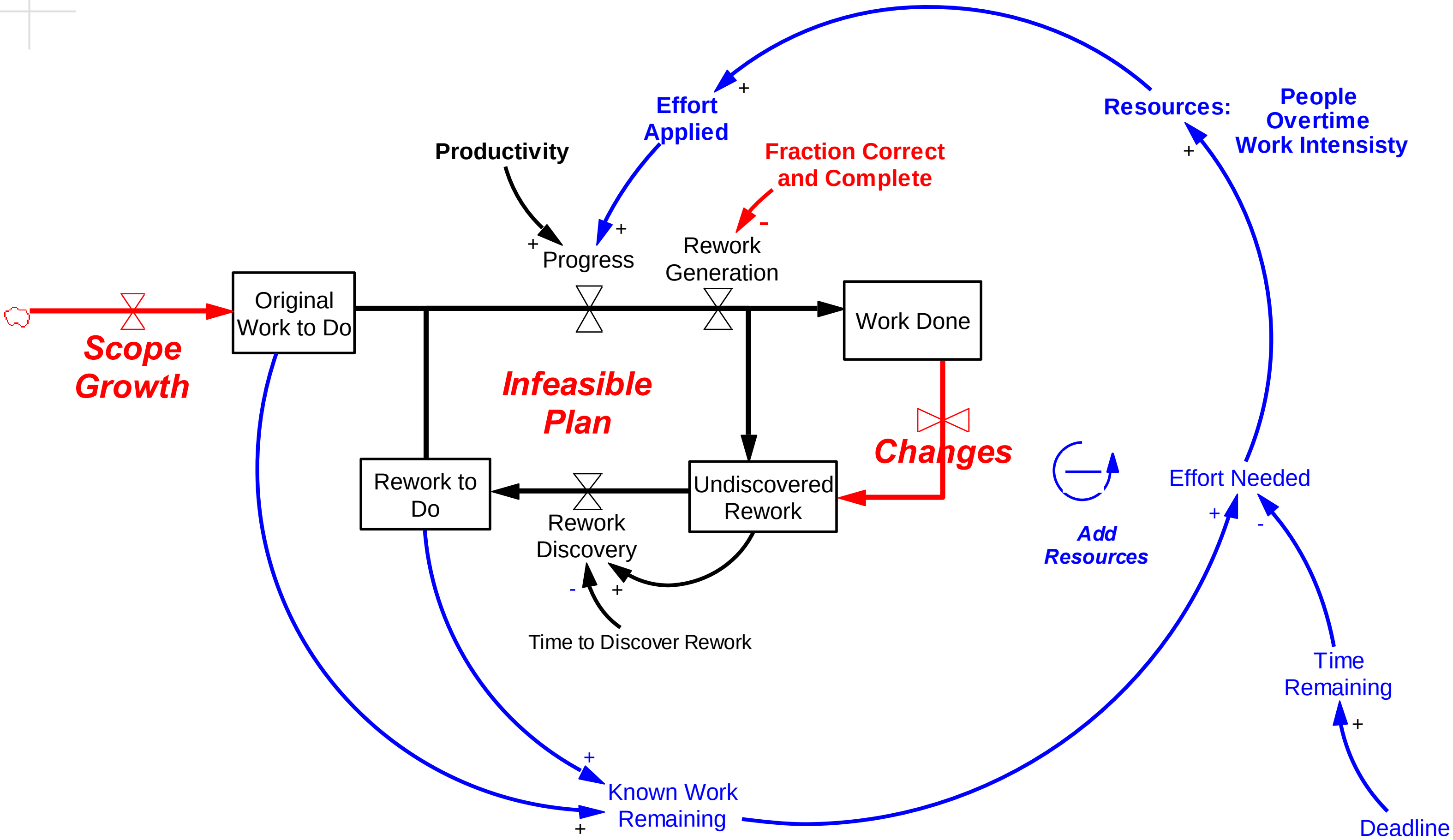
What You Do?		
	At 30%	***At 65%***
Add People	31.2%	33.3%
Longer Hours	28.0%	32.3%
Intensity	19.4%	12.5%
Slip	12.9%	9.4%
Cut Scope	8.6%	12.5%
Other	0.0%	0.0%

Brooks' Law

- "Adding manpower to a late software project makes it later." Brooks, Frederick P. Jr. The Mythical Man-Month. Reading, MA, Addison Wesley, 1995.

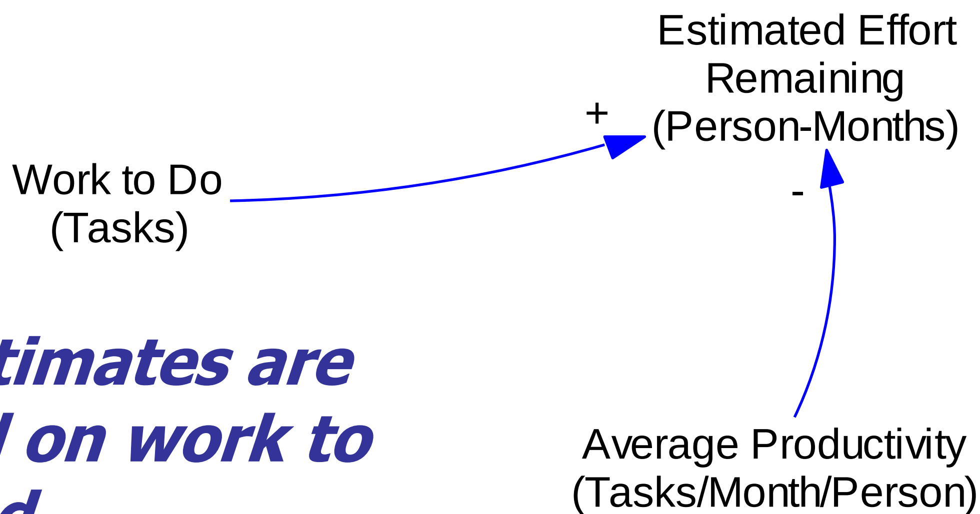
Homework 5 Analysis: Under what conditions is this true.

Qualitative model representation



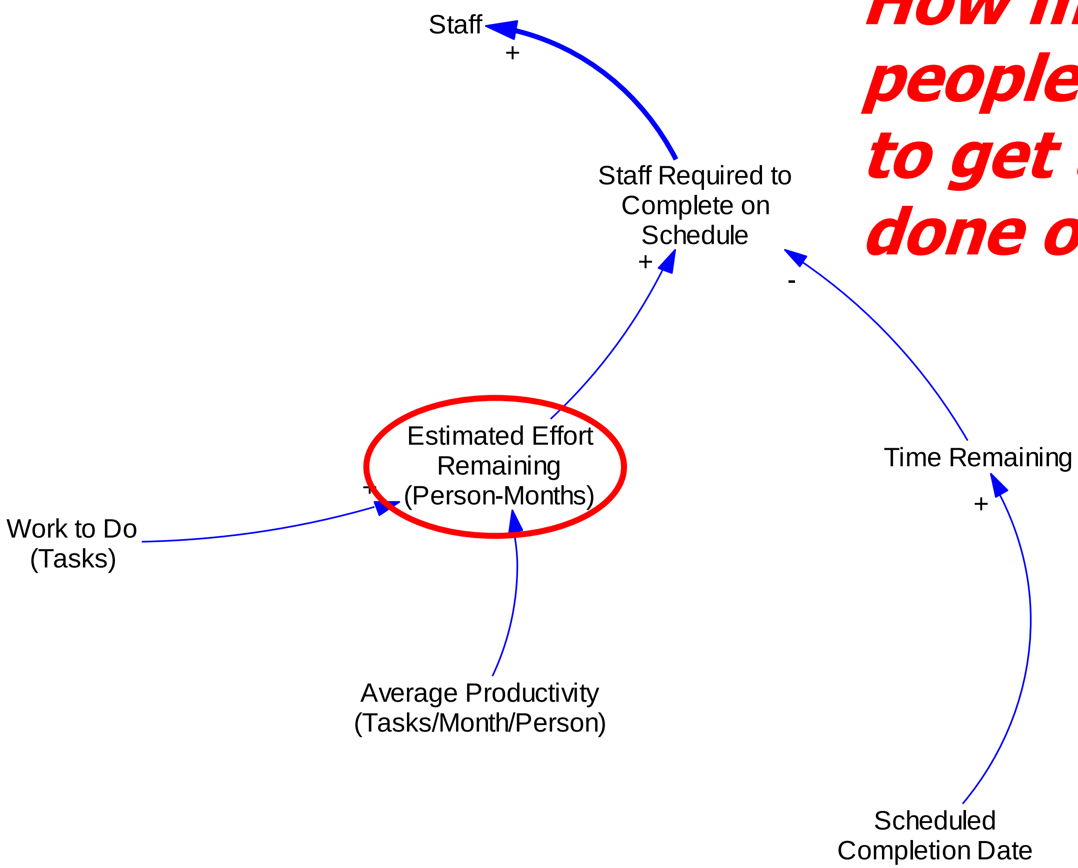
Project Control

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?)

Project Control -- Staffing



How many people do I need to get the job done on time?

Staff Required = ***Estimated Effort Remaining*** / **Time Remaining** *[People]*

Project Control – Schedule

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 + (***Estimated Effort Remaining***/**Staff**) *[Month]*

Project Control

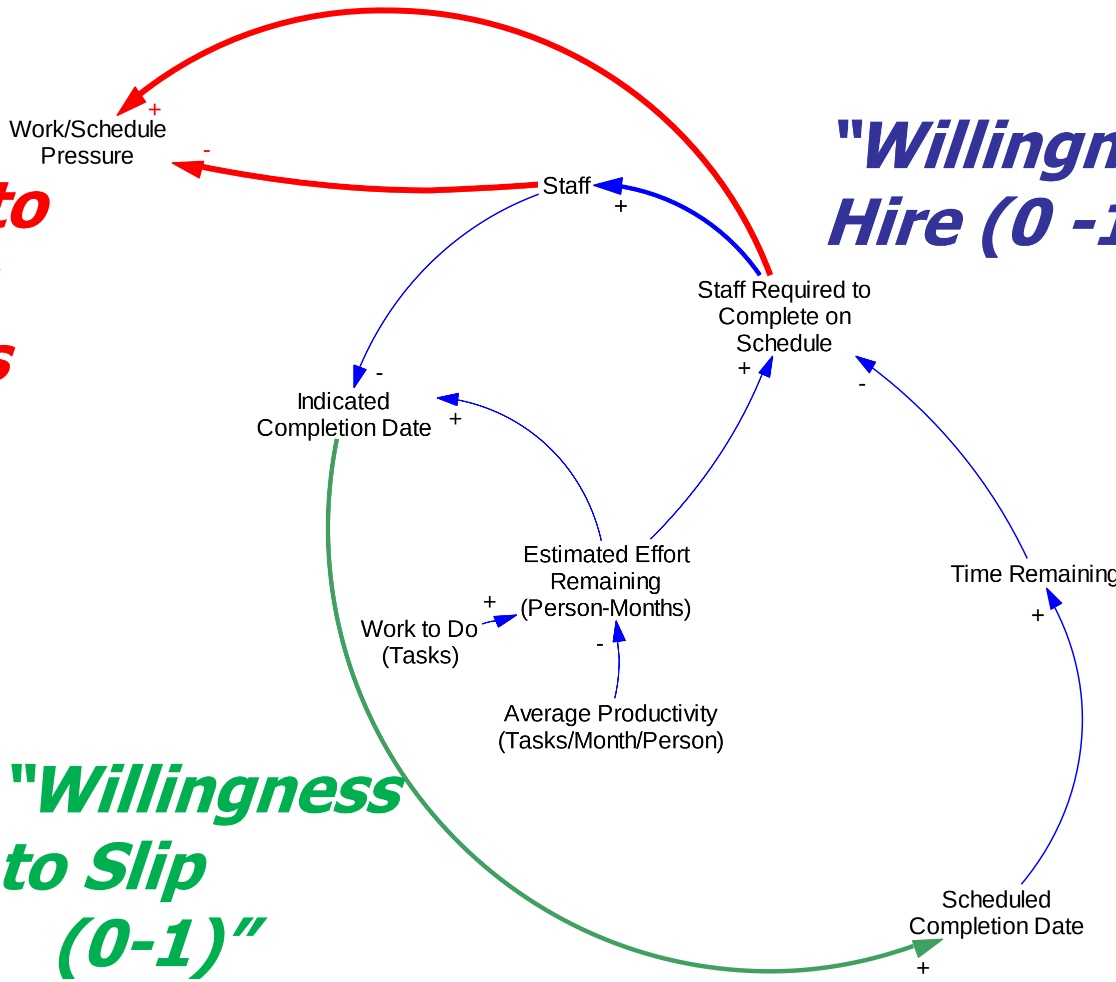
Based on Staff Required and Indicated Completion Date, three options:

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)

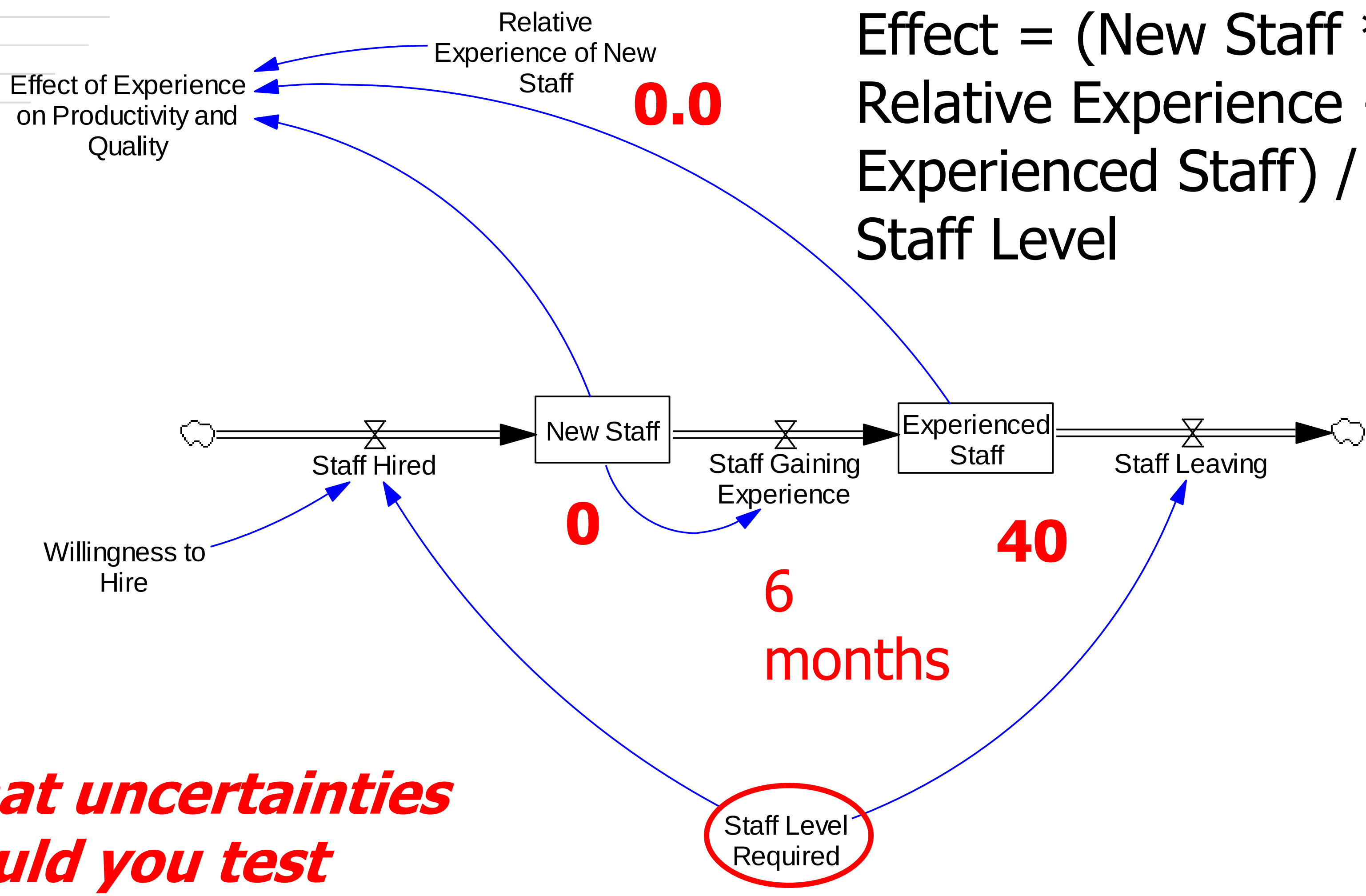
"Willingness to Hire (0 -1)"



"Willingness to Slip (0-1)"

Testing Brook's Law?

Effect = (New Staff * Relative Experience + Experienced Staff) / Staff Level



What uncertainties would you test sensitivity to?

Options

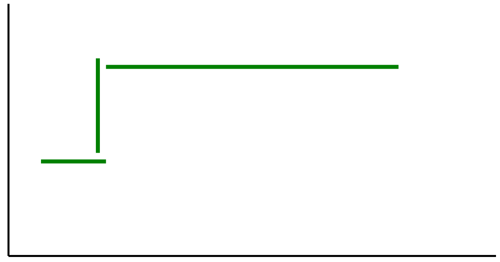
- Add Staff
- Work OT
- Increase “intensity”
- Slip Schedule
- Some Combination

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 …

Equivalent Staff



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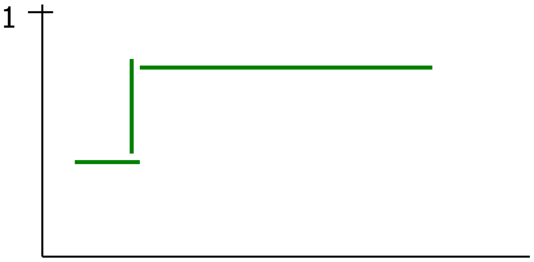
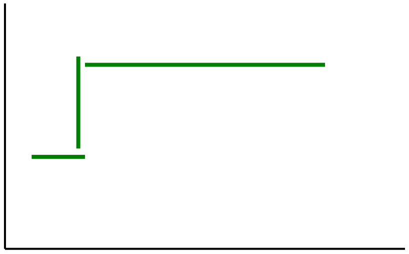
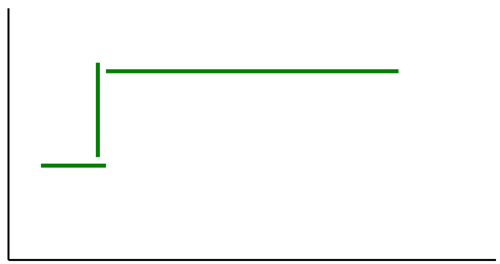


Net Output



Step Change in Staff– Impact on …

Equivalent Staff



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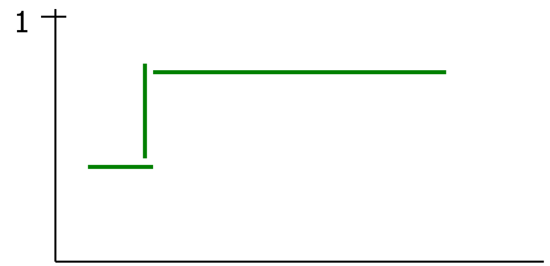

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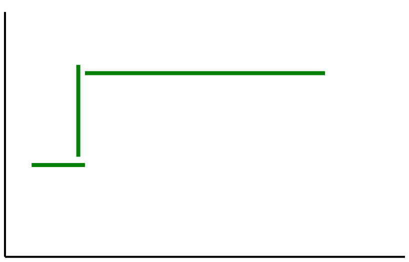
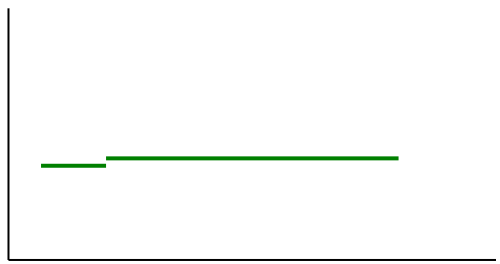


Change in Work Intensity – Impact on …

Equivalent Staff



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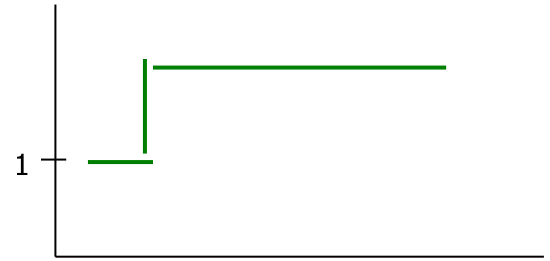

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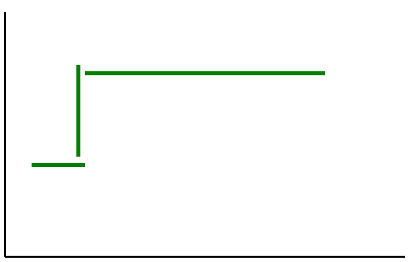


Project Control – Discussion Points

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?)

Lessons -- Control

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.

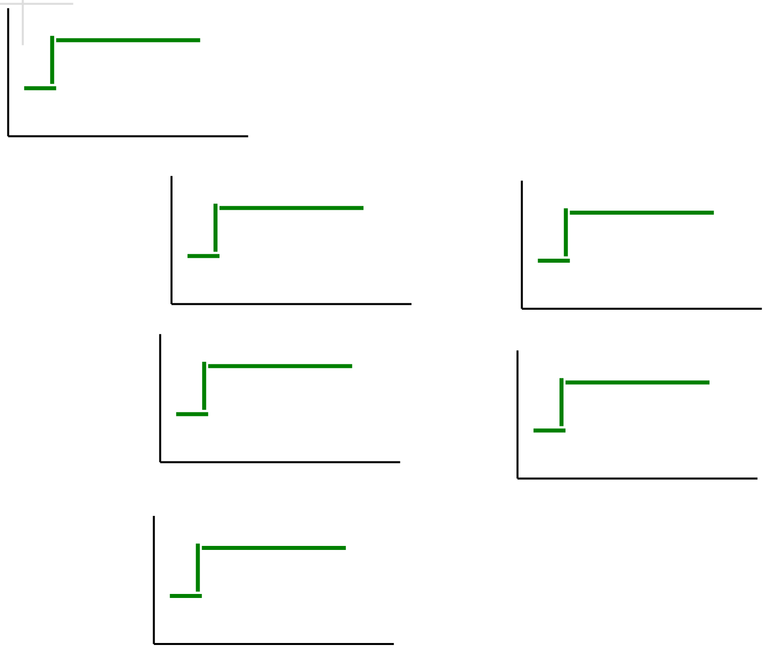
Next SD Class:

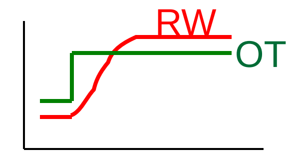
Case Examples of …

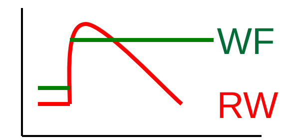
- Change management & disputes
- Risk management
- Project-to-Project Learning

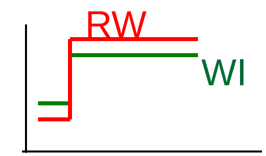
Multi-project dynamics

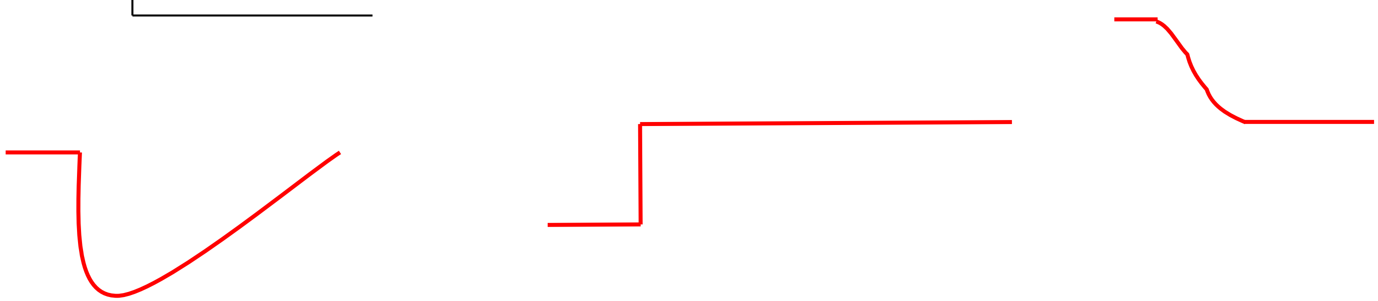
Resources Needed





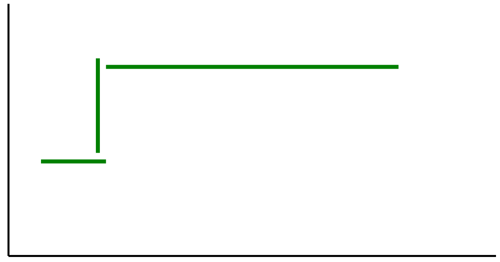






Step Change in Overtime – Impact on …

Equivalent Staff



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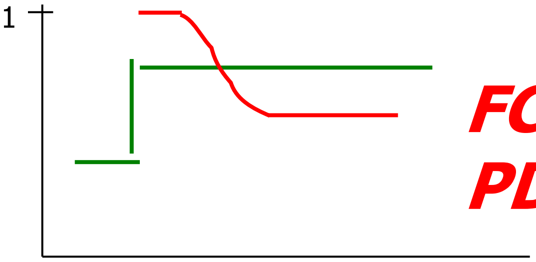

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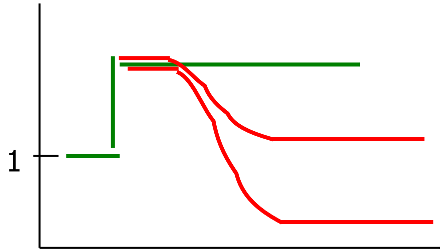
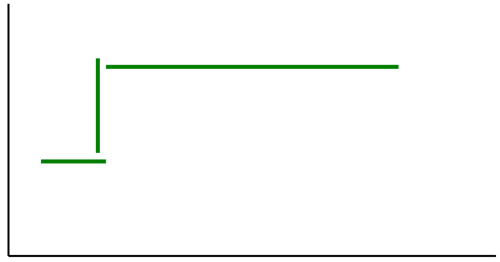
Net Output



Step Change in Staff– Impact on …

Equivalent Staff



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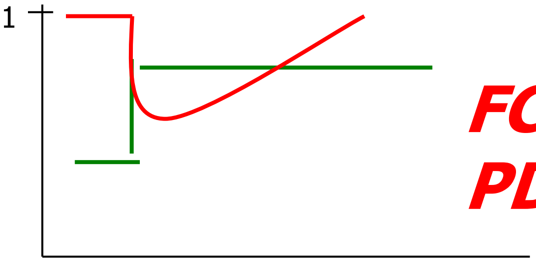

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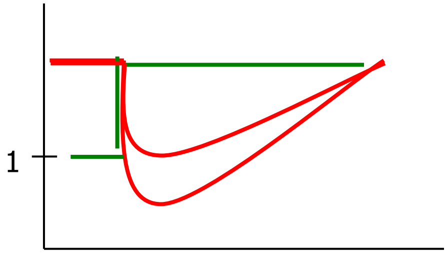
Net Output



Change in Work Intensity – Impact on …