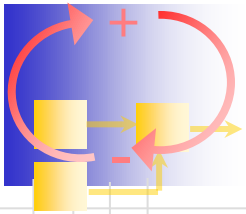
ESD.36 System Project Management

Lecture 13



Project Dynamics Applications and Cases

Instructor(s)

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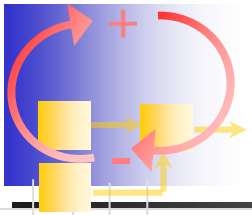
November 1, 2012

Massachusetts Institute of Technology



Today's Agenda

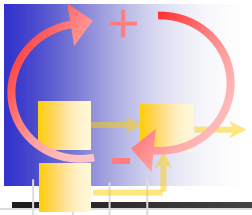
Managing Changes

- Case Example – Dispute Resolution
- Case Example – Change Management

Project-to-Project Learning

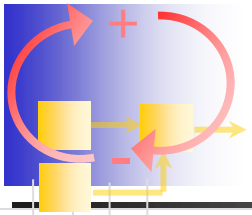
- Case Example – Risk Management
- Case Example – Bidding and Management

Broader issues – project portfolios, priorities and market interactions



SD Qualitative Insights – 3

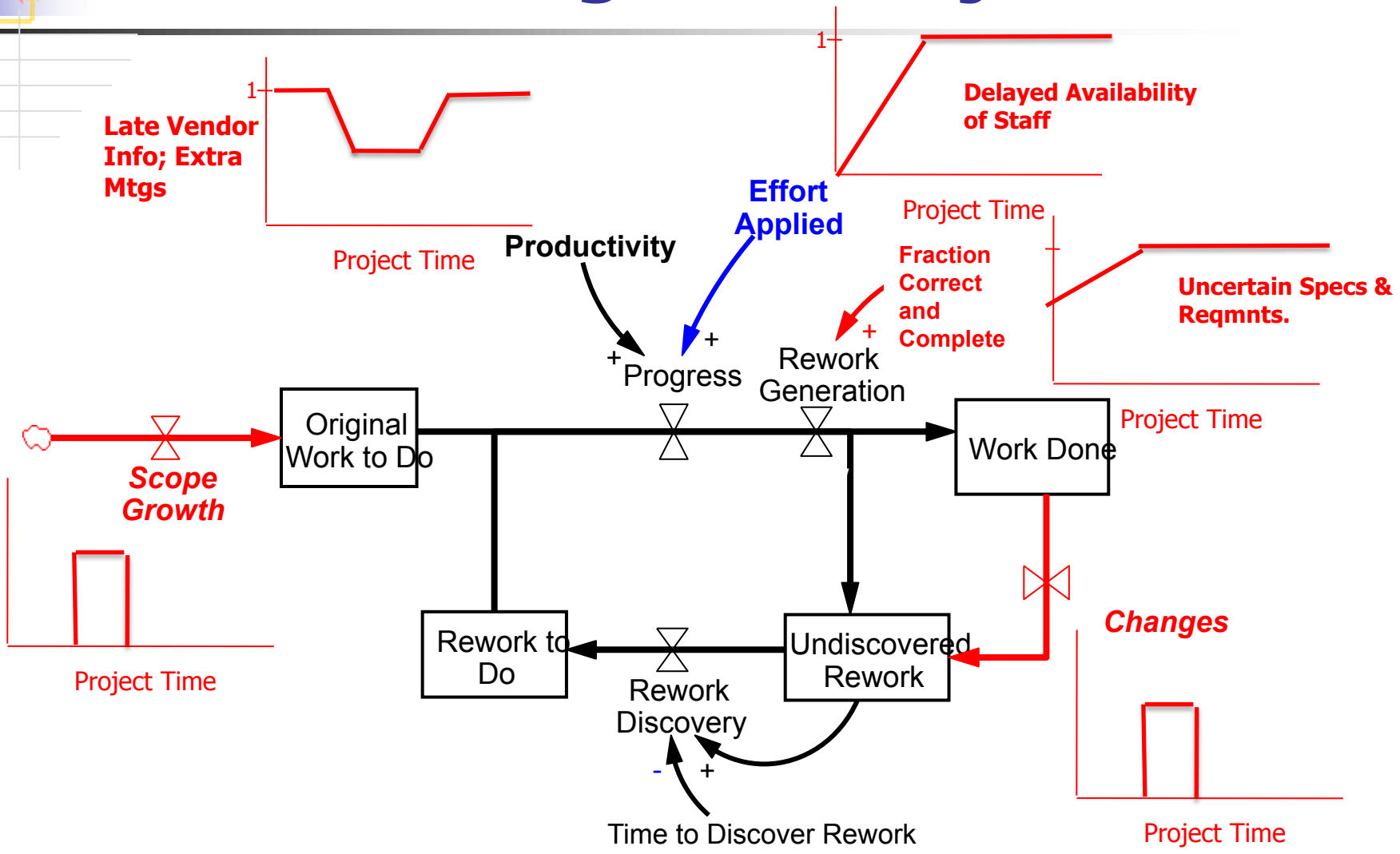
4. Attempts to achieve an infeasible plan via project control actions lead to "vicious circle" side effects which increase project cost and duration.
   - On complex projects, these costs usually exceed the "direct" costs of infeasibility
5. Project "changes," and risks which materialize, are fundamentally the same as an infeasible plan. *(Lecture 13)*



Using an SD Model in Practice

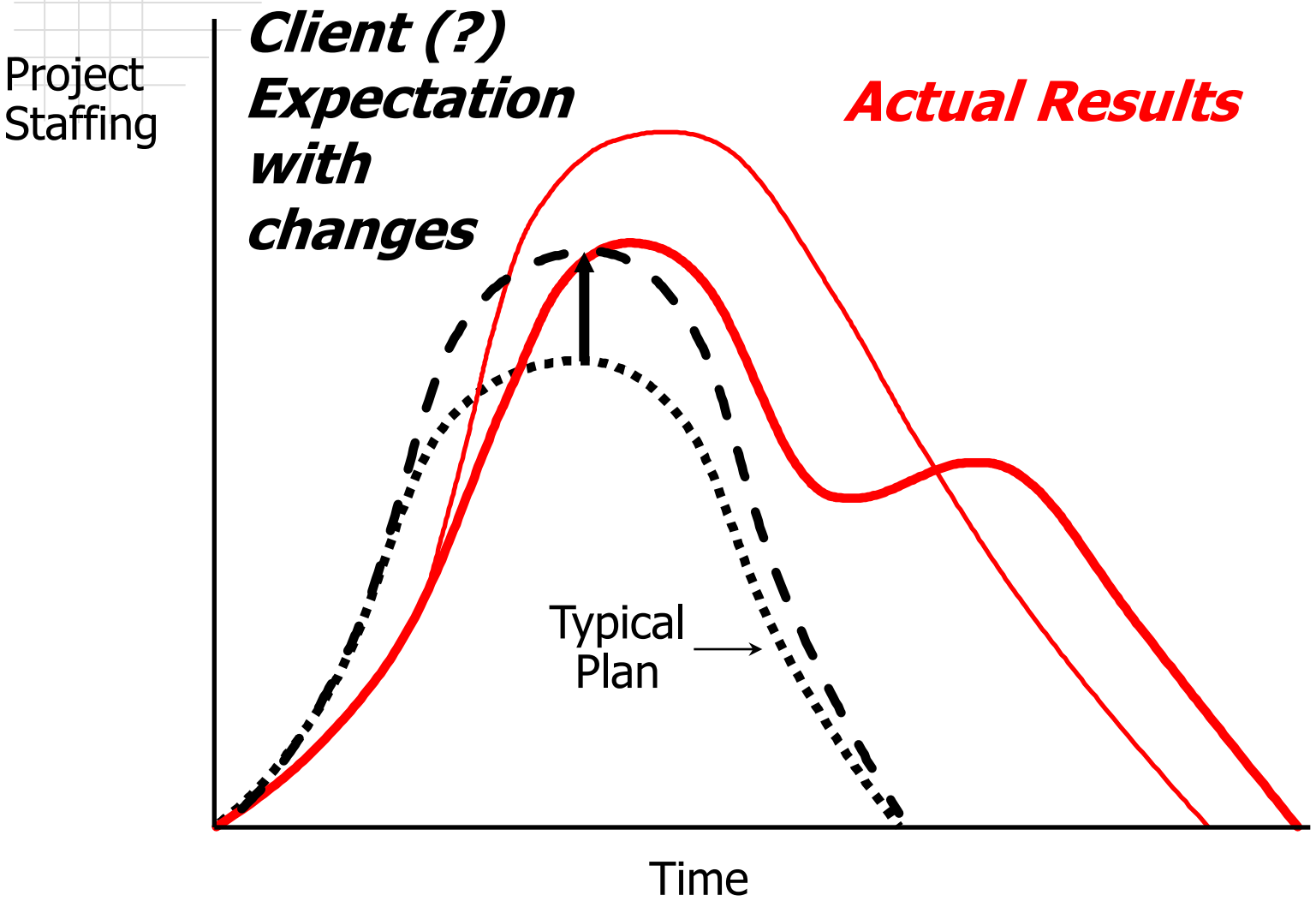
1. Set up model to represent project plan (the plan should reflect normal amounts of rework)
2. Specify exogenous inputs for all changes to the plan as they occur(ed) (external and internal, including new policies or processes)
3. Refine parameter and change estimates via model calibration (usually after project completion)

Direct Changes to Project Plan



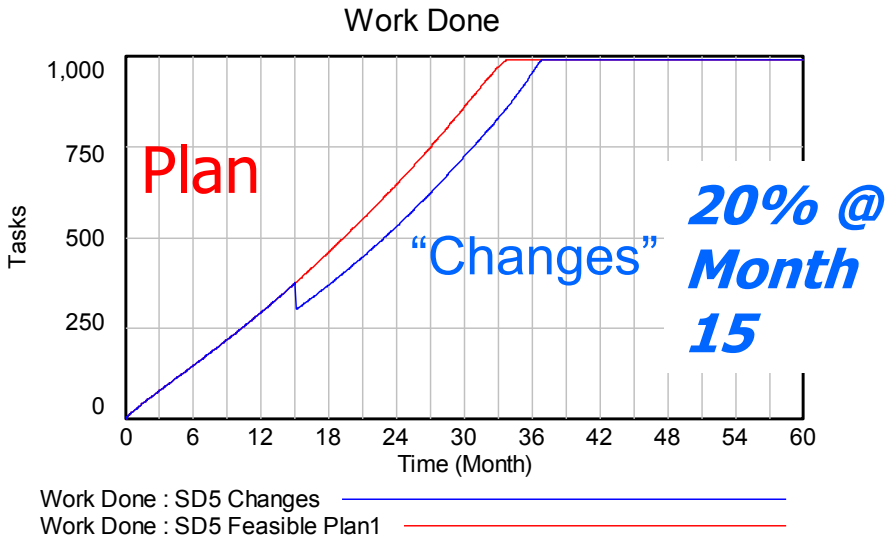
Typically many small changes, rather than one large change.

Project Behavior: 50 – 100 % Overrun

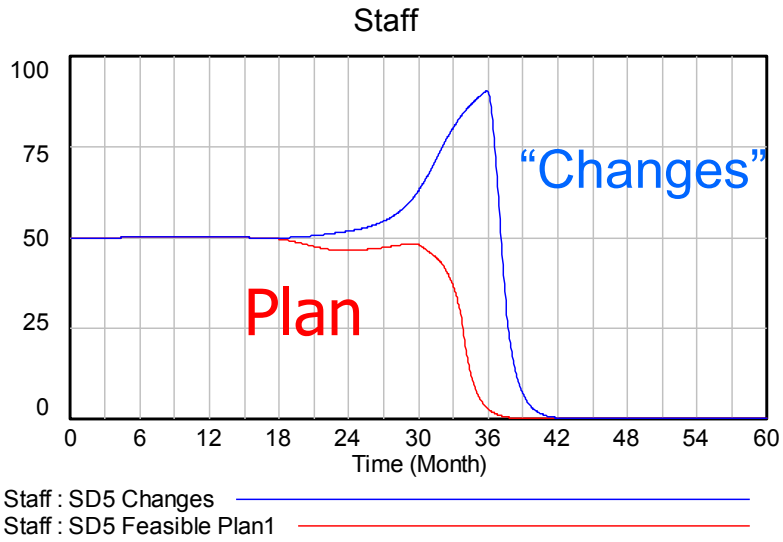


Example: Changes Obsolete Work

Work Done



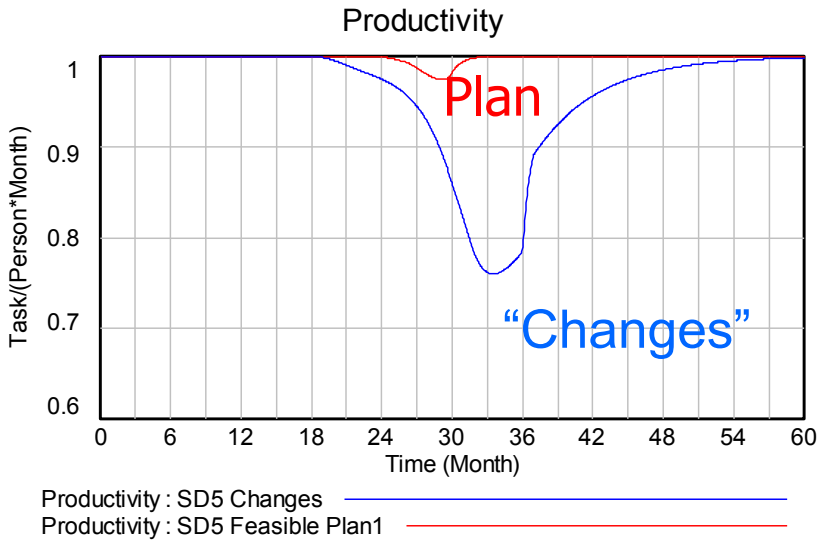
Staff Level



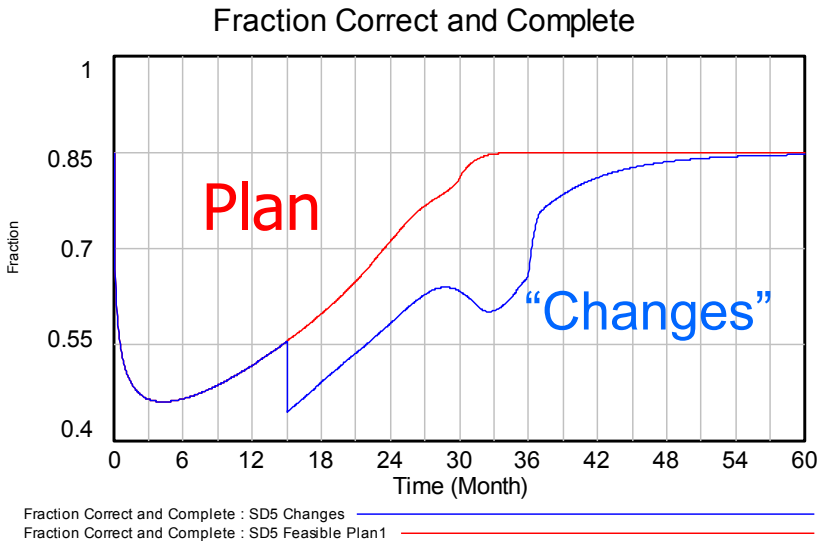
7% Tasks Redone → 28% Cost Increase! 4X Multiplier

Because of Lower Productivity and Fraction Correct

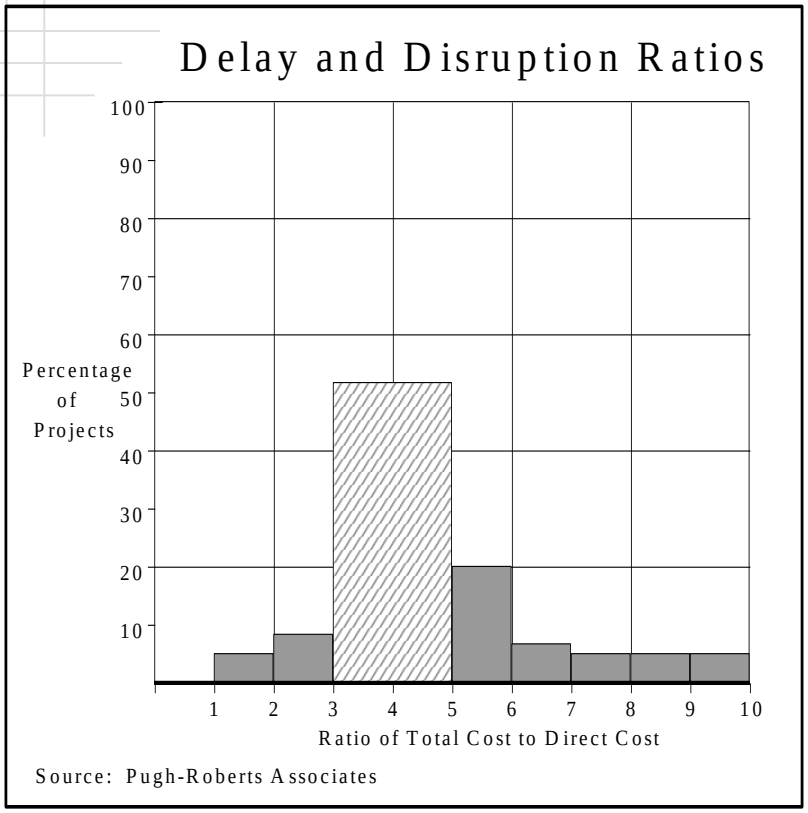
Productivity



Fraction Correct



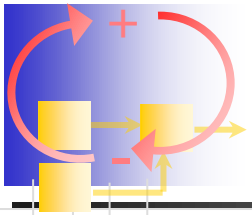
Data on "Multiplier"



Costs snowball, increasing non-linearly with:

- ***Cumulative magnitude of changes;***
- ***Duration and lateness in project***

Data: Ratio of total cost increase to direct cost increase 3-5X



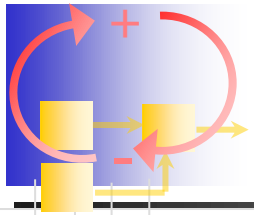
Consequences …

- **If contractor/client relationship →**

Disputes

- **If internal development →**

Risks materialize



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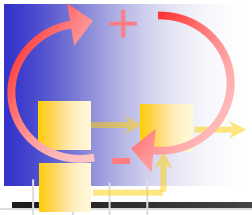


How SD in Project Management got started: Ingalls Shipbuilding vs. US Navy

- Ingalls Shipbuilding won contract for 9 LHA's and 30 DD963 destroyers in 1969 and 1970.
- 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

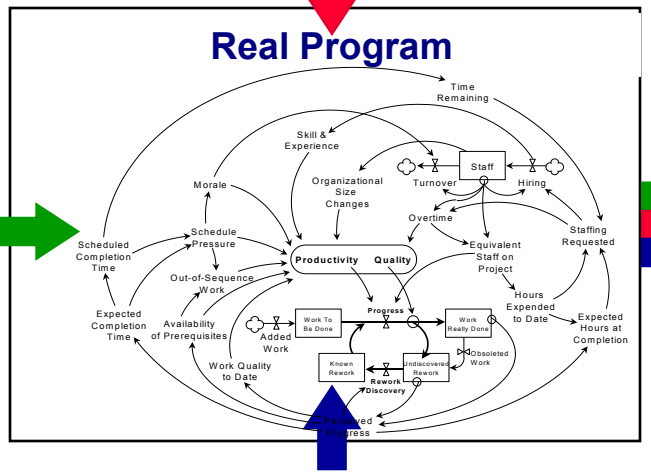
Assessing the Impact of Changes

Step 1: Recreate Program History (Project Plan + Changes)

Customer-Responsible Events & Conditions

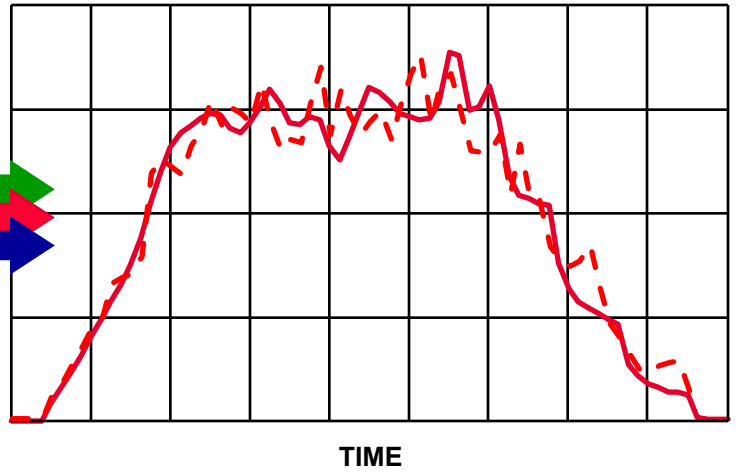
Planned Program Conditions

Real Program



Company Actions

Total Program Labor (Equiv. People)



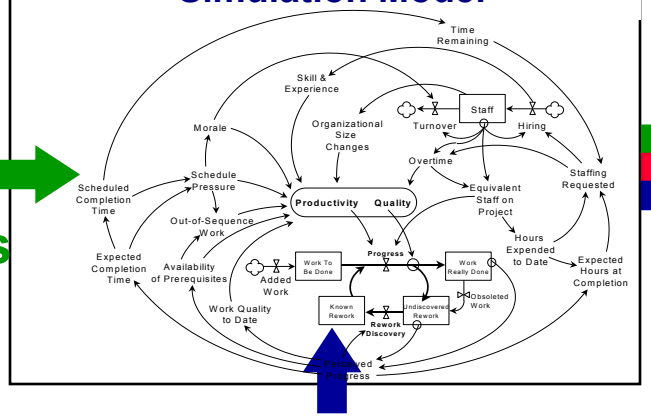
Assessing the Impact of Changes

Step 2: Remove Direct Impact of Changes – "But for …"

Customer-Responsible Events & Conditions

Planned Program Conditions

Simulation Model



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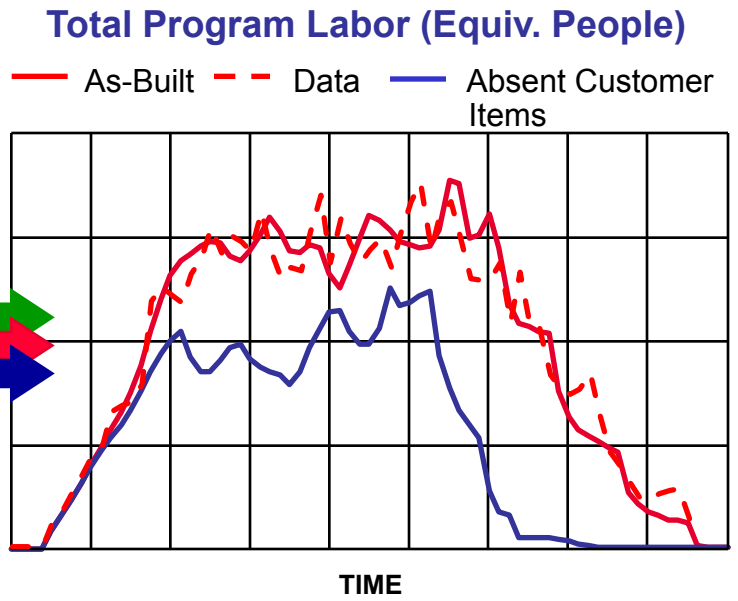
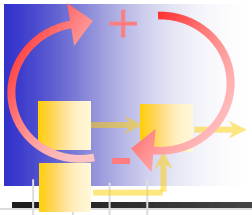


Company Actions

Changes removed in reverse chronological order to test cumulative impact.



Assessing the Impact of Changes

Step 3: Difference is cost "but for" client impacts, including secondary impacts.

Budget

+ Other Sources of Cost Overrun

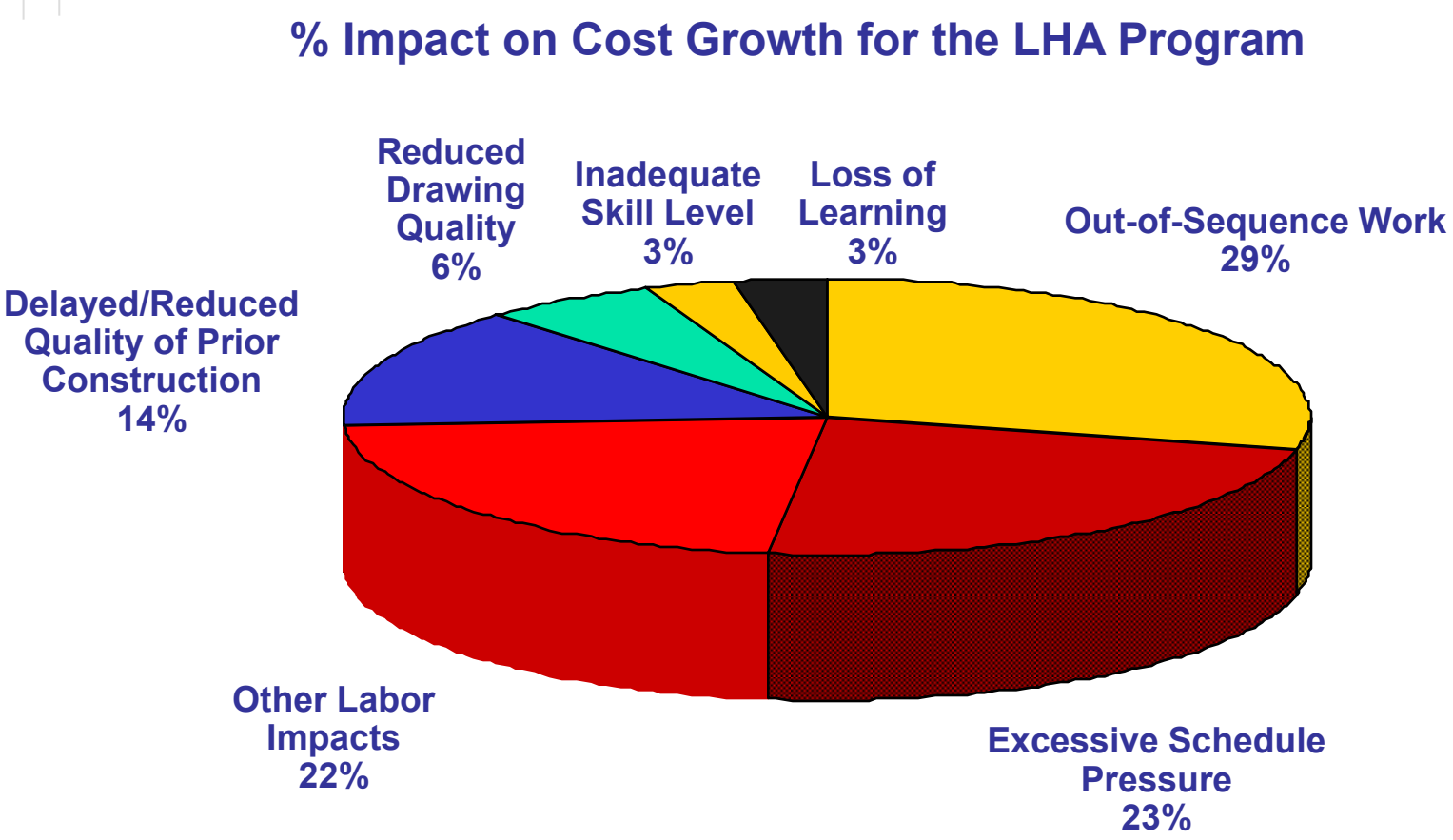
+ Direct Cost of Changes

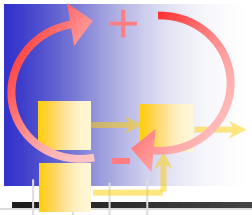
+ Indirect Cost of Changes (1-10 X Direct)

} ***Client Responsible Costs***

Total Project Cost

D&D Results from Impact on Productivity & Fraction Correct of Unchanged Work

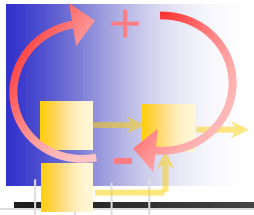




The Navy's starting position

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

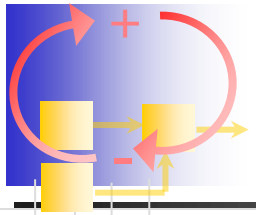
But after a review by MIT System Dynamics Professors …



How it all got started: Ingalls Shipbuilding vs. US Navy

- Case settled out of court for $447 million
- Model-generated analysis was the basis for $200-300 million of the claim.

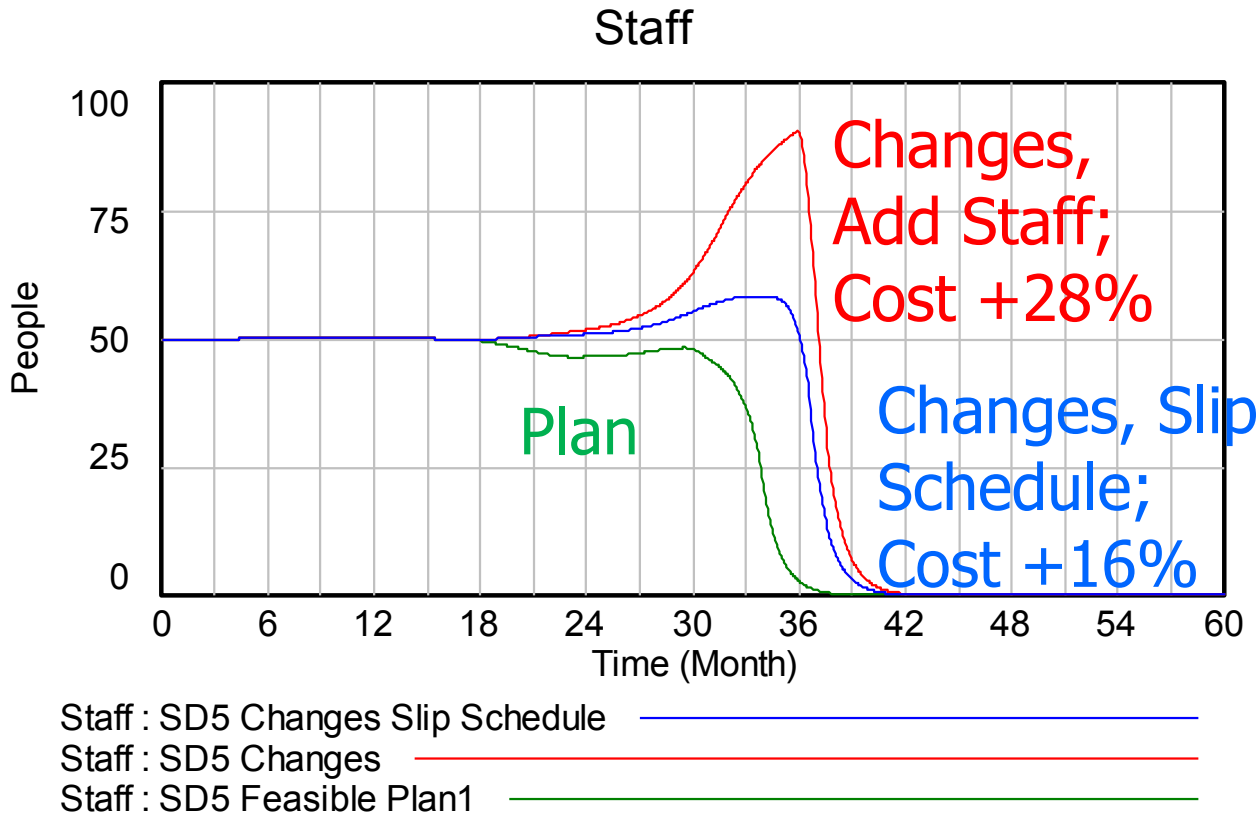
Source: Cooper, Kenneth G., 1980, Naval Ship Production: A Claim Settled and a Framework Built. *Interfaces.* 10(6) (December), 20-36.



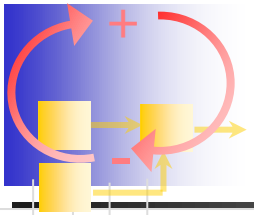
Since the beginning ...

- More than 50 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 150 "proactive" applications
  - In excess of $25 million in consulting fees
  - Conservatively saved clients $5 billion on cost and schedule performance

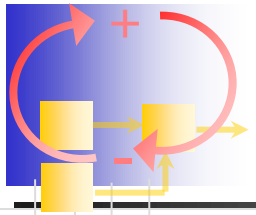
Managing Changes Proactively: Schedule Slip Mitigates Impact



7% of total scope directly redone (some multiplier inevitable b/c of technical interdependence)



Why, in face of changes, don't firms consider schedule slip (or price for full impact)?



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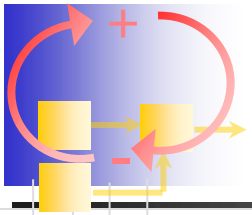
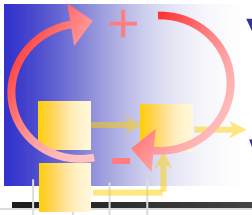


Case Example: Fluor Corporation

"*Architect to Industry" ($20 billion annual revenue)*

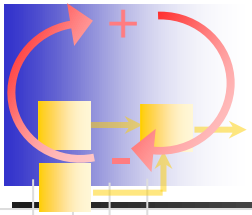
- Highly centralized
- Resistant to change
- Business line specific cultures
- Highly diversified
  - Energy (production, refining, chemicals, power)
  - Commercial (hotels, office buildings, concert halls, food products)
  - Industrial (mining, pharma/bio, manufacturing, consumer goods)
  - Infrastructure (airports, hospitals, highways, high speed & light rail, ports)
  - Federal Government - DOD, DOE (nuclear fuel cycle), DOS



"Improving change impact management is vital to corporate performance"*

- Waiting to recover for owner-induced change impacts via a dispute process is risky, expensive, and ***precludes impact mitigation***
- "Project changes represent the single largest source of project productivity impact" (2002 Fluor survey)
- Changes do not increase project profits, but in fact are a source of profit reduction

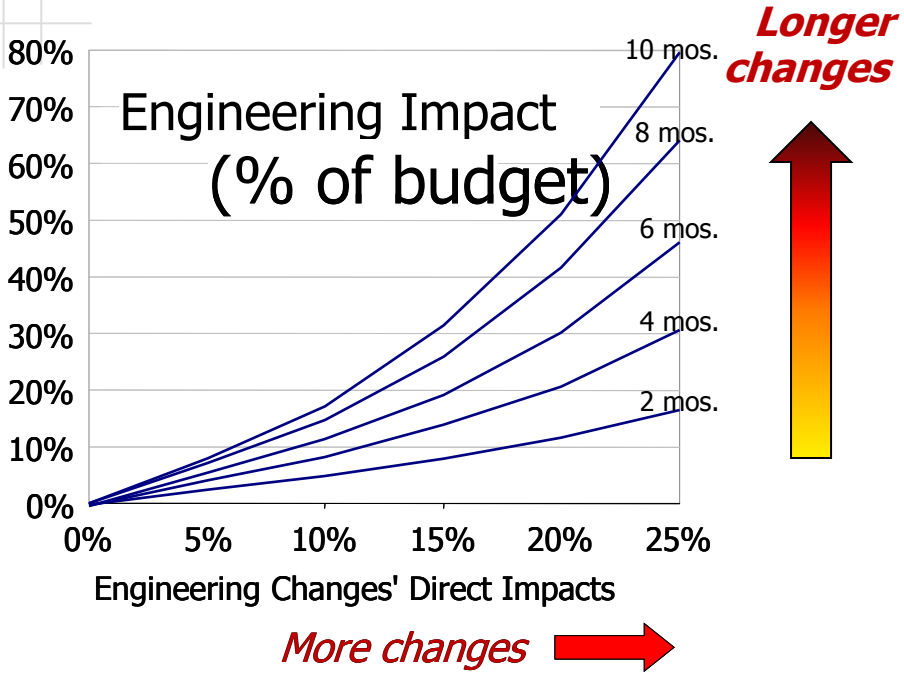
***Greg Lee, Senior VP**

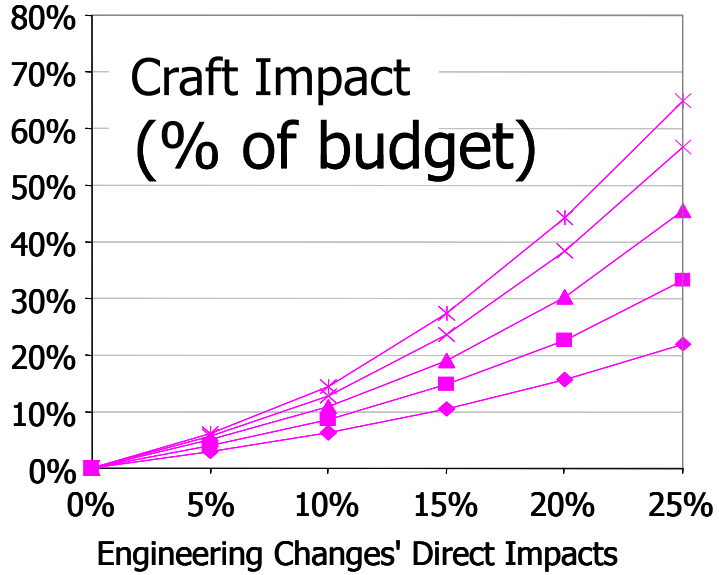


Change Impact Revenue Loss %

Proprietary Information

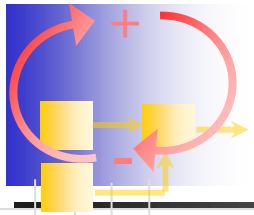
Cost Impacts of Change – Results in *Profitability Loss from Planned Rates*





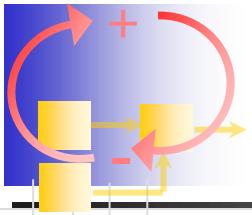
Learning Point: More and later changes create not just more impact, but disproportionately more impact.

Note: while these results are from a simulation model, an analysis of actual project results by Greg Lee of Fluor clearly demonstrated that projects which experienced more and/or longer change suffered reduced profitability from planned levels. "Changes" are not advantageous.



Fluor Now Uses SD Model as Basis for Change Management

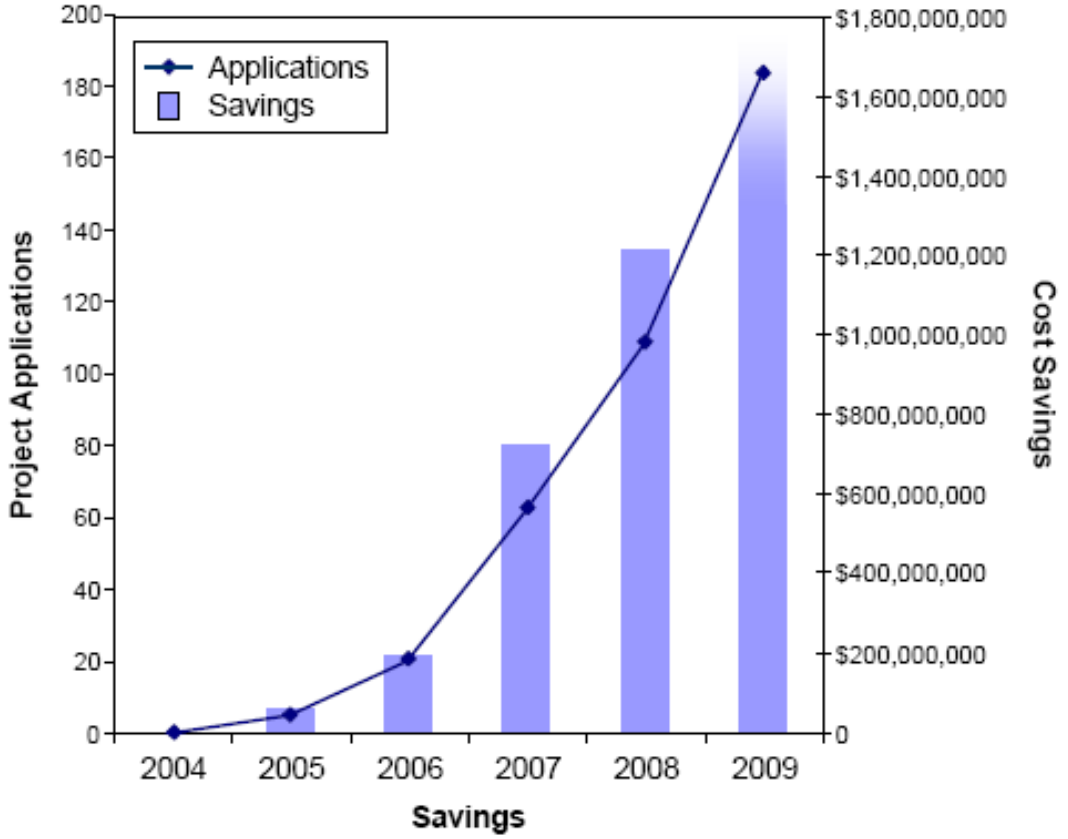
- Model set up and tailored to each engineering & construction project
- Used to:
  - Foresee future cost & schedule impacts of project changes & events
  - Explain "secondary impact" to clients
  - Price changes to include the full and cumulative impact for appropriate cost recovery
  - Find mitigating actions to reduce client costs
    - Avoid late changes
    - Resolve proposed changes quickly
    - Delay start/end of construction



Forecast Accuracy -- Fluor

- Quotes for project teams:
  - "The tool simulated our staffing almost perfectly."
  - Another team described how, contrary to expectations, the model foretold a different pace of engineering progress yet to come, an outcome that occurred just as simulated.
  - Yet another project team told of the "uncanny accuracy" from the simulation as the project progressed.

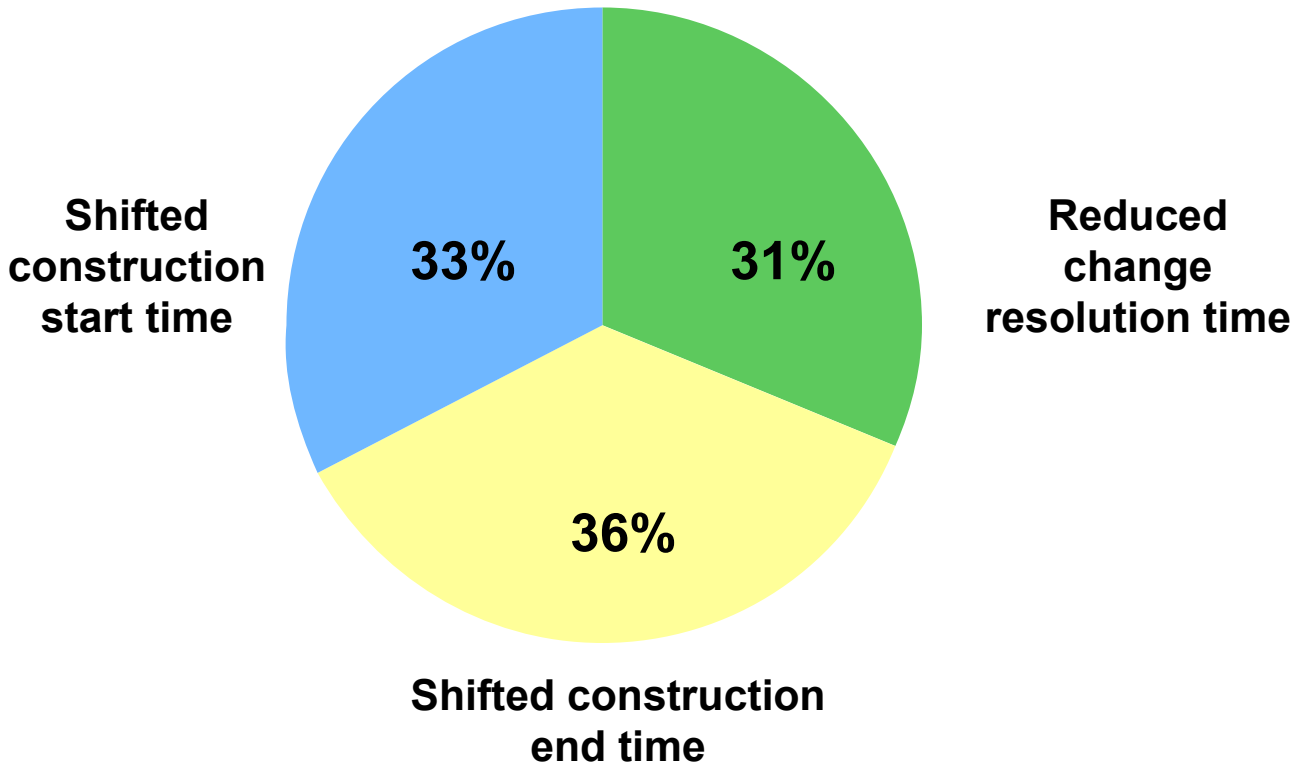
Cumulative project applications and benefits are growing strongly



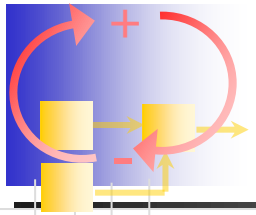
Hundreds of project managers and planners have been trained in the ongoing internal use of the system.

Cost impact savings come from different mitigations

Over $1,600 million savings from…

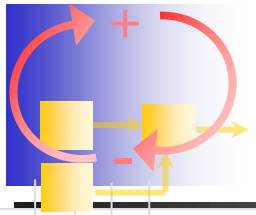


(All schedule shifts tested were less than or equal to the amount of engineering delay caused by changes)



Award-Winning Work

- Designation by Engineering Construction Risk Institute (ECRI) as "*Industry Best Practice*"
- *2009 System Dynamics Society Applications Award & 2011 Edelman Laureate*



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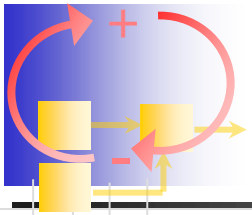
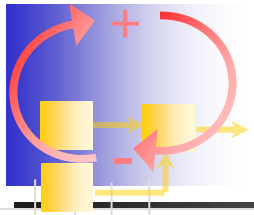


Project-to-Project Learning

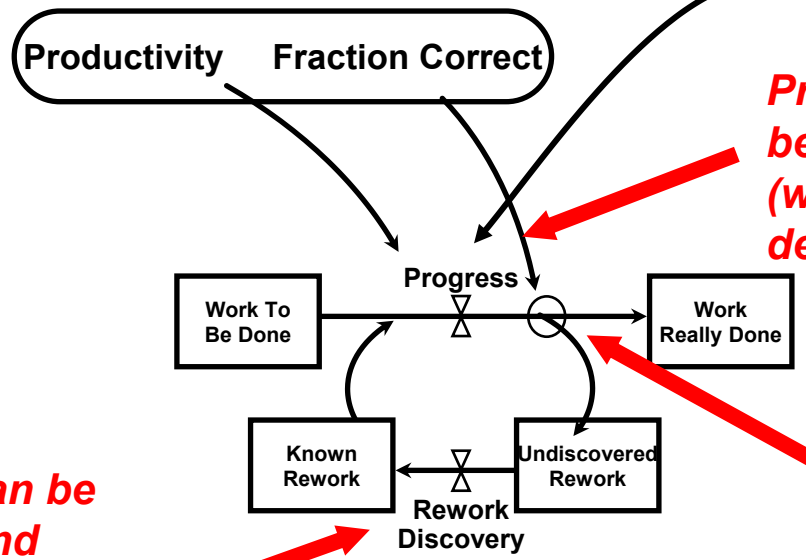
- Improve estimation and planning
- Assist in risk identification and quantification
- Determine effective processes and management actions



Useful Estimating & Planning Information

- Scope (tasks done)
- Rework
- Undiscovered rework profile
- Rework discovery profile
- Pattern of productivity and fraction correct

Data for estimation and control



Staff and Overtime

Cumulative effort

Progress Can be Measured (with some delay?)

But, the split cannot be determined as it is happening

Rework discovery can be measured and used to estimate split after the fact

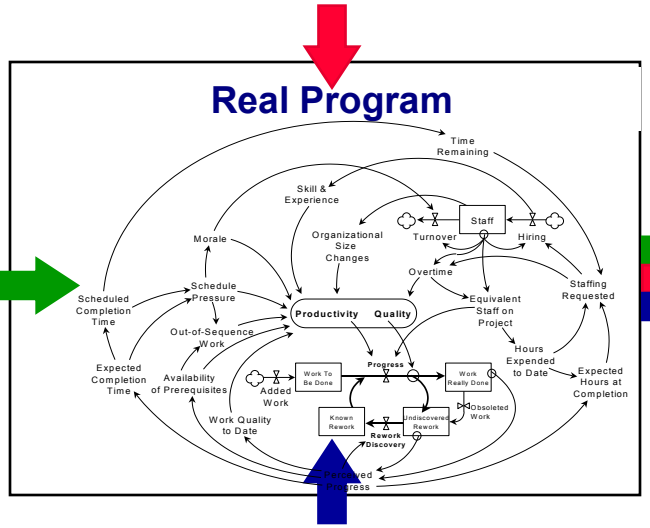
Cumulative work done

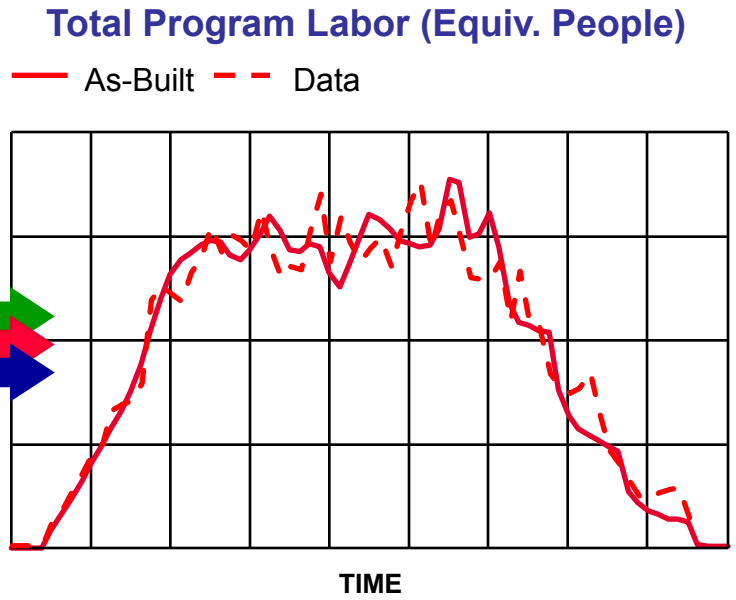
Risk Assessment

Analyze what happened on prior projects …

Changes to Plan

Planned Program Conditions (Plan)

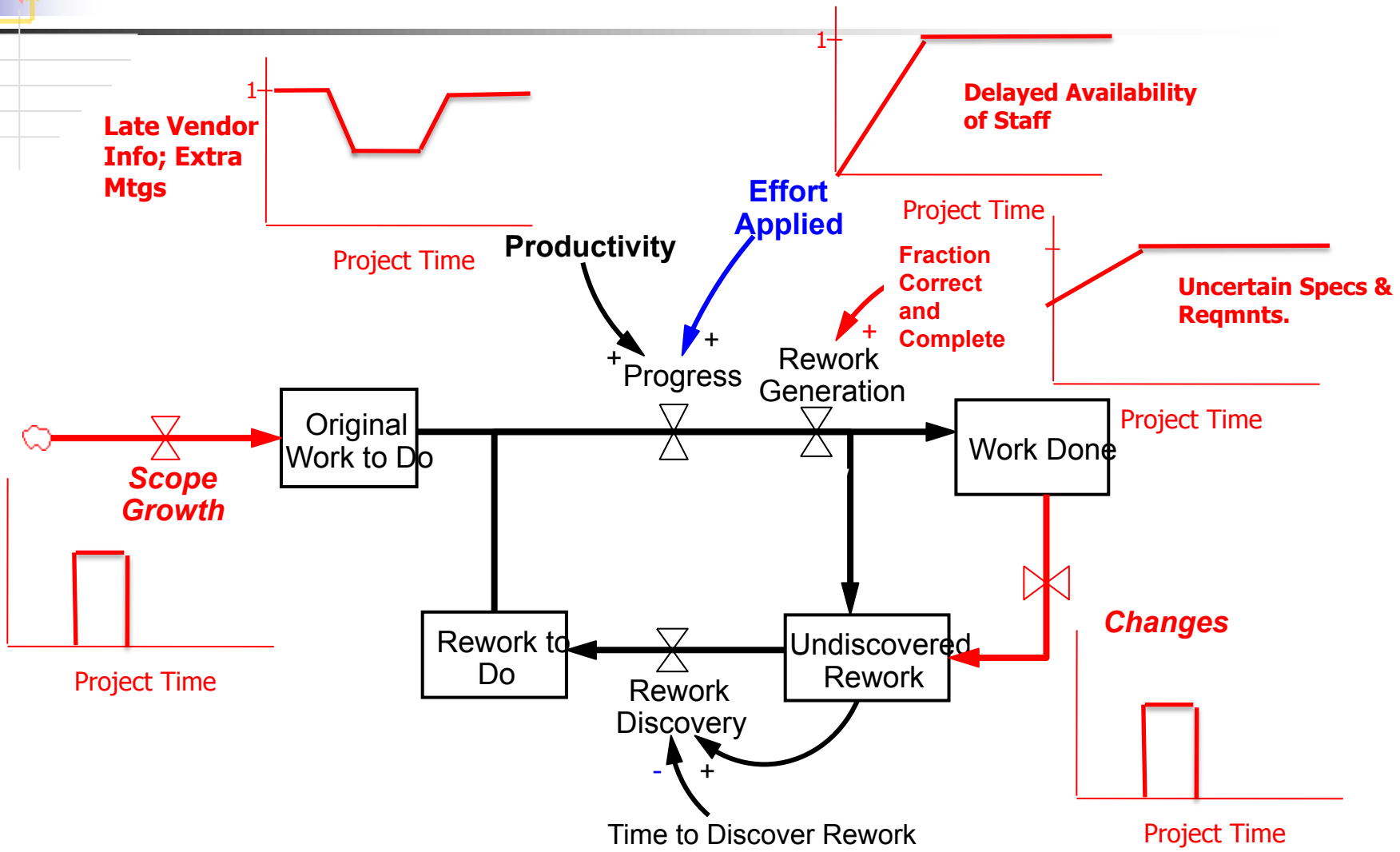




Management Actions

Large data bases of project performance histories; Scientific assessment of project performance: What happened and why, using "claims" process?

Data for Risk Assessment



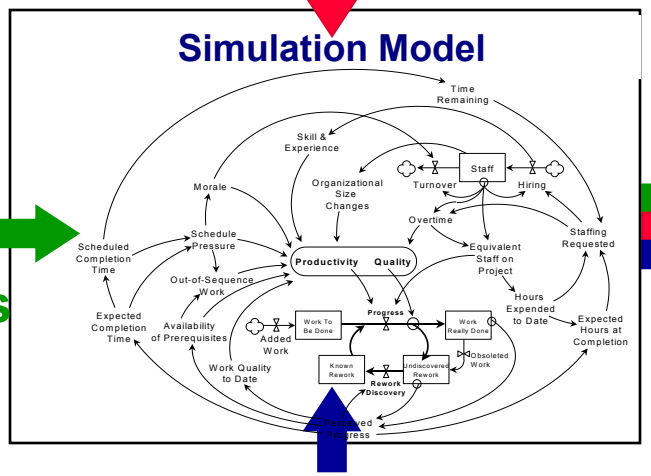
➔ ***Accumulate a data base of exogenous impacts***

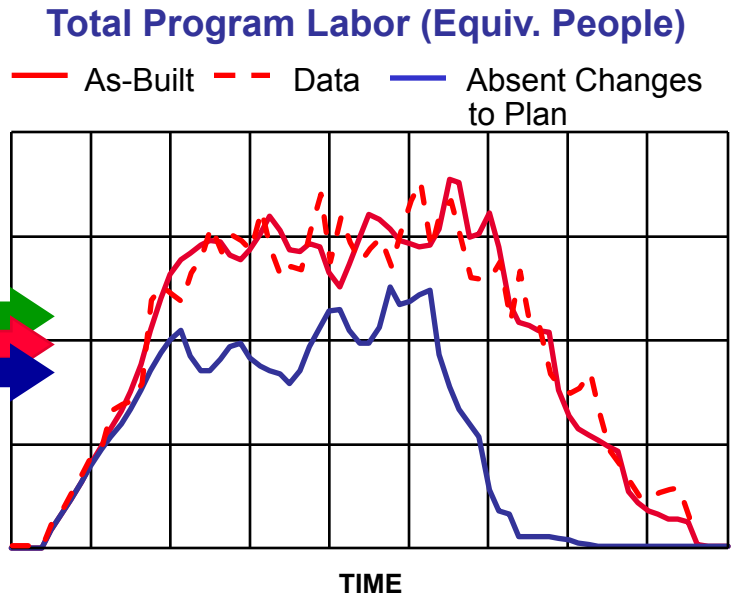
Identifying Risks for Future Projects

Identify, quantify & "remove" direct impact of all changes

Changes to Plan X

Planned Program Conditions





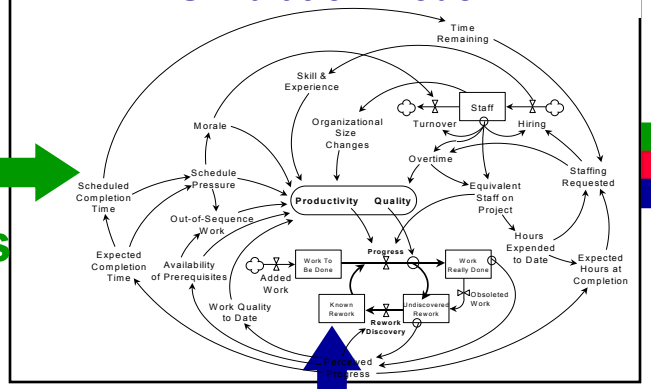
Management Actions

Identifying Effective Policies

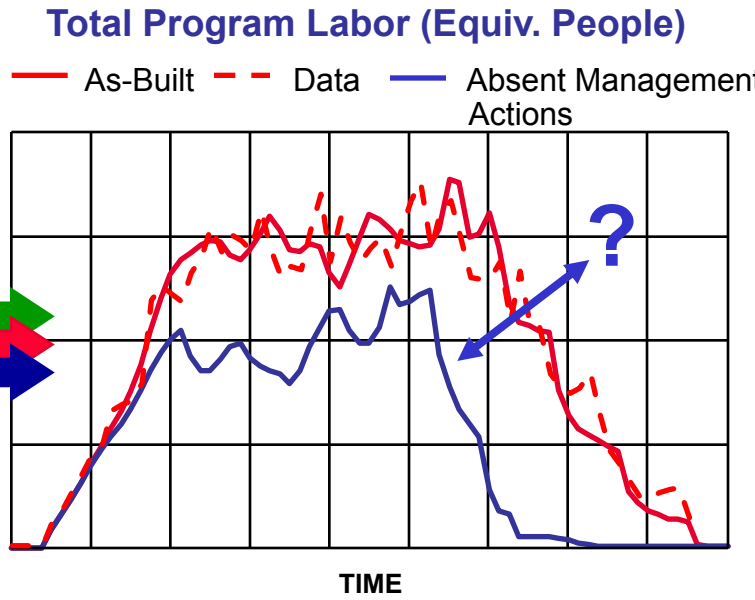
Changes to Plan

Planned Program Conditions

Simulation Model



Total Program Labor (Equiv. People)



Management Actions

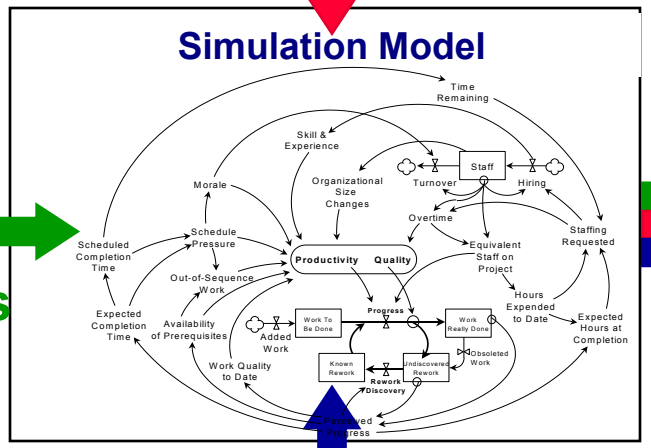
Identify, Quantify & Remove

Estimation: What Would Project Have Cost?

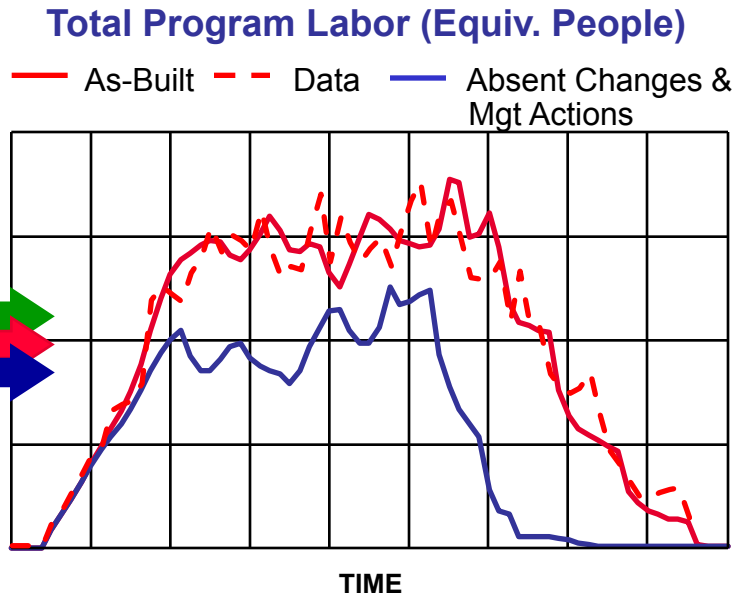
Change to Plan

Simulation Model

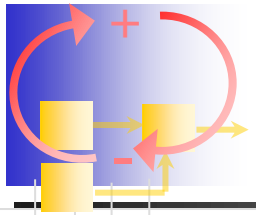
Planned Program Conditions



Management Actions



Note for projects: this is the process you might use for a post-mortem SD model

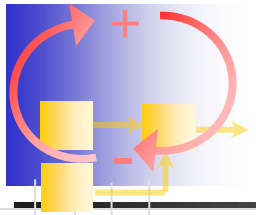


Example – Automotive Development

Post-mortem assessment of 11 projects using SD model – major sources of risk ranked in terms of impact on schedule and delivered:

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

Model used to price out mitigation savings for typical risks



Today's Agenda

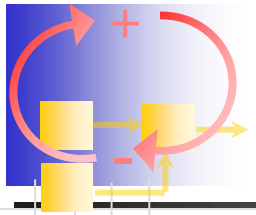
Managing Changes

- Case Example – Dispute Resolution
- Case Example – Change Management

Project-to-Project Learning

- Case Example – Risk Management
- Case Example – Bidding and Management

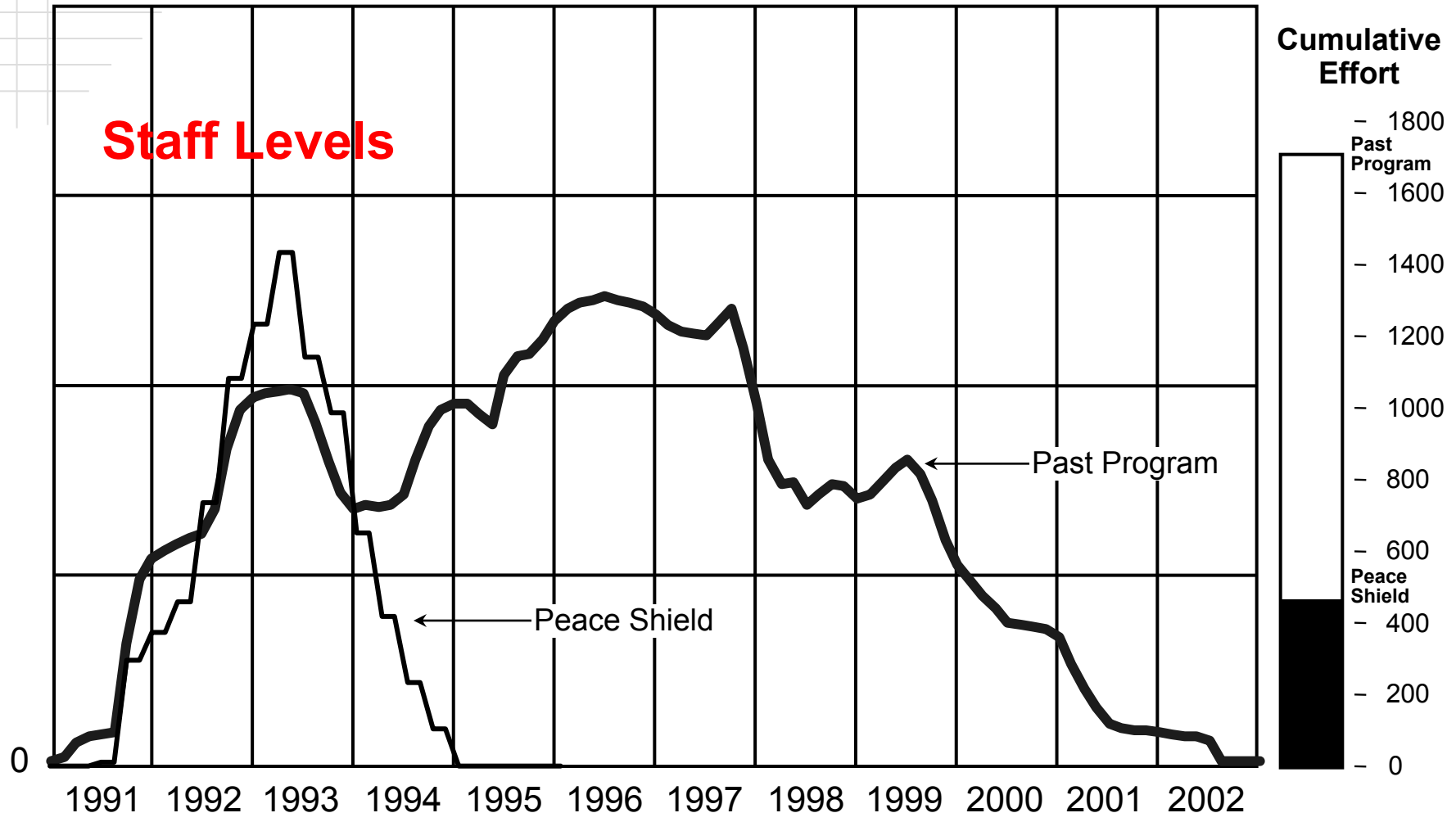
Broader issues – project priorities and market interactions

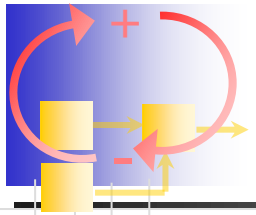


The Peace Shield Program

- Air defense system developed by Hughes AC
- System dynamics model was used for:
  - Bid support and risk assessment;
  - On-going project management (assessing impact of process and staffing changes)
  - ***Program successfully completed on time and on budget***
- ***Post-project learning and policy assessment***

Post-project learning ...





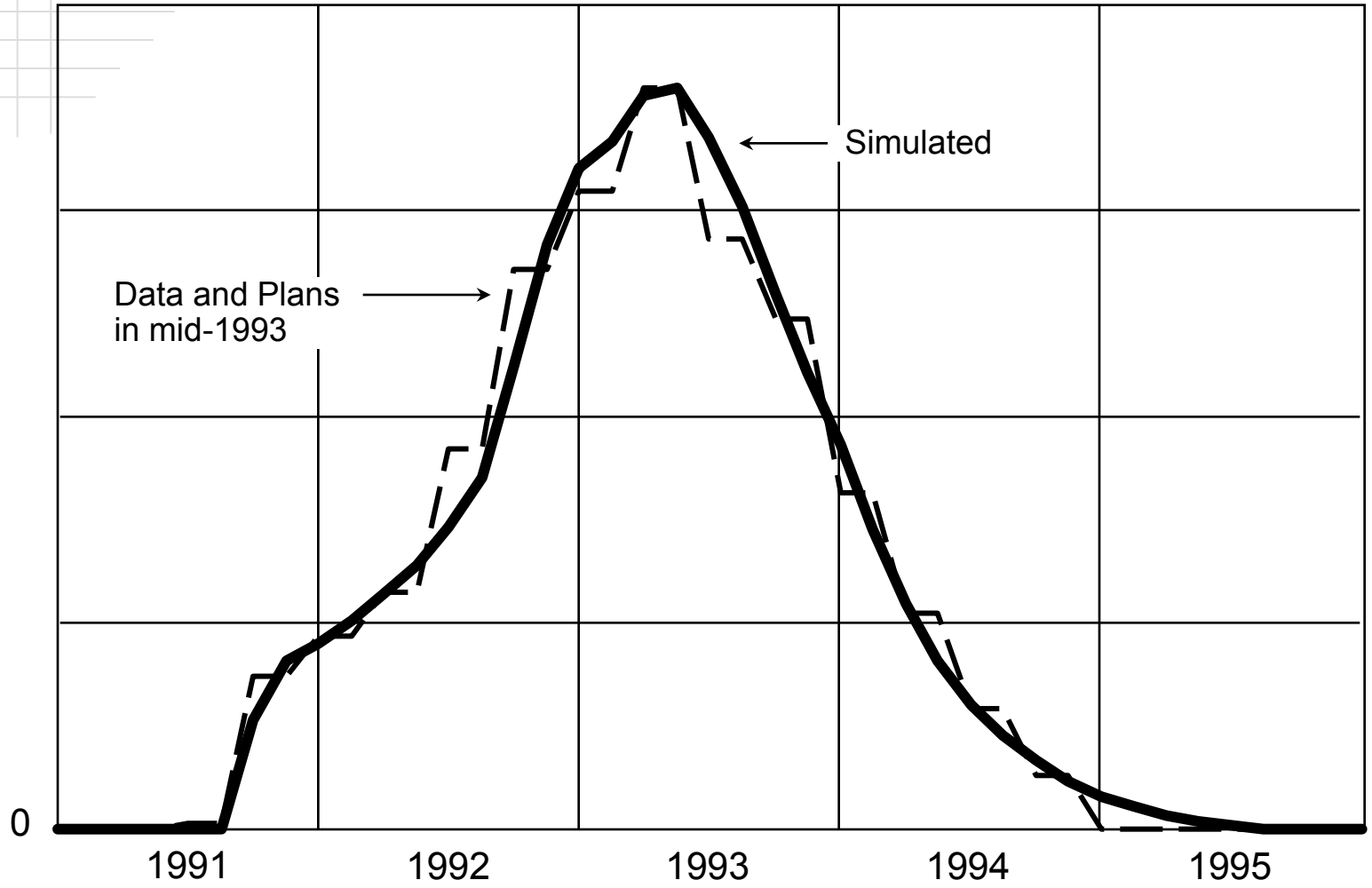
What caused the differences between Peace Shield and Past Program?

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

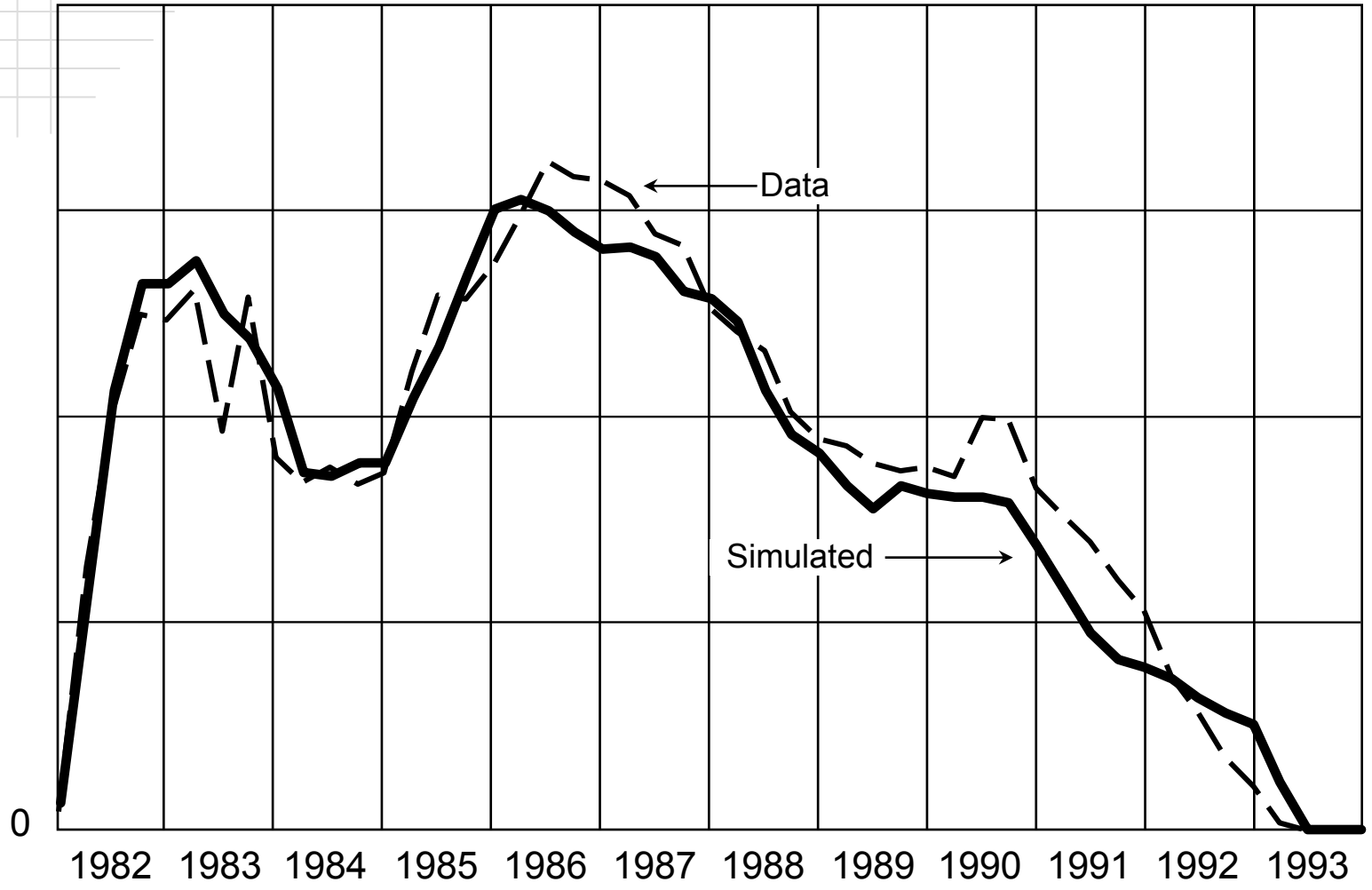
And how can a company learn from these differences, and therefore

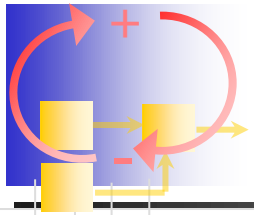
- Bid better?
- Plan better?
- Manage better?

The same model with different exogenous "change" and "management" inputs accurately replicated Peace Shield



… and the Past Program



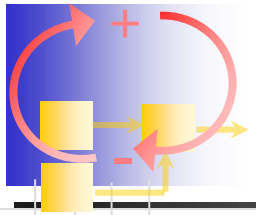


Major external differences

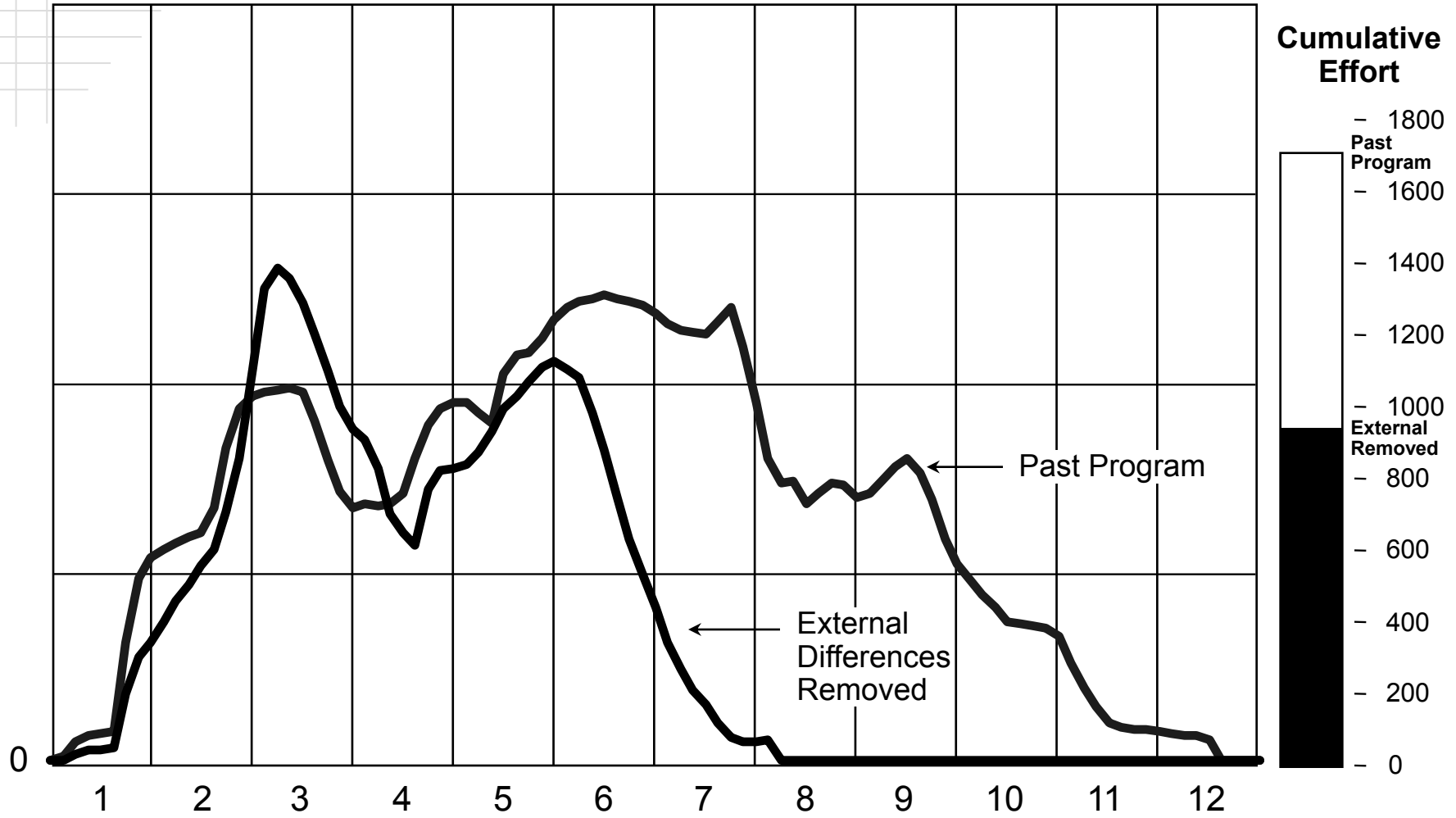
Peace Shield --

- 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 ...



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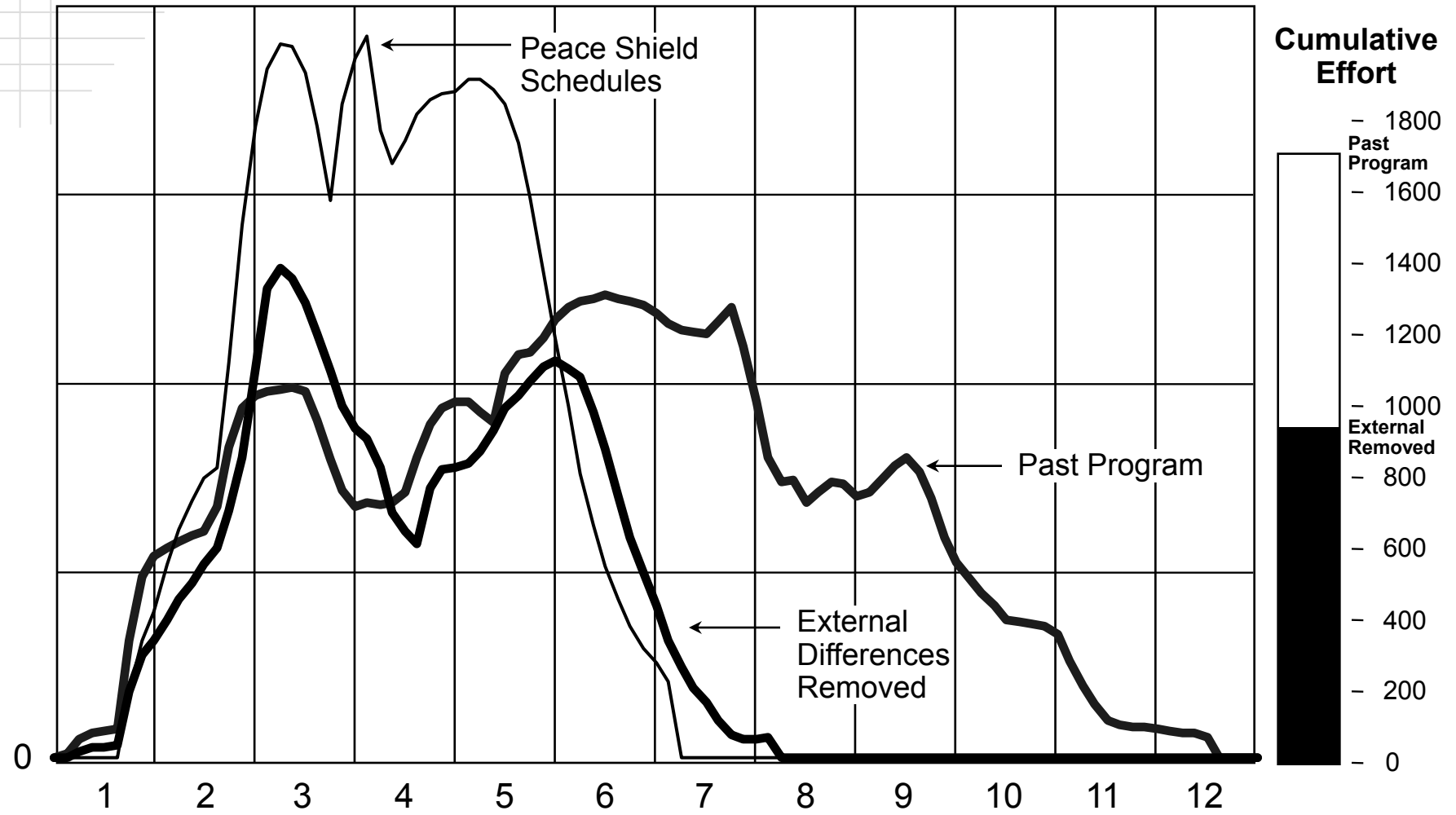
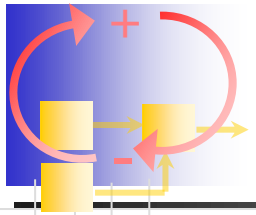




Management differences

Peace Shield --

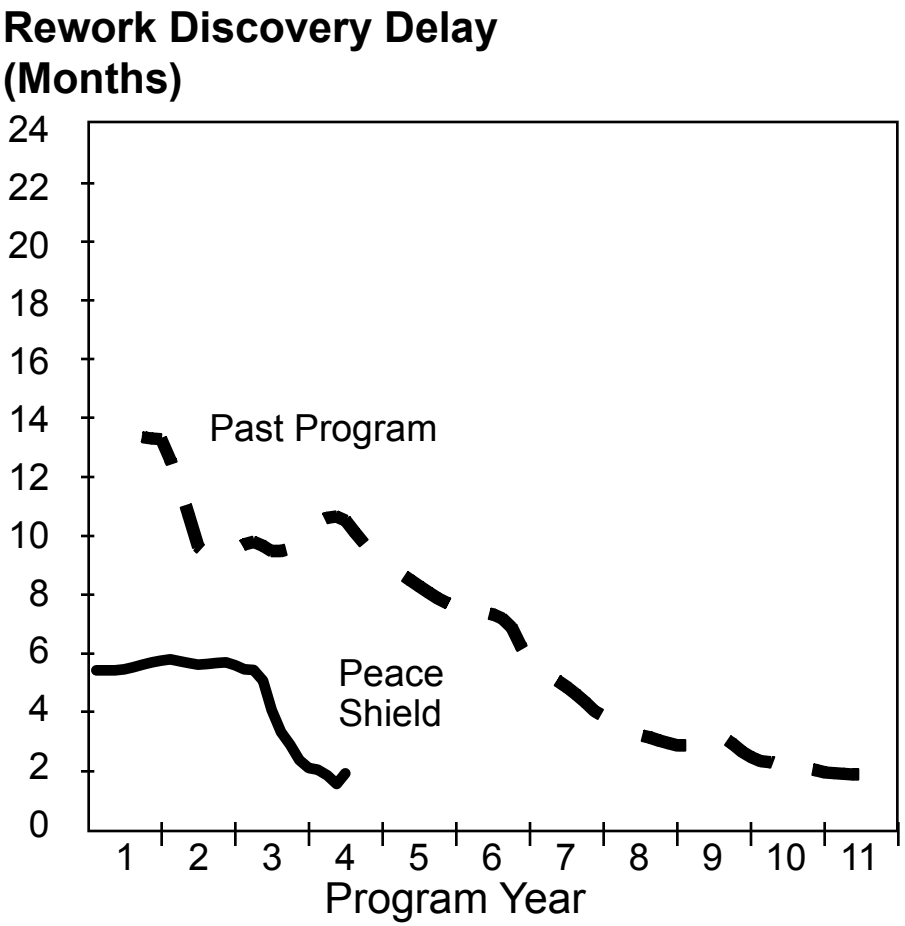
- Adopted teaming structure, including customer involvement in design reviews

➔ ***Lower productivity, faster rework discovery***

- Different phase overlap & staffing strategy:
  - Assigned staff "rolling off" to QA
  - Delayed start of downstream work

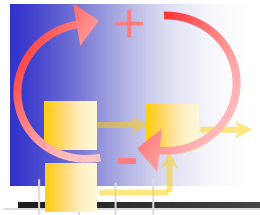
➔ ***Minimize "Errors on Errors" dynamic even if reported progress is lower***

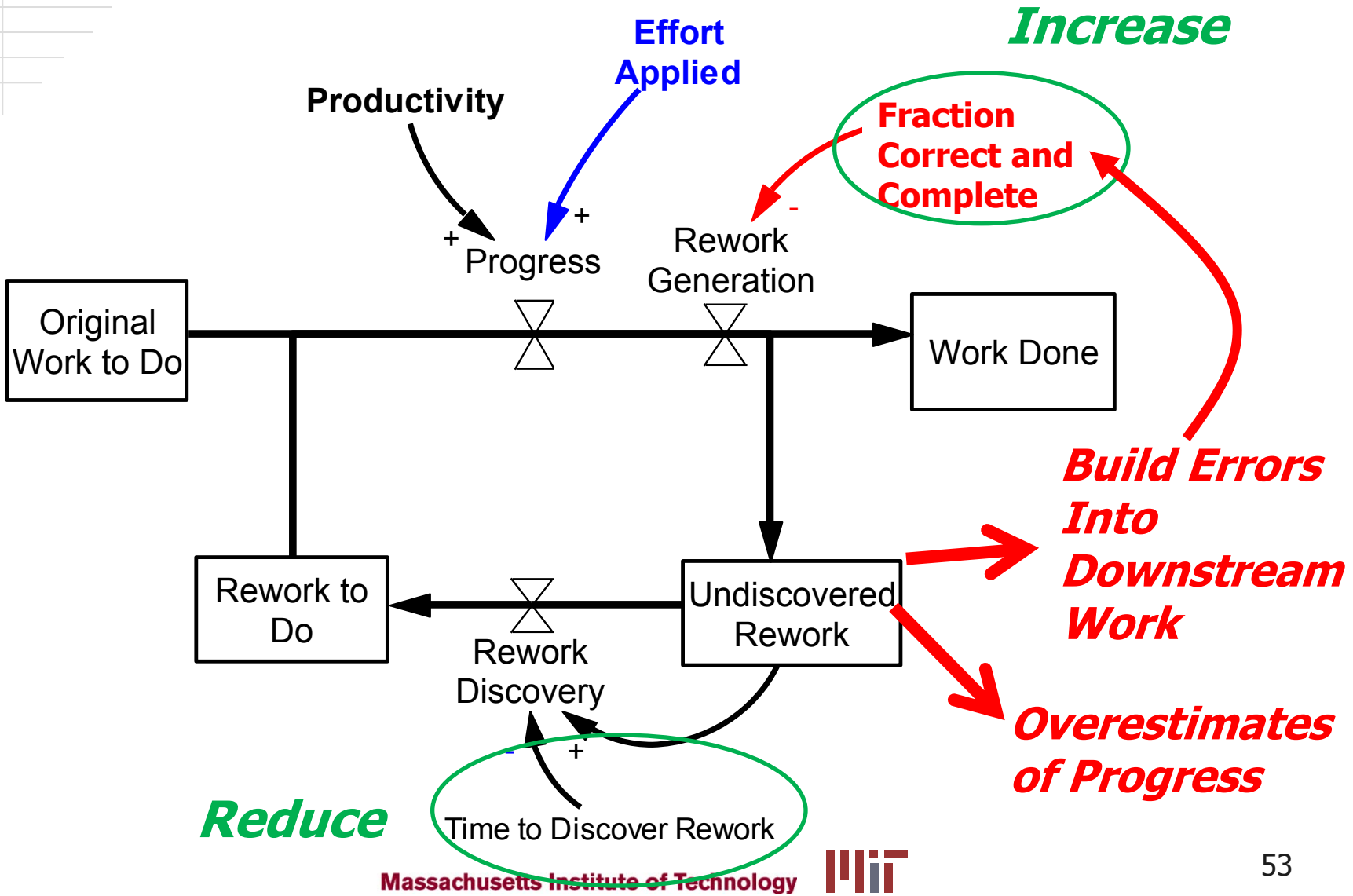
Shorter Rework Discovery Times on Peace Shield: Reduced "Errors on Errors" dynamic



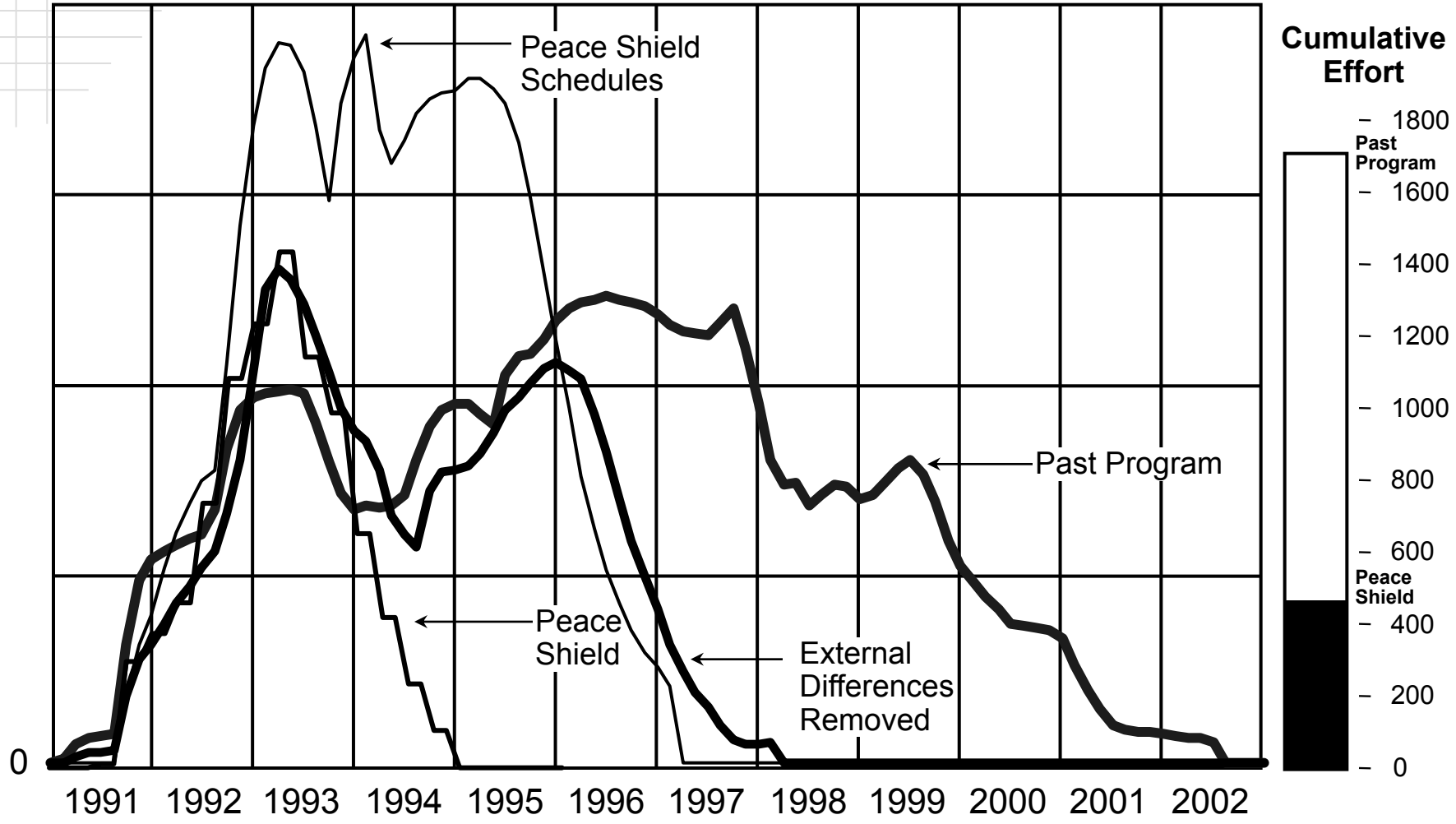
- **Teaming**
- **Delayed Roll-off of Staff**
- **Customer involvement in Design Reviews**

Lesson: Recognize the rework cycle and minimize its consequences

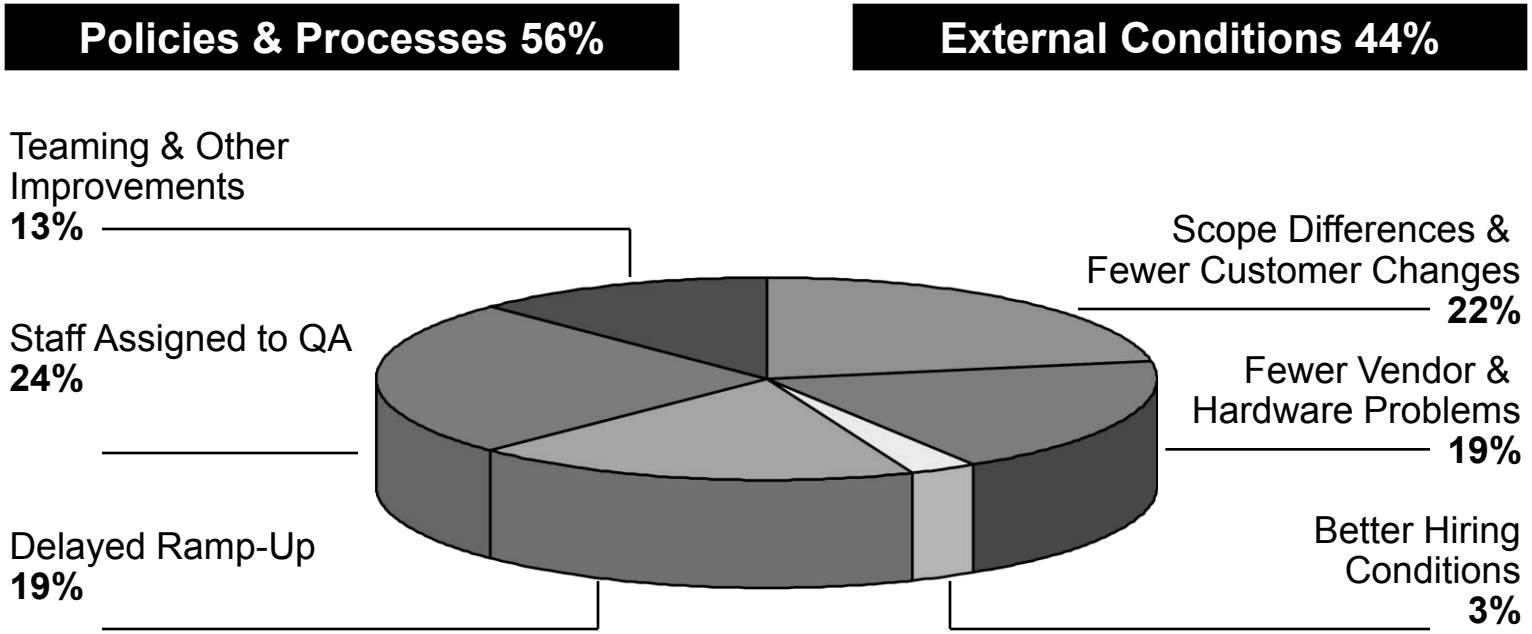




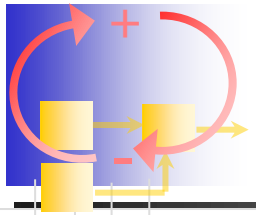
Removing management differences ...



Where Did The Cost Improvement Come From?



These are "free" cost savings!

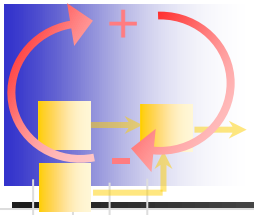


Sources & Additional Reading

Ingalls: Cooper, Kenneth G., 1980, Naval Ship Production: A Claim Settled and a Framework Built. *Interfaces.* 10(6) (December), 20-36.

Fluor: http://www.kcooperassociates.com/files/SD_Paper_for_Reprint_V3.pdf

Peace Shield: James Lyneis, Kenneth Cooper, and Sharon Els, "Strategic Management of Complex Projects," *System Dynamics Review*, Fall 2001 (on the course site)



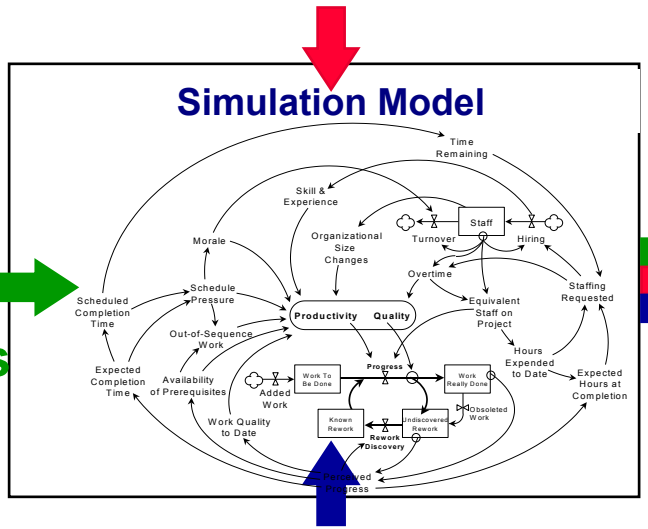
Why Do Organizations Seem So Poor at Learning Lessons From Prior Projects?

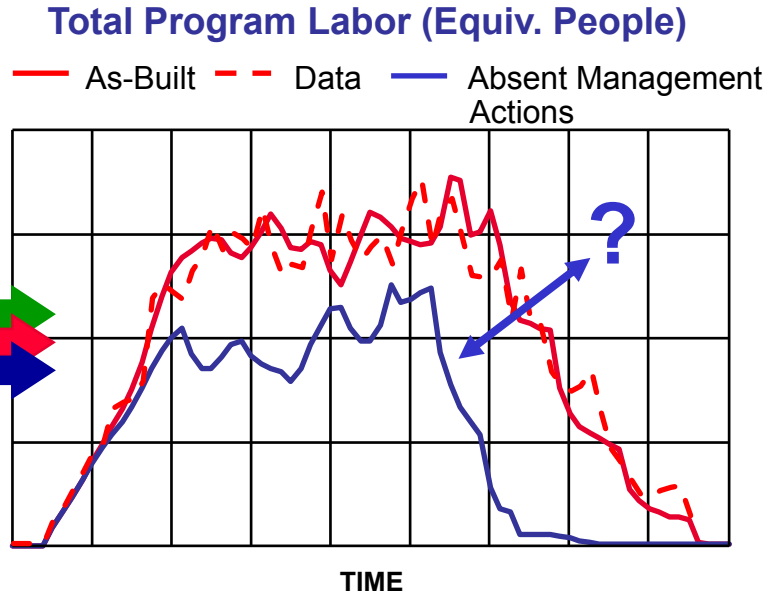
Project-to-Project Learning Requires a **Framework (Model/Data/Process)**

Analyze what happened on prior projects …

Changes to Plan

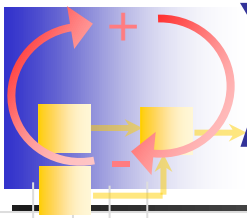
Planned Program Conditions





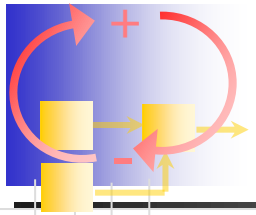
Management Actions

Rework cycle and feedback effects provide one framework for assessing dynamics similarities.



You're Uncomfortable With Quantifying All These Effects. What Are Your Options?

1. Ignore effects and estimate (simulate) impacts as if they did not exist
   - But that's the only value you know is wrong!
2. Use your experience/intuition/ "mental model" instead (no simulation)
   - I.e., try to account for effects simultaneously in your head that you can't do individually in a computer model
3. Use computer model with educated estimates …
   - Test sensitivity of results to exact values
   - Gather data (and calibrate where warranted)
   - Assemble a data base from prior projects



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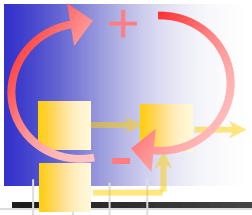
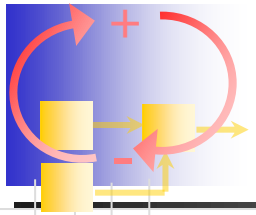
➡ Broader issues – project portfolios, priorities and market interactions



Broader Issues

- Issues in product portfolios
- Market and Customer Dynamics -- setting the mission dimension as a part of corporate strategy

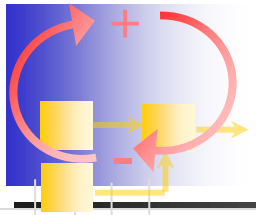


Issues in Product Portfolios

Portfolio interactions --

- staffing and other resources
- technical interdependencies

What happens on one project has significant knock-on effects to other projects. Aggressive project assumptions ("inconsistent mission") adversely affect more than the one project.

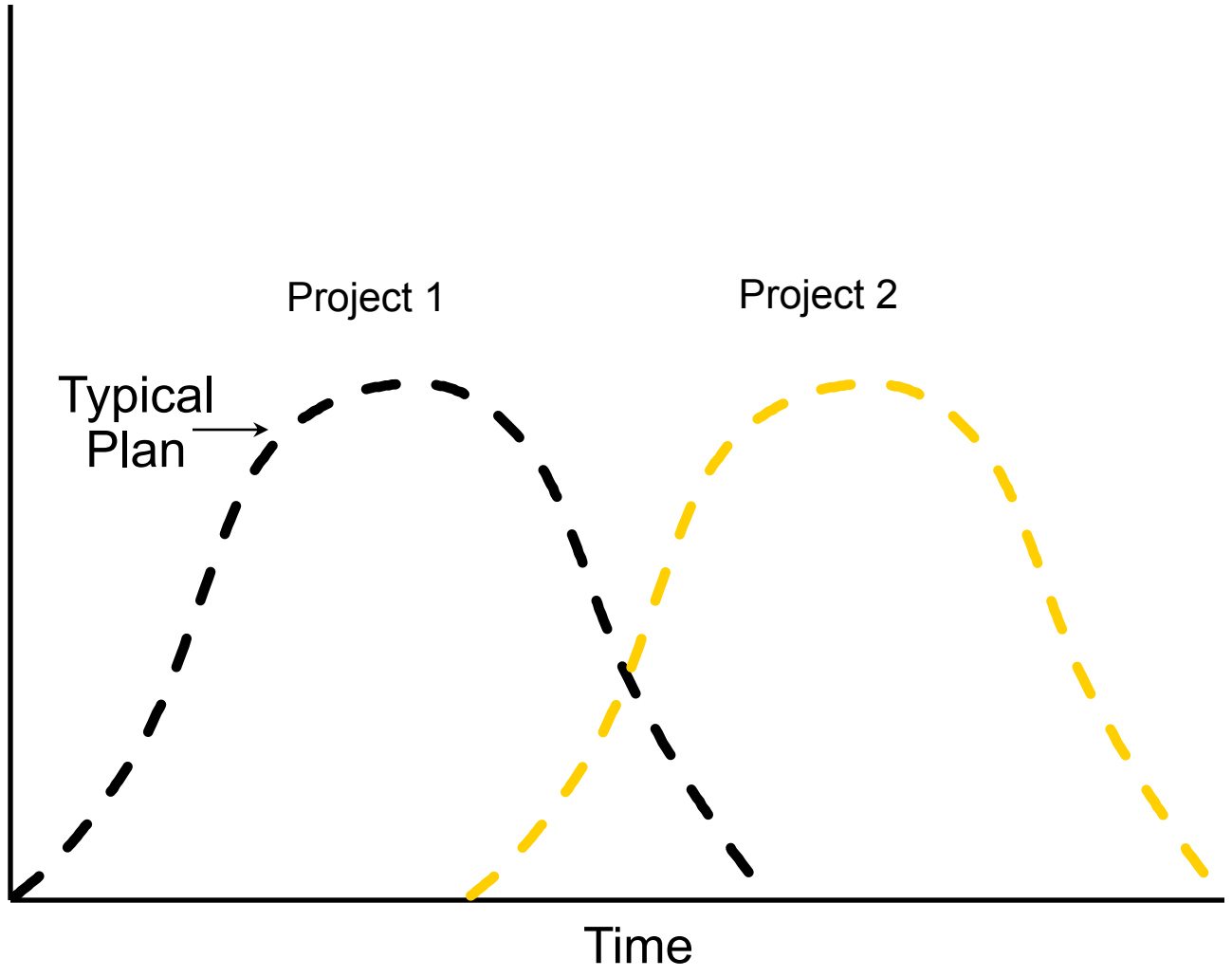


Portfolio Resourcing Issues

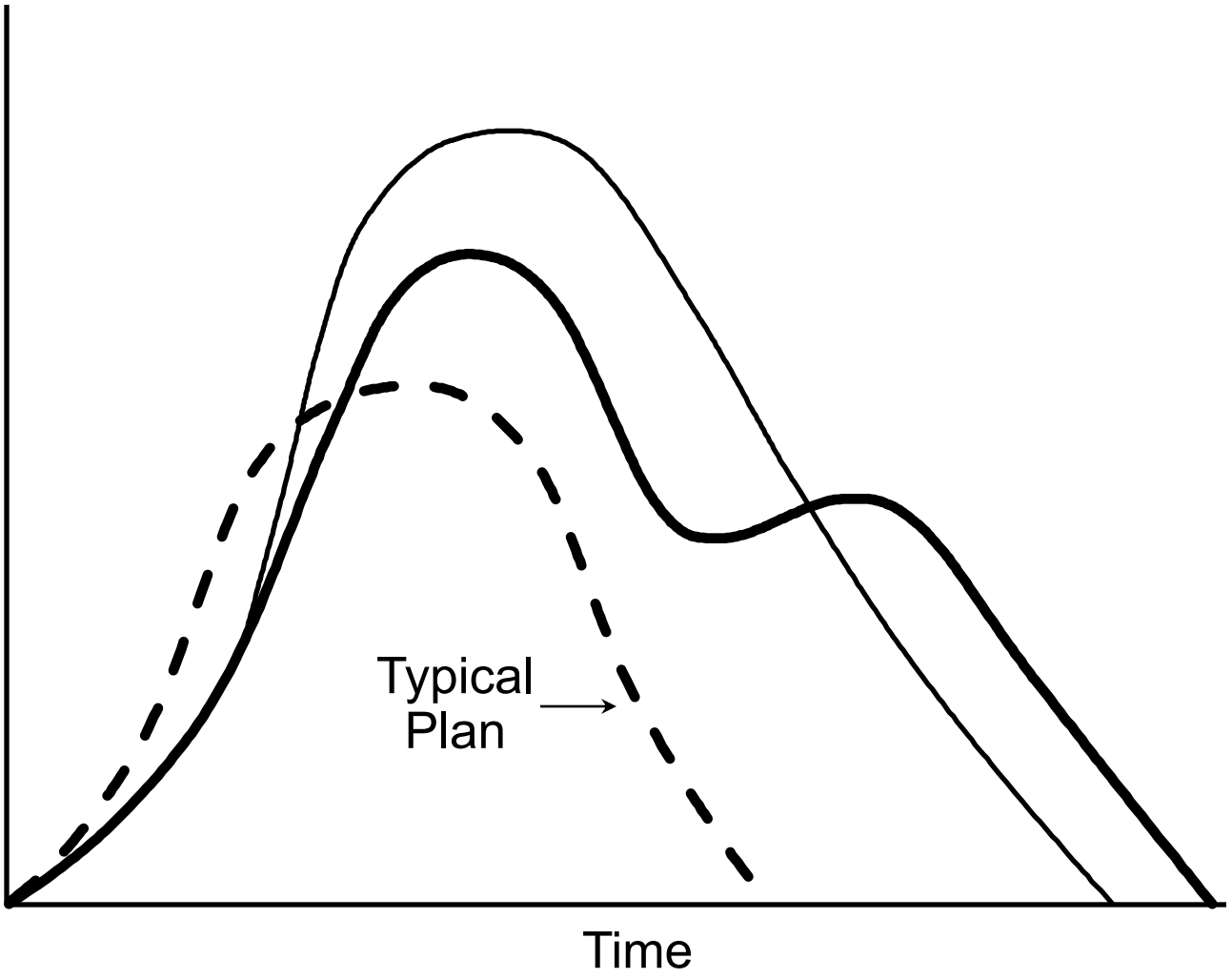
- Constraints on Shared Resources
  - Late and over-budget projects delay ramp-up of downstream projects
  - Shared resources (e.g. test facilities) can also create bottlenecks
  - Staff working simultaneously on multiple projects create inefficiencies and delays

Typically dealt with via exogenous inputs to single-project models, or via portfolio models

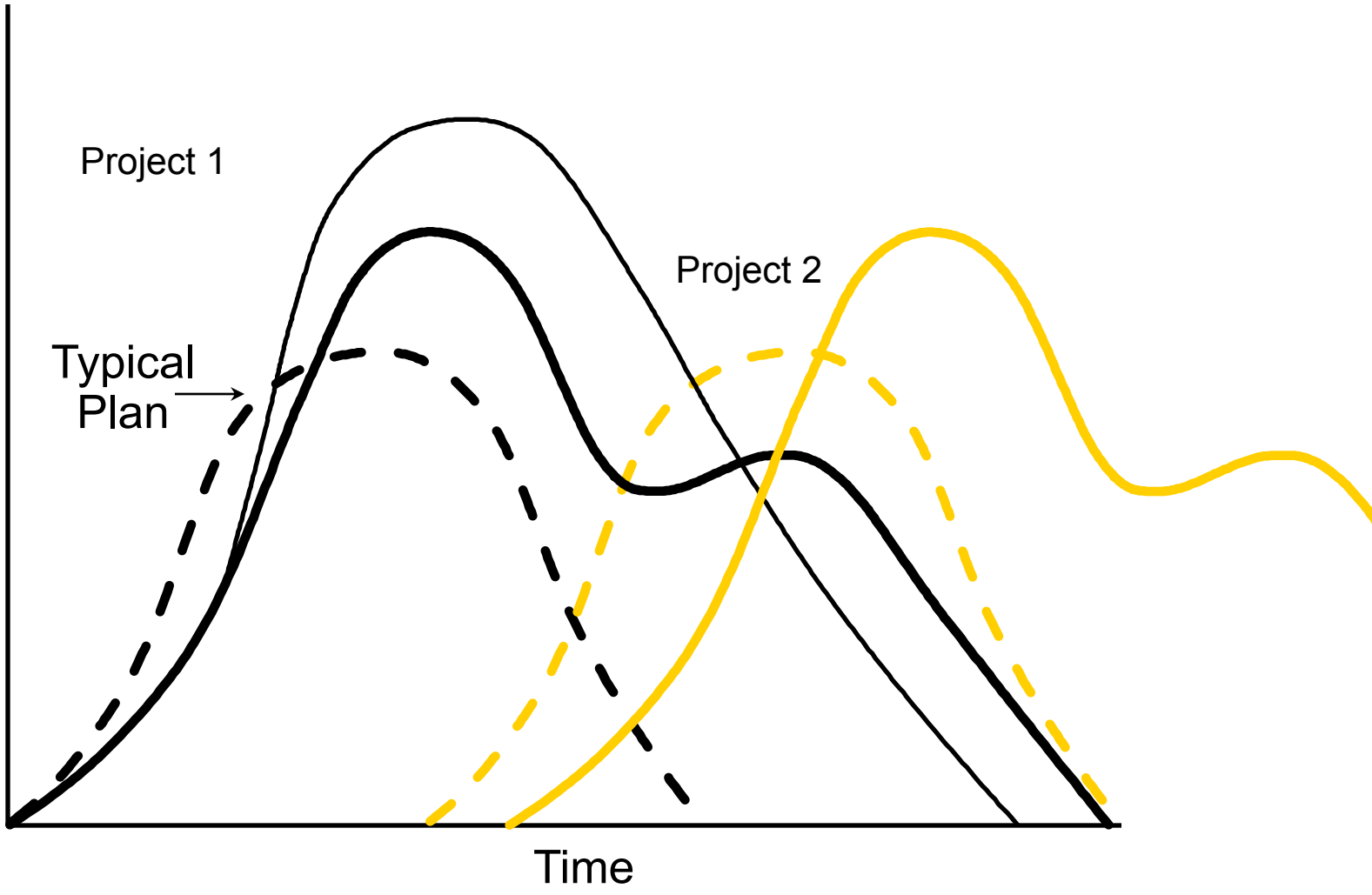
Phasing of Project Staffing

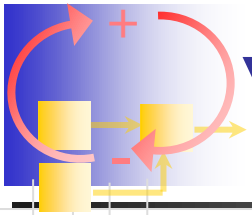


What happens when Project 1 fails to meet plan?



Phasing of Project Staffing



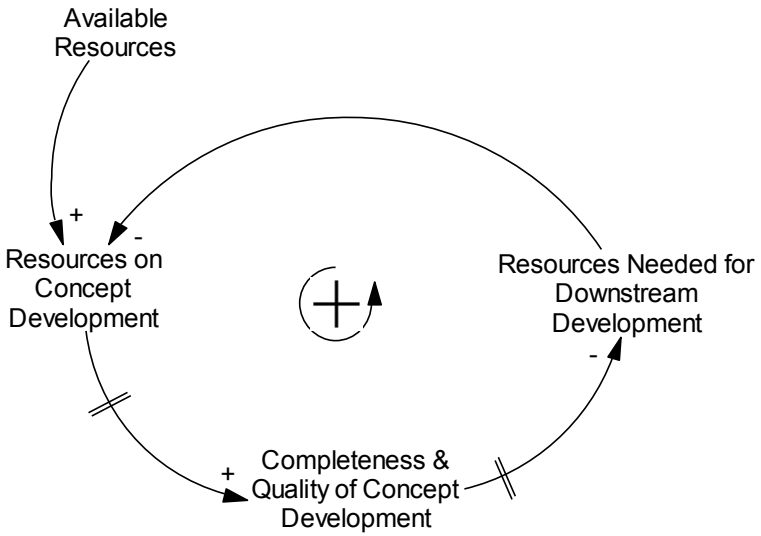


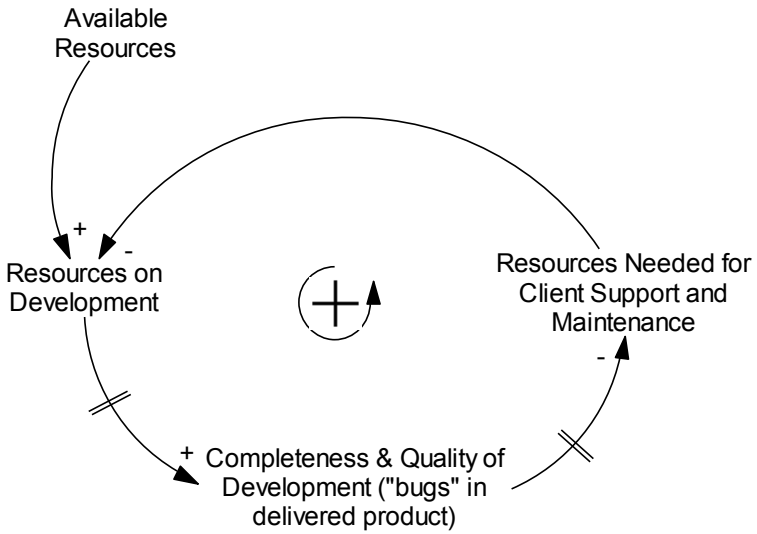
"Tipping Point" / "Fire-fighting" Research

- Not only are resources constrained, but because of technical interdependencies, failure to adequately complete the first "project" causes more work and rework on the second "project", etc.
- In a situation of limited resources, this can lock the organization into a permanently low mode of performance

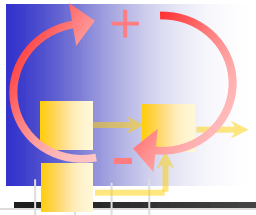
Two Examples

Temporary shortages of resources can …

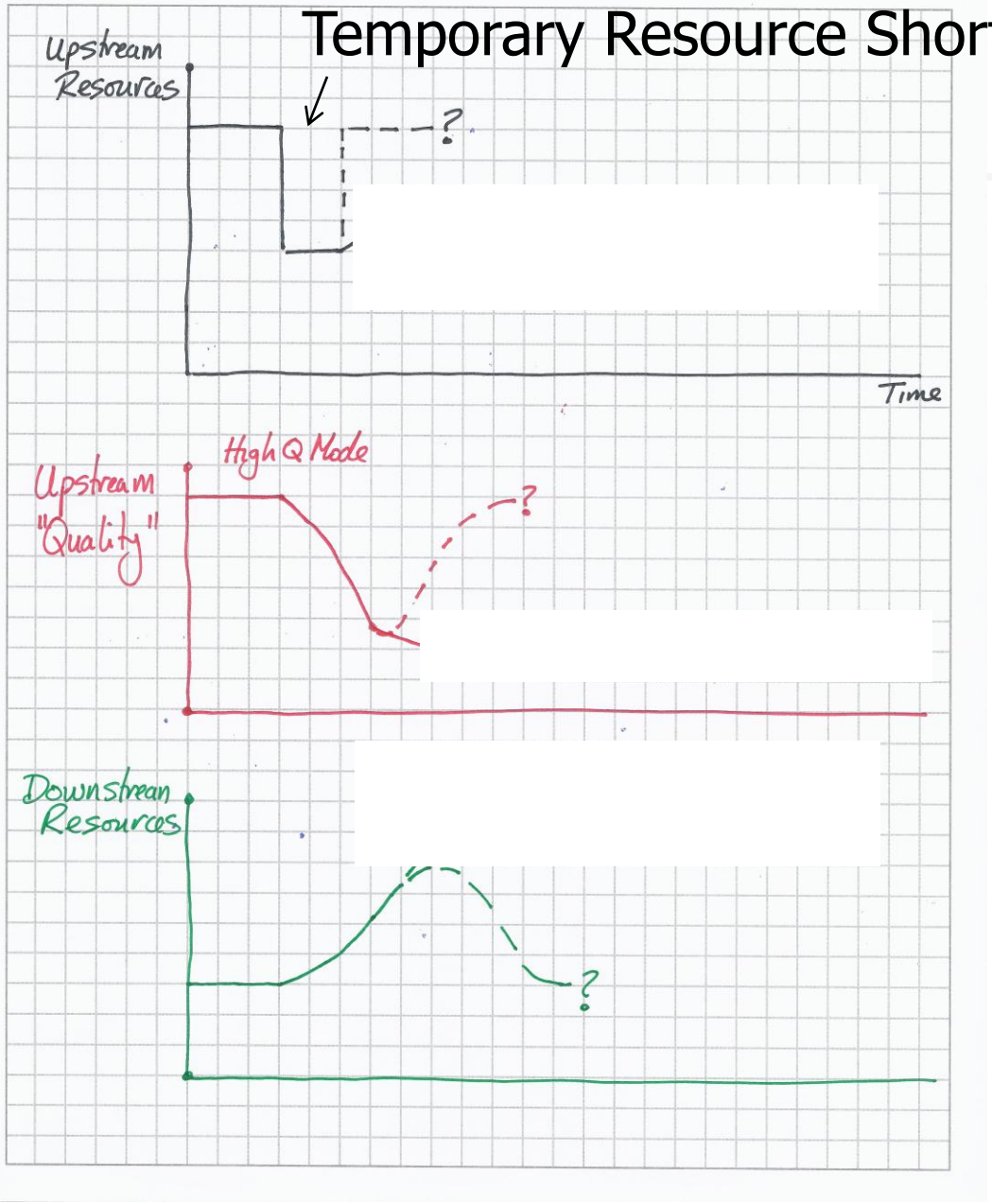




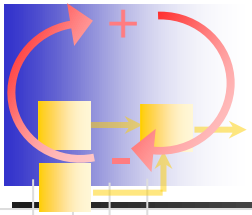
… lock organization into “low” mode of “quality”



Temporary Resource Shortage

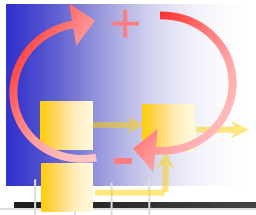


Can "tip" system to low quality mode.



"Tipping Point" Case Examples

- "Understanding fire fighting in new product development," The Journal of Product Innovation Management 18 (2001) [posted on the course site]
- Black, L. J. and N. P. Repenning. Why Firefighting Is Never Enough: Preserving High-Quality Product Development. System Dynamics Review Vol. 17, No. 1, Spring 2001.
- Rahmandad, H. and Weiss, D 2009. "Dynamics of concurrent software development." System Dynamics Review 25(3): 224-249.



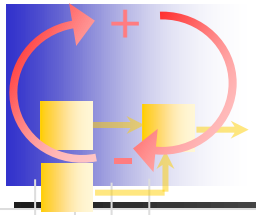
Corporate Strategy for the Project

Determining the fit of the project to business objectives (the "mission")

- features / scope
- schedule milestones (time to market)
- delivered quality (defects)
- resources & budget

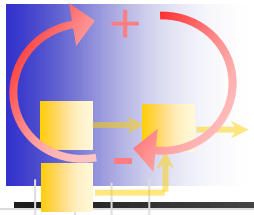
And the mix/timing of "projects" necessary to achieve corporate strategy

What gives when project gets in trouble?



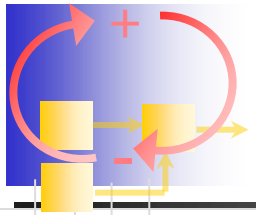
% Specifying 1st or 2nd Choice

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%



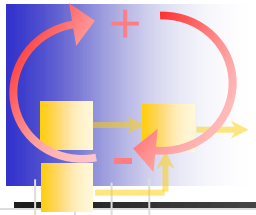
Control & Flexibility Actions Involve Tradeoffs

- Project resources: "haste makes waste," fatigue, experience dilution, …
- Slip schedule: penalties, loss of market share *(Lecture 13)*
- Cut "scope": loss of market share, need to upgrade later *(Lecture 13)*
- Ship with "bugs"/incomplete testing: loss of market share, diversion of resources to maintenance *(Lecture 13)*



Do you ever ship a project with known bugs in order to meet the schedule?

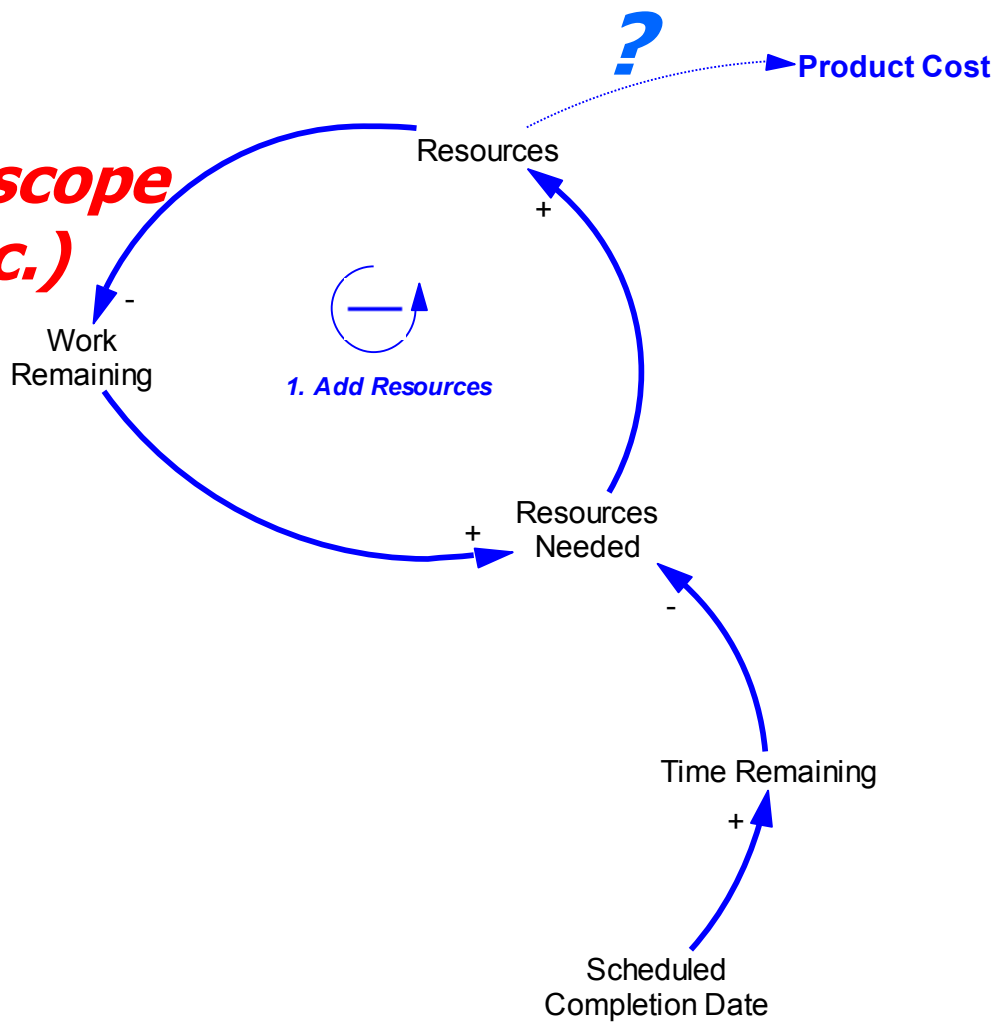
1. Yes
2. No



Why the focus on resource responses?

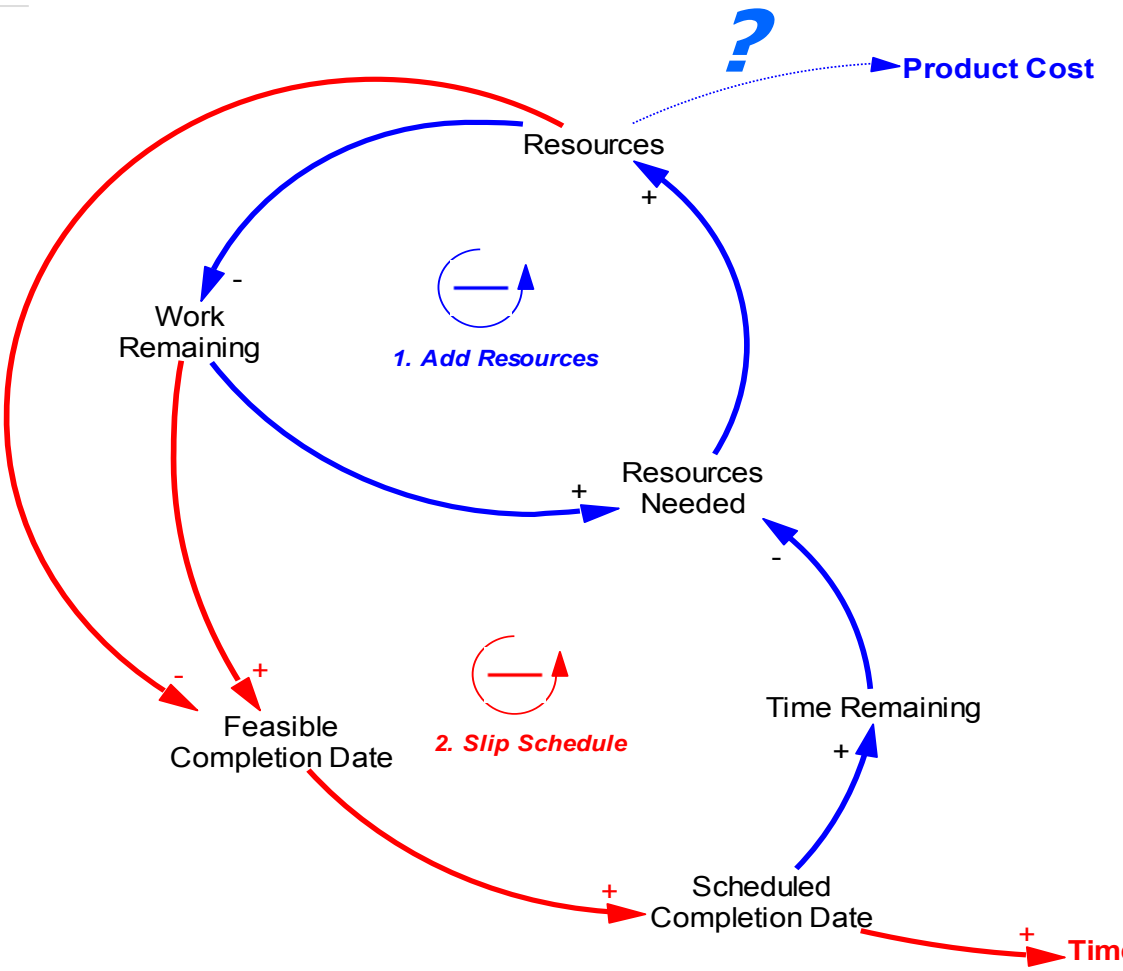
Consequences of Adding Resources to Meet Scope and Schedule Largely Constrained to Project Itself

Trigger (changes, scope growth, etc.)



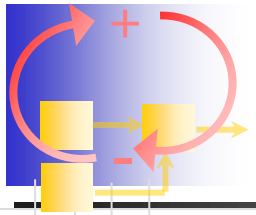
Responsibility of project manager?

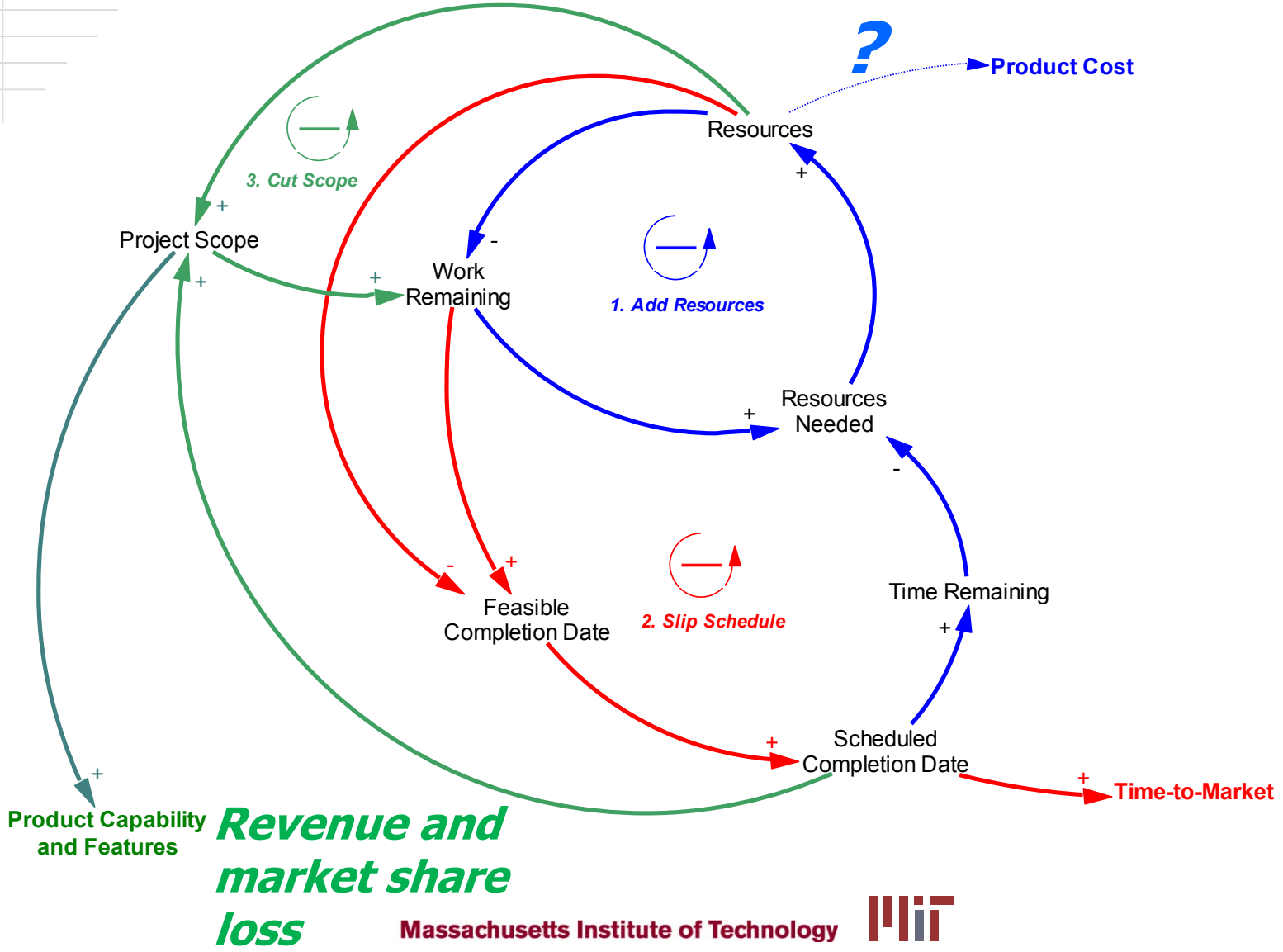
Whereas slipping schedule impacts time-to-market



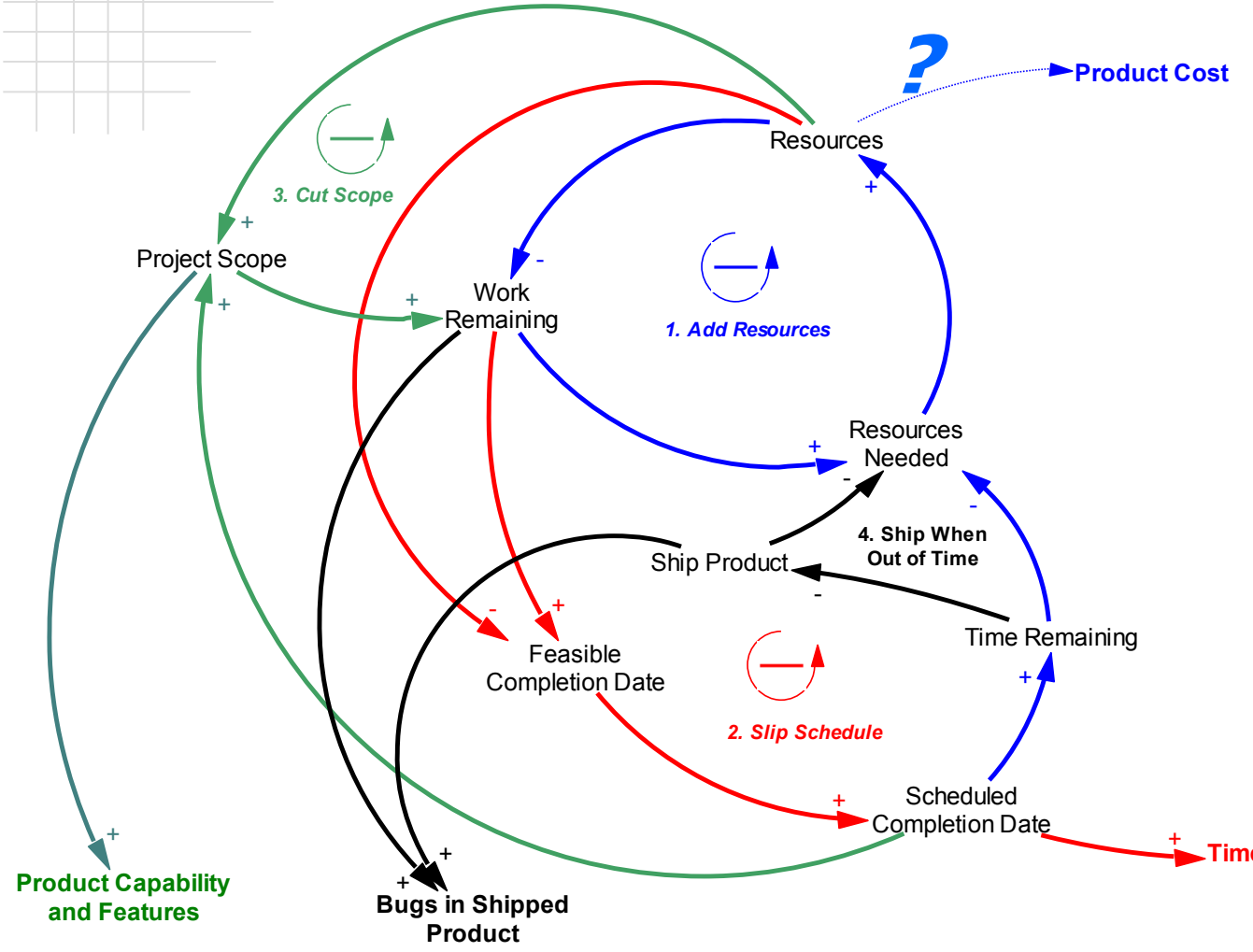
Revenue and market share loss

Cutting scope impacts product capability and features





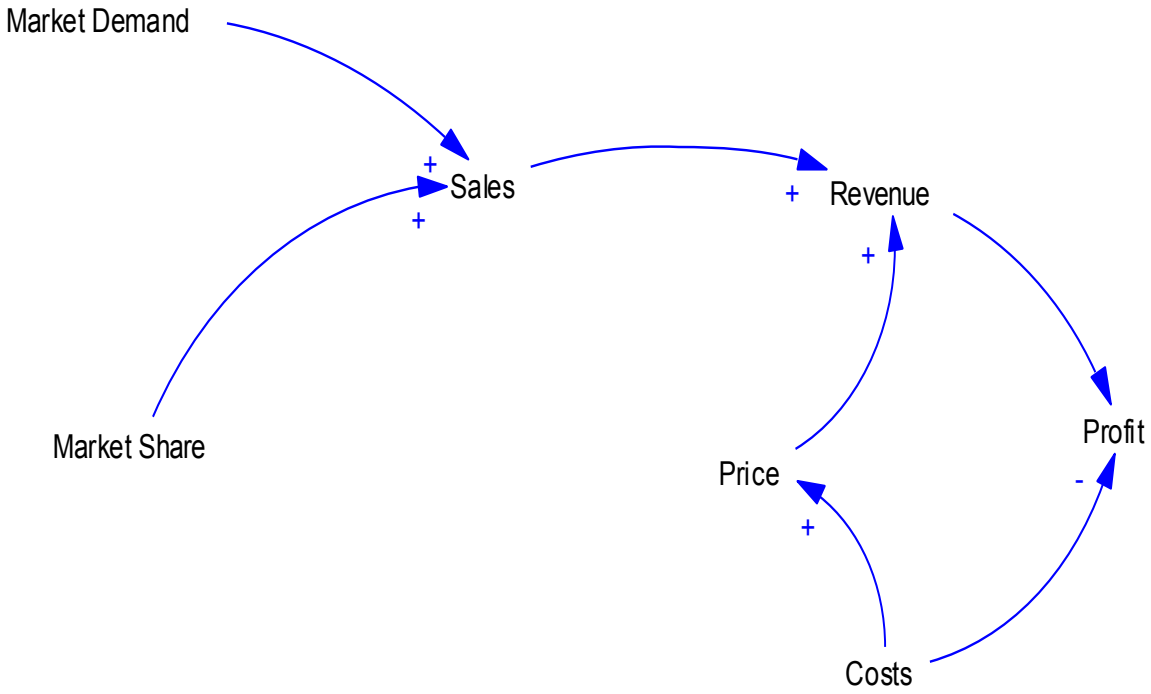
Shipping when out of time means delivered quality low



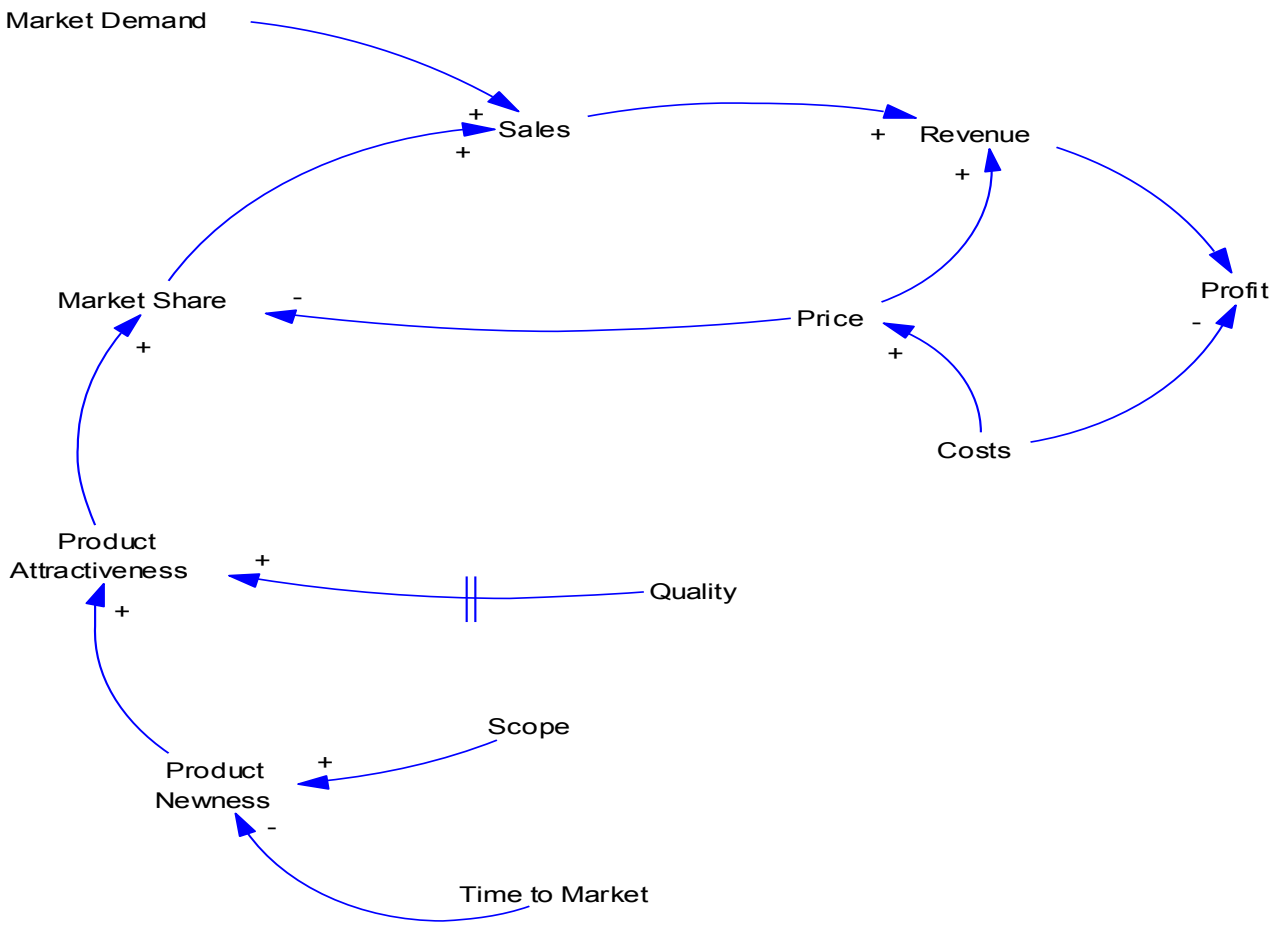
Because consequences of other control actions extend beyond the project and are difficult to measure, primary response is to add resources.

Evaluating market impacts requires a different model …

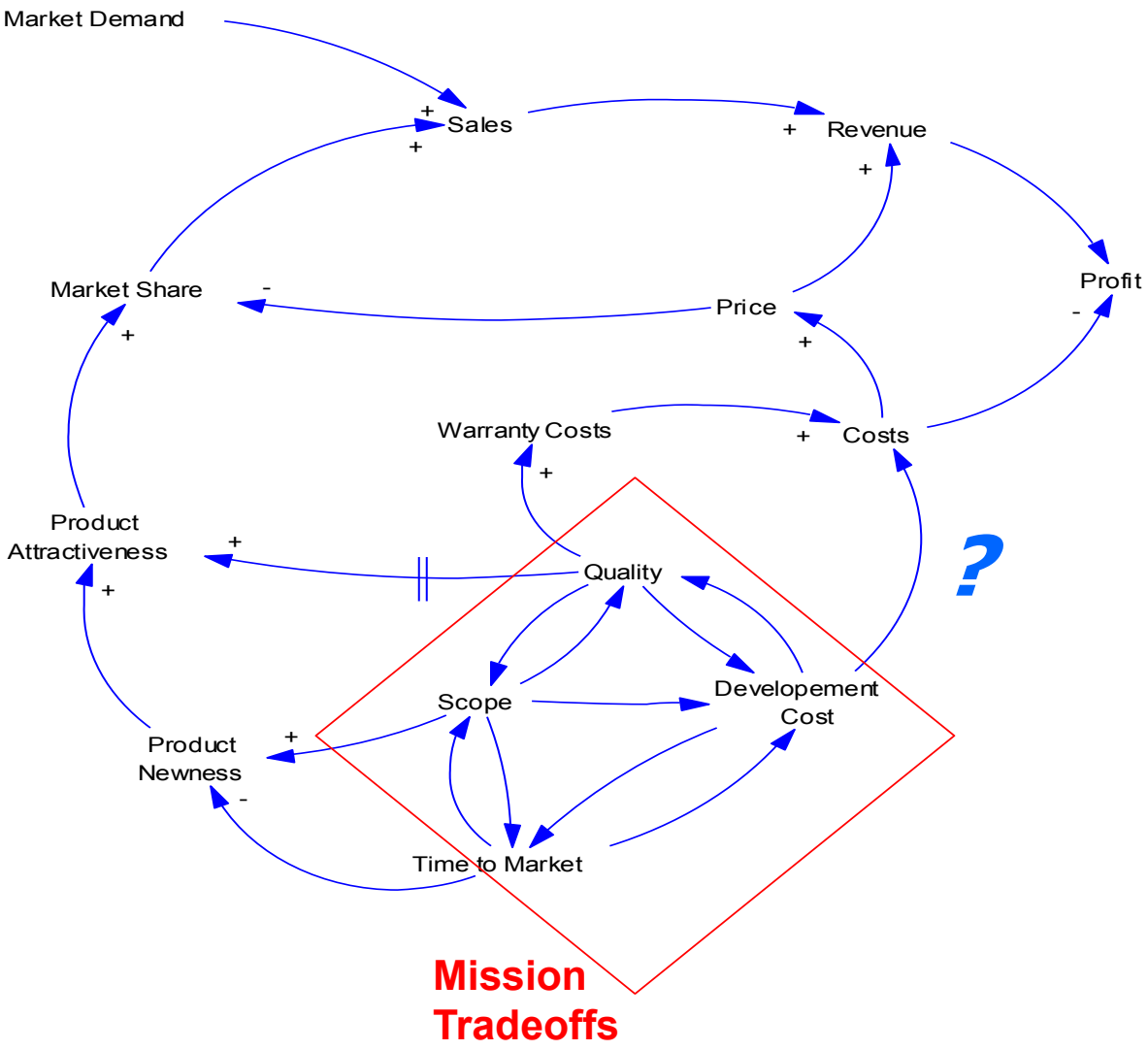
Revenue and Profit Drivers …



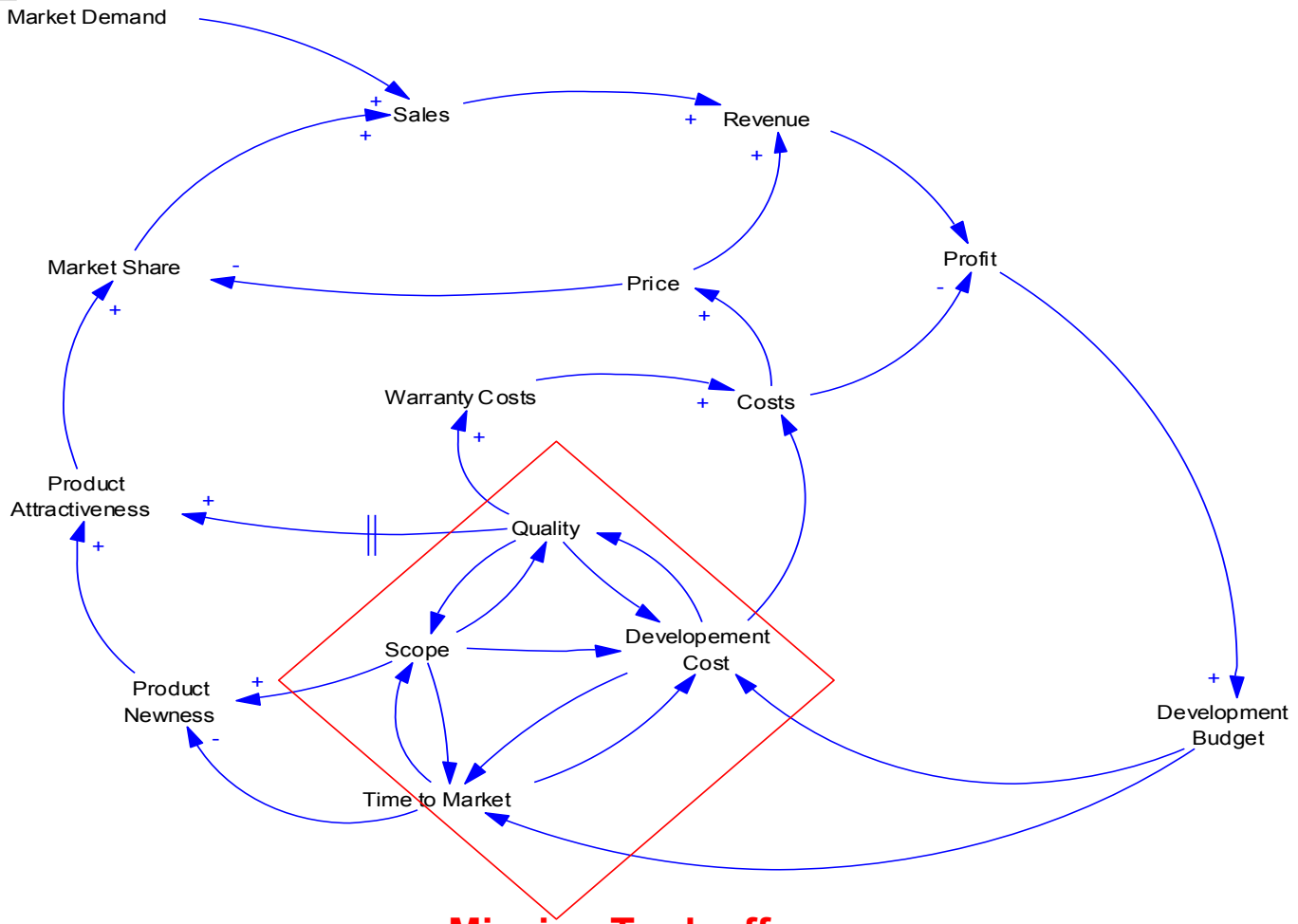
"Mission" Elements Affect Attractiveness



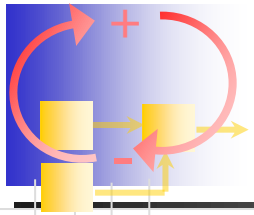
"Mission" elements have negative impacts as well …



Market Model with feedbacks through profit and budget



Mission Tradeoffs;
Product Portfolio



Selling System Dynamics (Modeling)

- Must be a persistent and costly dynamic problem
- Illustrate causes (use rework cycle and feedback examples)
- Provide an example of use relevant to your organization

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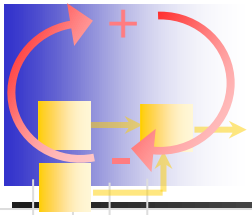
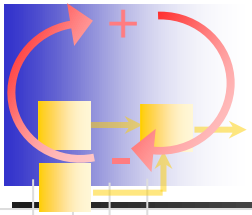


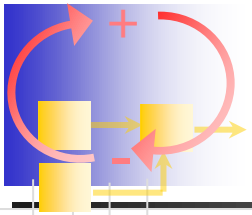
SD Qualitative Insights -1

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]



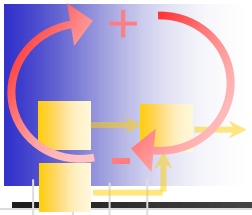
SD Qualitative Insights – 2

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.

ESD.36 System Project Management

Fall 2012