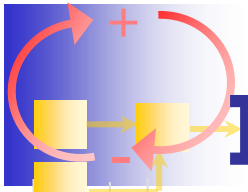
ESD.36 System Project Management

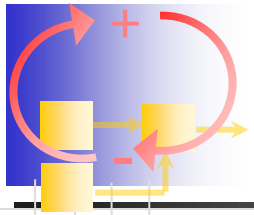
Lecture 6



Introduction to Project Dynamics

Instructor(s)

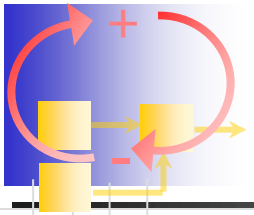
Dr. James Lyneis



System Dynamics Experience Survey

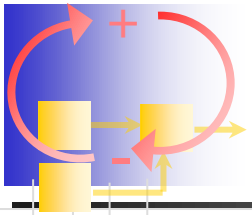
Have you taken ESD.74, or 15.871 and 15.872?

- A - Yes
- B – No
- C – Currently taking



Today's Agenda

- Project problems viewed dynamically
- Understanding dynamics: the system dynamics methodology
- Overview of system dynamics module
- Vensim



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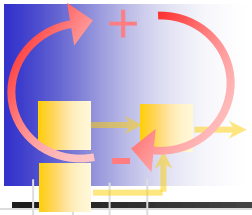
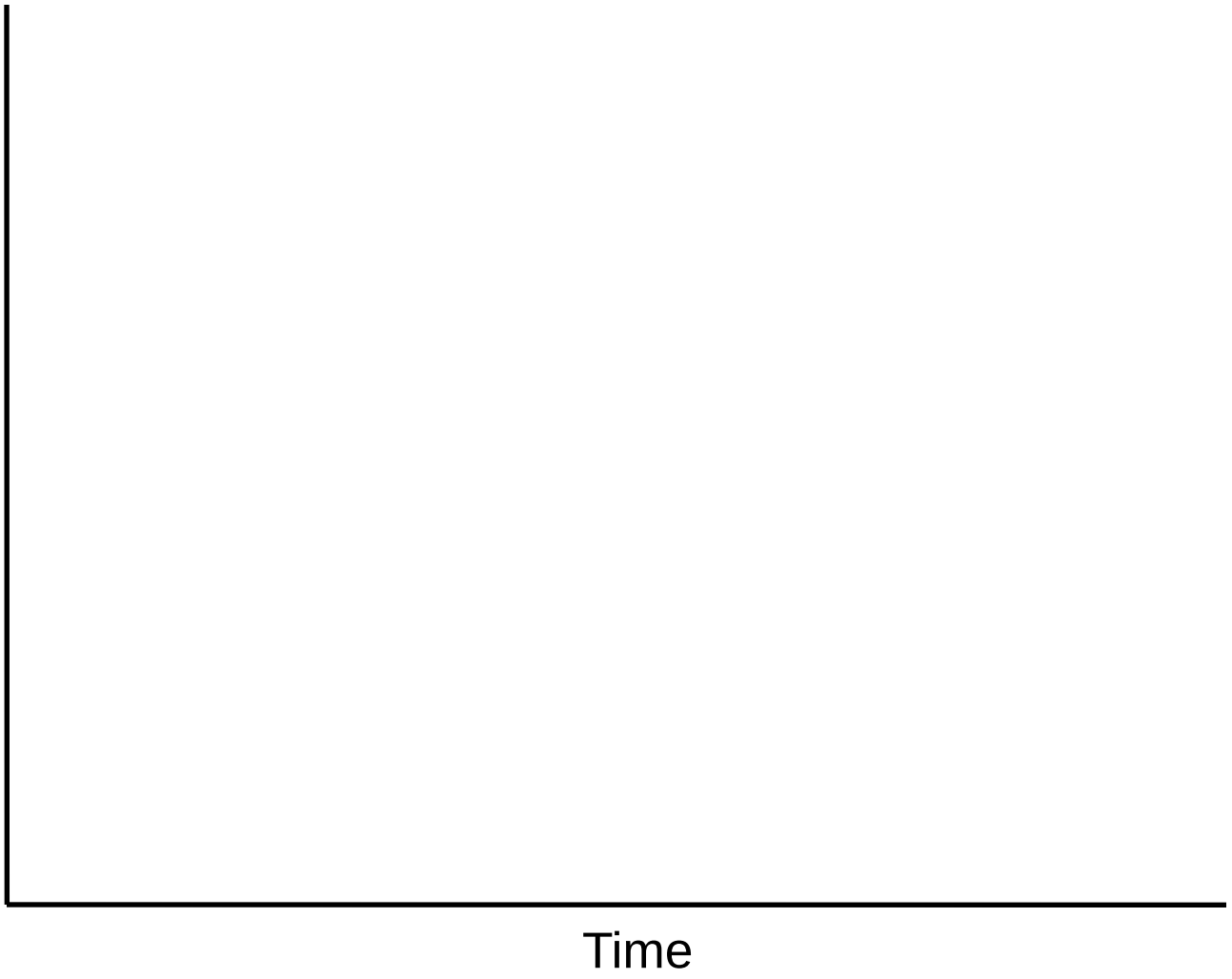


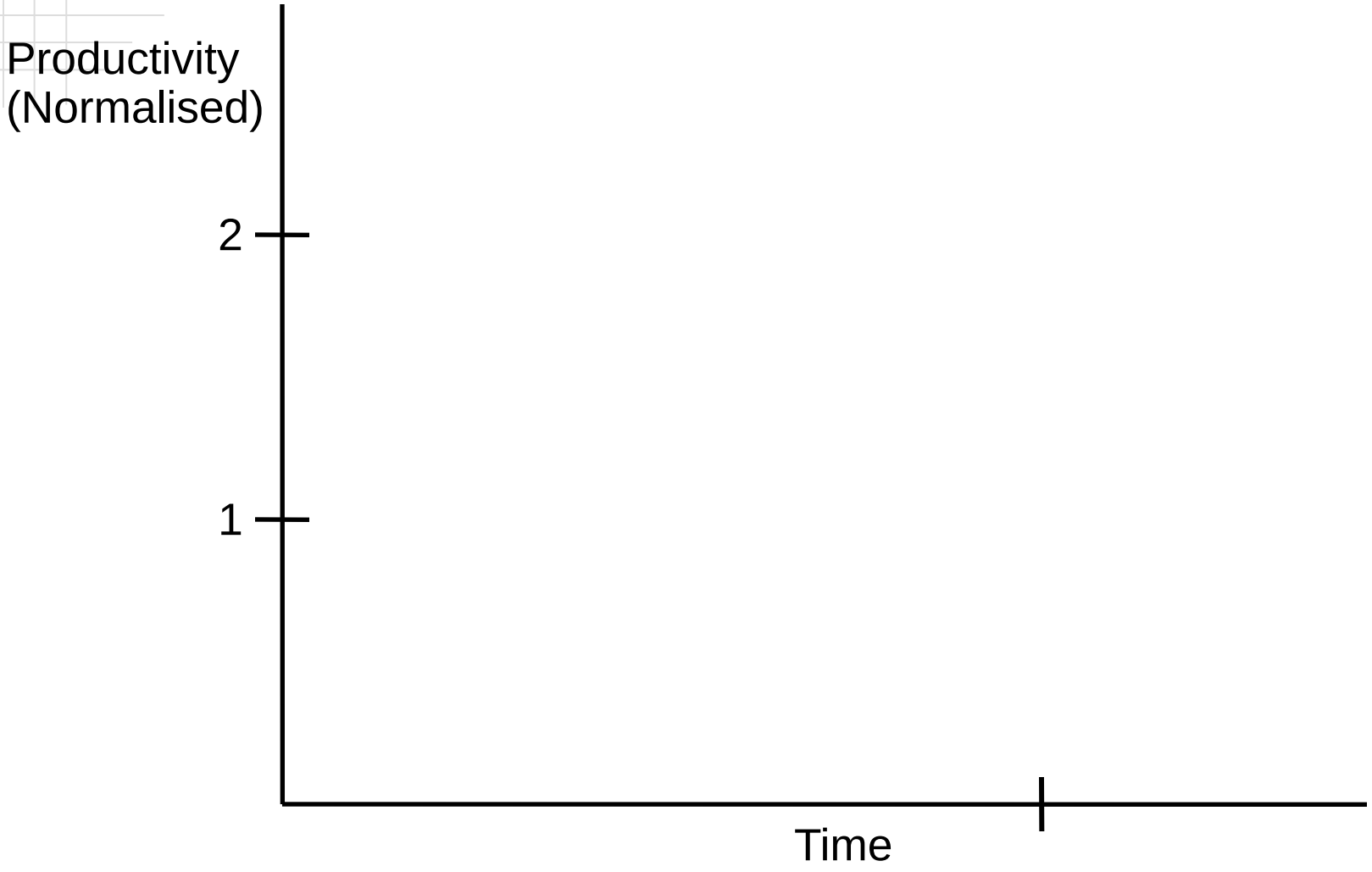
Project Dynamics

- What does “dynamic” mean in the context of a project?
- Sketch “desired” (or planned) and typical actuals for following performance measures …

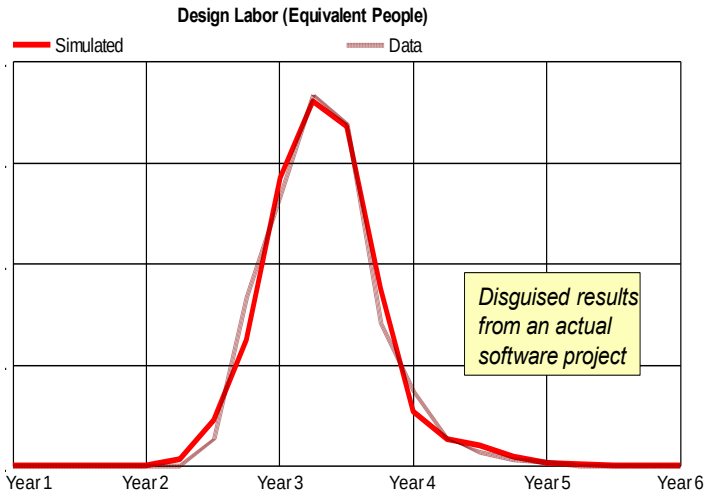
Sketch Plan and Actuals for ...

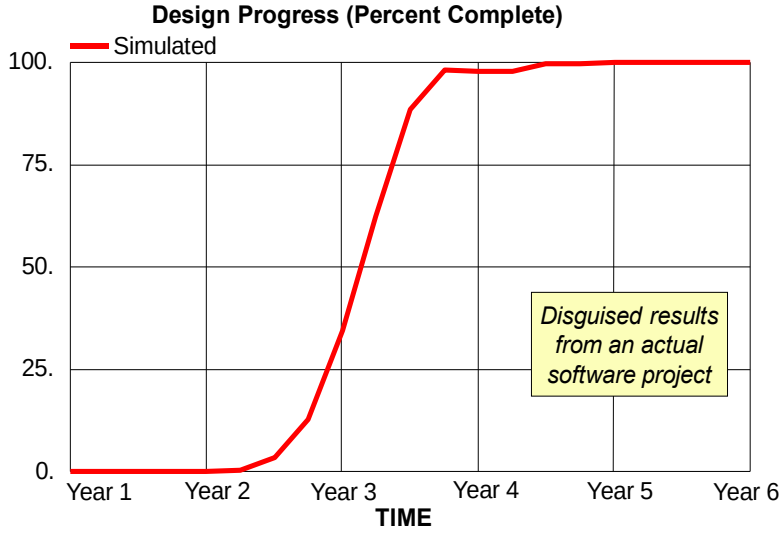


Sketch Plan and Actuals for ...



Trouble-free Projects Behave as Planned:

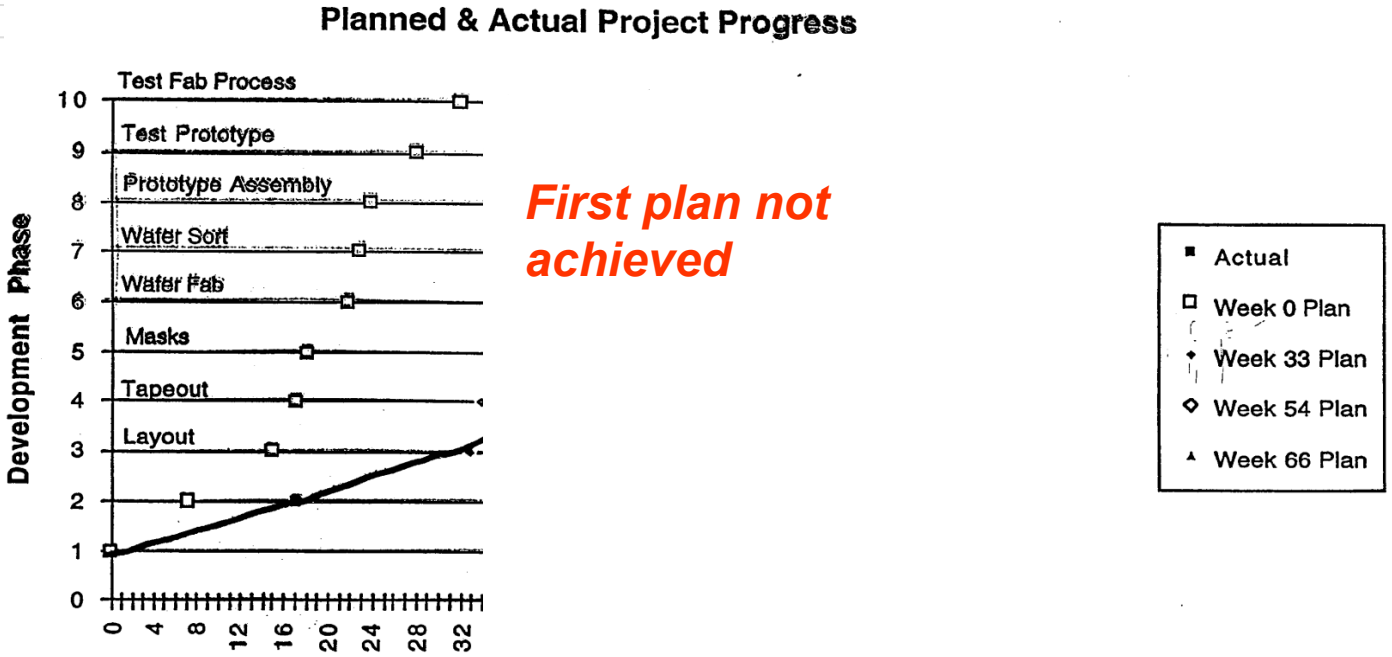




But on more typical developments ...

Overrun on a Semiconductor Design

SEMICONDUCTOR DESIGN



First plan not achieved

0 WEEKS 70

Overrun on a Semiconductor Design

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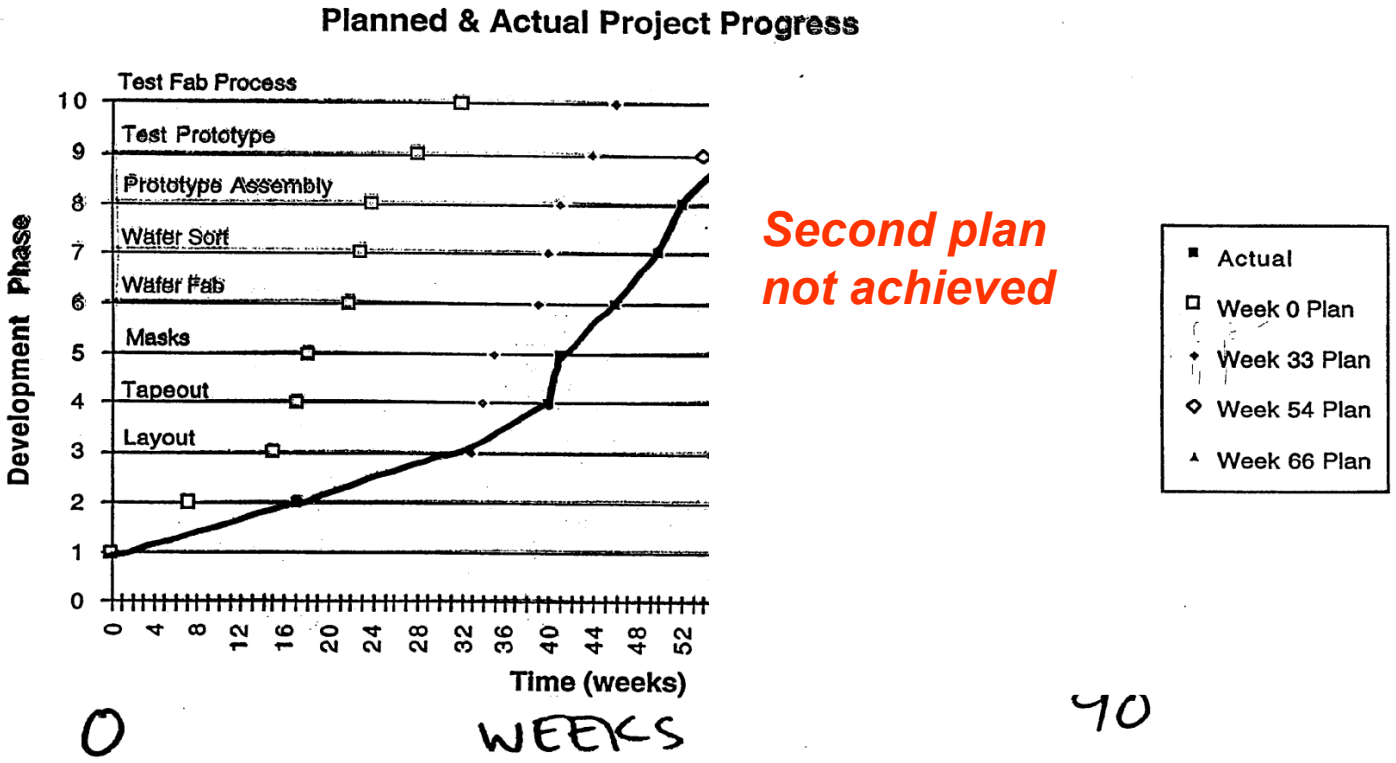
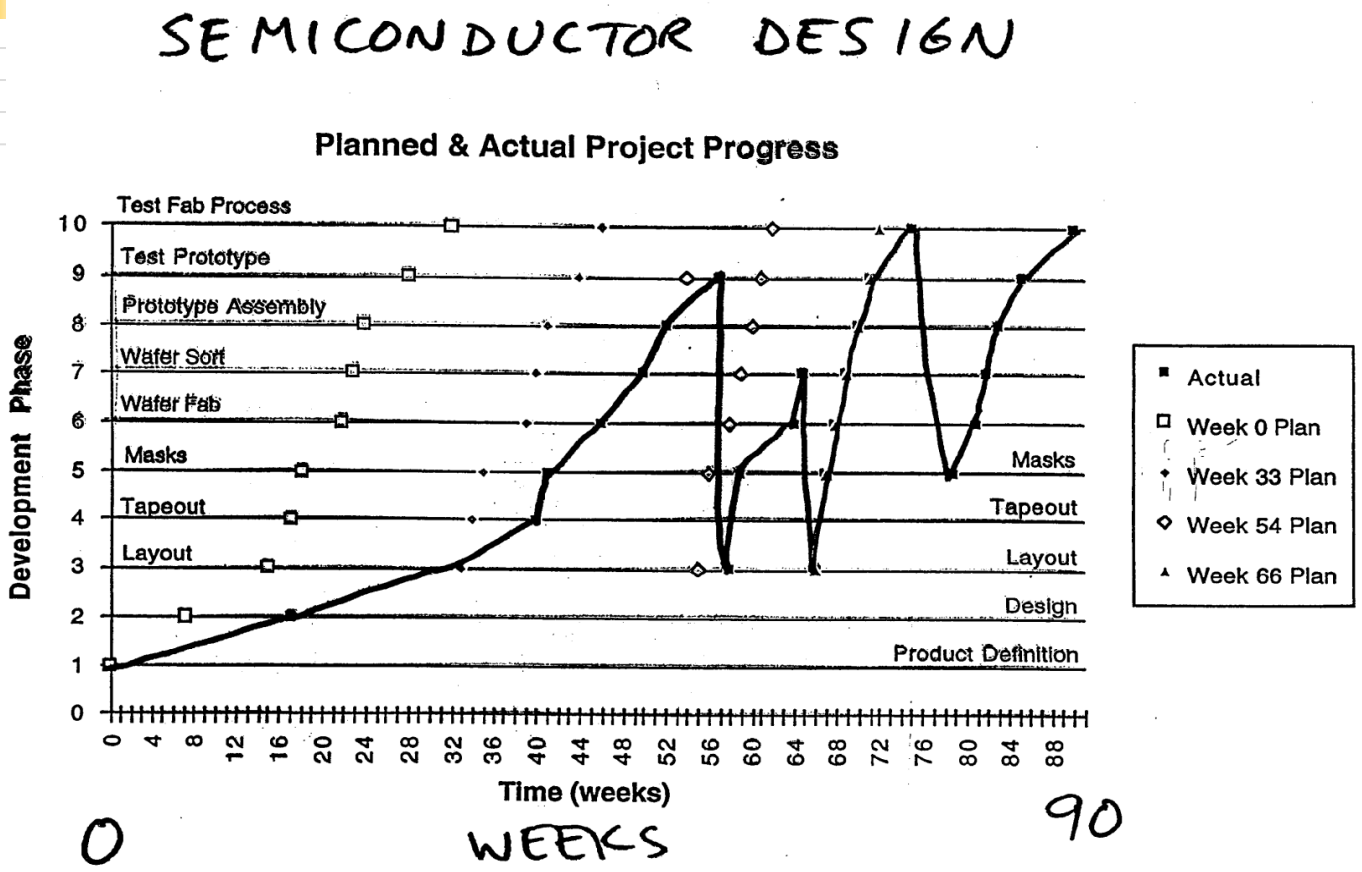


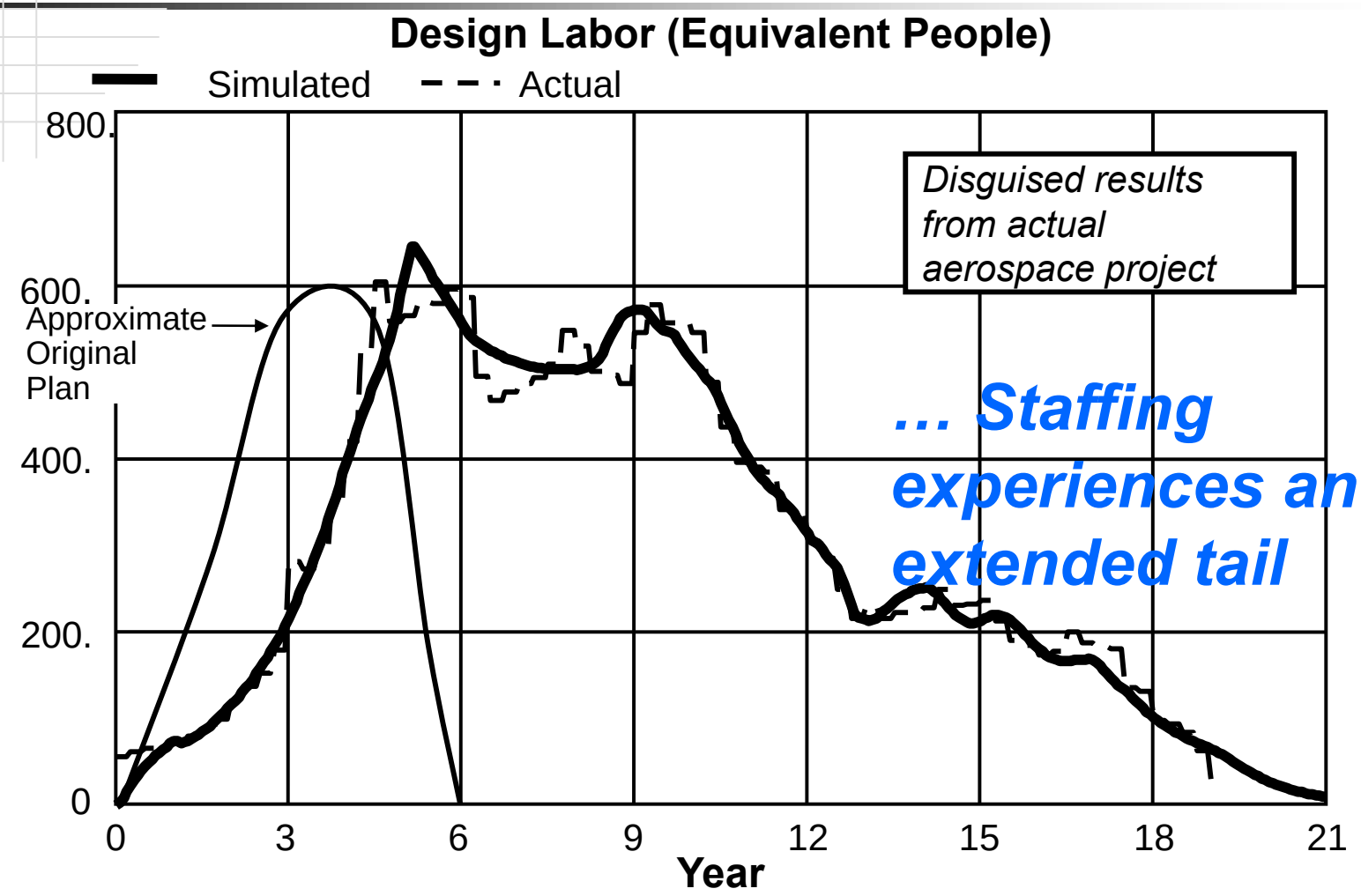
Second plan not achieved

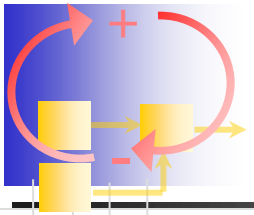
0 WEEKS 40

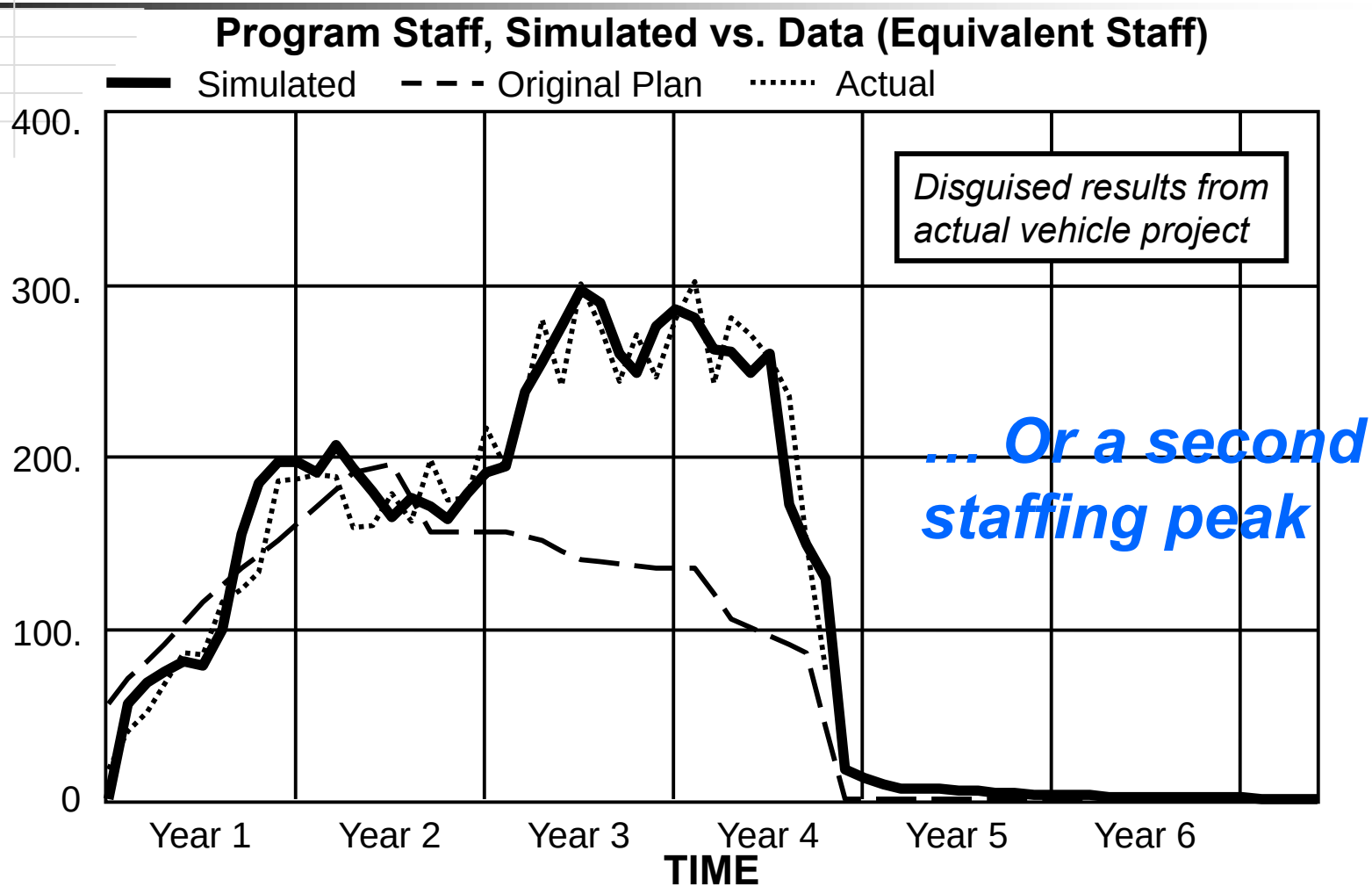
Overrun on a Semiconductor Design



On typical development projects …



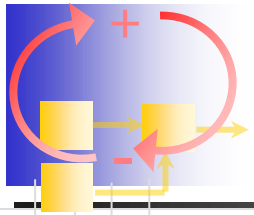




Progress has been made: Many firms have cut development times in half ...

Image removed due to copyright restrictions.

Source: Smith, Preston G. and Donald G Reinersten, *Developing Products in Half the Time* (2nd edition), Wiley 1998.

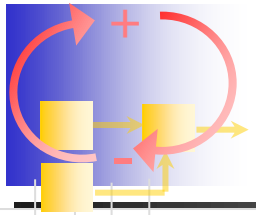


But project overruns persist in spite of numerous advances in the last 50 years

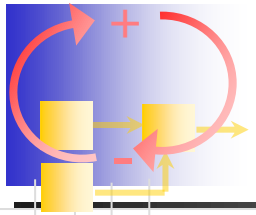
- PERT and Critical Path Method
- Waterfall, Spiral, …
- Emphasis on “soft,” people factors
- Microsoft Project

.. and **Learning** is not happening

Why???



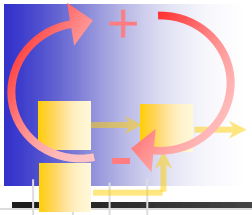
Why do projects overrun their budgets and/or schedules?



Why? – Notes from Prior Classes

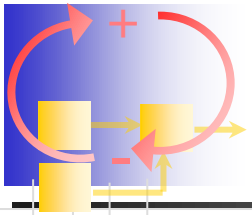
- Unrealistic schedule and/or budget
  - Poorly defined objectives
  - Schedule too aggressive
  - Inadequate funding
- Changing and/or growing system requirements
- "Complexity" – design uncertainty
- Politics/conflicting agendas (management, customers)
- Resource shortages
- Inappropriate skills mix/ high attrition
- Inappropriate processes

Characteristic: externally focused – others did it to us!



System Dynamics Viewpoint

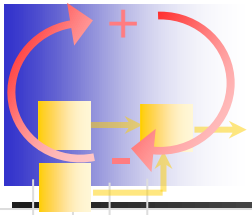
While external events are a fact of life on projects, project performance problems are fundamentally dynamic problems *that result from attempts to manage in the face of change and uncertainty*.



System Dynamics Viewpoint

Managers mental models and typical tools (computer models) are not helpful in understanding dynamics:

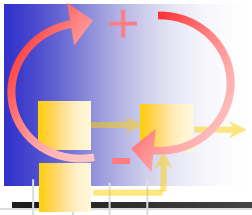
- Attribute problems to external factors
- View a project statically (no iteration, no feedback)
- Treat projects as if they were unique



Project Control

You're managing a 12-month project, and at ***~30% done*** you realize that changes and scope growth have put your project ~25% behind schedule …

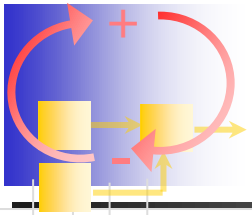
What do you do? Schedule is the top priority; cost the second priority.



What do you do at ~30% complete?

What is your (company's) response? Put a 1 next to your primary response, at 2 next to your secondary response, and so on. If you would not use a response, leave it blank, otherwise try to rank the options even if you rarely use them in practice.

1. Add people?
2. Work longer hours?
3. Work more "intensely" (including cutting corners, increasing concurrency, releasing work earlier than ideal)?
4. Slip the schedule?
5. Cut scope?
6. Other?



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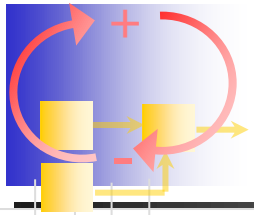

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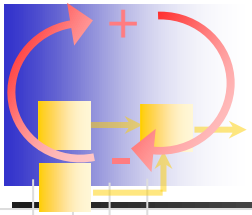

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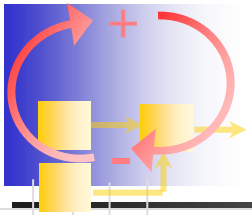
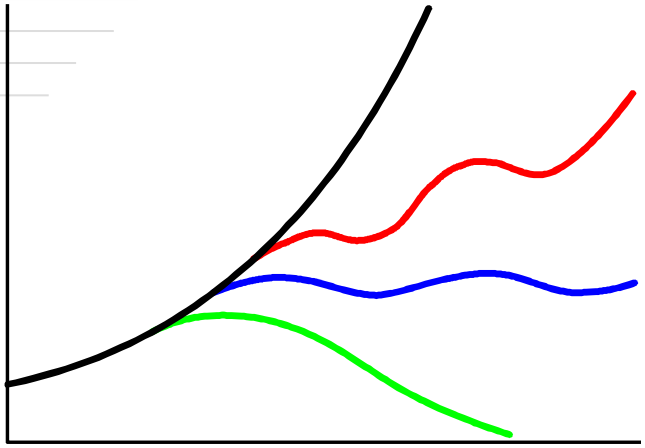


What is System Dynamics?

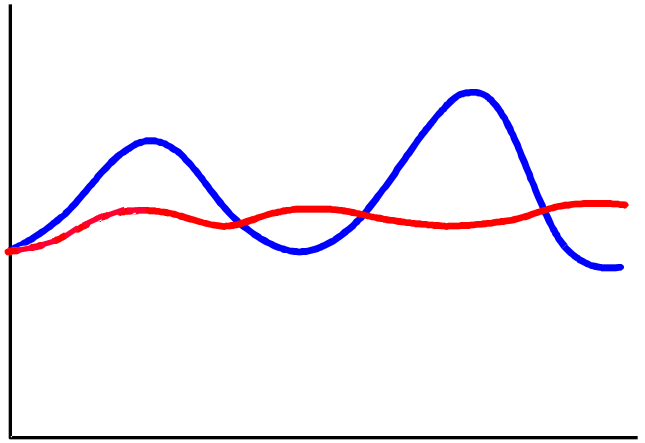
- Theory of Structure of Systems Creating Behavior
  - Feedback loops
  - Stocks and flows
- Scientific method applied to social and economic systems
  - Iterative, focus on testing and learning
  - Working with "clients" to solve problems
- Tools & Tricks & Software to Make Modeling Easier

Examples of Dynamic Behavior

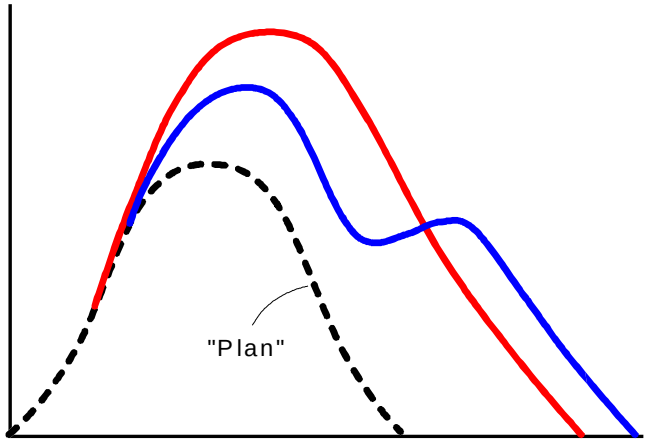
Growth

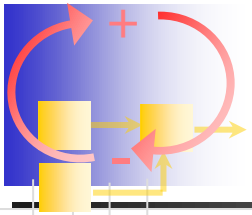


Stability



Project Staffing





What Causes Dynamics?

All dynamics are driven by –

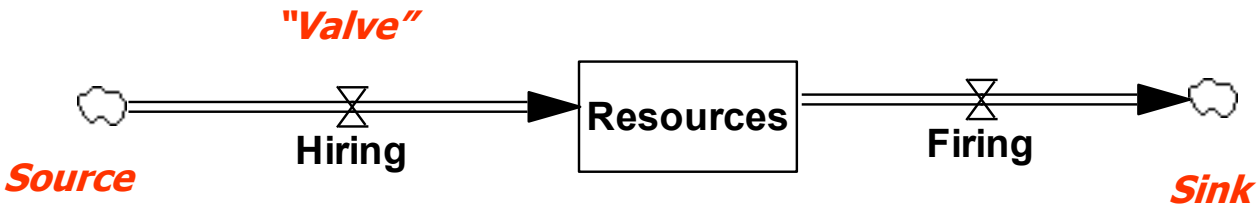
- Accumulation processes
- Feedback processes

Accumulation processes involve ...

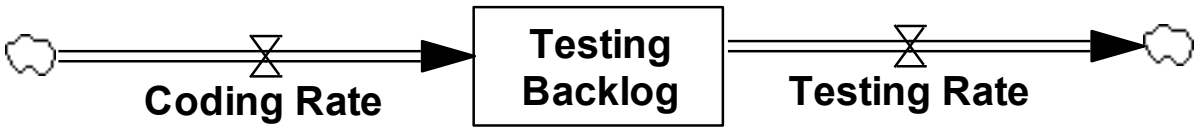
- Stocks or “levels” -- define the state of the system

- Flows or “rates” -- define the rate of change in system states

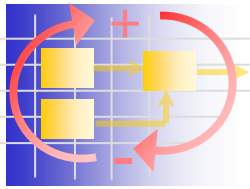
Connecting stocks and flows ...



"Clouds" represent stocks outside the model boundary



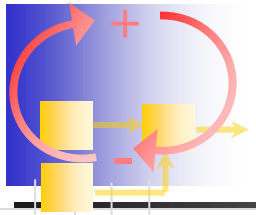
Stocks = Levels = States = Accumulations = Integration



Math behind Stocks and Flows

$$S_t = \int_{t_0}^{t} (Inflow - Outflow)\,ds + S_{t_0}$$

$$\frac{dS}{dt} = Inflow - Outflow$$



Stocks and Flows

Water in Tub

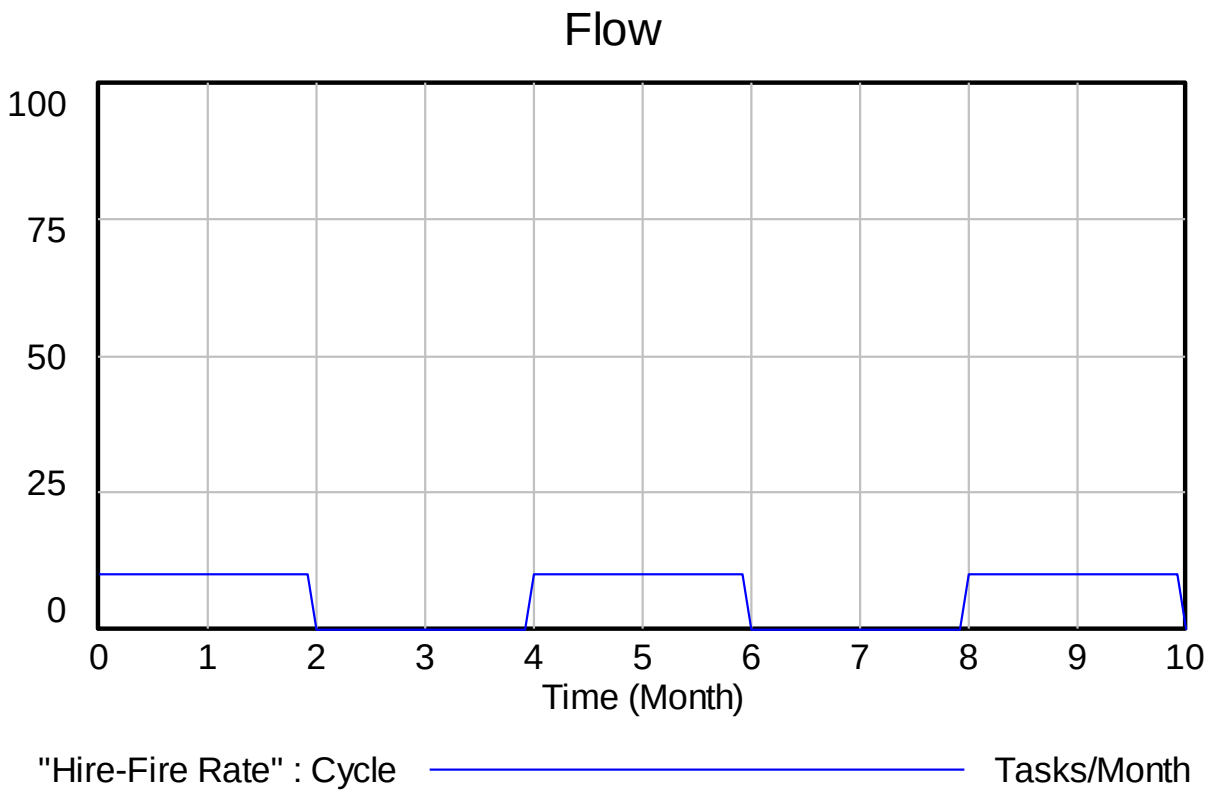
- **Inflow > Outflow: Quantity in tub is rising**
- **Inflow < Outflow: Quantity in tub is falling**
- **Inflow = Outflow: Quantity in tub is constant**

Estimating accumulation dynamics – "graphical integration"

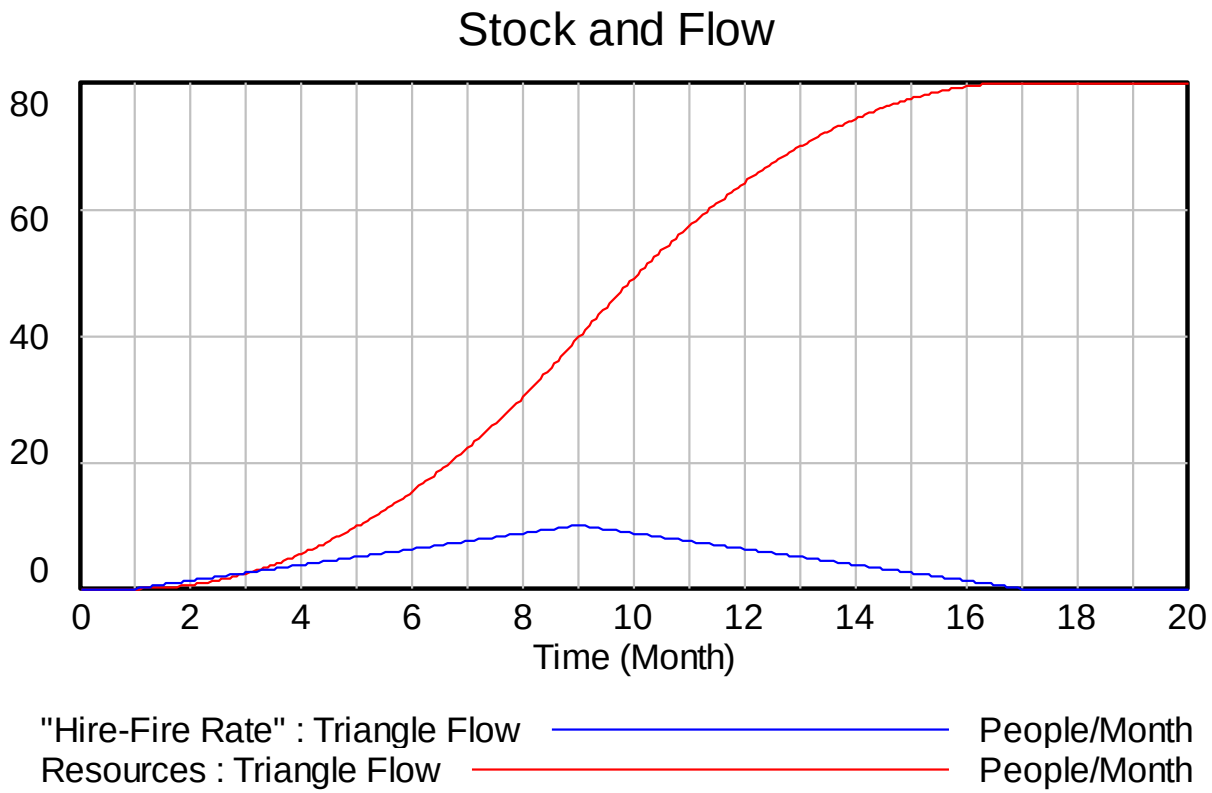
Two-flow Stock:

Condense to One Flow:

Sketch Resources if Hiring cycles between 0 and 10?



Triangular Hire-Fire Rate



Equations for Discrete Integration

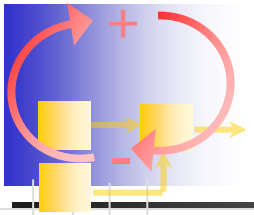
Resources (t+dt) = Resources (t) + dt * (Hire-Fire Rate $_{t \rightarrow t+dt}$)

dt = "delta time" = Δt = ***Time Step (term used in Vensim)***

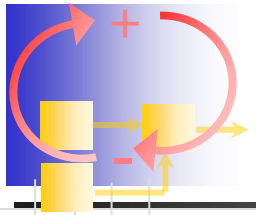
In Vensim:

Resources = INTEG(Hire-Fire Rate)

Note: In Vensim PLE 6.0 the INTEG appears to have been dropped!



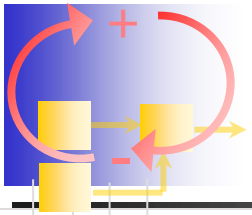
Please review draft textbook Chapter SD1, section SD1.2.1 (pages 7-16), for details and examples on graphical integration, discrete integration, and the behavior of stocks.



What are typical stocks & flows on a project?

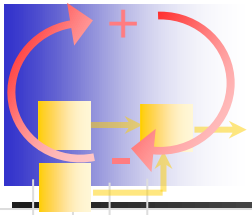
Stocks

Flows



Stocks and Project Management

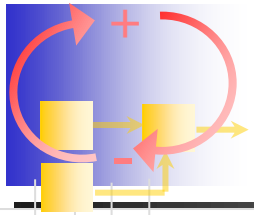
- A company's resources are stocks:
  - Management can only affect project performance by building resource levels, and this can only be achieved by actions that affect inflows and outflows



What Causes Dynamics?

All dynamics are driven by –

- Accumulation processes ✓
- Feedback processes
  - Balancing
  - Reinforcing



System Dynamics Tools

"Soft" tools --

- behaviour-over-time graphs
- cause-effect diagramming
- mental simulation

Tools for describing dynamics

"Hard" tools --

- computer models
- computer simulation (Vensim)
- calibration to data
- sensitivity and what-if analyses

Tools for quantifying dynamics

Causal loop diagrams -- causal links

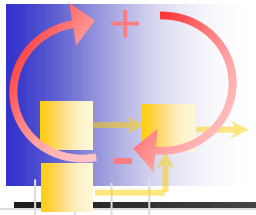
- An arrow with a positive sign (+) means that, all else remaining equal, an increase (decrease) in the first variable increases (decreases) the second variable ***above (below) what it would otherwise have been.***

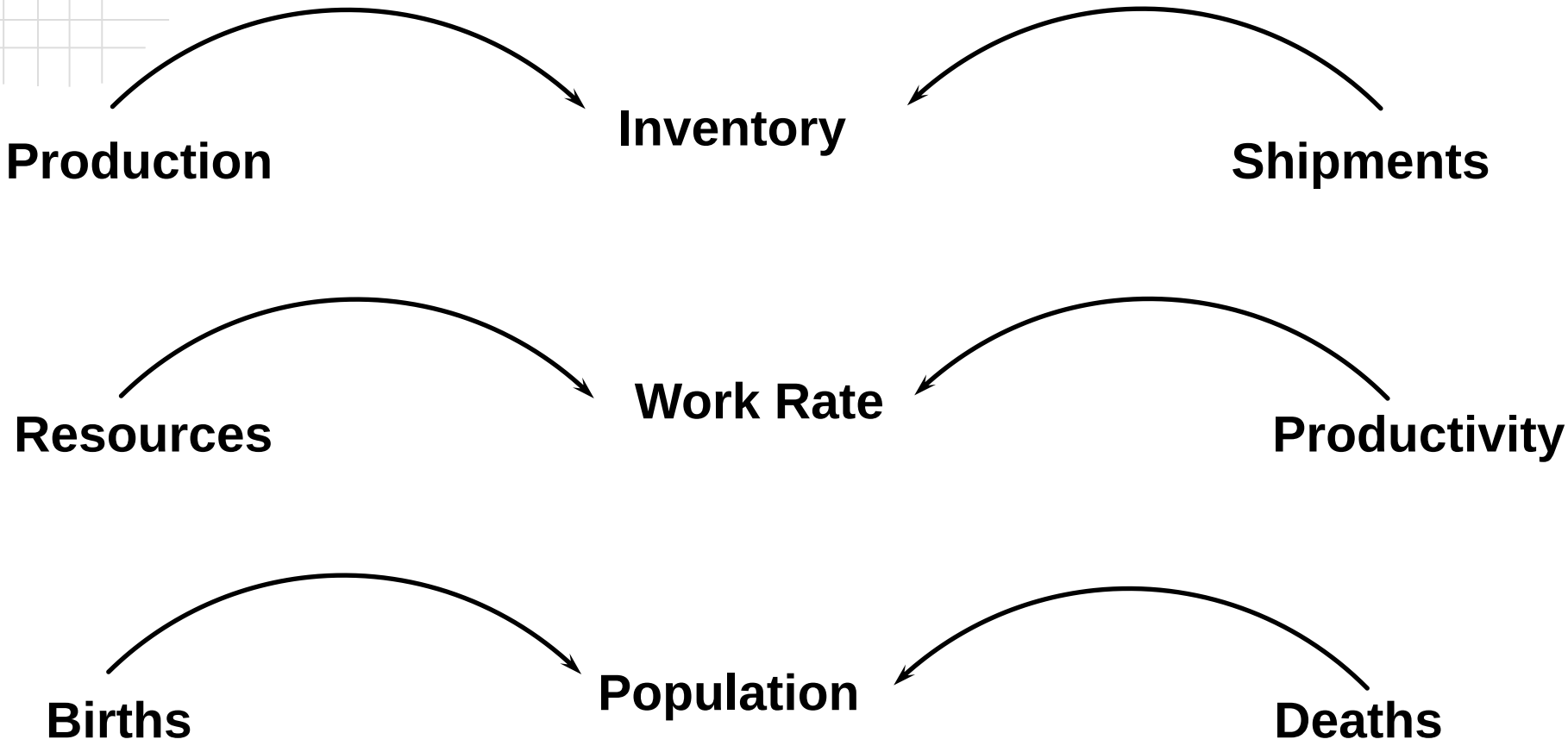
Causal loop diagrams -- causal links

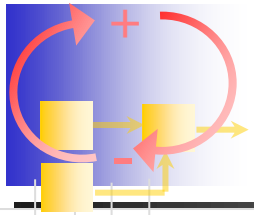
- An arrow with a positive sign (+) means that, all else remaining equal, an increase (decrease) in the first variable increases (decreases) the second variable ***above (below) what it would otherwise have been.***

- An arrow with a negative sign (-) means that, all else remaining equal, an increase (decrease) in the first variable decreases (increases) the second variable ***below (above) what it otherwise would have been.***

Exercise -- link and loop polarity



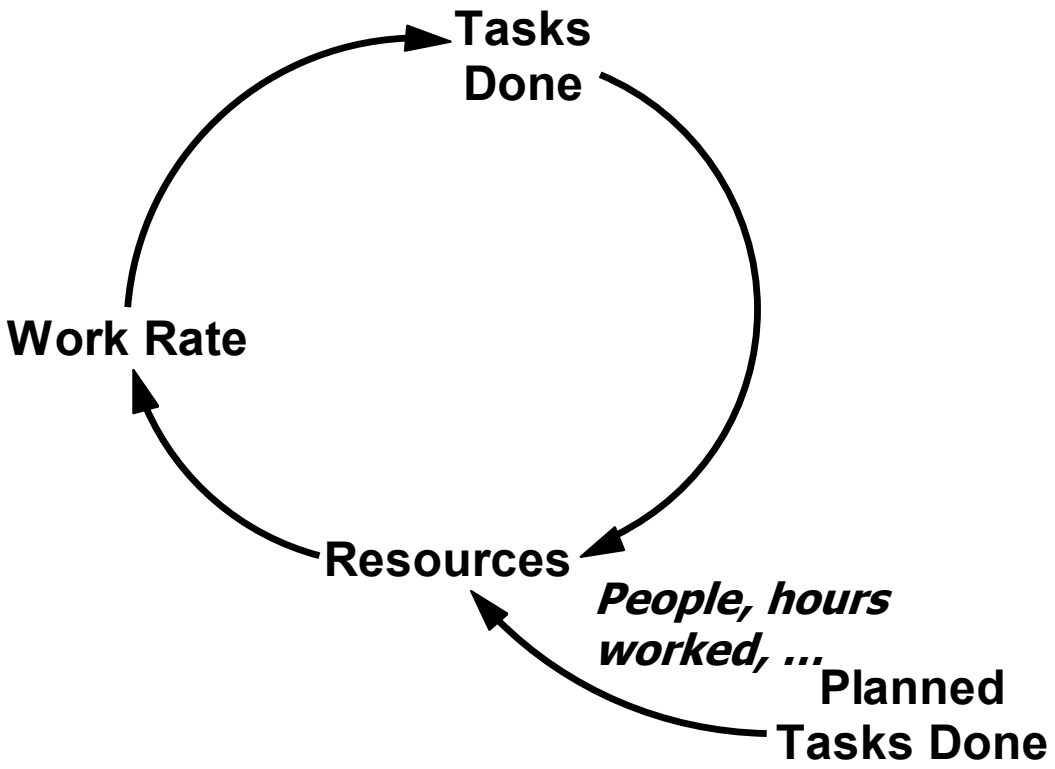




Causal loop diagrams -- loop polarity

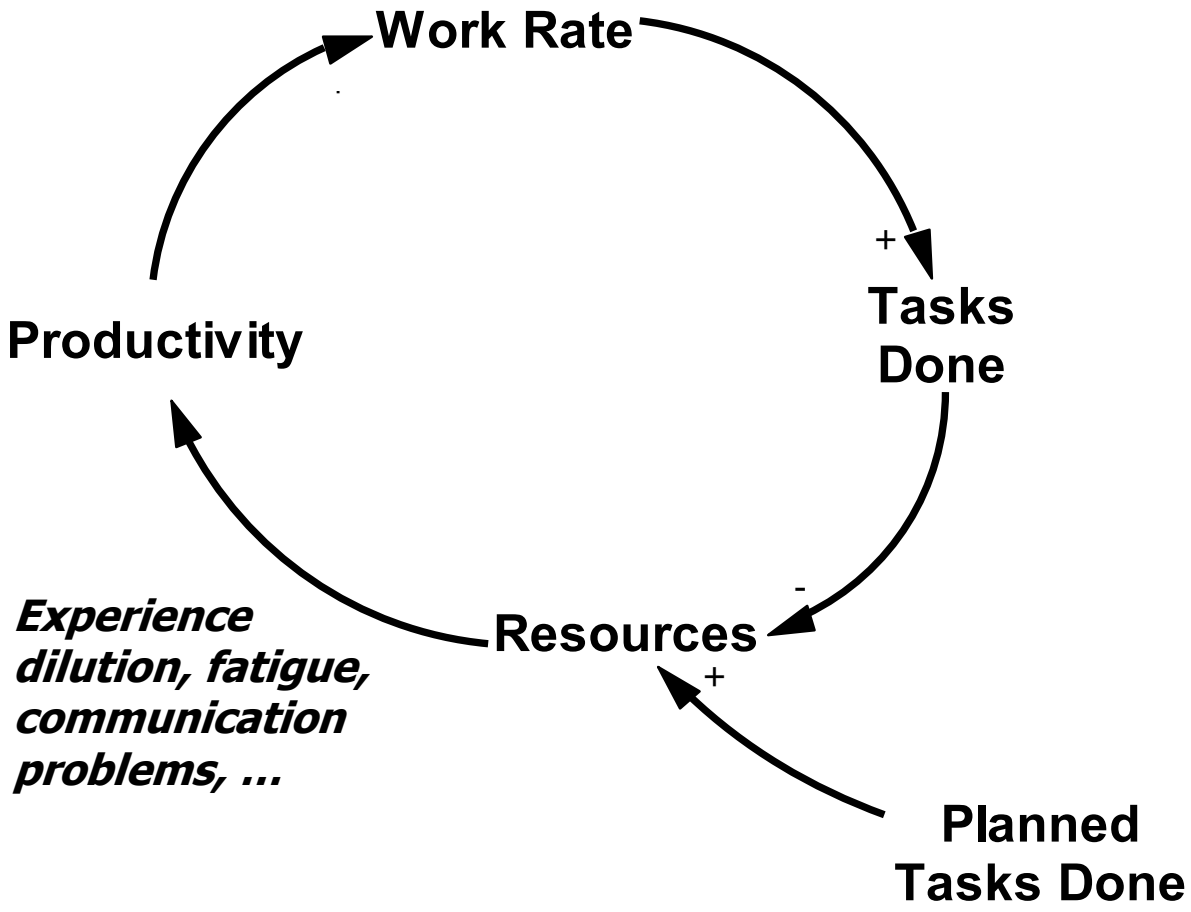
- Reinforcing loops -- loops with all positive or an even number of negative causal links ("positive" loop to engineers)
- Balancing loops -- loops with an odd number of negative causal links ("negative" loop to engineers)

Reinforcing or Balancing?

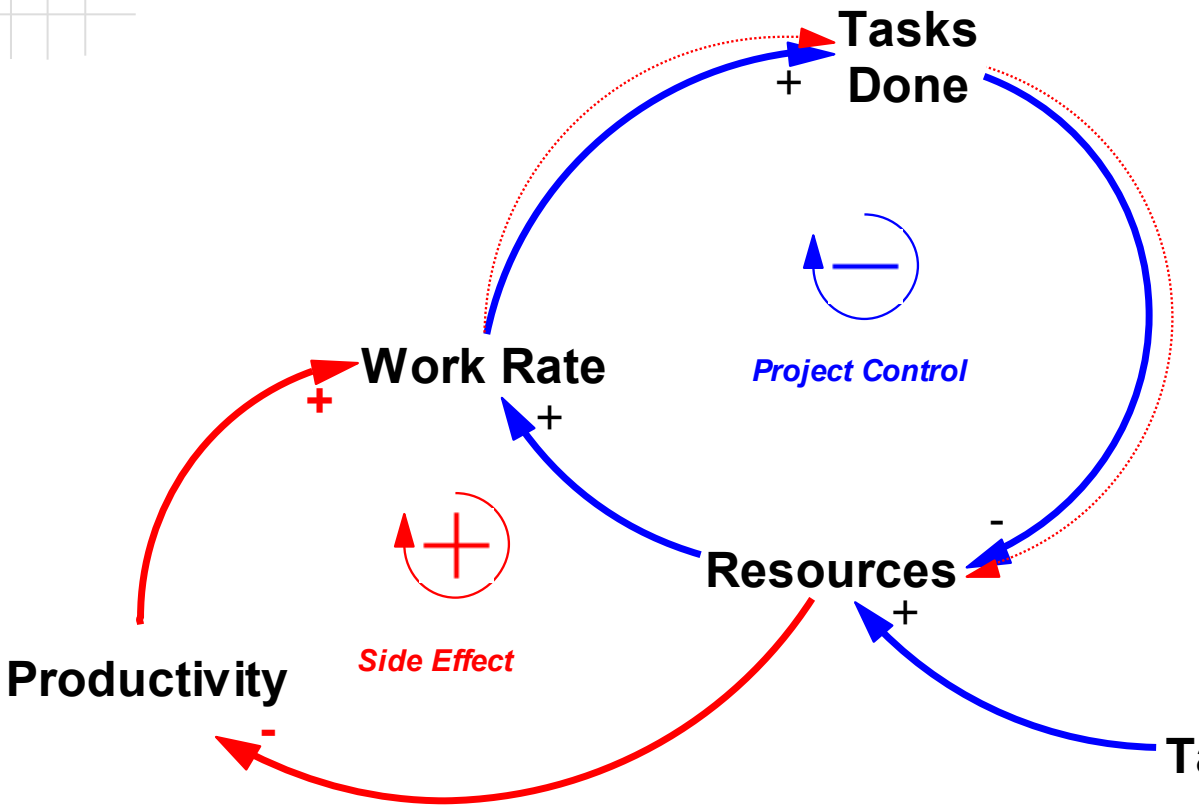


All negative loops have a goal

Reinforcing or Balancing?



Combining ...



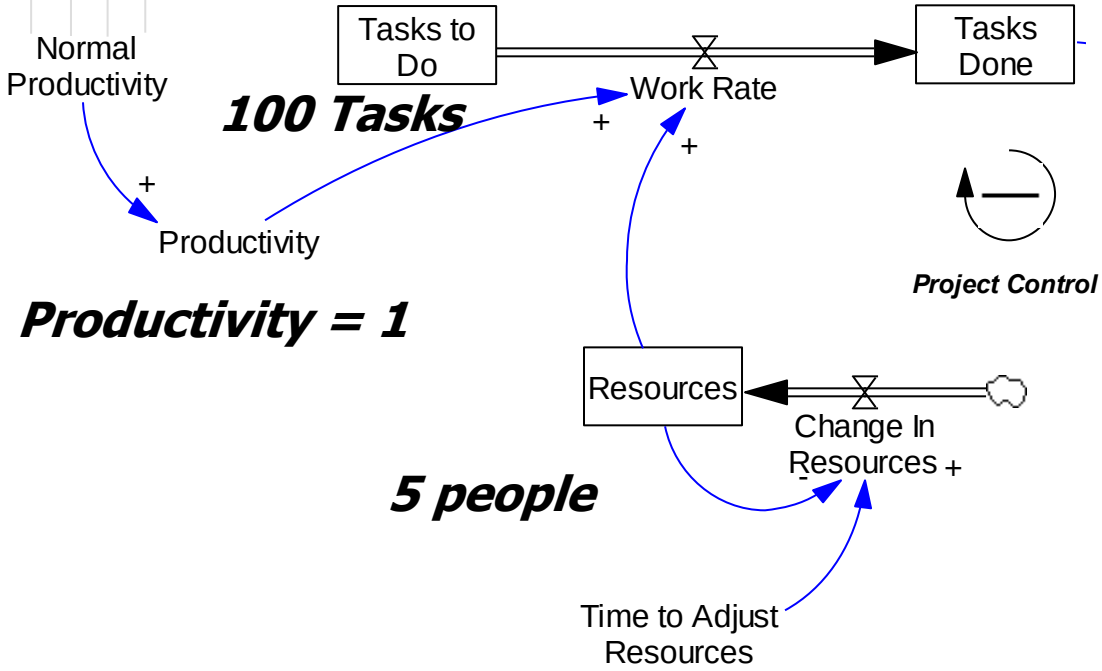
Any delays?

Which Variables are Stocks? Missing flows?

A Computer Model …

Details of this example are in Appendix SDA V3.pdf

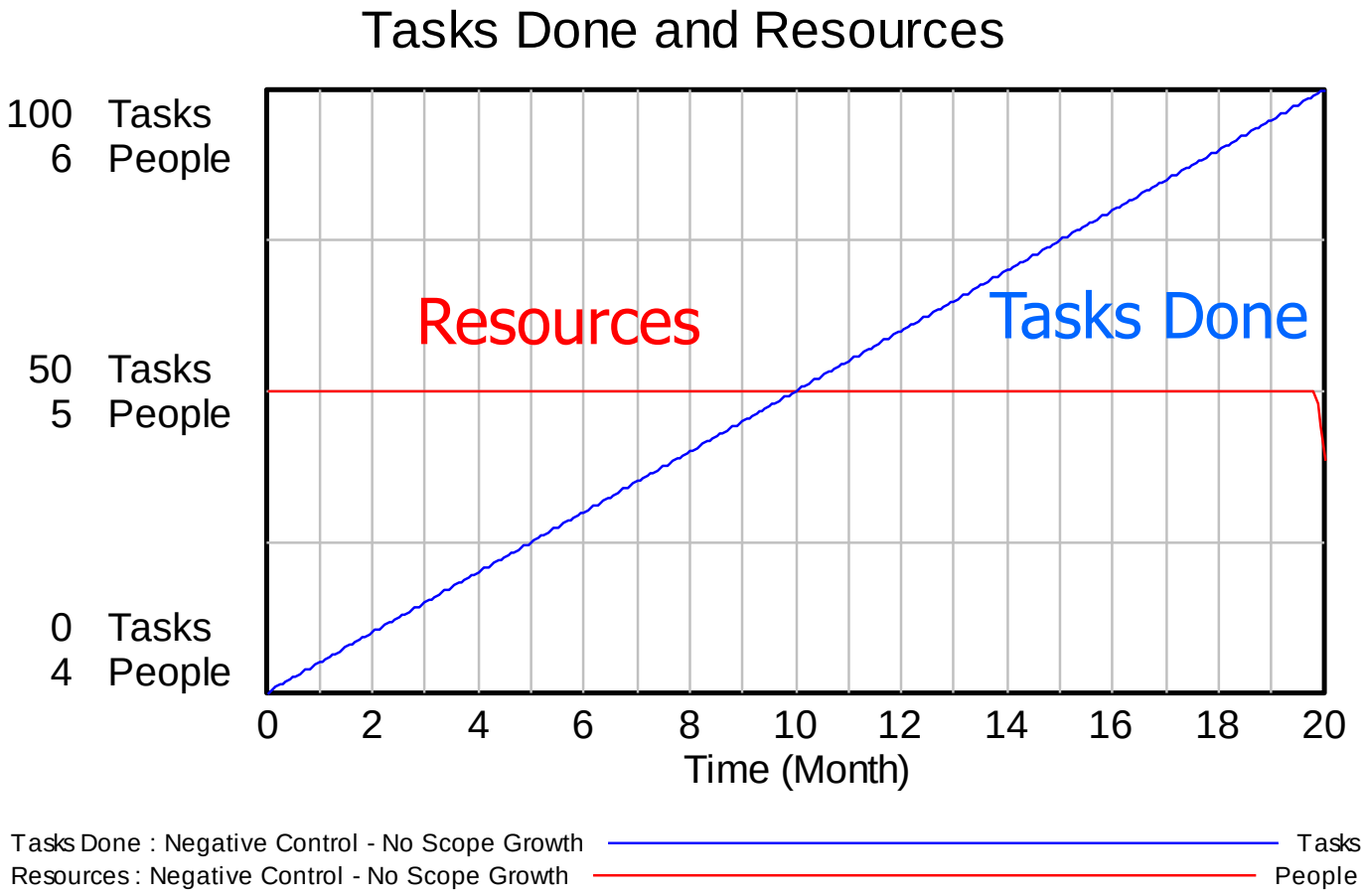
Work Rate = Resources * Productivity



Indicated Resources = (Total Tasks to Do-Tasks Done) / Time Remaining) / Productivity

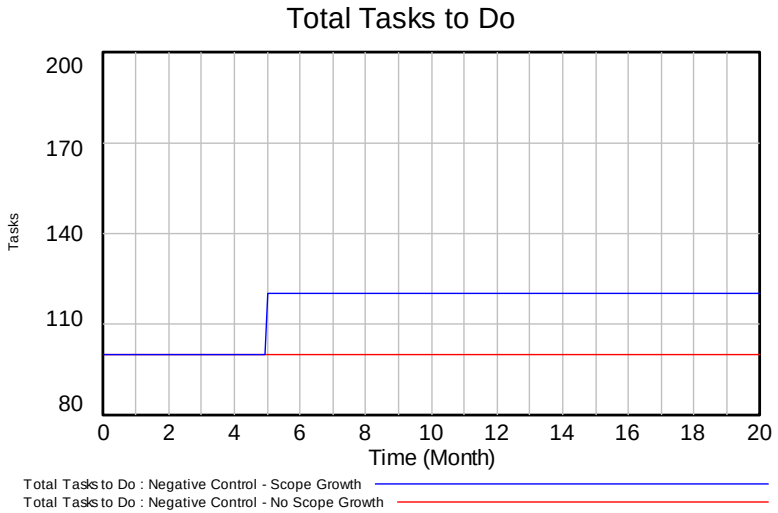
Change in Resources = (Indicated Resources – Resources) / Time to Adjust Resources

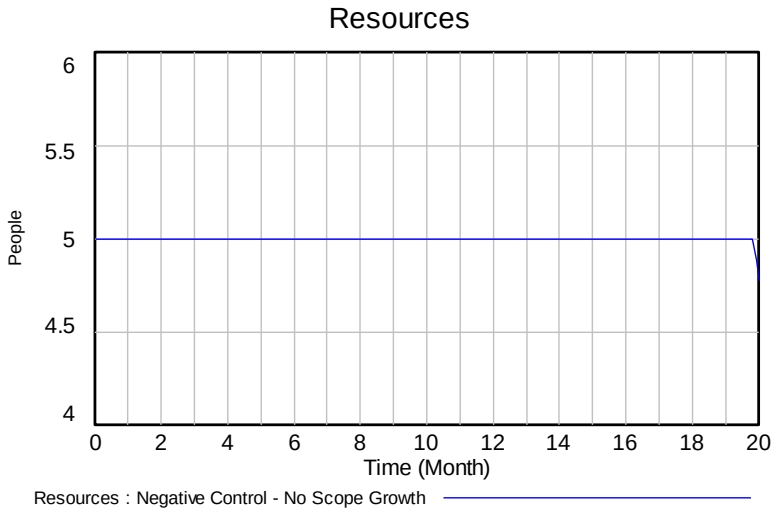
Simulating


Tasks Done and Resources
100 Tasks
6 People
50 Tasks
5 People
0 Tasks
4 People
Resources
Tasks Done
0
2
4
6
8
10
12
14
16
18
20
Time (Month)
Tasks Done : Negative Control - No Scope Growth
Tasks
Resources : Negative Control - No Scope Growth
People

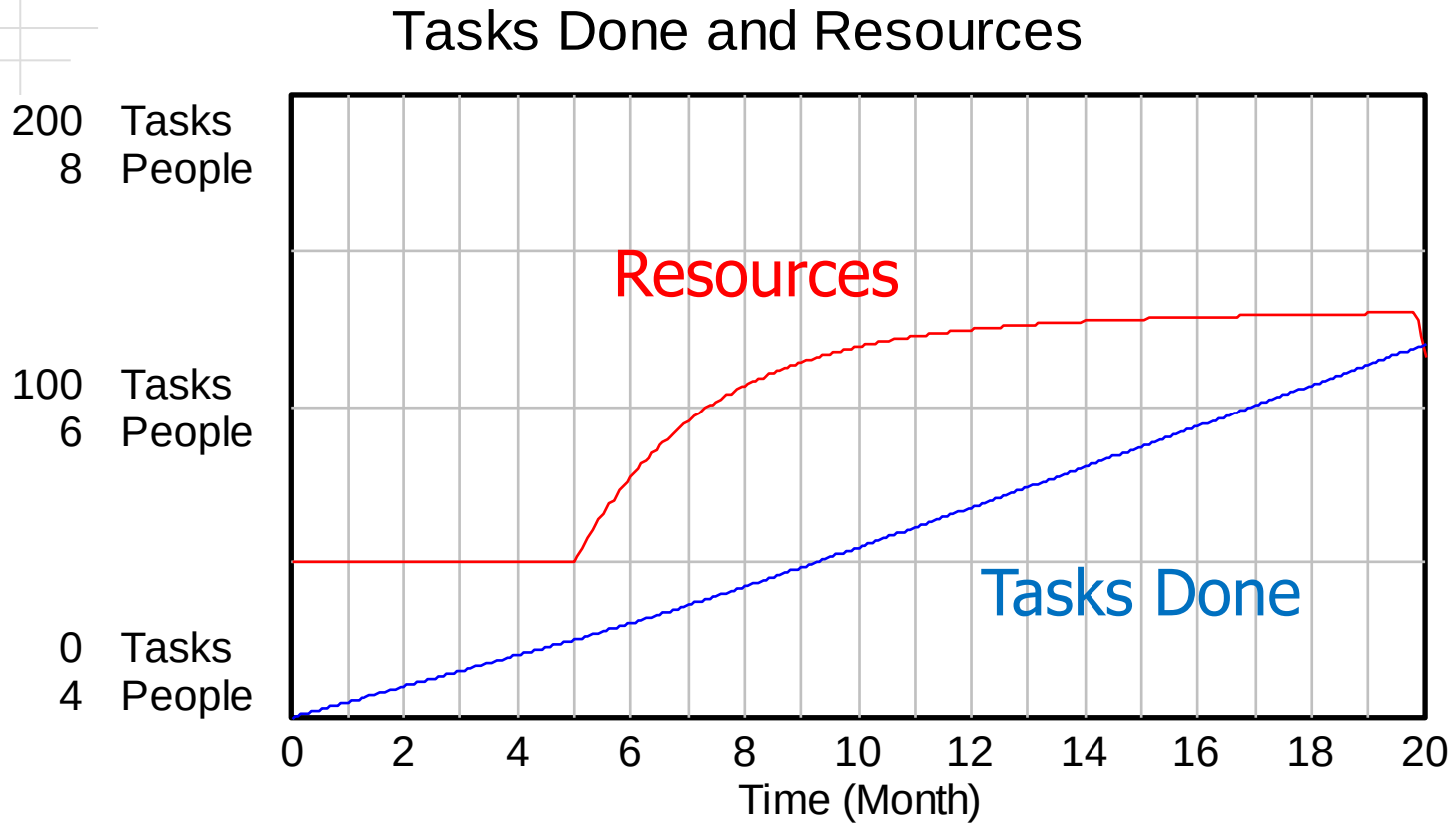
Response to Increase in Tasks to Do (20 @ Month 5)

?

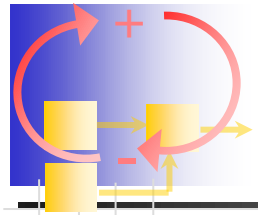


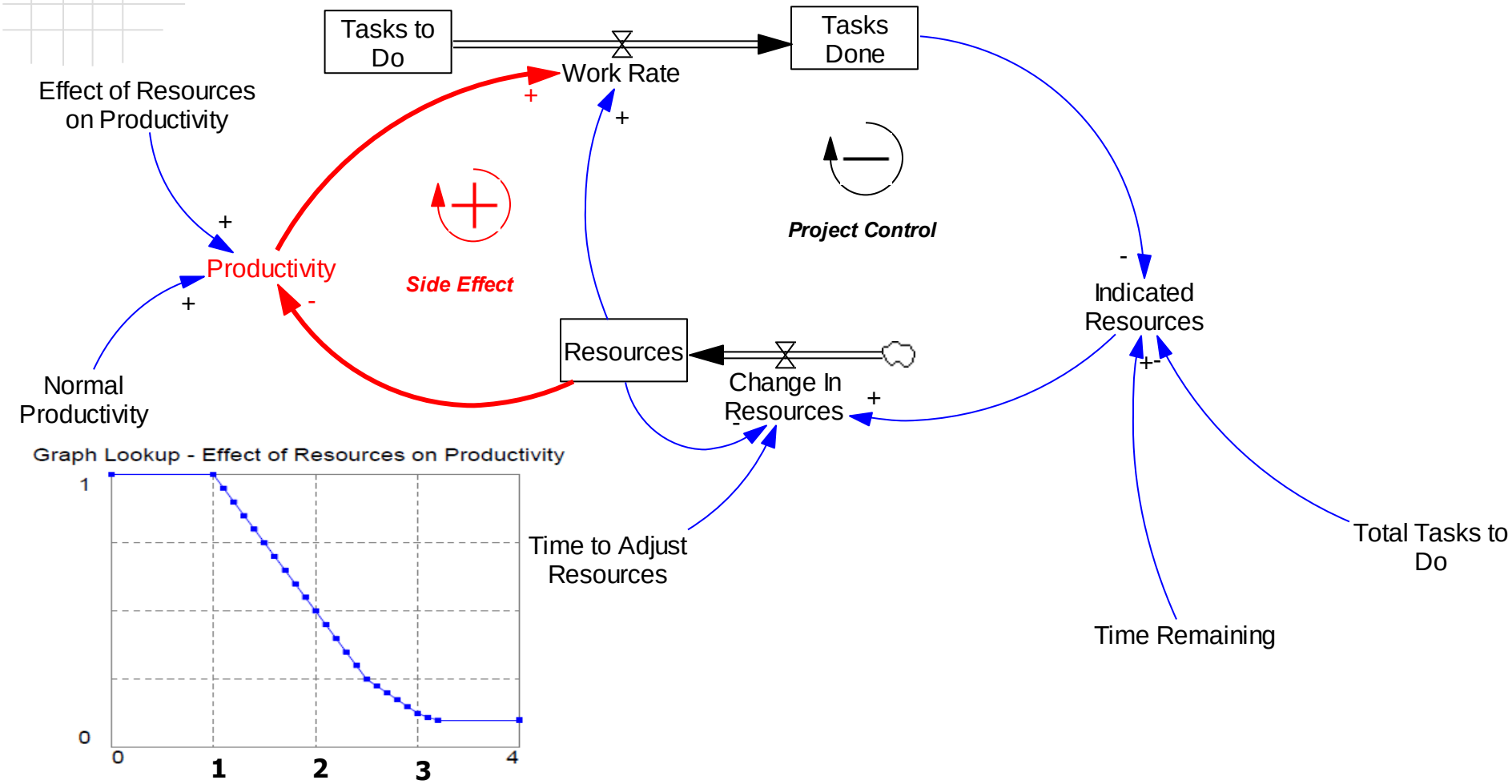


Simulating in Response to Increase in Tasks to Do (20 @ Month 5)



Adding reinforcing side effect loop





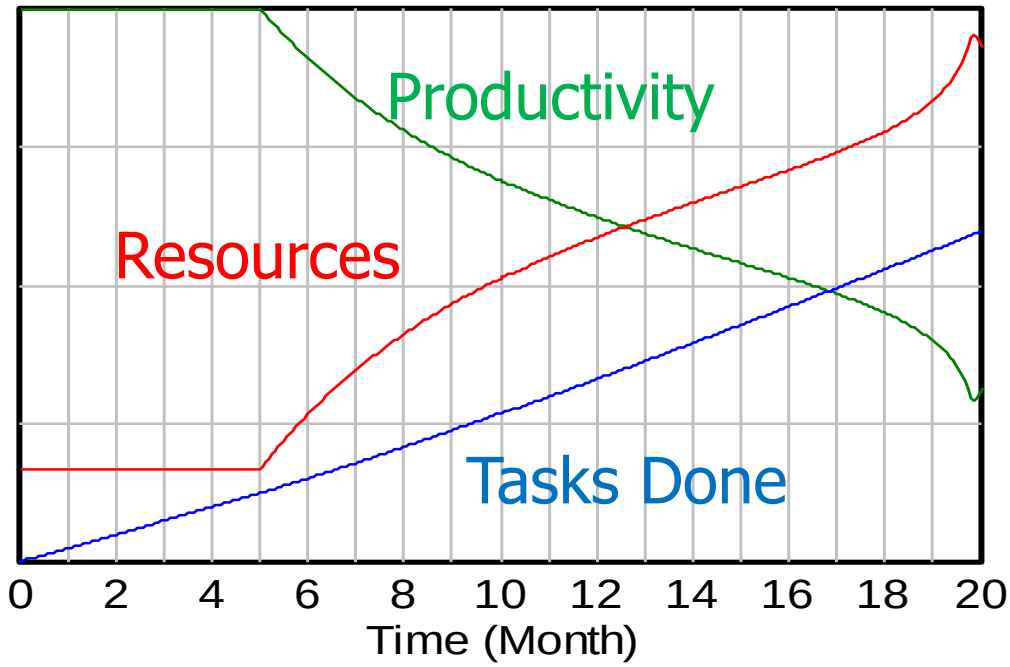
Resources/Initial Resources

Simulating ...

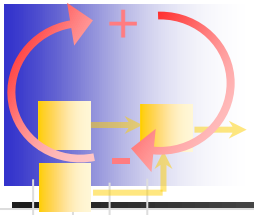
200 Tasks
10 People
1 Tasks/(Month*Person)

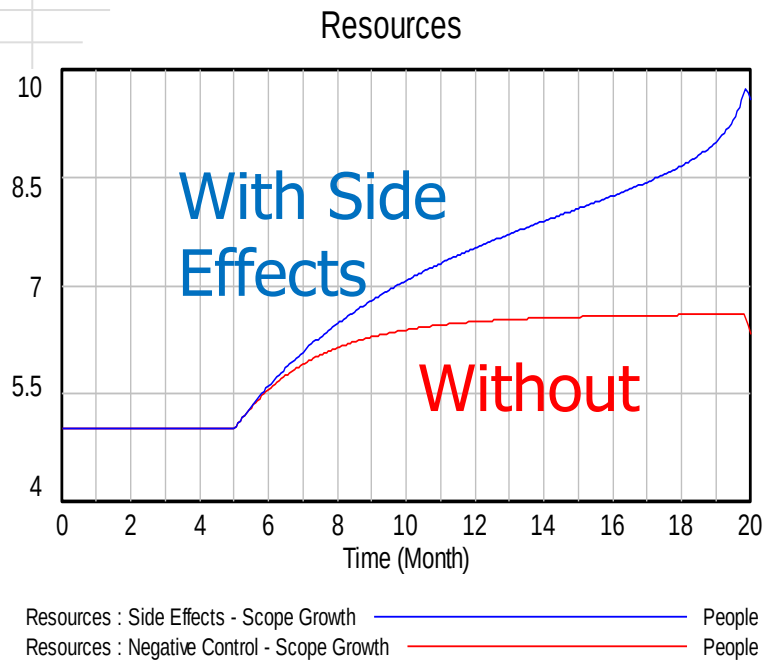
100 Tasks
7 People
0.8 Tasks/(Month*Person)

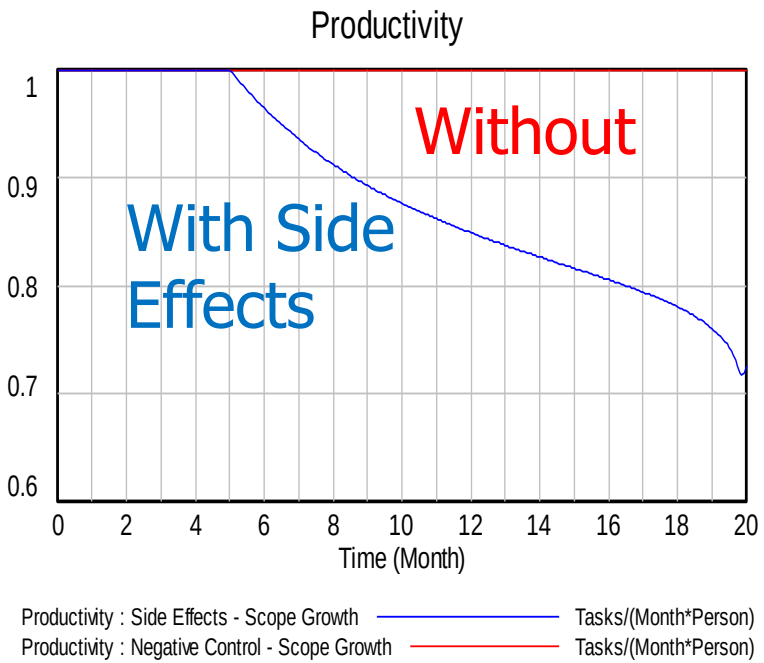
0 Tasks
4 People
0.6 Tasks/(Month*Person)



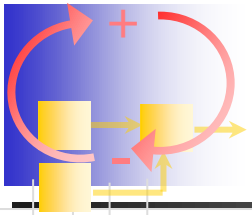
Tasks Done : Side Effects - Scope Growth — Tasks
Resources : Side Effects - Scope Growth — People
Productivity : Side Effects - Scope Growth — Tasks/(Month*Person)







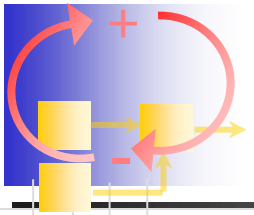
→ change in the behavior of the project as a result of our attempts to manage (achieve a schedule) in the face of the external change (increase in scope).



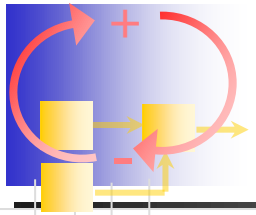
Survey Question

In your organization, what do you estimate is the relative contribution of the direct costs of External Changes and the costs of Management Responses to project overruns:

1. Costs of External Changes greater than costs of Management Responses
2. Costs of Management Responses greater than costs of External Changes
3. Costs of both about same
4. Varies too much by project to say for sure

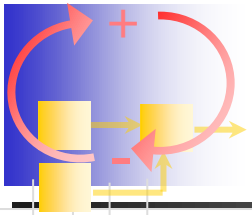


Interacting positive and negative feedback loops of cause-effect relationships, with stocks, flows, delays, and non-linearities, are capable of generating all observed modes of behavior.



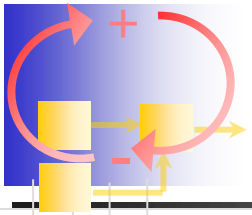
Today's Agenda

- Dynamic project problems
- Understanding dynamics: the system dynamics methodology
- ***Overview of system dynamics module***
- Vensim



What is SD useful for?

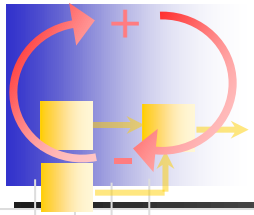
- Conceptualization of project dynamics and the issues/tradeoffs involved in strategic management of projects
- Quantification of above …
  - Hueristics
  - Specific forecasts and decision guidance
- Project-to-project learning



Purpose of system dynamics module

Managing the drivers of cost and schedule overrun …

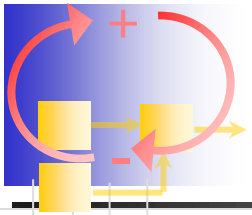
- Insight into project dynamics, and impact of management actions
- Introduction to tools for describing and for quantifying dynamics
- Develop two (simple) models of project dynamics
- Managing projects “strategically”



Uses of System Dynamics Models in Strategic Project Management

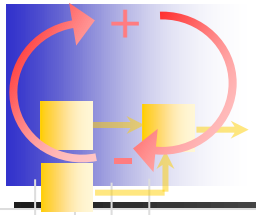
- Project estimating, planning, and risk assessment
- On-going project management
- Pricing mid-project changes & dispute resolution
- Learning

How can we best balance cost, schedule, scope, and delivered quality on a project?



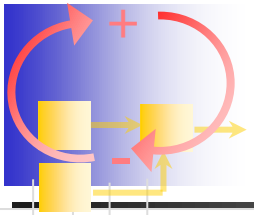
Next SD Classes

- SD#2 – Project dynamics – the rework cycle
  - HW#3 – Rework Cycle model & analyses
- SD#3 – Project dynamics -- feedbacks
- SD#4 – Analyses of strategic project management issues
  - HW#5 – Use model to explore planning and project control issues
- SD#5 – Cases, Multi-project



Important Administration

- Send me your model file if you have specific technical questions.



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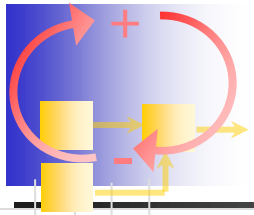

Vensim Familiarization (for HW#3 & HW#5)

- Get started with Vensim
  - Work through Vensim Tutorial Under Draft Book Chapters (Appendix SDA V3.pdf).
  - ***Ask a colleague who took ESD.74 or 15.874 (now 15.871&2)?***
- Download Vensim PLE
- Don't hesitate to email me (include you model – "dot" mdl – file); do not waste time on Vensim problems.

ESD.36 System Project Management

Fall 2012