“Breaking the Code”

Analyzing the Secondary Impacts of Change

RICE GLOBAL E&C FORUM

ELEVENTH ANNUAL FORUM SESSION

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Setting the stage - A tale of two projects

- **Both projects have:**
  - Exactly the same scope
  - Identical site conditions
  - Office and field teams with identical talent
  - The same tools, practices and procedures
  - Are subjected to exactly the same changes to the original scope
- **Project #1**
  - Relaxed schedule
  - Skilled office and field staff are plentiful
  - Skilled craft are plentiful
  - Change introduced early
- **Project #2**
  - Very aggressive schedule
  - Extremely tight labor market for office and field staff
  - Site craft resources are fully employed
  - Change is introduced over extended period of time

Will project #1 and project # 2 cost the same at the end of the day?

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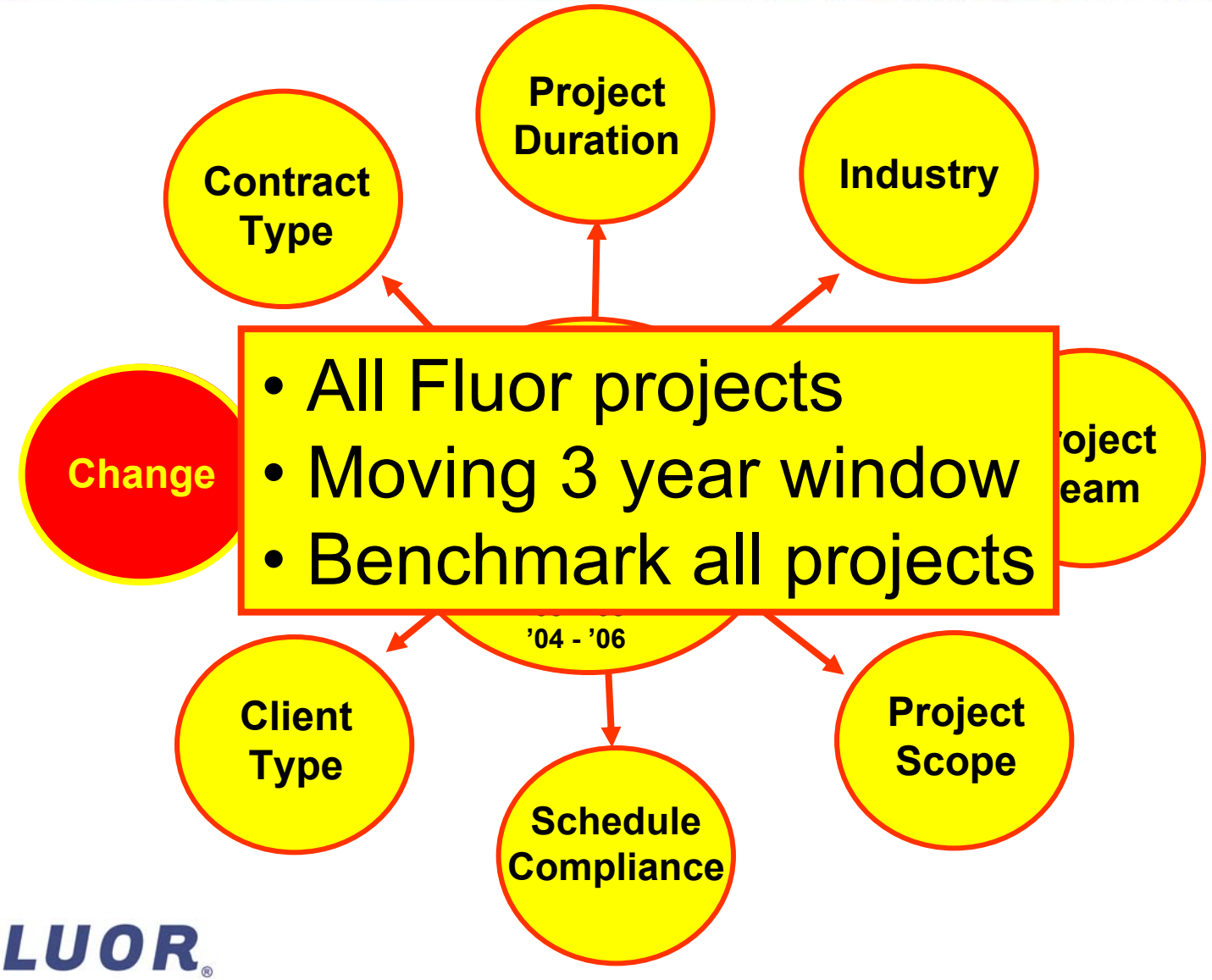
Project data characterization



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Project data characterization

What the data told us

Projects with change experienced both schedule and budget issues generally in proportion to the amount of change.

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Improving change impact management is vital to corporate performance

- "Project changes represent the single largest source of project productivity impact" -- Fluor survey.
- Waiting to address change impacts via a dispute process is risky, expensive, and precludes impact mitigation.
- Full secondary impacts of changes are difficult to measure and convey to internally (and particularly to clients).

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What the experts told us about "secondary impact"

of cha **What is secondary impact?** *work.*

…disruption

…cumulative impact

…productivity loss

…secondary effects

…knock-on impact

…ripple effects

…

Whatever the label, it's important, valuable and difficult to measure

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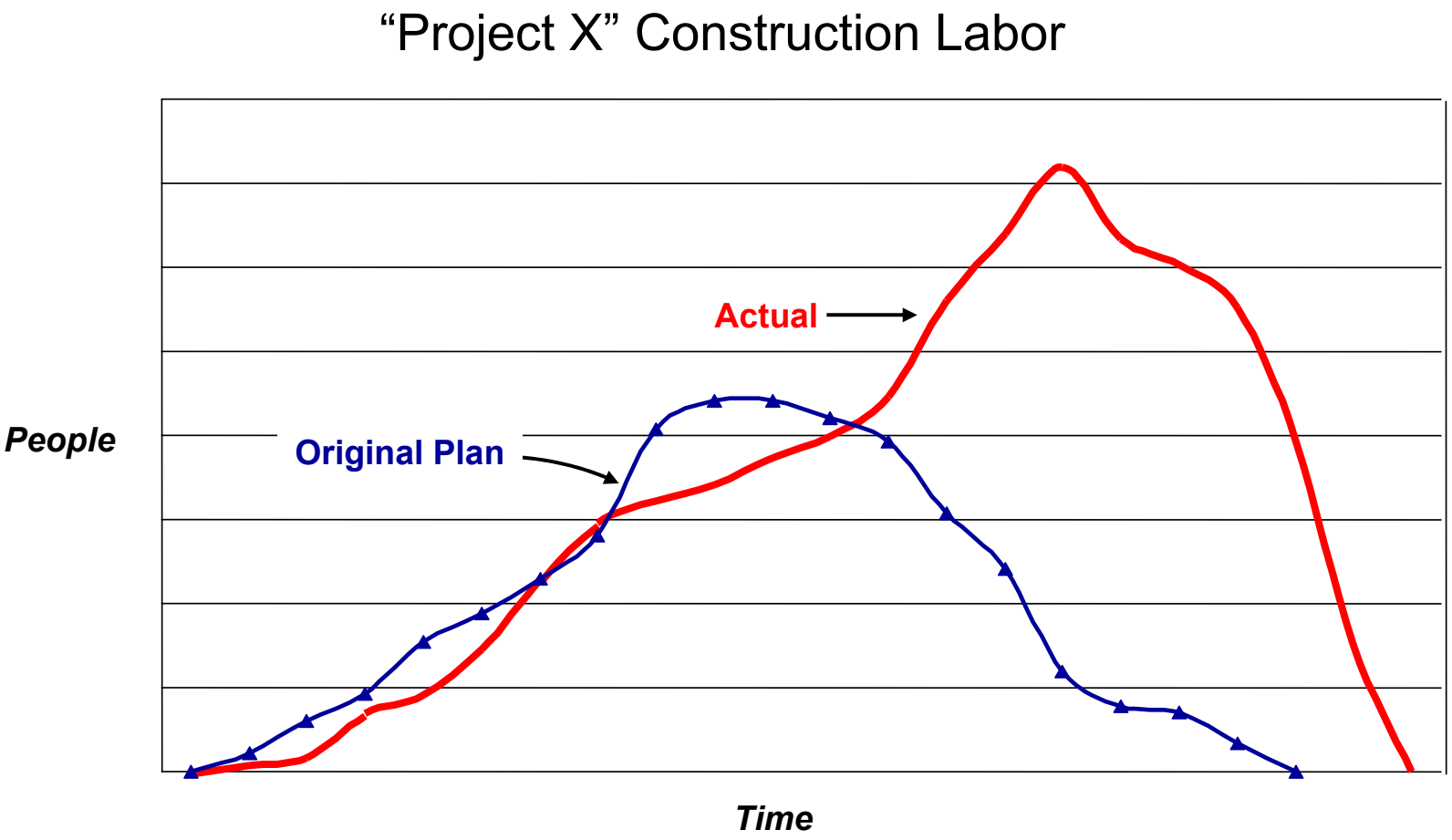
A True Story: Project X



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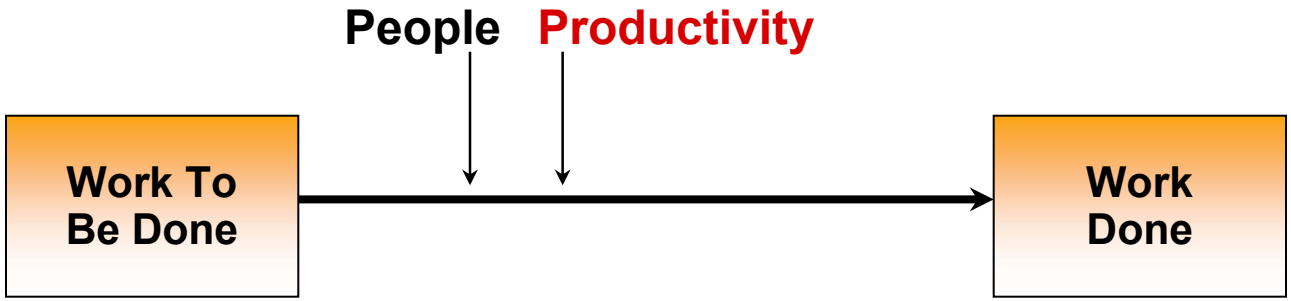
So, what happened on “Project X”?



“Our productivity was impacted.”

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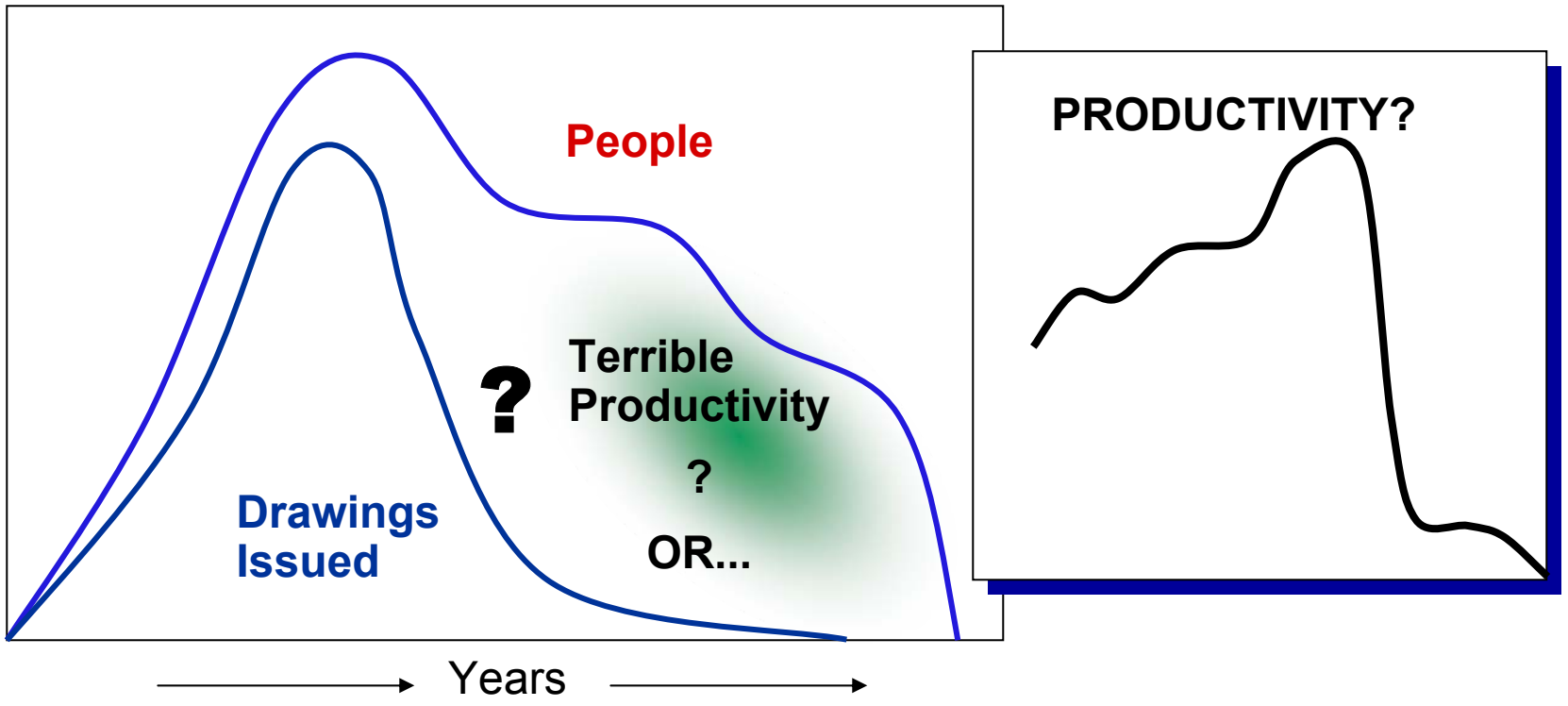
So, what happened on “Project X”?

We obtained data on engineering work done (drawings issued) and effort (people)



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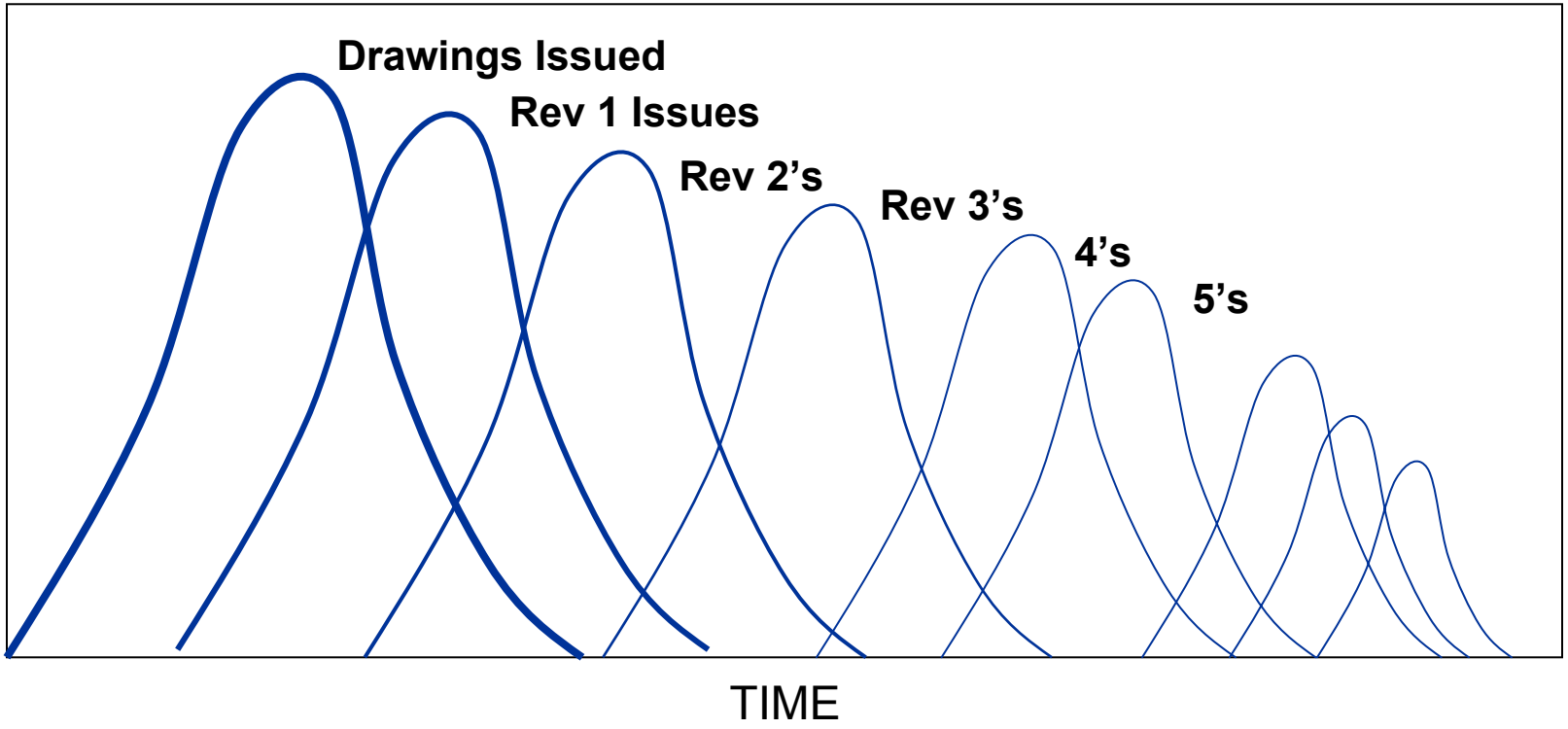
So, what happened on “Project X”?

Work ‘done’…and done and done…



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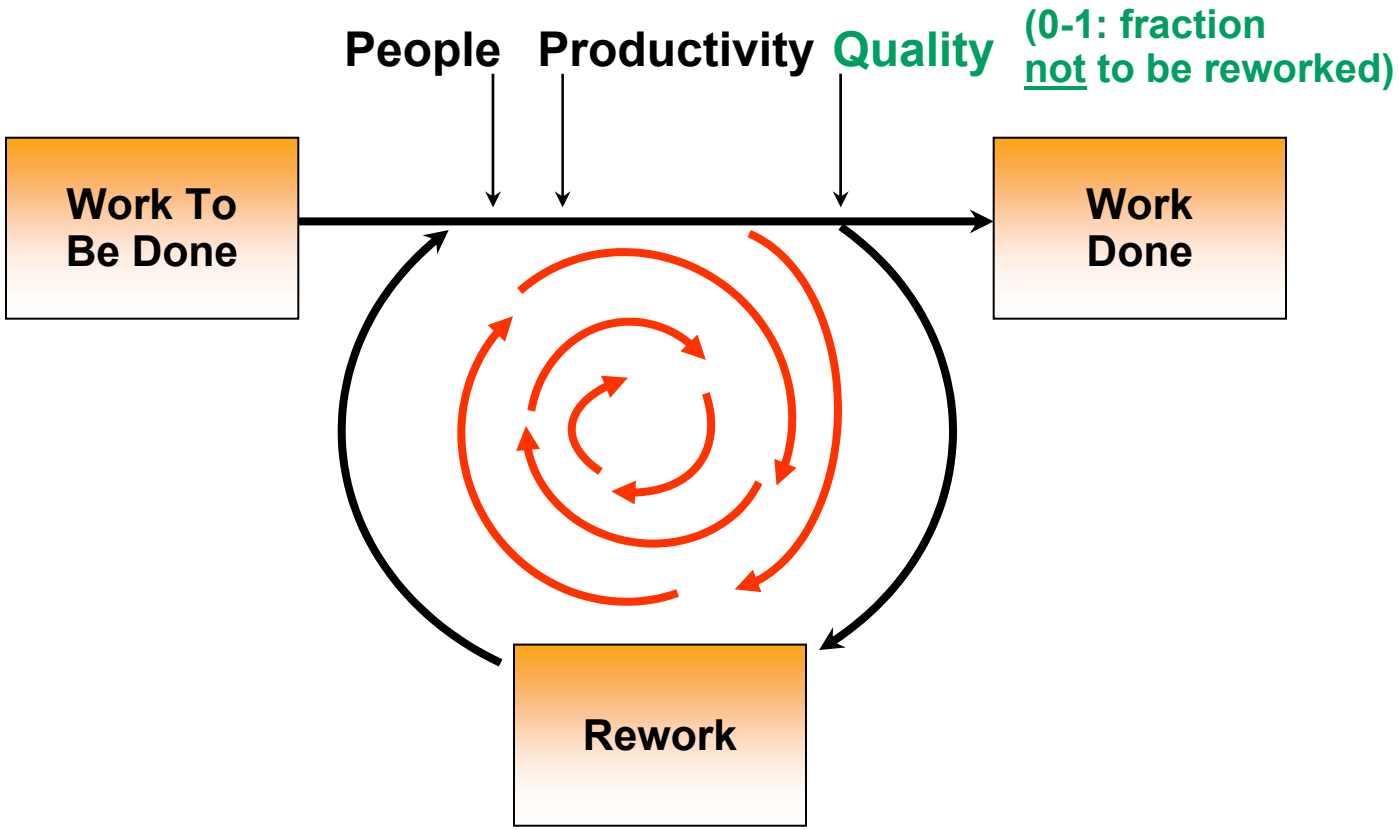
So, what happened on “Project X”?

So we added ‘rework’ to the model:



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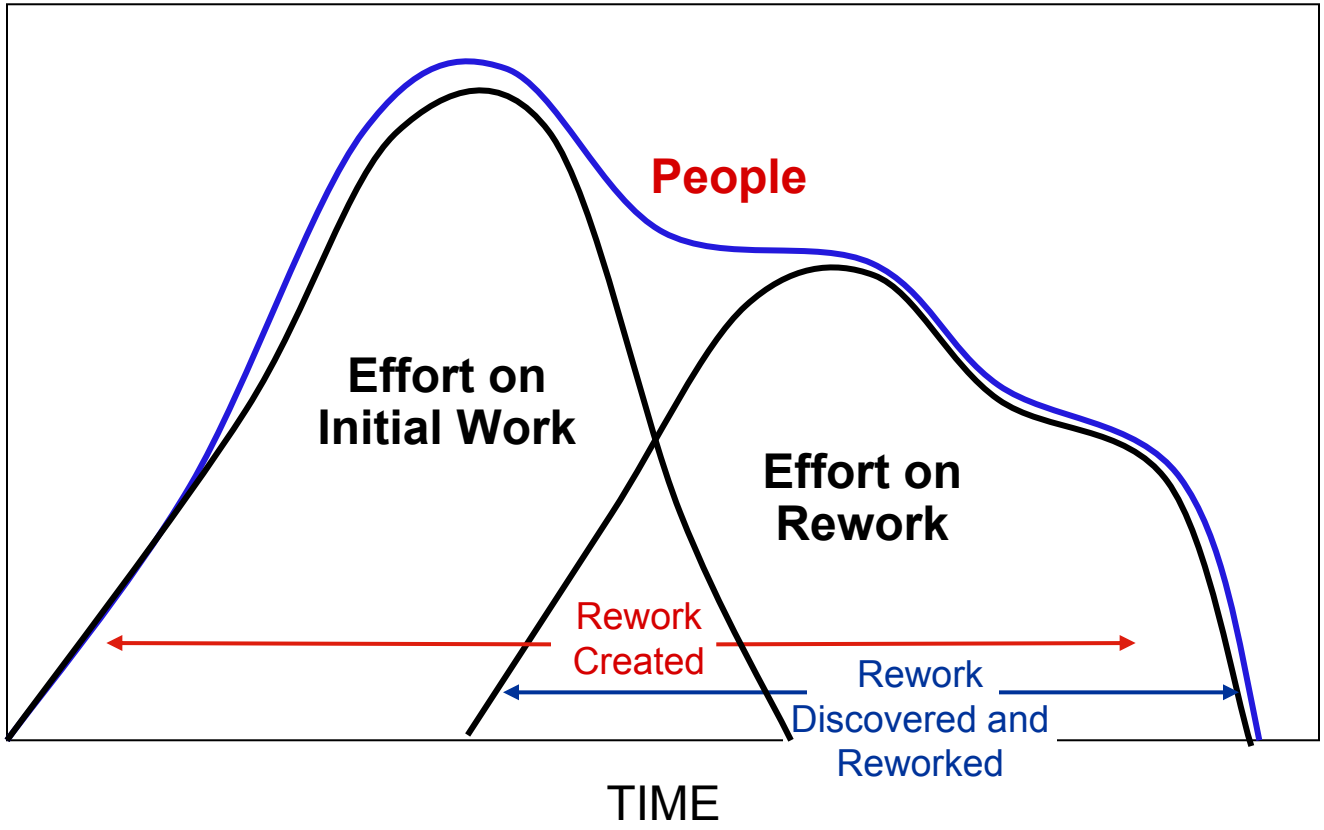
So, what happened on “Project X”?

Acknowledging effort spent on rework...



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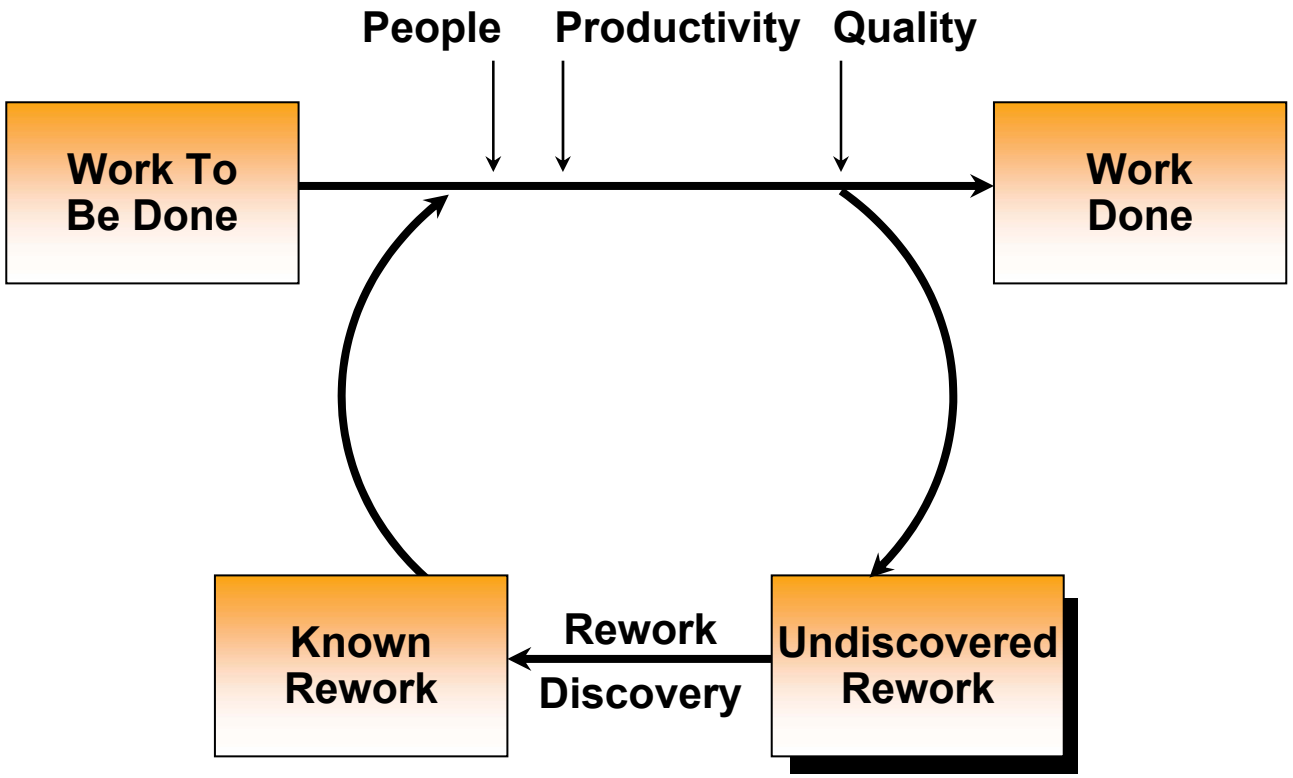
A better way of looking at projects and secondary impacts



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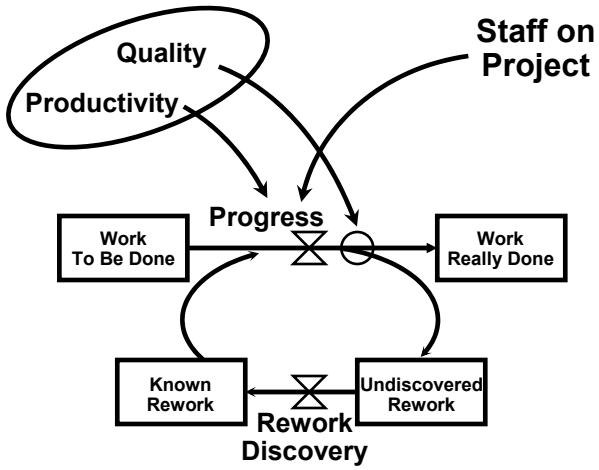
Starting with the "Rework Cycle", they continued explaining the secondary effects

Have you seen any of these next conditions on a project…?



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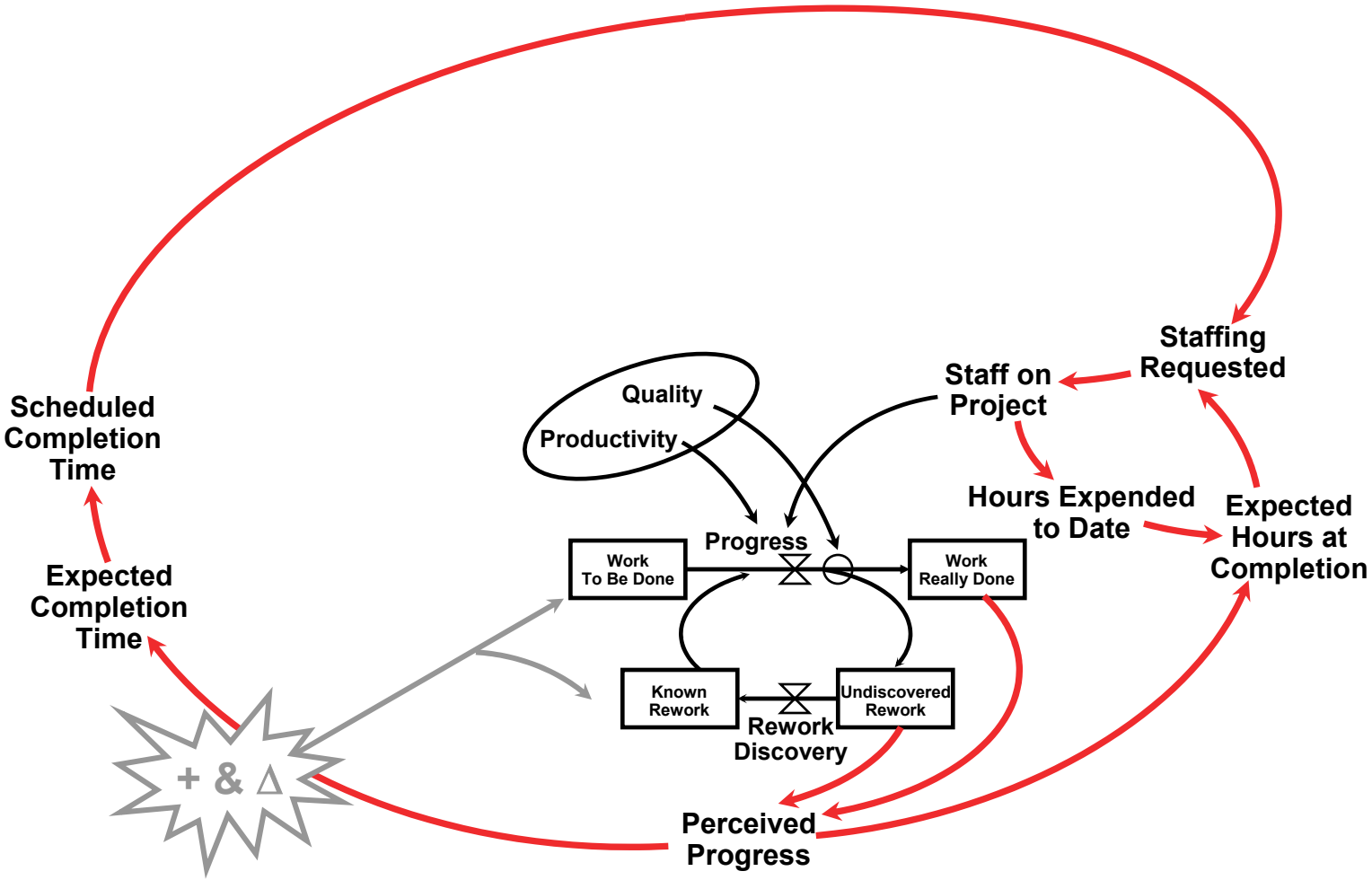
"Work was added (+) and changed (Δ) work so much, we staffed up more."



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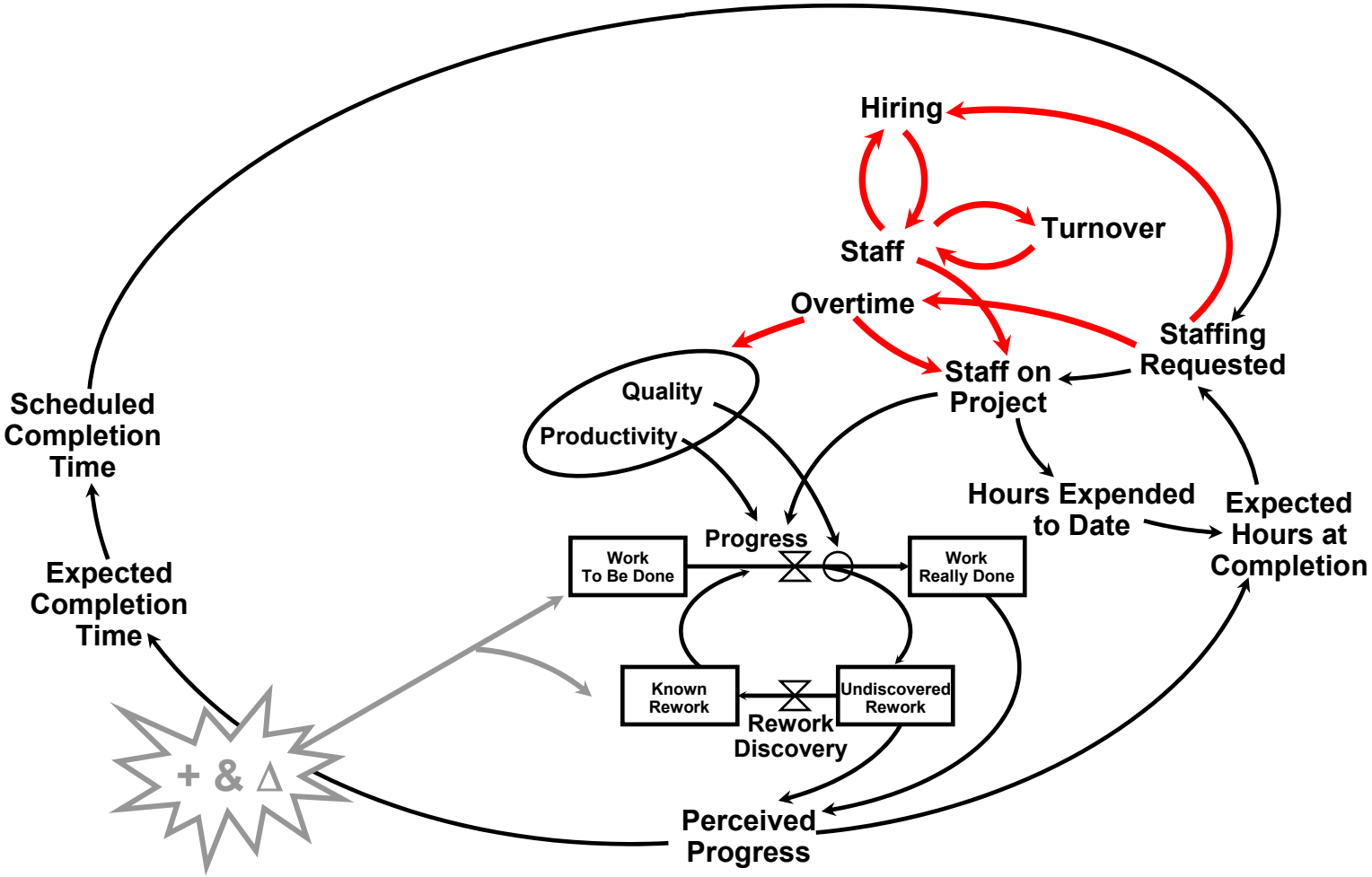
“We used lots of overtime and had to hire in tight markets.”



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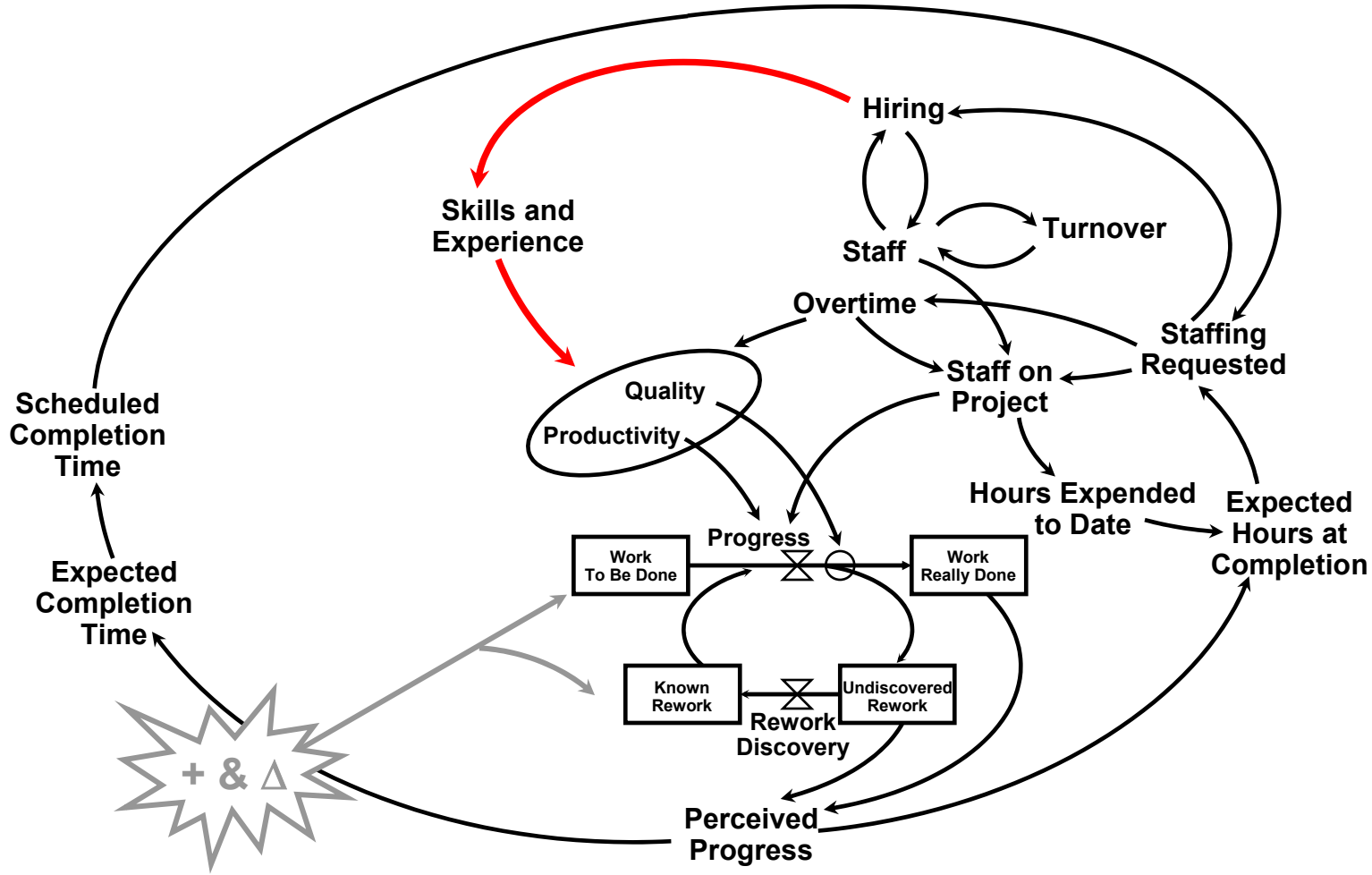
“Less skilled new hires also needed more supervision.”



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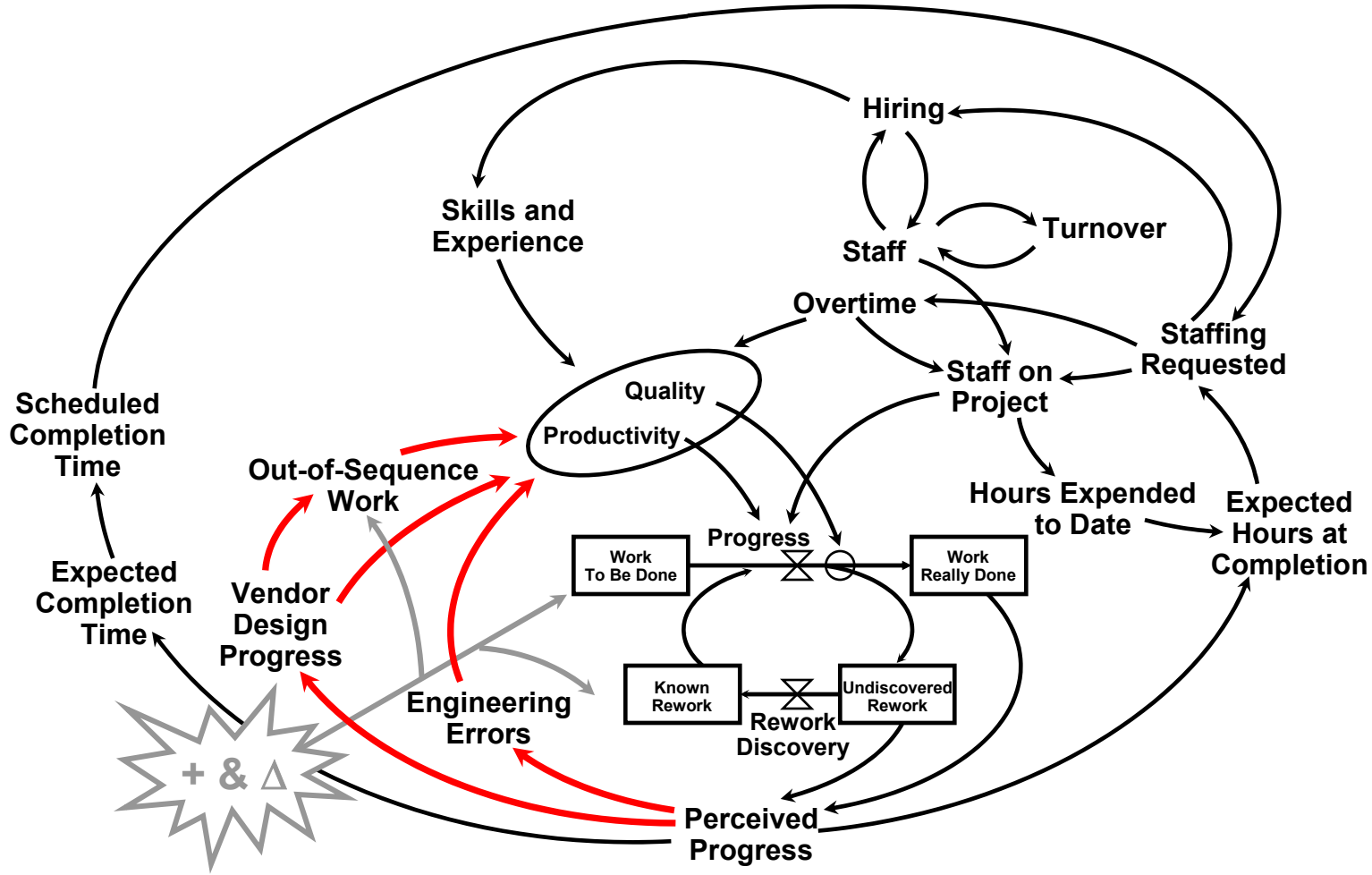
“Rework caused more rework.”



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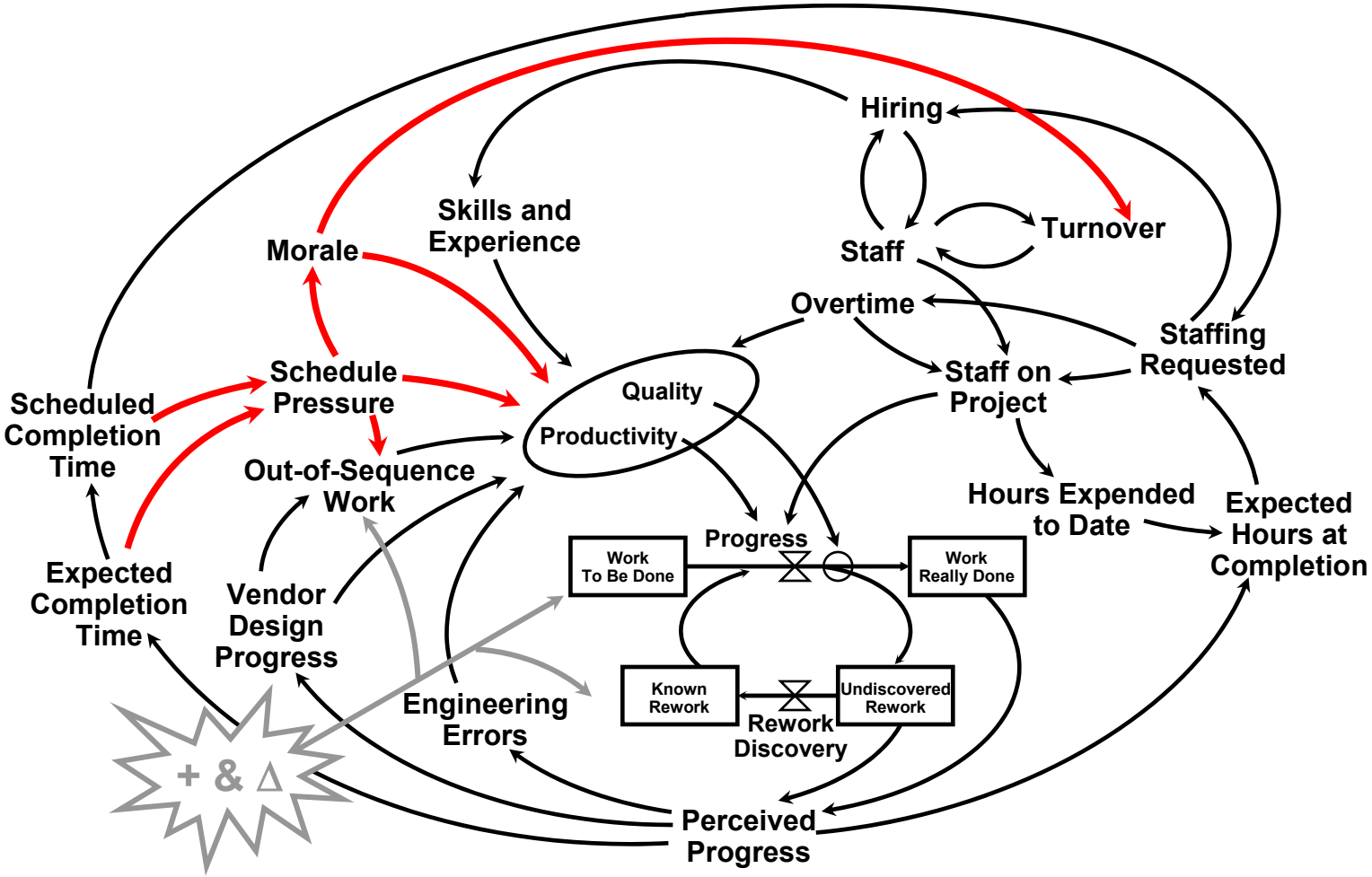
“Under pressure, morale suffered.”



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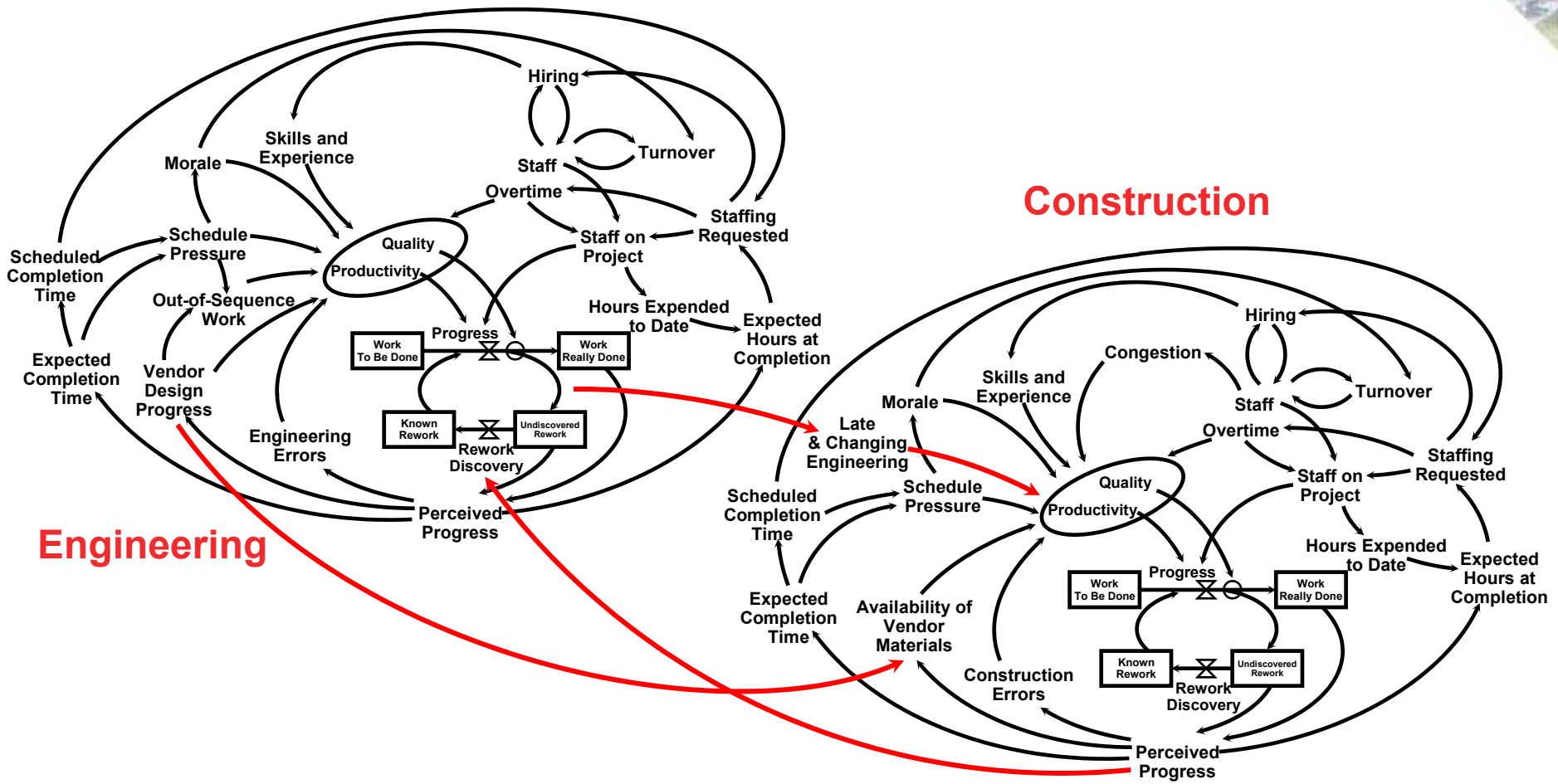
“Late and changing engineering hurt construction.”



With this, a ‘model’ of the project.

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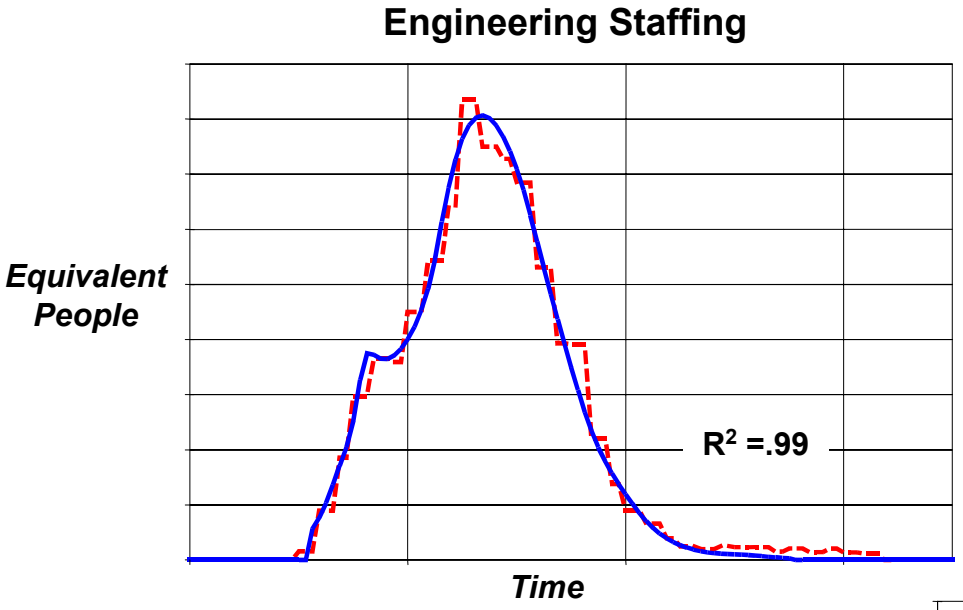
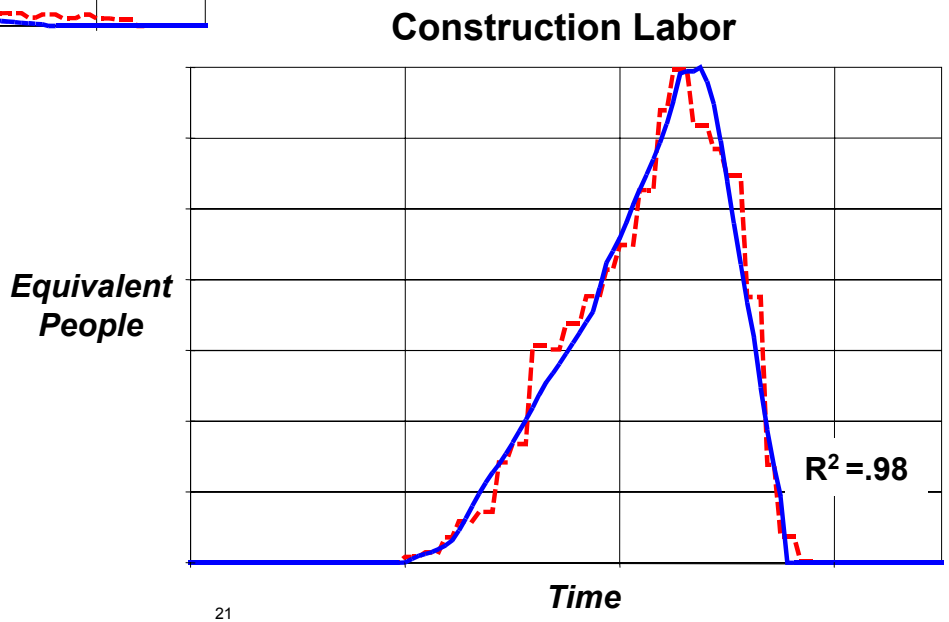
We built a model with that structure, recreating the project history





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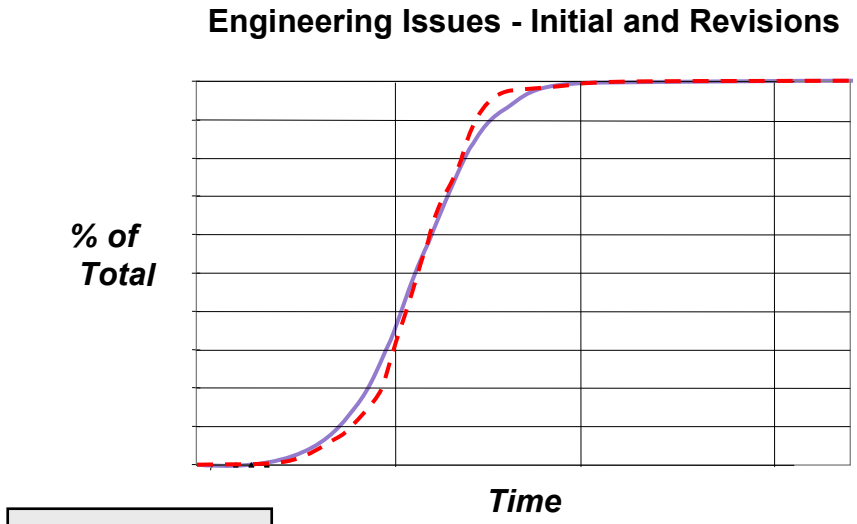
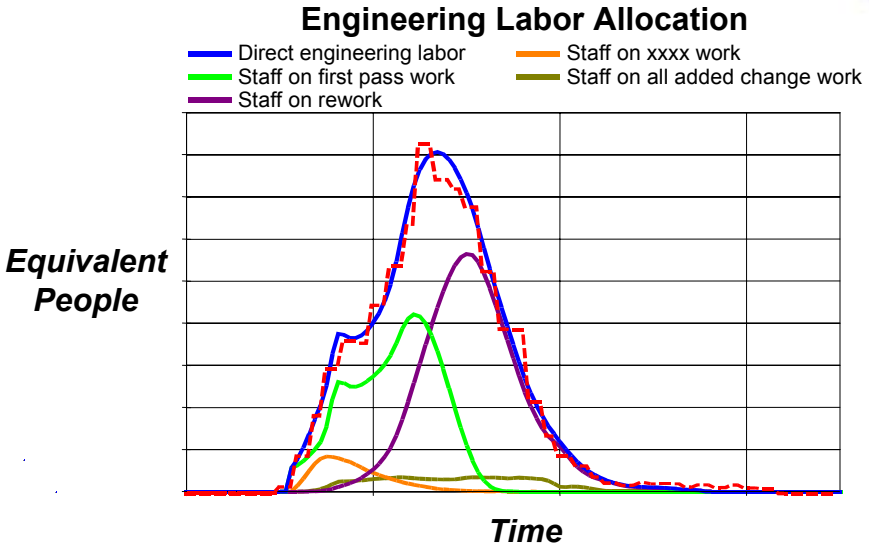
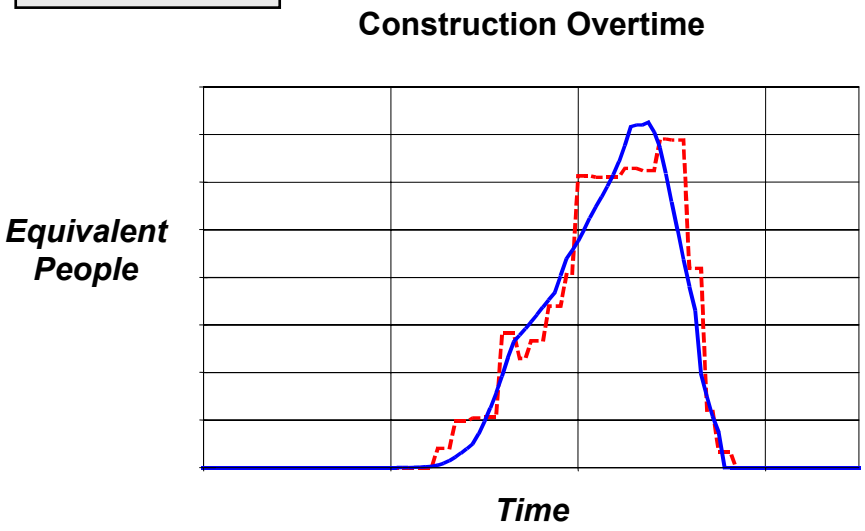
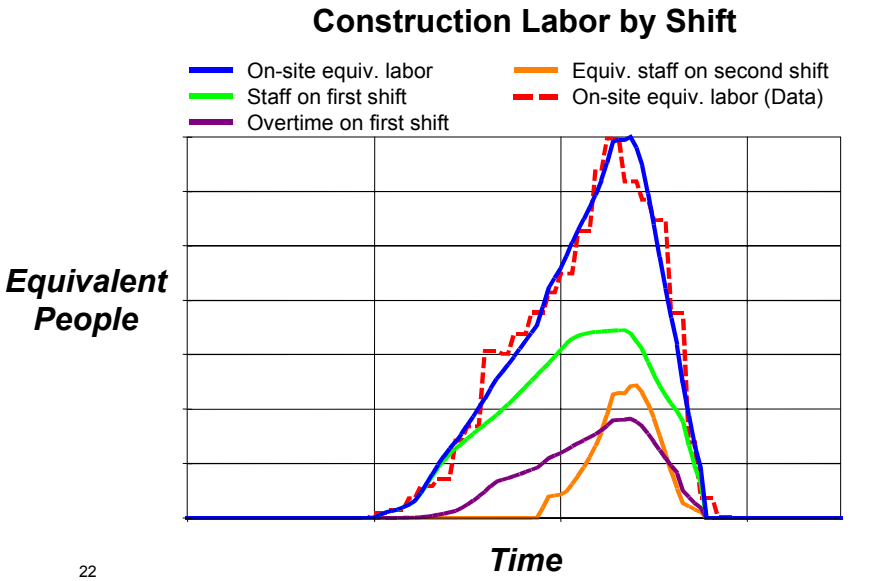
…and simulated many other elements of the project









A CIA analysis of one project consists of four steps

Step 1: Input project data to tailor model

Step 2: Specify the project change(s)

Step 3: Simulate project with and without change(s)

Step 4: Test mitigations

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A real project example:
What happens if FEED is delayed?

The Project:

- Nearing the end of FEED
- Post-FEED Detailed Engineering direct hour budget estimated to be just over 2 million hours
- Effective Construction begins 7 months later with a budget near 13.5 million hours, and is planned to finish in 42 months

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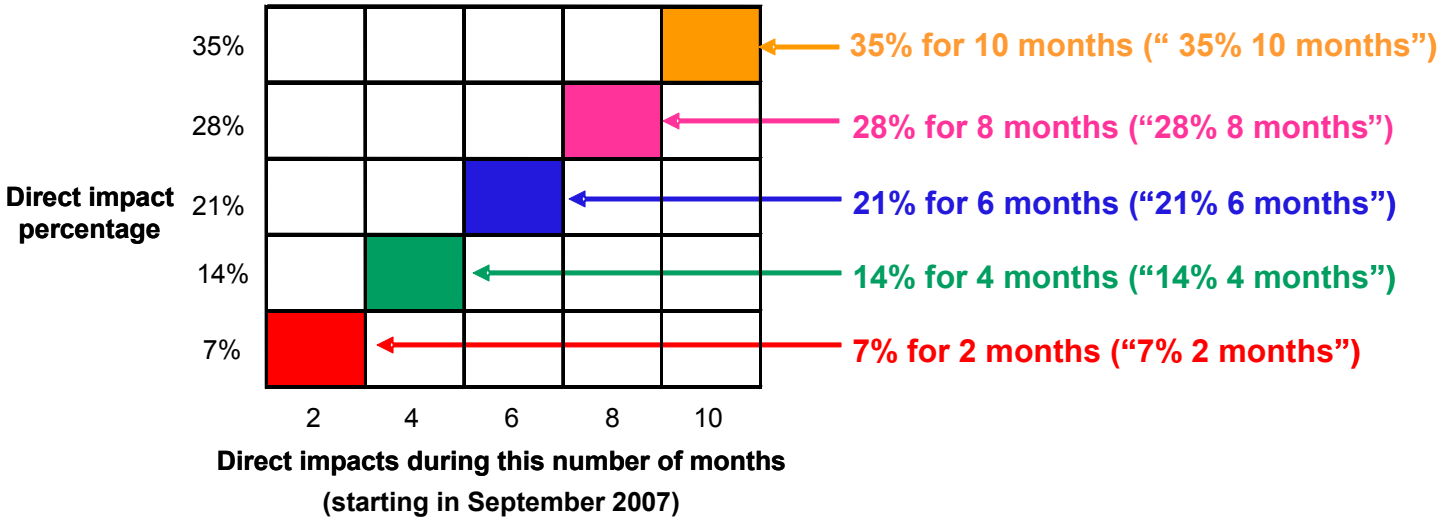
FEED delay scenarios displayed in plots



Increasing severity of impact

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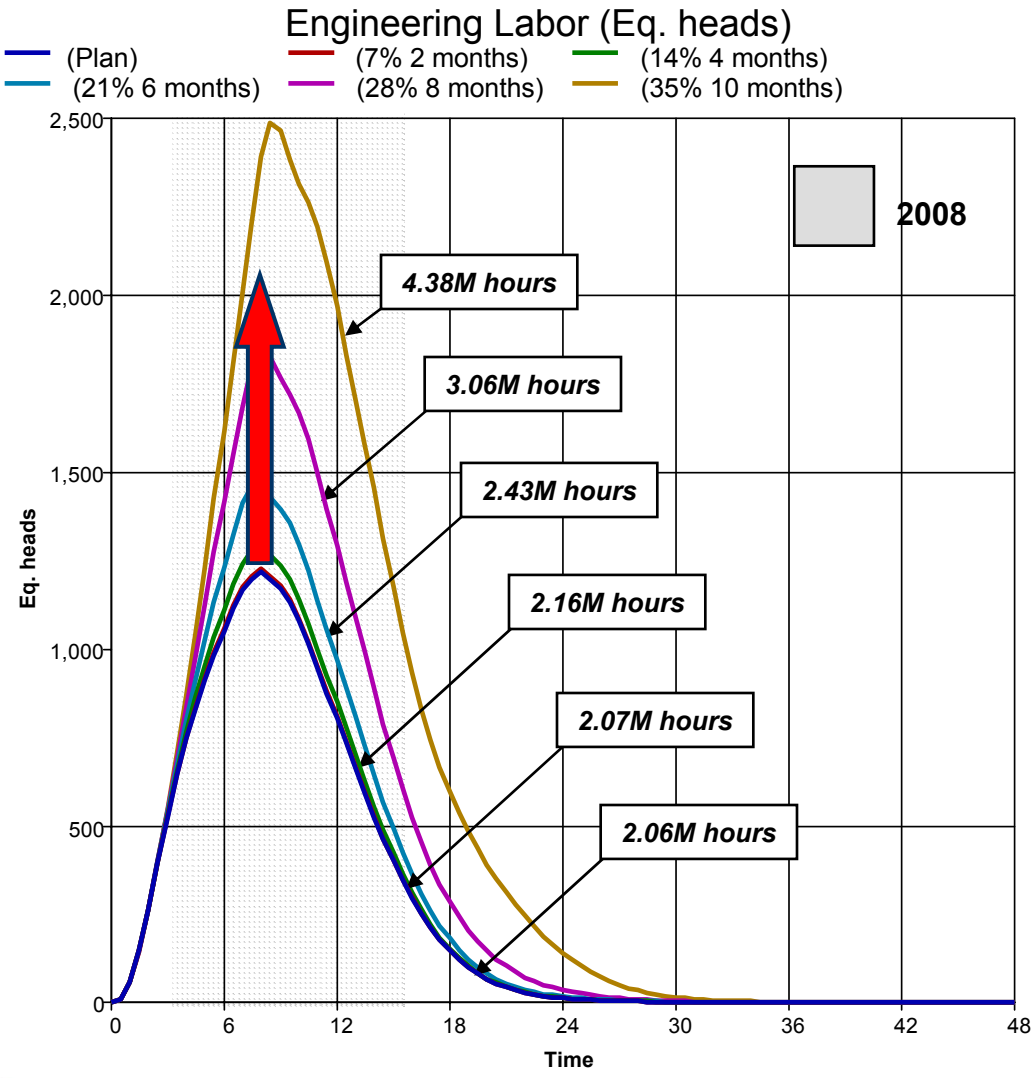
Engineering effort (equivalent heads) is increased and delayed by secondary impacts of more FEED delays…

Peak labor in the simulated plan occurs at the planned time; FEED delay impacts shift the peak substantially higher.



In the sections that follow, we address the questions of "why" and "what can be done" …

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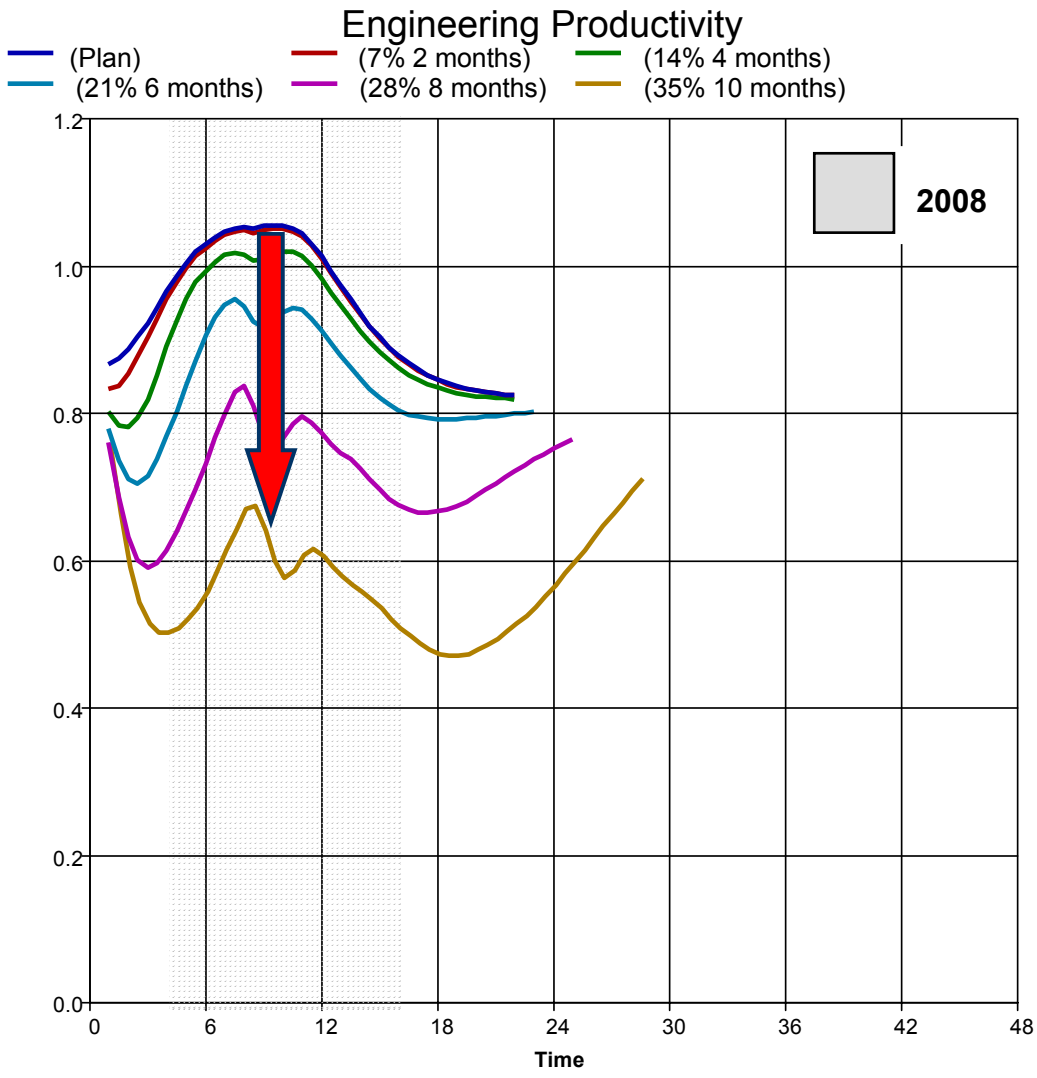
WHY: With more FEED delays, Engineering Productivity declines …

As FEED delays create uncertainty about design content, working "out of sequence" causes much of the early productivity loss.



With such FEED delays, productivity loss will be exacerbated by increased revisions, vendor delays, and inexperience of new hires.

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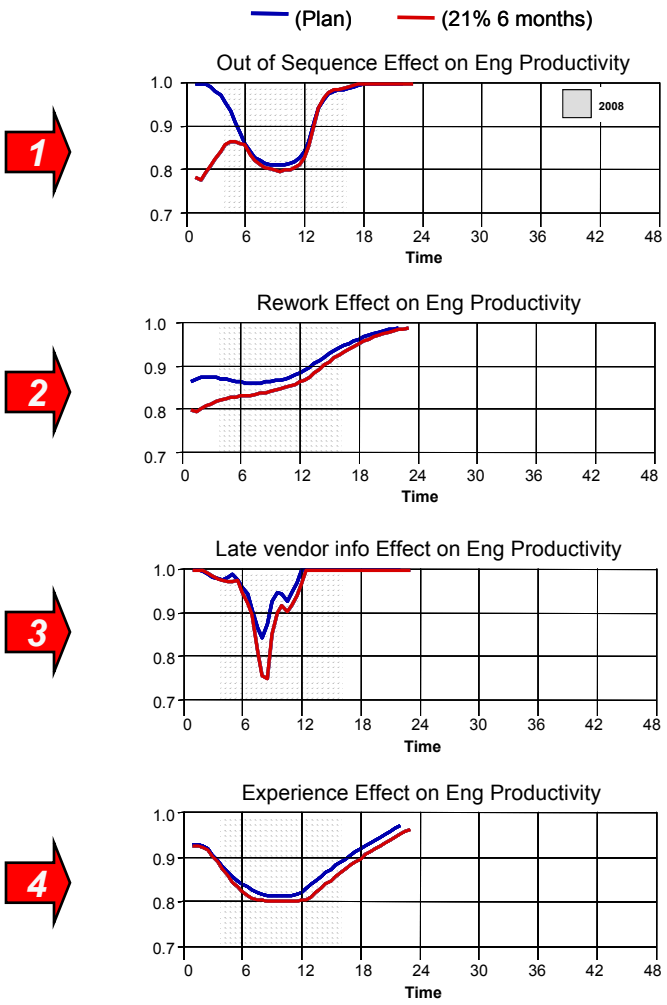
Waves of productivity impacts…



1

2

3

4

1) As FEED delays create uncertainty about design content, working "out of sequence" initially causes a significant productivity loss in late 2007, early 2008.

2) Increases in revisions add effort, and reduce productivity during late 2007 and throughout 2008.

3) Delays in receiving information from vendors further depresses productivity in mid-2008.

4) Finally, in order to meet schedule in the face of additional work and lower productivity, additional engineers are brought on in mid-2008. Lowered experience then further reduces productivity (and increases revision activity) during 2008 and beyond.

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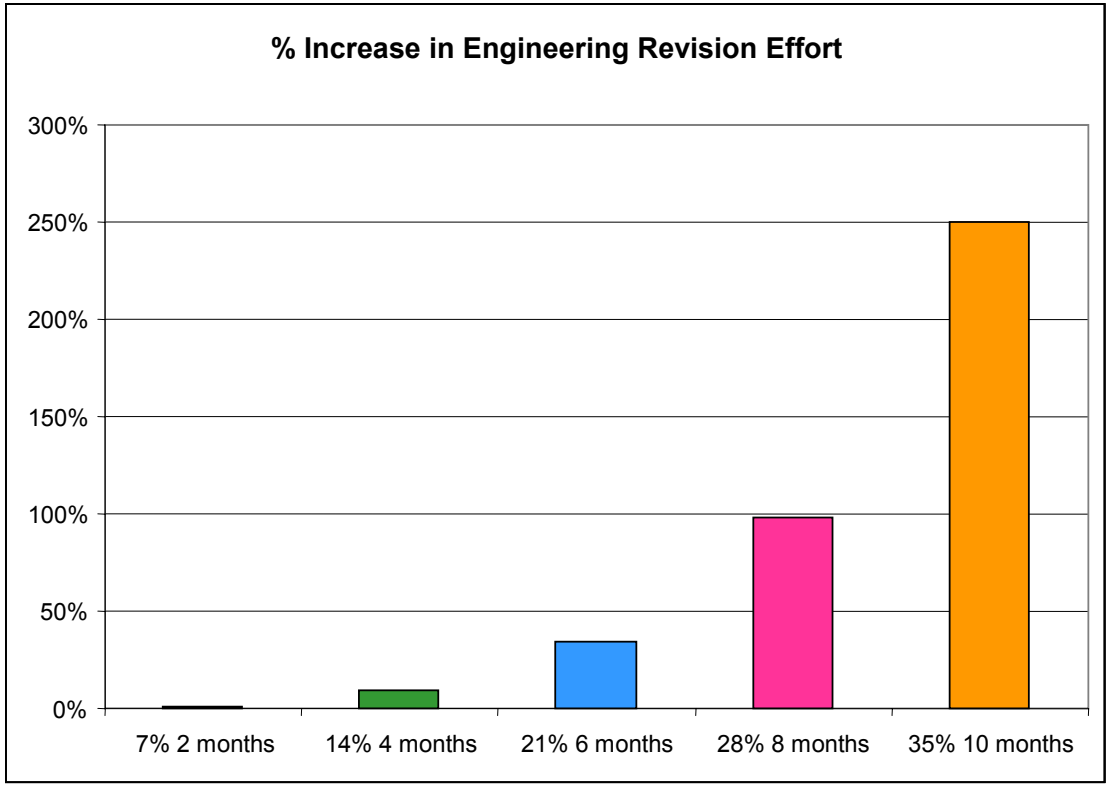
WHY: Effort on Engineering revisions climbs; the same factors that reduce productivity also increase revisions …

Revision effort increases nonlinearly with more FEED delays over longer time frames.



Revision effort doubles in the "28% 8 months" scenario.

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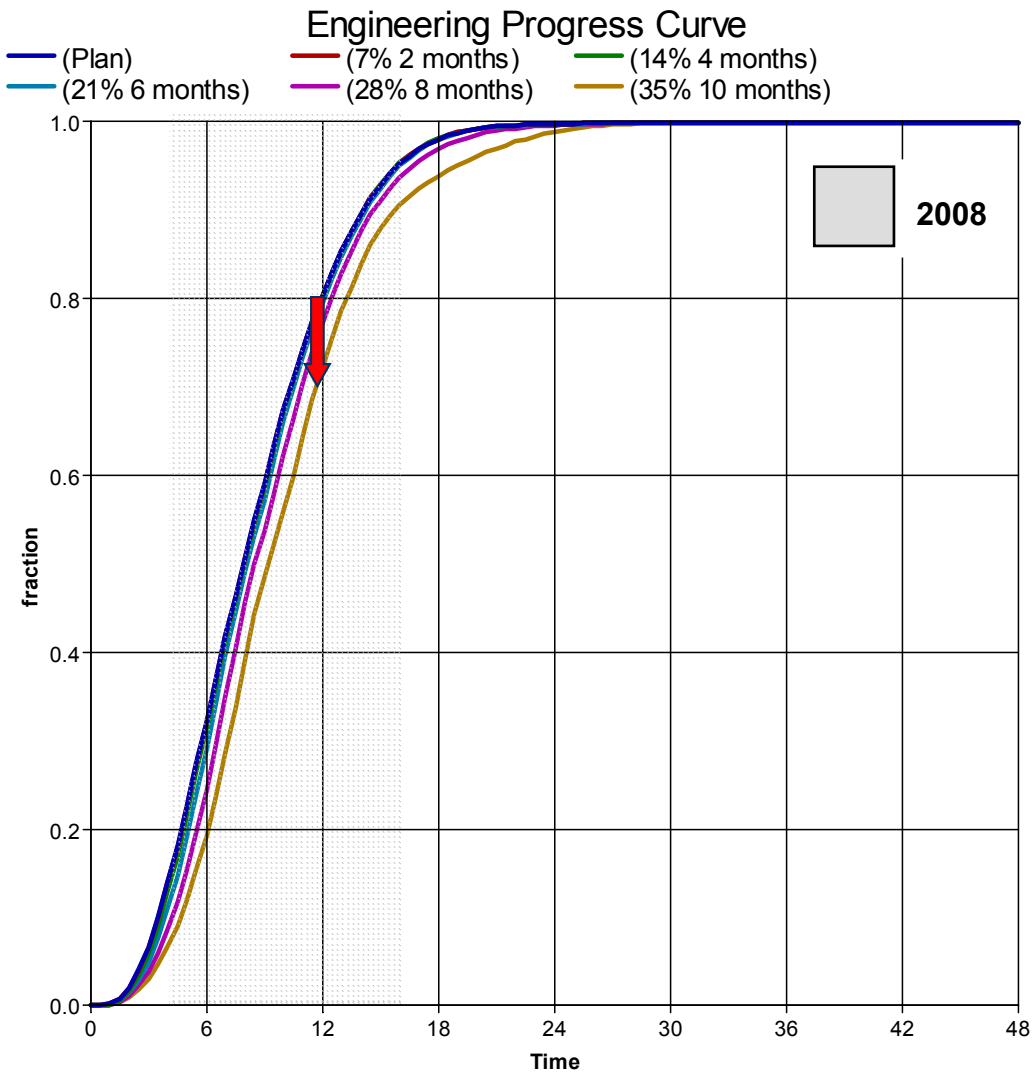
WHY: Engineering progress slows by more than 2 months in the extreme cases tested …

The impact on progress first becomes apparent in late 2007, and is worst in mid-2008. In the most extreme case tested, progress then is more than 10 percentage points lower than planned.



The simulations show that what had been planned as higher Engineering progress supporting early stages of Construction (important to limiting knock-on impacts on Construction) would be significantly reduced.

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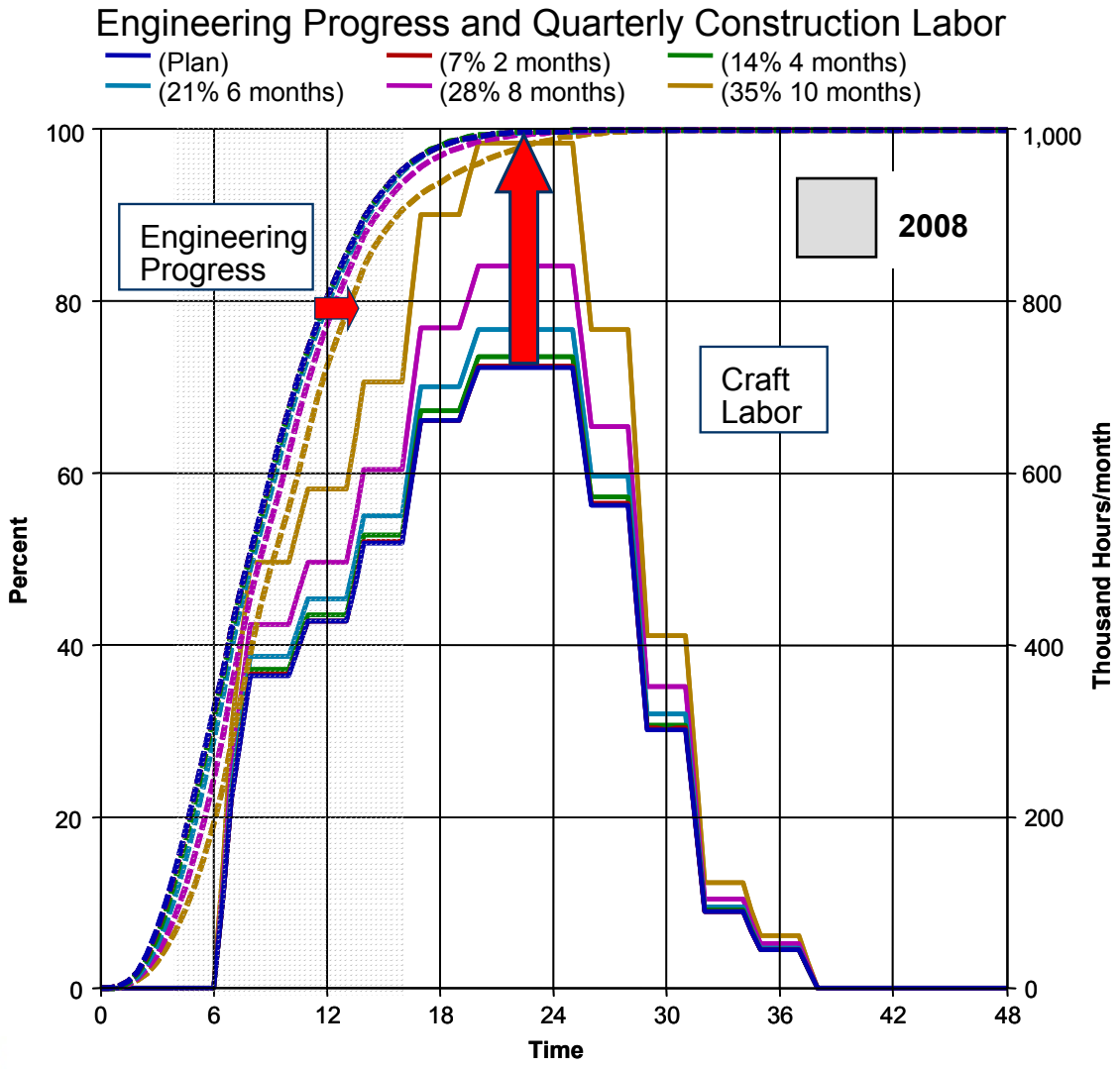
Any FEED-delayed Engineering progress reduces Construction productivity and raises labor expenditures

The level of FEED delays tested here could delay Engineering progress by 2 months as Construction labor ramps up.



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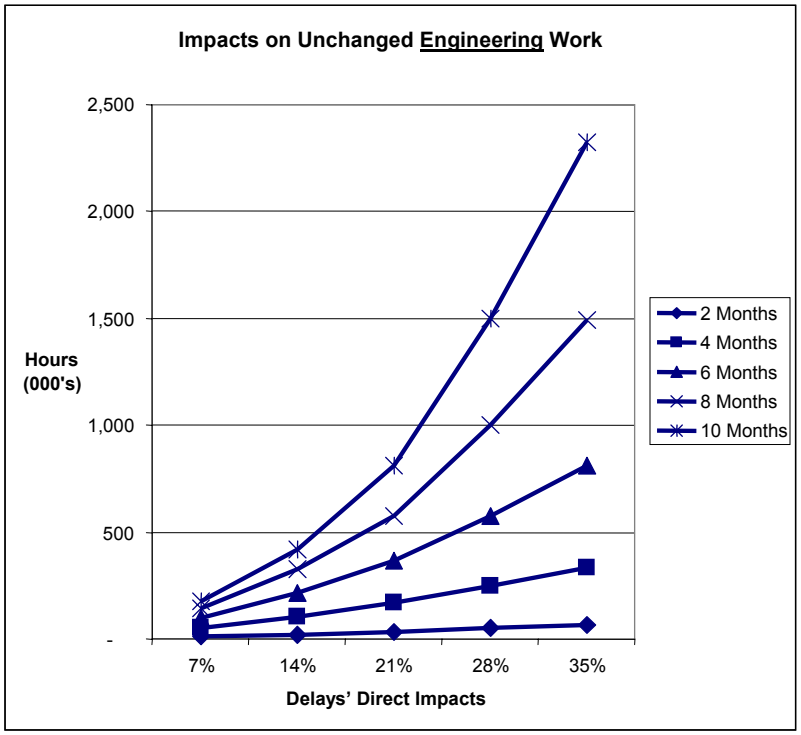
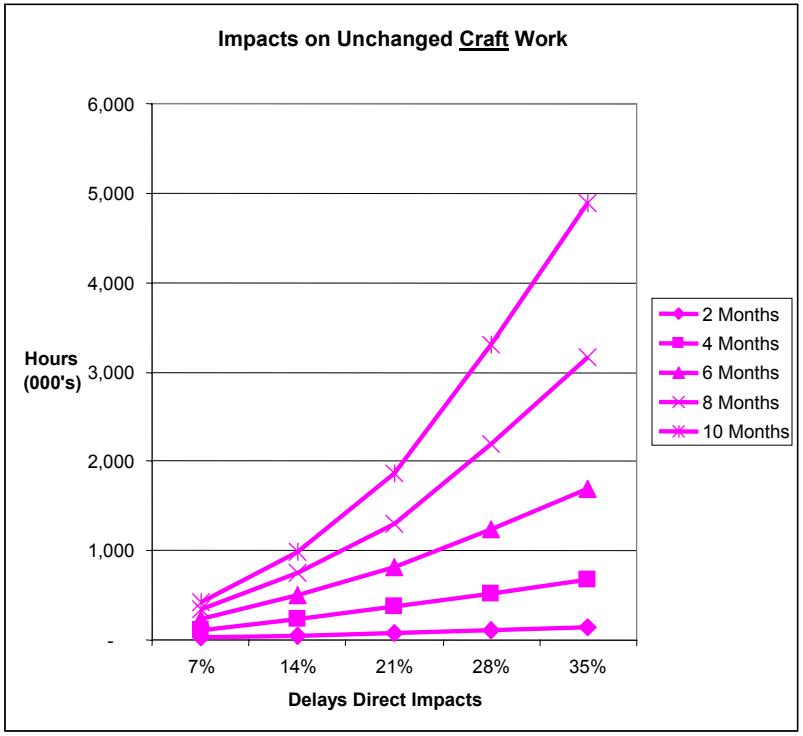
WHAT CAN BE DONE: Minimize FEED delays; they are highly disruptive to Detailed Engineering and Construction…





More FEED delays cause non-linear growth in impact on Detailed Engineering and Construction costs. For example, impacting up to 1/3 of Engineering design for 6 months would grow Engineering cost 35-40% and Construction hours 10-15%.

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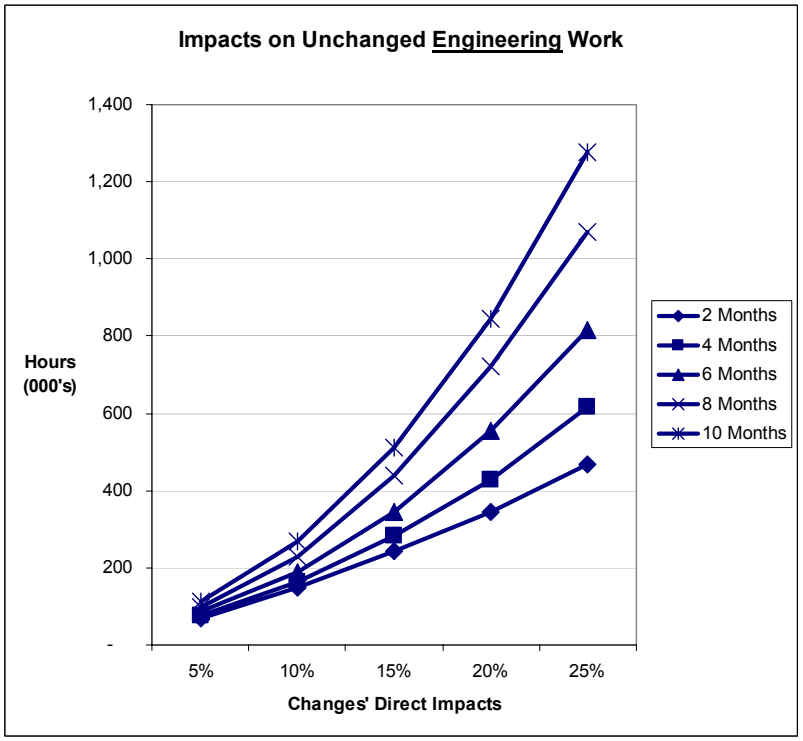
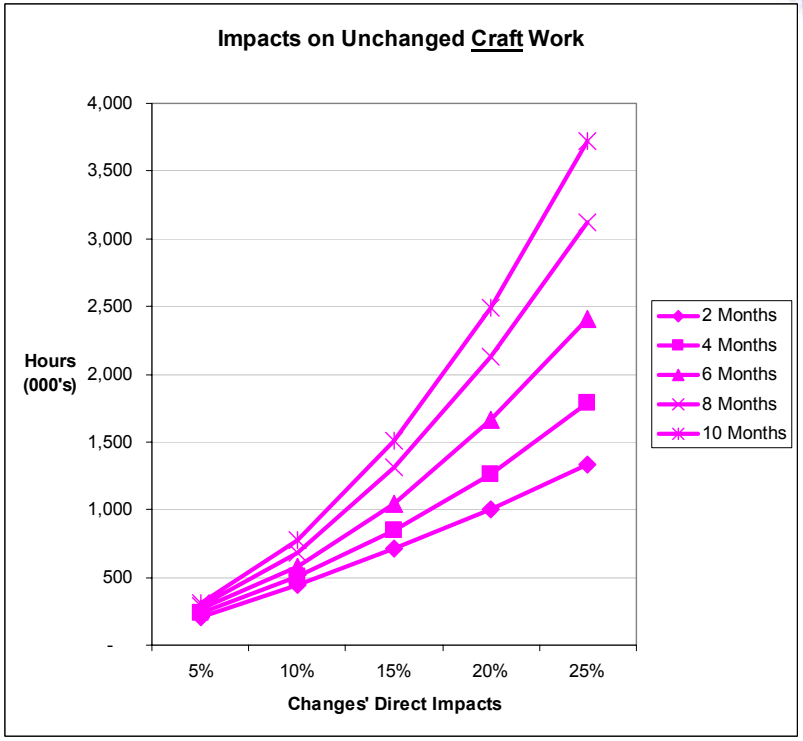
WHAT CAN BE DONE: Reduce Detailed Engineering changes to avoid more costly impacts…





More changes create not just more impact, but disproportionately more impact --"cumulative impact". At the extremes, the lowest and earliest-resolved changes cause secondary impact equal to about 2/3 hour for every hour of direct impact (a .65 ratio), and the highest and latest-resolved changes tested generate an impact ratio of about 2.5. Construction impact ratios vary from 0.3 to 1.1 over the range tested. Note that early resolution cuts impacts by 1/2 to 2/3 (in the extreme case, saving over 150 million euros).

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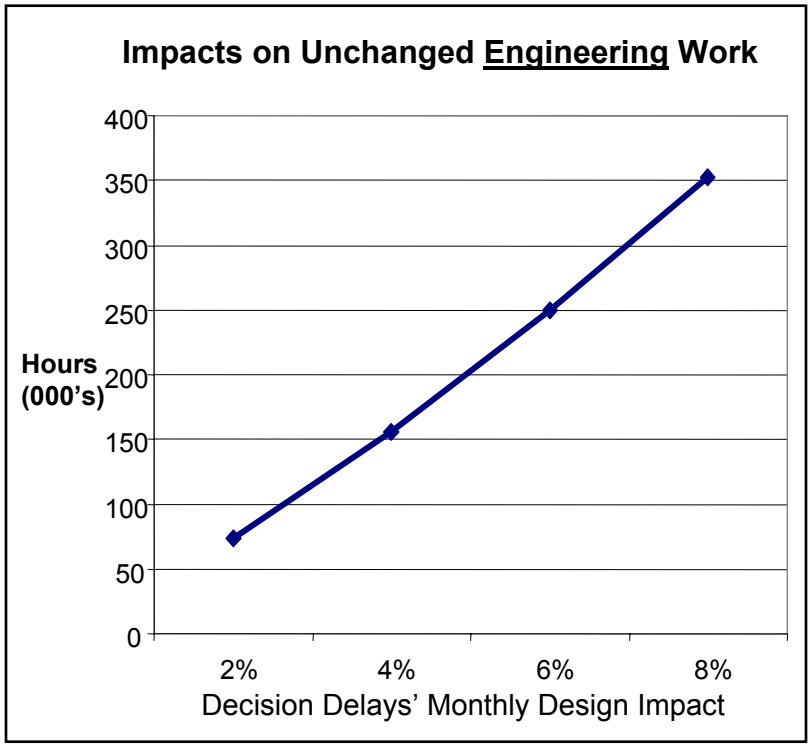
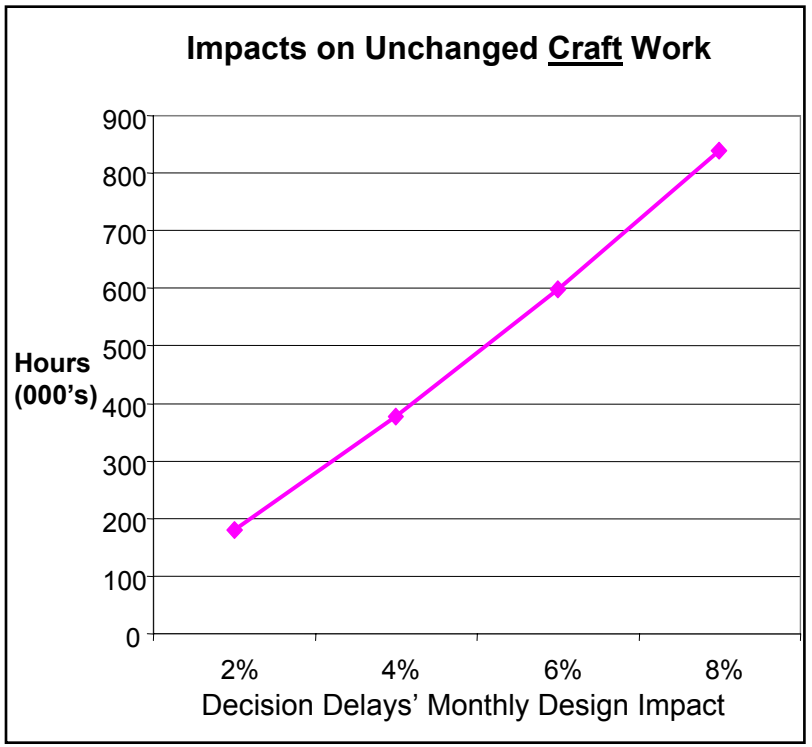
WHAT CAN BE DONE: Expedite technical decisions and approvals during Detailed Engineering. Avoid delays as these would increase costs and impacts…





Such delays would cause Engineering effort to grow as much as 350,000 hours (over 15%), due to lost productivity.

Further, there is a knock-on impact on Construction, increasing direct labor costs there by as much as 6%, about 840,000 hours.

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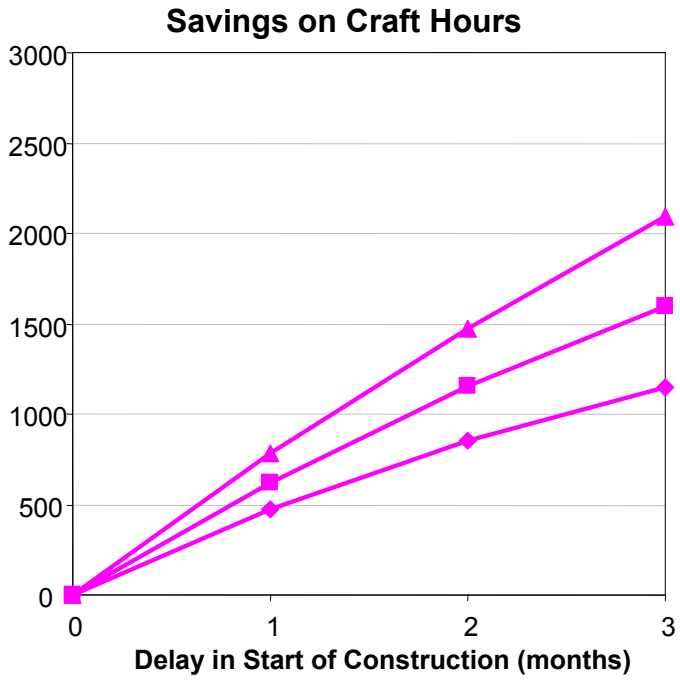
WHAT CAN BE DONE: Changes in construction schedule (if these can be considered)…

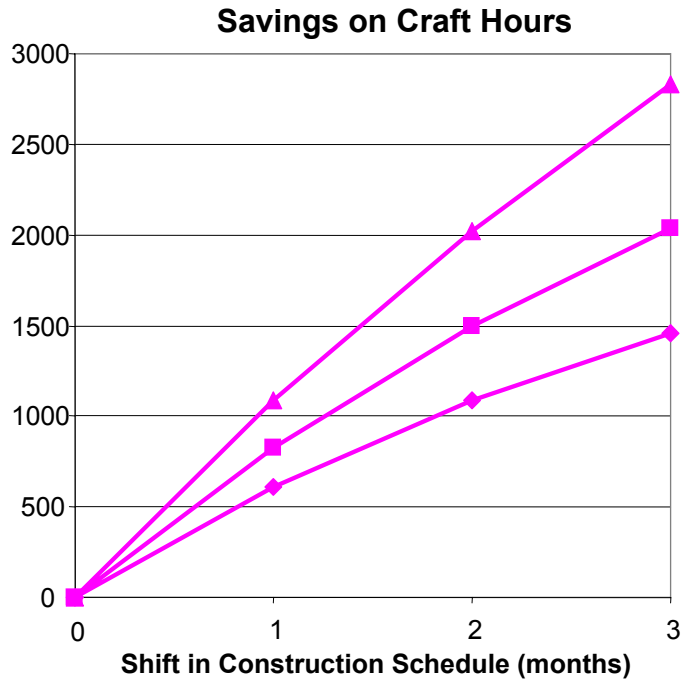
Savings from schedule extension would be driven primarily by improvements in Construction productivity that result from more mature (less changing) Engineering.

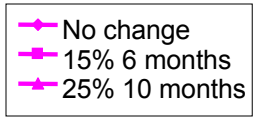
Throughout these tests, each month of schedule shift saves 4 to 5% of craft hours…or about 3% savings for each month of delaying just the Construction start.

Delay Construction start…



***Shift Construction schedule…** *





* *In the combined-impact case (see previous chart), the mitigation value of a three-month shift jumps to over 3,000 hours.*

(Of course, any schedule extensions need to balance the cost reduction from productivity savings against any time-related increase in costs, such as for equipment rentals.)

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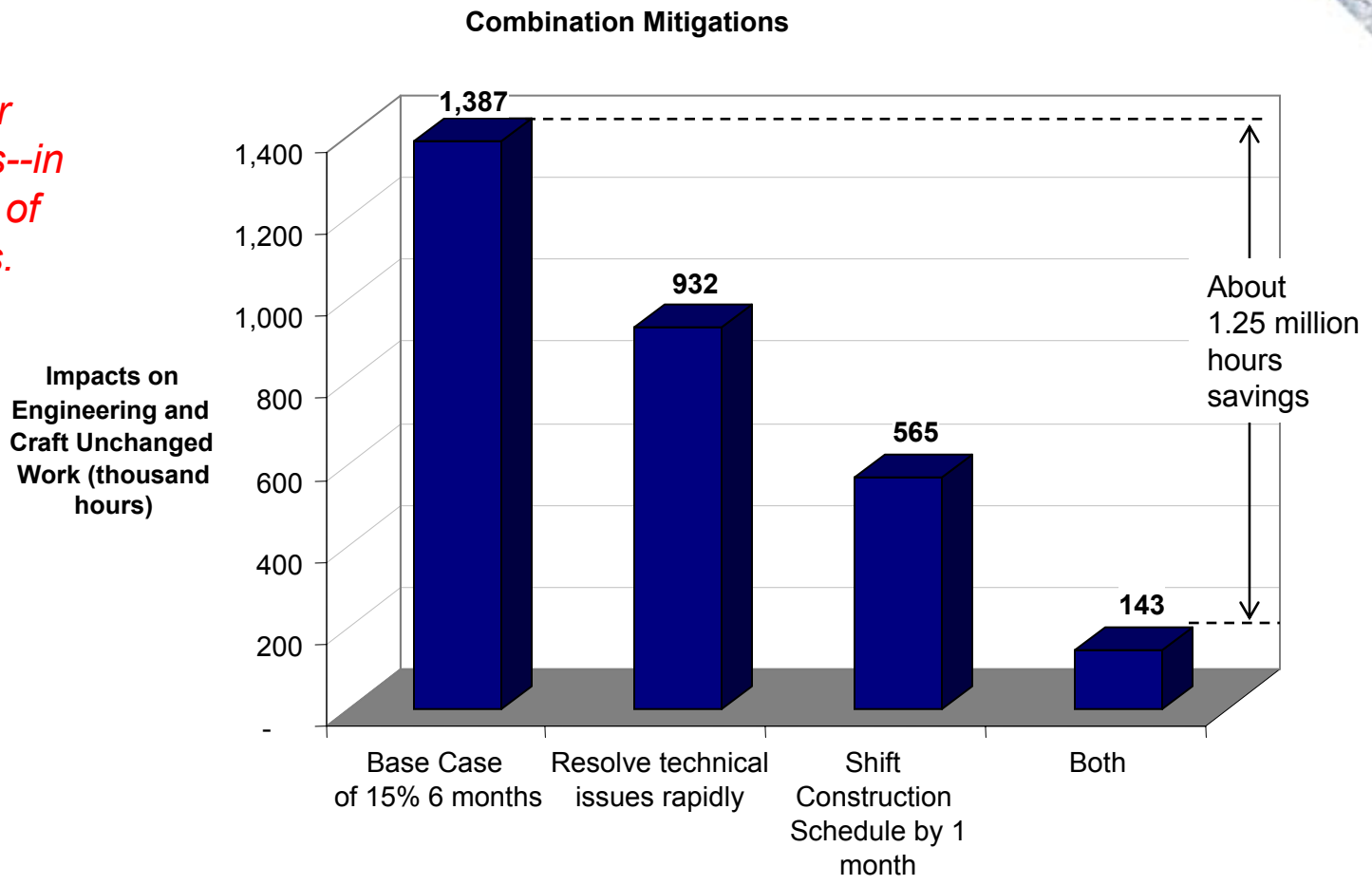
WHAT CAN BE DONE: Combined mitigation actions produce greater savings…

Savings total over 1.25 million hours--in this one example of combined actions.



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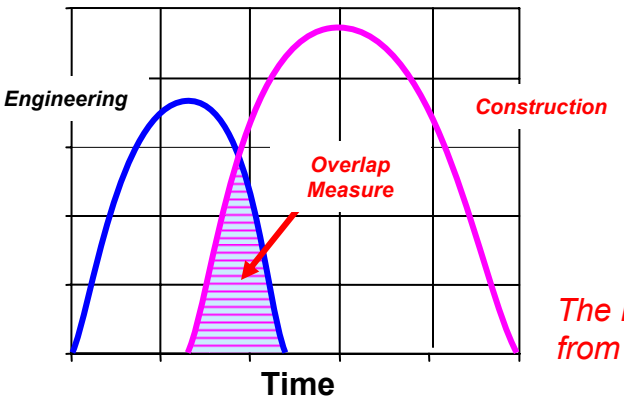
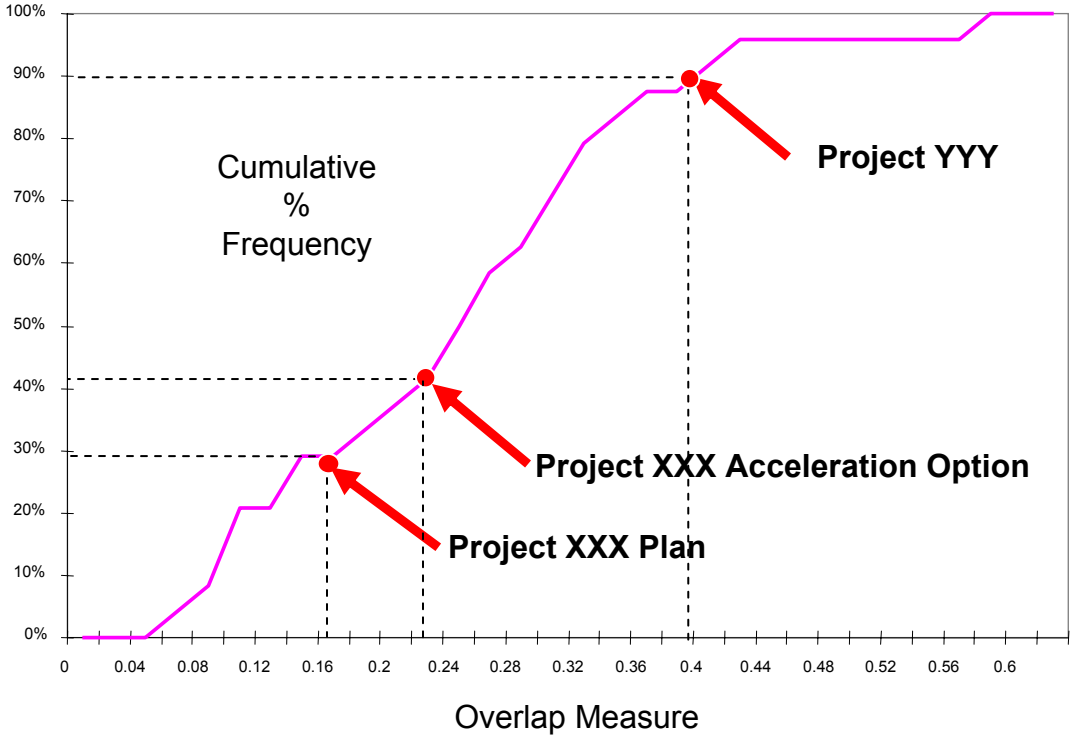
Engineering-Construction overlap analysis

Project XXX engineering -construction overlap is lower than 70% of all recently analyzed Fluor projects.

A 3-month acceleration moves the Construction overlap measure closer to the mid-point of the frequency distribution.





The Engineering-Construction overlap measure can theoretically vary from 0 (no overlap) to 1.0 (simultaneous execution).

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Typical areas of mitigation analysis

- ***WHAT CAN BE DONE: To mitigate the impact of FEED delays which can be highly disruptive to Detailed Engineering and Construction…***
- ***WHAT CAN BE DONE: To mitigate Detailed Engineering changes to avoid more costly impacts…***
- ***WHAT CAN BE DONE: To mitigate technical decisions delays and approvals during Detailed Engineering…***
- ***WHAT CAN BE DONE: To mitigate using changes in construction schedule (if these can be considered)…***
- ***WHAT CAN BE DONE: To better understand the impacts due to the degree of engineering and construction activity overlap…***

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Benefits of the proactive change analysis

- Promotes a fundamentally different understanding of how change impacts project success
- Quantifies secondary impacts in advance
- Helps communicate, objectively, change impacts and their causation
- Rapid analysis of mitigation options and schedule trade-offs; foresee the impacts, then seek to reduce them
- Reduces likelihood of “surprises”
- Highly credible, transparent underlying methodology

Remember:

You cannot mitigate what you do not foresee

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Questions?

Thanks for your time

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