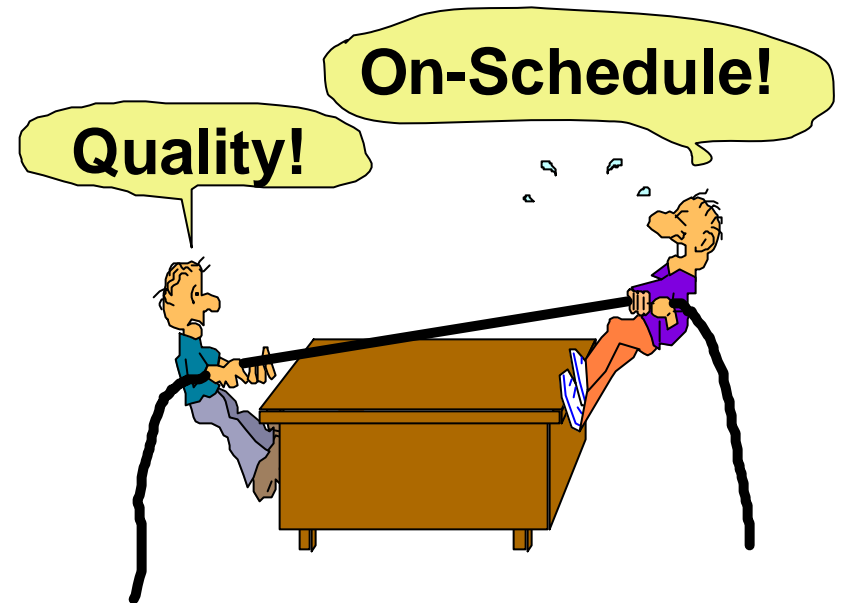
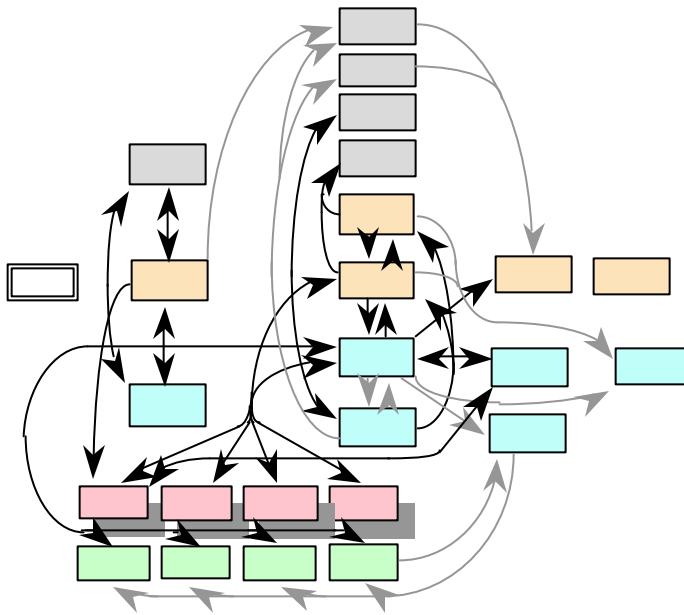


Predicting and Mitigating Organizational Risks in Fast-Paced Projects

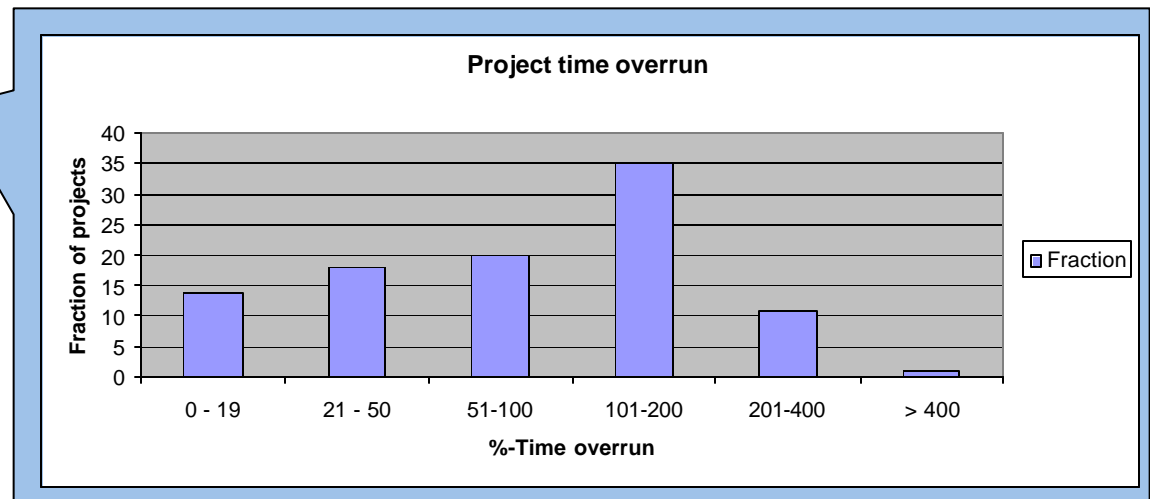
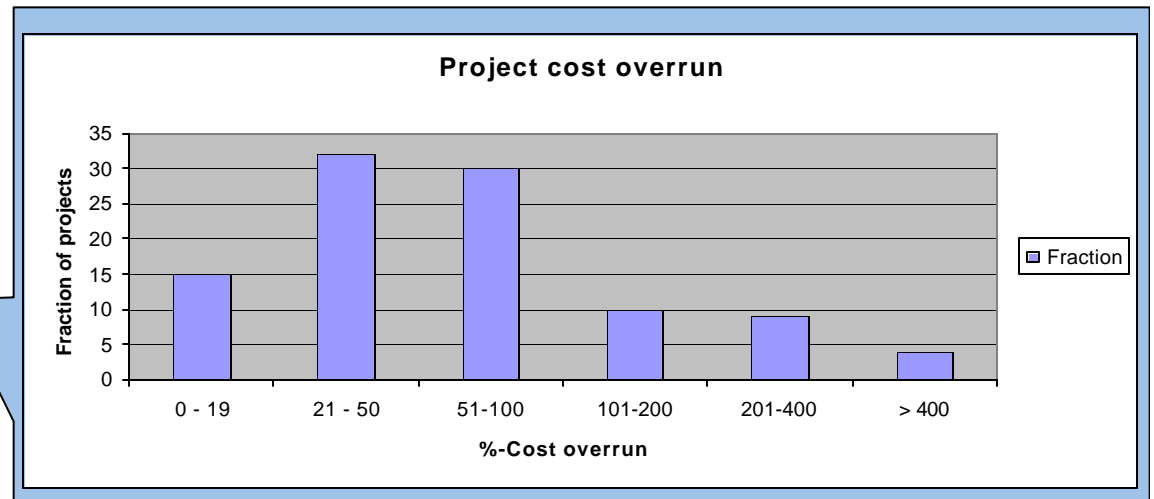


John C. Kunz, Raymond E. Levitt

CIFE Center for Integrated Facility Engineering
Stanford University

Problem for IT projects

- Restarts: 94 of 100 projects
- *Cost Overruns*
- Content deficiencies
- *Time Overruns*



Problem for factory construction

- Factory construction requirements (*cost, time*)
- <http://public.itrs.net/Files/2000UpdateFinal/FactoryInt2000final.pdf>

*Table 56 Facilities Technology Requirements***

YEAR TECHNOLOGY NODE WAFER DIAMETER	1999 180 nm 200 mm	2001 130 nm 300 mm	2004 90 nm 300 mm	2008 60 nm 300 mm	2011 40 nm 300 mm	2014 30 nm 450 mm
Factory construction cost per cleanroom area (\$/m ²) [1]	1999 factory costs	95% of previous node	95% of previous node	95% of previous node	95% of previous node	95% of previous node
Factory construction time (months)	12	11	10	10	10	9.5
Facilities services reliability (%)	99 %	99.5%	99.9%	99.9%	99.9%	99.9%
Cleanroom cleanliness class [2]	ISO Class 3–5 (Class 1–100)	ISO Class 3–5 (Class 1–100)	ISO Class 5–6 (Class 100–1000)	ISO Class 5–6 (Class 100–1000)	ISO Class 5–6 (Class 100–1000)	ISO Class 5–6 (Class 100–1000)

Solutions Exist

 Solutions Being Pursued

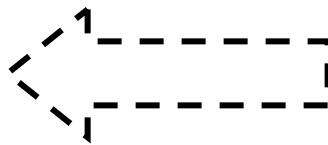
 No Known Solutions

- Enigma – companies work to do the simple “right thing” – and fail to achieve desired effects.

Overview

Dependent variables

- Cost
- Duration
- Quality

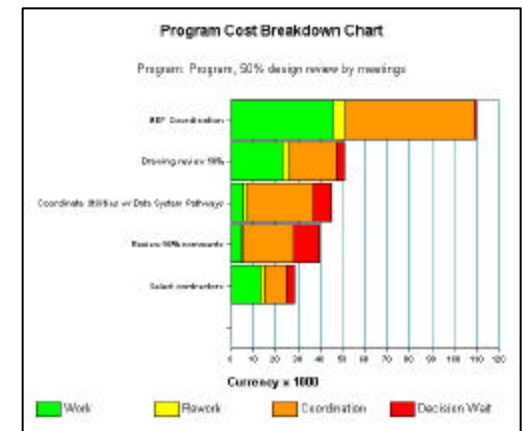


Independent variables

- Project scope
- Work process
- Organization

Goal: Develop, validate a theoretical method to predict quantitative outcomes and risks given assumptions

Method: Develop, implement theory in computer to predict *total effort* to do work



Research question

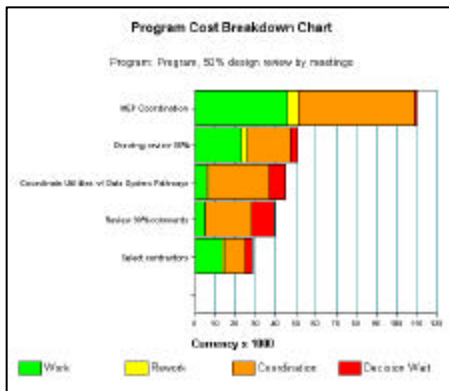
- Theoretically and practically, why are project predicted schedules late?
- What method can (quantitatively, analytically) predict project performance more accurately?
 - Metrics that are measurable
 - Scientifically, to enable validation
 - Practically, top aid management and control
 - Metrics that relate to project cost, duration, final product quality
 - Based on project design that can be manipulated by a manager

Virtual Design Team



The Big (Practical) Idea

Managers can design the project plan and organization as engineers design bridges



Legend	Meets Goal	Almost meets goal	Unmet Goal		
Case	Sim Finish Time	Sim Cost (K\$)	Risk	Comment	
*Contractor increase staff	3/21/2001	244	0.515	Not feasible	
All staff FT	4/16/2001	252	0.56	Very difficult for other projects	
50% Design review/meetings	5/7/2001	353	0.48	Force quick owner decisions	
Shorten 50% review tasks	5/21/2001	384	0.42	Encourage quick owner decisions	
John O. Full Time	6/6/2001	311	0.525	John O. plus Gary FT	
John H. Part Time	6/21/2001	324	0.545	John H. plus Gary FT	
Don S. Full Time	8/5/2001	321	0.56	Don S. plus Gary FT	
Gary S. Full Time	10/4/2001	335	0.485		
Split Contractor Tasks	10/19/2001	257	0.5	Add contractor resources	
Gary, Amy 50%	10/22/2001	251	0.395		
Baseline	12/11/2001	350	0.515		

- **External** (Eliminate cause of systematic optimistic bias)
 - ✓ Schedule
 - ✓ Cost
- **Internal coordination: Predict risks of**
 - ✓ Decision latency
 - ✓ Response latency
 - ✓ Field-generated Requests for Information
 - ✓ Rework

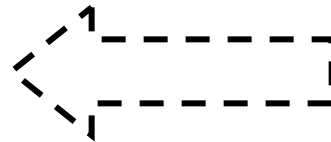


The Big (Theoretical) Idea

Information model (simulation) of the organization + process can quantitatively predict project performance

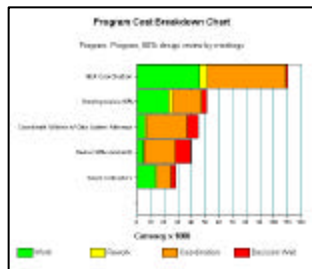
Dependent variables

- Cost
- Duration
- Quality

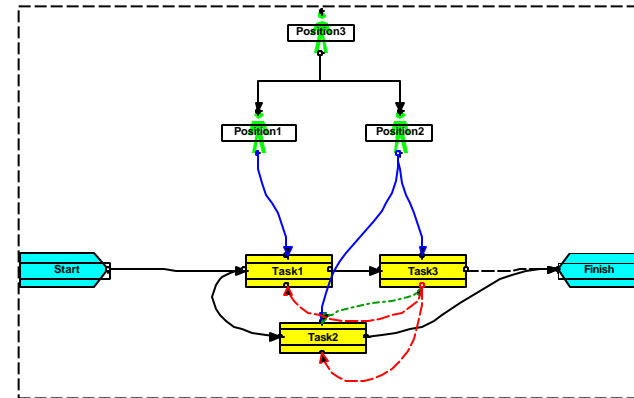


Independent variables

- Project scope
- Work process
- Organization



Legend	Meets goal	Almost meets goal	Unmet goal	
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John G. Full Time	6/6/2001	311	0.525	John G. plus Gary FT
John H. Part Time	6/21/2001	324	0.545	John H. plus Gary FT
Don S. Full Time	8/5/2001	321	0.56	Don S. plus Gary FT
Gary S. Full Time	10/4/2001	335	0.485	
Split Contractor Tasks	10/19/2001	297	0.5	add contractor resources
Gary, Amy 50%	10/22/2001	251	0.395	
Baseline	12/11/2001	350	0.515	

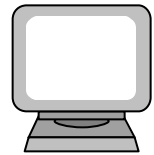


Theoretical frame of reference

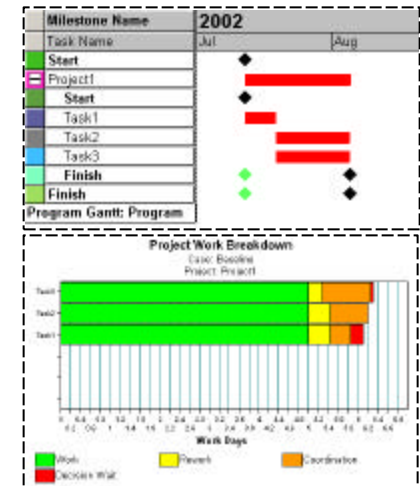
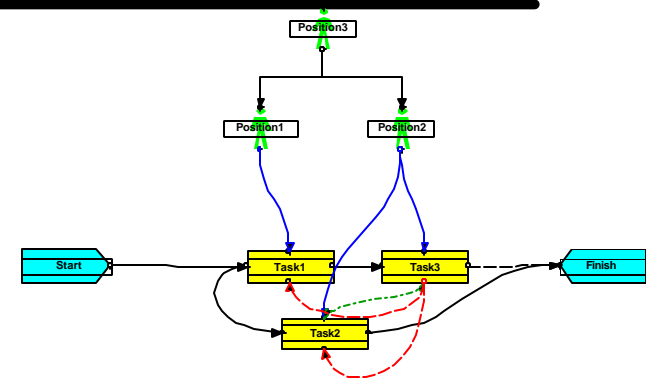
Distinguish

- *Description*: explicit observations or assumptions
- *Prediction*: implicit consequence of explicit description, based on
 - Argumentation, or
 - Validated analytical methods
- *Explanation*: why description, predictions
- *Evaluation*
 - Appropriateness of designs, given objectives
 - Effectiveness, efficiency of alternatives

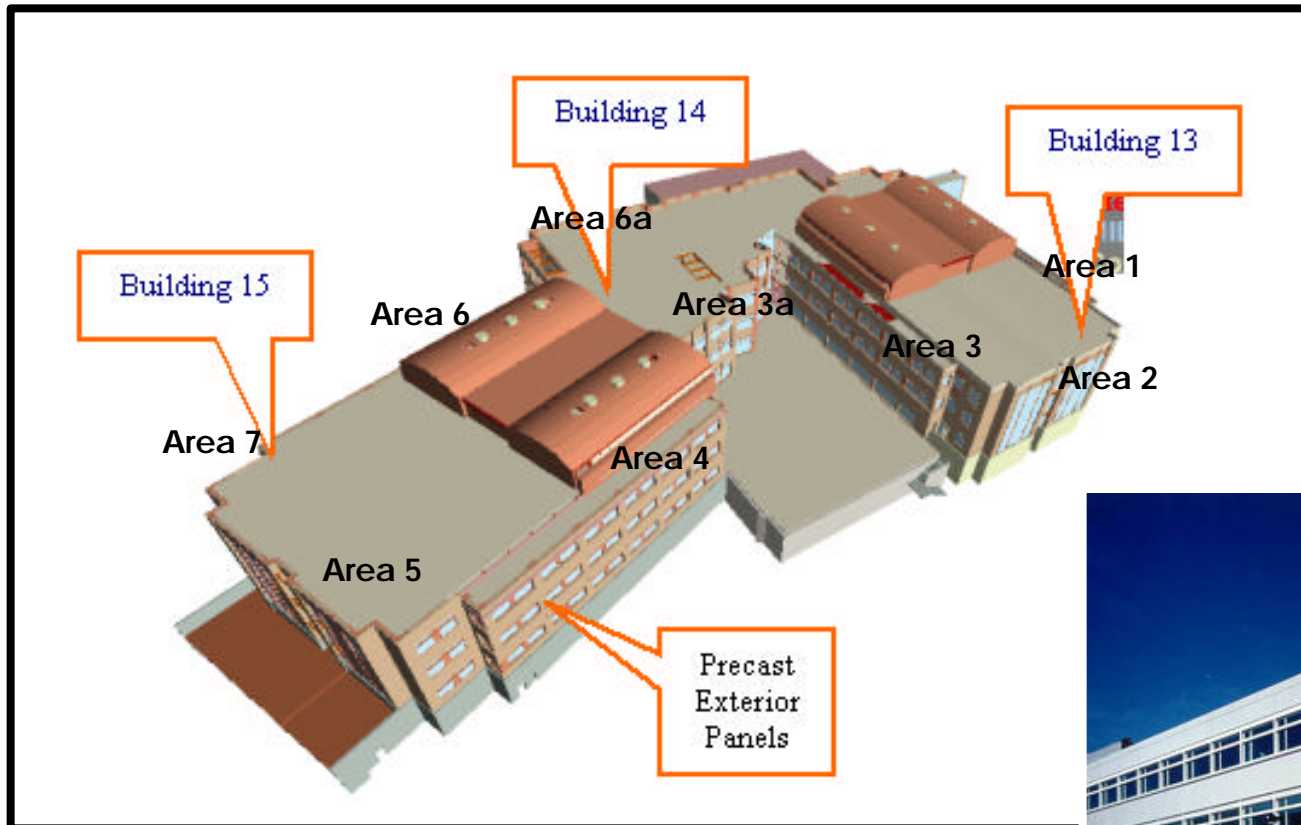
Theoretical method



- Explicitly model (entire) project:
 - work product (and major sub-products)
 - Complexity, uncertainty
 - project design-construction *process*
 - project design-construction *organization*
- Use models to
 - *Describe* assumptions (visual)
 - *Predict* performance (quantitative) using simulation
 - Total effort
 - Schedule
 - Process risk
 - *Explain* predictions
 - *Evaluate*
 - How well (product – process – organization) design meets goals
 - Alternatives



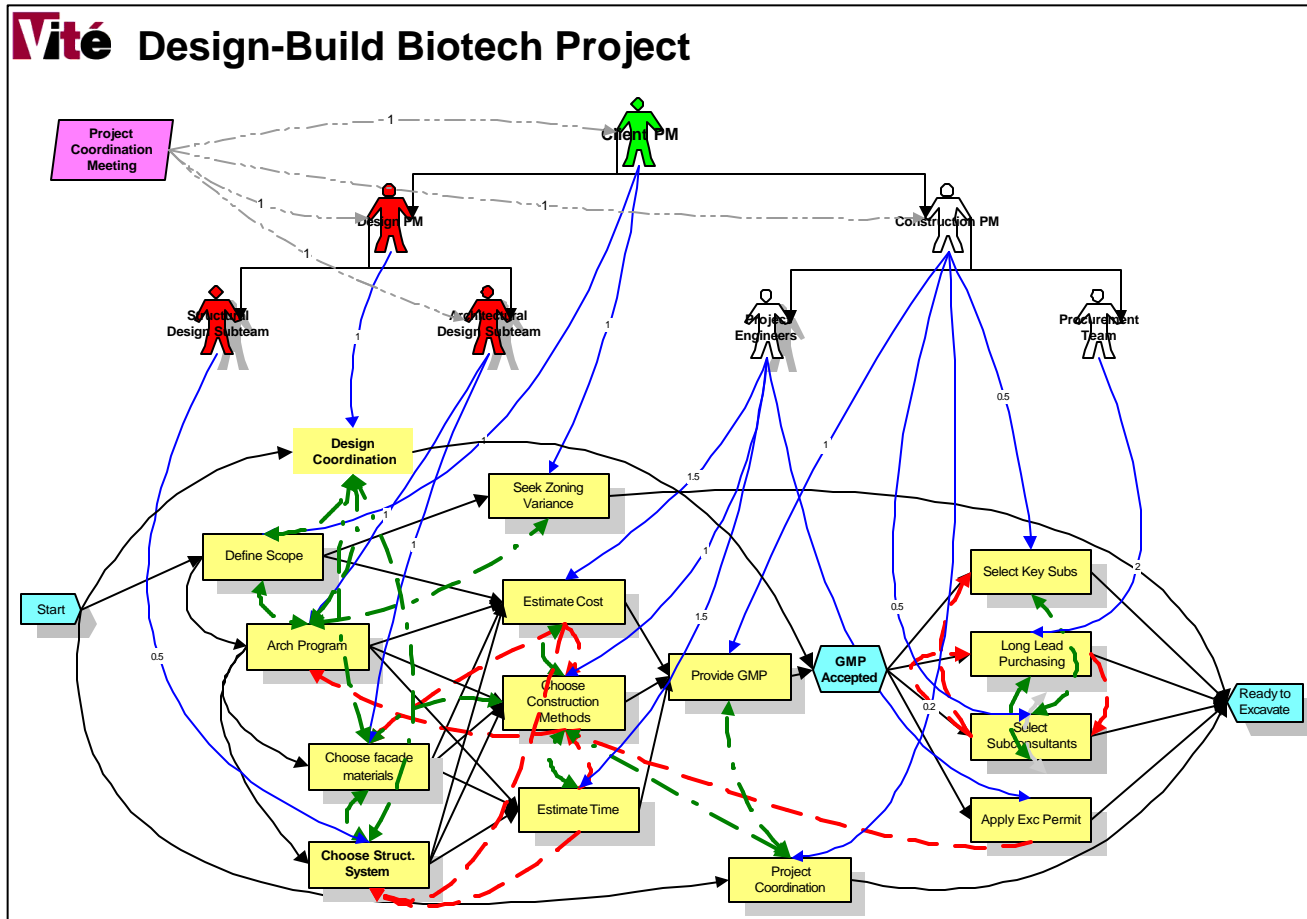
Example Product Description



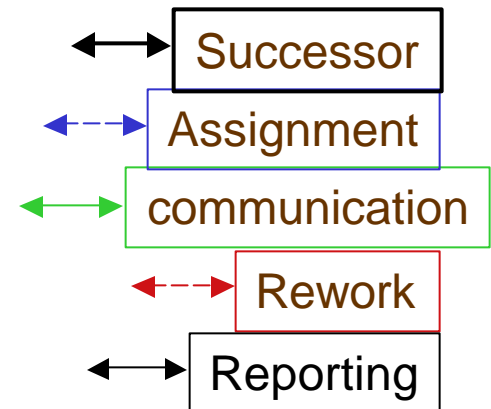
Business question: How plan, organize after delays?



Example Design-build project model



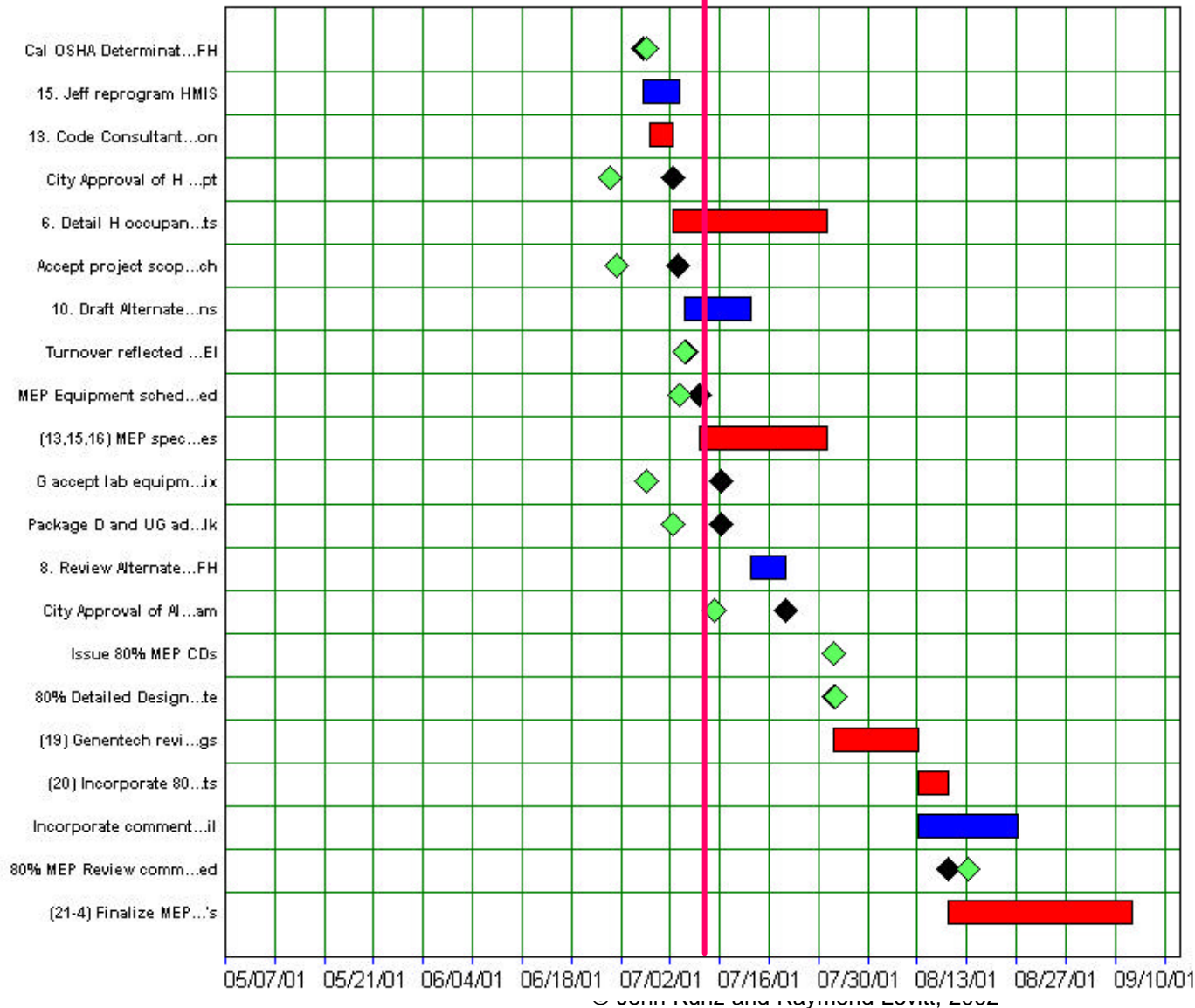
- Usual org chart, plan
- Few more relationships



www.vite.com



Predicted Schedule



1. Predict schedule
2. Track planned events:
 - Task start, finish
 - Actual early or late?
3. Why early, late?
4. Intervene



Predict needed coordination

- When task about to start, verify availability of groups responsible for dependent tasks
 - Coordination, rework
 - Managerial issue resolution



Co	Connected From	Connected To
1	37. *Reprogram B#15 Shafts	44. *Complete B#14 Officing Planning
2	38. *SRG Reprogram 13/14 interface, exiting, stairs	39. *Finalize MEP distribution and section
3	38. *SRG Reprogram 13/14 interface, exiting, stairs	39. *Finalize MEP distribution and section
4	40. *SRG Reprogram 15/14 interface, exiting, stairs	39. *Finalize MEP distribution and section
5	17. *Risick reprogram solvent distribution and waste	5. *Finalize lab & Equipment plans
6	5. *Finalize lab & Equipment plans	4. complete all Interior Architecture
7	40. *SRG Reprogram 15/14 interface, exiting, stairs	55. KPFF design stairs for 15/14
8	55. KPFF design stairs for 15/14	37. *Reprogram B#15 Shafts
9	40. *SRG Reprogram 15/14 interface, exiting, stairs	54. KPFF design stairs for 13/14
10	40. *SRG Reprogram 15/14 interface, exiting, stairs	51. Designate size, location of 14 MEP, teledata rooms
11	10. Draft Alternate means	8. Review Alternate Means w/impact on LEL and LFFH

Task / Milestone / Position / Meeting / Ghost Task / Ghost Milestone / Connector / Successor / Primary Assign



Predict and track Milestone Status

Milestone	Dates		
	G Original (*Actual) Goal	Vité prediction	7/2 Status
*Start	5/7	5/7	Complete
*Notice to proceed on structural changes	6/1	5/10	Complete
*City accept exiting	6/6	5/21	Complete
Genentech accept 15/14 interface	6/6	6/14	Late
*Lab Programming Complete	6/6	6/15	Complete
Bookend and Exterior program accepted by Genentech	6/8	6/18	Late
Package B structural modifications (CCD5)	6/8	6/7	Recinded
*Turnover lab DD plan to AEI	6/8	6/20	Complete
Architect program/MEP concepts Established By Design Team	6/13	6/28	
*Notice to proceed with detailed design	6/13	6/28	Complete
*Design Budget & Schedule for Changes Approved	6/20	7/2	Complete
*Package C skin modifications	6/20	6/28	Complete
Genentech accept 13/14 interface	6/27	6/15	
City Approval of H Concept	6/30	7/12	
Accept project scope: budget by Genentech	7/1	7/10	
B13 MEP HVAC, conduit, piping mains completed	7/2	6/13	
Cal OSHA Determination of LFFH	7/5	7/5	
Genentech accept lab equipment matrix	7/5	7/16	
Package D and UG addendum issued: underground utilities, vivarium catwalk	7/9	7/17	
MEP Equipment schedules finalized	7/10	7/13	
Turnover reflected ceiling plan to AEI	7/11	7/6	
City Approval of Alternate Means for Program	7/15	7/27	
80% Detailed Design Complete	8/1	7/27	
Issue 80% MEP CDs	8/1	8/2	
MEP CDs 95% complete	8/15	8/20	
80% MEP Review comments incorporated	8/20	8/20	
Finish	9/15	9/21	
Package E issued	9/15	8/31	

* Completed milestone

Milestone on critical path



Predict and track Milestone Status

1. Predict schedule
2. Track planned events:
 - Task start, finish
 - Actual early or late?
3. Why early, late?
4. Intervene

Result of using metrics:

- Design-phase PPC (Percentage between Planned and really Concluded) rose from ~25% - ~80%
- Design -phase Latency short (1-2 days)
 - Decision
 - Response
- Construction faster than scheduled!

Milestone	Dates		
	G Original (*Actual) Goal	Vité prediction	7/2 Status
*Start	5/7	5/7	Complete
*Notice to proceed on structural changes	6/1	5/10	Complete
*City accept exiting	6/6	5/21	Complete
Genentech accept 15/14 interface	6/6	6/14	Late
*Lab Programming Complete	6/6	6/15	Complete
Bookend and Exterior program accepted by Genentech	6/8	6/18	Late
Package B structural modifications (CCDS)	6/8	6/7	Revised
*Turnover lab DD plan to AEI	6/8	6/20	Complete
Architect program/MEP concepts Established By Design Team	6/13	6/28	
*Notice to proceed with detailed design	6/13	6/28	Complete
*Design Budget & Schedule for Changes Approved	6/20	7/2	Complete
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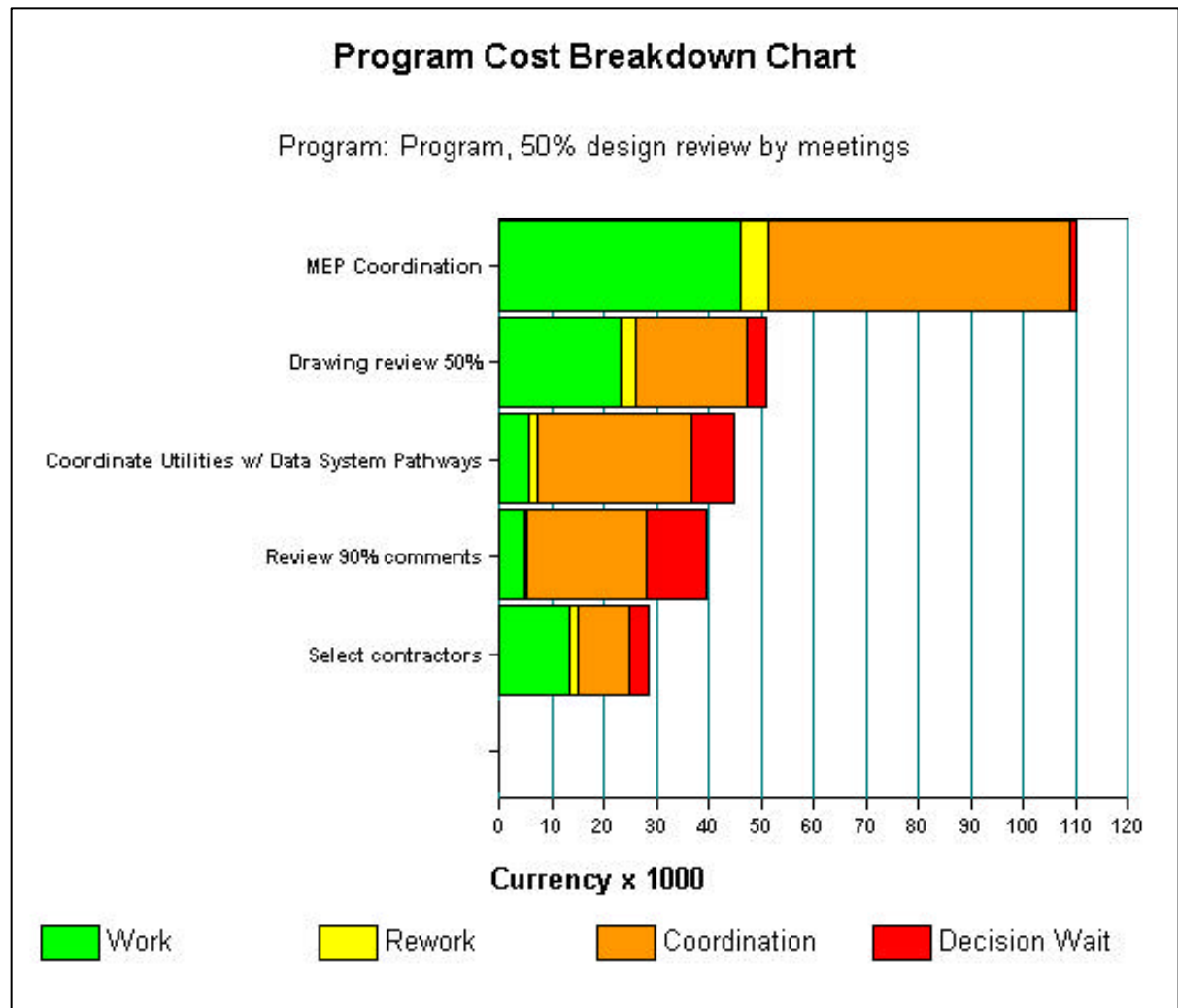
Milestone on critical path



Predict total effort

Effort

- Direct work (CPM)
- Rework
- Coordination
- Wait for decisions (decision latency)

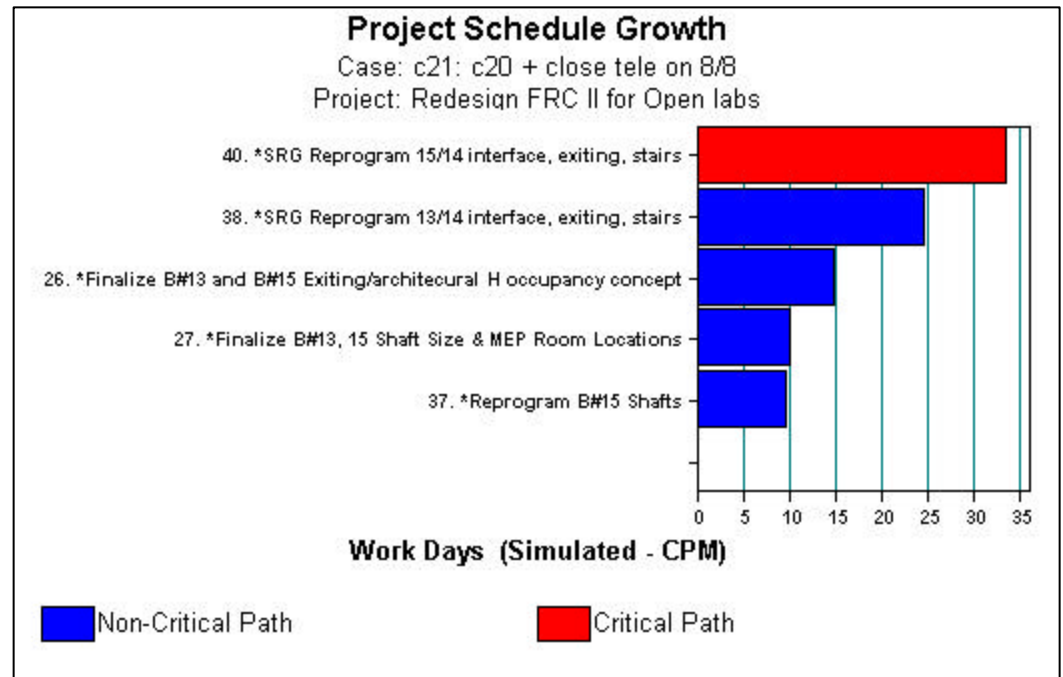




Predict schedule risk

Effect on
schedule of
predicted

- Rework
- Coordination
- Wait for decisions (decision latency)

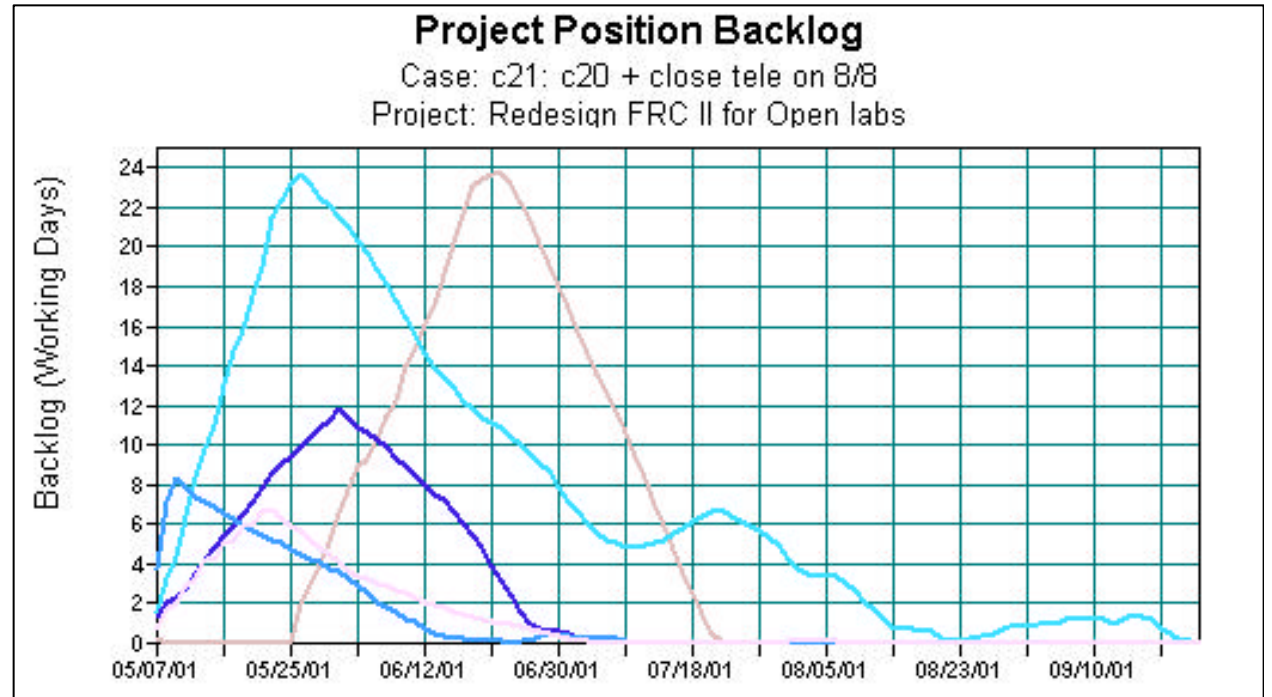




Predict worker backlogs

Predicted backlog shows risks

- Response latency
- Process, product Quality





Predict overall project performance

- “Executive dashboard” evaluates alternatives
 - Quantitatively predicted duration, cost, risk OK?
 - Evaluate multiple options

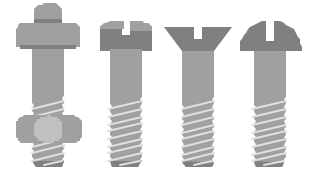
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Quality Management



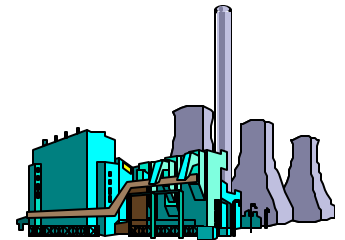
- <60s: Measure Product Quality

- Quality out of control by the time problems are detected
- Default QC: customers measure for you!
- Most costly QC approach



- <80s: Control Processes Variance

- First cause
- Predict quality problems before they arise
- Requires long production runs to calibrate measures
- Costly QC

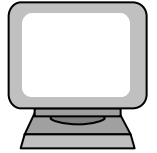


- >90s: Control Process Management

- Root cause: Organization
- **Predict** quality problems before they arise
- Applies to small production runs
- Least expensive QC

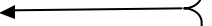






Project performance objectives

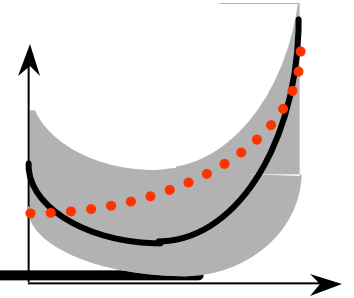


- **External**
 - **Schedule:** 2-sigma (95% on-time)
 - **Cost:** Objective: 95% of budgeted items within 2% of budgeted cost
 - **Quality:** product quality, measured by customer
- **Internal coordination**
 - **Decision latency (Decision-making promptness):** mean working days 1; 95% within 2 days
 - **Response latency (Decision-making no earlier than necessary):** mean working days < 1; 95% within 2 days
 - **Field-generated Requests for Information:** 0
 - **Rework:** 0 (field work); 10-20% of total for virtual work
- **Controllable**
 - **Explicitly shared project scope:** 100%
 - **Stakeholder decision participation:** > 90%
 - **Analytical Predictions:** > 90%
 - **>= 2 Design versions:** >= 80%
 - SimVision prediction
 - SimVision Risk prediction

Status of Research question

- Why are project predicted schedules late? 
 - What method can (quantitatively, analytically) predict project performance? 
 - measurable metrics 
 - Metrics that relate to project cost, duration, final product quality 
 - Based on project design that can be manipulated by a manager 
- Coordination, rework, waiting
 - *Information model (simulation) of the organization + process*
 - Dependent variables: cost, schedule
 - Process metrics: backlogs, latency, schedule, cost performance
 - Independent variables: task complexity, organization, process design

Conclusions



- *Overall finding:* Theory and methods exist to predict and mitigate Organizational Risks in Fast-Paced Projects
- *Applicability:* semi-routine, fast-paced projects with concurrent, interdependent activities
- *Descriptive Model:* Tasks, Milestones, Actors, Dependencies
- *Model behaviors:* actor, activity *micro*-behaviors
- *Predictions:* Project and task cost, duration, quality; position, person performance; risks
- *Use:* Allow managers to predict performance; intervene before problems arise
- *Validation:* Extensive empirical, Consistency