

Risk Control Tutorial

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Agenda (Part 2)

- **Risk Management Planning**
 - Possible Mitigation Strategies
 - Calculating the Risk Reserve
- **Risk Resolution**
 - Estimating Computer Usage
 - Trading Hardware and Labor Costs
- **Risk Monitoring**
 - Tracking (Earned Value)
 - Updating Estimates and Plans (ECP)
- **The Risk Management Process**
 - Feedback Loops
 - Team Risk Management

Developer-Specific Risks

- Application Type
- Product Requirements
- Product Design
- Product Installation
- Process
- Project Staff
- Project Plan
- Project Resources and Organization
- Business (liabilities, loss of profit)
- Customer

Buyer-Specific Risks

- Maintaining Operability
- Loss of Business
- Supportability
- Unprofitability
- Liability

Possible Mitigation Strategies

- **Transfer**
 - Negotiate contract Terms and Conditions (delimit responsibility, limit liability)
 - Provide a written warranty
 - Purchase insurance to cover losses
- **Reduce Probability of Occurrence**
 - Consult experts and historical data
 - Analyze the causes (studies, simulations)
 - Prototype high risk areas
 - Choose a better design (high reliability, fail-safe, excess capacity)
- **Reduce Consequences**
 - Provide a backup and restore capability
 - Provide a backup system (failover)
 - Purchase insurance to cover residual loss
 - Establish a reserve (to cover the losses)

Mitigation Actions for Requirements Risks*

Potential Risks	Possible Mitigation Actions										
	Elicitation				Validate			Control		Communicate	
	Subject Matter Experts	Study Similar Systems or Products	Visit the Customer's Site	Joint Application Development	Feasibility Study	Prototyping or Simulation	Formal Analysis Models	Document the Requirements	Control the Document	Communicate (e.g., Project Glossary)	Negotiate Responsibility, Authority, and Cutoff Dates (Contract Ts and Cs)
Omissions	X	X	X	X			X			X	
Validity	X	X		X	X	X	X			X	
Changes								X	X	X	X
Binding Approval								X			X

*From Chapter 17 in [Stutzke, 2003]

Mitigation Activities for Critical Software Modules*

NUMBER	SOURCE OF POTENTIAL PROBLEM	MITIGATION STRATEGY
1	The module interfaces with hardware which is being developed concurrently with the software	Implement the module early so that it may be tested with the hardware during development. Simulate or emulate the hardware to verify understanding of interfaces and behavior.
2	The module has a software interface with an external organization	Make early assignment of technical interface responsibility
3	The development of other modules depends upon the availability of the module being evaluated	Implement the module early.
4	Algorithms to implement the module are poorly understood and/or untested	Begin algorithm development and/or testing early. Some prototyping is advisable
5	The candidate algorithm for implementation of the module contains a structure which requires looping or searching	Investigate the execution timing of the algorithm. Prototype if appropriate.
6	There are accuracy or numeric convergence considerations in the use of the candidate algorithm	Investigate the numeric performance of the module. Prototype if appropriate
7	The module has memory requirements that are large relative to the available memory	Investigate memory usage and hardware growth potential.
8	The module makes heavy demands on I/O (disk, ports, channels) and/or processing resources	Investigate resource usage and hardware growth potential.
9	The module has stringent constraints on response time	Investigate the execution timing of the module. Prototype if appropriate.

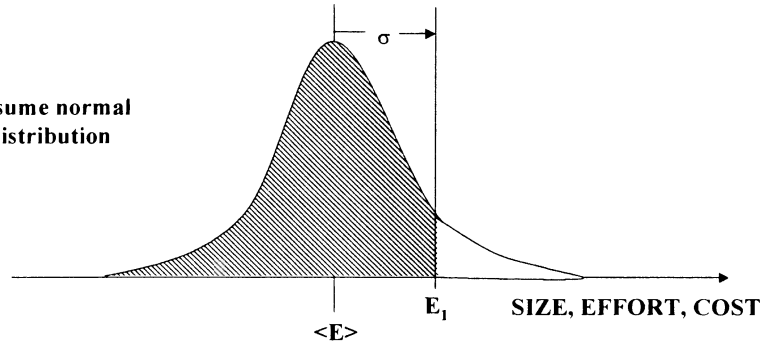
*From Chapter 17 in [Stutzke, 2003]

Goals of Planning

- Choose an “optimal” reserve amount (money)
 - Too large ⇒ overpriced
 - Too small ⇒ inadequate resources
- Provide justification for the amount
 - Hard reserve versus soft reserve
 - Documented calculations
- Scheduling the mitigation tasks
 - Preventative
 - Contingent

One Way to Determine the Reserve

Assume normal distribution



If $E_1 = \langle E \rangle + \sigma$, then:

Probability ($E \leq E_1$) = 0.50 + 0.34 = 0.84

(A good manager can influence project cost by ~ 20%.)

Reserve = $E_1 - \langle E \rangle$

Risk Analysis Spreadsheet*

Project:													
Date Prepared:													
A	B	C	D	E	F	G	H	I	J	K	L	M	N
Description ID	Owner	Title	Before Mitigation			Mitigation		After Mitigation			Analysis		
			Prob.	Cost (\$K)	Impact (\$K)	Action	Cost (\$K)	Prob.	Cost (\$K)	Impact (\$K)	Impact Red. (\$K)	RRL	Notes
1		A	0.4	45.0	18.0	A-1	10.0	0.05	10.0	0.5	17.5	1.75	
2		B	0.5	75.0	37.5	B-1	75.0	0.00	0.0	0.0	37.5	0.50	
3		C	0.3	25.0	7.5	C-1	2.0	0.00	0.0	0.0	7.5	3.75	
4		D	0.2	100.0	15.0	D-1	15.0	0.00	0.0	0.0	15.0	1.00	
5		E	1.0	150.0	150.0	E-1	5.0	0.00	0.0	0.0	150.0	30.00	
6		F	0.3	375.0	112.5	F-1	100.0	0.15	200.0	30.0	82.5	0.83	
7		G	0.1	1000.0	100.0	G-1	150.0	0.01	900.0	9.0	91.0	0.61	
8		H	0.2	1125.0	225.0	H-1	90.0	0.05	100.0	5.0	220.0	2.44	
9		I	0.4	500.0	200	I-1	30.0	0.10	500.0	50	150	5.00	
10		J	0.4	1500.0	600	J-1	100.0	0.15	500.0	75	525	5.25	

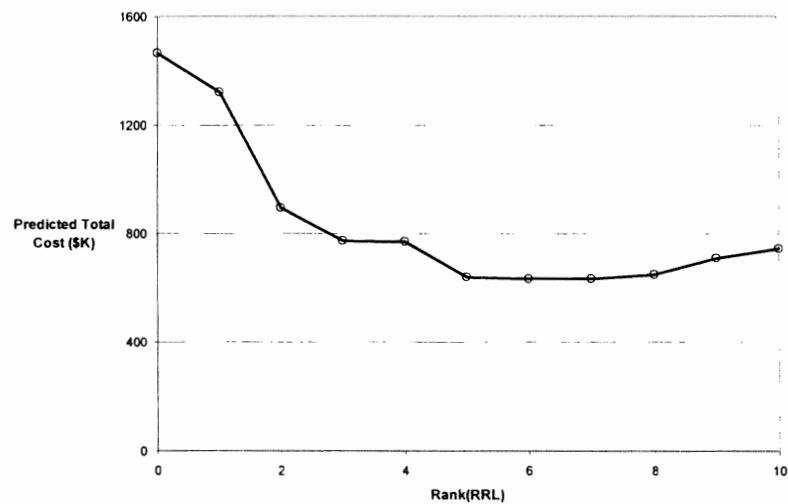
*Based on concepts in [Hwang, 1973] and [Army, 1979].

Computing the Appropriate Reserve

- Approach
 - Mitigate only risks with $RRL > 1$
 - Rank order risks by decreasing RRL
- Definition:

$$PTC = \text{Predicted Total Cost} = \sum_{RRL > 1} I_A + \sum_{RRL < 1} I_B + \sum_{RRL > 1} C_M$$

Predicted Total Cost vs Rank(RRL)



Cost Risk: Labor Rates and Contract Type

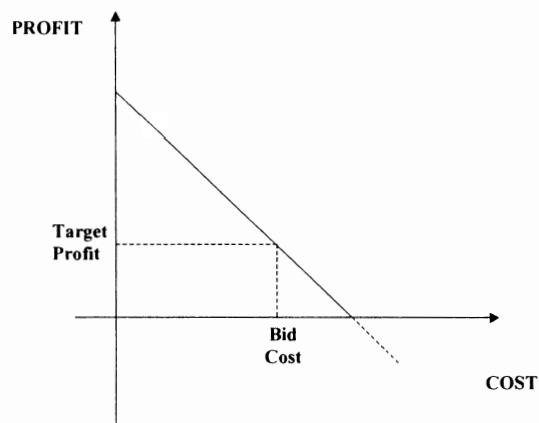
- Contract Terms Affect Financial Risks
 - Bid versus actual labor rates
 - Reward for risk (profit)
 - Reallocation rules
- Contract Types

Contract Type	Name
T&M	Time and Materials
CPFF	Cost Plus Fixed Fee
CPFF LOE	CPFF Level of Effort
CPIF	Cost Plus Incentive Fee
CPAF	Cost Plus Award Fee
FFP	Firm Fixed Price

Increasing
Risk to Seller
↓

Firm Fixed Price

- Developer delivers a product for a fixed price, B.



Example of Termination for Default Impact

Summary of Costs	
Contract Value for Original Supplier	\$20M
Contract Expenditures to date	\$15M
Contract Value with New Supplier	\$40M
Government Administrative Costs of Reprocurement	\$2M
Termination Cost for Original Supplier	\$1M

Profit Impact to Original Supplier	
Unrecovered Costs to Date	\$15M
Contract Value Cost Differential	\$20M
Government Administrative Costs of Reprocurement	\$2M
Termination Costs for Original Supplier	\$1M
TOTAL PROFIT IMPACT	\$38M

Software Risk Management

- **Risk Assessment**
 - Risk Identification
 - Risk Analysis
 - Risk Prioritization
- **Risk Control**
 - Risk Management Planning
 - **Risk Resolution**
 - Risk Monitoring

Ways to Estimate and Measure Computer Usage

- **Analytical Studies**
 - Scoping Models (allocation to key threads, scaling)
 - Queueing Network Models
- **Engineering Simulators**
 - Commercial Network Models
 - Vendor's Benchmarking Models
 - Custom-built Models (very flexible, any desired fidelity)
 - Hybrid models (queueing model results plus custom code)
- **Prototypes**
 - Key functions
 - Synthetic natural environment
- **Evolving System**
 - Data injection and collection tools
 - Resource-consuming stubs
 - Replace stubs with real code later

Only commit to performance measures associated with the pieces you build or configure.

How Cost Models Apply

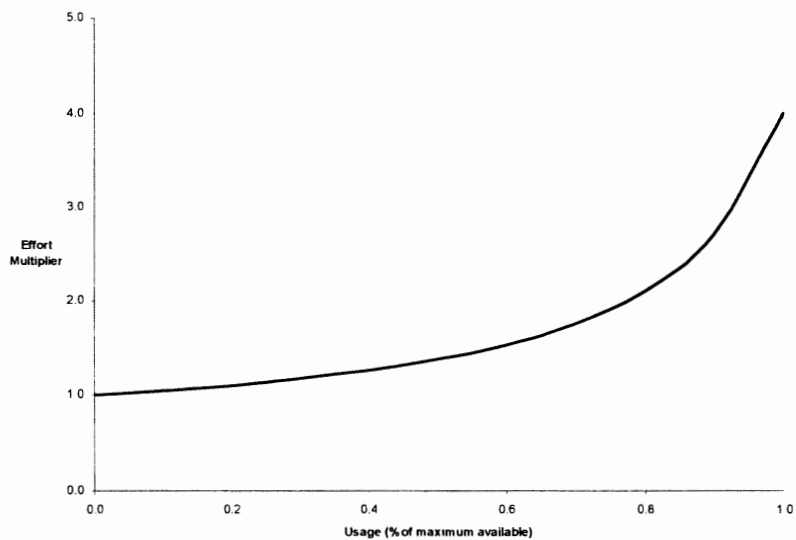
- Prototypes
 - Applications Composition Model
- Large Prototypes (a “mini-project”)
 - Large amounts of reused code in some cases
 - High REVL
- Trade Studies
 - Linear model (Level of Effort, ODCs, trips)*

*Augments parametric models

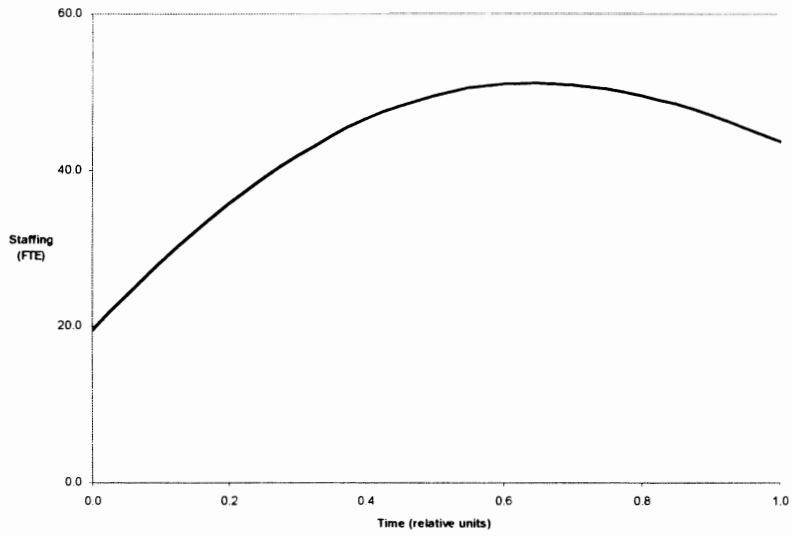
Example: Hardware Capacity Versus Development Cost

- Facts
 - Saturating the platform resources increases development effort (TIME, STOR)
 - Buying more capacity increases costs (materials)
- Questions to answer
 - Does buying more hardware reduce total project cost?
 - How late can I wait?

Shoehorn Curve



Staffing (Modified Rayleigh)

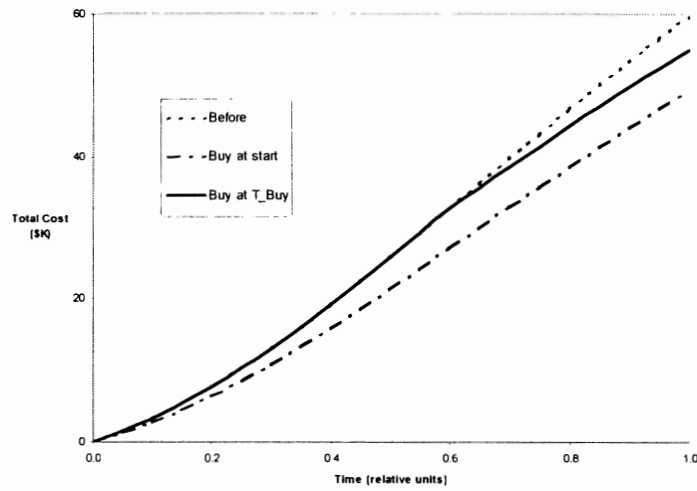


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Cumulative Effort vs T

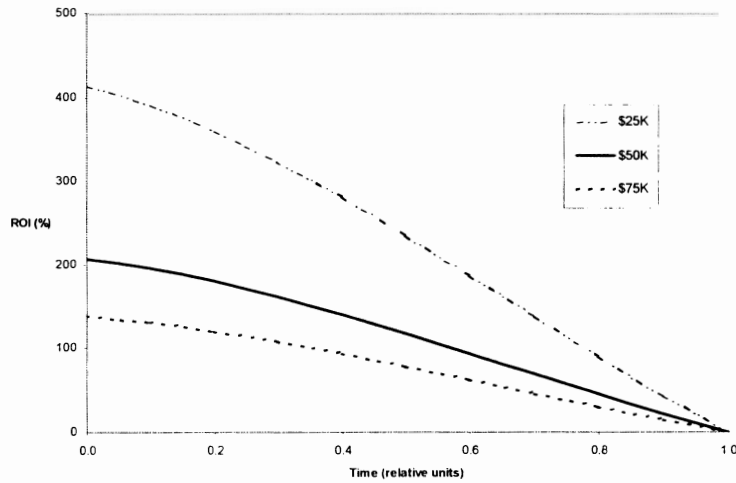


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ROI versus Time of Purchase



Software Risk Management

- **Risk Assessment**
 - Risk Identification
 - Risk Analysis
 - Risk Prioritization
- **Risk Control**
 - Risk Management Planning
 - Risk Resolution
 - **Risk Monitoring**

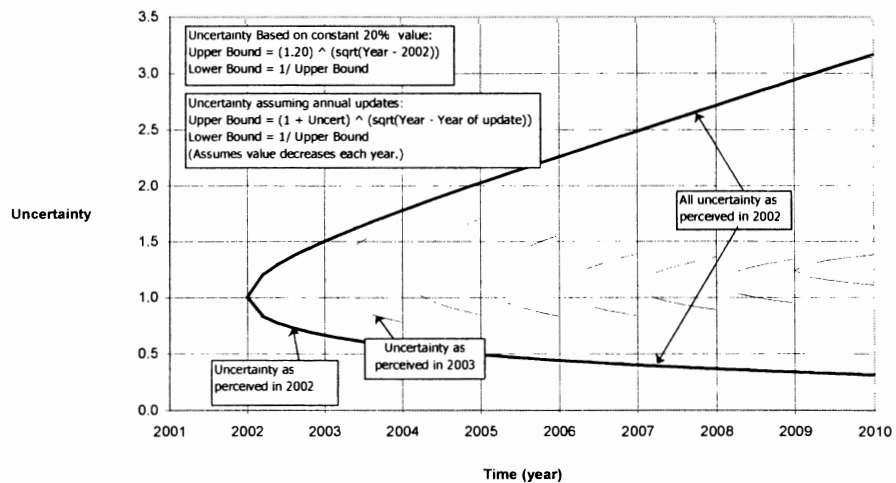
Estimates Predict the Future

- **Uncertainty in product, process, and project parameters***
 - Known unknowns
 - Unknown unknowns (ignorance)
- **External Influences**
 - Interfaces
 - Funding
 - Staffing

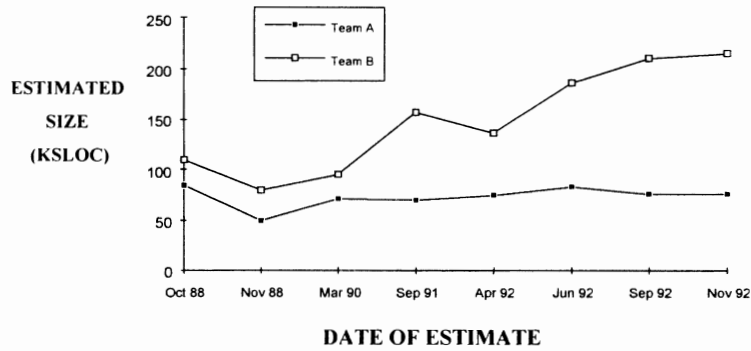
Must update estimates!

*Models are approximations, and also contribute to the uncertainty.

Updates Reduce the Uncertainty



Size Tracking Example



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Sources of Size Growth*

Source	% WRT Original Size
New Features	57
Add Missing Features	0
Correct Errors	14
Perfect the Code	24
Improve Usability	5

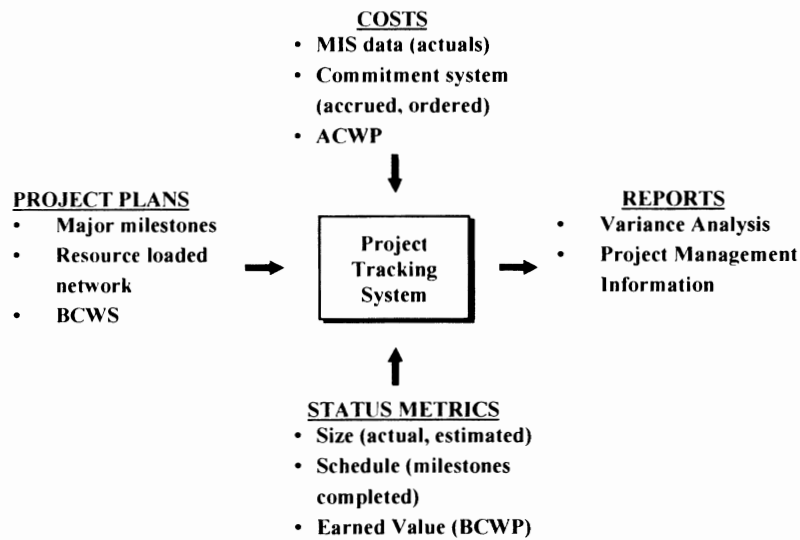
*Based on Chapter 9 in [Stutzke, 2003].

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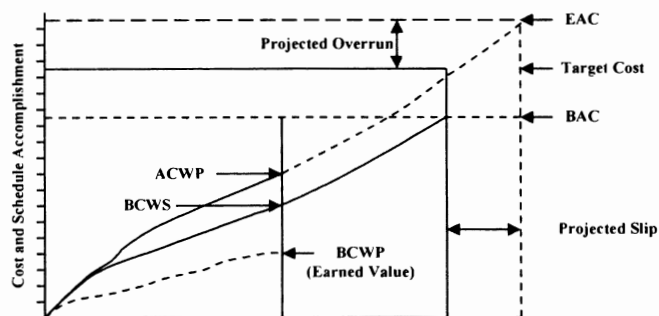
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Information Flow for Project Tracking



Basic Earned Value Variables



TC	Target Cost
BAC	Budget At Complete (planned)
MR	Management Reserve = TC-BAC
ACWP	Actual Cost of Work Performed (MIS + Open Commitments)
BCWS	Budgeted Cost of Work Scheduled (Plan)
BCWP	Budgeted Cost of Work Performed (Earned Value)
EAC	Estimate At Complete
ETC	Estimate To Complete = EAC-ACWP

Earned Value Metrics

- **Variations**

$$\text{Cost Variance} = \text{BCWP} - \text{ACWP}$$

$$\text{Schedule Variance} = \text{BCWP} - \text{BCWS}$$

$$\text{Cost Variance \%} = \frac{\text{Cost Variance}}{\text{BCWP}}$$

$$\text{Schedule Variance \%} = \frac{\text{Sch. Variance}}{\text{BCWS}}$$

- **Project Performance Indices**

$$\text{Schedule Performance Index} = \text{SPI} = \frac{\text{BCWP}}{\text{BCWS}}$$

$$\text{Cost Performance Index} = \text{CPI}_E = \frac{\text{BCWP}}{\text{BCWS}}$$

("Efficiency")

$$\text{Total Cost Performance Index} = \text{TCPI} = \frac{\text{BAC} - \text{BCWP}}{\text{EAC} - \text{ACWP}} = \frac{\text{Work Left}}{\text{Money Left}}$$

- **Estimates at Completion**

$$\text{EAC}_1 = \text{ACWP} + (\text{BAC} - \text{BCWP})$$

$$\text{EAC}_2 = \text{ACWP} + \frac{1}{\text{CPI}_E} (\text{BAC} - \text{BCWP})$$

Earned Value Example

- **Assumed Values**

$$\text{BAC} = 2000$$

$$\text{ACWP} = 565$$

$$\text{BCWP} = 480$$

$$\text{CPI}_E = 0.95$$

$$\text{SPI} = 0.85$$

- **Calculated Values**

$$\text{EAC}_1 = 565 + 2000 - 480 = 2085$$

$$\text{EAC}_2 = 565 + (2000 - 480)/0.95 = 2165$$

Risks

- Omitted Tasks
- Errors in Measured Data
 - Commitments (“estimated actuals”)
 - Accounting “noise” (provisional rates, unbillable costs)
- Errors in estimates
 - BAC
 - CPI_E (assumes process is stable)

Simple Estimate to Complete

Historical Data (% allocation)

	Units	Phase					TOTAL
		RA	PD	DD	CUT	SWIT	
Effort	%	7	17	24	26	25	100
Schedule	%	17	27	17	17	21	100

Project Plan (EDEV = 2000 phrs, TDEV = 12 CM, TDUR ≈ 240 w-days)

	Units	Phase					TOTAL
		RA	PD	DD	CUT	SWIT	
Effort	Phrs	140	340	480	520	520	2000
Schedule	CM	2.0	3.2	2.0	2.0	2.8	12.0
Duration	W-days	41	65	41	41	50	240

Observed Data (through PDR or LCA)

	Units	Phase					TOTAL
		RA	PD	DD	CUT	SWIT	
Effort	Phrs	165	400				
Schedule	CM	2.5	4.0				

What is the prognosis?

Estimate at Completion as of PDR (= LCA)

	Effort	Sched
Plan	480	5.2
Actual	565	6.5
“Work” Accomplished at PDR	24%	44%

Expected Total Effort = $2000 (565/480) = 2354$ phrs (18%)

Expected Total Schedule = $12.0 (6.5/5.2) = 15.0$ CM (25%)

An Equivalent Calculation

$$\begin{aligned}\text{Expected Total Effort} &= \frac{\text{Cumulative Actual Effort}}{\text{Cumulative Fractional Effort}} \\ &= \frac{565 \text{ phrs}}{0.24} = 2354 \text{ phrs}\end{aligned}$$

$$\text{Expected Remaining Effort} = \left(\frac{565}{0.24} \right) (1 - 0.24) = 1789 \text{ phrs}$$

These estimates are crude, but often provide a sanity check.

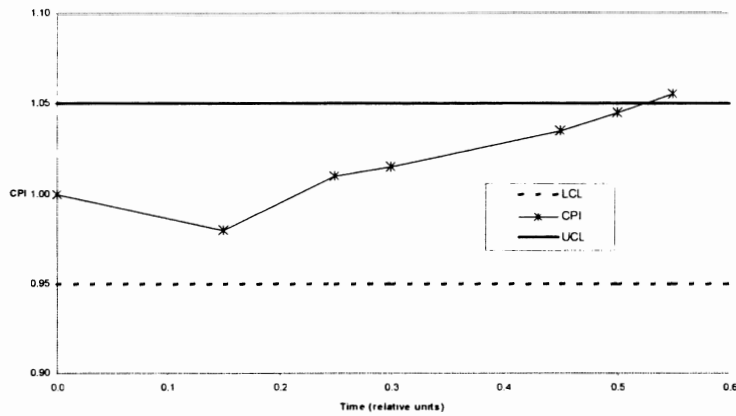
Reasons to Update Estimates

- **Revised requirements**
- **Altered scope, groundrules & assumptions**
- **Improved understanding of the product (size, performance)**
- **Improved understanding of the process (productivity, costs)**
- **Unplanned events (known risks, new problems)**
- **New risks identified**

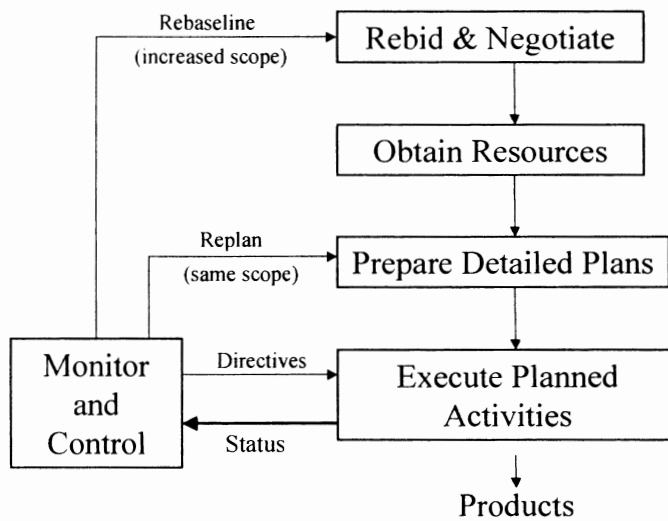
Updating Project Estimates

- **What to do**
 - **Reassess model inputs (System technical parameters, environmental factors)**
 - **Use actual measured values for parameters when available**
 - **Generate a revised cost estimate**
 - **Compare updated estimate with previous estimate(s)**
 - **Significant changes signal potential problem areas for management resolution**
- **When to do it**
 - **Iteratively during proposal phase**
 - **At project kickoff**
 - **At each major milestone (formal review)**
 - **At every change (formal change request)**
 - **When significant or unexpected events occur**

Using SPC to Detect Problems



Scope of Revisions to Plans



Items to Consider for a Change Proposal

- What must be delivered?
 - Code
 - Operational data
 - Documents
 - Training materials
 - Consulting and other services
 - Status reports and briefings
- What tasks must be done to produce each deliverable?
- How do the new tasks impact previously planned, incomplete tasks? (rework, schedule dependencies)
- What is the schedule for the tasks?
- What is the cost (effort, ODCs) of each task?
- What unresolved issues/risks could prevent accomplishing the tasks?

Scope of ECP Estimates*

Deliverables	Tasks	Effort	Costs			
		Labor Grades	Labor	Materials	ODCs	Travel
Software (new plus modify existing)	Design Code Test					
COTS Components	Select Install Test					
Operational Data	Collect Format Validate					
Documentation (Engr and User, new plus modified)	Write Review Revise					
Courseware	Develop Pilot					
Services & Support	CM QA Studies					
Coordination	PM Meetings					

*The scope includes risk mitigation tasks and associated reserves

Use Different Estimating Methods

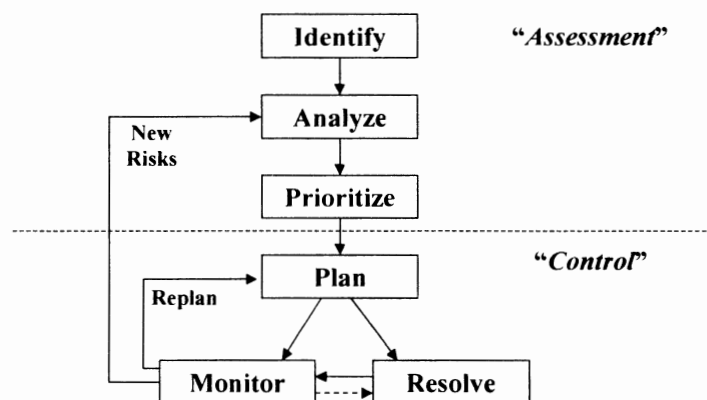
Time Type of Item	Bid	Execution
Development Tasks	Parametric Models, Linear, Historical, Analogy, Delphi, PERT	Scaling based on design elements, Actual Productivity, Expert Judgment
Production Tasks	Linear, Historical, Analogy, Delphi, PERT	Actual Productivity, Trend Analysis, Learning Curves, Expert Judgment
Other Tasks	Linear, Historical, Analogy, Delphi, PERT	Burn rate, Trend Analysis
Materials	Linear, Vendor Quotes, Delphi, PERT	Revised Quotes, Actual Invoices
Support Costs	Standard Rates, Historical, Analogy, Delphi	Actual Costs, Projections

Summary

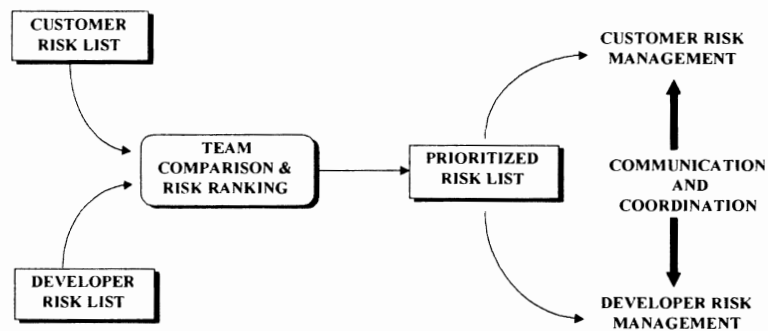
Activities for Risk Control

- Define ways to mitigate (Ts and Cs, tasks, materials)
- Estimate needed resources
- Re-estimate probabilities and cost of occurrence
- Choose best mitigation approach
- Integrate preventative and tracking tasks into project plan (WBS, RLN, budget)
- Establish reserves for contingent tasks (budget)
- Assign responsibilities for tasks (mitigate, tracking)
- Track identified risks and update priorities, etc.
- Assess progress of resolution tasks
- Continue to identify new risks
- Update plans and status
- Communicate status

The Risk Management Process



Team Risk Management



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