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

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Buyer-Specific Risks

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

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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 Activities for Critical Software Modules*

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>SOURCE OF POTENTIAL PROBLEM</th>
<th>MITIGATION STRATEGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The module has a software interface with an external organization</td>
<td>Implement the module early so that it may be tested with the hardware during development or even before the hardware is ready.</td>
</tr>
<tr>
<td>2</td>
<td>The module has a software interface with an external organization</td>
<td>Make early assignment of technical interface responsibilities.</td>
</tr>
<tr>
<td>3</td>
<td>The module has a software interface with an external organization</td>
<td>Implement the module early.</td>
</tr>
<tr>
<td>4</td>
<td>The module has a software interface with an external organization</td>
<td>High algorithm development stage using existing early, have programming in parallel.</td>
</tr>
<tr>
<td>5</td>
<td>The module has a software interface with an external organization</td>
<td>Investigate the execution timing of the module. Prototype if appropriate.</td>
</tr>
<tr>
<td>6</td>
<td>The module has memory requirements that exceed the memory capacity of the computer</td>
<td>Investigate the memory requirements of the module. Prototype if appropriate.</td>
</tr>
<tr>
<td>7</td>
<td>The module has memory requirements that exceed the memory capacity of the computer</td>
<td>Investigate memory usage and hardware growth potential.</td>
</tr>
<tr>
<td>8</td>
<td>The module has memory requirements that exceed the memory capacity of the computer</td>
<td>Investigate memory usage and hardware growth potential.</td>
</tr>
</tbody>
</table>

*From Chapter 17 in [Stutzke, 2003](#)

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### 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

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One Way to Determine the Reserve

Assume normal distribution

If \( E_1 \leq <E> + \sigma \), then:

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

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

Reserve = \( E_1 - <E> \)

Risk Analysis Spreadsheet*

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Risk</td>
<td>Prob.</td>
<td>Low</td>
<td>High</td>
<td>Mean</td>
<td>Std Dev</td>
<td>Variance</td>
<td>Prob.</td>
<td>Low</td>
<td>High</td>
<td>Mean</td>
<td>Std Dev</td>
<td>Variance</td>
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<td>12</td>
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<td>1</td>
<td>A</td>
<td>0.4</td>
<td>190</td>
<td>180</td>
<td>B</td>
<td>170</td>
<td>160</td>
<td>326</td>
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<td>0.00</td>
<td>0.00</td>
<td>575</td>
<td>1.75</td>
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<tr>
<td>2</td>
<td>B</td>
<td>0.6</td>
<td>190</td>
<td>200</td>
<td>C</td>
<td>170</td>
<td>180</td>
<td>326</td>
<td>0.50</td>
<td>0.00</td>
<td>0.00</td>
<td>575</td>
<td>1.75</td>
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<tr>
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<td>210</td>
<td>D</td>
<td>170</td>
<td>190</td>
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<td>0.00</td>
<td>575</td>
<td>1.75</td>
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<tr>
<td>4</td>
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<td>220</td>
<td>E</td>
<td>170</td>
<td>200</td>
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<td>0.00</td>
<td>575</td>
<td>1.75</td>
</tr>
<tr>
<td>5</td>
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<td>1.2</td>
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<td>230</td>
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<td>170</td>
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<td>0.00</td>
<td>0.00</td>
<td>575</td>
<td>1.75</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>1.4</td>
<td>190</td>
<td>240</td>
<td>G</td>
<td>170</td>
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<td>170</td>
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<td>326</td>
<td>0.50</td>
<td>0.00</td>
<td>0.00</td>
<td>575</td>
<td>1.75</td>
</tr>
<tr>
<td>8</td>
<td>H</td>
<td>1.8</td>
<td>190</td>
<td>260</td>
<td>I</td>
<td>170</td>
<td>250</td>
<td>326</td>
<td>0.50</td>
<td>0.00</td>
<td>0.00</td>
<td>575</td>
<td>1.75</td>
</tr>
<tr>
<td>9</td>
<td>I</td>
<td>2.0</td>
<td>190</td>
<td>270</td>
<td>J</td>
<td>170</td>
<td>260</td>
<td>326</td>
<td>0.50</td>
<td>0.00</td>
<td>0.00</td>
<td>575</td>
<td>1.75</td>
</tr>
<tr>
<td>10</td>
<td>J</td>
<td>2.2</td>
<td>190</td>
<td>280</td>
<td>K</td>
<td>170</td>
<td>270</td>
<td>326</td>
<td>0.50</td>
<td>0.00</td>
<td>0.00</td>
<td>575</td>
<td>1.75</td>
</tr>
</tbody>
</table>

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

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Computing the Appropriate Reserve

- Approach
  - Mitigate only risks with RRL > 1
  - Rank order risks by decreasing RRL
- Definition:
  \[ \text{PTC} = \text{Predicted Total Cost} = \sum_{RRL=1}^{1} \sum_{RRL=1}^{n} C_M \]

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

<table>
<thead>
<tr>
<th>Contract Type</th>
<th>Name</th>
<th>Increasing Risk to Seller</th>
</tr>
</thead>
<tbody>
<tr>
<td>T&amp;M</td>
<td>Time and Materials</td>
<td></td>
</tr>
<tr>
<td>CPFF</td>
<td>Cost Plus Fixed Fee</td>
<td></td>
</tr>
<tr>
<td>CPFF LOE</td>
<td>CPFF Level of Effort</td>
<td></td>
</tr>
<tr>
<td>CPIF</td>
<td>Cost Plus Incentive Fee</td>
<td></td>
</tr>
<tr>
<td>CPAF</td>
<td>Cost Plus Award Fee</td>
<td></td>
</tr>
<tr>
<td>FFP</td>
<td>Firm Fixed Price</td>
<td></td>
</tr>
</tbody>
</table>

Firm Fixed Price

- Developer delivers a product for a fixed price, B.
**Example of Termination for Default Impact**

<table>
<thead>
<tr>
<th>Summary of Costs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract Value for Original Supplier</td>
<td>$20M</td>
</tr>
<tr>
<td>Contract Expenditures to date</td>
<td>$13M</td>
</tr>
<tr>
<td>Contract Value with New Supplier</td>
<td>$40M</td>
</tr>
<tr>
<td>Government Administrative Costs of Reprocurement</td>
<td>$2M</td>
</tr>
<tr>
<td>Termination Cost for Original Supplier</td>
<td>$1M</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Profit Impact to Original Supplier</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Unrecovered Costs to Date</td>
<td>$15M</td>
</tr>
<tr>
<td>Contract Value Cost Differential</td>
<td>$20M</td>
</tr>
<tr>
<td>Government Administrative Costs of Reprocurement</td>
<td>$2M</td>
</tr>
<tr>
<td>Termination Costs for Original Supplier</td>
<td>$1M</td>
</tr>
<tr>
<td><strong>TOTAL PROFIT IMPACT</strong></td>
<td><strong>$38M</strong></td>
</tr>
</tbody>
</table>

---

**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 REV/L
- 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

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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.
Size Tracking Example

Sources of Size Growth*

<table>
<thead>
<tr>
<th>Source</th>
<th>% WRT Original Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Features</td>
<td>57</td>
</tr>
<tr>
<td>Add Missing Features</td>
<td>0</td>
</tr>
<tr>
<td>Correct Errors</td>
<td>14</td>
</tr>
<tr>
<td>Perfect the Code</td>
<td>24</td>
</tr>
<tr>
<td>Improve Usability</td>
<td>5</td>
</tr>
</tbody>
</table>

*Based on Chapter 9 in [Stutzke, 2003].
Information Flow for Project Tracking

**COSTS**
- MIS data (actuals)
- Commitment system (accrued, ordered)
- ACWP

**PROJECT PLANS**
- Major milestones
- Resource loaded network
- BCWS

**REPORTS**
- Variance Analysis
- Project Management Information

**STATUS METRICS**
- Size (actual, estimated)
- Schedule (milestones completed)
- Earned Value (BCWP)

---

Basic Earned Value Variables

![Earned Value Variables Diagram](image)

- **EAC (Estimate at Complete)**
- **ACWP (Actual Cost or Work Performed)**
- **BCWS (Budgeted Cost of Work Scheduled)**
- **BCWP (Budgeted Cost of Work Performed)**
- **TC (Target Cost)**
- **MIR (Management Reserve)**
- **BAC (Budget at Completion)**
- **EAC = TC - BAC + MIR**

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# Earned Value Metrics

- **Variances**
  - Cost Variance = $\text{BCWP} - \text{ACWP}$
  - Schedule Variance = $\text{BCWP} - \text{BCWS}$
  - Cost Variance % = $\frac{\text{Cost Variance}}{\text{BCWP}}$
  - Schedule Variance % = $\frac{\text{Sch. Variance}}{\text{BCWS}}$

- **Project Performance Indices**
  - Schedule Performance Index = $\text{SPI} = \frac{\text{BCWP}}{\text{BCWS}}$
  - Cost Performance Index ("Efficiency") = $\text{CPI}_E = \frac{\text{HCWP}}{\text{BCWS}}$
  - Total Cost Performance Index (Projected) = $\text{TCPI} = \frac{\text{BAC} - \text{BCWP}}{\text{EAC} - \text{ACWP}}$ = Work 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**
  - BAC = 2000
  - ACWP = 565
  - BCWP = 480
  - CPI_E = 0.95
  - SPI = 0.85

- **Calculated Values**
  - $\text{EAC}_1 = 575 + 2000 - 480 = 2085$
  - $\text{EAC}_2 = 565 + (2000 - 480)/0.95 = 2165$
Risks

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

Simple Estimate to Complete

Historical Data (% allocation)

<table>
<thead>
<tr>
<th>Phase</th>
<th>RA</th>
<th>PD</th>
<th>DD</th>
<th>CUT</th>
<th>SWIT</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effort</td>
<td>%</td>
<td>7</td>
<td>17</td>
<td>26</td>
<td>26</td>
<td>100%</td>
</tr>
<tr>
<td>Schedule</td>
<td>%9</td>
<td>27</td>
<td>37</td>
<td>57</td>
<td>71</td>
<td>100%</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Phase</th>
<th>RA</th>
<th>PD</th>
<th>DD</th>
<th>CUT</th>
<th>SWIT</th>
<th>TOTAL</th>
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<tbody>
<tr>
<td>Effort</td>
<td>Phys</td>
<td>240</td>
<td>340</td>
<td>400</td>
<td>550</td>
<td>720</td>
</tr>
<tr>
<td>Schedule</td>
<td>CM</td>
<td>2.0</td>
<td>3.1</td>
<td>2.8</td>
<td>1.6</td>
<td>5.6</td>
</tr>
<tr>
<td>Percent</td>
<td>Phys</td>
<td>41</td>
<td>29</td>
<td>42</td>
<td>41</td>
<td>82</td>
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<tr>
<td>Units</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
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</table>

Observed Data (through PDR or LCA)

<table>
<thead>
<tr>
<th>Phase</th>
<th>RA</th>
<th>PD</th>
<th>DD</th>
<th>CUT</th>
<th>SWIT</th>
<th>TOTAL</th>
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<tbody>
<tr>
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<td>Phys</td>
<td>465</td>
<td>480</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Schedule</td>
<td>CM</td>
<td>2.0</td>
<td>4.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
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</table>

What is the prognosis?

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**Estimate at Completion as of PDR (= LCA)**

<table>
<thead>
<tr>
<th>Effort</th>
<th>Sched</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan</td>
<td>480</td>
</tr>
<tr>
<td>Actual</td>
<td>565</td>
</tr>
</tbody>
</table>

"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**

\[
\text{Expected Total Effort} = \frac{\text{Cumulative Actual Effort}}{\text{Cumulative Fractional Effort}}
\]

\[
= \frac{565 \text{ phrs}}{0.24} = 2354 \text{ phrs}
\]

Expected Remaining Effort = \(565 \times (1 - 0.24) = 1789\) phrs

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

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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

- Rebaseline (increased scope)
- Replan (same scope)
- Monitor and Control
- Obtain Resources
- Prepare Detailed Plans
- Execute Planned Activities
- Status
- Directives
- Products
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*

<table>
<thead>
<tr>
<th>Deliverables</th>
<th>Tasks</th>
<th>Effort</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software (new plus modify existing)</td>
<td>Design, Code, Test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COTS Components</td>
<td>Select, Install, Test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operational Data</td>
<td>Collect, Format, Validate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Documentation (Eng and User, new plus modified)</td>
<td>Write, Review, Revise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Courseware</td>
<td>Develop Files</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Services &amp; Support</td>
<td>CM, QA, Studies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordination</td>
<td>PhD, Meetings</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The scope includes risk mitigation tasks and associated reserves

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## Use Different Estimating Methods

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

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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

```
Identify -> Analyze -> Prioritize
```

```
Plan -> Monitor -> Resolve
```

"Assessment"

"Control"
Team Risk Management

CUSTOMER RISK LIST

TEAM COMPARISON & RISK RATING

DEVELOPER RISK LIST

CUSTOMER RISK MANAGEMENT

COMMUNICATION AND COORDINATION

DEVELOPER RISK MANAGEMENT

PRIORITIZED RISK LIST

References


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