Risk Management

What can go wrong?
What is the likelihood?
What will the damage be?
What can we do about it?
What is A Risk?

- “The chance or possibility of suffering loss, injury, damage, or harm” – Webster’s dictionary, 1981
- “problems that could cause some loss or threaten the success of projects, but which has not happened yet”
- No universally accepted definition
- All definitions share the following characteristics:
  - *Uncertainty* – an event may or may not happen
  - *Loss* – an event has unwanted consequences or losses
If you don actively attack the risks?

The risks will actively attack you!

–Tom Gilb–
Reactive Risk Management

- Project team reacts to risks when they occur
- Mitigation: plan for additional resources in anticipation of fire fighting
- Fix on failure: resource are found and applied when the risk strikes
- Crisis management: failure does not respond to applied resources and project is in jeopardy
Proactive Risk Management

• Formal risk analysis is performed
• Organization corrects the root causes of risk
  – TQM concepts and statistical SQA
  – examining risk sources that lie beyond the bounds of the software
  – developing the skill to manage change
Seven Principles

- Maintain a global perspective—view software risks within the context of system and the business problem
- Take a forward-looking view—think about the risks that may arise in the future; establish contingency plans
- Encourage open communication—if someone states a potential risk, don’t discount it.
- Integrate—a consideration of risk must be integrated into the software process
- Emphasize a continuous process—the team must be vigilant throughout the software process, modifying identified risks as more information is known and adding new ones as better insight is achieved.
- Develop a shared product vision—if all stakeholders share the same vision of the software, it likely that better risk identification and assessment will occur.
- Encourage teamwork—the talents, skills and knowledge of all stakeholder should be pooled
Risk Management is aimed at addressing the risks within the project management environment. Not just the technical risks.
Is This A Risk?

• We just started integrating the software
  – and we found out that COTS* products A and B just can’t talk to each other
• We’ve got too much tied into A and B to change
• Our best solution is to build wrappers around A and B to get them to talk via CORBA**
• This will take 3 months and $300K
• It will also delay integration and delivery by at least 3 months

*COTS: Commercial off-the-shelf
**CORBA: Common Object Request Broker Architecture
Is This A Risk?

• No, it is a problem
  − Being dealt with reactively

• Risks involve uncertainties
  − And can be dealt with pro-actively
  − Earlier, this problem was a risk
Earlier, This Problem Was A Risk

• A and B are our strongest COTS choices
  – But there is some chance that they can’t talk to each other
  – Probability of loss P(L) [or P(UO)]
  – If we commit to using A and B
  – And we find out in integration that they can’t talk to each other
  – We’ll add more cost and delay delivery by at least 3 months
  – Size of loss S(L) [or L(UO)]

• Risk Exposure (RE)
  \[ RE = P(L) \times S(L) \]
Risk-Analysis: Decision Tree

Do IV&V

- P(UO)=0.36
  - Find CE: L(UO)=$0.5M
  - P=0.04
    - Don’t find CE: L=$20.5M
- P=0.06
  - No CE: L=$0.5M

No IV&V

- P(UO)=0.3
  - Find CE: L(UO)=$0
  - P=0.1
    - Don’t find CE: L=$20M
- P=0.6
  - No CE: L=$0

Risk Exposure:
- $0.18M
- $0.82M
- $0.30M

Combined Risk Exposure:
- $1.3M

More attractive option:
- $0
- $2M
- $2M
Using Risk to Determine “HOW MUCH ENOUGH”

- RE due to inadequate plans
- RE due to market share erosion
- Sum of risk exposures

**Sweet Spot**

- high $P(L)$: inadequate plans
- high $S(L)$: major problems (oversights, delays, rework)

- high $P(L)$: plan breakage, delay high $S(L)$: value capture delays

- low $P(L)$: few plan delay low $S(L)$: early value capture

- low $P(L)$: thorough plans low $S(L)$: minor problems

Time and Effort Invested in Plans
RISK vs. PROBLEM

• Example:
  – A risk: threat of your top technical people being hired away by the competition
  – A problem: unable to hire right skilled staff

• Current, real problems
  – Requires prompt corrective actions

• Looming risk
  – Dealt with several different ways
How to Deal with Risks?

- Buying Information
- Risk Avoidance
- Risk Transfer
- Risk Reduction
- Risk Acceptance
Risk Management Strategies - I

Buying Information

- Let’s spend $30K and 2 weeks prototyping the integration of A and B
- This will buy information on the magnitude of P(L) and S(L)
- If RE = P(L) * S(L) is small, we’ll accept and monitor the risk
- If RE is large, we’ll use one/some of the other strategies

Risk Avoidance

- COTS product C is almost as good as B, and it can talk to A
- Delivering on time is worth more to the customer than the small performance loss
Risk Transfers
- If the customer insists on using A and B, have them establish a risk reserve.
- To be used to the extent that A and B can’t talk to each other

Risk Reduction
- If we build the wrappers and the CORBA corrections right now, we add cost but minimize the schedule delay

Risk Acceptance
- If we can solve the A and B interoperability problem, we’ll have a big competitive edge on the future procurements
- Let’s do this on our own money, and patent the solution
Risk of Delaying Risk Management:

- Smaller software projects
- Larger software projects

Relative cost to fix defect

- Requirements
- Design
- Code
- Development
- Acceptance
- Operation

Phase in Which defect was fixed

- Median (TRW survey) 80%
- Median (TRW survey) 20%
- SAFEGUARD
- GTE
- IBM-SSD
Steeper Cost-to-fix for High-Risk

Major Rework Sources:
- Off-Nominal Architecture-Breakers
  - A - Network Failover
  - B - Extra-Long Messages

TRW Project A
373 SPR’s

TRW Project B
1005 SPR’s

% of Software Problem Reports (SPR’s)

% of Cost to Fix SPR’s
Software Risk Management

Risk Management

Risk Assessment

Risk Identification
- Checklists
  - Decision driver analysis
  - Assumption analysis
  - Decomposition

Risk Analysis
- Performance models
- Cost models
- Network analysis
- Decision analysis
- Quality factor analysis

Risk Prioritization
- Risk exposure
- Risk leverage
- Compound risk reduction

Risk mgmt Planning
- Buying information
- Risk avoidance
- Risk transfer
- Risk reduction
- Risk element planning
- Risk plan integration

Risk Resolution
- Prototypes
- Simulations
- Benchmarks
- Analyses
- Staffing
- Milestone tracking
- Top-10 tracking
- Risk reassessment
- Corrective action

Risk Monitoring

Risk Assessment

Risk Analysis

Risk Prioritization

Risk mgmt Planning

Risk Resolution

Risk Monitoring
WE'LL NEED A RISK ANALYSIS ON THIS PROJECT BEFORE I CAN APPROVE IT.

RISK 1: INDECISIVENESS
RISK 2: OVERANALYSIS
RISK 3: CLUELESSNESS
RISK 4: MICROMANAGEMENT...

I DON'T UNDERSTAND THESE RISKS.

THAT'S NUMBER THIRTY-SIX.
Risk Identification

• Produce lists of the project specific risk items likely to compromise a project’s success

• Typical risk Identification Techniques
  – Risk-item checklists
  – Decision driver analysis
  – Comparison with experience (Assumption Analysis)
  – Win-lose, lose-lose situations
  – Decomposition
    • Pareto 80 – 20 phenomena
    • Task dependencies
    • Murphy’s law
    • Uncertainty areas
  – Analysis of Model Clashes
Example: Risk Item Checklist

- Will you project really get all the best people?
- Are there critical skills for which nobody is identified?
- Are there pressures to staff with available warm bodies?
- Are there pressures to overstaff in the early phases?
- Are the key project people compatible?
- Do they have realistic expectations about their project job?
- Do their strengths match their assignment?
- Are they committed full-time?
- Are their task prerequisites (training, clearances, etc.) Satisfied?
Example: Examination of Decision Drivers

- Political versus Technical
  - Choice of equipment
  - Choice of subcontractor
  - Schedule, Budget
  - Allocation of responsibilities
- Marketing versus Technical
  - Gold plating
  - Choice of equipment
  - Schedule, budget
- Solution-driven versus Problem-driven
  - In-house components, tools
  - Artificial intelligence
  - Schedule, Budget
- Short-term versus Long-term
  - Staffing availability versus qualification
  - Reused software productions engineering
  - Premature SRR, PDR
- Outdated Experience
# Top 10 S/W Risk Items

<table>
<thead>
<tr>
<th>Risk item</th>
<th>Risk-management technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel shortfalls</td>
<td>Staffing with top talent, job matching, team building, key personnel agreements, cross training.</td>
</tr>
<tr>
<td>Unrealistic schedules and budgets</td>
<td>Detailed multisource cost and schedule estimation, design to cost, incremental development, software reuse, requirements scrubbing.</td>
</tr>
<tr>
<td>Developing the wrong functions and properties</td>
<td>Organization analysis, mission analysis, operations-concept formulation, user surveys and user participation, prototyping, early users’ manuals, off-nominal performance analysis, quality-factor analysis.</td>
</tr>
<tr>
<td>Developing the wrong user interface</td>
<td>Prototyping, scenarios, task analysis, user participation.</td>
</tr>
<tr>
<td>Gold-plating</td>
<td>Requirements scrubbing, prototyping, cost-benefit analysis, designing to cost.</td>
</tr>
<tr>
<td>Continuing stream of requirements changes</td>
<td>High change threshold, information hiding, incremental development (deferring changes to later increments).</td>
</tr>
<tr>
<td>Shortfalls in externally furnished components</td>
<td>Benchmarking, inspections, reference checking, compatibility analysis.</td>
</tr>
<tr>
<td>Shortfalls in externally performed tasks</td>
<td>Reference checking, preaward audits, award-fee contracts, competitive design or prototyping, team-building.</td>
</tr>
<tr>
<td>Real-time performance shortfalls</td>
<td>Simulation, benchmarking, modeling, prototyping, instrumentation, tuning.</td>
</tr>
<tr>
<td>Straining computer-science capabilities</td>
<td>Technical analysis, cost-benefit analysis, prototyping, reference checking.</td>
</tr>
</tbody>
</table>


1989
1. Personnel shortfalls
2. Schedules and budgets
3. Wrong software functions
4. Wrong user interface
5. Gold plating
6. Requirements changes
7. Externally-furnished components
8. Externally-performed tasks
9. Real-time performance
10. Straining computer science

1995
1. Personnel shortfalls
2. Schedules, budgets, process
3. COTS, external components
4. Requirements mismatch
5. User interface mismatch
6. Architecture, performance, quality
7. Requirements changes
8. Legacy software
9. Externally-performed tasks
10. Straining computer science
Risk Context & Source(s)

Source 1
- Too much work

Source 2
- More salary from a competitor

Condition
- Our lead developer left the project

Consequence
- We might have problems finding a good replacement

Context

Consequence 2
- Team morale may drop tremendously
• Questionnaire organized according to the taxonomy of software development for the purpose of identifying risks by interviewing a group of one or more individuals in a structured brainstorming

• TBQ can be tailored or expanded to meet additional needs

CMU/SEI-93-TR-006 : “Taxonomy-Based Risk Identification”
S/W Development Risk Taxonomy

Software Development Risks

- **Class**
  - Risks of the Product
  - Risks of the Process
  - “Fixed” Risks

- **Element**
  - Product Engineering
    - Requirements
    - Engineering Specialties
  - Development Environment
    - Development Process
    - Work Environment
  - Program Constraints
    - Resources
    - Externals

- **Attribute**
  - Stability
  - Scale
  - Formality
  - Product Control
  - Schedule
  - Facilities
Example: TBQ Questions

Class  A. Product Engineering

Element  2. Design

Attribute  d. Performance

[Are there stringent response time or throughput requirements?]

Starter  [22] Are there any problems with performance?
  • throughput

Cues  • scheduling asynchronous real-time events
  • real-time response
  • recovery timelines
  • response time
  • database response, contention, or access

Starter  [23] Has a performance analysis been done?
  (Yes) [23.a] What is your confidence in the performance analysis?
  (Yes) [23.b] Do you have a model to track performance through design and implementations?
Risk Analysis and Prioritization

- Analyze & Prioritize Risks
  - Evaluate
  - Classify
  - Prioritize

Statements of Risk
- Condition
- Consequence
- Context

Risk Classification

List of Risks

Top N Risk List

Impact
Probability
Time Frame
Classification
Rank
Risk Analysis

• Assess the loss of probability and loss magnitude for each identified risk item

• Assess compound risks in risk-item interactions

• Typical risk analysis techniques
  – Performance models
  – Cost models
  – Network analysis
  – Statistical decision analysis
  – Quality factor analysis (reliability, availability, security, etc.)
Risk Attributes

There is water on the hall floor; someone might slip in it and get hurt.

• Understand risk better by determining its probability, timeframe, and impact
  – Generate values for
    • Impact: The potential loss or the effect on the project if the risk occurs
    • Probability: The likelihood that the risk would occur
    • Timeframe: The period of time left until the risk should be addressed
### Various Levels of Evaluation

<table>
<thead>
<tr>
<th>Level</th>
<th>Impact</th>
<th>Probability</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binary</td>
<td>Significant, Insignificant</td>
<td>Likely, Not likely</td>
<td>Significant, Insignificant</td>
</tr>
<tr>
<td>3-Level</td>
<td>High, Moderate, Low</td>
<td>High, Moderate, Low</td>
<td>Near, Mid, Far</td>
</tr>
<tr>
<td>5-Level</td>
<td>Very High, High, Moderate, Low, Very Low</td>
<td>Very High, High, Moderate, Low, Very Low</td>
<td>Imminent, Near, Mid, Far, Very Far</td>
</tr>
<tr>
<td>N-Level</td>
<td>N-levels of impact</td>
<td>N-levels of probability</td>
<td>N-levels of timeframe</td>
</tr>
</tbody>
</table>
**Possible Definitions**

- **Impact**
  - Catastrophic
    - Schedule slip > 20%, Cost overrun > 25%
  - Critical
    - Schedule slip 10-20%, Cost overrun 10-25%
  - Marginal
    - Schedule slip 5-10%, Cost overrun 5-10%

- **Probability**
  - Very likely > 70%
  - Likely ~50%
  - Not likely < 30%

- **Timeframe**
  - Near term Within a month or so
  - Mid term Within three months or so
  - Long term Within six months or so
Risk Exposure

\[ RE = P(L) \times S(L) \]

- **High Risk Probability**
  - Check
  - Utility - Loss Estimate
  - Major Risk

- **Low Risk Probability**
  - Little Risk
  - Check Probability Estimate

- **Loss of Utility**
  - Low
  - High
## Risk Exposure Matrix

### Probability

<table>
<thead>
<tr>
<th>Impact</th>
<th>Very High</th>
<th>High</th>
<th>Moderate</th>
<th>Low</th>
<th>Very Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catastrophic</td>
<td>High (9)</td>
<td>High (8)</td>
<td>High (7)</td>
<td>Med (6)</td>
<td>Med (5)</td>
</tr>
<tr>
<td>Moderate</td>
<td>High (7)</td>
<td>Med (6)</td>
<td>Med (5)</td>
<td>Med (4)</td>
<td>Low (3)</td>
</tr>
<tr>
<td>Marginal</td>
<td>Med (6)</td>
<td>Med</td>
<td>Med</td>
<td>Low (3)</td>
<td>Low (2)</td>
</tr>
<tr>
<td>Negligible</td>
<td>Med (5)</td>
<td>Med (4)</td>
<td>Low (3)</td>
<td>Low (2)</td>
<td>Low (1)</td>
</tr>
</tbody>
</table>

*Air force Systems command/logistics command Pamphlet 800-45, 1988*
Risk Prioritization: NASA NPD 2820

- Consequences of Software Failure:
  - Insignificant
  - Marginal
  - Substantial
  - Grave

- Total likelihood of Software Failure:
  - LOW
  - MEDIUM
  - HIGH

Graph mapping the consequences of software failure against the total likelihood of failure, illustrating the risk prioritization matrix.
Risk Prioritization

• Produce a ranked ordering of the identified and analyzed risk items
  – Figure out which risks are most important
  – Establish which risks should be dealt with first

• Typical risk prioritization techniques
  – Risk exposure analysis
  – Risk reduction leverage analysis (Cost-Benefit analysis)
  – Pareto Top N risks
  – Delphi or Group consensus (Multivoting) techniques
## Risk Exposure Factors
(Satellite Experiment Software)

<table>
<thead>
<tr>
<th>Unsatisfactory Outcome (UO)</th>
<th>Prob (UO)</th>
<th>Loss (UO)</th>
<th>Risk Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. S/W error kills experiment</td>
<td>3 - 5</td>
<td>10</td>
<td>30 - 50</td>
</tr>
<tr>
<td>B. S/W error loses key data</td>
<td>3 - 5</td>
<td>8</td>
<td>24 - 40</td>
</tr>
<tr>
<td>C. Fault tolerance features cause unacceptable performance</td>
<td>4 - 8</td>
<td>7</td>
<td>28 - 56</td>
</tr>
<tr>
<td>D. Monitoring software reports unsafe condition as safe</td>
<td>5</td>
<td>9</td>
<td>45</td>
</tr>
<tr>
<td>E. Monitoring software reports safe condition as unsafe</td>
<td>5</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>F. Hardware delay causes schedule overrun</td>
<td>6</td>
<td>4</td>
<td>24</td>
</tr>
<tr>
<td>G. Data reduction software errors cause extra work</td>
<td>8</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>H. Poor user interface causes inefficient operation</td>
<td>6</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>I. Processor memory insufficient</td>
<td>1</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>J. DBMS software loses derived data</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>
Risk Exposure Factors and Contours

Satellite Experiment Software

RELATIVE PROB (UO)

RELATIVE LOSS (UO)
Risk Reduction Leverage (RRL)

\[
RRL = \frac{\text{RE}_{\text{BEFORE}} - \text{RE}_{\text{AFTER}}}{\text{RISK REDUCTION COST}}
\]

- **Spacecraft Example**

<table>
<thead>
<tr>
<th></th>
<th>LONG DURATION TEST</th>
<th>FAILURE MODE TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOSS (UO)</td>
<td>$20M</td>
<td>$20M</td>
</tr>
<tr>
<td>PROB (UO) (_B)</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>RE(_B)</td>
<td>$4M</td>
<td>$4M</td>
</tr>
<tr>
<td>PROB (UO) (_A)</td>
<td>0.05</td>
<td>0.07</td>
</tr>
<tr>
<td>RE(_A)</td>
<td>$1M</td>
<td>$1.4M</td>
</tr>
<tr>
<td>COST</td>
<td>$2M</td>
<td>$0.26M</td>
</tr>
<tr>
<td>RRL (\frac{4-1}{2})</td>
<td>1.5</td>
<td>(\frac{4-1.4}{0.26}) = 10</td>
</tr>
</tbody>
</table>
Risk Prioritization: Pareto Top N

- Calculate Risk Exposure
- Rank all the risks
- Decide on a cut-off mark
- Easy, Straightforward, Not resource intensive method

<table>
<thead>
<tr>
<th>Risk</th>
<th>I</th>
<th>P</th>
<th>RE</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pareto Top N
1
2
3
4
•
N
Risk Prioritization: Multivoting

• Quick, Straightforward, Easy-to-use method

• When to use:
  – When facing a group decision.
  – To select the most important risks from a list.
  – To select from a small- mid size list <50.

Tally of Votes

<table>
<thead>
<tr>
<th>Item</th>
<th>Votes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5, 9, 16, 3, 7</td>
<td>40</td>
</tr>
<tr>
<td>B</td>
<td>11, 8, 6, 9, 14</td>
<td>48</td>
</tr>
<tr>
<td>C</td>
<td>2, 1, 4</td>
<td>7</td>
</tr>
</tbody>
</table>

Number of votes

One participant vote
Risk Management Planning

• **Help you prepare to address each risk item**
  – Buying information, risk avoidance, risk transfer, risk reduction
  – Includes the coordination of the individual risk-item plans with each other and with overall project plan

• **Typical Risk Mgmt. techniques**
  – Checklist of risk-resolution techniques
  – Cost-benefit analysis
  – Standard risk management plan outlines, forms, and elements

• **For Each Risk Item, Answer the Following Questions:**

  1. **Why?**
     Risk Item Importance, Relation to Project Objectives
  2. **What, When?**
     Risk Resolution Deliverables, Milestones, Activity Nets
  3. **Who, Where?**
     Responsibilities, Organization
  4. **How?**
     Approach (Prototypes, Surveys, Models, …)
  5. **How Much?**
     Resources (Budget, Schedule, Key Personnel)
Risk Resolution (Mitigation)

• Produces a situation in which the risk items are eliminated or otherwise resolved
  – e.g.: Risk avoidance via relaxation of requirement

• Typical Risk Resolution Techniques
  – Prototypes, Simulation, Benchmarks, Mission Analyses, Key-personnel agreements, design-to-cost approaches, and incremental development
Risk Monitoring

• Involves the followings:
  – Tracking the project’s progress toward its resolving risk items
  – Taking corrective action where appropriate

• Typical Risk Monitoring Techniques
  – Milestone Tracking
    • Monitoring of risk Management Plan Milestones
  – Top-10 Risk Item Tracking
    • Identify Top-10 risk items
    • Highlight these in monthly project reviews
    • Focus on new entries, slow-progress items
    Focus review on manager-priority items
  – Risk Reassessment
  – Corrective Action
What Risk Management is not?

- Silver Bullet

- A way to solve project management problems with respect to:
  - Budget
  - Planning
  - Scheduling
  - Passive
  - A one time deal
Risk Management is:

• Ongoing (Continuous)
• A Team sports
• The key is to identify the right risks
• You get better at it over time but you have to start
• Start Now, start early in your project as your risks will not go away if you ignore them
Key Contributions of Risk Mgmt.

- Create focus on critical success factors in the process
- Provide techniques that let the project deal with the critical success factors
- Provides some of skills, an emphasis on getting good people, and a good conceptual framework for sharpening judgments

But, Risk Mgmt. : Not a cookbook approach
- Great Measure of human judgment is required to handle all the complex people oriented and technology-driven success factors in projects
Q & A