CRITICAL THINKING.
SOLUTIONS DELIVERED.

Risk vs. Uncertainty: *What's the difference?*

2016 ICEAA Professional Development and Training Workshop

Mel Etheridge, CCEA

Topics

- Definitions – common ground
  - Risk
  - Uncertainty
- Analytical techniques in Excel
  - No high order math or big equations

Cost Risk

- *What is cost risk?*
  - For a Program Manager it is the risk that he/she will run out of money before running out of scope
  - Most programs have identified a risk that the cost estimate will not capture all costs, or funding will be inadequate, etc.
  - *But,* if the cost estimate captures all the scope, the term has no real applicability in cost estimating
    - What is *cost risk* to the PM is *cost uncertainty* to the cost estimator
    - Cost uncertainty is due to possible effects of program risks and input uncertainty

Risk Defined

- *The possibility of suffering harm or damage*
  - America Heritage World Dictionary, 2nd College ed.
- *An event, which may occur, that will have an adverse effect on an project's execution in terms of time or money.*
  - Note that an event with a positive effect is called an *opportunity*
  - Example: *The system may fail environmental testing during Developmental Test and Evaluation. This will require using upgraded hardware components.*

Uncertainty Defined

- *The condition of being in doubt*
  - American Heritage World Dictionary, 2nd College ed.
- *A quantitative input to a cost model which is not known to an accuracy sufficient for the estimate*
  - Example: number of software source lines of code
    - We may only need to get a SLOC count to the nearest 1,000
    - While we have a most likely value, we don't really *know* what the SLOC count will really be, even ± 500 SLOC

Risk vs. Uncertainty

- A risk is a discrete event with a probability of occurrence. The risk effect (impact) is only felt if / when the event occurs.
- There is no probability of occurrence with an uncertainty – you know that you don't know the actual value.

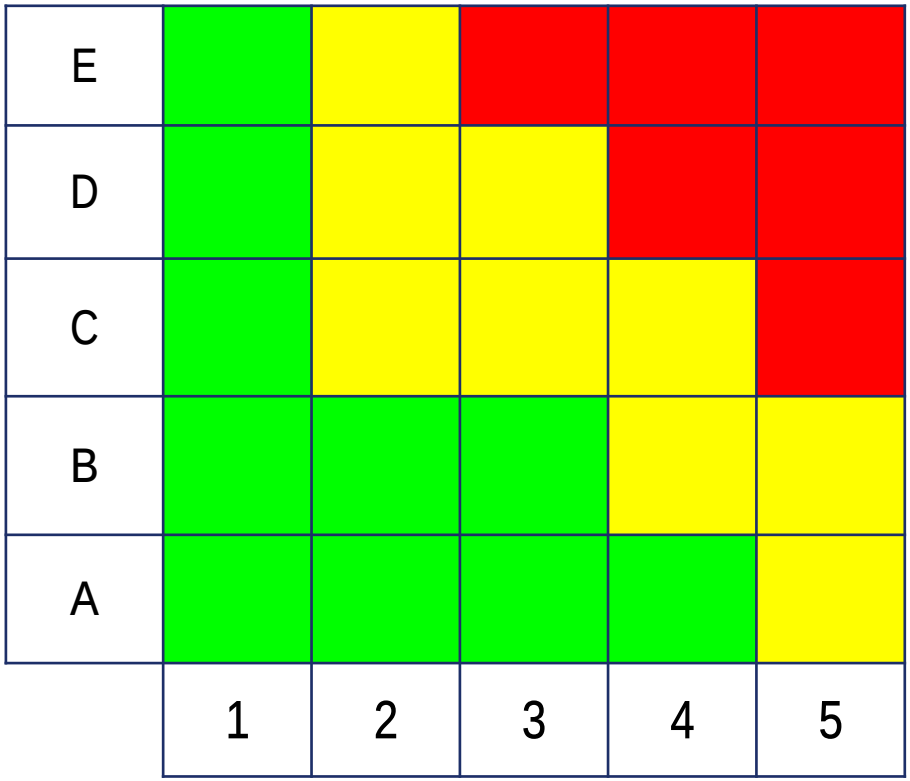
Program Risk Categorization

- Risks are categorized by:
  - Probability of occurrence (likelihood)
    - 5 categories *A* (low) to *E* (high)
    - Each category has a range of values
  - Effect given occurrence (impact)
    - 5 categories *1* (low) to *5* (high)
    - Each category has a range of values, often percentages of <u>total</u> program costs
  - Each risk has a rating that is a combination of likelihood and impact; e.g., *A2*, *C4*

Risk Management Categories (sample)

Probability

A = 0% < 20%
B = 20% < 40%
C = 40% < 60%
D = 60% < 80%
E = 80% ≤ 100%



High
Medium
Low

Cost Increase

1= 0% < 0.1% 2 = 0.1% < 1% 3 = 1% < 5% 4 = 5% < 10% 5 > 10%

Program Risk Management

- Risks are identified, categorized, tracked, and reported by a Risk Management Team / Board / Group / Committee / etc. in the Program Management Office
  - Multi-disciplinary
  - Internal stakeholder representation
- Likelihoods and impacts are often “expert” opinion, particularly costs

Program Risk Reduction

- The Risk Management Team identifies one or more strategies which have the potential, if implemented, of reducing likelihood and/or impact
  - Risk reduction strategies will have a cost and/or schedule impact if implemented.
    - Becomes part of the point estimate
    - Risk rating improves
- One strategy is always to accept the risk; i.e., do nothing
  - Cure may be worse than the disease

Program Risk Cost Analysis

- Identify input(s) or cost element(s) which will be affected by each risk
  - Impact may (should probably) vary for different inputs / elements
  - Cost impact is often expressed as a percentage increase in total program cost
    - This translates to a dollar amount based on the point estimate
    - Work with Risk Management Team to allocate to inputs / elements

Program Risk Cost Analysis
(continued)

- Calculate the expected value of each risk for each input / element affected:

$$EV = P_O * E \mid O$$

Where:

P_O = Probability of occurrence (likelihood)

$E \mid O$ = Effect given occurrence (impact)

- Both likelihood and impact should be ranges
  - Work with Risk Management Team to assign distribution (often uniform) and parameters

Uncertainty Analysis

- Input variables often not expressed as ranges
  - Work with input source SMEs to specify range and distribution appropriate to variable
  - SMEs often do not think probabilistically and tend to assign unrealistically narrow, symmetrical ranges
- Common distributions:
  - Triangular: easiest to discuss: min, most likely, max
  - Normal: mean, standard deviation
  - Log-normal: skewed right, smoother than triangular, > 0
  - Uniform: no central tendency: max, min
  - Discrete integer: when fractions not appropriate (people, days on travel, etc.)

Cost Uncertainty Analysis

- The effects of both program risks and input uncertainties are analyzed simultaneously using Monte Carlo simulation
- Excel™ models use add-ins such as Crystal Ball™, @Risk™, etc.

Example – Inputs

Variable	Value	Units
Average Unit Cost	$25	BY $K
Total Quantity	500	Units
Cost per contractor FTE	$200	BY $K
Contractor FTEs, PM support	5	FTEs
System software development labor hours	25,000	labor hours
Risk reduction software development labor hours	5,000	labor hours
Labor hours per FTE	2,000	labor hours

Example – Program Risks

	Program Risks	Costs affected	Risk Rating	Likelihood		Impact (Increase in Total Program F&E $K)	
				Min	Max	Min	Max
			Unmitigated				
1	The system may require a more powerful processor	Hardware production	C4	40%	60%	5%	10%
	Risk Reduction Strategy: Write additional software: 5,000 labor hours		***Mitigated***				
			B2	20%	40%	0.10%	1.00%
2	The program schedule may slip	Not a discrete event: treat as an uncertainty					

Example – Point Estimate

Cost Element	Methodology	Calculation	BY $K FY 20XX
Hardware Production	AUC * Quantity	$25.0 * 500	$12,500
Software Development	(Dev Hrs./Hrs. per FTE) * Cost per FTE	{(25,000+5,000)/2000}*$200	$3,000
Contractor Program Management Support	FTEs * Cost per FTE	5 * $200	$1,000
Total			$16,500

Example – Program Risk Cost Allocation

	Program Risks	Costs affected	Risk Rating	Likelihood Min	Likelihood Max	Impact (Increase in Total Program F&E $K) Min	Impact (Increase in Total Program F&E $K) Max
			Unmitigated				
1	The system may require a more powerful processor	Hardware production	C4	40%	60%	5%	10%
	Risk Reduction Strategy:	Write additional software: 5,000 labor hours					
			Mitigated				
			B2	20%	40%	0.10%	1.00%
			Total F&E (from point estimate)			$16,500	$16,500
			Cost impact			$17	$165
			Increase in Hardware Production			0.13%	1.32%
2	The program schedule may slip	Not a discrete event: treat as an uncertainty					

Example – Cost Uncertainty Analysis

Risk	Min	Max	Assumption Value
	Mitigated Likelihood		
Processor Risk	20.0%	40.0%	30.0%
	Mitigated Impact		
	0.1%	1.3%	0.7%

Expected Value AUC Increase:	1 + (30% * 0.7%) = 100.2%

Uncertainties	Distribution	Min	Most Likely	Max	Assumption Value
Cost per FTE	Triangular	$175.0	$200.0	$250.0	$200.0
Contractor FTEs, PM support*	Triangular	5.0	5.0	7.0	5.0
			Mean	**Std. Dev.**	
Software Development Hours	Normal		30,000	5,000	30,000

* Due to possible schedule slip

Example – Forecast Cells

Cost Element	BY $K 20XX
Hardware Production	$12,527
Software Development	$3,000
Contractor Program Management Support	$1,000

Example – Cumulative Distribution Function

Percentiles	Contractor Program Management Support (BY $K)	Hardware Production (BY $K)	Software Development (BY $K)
0%	$879	$12,503	$1,183
10%	$1,018	$12,509	$2,416
20%	$1,063	$12,513	$2,649
30%	$1,100	$12,518	$2,823
40%	$1,136	$12,522	$2,970
50%	$1,168	$12,526	$3,107
60%	$1,201	$12,530	$3,249
70%	$1,242	$12,534	$3,414
80%	$1,291	$12,539	$3,607
90%	$1,359	$12,547	$3,870
100%	$1,700	$12,565	$5,440

Example – "Risk Adjusted" Estimate

Cost Element	BY $K	
	Point Estimate	Risk Adjusted
Hardware Production	$12,500	$12,539
Software Development	$3,000	$3,607
Contractor Program Management Support	$1,000	$1,291
Total	$16,500	$17,438

Summary

- *Uncertainty* – Pertains to quantitative inputs
  - Likelihood = 1.0
- *Risks* – Discrete events with a negative impact on program cost (or schedule).
  - Likelihood < 1.0
  - Impact given occurrence either in percent cost increase (usual) or dollars
- Risk likelihoods and impacts and input uncertainties should be expressed as random variables
- Cost impacts of both uncertainties and risks analyzed using Monte Carlo simulation

MCR

CRITICAL THINKING.
SOLUTIONS DELIVERED.

INTEGRATED PROGRAM MANAGEMENT

Defense | Energy | Information Management | National Security | Space | Transportation