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COSYSMO Risk Prototype

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Outline

- Unrealistic Pricing, Risk, and Confidence
- COSYSMO Size & Cost drivers
- COSYSMO Risk Prototype
  - COSYSLABRISK
  - COSSIZEDR
  - COSTDRIV

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Setting The Stage: The State of the Management World

- Managers and technical personnel need to make decisions under uncertainty.
- They should assess the extent of the uncertainty in the data and quantitative information that they rely on so that they can make better decisions.
  - Program managers often get a lot of (raw) data and frequently very little information.
  - Assess uncertainty using a systematic process. Recognize that there is uncertainty in both program input data (e.g.,goals, historical data, estimates) and program outcomes and assessing them is key.
  - Associate this process with "early/ leading indicators."
- All too often, "the" value for effort or schedule is presented, unaccompanied by any statement of the degree of uncertainty in that value. Program managers and others involved in developing estimates for proposals should be able to quantify the degree of uncertainty in the estimates that they produce. Estimating cost, schedule, and other product or process variables as single numbers fails to provide decision makers with information sufficient to make good bidding and other decisions.

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The Problem of Unrealistic Pricing & Schedule

"Projects often overrun their cost estimates, sometimes by staggering amounts. This occurs even with carefully-constructed bottom-up cost estimates completed to a very detailed level by experienced project teams."

"Initial cost and schedule estimates for major projects have invariably been over-optimistic. The risk that cost and schedule constraints will not be met cannot be determined if cost and schedule estimates are given in terms of single points rather than distributions."

"The purpose of a cost uncertainty analysis is to provide the project manager with a cost that has an acceptable probability of being exceeded." The notion that there is a probability of exceeding an EAC is a difficult one for some people. But, the fact is that every project has risk, and ignoring risk does not make it go away."

Quotes from Dr. David Hulett, Hulett & Associates LLC

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What is "Risk" ?

•Risk is commonly evaluated as the product of the likelihood (taken as the probability) of an occurrence of an event and the impact or consequence of the event with respect to a specific factor (cost, schedule, technical parameter, etc).

•A plot of occurrence probabilities and consequences is a "risk profile" or a "Farmer curve." The probability is often referred to as the "exceedance" probability, because it is the *probability* that the *consequence value* will be exceeded*.

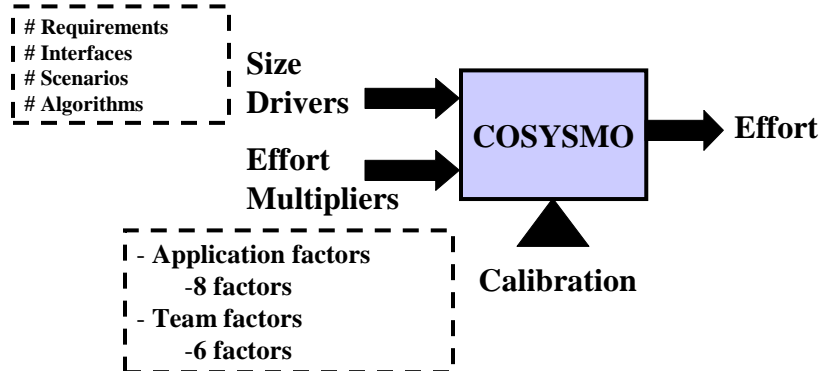*Ayyub, Bilal M., Risk Analysis in Engineering and Economics, Chapman and Hall/CRC, 2003.

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"Risk" Vs. "Confidence," Alternative Views or Perceptions, page 1 of 2

- You can **consider uncertainty** in terms of the "risk" in a figure or the "confidence" in it.
- Example Definitions:
  - **Effort Risk**=Probability (complementary cumulative distribution) that the effort **will exceed** the indicated value. Called the "exceedance probability" in some risk literature.
  - **Effort Confidence**=Probability (cumulative distribution) that the effort **will not exceed** the indicated value. This is the upper bound of an effort estimate at the stated **confidence** level. Example: 90% confidence=10% risk.

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"Risk" Vs. "Confidence," Alternative Views or Perceptions, page 2 of 2

- It depends on with whom you are talking and how you want to communicate the data and the **best way that you can communicate the uncertainty in the data (and information)**.
- It depends on what question you are trying to answer. For example:
  - If you are a program manager or upper management of the contracting or bidding organization, you might be asking "What is my cost (effort) exposure or risk if I bid this figure?"
  - If you are the customer or acquirer or you are the bidder trying to communicate to this person, you might be asking "What is the bidder's confidence in this cost (effort) figure ?"
- That is, there are **two alternative points** of view. Both are correct. It depends to whom the message quantifying uncertainty is being conveyed.

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COSYSMO Operational Concept

- # Requirements
- # Interfaces
- # Scenarios
- # Algorithms

Size Drivers

Effort Multipliers

COSYSMO → **Effort**

- Application factors
  - -8 factors
- Team factors
  - -6 factors

Calibration

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COSYSMO Cost Drivers

- **Application Factors**
  - Requirements understanding
  - Architecture complexity
  - Level of service requirements
  - Migration complexity
  - Technology Maturity
  - Documentation Match to Life Cycle Needs
  - # and Diversity of Installations/Platforms
  - # of Recursive Levels in the Design

- **Team Factors**
  - Stakeholder team cohesion
  - Personnel/team capability
  - Personnel experience/continuity
  - Process maturity
  - Multisite coordination
  - Tool support

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COSYSMO Risk Tool Prototype Overview

This excel-based tool is a prototype of an add-on to the COSYSMO systems engineering labor estimation model. It enables the user to quantify his belief in the uncertainties in the values of various parameters of the COSYSMO model, and hence in the value of the output of the model, systems engineering person months (PM). Each uncertainty is represented by two equivalent distributions, "**risk**"and the other for "**confidence,**" as was defined before.

The tool uses a three-point estimator to approximate the distribution of the values of each uncertain quantity for which data is applied in the model/tool.
The three values required from which the distribution function is approximated are:
the 5% fractile, the median, and the 95% fractile. Operationally, these values are obtained from a combination of expert opinion and historical data (as available and relevant). Due to the uncertainties that often prevail, the three points elicited are frequently somewhat loosely interpreted as the smallest, most likely, and largest, allowing for some margin below the smallest value and some beyond the largest.

The tool consists of five sheets:
-TOOL Description
-COSYSLABRISK
-COSSIZEDR
-COSTDRIV
-PLOTS

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COSYSLABRISK

This is the "main" part of the model/tool. It computes both the PM Risk and PM Confidence distributions, based in part on distribution vales for the equivalent requirements size (see **COSSIZEDR** tool sheet description) and cost drivers product value (see **COSTDRIV** tool sheet description). It also computes a PM Overrun Risk, the range of probabilities for a range of possible overruns, relative to some target PM that the user enters.
This tool sheet determines the range for PM per the following equation:

Person Months, PM=A*S^E*D; where: D=Cost Driver Product Value, S=Equivalent Requirements Size, A=Local Calibration Factor, and E=Exponent.

This tool sheet requires the user to enter the three-point distribution approximation values for A and E. The tool sheet obtains the three-point values for D and S from the **COSTDRIV** and **COSTSIZEDR** tool sheets.
This tool sheet must be executed whenever you change the value of at least one parameter (ones that may be changed are in yellow cells). To execute this sheet press "cntrl+b."

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PROTOTYPE COSYSMO EFFORT RISK ESTIMATOR

31-May-05

Place value in each box in dicated in yellow.
DO NOT MAKE ENTRIES IN ANY OTHER CELLS.
Then, press cntrl+b to execute the tool and obtain the .
**person month risk and cumulative probabilities**

Risk Component		Range Estimate Values		
Number	Name	Low Estimate	Likely Estimate	High Estimate
1	A	2.40	3.00	3.60
2	S	3829	4244	5039
3	E	0.95	1.00	1.10
4	D	0.4420	1.1310	1.9688

Person Months, PM=A*S^E*D; where: D, cost driver product, an S, size driver, are obtained from other tool sheets.

Most Likely PM
14399

PM Target
25000

Summary COSYSMO Person Months Risk/Confidence Statistics

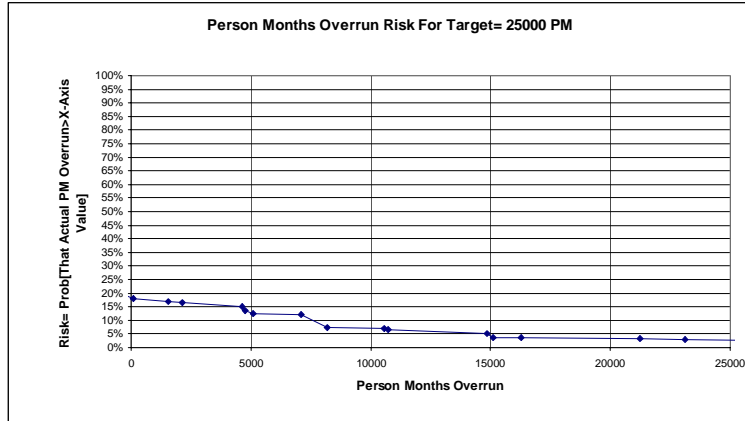|	
Minimum PM=	2689
Risk=	99.88%
Confidence=	0.12%
Most Likely PM=	14399
Risk=	42.52%
Confidence=	57.48%
Maximum PM=	83762
Risk=	0.00%
Confidence=	100.00%
20% Risk/ 80% Confidence PM=	23808
30% Risk/ 70% Confidence PM=	17096
50% Risk/ 50% Confidence PM=	13902
95% Risk/5% Confidence PM=	4447
5% Risk/95% Confidence PM=	39838
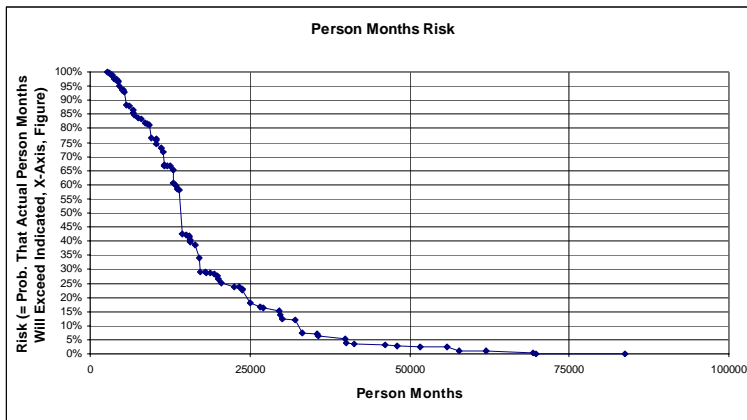
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Person Months Overrun Risk For Target= 25000 PM

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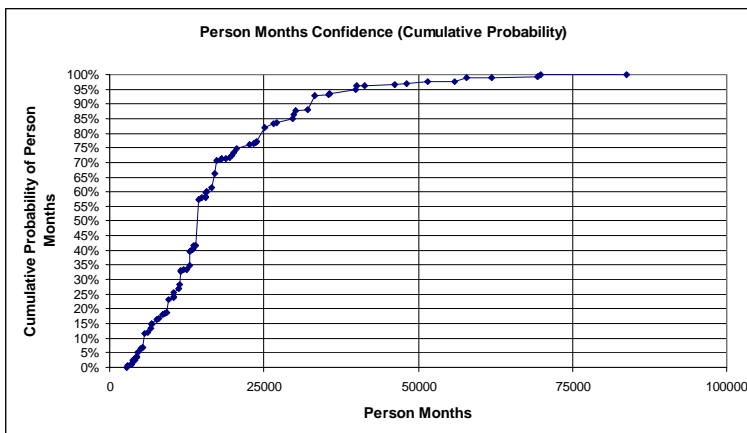
COSSIZEDR

This tool sheet develops the distribution function for the values of
the four drivers from which the value for Equivalent Requirements is computed: The drivers are: system
requirements, system interfaces, system specific algorithms, and operational scenarios. Four
distributions are developed, one for each driver. The three points for each of them is a weighted sum for the counts
of the "Easy," "Nominal," and "Difficult" values for each of the four drivers. The distribution approximation obtained
has 81 points (81=3*3*3*3). This number of points provides a relatively smooth distribution curve.
**This tool sheet must be executed whenever you change the value of at least one parameter
(ones that may be changed are in yellow cells). To execute this sheet press "cntrl+a."**

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COSYSMO Equivalent Requirements [1] Size Range/Risk Estimator   31-May-05

cntrl+a macro1

Size Driver Weights

Driver Name	Easy	Nominal	Difficult	
# of System Requirements		0.50	1.00	4.23
# of System Interfaces		1.50	3.90	8.20
# of System-Specific Algorithms		3.00	5.80	16.60
# of Operational Scenarios		10.30	24.60	53.80

Note: These weights should not be modified without the agreement of the COSYSMO model owner.

(1): Number of Equivalent Requirements=Weighted Sum of Each of Four Easy,Nominal, and Difficult Size Driver Values.

Size Driver Range Values Data Entry

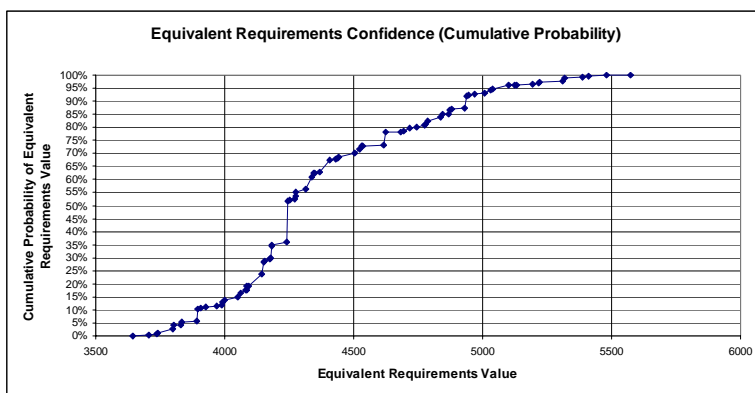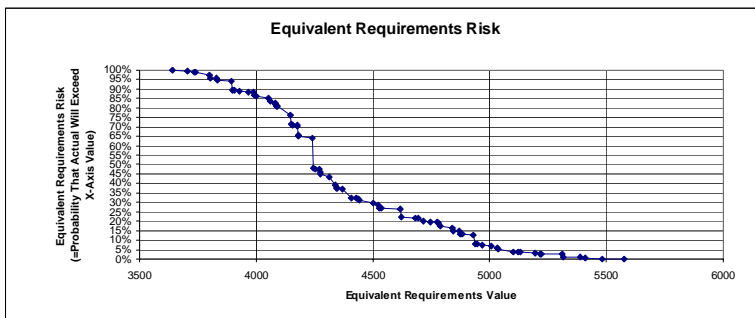| Driver Name	Range Values[1]	Number of Driver Items At Difficulty Level [2]			Estimator Range Value [3]	Size Driver Value [4]	Data Entry Error Message Board [5]
		Easy	Nominal	Difficult			
# of System Requirements	Low Estimate	47.5	71.25	261.25	95.00%	1200	
	Likely Estimate	50	75	275	100.00%	1263	
	High Estimate	65	97.5	357.5	130.00%	1642	
# of System Interfaces	Low Estimate	27	54	72	90.00%	842	
	Likely Estimate	30	60	80	100.00%	935	
	High Estimate	33	66	88	110.00%	1029	
# of System-Specific Algorithms	Low Estimate	12.75	17	25.5	85.00%	560	
	Likely Estimate	15	20	30	100.00%	659	
	High Estimate	18.75	0	0	125.00%	824	
# of Operational Scenarios	Low Estimate	7.5	11.25	12.75	75.00%	1040	
	Likely Estimate	10	15	17	100.00%	1387	
	High Estimate	15	22.5	25.5	150.00%	2080	

Caution: Enter data in yellow cells only!

Size Data Entry Notes:

(1): The probability distributions for each of the four size drivers are estimated based on the nominal (assumed to be the mode) and the Low (assumed to be the 5% fractile), and the High (assumed to be the 95% fractile). This is done for the count values that you enter for easy, nominal, and difficult levels of difficulty.

(2): The size driver values for the Low Range (5% fractile) and the High Range (95% fractile) are entered as percents of the nominal values. The estimator tool proportions the counts for Easy, Nominal, and Difficult.

(3): The percentages for the Low and the High range values are entered as percents of the Nominal range value.

(4): The size driver value is equal to the weighted sum of the number of Easy, Nominal, and Difficult size driver counts for each of the four size drivers. The weights used are provided above.

(5): Error messages are given if you enter a Low Range Value >100% of the Nominal and/or if you enter a High Range Value <100% of the Nominal.

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Summary COSYSMO Equivalent Requirements Size Risk/Confidence Statistics

Minimum Size=	3642
Risk=	99.88%
Confidence=	0.12%
Most Likely Size=	4244
Risk=	48.15%
Confidence=	51.85%
Maximum Size=	5574
Risk=	0.00%
Confidence=	100.00%
20% Risk/80% Confidence Size=	4716
30% Risk/70% Confidence Size=	4441
50% Risk/50% Confidence Size=	4239
95% Risk/5% Confidence Size=	3829
5% Risk/95% Confidence Size=	5039

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COSTDRIV

This tool sheet develops the distribution for the product of four of the COSYSMO
cost drivers: Requirements Understanding, Technology Risk, Personnel/Team Capability, and Tool
Support. More or even all of the cost drivers could be covered in a future prototype or final version of
COSYSMO as may be desired. The four chosen were somewhat arbitrarily selected to illustrate the process
of estimating the uncertainty of cost driver values and the application of the uncertainty in determining
the uncertainty of the value of Person Months by COSYSMO.
This tool sheet must be executed whenever you change the value of at least one parameter
(ones that may be changed are in yellow cells). To execute this sheet press "cntrl+c."

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PROTOTYPE COSYSMO COST DRIVER RISK ESTIMATOR **31-May-05**

Place one "X" in each row to select the lower, the most likely, and Upper values covering the range of your
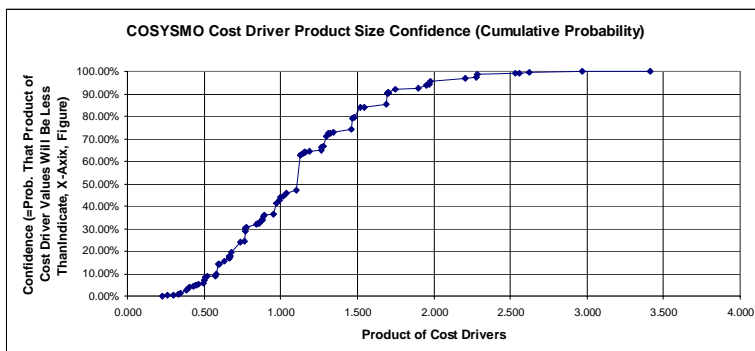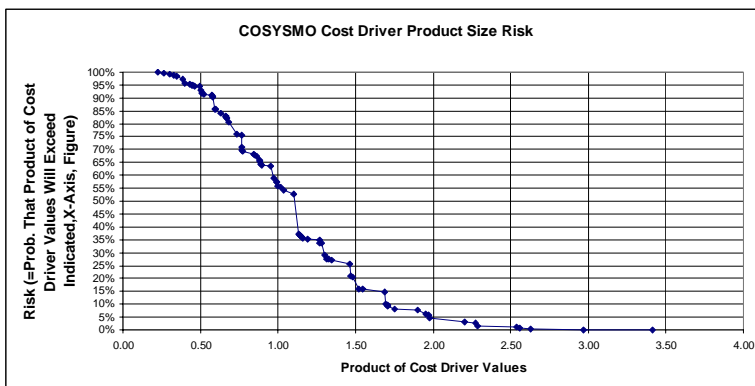uncertainty in the value of each of the four cost drivers.

Then, press **cntrl+c** to execute the tool and obtain the risk curve and cumulative probabilities for the product of
the values of these cost drivers.

DO NOT MAKE ENTRIES IN ANY CELLS EXCEPT THOSE INDICATED IN YELLOW.

Note: Values inidcated in **red** from COSYSMO team; others are hypothetical.

Number	Name	XL	VL	L	N	H	VH	XH
1	**Reqm'ts. Under.**	1.9	1.71	1.30	1.00	0.75	0.65	0.50
	Low Estimate			x				
	Likely Estimate				x			
	High Estimate						x	
2	**Technol. Risk**	0.5	0.68	1.26	1.00	1.3	1.75	2.00
	Low Estimate		x					
	Likely Estimate					x		
	High Estimate						x	
3	**Pers/Team Cap.**	1.59	1.5	1.12	1.00	0.87	0.68	0.62
	Low Estimate		x					
	Likely Estimate			x				
	High Estimate						x	
4	**Tool Support**	1.43	1.4	1.1	1.00	0.87	0.75	0.62
	Low Estimate			x				
	Likely Estimate					x		
	High Estimate						x	

Most Likely Driver Product Value= 1.131

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COSYSMO Cost Driver Product Size Risk

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COSYSMO Cost Driver Product Size Confidence (Cumulative Probability)

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Current Calibration Data Set
(Maintained by USC Center for Software Engineering)

Raytheon	*Intelligence & Information Systems (Garland, TX)*
Northrop Grumman	*Mission Systems (Redondo Beach, CA)*
Lockheed Martin	*Transportation & Security Solutions (Rockville, MD)*
	Integrated Systems & Solutions (Valley Forge, PA)
	Systems Integration (Owego, NY)
	Aeronautics (Marietta, GA)
	Maritime Systems & Sensors (Manassas, VA; Baltimore, MD; Syracuse, NY)
General Dynamics	*Maritime Digital Systems/AIS (Pittsfield, MA)*
	Surveillance & Reconnaissance Systems/AIS (Bloomington, MN)
BAE Systems	*National Security Solutions/ISS (San Diego, CA)*
	Information & Electronic Warfare Systems (Nashua, NH)
SAIC	*Army Transformation (Orlando, FL)*
	Integrated Data Solutions & Analysis (McLean, VA)

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