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Commercial Off the Shelf (COTS) Estimating Metrics for Increased Cost Accuracy

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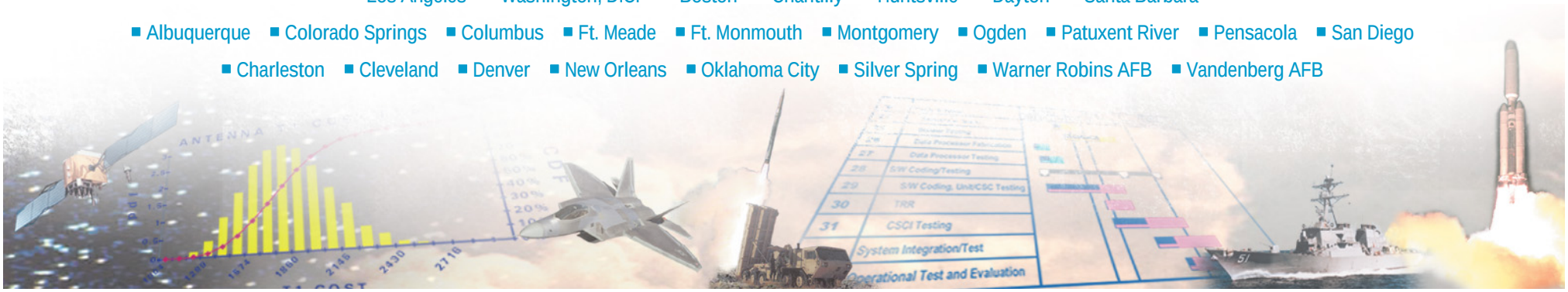

Introduction

- **Problem:** Estimates based on online prices were significantly higher than recent contract award values for COTS Hardware (HW) and Software (SW)
  - Online prices did not capture market forces

- **Solution:** Create an approach to provide increased accuracy on future COTS estimates

  - **Why it matters:**
  - Affordability/Budget Constraints
    - Increased estimate accuracy allows more program requirements to be executed
  - Avoid out-year funding cuts due to under execution
  - Arms the program manager with a valuable negotiating tool

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Available Data: Starting Point

- **Negotiated COTS HW/SW unit prices and quantities**
  - **Scenarios reflect purchase of COTS HW/SW by prime contractor through subcontractor in a generally competitive environment**
  - **Purchased specific HW/SW products at known quantities on Firm Fixed Price (FFP) Contracts**
  - **Cost growth above contract award value was only possible if contract modification increased quantities**
- **Negotiated Annual Maintenance Support prices by product**
- **Online Prices from various websites for cost drivers and most other products**

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Developed Metrics

- **Actual Contract Price as a Percentage (%) of the Vendor List Price/Mean Online Price**
- Annual Maintenance Support Actual Contract Price as a % of Actual HW/SW Initial Cost
- Annual Maintenance Support Actual Contract Price as a % of a Vendor Quote

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Detailed Methodology

- 24 List of Materials (LOM's) were sorted by part number and vendor from 20 different contracts
  - 5 LOM's were on one contract, remaining LOM's were on separate contracts
- Chose 8 websites based on size and variety of vendors to research online pricing for quantity of 1:
  - PEPPM.org, Insight.com, CDW.com, PCConnection.com, PCMall.com, SoftChoice.com, TechDepot.com, and Zones.com
- Mean Online Price computed as the average price from all available websites for each unique part number
- Normalized Actual Contract Prices and Mean Online Prices using ACEIT Inflation Utility

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Detailed Methodology (Cont.)

- **For each LOM the following ratios were computed:**

$$\frac{\text{Sum (Actual Contract Price x Quantity)}}{\text{Sum (Vendor List Price x Quantity)}}$$

$$\frac{\text{Sum (Actual Contract Price x Quantity)}}{\text{Sum (Mean Online Price x Quantity)}}$$

- **1 Ratio per LOM considered a unique data point**
  - **If ratio at the part number level were all considered unique data points, data would be skewed**
- **Used CO$TAT Distribution Finder (DF) to calculate best fitting distribution**

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Mean Online Price vs. Vendor List Price

Actual Contract Price as a % of Vendor List Price	Actual Contract Price as a % of Mean Online Price
24.8%	33.7%
32.1%	35.9%
27.5%	45.1%
37.3%	55.8%
32.2%	56.3%
38.3%	64.9%
49.8%	70.4%
74.9%	71.3%
42.4%	71.7%
55.1%	73.7%
47.5%	74.0%
57.9%	75.1%
57.3%	76.7%
65.5%	77.8%
71.0%	78.7%
50.9%	79.8%
64.9%	81.5%
73.6%	82.2%
81.4%	84.2%
77.3%	84.3%
60.5%	89.0%
64.1%	89.1%
54.0%	91.5%
70.2%	106.3%
Mean=54.6%	**Mean=72.9%**

Paid ~71% of Mean Online but only ~75% of Vendor List Price

Paid ~71-74% of Mean Online Price and ~42-75% of Vendor List Price

Paid more than the Mean Online Price

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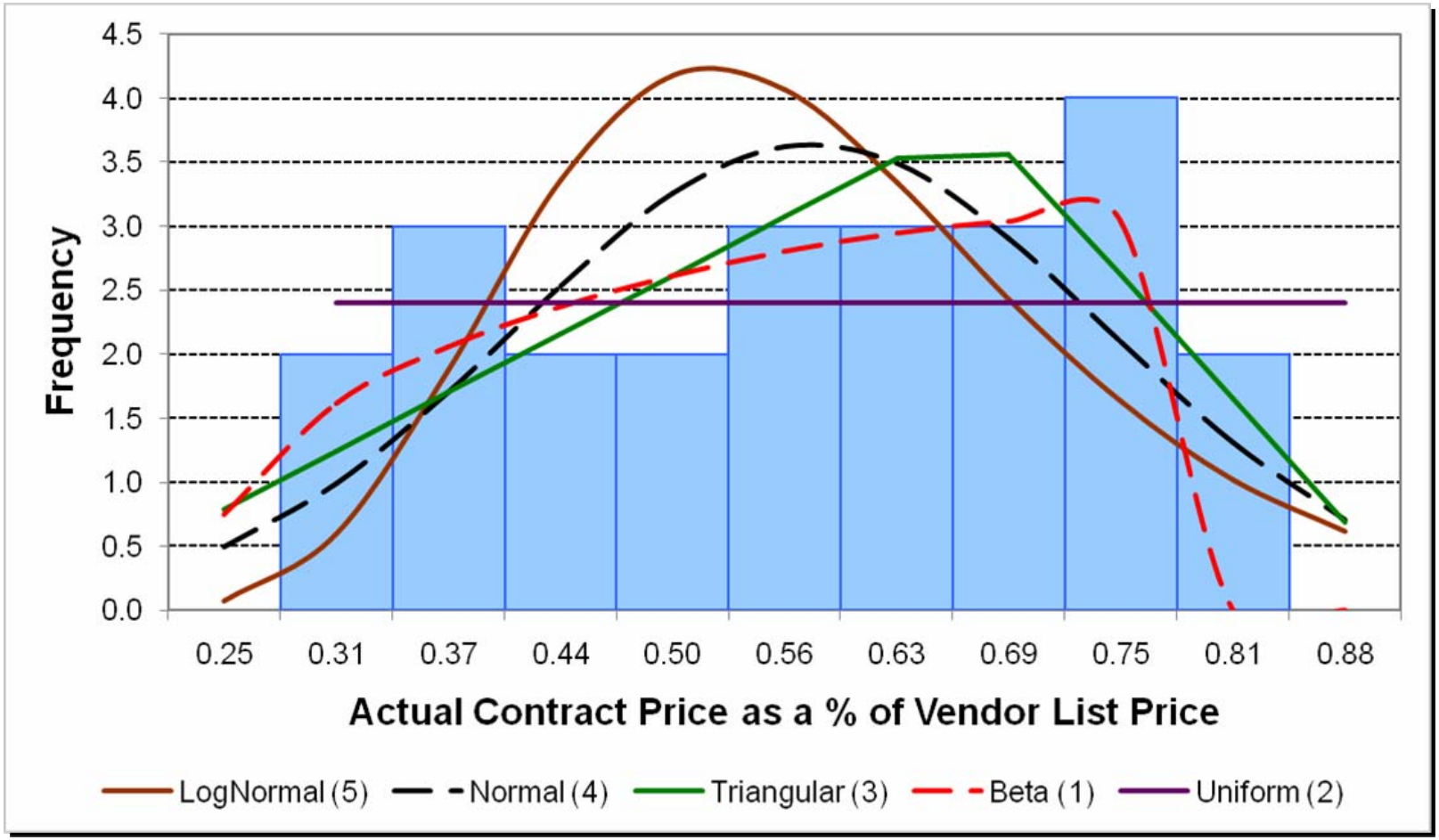
Histogram: % of Vendor List Price



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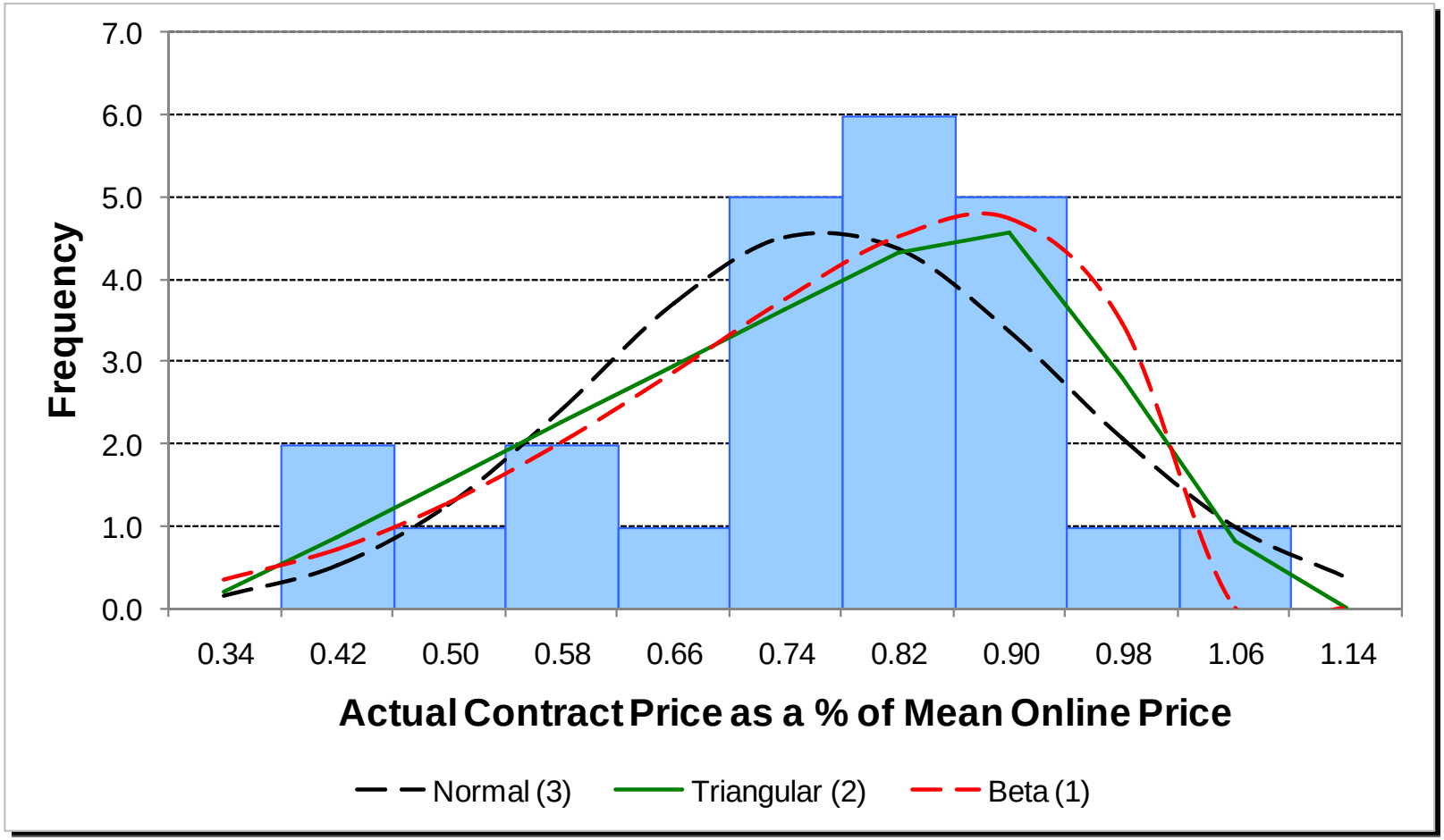
Histogram: % of Mean Online Price



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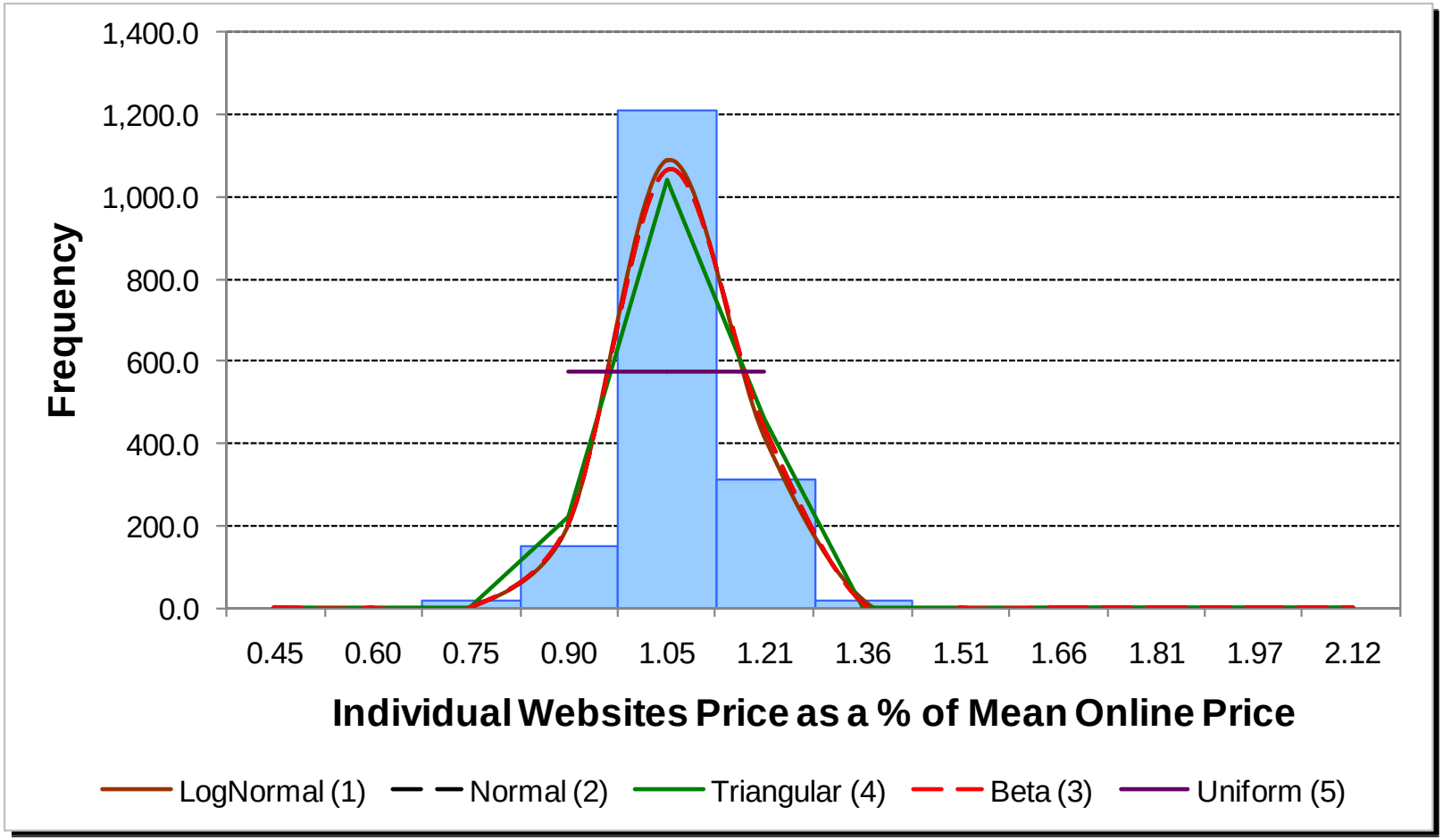
Variance Amongst Individual Websites to the Mean Online Price



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Why Mean Online Price is the Better Method

- Lower dispersion of data (i.e. lower CV)
- Online Pricing allows discounting from a common point
- Market forces provide a baseline for the Mean Online Price metric
- For example, car dealers always offer huge discounts off of the MSRP to try to convince consumers they are getting a great deal
  - Which client got the better deal?
    - Client A $10K off MSRP
    - Client B $1K less than the average cost paid by other consumers

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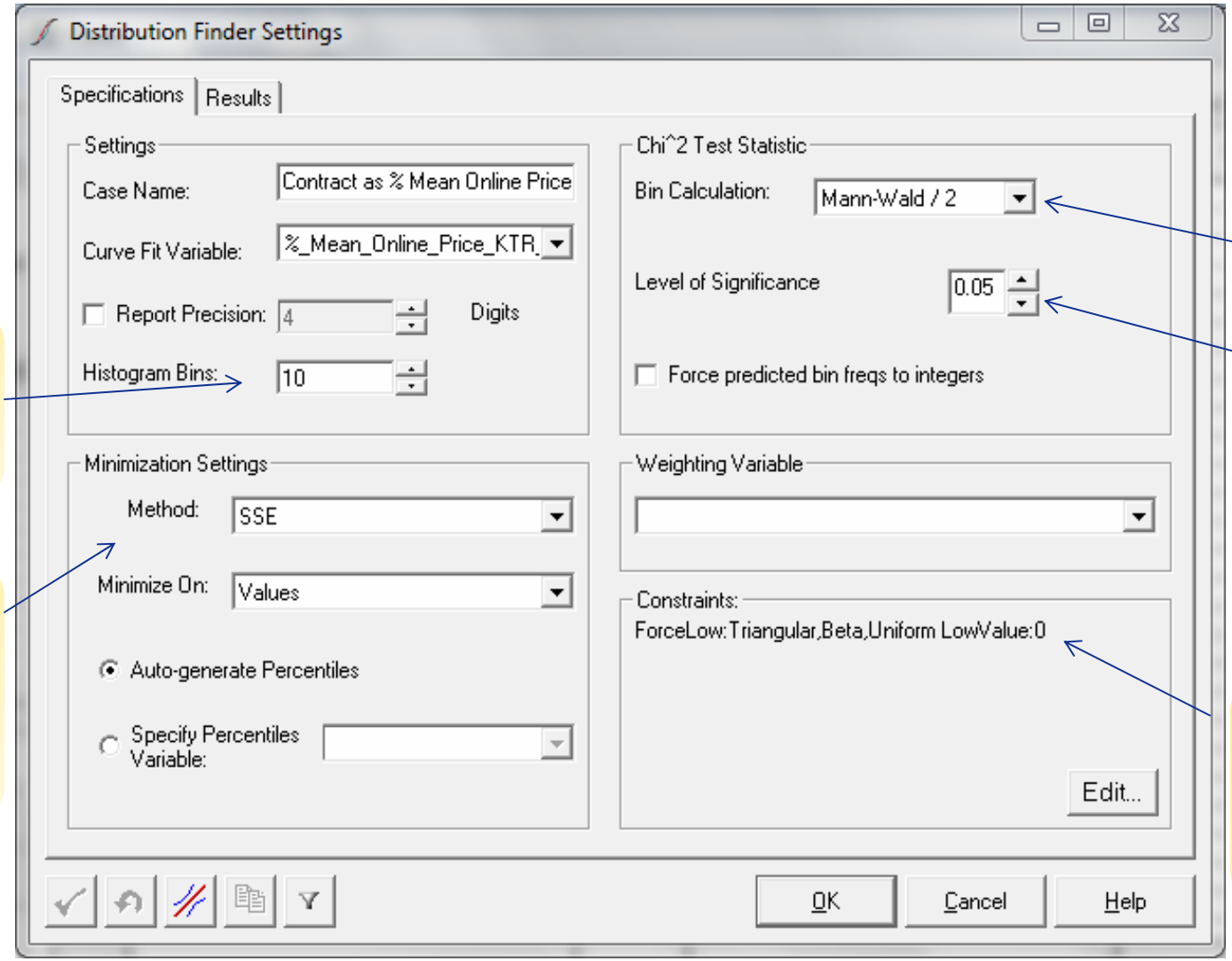
CO$TAT Distribution Finder Tool



Impacts visual output of histogram only

Minimized on SSE (difference between prediction and sample)

Bin calculation for Chi^2 Test

Level of Significance

Constrained Triangular, Beta, and Uniform Distribution to a low value of 0

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DF Analysis: % of Mean Online Price

	Sample	LogNormal	Normal	Triangular	Beta	Uniform
Mean	0.729	0.731	0.729	0.729	0.728	0.729
StdDev	0.173	0.157	0.167	0.165	0.166	0.157
CV	0.237	0.215	0.229	0.227	0.227	0.216
Low	0.337			0.276	0.000	0.456
Mode		0.683	0.729	0.854	0.847	
High	1.063			1.056	0.990	1.001
Alpha					4.376	
Beta					1.571	
Data Count	24	**% < 0 =**	0.00%	None	None	None
Standard Error of Estimate		0.064	0.048	0.043	0.042	0.064
Rank		4	3	2	1	5
SEE / Fit Mean		8.72%	6.60%	5.87%	5.75%	8.84%
Chi^2 Fit test 7 Bins, Sig 0.05		Poor (4%)	Good (14%)	Good (12%)	Good (10%)	Poor (2%)

- With a significance level of .05, Beta, Triangular and Normal distributions passed the Chi Square Test
  - Chi Square (Goodness of Fit) Test summarizes the discrepancy between observed values and expected values of a frequency distribution
- Beta Distribution ranks #1 based on the Standard Error of Estimate (SEE) / Fit Mean
  - Recommend to only use Beta when it is the best fit and no other distribution is statistically significant
- Based on the histogram, Triangular appears to be the best fitting distribution and the SEE/Fit Mean is very similar to Beta
  - Mean = .729
- Export metric risk distribution to ACE

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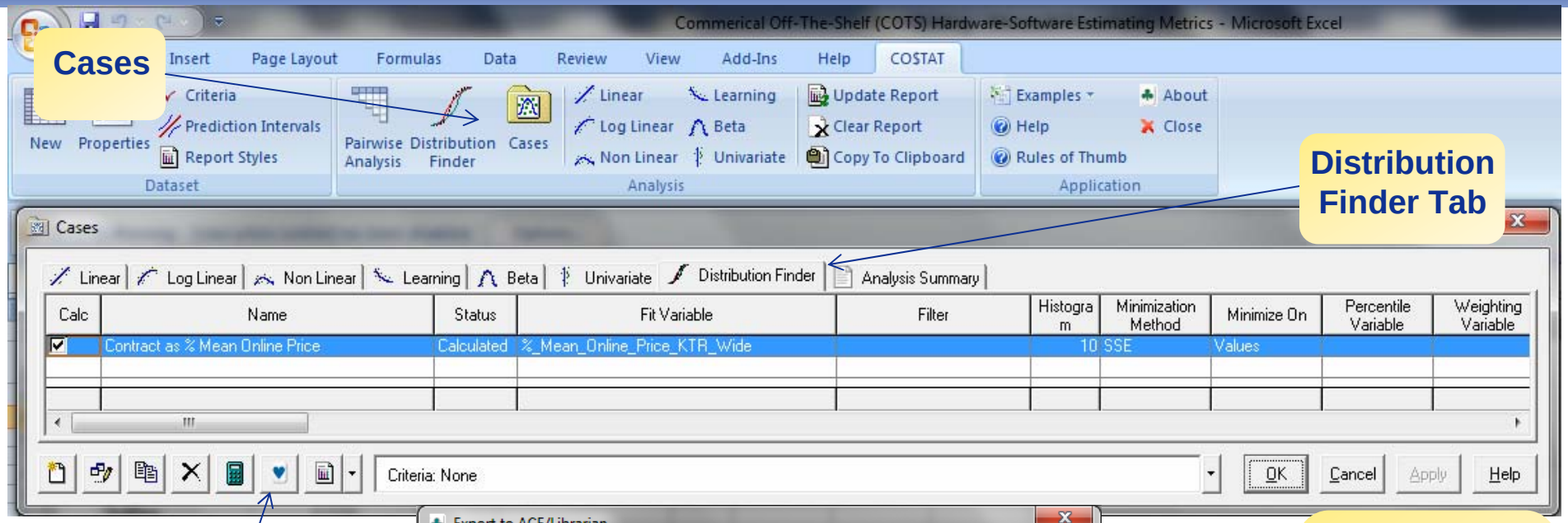
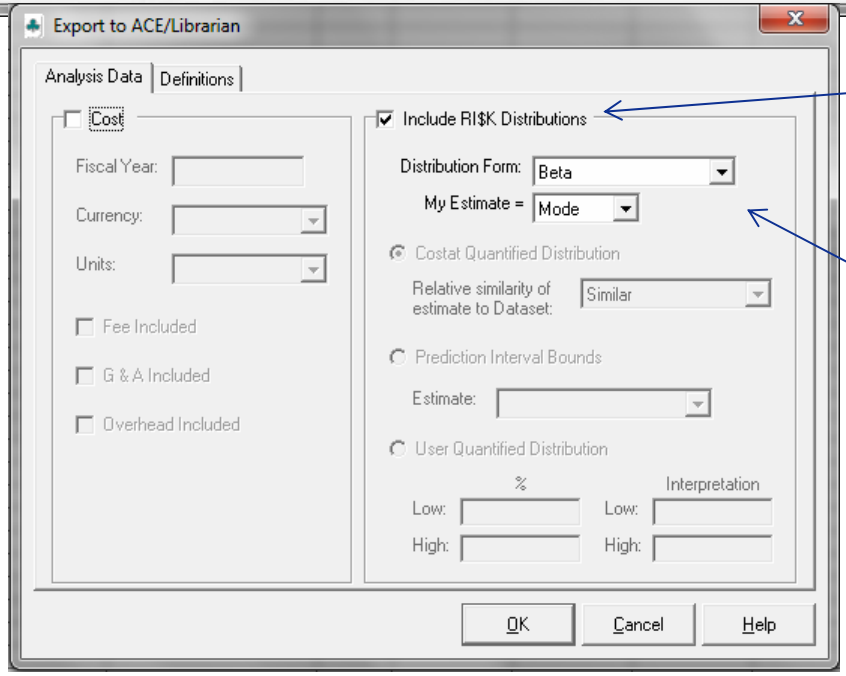
Using CO$TAT to Export Risk Distribution to ACE





Cases

Distribution Finder Tab

Export Selected Cases to ACE/Librarian

"Include RI$K Distributions" should be checked

Choose Distribution Form and My Estimate (Mean, Median, Mode)

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Risk Adjusted Results: CO$TAT Export vs. Manual

Ri$K Distributions.aceit - RI$K All Columns (BY2012$K)

	WBS/CES Description	Point Estimate	Distribution Form	PE Position in	Std Dev (% of PE)	Coefficient of Variation	Low (% of PE)	High (% of PE)	Low (Value)	High (Value)	Low (Percentile)	High (Percentile)	Alpha	Beta	Mode (% of PE)	Mean (% of PE)
3	*Export from CO$TAT															
4	Contract$ as % of Mean Online Price	0.847 (72%) *	Beta	Undefined			0	116.928			0	100	4.3759	1.5714		
5	Contract$ as % of Mean Online Price	0.854 (74%) *	Triangular	Undefined			32.292	123.657			0	100			100	
6	Contract$ as % of Mean Online Price	0.729 (50%) *	Normal	Undefined	22.89706											100
7	*Manual															
8	Contract$ as % of Mean Online Price	0.847 (72%) *	Beta	Mode		.2274							4.3759	1.5714		
9	Contract$ as % of Mean Online Price	0.854 (74%) *	Triangular	Mode					.276	1.056	0	100				
10	Contract$ as % of Mean Online Price	0.729 (50%) *	Normal	Mean		.229										

WBS/CES | Methodology | RI$K All Columns

- **Using different risk inputs yields the same results when run at 3000 risk iterations**

Row	WBS/CES	Point Estimate	Mean	Std Dev	CV	5.0% Level	15.0% Level	50.0% Level	85.0% Level	95.0% Level
3	*Export from CO$TAT									
4	Contract$ as % of Mean Online Price (Beta)	0.847 (72%)	0.728	0.166	0.228	0.414	0.545	0.756	0.901	0.948
5	Contract$ as % of Mean Online Price (Triangular)	0.854 (74%)	0.729	0.165	0.227	0.426	0.536	0.751	0.902	0.967
6	Contract$ as % of Mean Online Price (Normal)	0.729 (50%)	0.729	0.167	0.229	0.454	0.556	0.729	0.902	1.003
7	*Manual									
8	Contract$ as % of Mean Online Price (Beta)	0.847 (72%)	0.728	0.166	0.227	0.415	0.546	0.756	0.901	0.948
9	Contract$ as % of Mean Online Price (Triangular)	0.854 (74%)	0.729	0.165	0.227	0.426	0.536	0.751	0.902	0.967
10	Contract$ as % of Mean Online Price (Normal)	0.729 (50%)	0.729	0.167	0.229	0.454	0.556	0.729	0.902	1.003

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Metrics Application

- **Research online pricing for all unique part numbers in a LOM and compute Mean Online Price**
- **Multiply Mean Online Price by corresponding quantity and Mean Online Price metric**
- **Specify metric risk distribution in ACE**
- **Example**
  - **Given: Mean Online Price Component A = $10.9K; Quantity = 5**
    Mean Online Price Component B = $12.5K; Quantity = 4
  - **Where…**
    - **n = number of COTS Components**
    - **Q = Quantity**
    - **MOP = Mean Online Price**
    - **m = Mean Online Price metric**
    - $\sum^{n}$ **(MOP x Q) x m = Estimate**
  - **[($10.9K x 5) + ($12.5K x 4)] x .729 = $76.2K**

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Developed Metrics

- Actual Contract Price as a Percentage (%) of the Vendor List Price/Mean Online Price
- **Annual Maintenance Support Actual Contract Price as a % of Actual HW/SW Initial Cost**
- Annual Maintenance Support Actual Contract Price as a % of a Vendor Quote

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Detailed Methodology

- Given the initial procurement HW/SW cost, what is the Annual Maintenance Support cost?
  - HW: Warranty
  - SW: License upgrades, patches, help desk
- Calculated the following ratio from 25 different LOM's from various contracts:

$$\frac{\text{Annual Maintenance Support Actual Contract Price}}{\text{Actual HW/SW Initial Cost}}$$

- Used CO$TAT Distribution Finder to calculate best fitting distribution

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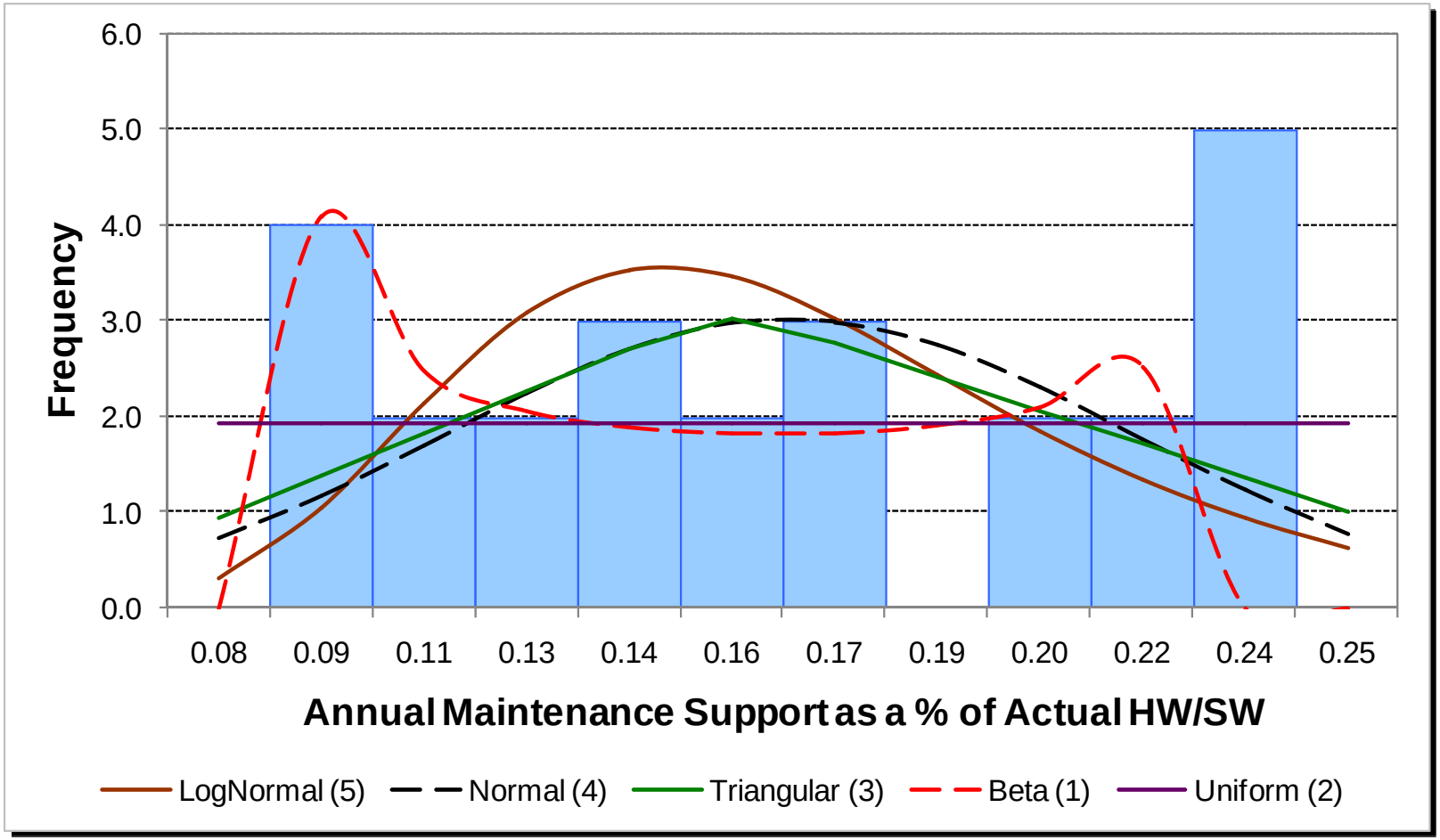
Histogram: Annual Maintenance Support as a % of HW/SW



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DF Analysis: Annual Maintenance Support as a % of HW/SW

	Sample	LogNormal	Normal	Triangular	Beta	Uniform
Mean	0.158	0.159	0.158	0.158	0.158	0.158
StdDev	0.054	0.050	0.052	0.052	0.052	0.052
CV	0.341	0.312	0.331	0.328	0.332	0.332
Low	0.078			0.036	0.080	0.067
Mode		0.138	0.158	0.149		
High	0.237			0.290	0.235	0.249
Alpha					0.591	
Beta					0.578	
Data Count	25	**% < 0 =**	0.13%	None	None	None
Standard Error of Estimate		0.018	0.014	0.012	0.006	0.007
Rank		5	4	3	1	2
SEE / Fit Mean		11.43%	8.94%	7.81%	3.97%	4.26%
Chi^2 Fit test 7 Bins, Sig 0.05		Good (13%)	Good (16%)	Good (44%)	Good (15%)	Good (51%)

- With a significance level of .05, all distributions passed the Chi Square Test
- Beta Distribution ranks #1 based on the Standard Error of Estimate (SEE) / Fit Mean
  - Recommend to only use Beta when it is the best fit and no other distribution is statistically significant
- Based on the histogram, Uniform appears to be the best fitting distribution and the SEE/Fit Mean is very similar to Beta
  - Mean = .158 (i.e. Annual Maintenance Support is 15.8% of Initial HW/SW)
- Sample Low= .078, High = .237
- Export metric risk distribution to ACE

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Developed Metrics

- Actual Contract Price as a Percentage (%) of the Vendor List Price/Mean Online Price
- Annual Maintenance Support Actual Contract Price as a % of Actual HW/SW Initial Cost
- **Annual Maintenance Support Actual Contract Price as a % of a Vendor Quote**

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Detailed Methodology

- Collected 89 unique data points
- Normalized data using ACEIT Inflation Utility
- Calculated the following ratio:

$$\frac{\text{Annual Maintenance Support Actual Contract Price}}{\text{Vendor Quote}}$$

- Used CO$TAT Distribution Finder to calculate best fitting distribution

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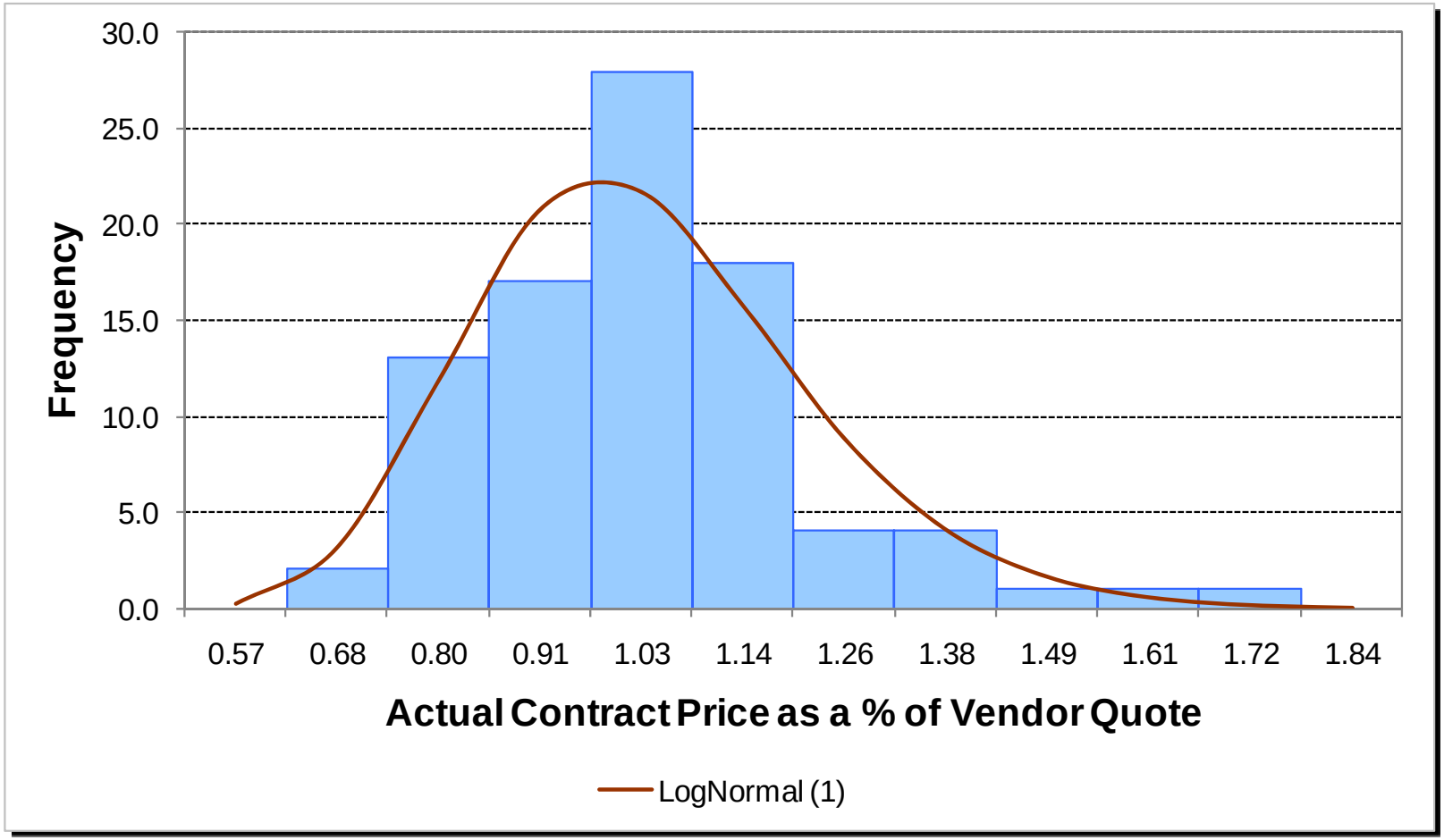
Histogram: Annual Maintenance Support as a % of Vendor Quote



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DF Analysis: Annual Maintenance Support as a % of Vendor Quote

	Sample	LogNormal	Normal	Triangular	Beta	Uniform
Mean	0.974	0.974	0.974	0.974	0.974	0.974
StdDev	0.190	0.189	0.184	0.182	0.187	0.174
CV	0.195	0.194	0.189	0.187	0.192	0.178
Low	0.566			0.577	0.567	0.673
Mode	0.991	0.921	0.974	0.889	0.893	
High	1.723			1.455	3.977	1.274
Alpha					4.062	
Beta					30.000	
Data Count	89	**% < 0 =**	0.00%	None	None	None
Standard Error of Estimate		0.034	0.047	0.052	0.037	0.075
Rank		1	3	4	2	5
SEE / Fit Mean		3.52%	4.81%	5.37%	3.76%	7.70%
Chi^2 Fit test 12 Bins, Sig 0.05		Good (6%)	Poor (2%)	Poor (1%)	Poor (2%)	Poor (0%)

- With a significance level of .05, only the Lognormal Distribution passed the Chi Square Test
- Mean is .974 (i.e. Actual Contract Price is 97.4% of Vendor Quote)
  - Contract costs vary from Vendor Quote due to Period of Performance (PoP) changes, scope changes, vendor discounts, etc.
- Data is not weighted, therefore low cost data points affect the distribution the same as high cost data points
  - Prices on Contract range from ~$1K-$11M
- CV is .194
- Does the elimination of low cost data points affect the distribution…

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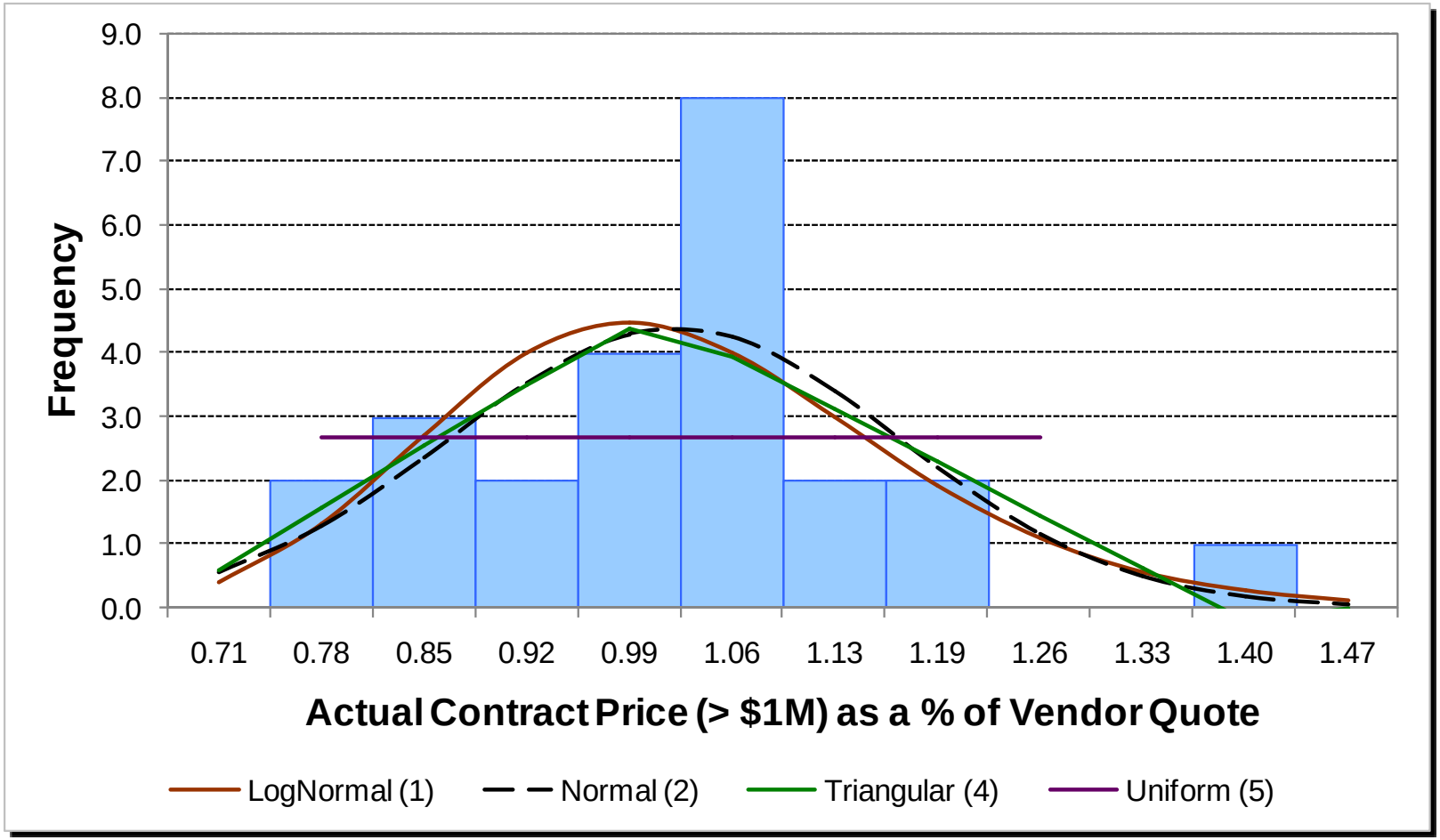
Histogram: Annual Maintenance Support (> $1M) as a % of Vendor Quote



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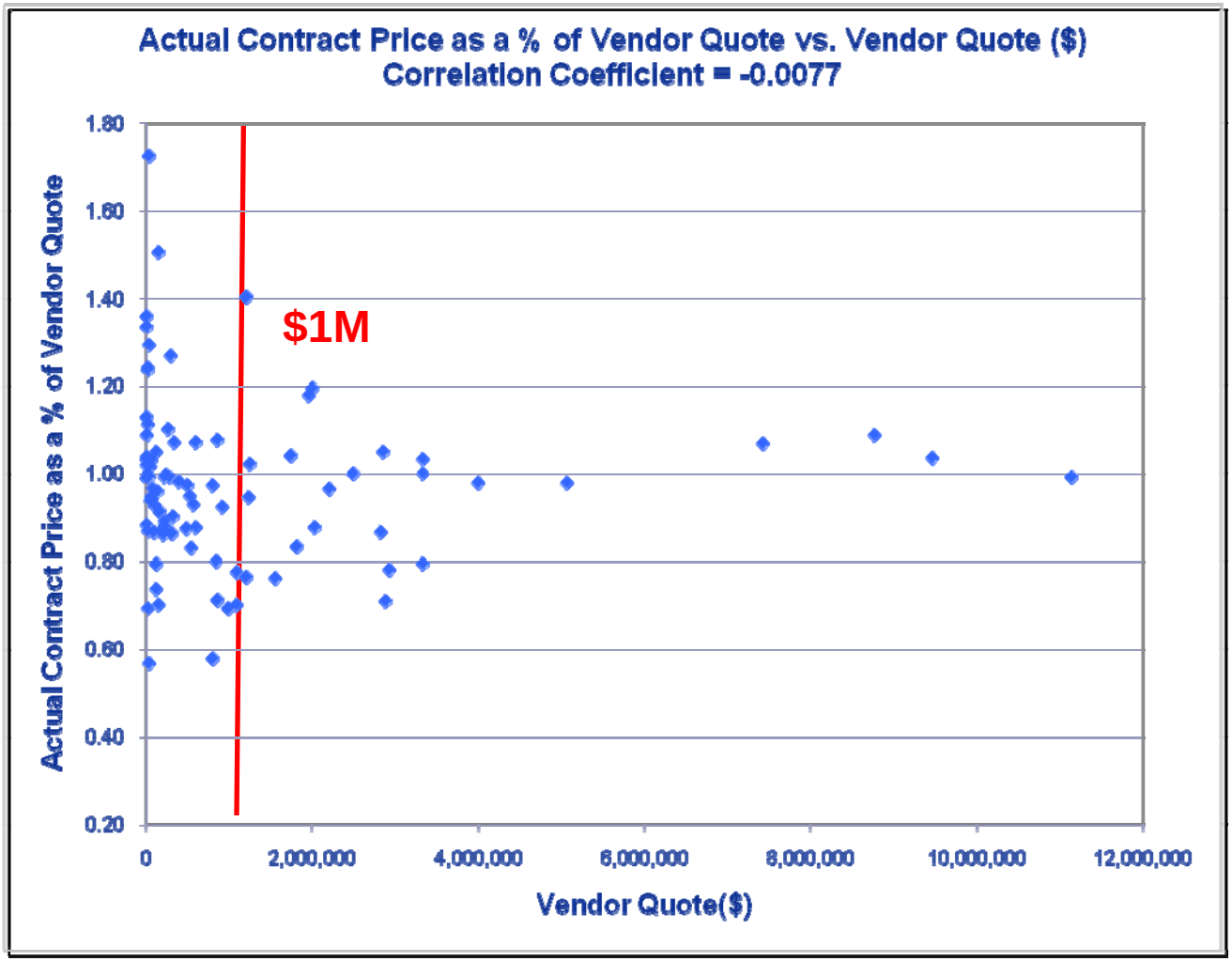
Scatter Plot: Annual Maintenance Support (> $1M) as a % of Vendor Quote

- CV decreases due to less dispersion beyond $1M



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DF Analysis: Annual Maintenance Support (> $1M) as % of Vendor Quote

	Sample	LogNormal	Normal	Triangular	Beta	Uniform
Mean	0.983	0.983	0.983	0.983	0.983	0.983
StdDev	0.153	0.151	0.150	0.146	0.149	0.141
CV	0.156	0.154	0.152	0.149	0.152	0.144
Low	0.711			0.634	0.000	0.738
Mode		0.949	0.983	0.964	0.983	
High	1.402			1.350	1.964	1.227
Alpha					21.210	
Beta					21.181	
Data Count	24	**% < 0 =**	0.00%	None	None	None
Standard Error of Estimate		0.033	0.037	0.041	0.039	0.054
Rank		1	2	4	3	5
SEE / Fit Mean		3.37%	3.72%	4.13%	3.97%	5.49%
Chi^2 Fit test 7 Bins, Sig 0.05		Good (7%)	Good (27%)	Good (6%)	Poor (2%)	Good (11%)

- With a significance level of .05, all distributions passed the Chi Square Test except Beta
  - Lognormal remains ranked #1; Mean increases to .983
- Number of data points reduced to 24
- CV decreased to .154

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Example: How to Use Both Annual Maintenance Support Metrics

- **Given:**
  - **Actual HW/SW Initial Cost = $990K**
  - **Annual Maintenance Support Vendor Quote = $250K**
  - **Annual Maintenance Support as % of HW/SW metric = .158**
  - **Annual Maintenance Support as % of a Vendor Quote metric = .974**
- **Where…**
  - **HWI = Actual HW/SW Initial Cost**
  - **VQ = Vendor Quote**
  - **MXI = Annual Maintenance Support as % of HW/SW metric**
  - **MXV = Annual Maintenance Support as % of a Vendor Quote metric**
  - **HWI x MXI = Estimate or VQ x MXV = Estimate**
- **$990K x .158 = $156.4K or $250K x .974 = $243.5K**
- **Use both metrics to cross check each other and assess vendor quote validity**
- **In the above example is the vendor quote reasonable?**

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Conclusion

- Approaches presented in this briefing were used to increase accuracy for Life Cycle Cost Estimates of COTS HW/SW
  - Use of Mean Online Price approach increases accuracy by providing realistic risk bounds around the Mean Online Price
  - Impact of competitive market forces quantified
  - Both annual maintenance support approaches can be used as primary and secondary methodologies
    - Cross check used to validate vendor quotes
- Factors should be program specific to reflect acquisition strategy
- Continue to develop metrics including:
  - Discount resulting in change from Sole Source to Open Competition contracting strategy
  - Modernization Cost as a % of Initial Cost

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Questions?

Backup

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When to Use Vendor List Price Metric

- What if online pricing isn't available for any products in a given LOM?
  - Use Actual Contract Price as a % of the Vendor List Price
- What if online pricing isn't available for some products in a given LOM?
  - Use combination of both metrics
- Use as a Vendor List Price Metric as a crosscheck

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DF Analysis: % of Vendor List Price

	Sample	LogNormal	Normal	Triangular	Beta	Uniform
Mean	0.546	0.549	0.546	0.546	0.546	0.546
StdDev	0.166	0.155	0.164	0.163	0.162	0.161
CV	0.303	0.282	0.301	0.298	0.297	0.295
Low	0.248			0.109	0.198	0.267
Mode		0.489	0.546	0.639	0.695	
High	0.814			0.889	0.813	0.825
Alpha					1.435	
Beta					1.103	
Data Count	24	**% < 0 =**	0.04%	None	None	None
Standard Error of Estimate		0.048	0.028	0.018	0.013	0.019
Rank		5	4	2	1	3
SEE / Fit Mean		8.83%	5.20%	3.29%	2.39%	3.48%
Chi^2 Fit test 7 Bins, Sig 0.05		Good (27%)	Good (80%)	Good (92%)	Good (78%)	Good (80%)

- **With a significance level of .05, All Distributions passed the Chi Square Test but the CV is higher than the Mean Online Price metric**
- **Beta Distribution ranks #1 based on the Standard Error of Estimate (SEE) / Fit Mean**

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Using CO$TAT Results to Manually Input Risk Specifications in ACE

Distribution Type	PE Position	Priority 1	Priority 2	Priority 3	Priority 4	Priority 5	Priority 6	Priority 7
Normal	Mean/Median/ Mode	CV	SD	Sp	H	L		
	Low	High						
Log Normal	Mean/Median/ Mode	ASE	CV	SD	Sp	H	L	
	Low	High						
Triangular (See Note 1)	Mode	L,H	Mode%,H *or* Mode%,L	Sk,H *or* Sk,L	SD,H *or* SD,L	Sp,H *or* Sp,L	Mode%,CV *or* Mode%,SD *or* Mode%,Sp	Sk,CV *or* Sk,SD *or* Sk,Sp
Beta	Mode	CV,alpha, beta	L,H,alpha, beta	L,H	alpha,beta	H,alpha, beta	L,alpha, beta	
Uniform (see Note 2)	Mode	Mode%,CV *or* Mode%,SD *or* Mode%,Sp	Sk,CV *or* Sk,SD *or* Sk,Sp	Mode%,H *or* Sk,H	Mode%,L *or* Sk,L			
	Mean/ Median	CV *or* SD *or* Sp *or* H						
	Undefined	CV, H *or* SD, H *or* Sp, H						
	Low	H						

Legend:

L = Low (Value) or Low (% of PE)

H = High Value or High (% of PE)

Note that you should also enter Low Percentile and High Percentile when entering Low and/or High values.

Sp = Spread

Sk = Skew

ASE = Adjusted SE

CV = Coefficient of Variation

SD = Standard Deviation

Mode = Most likely value

Mode% = Confidence probability of the mode

Note 1:

For the Triangular distribution, enter the confidence level of the mode in the Mode % column. The confidence must be between 0 and 100. Enter the PE variation with fixed range in the Spread field.

Note 2:

For the Uniform distribution, enter the confidence level of the input cost in the Mode% column. The confidence must be between 0.0 and 1.0. Even more specifications for Uniform are allowed. See help topic for Uniform for the complete list.