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Calculating a Project's Reserve Dollars from its S-Curve (cost distribution)

A method to estimate funds needed to cover
your project if it exceeds its Point Estimate

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Outline

- **Background**
  - Cost Research Task (2015 – 2016) followed by In-house Effort (2016 – present)
  - NASA Policy with respect to Unallocated Future Expenses (UFE)
  - Value at Risk (VaR) and Conditional Tail Expectation (CTE)
- **Reserves Tool Methodology**
  - Purpose of the Reserves Tool
  - Required User-Inputs
  - Flow Diagram of inputs, analysis and outputs
  - Notional example to illustrate "essence" as to how the tool calculates cost reserves
  - Converting user-inputs to logNormal
  - How the Reserves Tool was Developed (in 6 steps)
- **Screen Shot Examples**
  - User-input Sheet (enter CV, LCC and PE), with Basic Output (HQ UFE estimate)
  - Additional output: Sensitivity Table of UFE, S-curve and "Bell" Curve
- **Past & Future Efforts**
- **Final Thoughts**
- **Reserves Tool Demonstration (**if time permits**)**

BACKGROUND

Percentile Budgeting is Only Half the Story

- Risk analysis provides insight into the cost and schedule range and likelihood of achieving the cost and launch dates.
- Percentile budgeting (choosing a specific confidence level) uses the risk analysis results to ensure that enough money is available in the budget to protect for that likelihood of success, and/or that enough time has been reserved to protect for the target launch dates.
- Percentile budgeting establishes a protection level, but there is the other dimension of the **"risk" of overrun.**
  - A 70% budget indicates that 30% of the time there is an overrun
  - Overruns affect the portfolio & require re-allocation to ensure that the project can continue
  - Current techniques do not provide insight into the likelihood and magnitude of the potential overruns and how it can affect the portfolio

Cost Research Task (2015 - 2016)

NASA-funded work completed by Tecolote Research Incorporated (TRI)

- Develop techniques to assess the overall risk exposure a project holds at any given time.
  - What is meant by project risk exposure?
  - How is project risk exposure calculated?
  - What are metrics of risk exposure?
- Develop methodology and metrics to determine the risk exposure a program, theme, or directorate (an Agency portfolio) is carrying at any given time.
  - What does portfolio risk exposure mean?
  - How is portfolio risk exposure calculated?
  - How can portfolio risk exposure be used to support fund allocation?
- Develop a prototype tool to support calculations and visualization of metrics for a project's risk exposure and support communication within NASA stakeholders
- Conduct a test case on a sample NASA portfolio

In-house NASA Effort (2016 - present)

- Consolidated 2015 deliverables into a single Excel worksheet
- Changed calculations from simulated to deterministic
- Added a "data table" for enabling sensitivity analysis
- Added two graphical outputs to worksheet
- Added a "help worksheet" to enable user to estimate:
  - a project's reference life cycle cost (default: average LCC)
  - a project's cost risk, measured as its "coefficient of variation" (CV)
- Validation: Compared HQ $UFE_{estimated}$ versus HQ UFE_{actual}
- Derived cost curves & a single equation to estimate HQ UFE
  - *Note*: Marked as DRAFT slides because currently being updated

Reserves per NASA Policy (aka "UFE")

- During Formulation, the Decision Memorandum shall establish a target life-cycle cost range (and schedule range, if applicable) as well as the Management Agreement addressing the schedule and resources required to complete Formulation. The Decision Memorandum also documents any additional resources beyond those explicitly estimated or requested by the program/project (e.g., additional schedule margin) when the Decision Authority determines that this is appropriate.

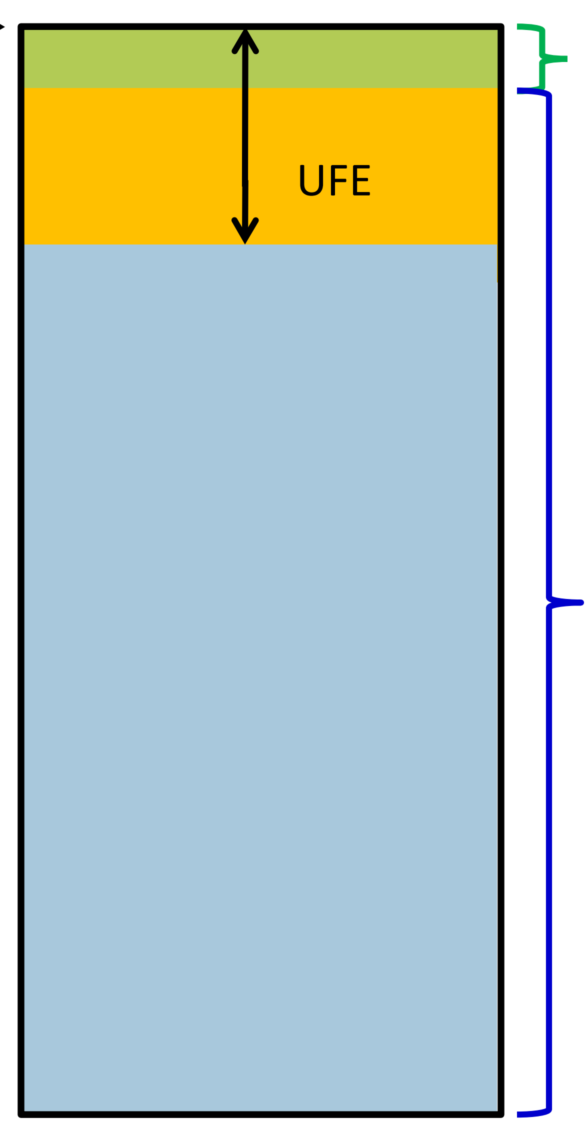
- This includes Unallocated Future Expenses (**UFE**), which are costs that are expected to be incurred but cannot yet be allocated to a specific WBS sub-element of a program's or project's plan. Management control of some UFE may be retained above the level of the project (i.e., Agency, Mission Directorate, or program).

- All projects and single-project programs shall document the Agency's life-cycle cost estimate and other parameters in the Decision Memorandum for Implementation (KDP C), and this becomes the Agency Baseline Commitment (**ABC**). The ABC is the baseline against which the Agency's performance is measured during the Implementation Phase. The ABC for projects with a life-cycle cost of $250 million or more forms the basis for the Agency's external commitment to OMB and Congress.

NASA Baseline Policy-Project-Simplified Cost Agreement at KDP-C

This UFE is managed above the Project.

Agency Baseline Commitment (ABC)
- External Commitments



At KDP-C* and subsequent ABC re-baselines, the ABC and the life cycle cost estimate are equal.

Management Agreement (MA)
- Managed by Project Manager

Not to Scale

*** KDP-C: Key Decision Point C.**

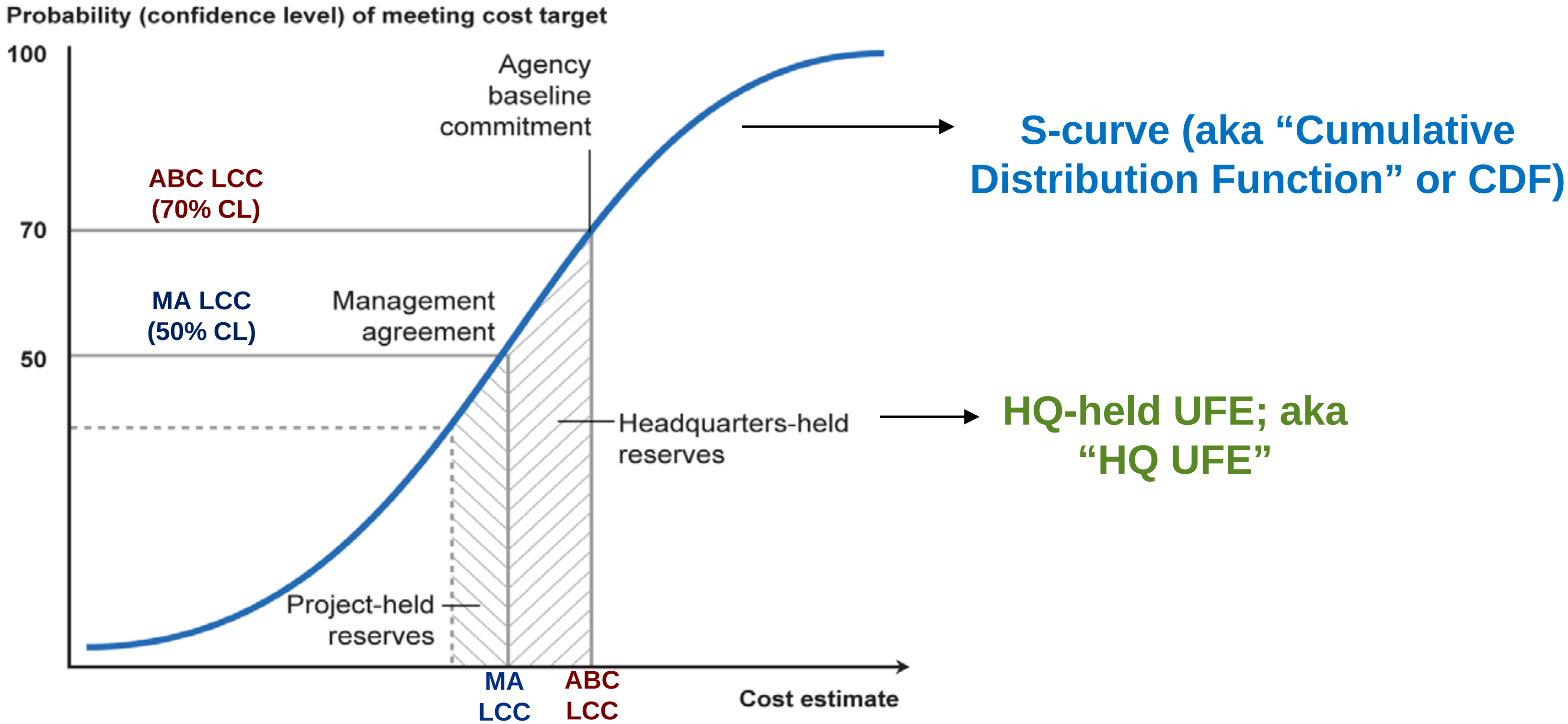
NASA Baseline Policy- UFE (i.e., Reserves) Managed Above the Project

Management Agreement (MA) *(Includes Project UFE)* **+** **Program / Mission Directorate (MD) UFE** **=** **Life Cycle Cost (LCC)**

Reserves, managed "above the project" (also called "HQ UFE")

- **Occurs throughout Project Life Cycle**
- **MA includes Project Managed UFE and Schedule Margin**
- **Reflects the integration of cost, schedule, and risk**

Notional S-curve (e.g. to support KDP-C)
UFE (i.e., Reserves) Managed Above the Project



Source: GAO analysis of National Aeronautics and Space Administration data. | GAO-17-303SP

In most cases, at Confirmation:

ABC LCC (70% CL) – MA LCC (50% CL) = HQ-held UFE

e.g. Mission A: $1,127M (70% CL) - $1,060M (50% CL) = $67M HQ UFE

Value at Risk (VaR)

- **The most popular and traditional measure of risk is volatility**
  - Volatility gives no insight into direction
  - Volatility gives no insight into potential loss
- **Investors (funding agencies) are interested in the potential for loss which can be determined from Value at Risk (VaR) statistics**
  - What is my worst-case scenario?
  - How much could I lose in a really bad day? month? Year?
  - Recall: VaR funding at the 70th percentile means that there is a 30% chance of final project cost exceeding the funded amount.
- **VaR calculates the maximum loss expected (or worst case scenario) on an investment over a given time period and given a specified degree of confidence; basically three components**
  - Time period, Confidence level and Loss amount (or percentage)
- **VaR metrics typically take one of three forms**
  - Those that quantify exposure (e.g., delta range)
  - Those that quantify uncertainty (e.g., Standard Deviation)
  - Those that quantify exposure and uncertainty (e.g., Expected tail loss)

Conditional Tail Expectation (CTE)

- VaR can be quantified in terms of an S-curve's "Tail Value at Risk," also known as "Conditional Tail Expectation" (CTE).
- CTE methods have been applied in the private sector since the 1990's
- The Reserves Tool presented herein leverages not only TRI's cost research effort but also Dr. Christian Smart's past efforts applying CTE.

Dr. Smart (MDA) introduced ways to apply CTE to provide an alternative to percentile budgeting in acquisition. Per his presentation "*Here There Be Dragons Considering the Right Tail in Risk Management* " (presented at the 2010 ISPA/SCEA Joint Annual Conference and Training Workshop):

> "Conditional tail expectation was introduced in the late 1990s and quickly became the preferred standard for setting liabilities for insurance settings. In Canada, the "actuarial Standards of Practice promulgate the use of the CTE whenever stochastic methods are used to set balance sheet liabilities". It is also the basis for the Swiss Solvency Test, which forms a major part of Swiss insurance policy. And the National Association of Insurance Commissioners recommends setting reserves using CTE."

Thus, the Reserves Tool is not breaking new ground. Instead, it builds upon what is already out there (and available) in the public domain.

RESERVES TOOL METHODOLOGY

Note: Herein, "**HQ UFE**" and "**Reserves**" will be treated as synonymous terms

Purpose of using Reserves Tool

#1 purpose: Estimate a "feasible range" of HQ UFE values …

- ***By Project*. Enables estimating potential "extra dollars" needed for a project = amount project's LCC exceeds its MA LCC.**
  - "Extra dollars" = amount of funds in excess of the MA LCC (aka "Point Estimate").

- ***By Portfolio*. Enables ability to estimate potential "extra dollars" needed for a portfolio = amount portfolio LCC exceeds its respective sum of MA LCCs.**
  - "Extra dollars" = sum of each project's HQ UFE
  - Total reserve amount can also be calculated as % of total project funds.

Why a range? b/c reserves tool is applied to an S-curve estimate

- The HQ UFE estimate is an average of ALL expected values above the MA LCC.
- Input values to the tool's 4 inputs are subject to debate. For example:
  a) Cost Risk, depicted by the S-curve spread (σ), is hard to predict during concept phase.
  b) MA LCC can have inherent optimistic bias due to cost caps, funding constraints, etc.
  c) Reference Cost can be a derived from Contractors, SRB, RAO or a hybrid of sources.
  d) Confidence Level of the Reference Cost is a function of at least (a) and (c)

Required User-Inputs for Reserves Tool

1. **The <u>Coefficient of Variation (CV)</u>, is a measure of relative variability. It is the ratio of the standard deviation to the mean (average).**
   - Example: You pay, on-average, $3 per gal for gasoline. You predict this cost will vary, on-average, by +/- $0.30 per gal. **CV** = 0.30/3.00 = **10%**.

2. **The <u>Reference Life Cycle Cost (Ref LCC)</u> is a "reference" cost on the S-curve. The simplest assumption is that this is the Average LCC based upon one or more analogous missions.**
   - Example: User enters "Ref LCC" = $200M and specifies that this LCC is at the 57% Confidence Level. The Reserves Tool uses this reference information to calculate the "Average LCC."

3. **The <u>Project Point Estimate (PE),</u> another cost on the S-curve, is the LCC put forth by the project that excludes HQ UFE.**

THE Most Challenging Part of Estimating HQ UFE is NOT using the tool, but having defensible values for CV, Ref LCC, CL of Ref LCC and PE!

Mission / Portfolio Analysis Process

Inputs, Analysis & Outputs for Cost Reserves Estimation Method

Initial State-of-Knowledge

Inputs
Coefficient of Variation (CV)
Reference Life Cycle Cost (LCC)
Confidence Level (CL) of LCC
Point Estimate (PE) *

Captured just prior to any of the following milestones:

- SRR: System Readiness Review
- PDR: Preliminary Design Review
- CDR: Critical Design Review
- SIR: System Integration Review
- KDP-D: Key Decision Point (just prior to launch)
- Replan: Can occur at any point between SRR & Launch

Analysis for a
One Mission
>One Mission **
Theme **
All Missions **

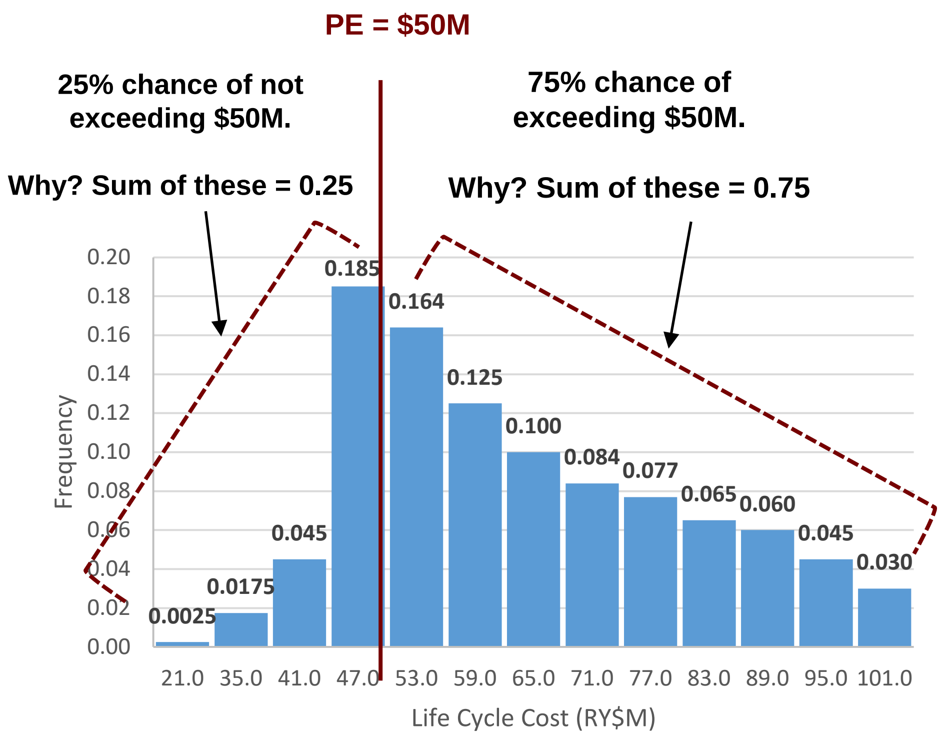
New State-of-Knowledge

Key Outputs
Likelihood of Exceeding Point Estimate
Cost Reserves (HQ UFE) for a Mission
"Effective" Confidence Level for a Mission
Cost Reserves (sum HQ UFE) for a Portfolio ***
"Effective" Confidence Level of a Portfolio ***

*** Point Estimate (PE), which includes project management reserve, is typically MA LCC at KDP-C**
**** These are different types of Portfolios**
***** This is a collection of missions that can be grouped by mission theme, all NASA missions or a customized subset.**

Example for a Notional Project

Point Estimate (PE) = **$50M at 25% Confidence Level (CL)** *



Expected Average Cost Overrun =
Sum of the <u>expected</u> "deltas" …

Actual Cost that Exceeds the PE		PE		"Overrun" = Actual Cost versus PE		Likelihood of Specic "Overrun"		Expected Value of Specic "Overrun"
53	-	50	=	3	x	0.164	=	0.492
59	-	50	=	9	x	0.125	=	1.125
65	-	50	=	15	x	0.100	=	1.500
71	-	50	=	21	x	0.084	=	1.764
77	-	50	=	27	x	0.077	=	2.079
83	-	50	=	33	x	0.065	=	2.145
89	-	50	=	39	x	0.060	=	2.340
95	-	50	=	45	x	0.045	=	2.025
101	-	50	=	51	x	0.030	=	1.530
				Sum of Expected Values			=	**15.00**

If the PE was not adjusted (i.e., stayed at $50M despite low confidence level), then:

Project PE (Life Cycle Cost or "LCC") = $50M (*at the 25% Confidence Level or "CL"*)
<u>Estimated "on average" HQ UFE = $15M</u>
Total LCC IF it exceeds the PE = $65M (*at the 38% Confidence Level or "CL"*)

Note: Examples that follow will have CL's more in-line with NPR 7120.5 Policy

*** $50M Point Estimate (PE) includes project management reserve**

Converting User Inputs to LogNormal

When given the unit-space mean (μ) and standard deviation (σ) of a distribution, we can derive its log-space mean (μ_L) and standard deviation (σ_L) as follows:

$$\sigma_L = \sqrt{\ln\left(1 + \left(\sigma/\mu\right)^2\right)}$$

μ = Avg. Life Cycle Cost

$$Coefficient\ of\ Variation\ (CV) = \left(\sigma/\mu\right)$$

Therefore: $\sigma_L = \sqrt{\ln(1 + CV^2)}$

$$\mu_L = \ln(\mu) - \sigma_L^2/2$$

aka "Fit-space variance"

Using μ_L , σ_L , and percentiles, ***dollar values*** (*x*) can be derived from ***confidence levels*** on the lognormal CDF. For example, using Excel formula, the cost (*x*) at a CDF's 80th percentile is:

$$Cost\ @\ 80th\ percentile = exp\left(\mu_L + \sigma_L * NORM.INV(0.8)\right) = LOGNORM.INV(0.8, \mu_L, \sigma_L)$$

Using μ_L , σ_L *and* dollar values (*x*) from the CDF, ***confidence levels*** on the lognormal PDF can be derived from ***dollar values*** (x) using the following Excel formula:

$$Percentile\ at\ cost\ x = LOGNORM.DIST(x, \mu_L, \sigma_L, , FALSE)$$

How the Reserves Tool was Developed

Requires having 3 primary user inputs: Avg. LCC, CV and PE

1. **Create detailed CDF ("S-curve)** *where inputs are fit-space Avg. LCC and σ ...*

   Step a: σ = (Avg. LCC) x (CV) [i.e., Values are unit space to start off]

   Step b: Fit-space Variance = LN(1 + (σ / Avg. LCC) ^{2}) = LN(1 + CV ^{2})

   Step c: Fit-space σ = SQRT (Fit-space Variance)

   Step d: Fit-space Avg. LCC = LN(Avg. LCC)-0.5*Fit-space Variance

   Step e: =LOGNORM.INV (Confidence Level, Fit-space Avg. LCC, Fit-space σ)

   – Produces ***dollar values*** based upon 10,000 confidence levels (sorted from 0% to 100%)

   Step f: Plot confidence levels versus respective dollars to create a CDF (aka "S-curve")

2. **Create a "1000-interval" histogram to approximate a PDF.**
   - Where, as was shown in slide 17, each interval had a specific discrete probability

3. **Apply conditional to this histogram to identify overruns (i.e., $ > PE):**
   - If "mid-point" value, V(i), of the given interval > Pt. Estimate (PE), then V(i) – PE, else $0.

4. **Take the SUMPRODUCT of #2 and #3 to estimate Reserve $**
   - Produces the expected "on average" dollar amount to hold "in reserve" above the project

5. **Obtain confidence levels of PE and (PE + Reserve $) using:**
   - LOGNORM.DIST(PE,LN(Avg. LCC),(Fit-space σ/Fit-space Avg. LCC)*LN(Avg. LCC),TRUE),1)

6. **Create "data table" to show HQ UFE sensitivity to PE & CV changes**

SCREEN SHOT EXAMPLES

Example Inputs and Outputs (1 of 3)

- Assume you've been provided Project's PE of $3,500 (RY$M)
- Assume an Independent Cost Estimate (ICE) provides you an S-curve which enables you to obtain:
  - the project's average life cycle cost (Avg. LCC) = $4,000 (RY$M)
  - the project's cost risk ("coefficient of variation", CV) = 40% (High Risk)

Enter values in GREEN cells! | **Budget UFE Reserves (BUFER) Calculator for ... Electro-Nuclear Geosynchronous Observation Instrument (E-NGOI)**

Estimates are for Mission Directorate Unallocated Future Expense (MD UFE) | **All Costs are in RY$M**

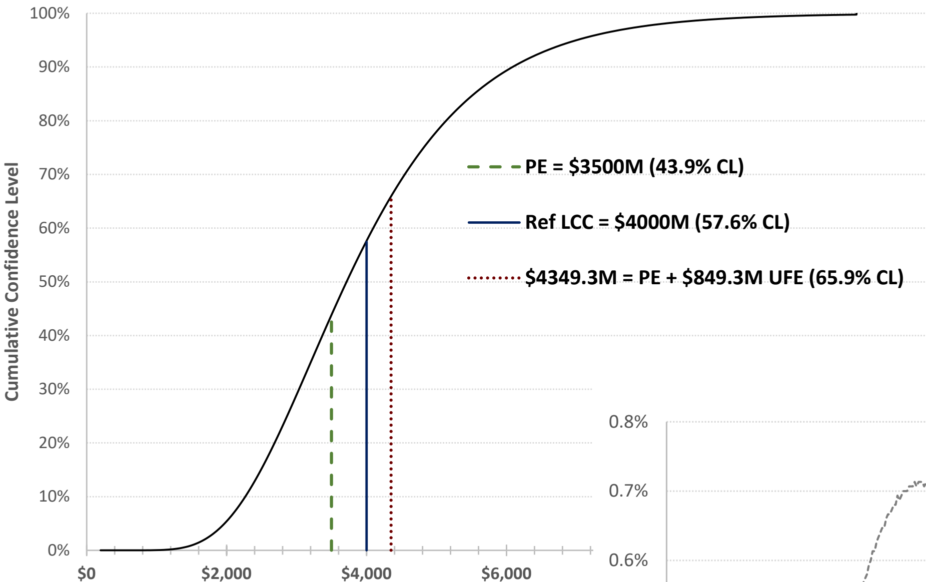
Coef of Var (CV):	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	>50%
	Neglible Risk ---->	Low Risk	------------>	Nominal Risk	------------>	High Risk	------------>	Very High Risk	------------>	Extemely High Risk ----->	

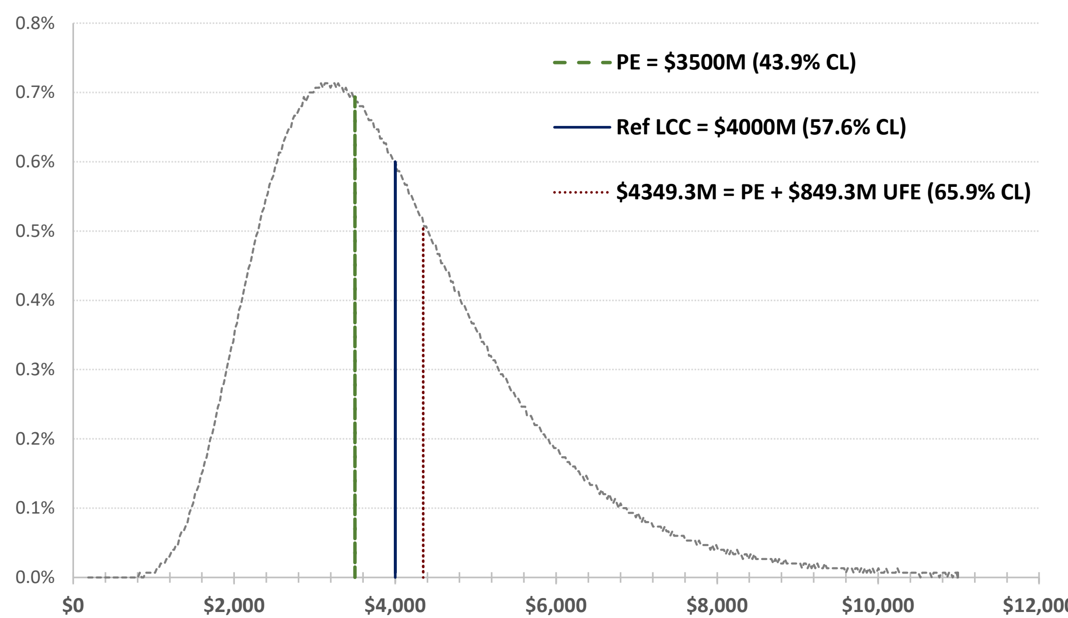
Coefficent of Variation (must be at least 5%):	40.0%	*The project cost exhibits a* ***Very High Risk***	***Notes on the Coefficient of Variation (CV)***
Reference Life Cycle Cost (Default = Avg. LCC) =	$4,000	*Enter CL, if known. Otherwise leave blank:*	*CV is "spread" of +1 std dev above Ave LCC.*
Project Point Estimate (PE) =	$3,500	*Example: The PE is Management Agreement LCC at KDP-C*	*One σ towards right tail is at the 84% CL.*
PE / Reference LCC =	0.8750	*The Project PE is equal to 87.5% of the project's Ave LCC.*	*All CV entries > 50% are "Very High" Risks*
			Estimate CV using "LCC & CV Calculators" sheet
MD Unallocated Future Expenses (UFE)=	**$849.3**	*"On average" funds needed for scenarios when the PE > $3,500*	
Project's Point Estimate (PE) =	$3,500	*The Project PE is at the 43.9 % confidence level. The likelihood of exceeding the Project's PE = 56.1%*	
PE + MD UFE =	**$4,349**	*The (PE + UFE) is at the 65.9 % confidence level. The likelihood of exceeding the (PE + UFE) = 34.1%*	
		The (PE + UFE) is 349.3 $M over the Ave LCC of 4000 $M	

If the project cost exceeds its $3.50B PE (i.e., exceeds 44% CL), then "assigning" the PE with $849M in reserve results in an "effective" PE of $4.35B with an "effective" 65.9% CL

Example Inputs and Outputs (2 of 3)

You can view the Project's PE with & without reserves in 2 ways (CDF & PDF):





Example Inputs and Outputs (3 of 3)

- During formulation, Project PE and its Cost Risk are **uncertain**
- Sensitivity analysis helps address such uncertainties by:
  - varying the project's PE ($3.5B) to cover the range from $3.15 - $3.85B
  - varying the project's cost risk (CV = 40%) to go from 30% to 50%

2-way Sensitivity Analysis		High Risk	High to Very High Risk	Very High Risk	Extremely High Risk	Extemely High Risk
UFE Estimate =	**$849**	***30%***	***35%***	***40%***	***45%***	***50%***
	$3,150	$965	$1,013	$1,063	$1,113	$1,163
	$3,238	$902	$953	$1,006	$1,059	$1,111
Cost < PE	*$3,325*	$841	$896	$951	**$1,007**	$1,061
	$3,413	$782	$841	$899	$957	$1,014
Current PE =	***$3,500***	**$727**	**$788**	**$849**	**$909**	**$968**
	$3,588	$674	$738	$802	$864	$924
Cost > PE	*$3,675*	$624	**$691**	$756	$820	$881
	$3,763	$577	$646	$713	$778	$841
	$3,850	$533	$603	$672	$738	$802

If, for example, the PE stays at $3.50B PE, but tech scope causes cost risk (CV) to go from 40% to 35%, the UFE would go from $849M to $788M, a savings in $61M.
The "effective" PE (now reduced by $61M) goes to $4.29B with an "effective" 64.6% CL

Elaine, don't get too down. Everything will even out. See, I have two friends. You were up, he was down. Now he's up, you're down.

You see how it all evens out for me?
Quote from S05E22 - The Opposite

We can say the same phenomenon tends to happen to the net cost reserves for a group of projects, aka "Law of Averages."

… the principle that supposes most future events are likely to balance any past deviation from a presumed average.

This Reserves Tool estimates "on-average" reserves by project whereas, in reality, each project's actual reserves fell above and below their (estimated) average cost reserve.

After summing up "on-average" reserves by project into their respective portfolios, we observed more accurate predictions of reserves by portfolio (versus by individual project).

PAST & FUTURE EFFORTS

Past Use of Reserves Tool

- 2016: Is a “Rule-of-Thumb” of HQ UFE = 10% of PE sufficient for our portfolio?
- 2017: What’s a ballpark HQ UFE range for my $100M Earth Science mission?
- 2018: What is a “probable range” of HQ UFE given my CV and PE are uncertain?
  - Project is in Formulation when an estimate of HQ UFE is not yet (typically) required.

In other words, the Reserves Tool was used mainly as a cross-check.

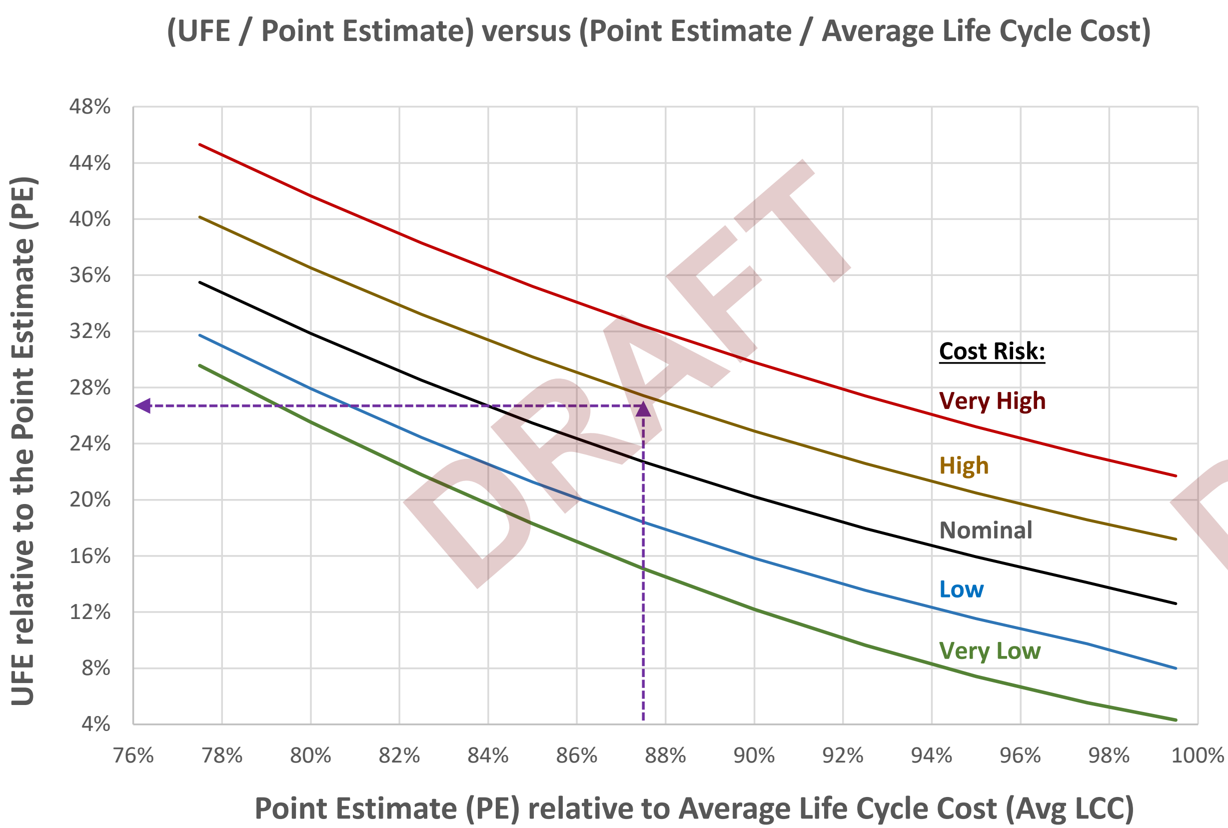
Also, for these 3 cases, there was a good amount of discussion on common programmatic issues such as potential for de-scopes, amount of heritage, assumptions & methods supporting the ICE, etc.

Such discussions were critical to having a comfort-level with the user-inputs required for the tool (and calculations produced by tool).

Updating "Reserve Curves"

Derived by plotting (UFE / PE) against (PE / Avg. LCC)

- Calculated multiple UFE values to create "reserve curves"
  - Varied PE values from 77.5% to 99.5% of Avg. LCC
  - Varied Cost Risk values where CVs went from 10% to 50%



Example:
You are asked to estimate the reserves for a project with a $3.5B Point Estimate (PE).

Based upon the given ICE's S-curve, this PE is at the 33% CL. The Average LCC (on the same S-curve) is $4.0B.

All SMEs concur that this project has a High Cost Risk (CV ~ 40%).

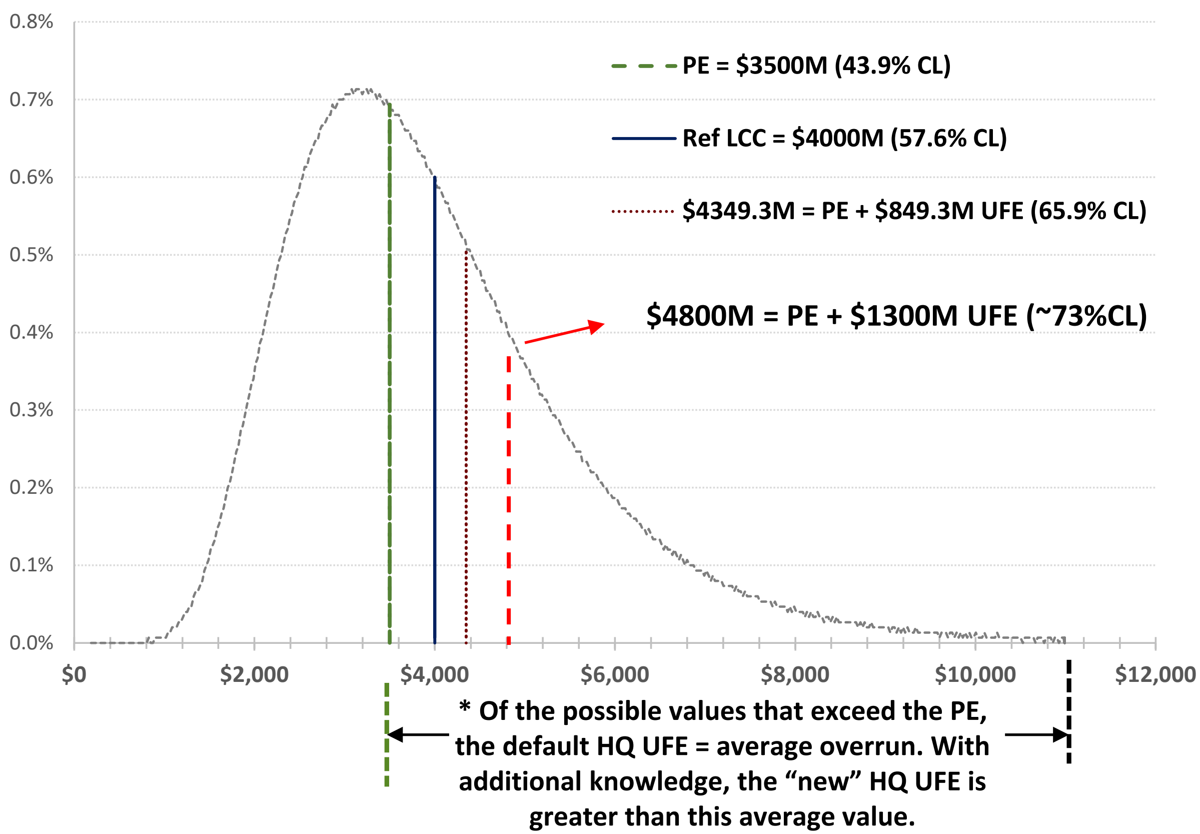
Per the "High" curve, the x-axis' (PE / Avg LCC) = ($3.5 / $4.0) = 0.875 or 87.5%

The corresponding value on the Y-axis is 27% = (UFE / PE)

Therefore: UFE = 0.27 x $3.5B
UFE = $945M

In Development: Stochastic Feature

Notional Example: Say you're the odd-ball analyst assigned to SID's Heliophysics Portfolio. They just got ATP for the Corona Light Mission. After sitting with project team members, PEs, independent assessors, etc. you "sense" that the mission will become THE biggest priority in the Heliophysics portfolio over the next 5 years. As a result, in addition to estimating the mission's on-average HQ UFE (~ 50% likelihood*), you also estimate an HQ UFE that has a 65% likelihood*.



Final Thoughts

- Such a Reserves Tool may be useful to frame discussion early-on about Cost and Cost Risk. Some examples …
  - How would cost variance be impacted with immature technologies (e.g., TRL 5)?
  - Will the new project require more than normal technical interfaces?
  - Will the new project have a very high level of organizational complexity?
  - Will the fact that the project is cost capped impact overall cost and its variance?
  - Does the future project inherently put us into a high risk “aggressive” schedule?
  - If the schedule is “risky”, how could this impact cost and its variance?
  - Will the new project be “in-family” with ____?;
  - Is the new project really half the cost of _____?
  - Should our team consider doing an Independent Cost Estimate (ICE) prior to Award?
  - Prior to awarding a contract, should we approximate what the HQ UFE might be?
  - Using sensitivity table and stochastic output, should we calibrate the discrete HQ UFE estimate to accommodate risk disposition (Refer to notional example on slide 24).

A key factor not covered in this presentation is that, when using the tool, productive communication with the project is essential!

RESERVES TOOL DEMONSTRATION

(If Time Permits)

BACKUP SLIDES

Cost Research Task: Tecolote Team

- Darren Elliott (Lead)
  - Nick Detore (Analyst)
  - Shu-Ping Hu (Statistician)
  - Matt Blocker (Automation & Visualization)

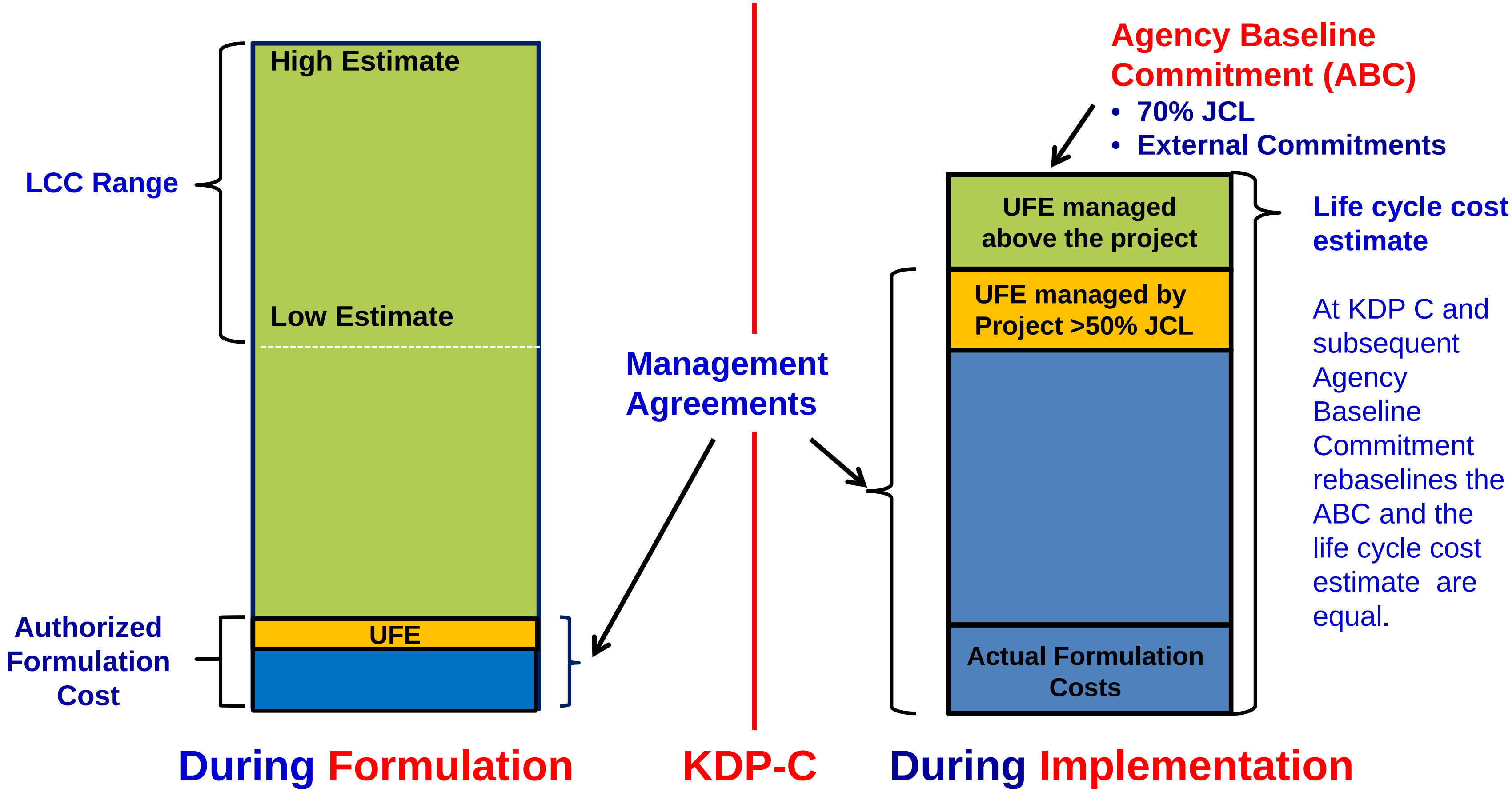
Baseline Policy-
Management Agreement (MA)

- The parameters and authorities over which the program or project manager has management control.
- The PM is accountable for compliance with the terms of their Management Agreement and has the authority to manage within the agreement.
- View as a contract between the Agency and the PM.
- A significant divergence from the Management Agreement must be accompanied by an amendment to the Decision Memorandum *.

Baseline Policy- Agency Baseline Commitment (ABC)

- For all projects and Tightly Coupled Programs, the life cycle cost estimate (and other parameters) at KDP C is the Agency's Baseline Commitment (ABC) for that Project or Program.
- The ABC is documented in the Decision Memorandum.
- The NASA AA approves the ABC for all projects with a life cycle cost estimate > $250 million.
- The ABC is the baseline against which the Agency's performance is measured during Implementation.

NPR 7120.5E Project Life Cycle Cost Agreements and Commitments



Five –year budget run out and schedule estimates are reported to Congress. If a project signs a contract > $50 M, LCC range is reported to OMB. For selected projects, LCC and schedule ranges are reported to GAO

Notional and Not to Scale

From this point, Congress, OMB and GAO get detailed cost and schedule information. All changes are tracked back to the ABC.

Example Questions for Decision-makers

Related to life cycle cost

- How many projects should we select this year?
- Is it possible to estimate a "reasonable" UFE for each project? For the portfolio?
  - Will these estimates account for dollar savings due to potential de-scopes?
  - Can this analysis be performed to support the PPBE process? To support decisions at reviews?
- If de-scopes already exercised, is the project's UFE at Decision Gate reasonable?
- Is project's cost risk going down over time? If so, how does this impact its UFE?
- How could a change in a given project's cost risk impact Directorate's portfolio?
- How could adding a project into the portfolio impact the portfolio's overall cost risk?
- What's the "cost risk exposure?" How does UFE allocation reduce such exposure?
- How can we choose among mutually exclusive projects?
- What "should" be a reasonable UFE be as a %-age of the sum of project costs?
- To what extent can de-scopes reduce our overall UFE?
- What are preferred ways to allocate UFE across projects?
- What's a good confidence level for a project Pt Estimate? For the whole Portfolio?
- What data is needed to run the reserves calculator? How do we obtain this data?

Overview of Required Model Inputs

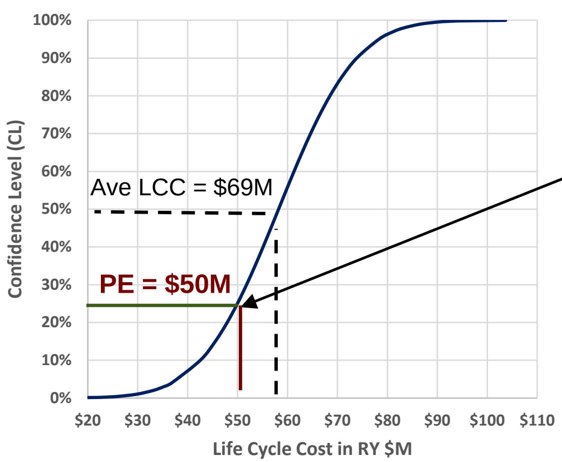
Note: Technical de-scope inputs not covered in this slide

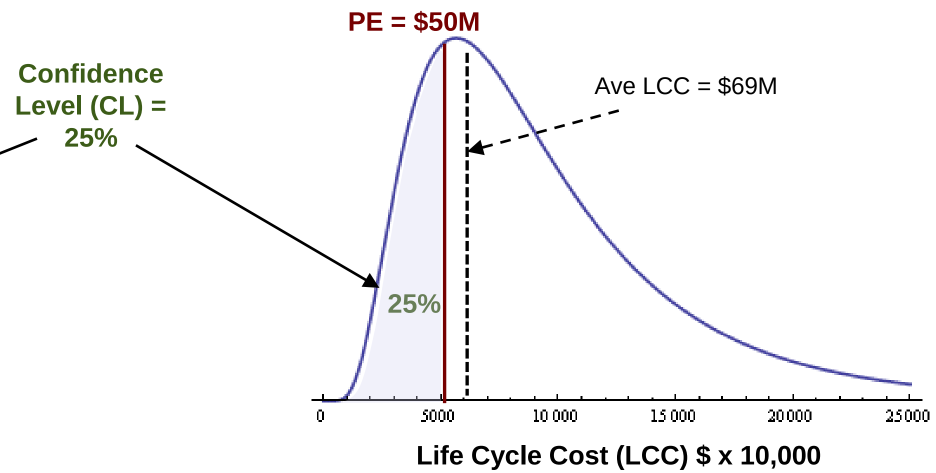
- **The Point Estimate (PE) is the Project's Life Cycle Cost (LCC) estimate**
  - Example: PM puts forth **$50M** estimate as the basis for her funding request
- **The LCC Coefficient of Variation (CV) measures relative cost dispersion**
  - A CV is the LCC's **Standard Deviation** divided by the **Average LCC**
  - Example: The Project has an average LCC of **$69M** with a standard deviation of **$12M**

$$\textbf{CoV} = \frac{\text{Standard Deviation}}{\text{Average LCC}} = \mathbf{\$12M} \;/\; \mathbf{\$69M} = \mathbf{17.75\%}$$

- **The Confidence Level (CL) is the likelihood of the LCC being at/below the PE**
  - Example: Given a PE of $50M at the 25% Confidence Level …

"There's a 25% chance that the project LCC will end up at or below $50M"





"Look-up" Curves & Single UFE Equation

Notional example on how the model calculates UFE using 3 inputs

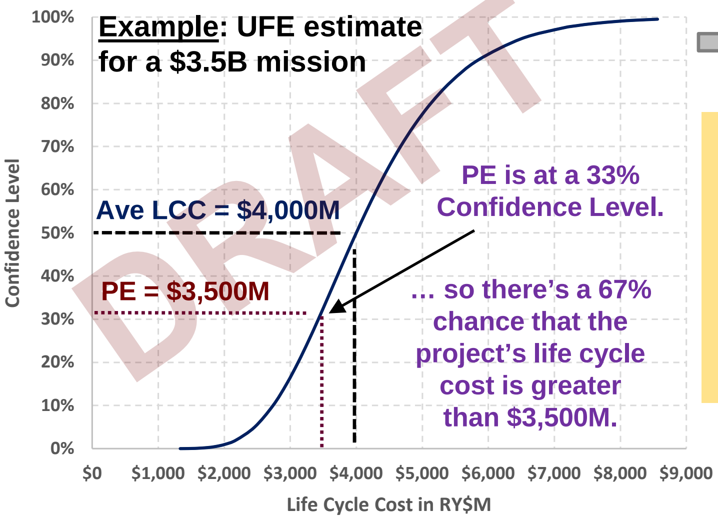
- The model provides an estimate of UFE based upon 3 Inputs:
  - Point estimate (PE). Typically the project's estimated life cycle cost.
  - Average life cycle cost (Avg. LCC). Typically based upon similar missions.
  - Life cycle cost "spread" (Cost Risk). Driven by known and unknown risks.

For Notional Example:

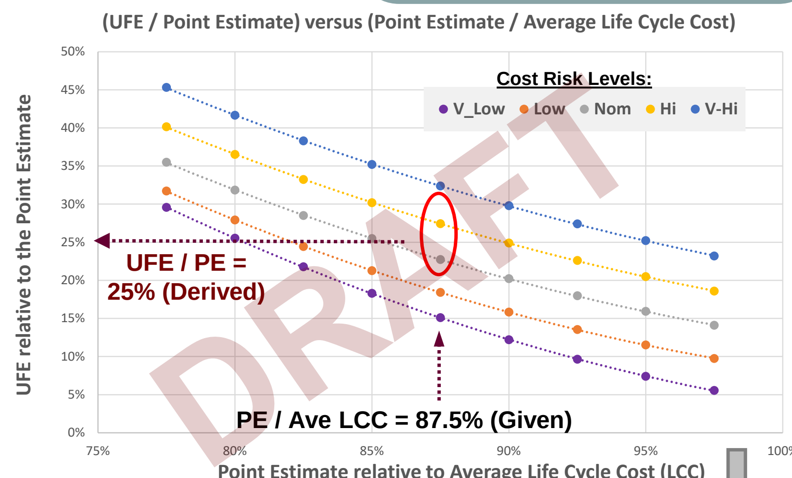
PE = $3,500M

Ave LCC = $4,000M

Nominal/High Cost Risk



How much UFE would "cover" the project if, at a later time, the cost exceeds it's current PE of $3,500M?



	Cost Risk:	Low/Nominal------>	Nominal ----------------------	->	High	------->Very High
Project's Point	*$3,150*	$1,105	$1,177	$1,257	$1,341	$1,429
Estimate ($M):	*$3,238*	$997	$1,071	$1,152	$1,236	$1,324
	$3,325	$897	$972	$1,053	$1,138	$1,225
	$3,413	$803	$880	$962	$1,046	$1,133
Current PE =	***$3,500***	**$718**	**$795**	**$877**	**$961**	**$1,046**
	$3,588	$639	$717	$799	$882	$966
	$3,675	$568	$646	$727	$809	$893
	$3,763	$504	$582	$662	$743	$826
	$3,850	$448	$525	$604	$684	$765

A single equation * gives a more precise UFE estimate; it also enables seeing how UFE varies with changes in the Program's PE and Cost Risk.

Referring to the graph above:

UFE = 25% x PE

UFE = 25% x $3,500M

UFE = $875M

Total = PE + UFE = $4,375M (at the 62% confidence level)