Pre-Aerosols, Clouds & Ecosystems (PACE) Mission - Polarimeter based on the 2009 Passive Aerosol and Cloud Suite (PACS)

~ Parametric Cost Presentation~

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IDL Parametric Cost Modeling

PACE-Polarimeter Parametric Inputs:

- IDL Discipline Presentations
- Master Equipment List (MEL)

Key Assumptions:

- Class S Electronics
- All Parts of Instrument (s) built by Contractors (GSFC Contractor Bid Rates used in model)
- PRICE-H Model with Constant Yr $12
- No existing Manufacturing Process and Assembly Line
- PRICE-H Estimate for (1) Flight Unit, (1) ETU, and (1) EDU
- Schedule used:

Phase B Start	7/2013
Instrument PDR	5/2014
Instrument CDR	5/2015
Instrument Production End (SIR)	11/2016
Payload Delivery to Observatory I&T	11/2017
Launch Readiness Date	12/2018

- SEER-H SpyGlass Estimates for Detectors
- IDL Grassroots Estimate for FSW GSE and Development Environment & Simulator SW (in FY$12)
- IDL Grassroots Estimate for Development for FPGAs & Specific Algorithms (in FY$12)

Output Products:

- Powerpoint presentation
- PRICE H model results exported to Excel Spreadsheet

Cost Assumptions (2 of 3)

Build Assumptions:

- Out of House

Cost Assumptions

- 60/40 Real Year CBE

Class of Mission

- Class B Mission use Class S electronics

Throughput or Purchased Item(s)

- None

Cost Assumptions (3 of 3)

- Detectors is using SEER-H to estimate Detectors costs
- Firmware for FPGAs will use Grass Roots. The methodology will be in the electrical presentation
- FSW Software is using SEER-SEM
- Additional Hardware Costs for PACE-Polarimeter
  - Ground Support Equipment (GSE) - 5% of Estimated Instrument Hardware Cost to Estimate
  - Environmental Testing - 5% of Estimated Instrument Hardware Cost
  - Engineering Test Unit (ETU) – 5% of Estimated Instrument Hardware Cost Component Level
  - Flight Spares - 10% of Estimated Instrument Hardware Cost
  - Instrument to S/C Bus Integration & Test - 5% Estimated Instrument Hardware Cost. Typically Included in WBS 10.0

PACE_POL_Paramest_092611_PresentationVer.xlsx

Summary Cost Estimate (GSFC Contractor bid rates, '12 Dollars)

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PACE Polarimeter IDL Parametric Cost Estimate (IDL = Instrument Design Lab) (Development and Production Costs)	Flight Units = 2 Eng Design Units = 1 Cost Estimate (FY$12)	
PRICE-H Cost Model Summary 21-Sep-11		
Polarimeter Instrument Assembly (Contractor Rates, Class S EE Parts, includes EDU) (171 kg) --FIRST UNIT COST incl NRE	$117,047,353	
UV Channel Assembly (13 kg)		*$9,446,651*
VNIR Channel Assembly (13 kg)		*$9,443,316*
SWIR Channel Assembly (20 kg)		*$13,980,292*
Aperture Wheel Mechanism Assembly (External Calib) (15 kg ea)		*$6,991,631*
Polarization Monitor/Calib Hemisphere Assembly (2 kg)		*$4,350,143*
Sun Shade (1 kg)		*$165,096*
Instrument Structure Assembly (20 kg)		*$3,063,065*
Alignment Mechanism Control Box Assy (Redundant at Cd Lvl) (7 kg)		*$13,034,088*
Mechanism Control Box Assembly (Redundant at Cd Lvl) (6 kg)		*$14,150,876*
Main Electronics Box Assembly (Qty 2, Redundant at Box Lvl) (8 kg ea)		*$24,678,196*
Harness Assembly (28 kg)		*$2,486,214*
Radiator Cover Deployment Assembly (1 kg)		*$350,910*
Detector Two Stage Radiator Mechanical Support Assy (1 kg)		*$318,216*
MEB Radiator Mechanical Support Assembly (1 kg)		*$305,881*
MCEB/AMCEB Radiator Mechanical Support Assembly (1 kg)		*$305,881*
Thermal Subsystem Assembly (25 kg)		*$6,094,422*
Polarimeter Instrument Assy Integration and Test		*$7,882,477*
Polarimeter Instrument Assy--SECOND UNIT COST-- (no NRE included)	$4,644,747	
Detector Throughputs:		
UV 1024 X 1024 Silicon (Qty 3 Flt, 1 Flt Spr, 4 Prototype, SEER-H Est, FY2012$)	$2,614,967	
VNIR 1024 X 1024 Silicon (Qty 3 Flt, 1 Flt Spr, 4 Prototype,SEER-H Est, FY2012$)	$2,614,967	
SWIR 1024 X 1024 HgCdTe (Qty 3 Flt, 1 Flt Spr, 4 Prototype, SEER-H Est, FY2012$)	$5,670,025	
PRICE-H Instrument Payload Estimate	$132,592,059	

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Summary Cost Estimate (GSFC Contractor bid rates, '12 Dollars)

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The Following are NOT PRICE-H estimates but are derived from PRICE-H estimates. These are included for completeness and are considered ROM 'Grass-roots' estimates. Consult the Grass-roots estimating organization for a more accurate estimate.	
Flight Software (SEER-SEM FSW Cost Estimate, Basis : IDL PACE-Polarimeter FSW SLOC Estimates, FY2012$)	$559,712
FSW Sustaining Engr (SEER-SEM, Basis : IDL PACE-Polarimeter FSW SLOC Est, Typically p/o Phase-E cost, FY2012$)	$641,660
FSW Development Environment & Simulator SW (IDL Grassroots Cost Estimate, Full Cost Builder Burdened Labor Rates)	$181,070
FSW Ground Support Equipment (FSW-GSE) (IDL Grassroots Cost Estimate)	$175,000
FPGA Development (4 Unique FPGAs & 4 Unique Algorithms identified) ($448.1K/FPGA minimum+ $224.1K/specific algorithm)	$2,688,800
Ground Support Equipment (GSE) (5% of Instrument Cost Estimate)	$6,629,603
Environmental Testing (5% of Instrument Cost Estimate)	$6,629,603
Flight Spares (10% of Instrument Cost Estimate)	$13,259,206
Engineering Test Unit (ETU) (5% of Instrument Cost Estimate for Environmental Test)	$6,629,603
Instrument to S/C Bus Integration & Test (5% of Instrument Cost Estimate, Typically Included in WBS 10.0) ($6.63M)	<<include in WBS 10.0
Instrument Subtotal with Wraps	**$169,986,316**
Institutional Charges (Basis of Estimate: GSFC CM&O-not applicable) (For GSFC, Contact Code 153 to verify applicability to your project)	**$0**
Instrument Total, WBS 5.0, FY2012$	**$169,986,316**

Estimate in R$Y for 60/40 Cost Fraction Option

NOTE: The Resulting Values below are calculated using 'Cost Spreading Calculator' on NASA JSC Website http://cost.jsc.nasa.gov/beta.html, and using 2010 NASA New Start Inflation Index from Explorer AO

			Point Estimate	
		Constant Yr$ to Spread	$165,678,671	
		Begin Year	2013	
		End Year	2018	
		Cost Fraction	0.6	
Year	Cumulative Cost fraction	Inflation Index	Annual Cost (Yr$11)	Annual Cost (Real Yr$)
2013	0.026395365	0.027	$4,373,149	$4,607,996
2014	0.220480469	0.026	$32,155,762	$34,763,538
2015	0.522536339	0.026	$50,044,215	$55,509,384
2016	0.805596985	0.026	$46,897,111	$53,371,079
2017	0.967970394	0.026	$26,901,811	$31,411,506
2018	1	0.026	$5,306,622	$6,357,301
Total Cost Estimate			$165,678,671	$186,020,804

*Note: This estimate is based upon a Point Design at CBE mass. It does not represent the uncertainty associated with the eventual actual design, which will vary from the point design. It is recommended that Point Design Estimate values be multiplied by 1.5 and used as a placeholder until the Confidence Level (CL) Cost analysis is completed. The GSFC goal is to have a cost at the 70% CL.

JSC Typical Values : Cost Fraction = 0.6 ; 60% of the cumulative cost has been expended when 50% of cumulative time has been reached (A=0.32 & B=0.68)

Note: Price-H estimate in 2012$ which was deflated to 2011 for use in this real year calculation tool.

BACKUPS

NASA Cost Estimating Overview

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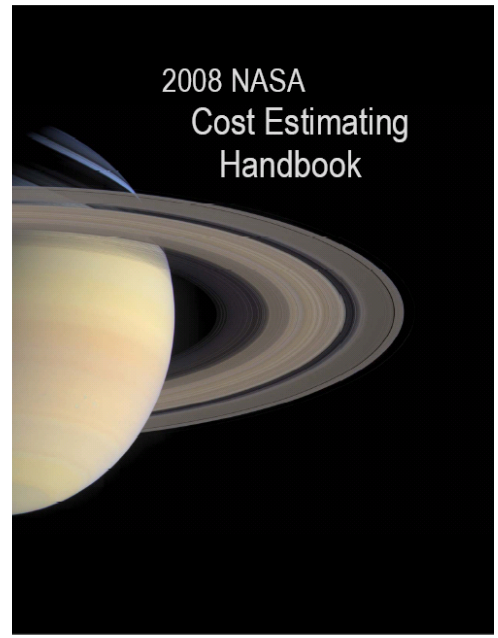
NASA Cost Estimating Handbook 2008

- Defines three cost estimating Methodologies
  - Parametric: based on key engineering data and Cost Estimating Relationships (CERs)
  - Analogy: comparison and extrapolation to like items or efforts
  - Engineering Build-Up (i.e., “grass-roots”): Labor and Material estimates based on experience and “professional judgment”
- Defines two cost estimating Processes
  - Advocacy Cost Estimates (ACE)
    - Cost Estimators are members of program/project team
  - Independent Cost Estimates (ICE)
    - Cost Estimators are from an organization separate from project
- Encourages parametric modeling and analogy estimates during pre-Phase A and Phase A studies

http://www.nasa.gov/offices/pae/organization/cost_analysis_division.html

http://ceh.nasa.gov



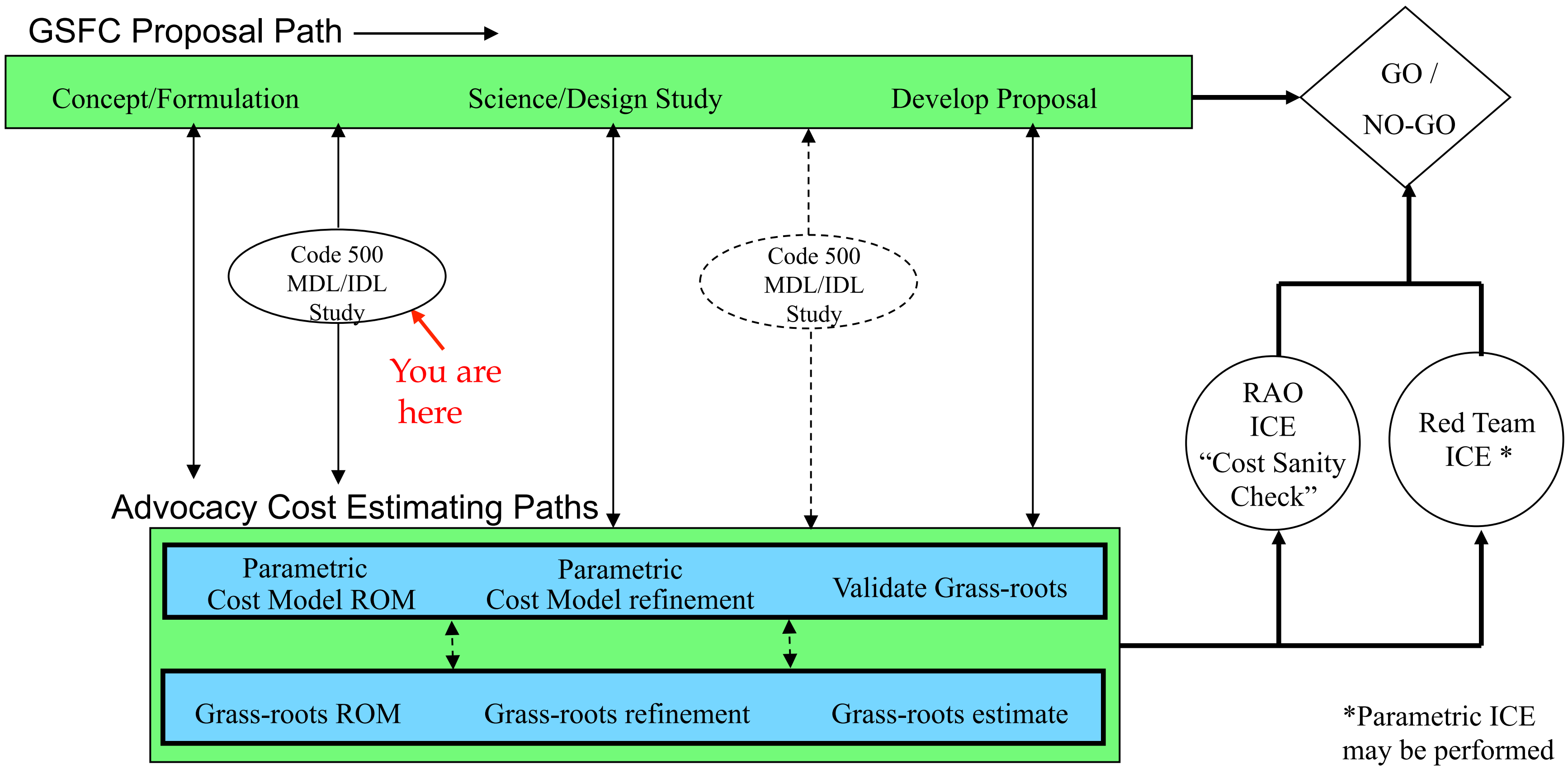
Proposal cost estimates evaluated at NASA Langley Research Center during Technical, Management, and Cost (TMCO) review

- Parametric models used to validate proposal cost estimate
- Assumed criteria for validation of Step 1 proposal (based on feedback): proposal estimate and TMCO consensus estimate within 20%

Current GSFC Proposal Cost Estimating “Best Practices”

- **Advocacy Cost Estimating**
  - **MDL, Proposal Teams**
    - Grassroots estimate based on Work Breakdown Structure (WBS)
    - Parametric modeling used for Grassroots validation
  - **IDL**
    - Parametric modeling used to generate a stand-alone cost estimate
    - No Grassroots (WBS) cost estimate to validate
- **Independent “Assessment” (provided by RAO)**
  - Internal cost estimating tools and historical databases
  - Provides critical “Sanity Check”
- **Evolving “Best Practices”**
  - GSFC Chief Financial Officer (CFO)
  - NASA Cost Analysis Steering Group
  - NASA Cost Estimating Handbook

Proposal Cost Estimating Process



*Parametric ICE may be performed on proposal

Cost estimating is an on-going iterative process

Parametric Cost Estimating Tools

- NASA Cost Estimating Handbook 2008 describes two commercial tools
  - PRICE: Parametric Review of Information for Costing and Evaluation
    - Separate modules for Hardware, Software, Integrated Circuits, and Life Cycle
    - PRICE H (Hardware) approaches cost estimates by parametrically defining:
      - Hardware to be built
      - Development and manufacturing environments
      - Operational environment
      - Schedule
    - PRICE H model is built from key engineering data (e.g., MEL: Master Equipment List)
    - Tool Heritage: Developed by RCA in the 1960's for the U.S. NAVY, Air force & NASA; Commercialized by PRICE Systems, L.L.C.
    - NASA-wide site license for PRICE H managed by Langley Research Center (GSFC Contact: Dedra Billings, Code 305.0, e-mail: Dedra.S.Billings@nasa.gov)
    - PRICE H use at GSFC:
      - Mission Design Lab (MDL/IMDC), 10+ years experience and 150+ S/C Bus models
      - Instrument Design Lab (IDL/ISAL), 8+ years experience and 120+ Instrument models
      - Code 600, 10+ years experience, 100+ S/C Bus and 100+ Instrument models
  - SEER: System Evaluation & Estimation of Resources
    - Separate modules for Hardware, Software, Integrated Circuits, Manufacturability and Life Cycle
    - NASA-wide site license for SEER managed by Langley Research Center
    - Application-specific use of SEER-H at GSFC (e.g., detectors, cryocoolers, etc.)

PRICE H: Key Input Parameters

- Global Parameters:
  - Labor Rates (set as appropriate)
    - GSFC Bid Rates (used for in-house build of spacecraft/instrument)
    - This Study → GSFC Typical Contractor Rates
      - Used for GSFC vendor provided hardware
      - Used when actual rates are not available
      - 10% G&A, 14% Fee
    - PRICE H Industry Labor Rates (default labor rates provided by Price Systems, Inc.)
      - ?% G&A, ?% Fee
  - Inflation (NASA escalation rates)
  - Engineering Environment (Defined for NASA by PRICE Systems, Inc. calibration study)
    - Emphasizes: System Engineering, Project Management, Automated design capabilities
- Individual Cost Component Parameters:
  - Complexity Factors (Table driven, defined by Price Systems from industry experience)
  - Modification Level/Remaining Design Factor (Heritage)
  - Quantity and Design Repeat (Learning Curve)
  - Composition (Structure, Electronic, Purchased, Cost Pass-through)
  - Mass
  - Operating Platform (Unmanned Space – High Reliability)

IDL Point Design Estimate & Cost Risk

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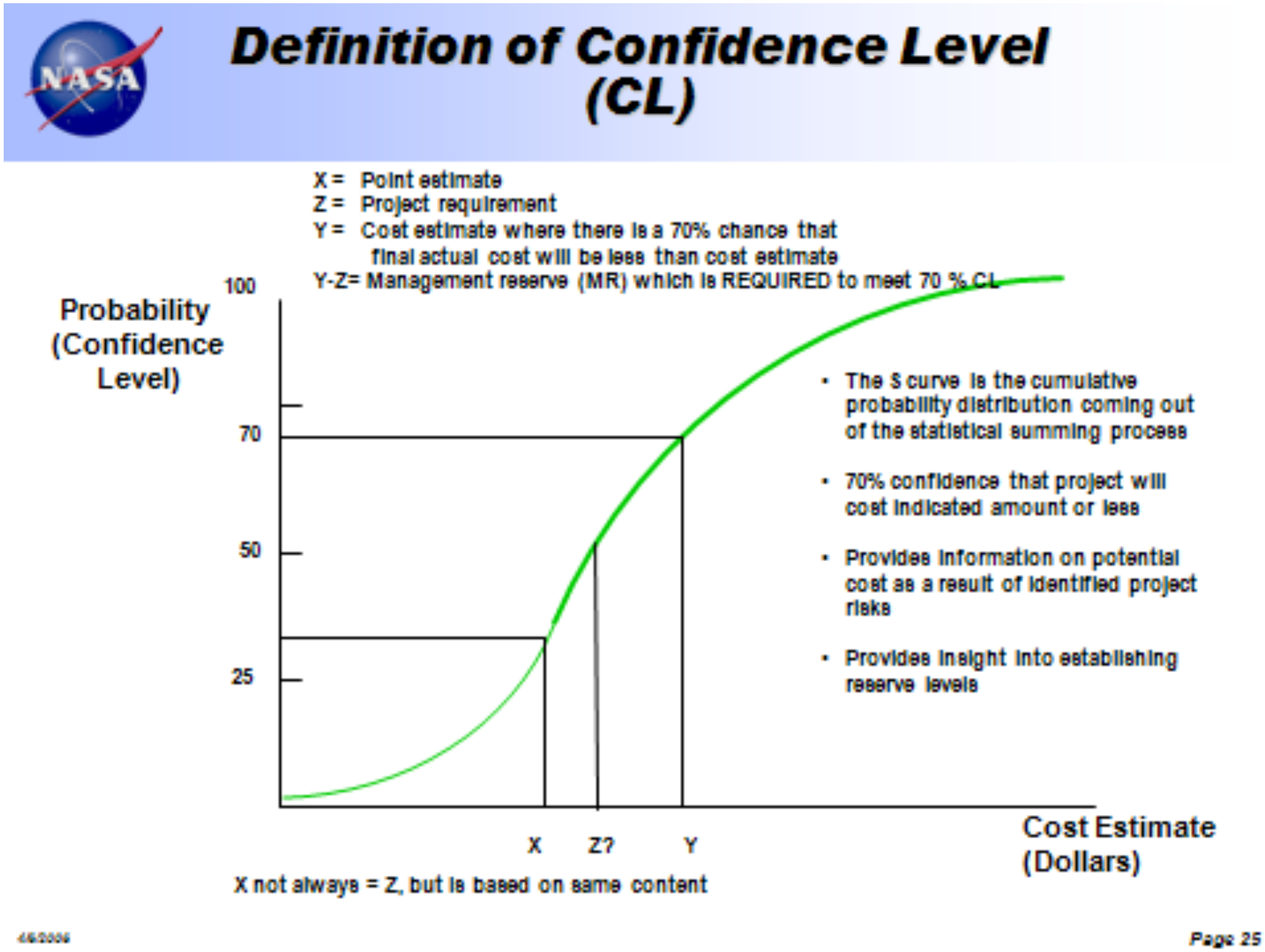
- The IDL Cost Estimate is a Point Estimate based on the single point design of the instrument
- The point design that the IDL derives in a 1-week study is an engineering solution, but not necessarily THE solution that will be implemented for flight
- The point estimate is described by the IDL in the MEL in terms of Current Best Estimate (CBE) of mass and materials, and represents a single estimate among a range of feasible possibilities
- Cost risk analysis attempts to address the risk that the eventual outcome of the parameters may differ from the CBE selections made at the conceptual design phase of pre-formulation
- Cost risk capabilities within the parametric cost modeling tool allow a range of input values to be entered to generate a range of cost outcomes
- Cost risk simulation is performed using well known sampling techniques (e.g. Monte Carlo simulation) of the parameter ranges resulting in a Probability Distribution Function (PDF) of possible outcomes, also known as a Density Curve
- PDF can also be represented as a Cumulative Distribution Function (CDF), also known as an S-Curve to provide a graphical representation of the possibilities of various cost outcomes
- Cost risk analysis takes additional labor and is beyond a 1-week IDL study, and is not recommended for the initial instrument conceptual design, but will be necessary for proposal development

Cost Product

Using your Point Design Estimate

- Often, early formulation Managers must get their designs into a cost box during IDC studies, before cost risk analysis can be performed
- Doing this requires trades and descopes against science performance, so descopes should be minimized whenever possible
- However, failure to fully understand the difference between a point design cost estimate and a probabilistic cost estimate can result in unexpected sticker shock later
- NASA desires probabilistic cost estimates at the 70% Confidence Level (CL) so that our endeavors have a 70% chance of succeeding without a cost overrun
- The point design cost estimate is ALWAYS well below the 70% CL, so Managers should realize this when working with a point estimate and use a rule of thumb multiplier to act as a placeholder for the extra money that will be required for a 70% CL price
- A reasonable multiplier is 1.5 X CBE point design cost, to use as a placeholder until you can complete the full cost risk analysis, when checking to see if your price is “in-the-box”
- This will allow Managers to make trades/descopes during very early engineering formulation, such as IDC studies, AND avoid sticker shock when the eventual cost risk analysis is completed, which requires a fair amount of design maturity to be developed first

Cost Confidence Level



Selected Slide, Definition of Confidence Level (CL), from “NASA Cost Risk Workshop at GSFC”.