Development of a Project Cost Estimating Capability

NASA Cost Symposium

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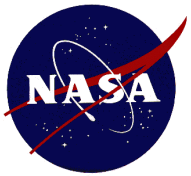

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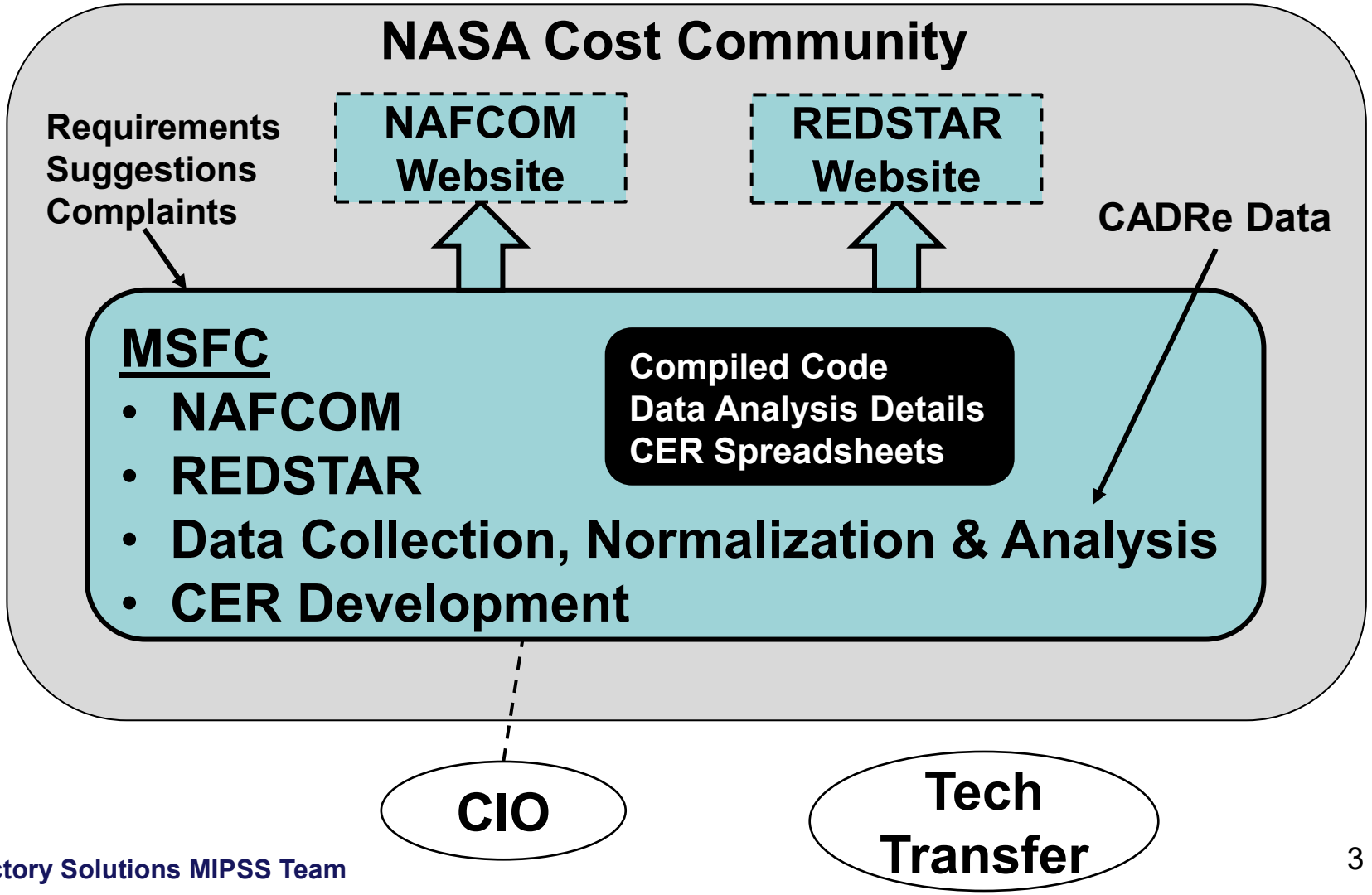
Outline

- A New Universe
- Overview of the Requirements and Architecture
- Overview of v1
- The Challenges
- Way Forward

The NAFCOM Universe

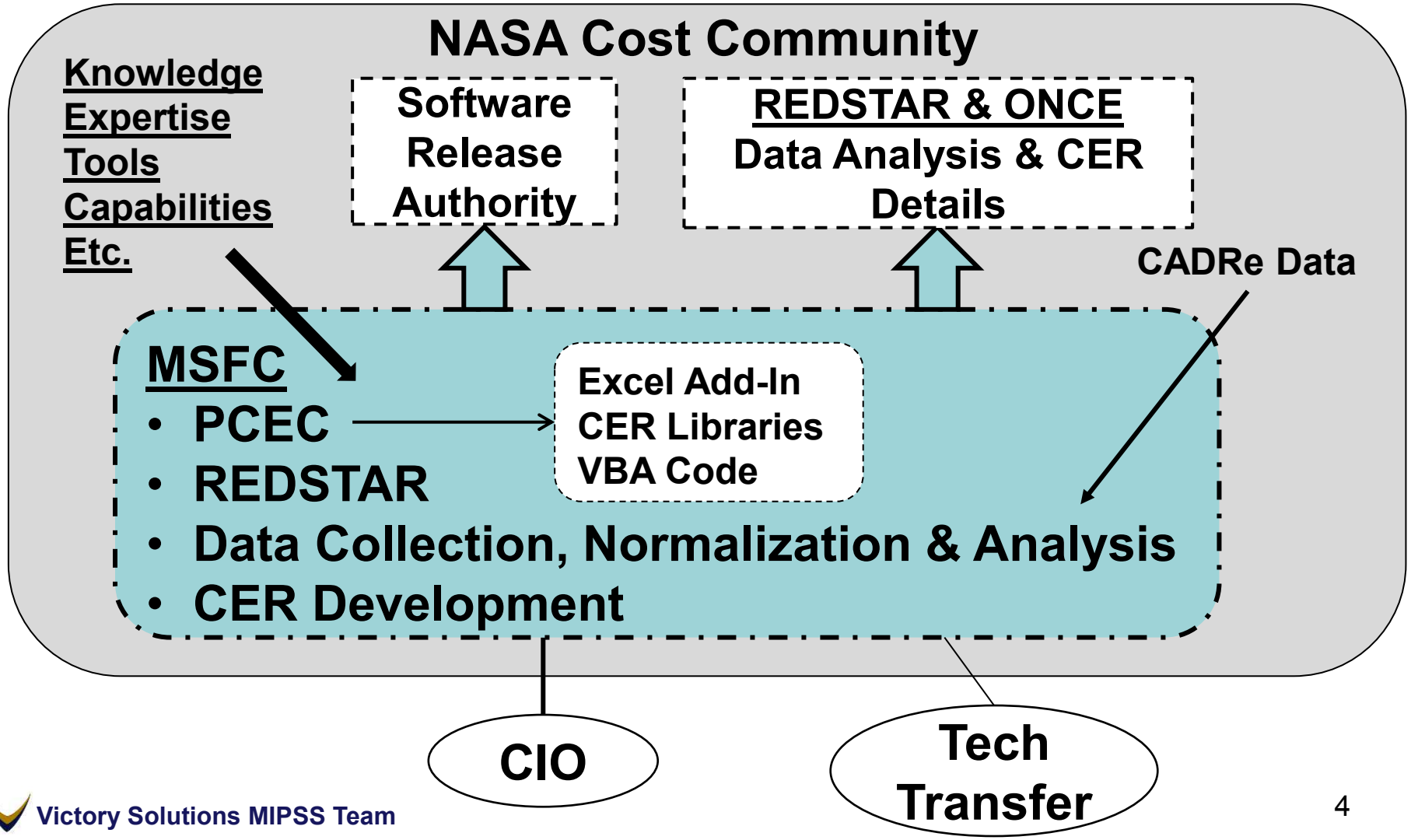
Engineering Cost Office

Closed System



The PCEC Universe

Open and Transparent System



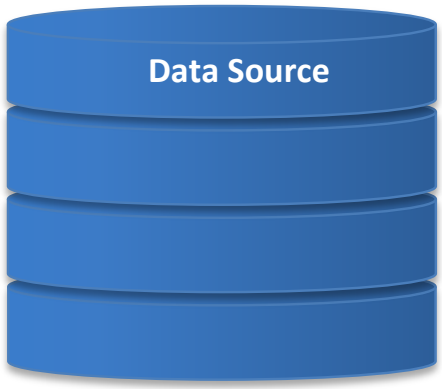
PCEC Requirements

- **The PCEC team formed a PCEC Steering Committee to guide, define, and develop core requirements**
  - Total of 25 Requirements Spread over 3 Levels
- **Key Attributes:**
  - Transparent and Customizable
  - Meet all NASA IT Security Requirements
  - Include Documentation and Statistics for all CERs
  - Traceable to the NASA Standard WBS
  - Separate CER Libraries and Software
  - Contain No Data or Links to Databases
  - *Implement an Agreed-Upon List of NAFCOM Capabilities to Carry Forward*

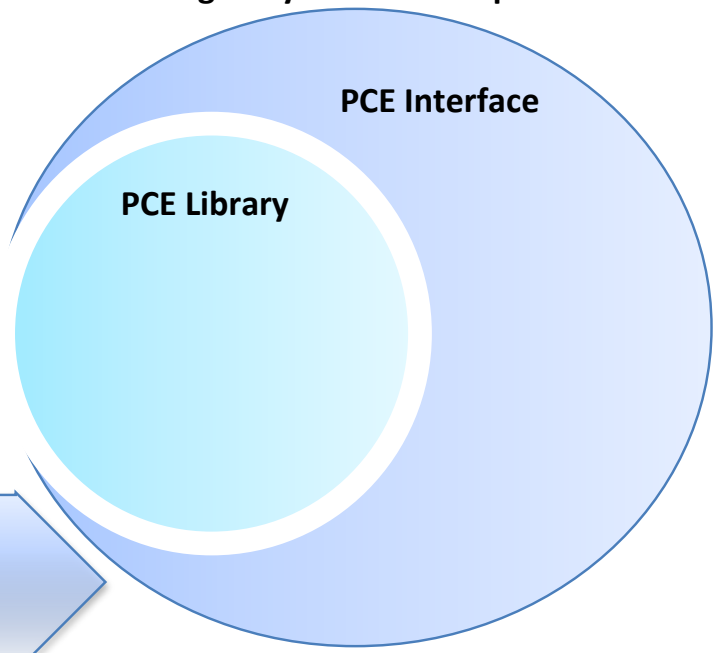
The PCEC Architecture

Key Elements of Project Cost Estimating Capability (PCEC) – Overview

- REDSTAR Library
- One NASA Cost Engineering (ONCE) Database



PCEC: Managed by PCEC Development team



CER Development & Source Documentat ion

Accessible with NASA User ID and Account Approval

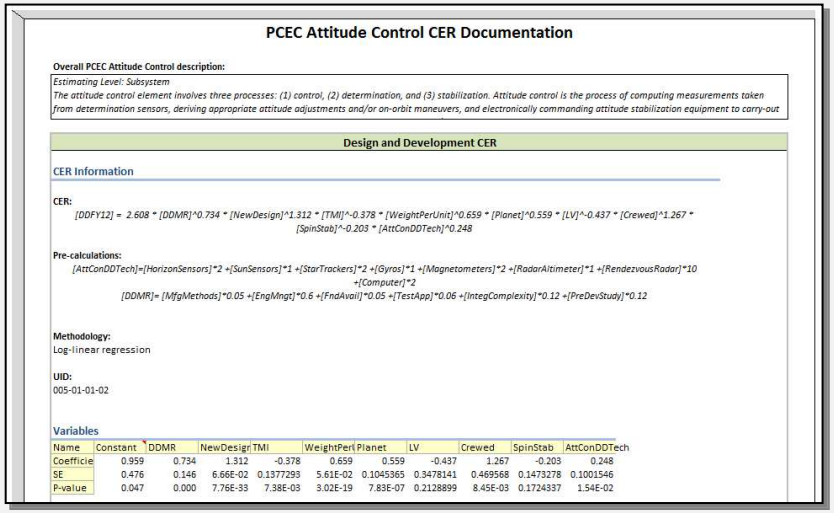
Publically Releasable via NASA Software Release Authority Process

NASA IT Security Interface

PCEC Elements

PCEC Library

- Store core cost estimating artifacts (CERs, WBS, Inflation, basic historical mission data)
- Contains NAFCOM12 CERs with associated statistics, as well as NAFCOM WBS templates and other information
- Excel Workbook



PCEC Attitude Control CER Documentation

Overall PCEC Attitude Control description:

Estimating Level: Subsystem
The attitude control element involves three processes: (1) control, (2) determination, and (3) stabilization. Attitude control is the process of computing measurements taken from determination sensors, deriving appropriate attitude adjustments and/or on-orbit maneuvers, and electronically commanding attitude stabilization equipment to carry-out

Design and Development CER

CER Information

CER:

*[DDFY12] = 2.608 * [DDMR]^0.734 * [NewDesign]^1.312 * [TMI]^-0.378 * [WeightPerUnit]^0.659 * [Planet]^0.559 * [LV]^-0.437 * [Crewed]^1.267 * [SpinStab]^-0.203 * [AttConDDTech]^0.248*

Pre-calculations:

*[AttConDDTech]=[HorizonSensors]*2 +[SunSensors]*1 +[StarTrackers]*2 +[Gyros]*1 +[Magnetometers]*2 +[RadarAltimeter]*1 +[RendezvousRadar]*10 +[Computer]*2*

*[DDMR]= [MfgMethods]*0.05 +[EngMngt]*0.6 +[FndAvail]*0.05 +[TestApp]*0.06 +[IntegComplexity]*0.12 +[PreDevStudy]*0.12*

Methodology:
Log-linear regression

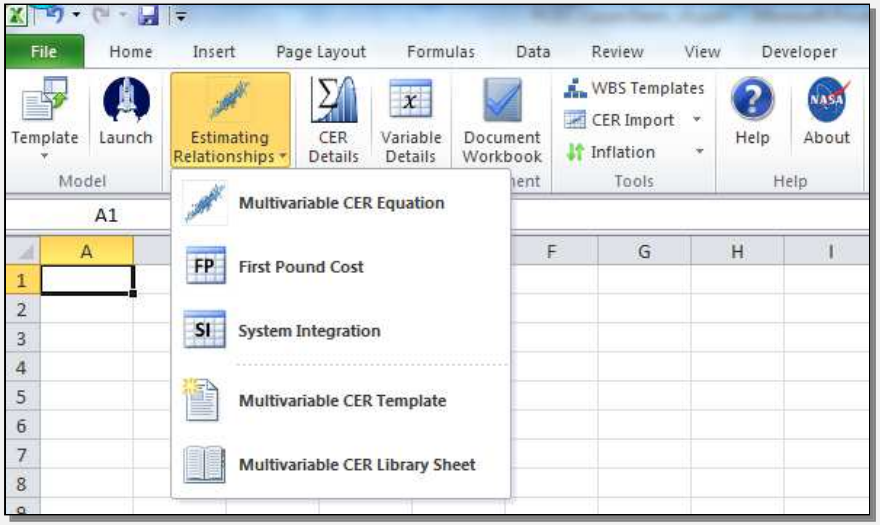
UID:
005-01-01-02

Variables

Name	Constant	DDMR	NewDesign	TMI	WeightPer	Planet	LV	Crewed	SpinStab	AttConDDTech
Coefficie	0.959	0.734	1.312	-0.378	0.659	0.559	-0.437	1.267	-0.203	0.248
SE	0.476	0.146	6.66E-02	0.1377293	5.61E-02	0.1045365	0.3478141	0.469568	0.1473278	0.1001546
P-value	0.047	0.000	7.76E-33	7.38E-03	3.02E-19	7.83E-07	0.2128899	8.45E-03	0.1724337	1.54E-02

PCEC Interface

- Facilitate the use of the PCEC Library information (e.g., inserting CERs, building WBSs) for creating estimates
- Automate redundant estimating processes
- Excel Add-In



CER Library Organization

- **Introduction**
- **General Information**
  - Variable List
  - Variable Influence Tables
  - Mission Information
  - WBS Dictionary
  - Inflation Table
  - CER Documentation Help
- **WBS Templates**
  - NASA NPR 7120.5E
  - NASA CADRe
  - NC12 Earth Orbiting Spacecraft
  - NC12 Planetary Spacecraft
  - NC12 Uncrewed Spacecraft
  - NC12 Crewed Spacecraft
  - NC12 Launch Vehicle Stage
- **Recommended CERs**
  - System Level
  - Group Level
  - Subsystem Level
  - Component Level
- **Legacy CERs**
  - Group Level
  - Subsystem Level
  - Component Level

Contents of Each CER Tab

- **CER Documentation**
- **Cost Calculation**
- **Risk Calculations**

CER Interface Organization

- **Microsoft Excel Add-in Workbook (XLAM)**
- **Provide features to facilitate the integration of project estimating artifacts contained in the *PCEC Library* into Excel-based cost models**
  - Automate Some of the Redundant Processes in Developing a Cost Estimate
  - Custom Tab on Excel's Ribbon
  - VBA based Methods for Formatting and Manipulating Worksheets

The ribbon contains the following button groups:

Models/Estimate

- Load and save model templates
- Launch an Estimate to get stared quickly with a custom model
- Insert individual CERs as a few lines or entire preformatted worksheets

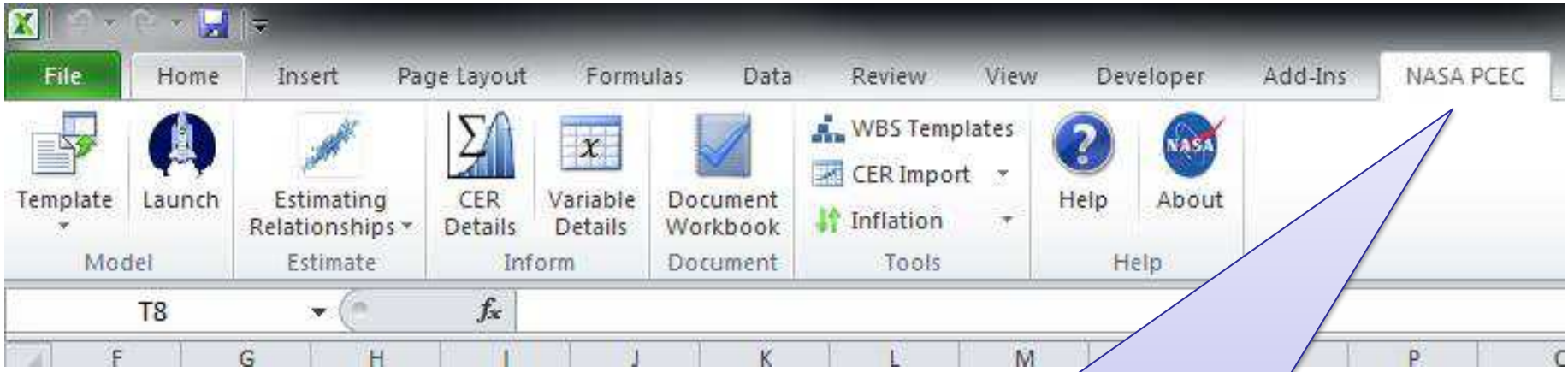
Inform/Document

- Learn more about CERs and variables
- Document and validate CERs used in your workbook

Tools/Help

- Insert WBS templates, Library worksheets and Inflation information into your workbook
- Use the in-tool Help file to learn more about what the PCEC can do for you

PCEC v1 Interface
Ribbon



The PCEC Ribbon Tab provides ease of access to all PCEC features, including:

- Cost Estimating Relationships
- Templates and Model Generation
- Documentation and Information
- Work Breakdown Structures
- Inflation tool
- Help

Near-Term PCEC Activities

- **Following an Incremental Development Approach to Incorporate Updates over the Next Several Releases (v1.x)**
  - Implementation of Uncertainty for First-Pound and System Integration
  - Integration of Outputs from other Excel-based Models: NICM, SOCM, etc.
  - Phasing
  - User-requested Improvements/Updates
  - Under the Hood Enhancements
- **Establishment of the PCEC Review & Release Process**
- **Upload v1 Data and CER Spreadsheets to REDSTAR**
- **Development of Training Materials and Example Models with Uncertainty/Risk**
- **Get State Department Approval for General Release!!**

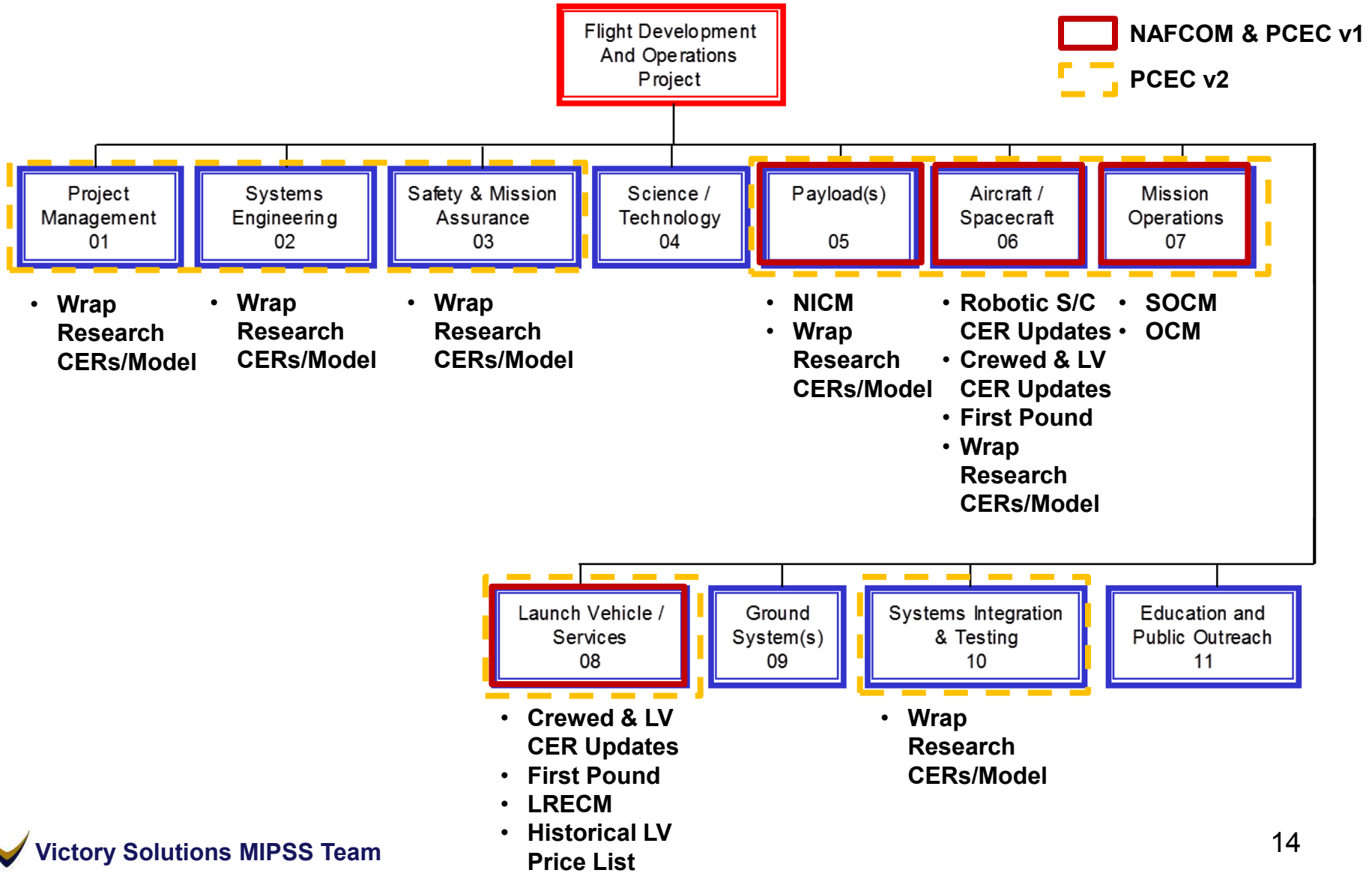
PCEC v2 Challenges

- **Integrated Model Construct**
  - Integration of Parallel Model Development Efforts
  - Incorporation of Legacy Tools (i.e. NICM)
  - CERs vs. Models
- **CADRe vs. Pre-CADRe Data**
- **Limited Data Sets for Crewed System, Launch Vehicles, and Space Transportation Systems**
  - Modeling Development and Production Environments
- **Approach to Data Analysis**
  - Full Cost Accounting
  - WBS and FBS
  - Cost Allocation by Phase
- **Objective vs. Subjective Variables**
- **Modeling System Level Costs**

Future PCEC Development

- **PCEC Library and Interface v2**
  - Changes in the Estimating Framework but…
  - Same Look, Feel, and Operation as the Existing Interface
- **Key Changes for v2**
  - NASA Standard WBS: Migration away from NAFCOM WBS
  - Space Flight hardware CER updates: New normalizations, new missions added, Tailored CERs/Models by Mission Type (robotic, crewed, launch vehicles)
  - New CERs for “wraps”: Results of Ongoing PM/SE/MA/I&T Research
  - Inclusion of more Models/Capabilities that Enable Total Life-Cycle Cost Estimating
- **New Data Normalization/Analysis and CER Workbooks Uploaded to REDSTAR (and ONCE?)**
- **PCEC v2 is Planned for Release 1Q FY15**

PCEC v2 & NASA Std WBS



Questions?

Backup

PCEC Library

PCEC CER Library
CER Documentation (1 of 3)

Engineering Cost Office

Overall PCEC Antenna description:

Estimating Level: Component
The antenna is the part of the uplink/downlink that enables a signal to be transmitted and/or received. There are many different types of antennas, but using one method of

Design and Development CER

CER Information

CER:

[Deployable]^1.708

Pre-calculations:

Methodology:
Log-linear regression

UID:
016-01-01-01

CER Name and description of what is being estimated

Text versions of the CER and any precalculations

PCEC CER Library
CER Documentation (2 of 3)

Engineering Cost Office

Variables

Name	Constant	WeightPerU	CommSC	ReconSC	TMI	Crewed	DDMR	NewDesign	Deployable
Coefficien	3.877	0.490	-0.395	-1.032	-1.586	1.279	0.098	1.651	1.7
SE	0.922	0.066	0.23336954	0.36861582	0.34973144	0.48633191	0.30590261	0.24181503	0.48992586
P-value	0.000	0.000	9.64E-02	7.10E-03	3.24E-05	1.11E-02	0.74977497	7.85E-09	9.79E-04

Regression Statistics

	Logspace				Logspace	Unit space
R^2	0.868	Regression DF	8	SSR	179.037	5964.2
Adj R^2	0.849	Residual DF	54	SSE	27.185	5888.8
F-Stat	44.455	Total DF	62	SST	206.222	15426.5
F-Stat P-V	0.000			SEE	0.710	10.443
PING Fact	1.241			Y_Bar	0.129	6.190
SPE	1.06227925			CV	5.495	1.687
				Pearson's Cc	0.932	0.81476191

Descriptive Statistics

Name	DDFY12	WeightPerU	CommSC	ReconSC	TMI	Crewed	DDMR	NewDesign	Deployable	R
Min	0.017	0.300	1.000	1.000	4.000	1.000	0.245	0.250	1.000	
Max	91.068	155.900	2.718	2.718	12.000	2.718	0.797	1.000	2.718	4
Mean	6.190	19.741	1.682	1.136	10.381	1.136	0.507	0.634	1.070	
Median	0.999	5.600	1.000	1.000	12.000	1.000	0.482	0.640	1.000	0.
SD	15.774	32.004	0.847	0.468	2.732	0.468	0.160	0.249	0.326	9.727

Correlation Matrix

	DDFY12	WeightPerU	CommSC	ReconSC	TMI	Crewed	DDMR	NewDesign	Deployable
DDFY12	1.0000	0.5415	0.1109	-0.3090	-0.6315	0.5275	0.2716	0.6093	0.3118
WeightPerU	0.5415	1.0000	0.3682	-0.2874	-0.2452	-0.0376	-0.0633	0.0339	0.1533
CommSC	0.1109	0.3682	1.0000	-0.2381	-0.2488	-0.2381	0.1652	-0.0243	-0.0115
ReconSC	-0.3090	-0.2874	-0.2381	1.0000	0.1614	-0.0862	-0.2393	0.0652	
TMI	-0.6315	-0.2452	-0.2488	0.1614	1.0000	-0.5564	-0.2324	-0.2947	
Crewed	0.5275	-0.0376	-0.2381	-0.0862	-0.5564	1.0000	0.3118	0.3682	
DDMR	0.2716	-0.0633	0.1652	-0.2393	-0.2324	0.3118	1.0000	0.3056	
NewDesign	0.6093	0.0339	-0.0243	0.0652	-0.2947	0.3682	0.3056	1.0000	0.2141
Deployable	0.3118	0.1533	-0.0115	-0.0648	0.0657	-0.0648	0.0423	0.2141	1.0000

Red Flag if Abs >=	0.7
Yellow Flag if Abs >=	0.6

Coefficients and associated regression information

Regression analysis information and statistics

Data descriptive statistics

Data correlation matrix

PCEC CER Library
CER Documentation (3 of 3)

Engineering Cost Office

Missions Used

AE-3	DMSP-5D	GPSMYP	NATO III	TDRSS
AMPTE-CCE	DMSP-5D3	HEAO-1	OMV	TOPEX
Apollo LM	DSCS-II	INTELSAT-IV	OSO-8	UFO
ATS-6	DSCS-IIIA	LRO	P78	
Chandra	DSP	MARISAT	SMS-1	
CRRES	GPS-IIR	Mars Pathfinder	TACSAT	

Missions whose data was used for regression

Variable Descriptions

INPUTS:

Name	Brief Desciption	Possible Values
WeightPerUnit	Weight Per Unit: Weight of each unit (pounds)	pounds, 0+
CommSC	Communication Spacecraft: Denotes whether the spacecraft class is Communication	1 if No, =EXP(1) if Yes.
ReconSC	Recon Spacecraft: Denotes whether the spacecraft class is Reconnaissance	
TMI	TMI: Technology Maturity Index of the element	
Crewed	Crewed: Denotes whether system is Crewed	
NewDesign	New Design: Rating based on the amount of new design expected for a subsystem	
Deployable	Deployable: Denotes whether the antenna is deployable	
MfgMethods	Manufacturing Methods: Rating that denotes the degree of use of advance manufacturing techniques	0-100% (Decimal in [0-1])
EngMngt	Engineering Management: Rating based on the level of engineering management for the system.	0-100% (Decimal in [0-1])
FndAvail	Funding Availability: Rating that reflects the anticipated funding availability for the system	0-100% (Decimal in [0-1])
TestApp	Test Approach: Rating based on the level of testing be conducted on the system	0-100% (Decimal in [0-1])
IntegComplexity	Integration Complexity: Rating based on the expected number of interfaces involving multiple contractors and/or centers	0-100% (Decimal in [0-1])
PreDevStudy	Pre-Development Study: Rating based on the amount of the study efforts that were/are being conducted prior to the start of	0-100% (Decimal in [0-1])

Variable descriptions

CALCULATED:

Name	Brief Desciption	Possible Values
DDFY12	DD FY12: Design & Development (D&D) Cost in fiscal year 2012 millions of dollars (FY12 $M)	FY12 $M, 0+
DDMR	DD Management Rating: Design and Development Management Rating	0-100% (Decimal in [0-1])

Model Uncertainty Analysis Information

Prediction Interval Distribution

Distribution: T-Distribution

Degrees of Freedom: 54

Squared Design Matrix

Constant	63	117.48375	24.9999832	4.99999664	144.158187	4.99999664	-46.202783		
WeightPerU	117.48375	375.449975	64.4989148	1.6140661	260.121996	8.31594564	-88.30718		
CommSC	24.9999832	64.4989148	24.9999664	0	54.4618716	0			
ReconSC	4.99999664	1.6140661	0	4.99999327	12.4245249	0	-5.0598765		
TMI	144.158187	260.121996	54.4618716	12.4245249	337.932302	8.05069797	-107.51333		
Crewed	4.99999664	8.31594564	0	0	8.05069797	4.99999327	-1.8516953		
DDMR	-46.202783	-88.307181	-16.594409	-5.0598765	-107.51333	-1.8516953	41.2446466	27.8983275	-1.7987906
NewDesign	-34.16088	-62.248428	-13.879504	-2.231434	-81.040663	0	27.8983275	30.3028771	-0.3302715
Deployable	2.69314584	7.97083671	0.99999865	0	6.44958287	0	-1.7987906	-0.3302715	2.48045032

Uncertainty information

PCEC CER Library
CER Calculation (1 of 2)

Engineering Cost Office

PCEC Antenna Cost Calculation

A calculating version of the CER set up similar to NAFCOM12 with dropdown lists for certain inputs

Value Name	*Input/ Calculation*			
Major Inputs				
	Weight			
Total Weight				
	Thruputs			
Design & Development				
System Test Hardware				
Flight Unit				
	Common Multivariable Inputs	**DD**	**FU**	
Manufacturing Methods	(3) Mod. Mfg Techniques	5%	65%	0.5
Engineering Management	(3) Mod Design Changes	60%	5%	0.5
New Design	(8) New design. Components validated in lab environ or relevant environment (100%)			1
Funding Availability	(2) Some Infrequent Delays Possible	5%	5%	0.5
Test Approach	(2) Moderate Testing, Qualification at Prototype/Protoflight Level	6%	15%	0.5
Integration Complexity	(1) Minimal Major Interfaces Involving Multiple Contractors/Centers	12%	5%	0.25
Pre-Development Study	(3) Less Than 9 Months of Pre-Phase C/D Study	12%	5%	0.75
	PCEC Antenna Component Specific Inputs			
Deploy	Yes			2.718281828
Spacecraft Class	(1) Communication			1
TMI	(12) Technology is mature (> 10 yrs) of flight experience encompassing at least 5 missions and			12

PCEC CER Library
CER Calculation (2 of 2)

Engineering Cost Office

Other Inputs		
Quantity Next Higher Level	1	1

CER Methodology		
Multivariable Type	(6) Shuttle Calibrated	

Globals		
Flight Year	2015	2015
Units	Thousands	1000

System Test Hardware (STH)		
STH Quantity	1	1
FU Percent	130	130

DD Point Estimate $FY12	$	1
STH Point Estimate $FY12	$	
FU Point Estimate $FY12	$	12,915.03
Total $FY12	$	141,335.85

Additional CER inputs

CER outputs

PCEC CER Library
Uncertainty Calculations

Engineering Cost Office

Placeholder for inserting a probability distribution from a Monte Carlo Excel Add ins

A calculating version of modeling uncertainty.

Takes point estimate from previously discussed Cost Calculation section

Outputs can be used in directly in a Monte Carlo model

This section shows uncertainty around the current point estimate as a CDF and at certain percentiles

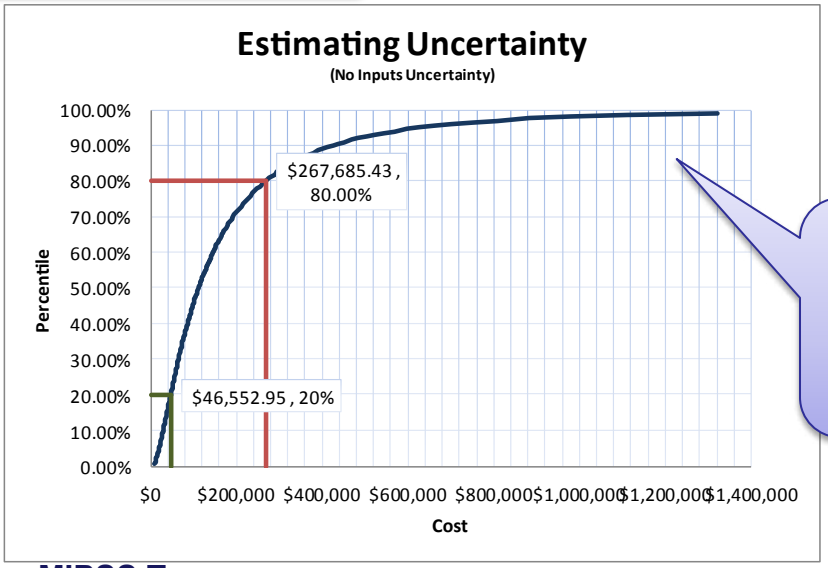
Uncertainty Adjusted Cost Estimate

...timate from the Cost Calculation section and a probability distribution function... ...e a range of cost values. This can be used directly in a Monte Carlo simulation...

Distribution type:		T-Distribution
...Freedom:		54
...y Distribution here:		
Standard Error Factor:		1.031
Log space Point Estimate:		4.715
Uncertainty Adjusted Log Space Estimate:		4.715
Uncertainty Adjusted Unit Space Estimate:	$	111.63
Uncertainty Adjusted Cost Value $FY12:	$	111,631.29

...ession Error Cumulative Distribution Function

... error surrounding the current point estimate from the Cost Calculation section.



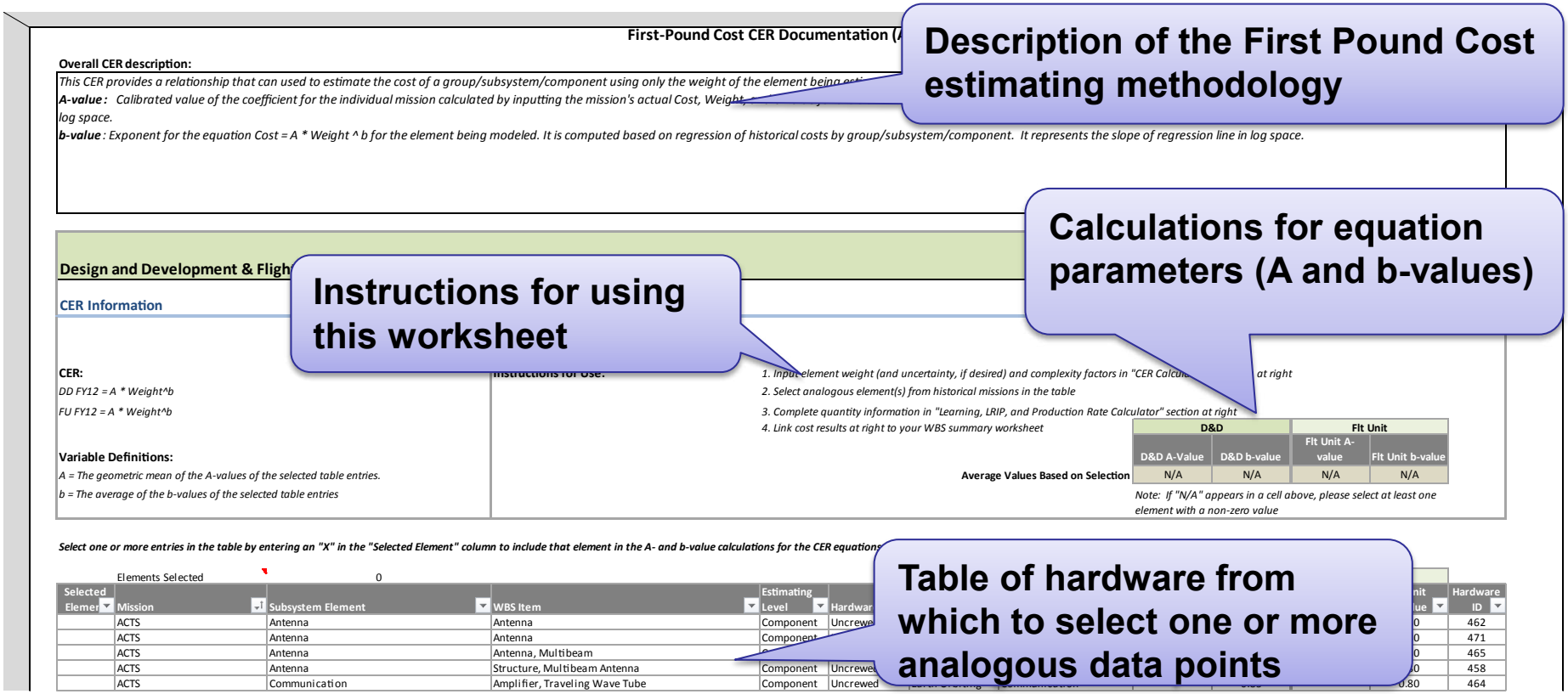
S-Curve Percentiles

20%	$ 46,552.9
80%	$ 267,685.4

Percentile	Cost $FY12
80%	$ 267,685.4
90%	$ 425,312.7

PCEC CER Library
First Pound Cost (1 of 2)

Engineering Cost Office



First-Pound Cost CER Documentation (A

Overall CER description:

This CER provides a relationship that can used to estimate the cost of a group/subsystem/component using only the weight of the element being esti

A-value: *Calibrated value of the coefficient for the individual mission calculated by inputting the mission's actual Cost, Weight, [illegible] log space.*

b-value*: Exponent for the equation Cost = A * Weight ^ b for the element being modeled. It is computed based on regression of historical costs by group/subsystem/component. It represents the slope of regression line in log space.*

Design and Development & Fligh

CER Information

CER:

*DD FY12 = A * Weight^b*

*FU FY12 = A * Weight^b*

Variable Definitions:

A = The geometric mean of the A-values of the selected table entries.

b = The average of the b-values of the selected table entries

Instructions for Use:

1. Input element weight (and uncertainty, if desired) and complexity factors in "CER Calcu[illegible] at right

2. Select analogous element(s) from historical missions in the table

3. Complete quantity information in "Learning, LRIP, and Production Rate Calculator" section at right

4. Link cost results at right to your WBS summary worksheet

	D&D		Flt Unit	
	D&D A-Value	D&D b-value	Flt Unit A-value	Flt Unit b-value
Average Values Based on Selection	N/A	N/A	N/A	N/A

Note: If "N/A" appears in a cell above, please select at least one element with a non-zero value

Select one or more entries in the table by entering an "X" in the "Selected Element" column to include that element in the A- and b-value calculations for the CER equations

Elements Selected 0

Selected Elemen	Mission	Subsystem Element	WBS Item	Estimating Level	Hardwar	Hardware ID
	ACTS	Antenna	Antenna	Component	Uncrewe	462
	ACTS	Antenna	Antenna	Component		471
	ACTS	Antenna	Antenna, Multibeam			465
	ACTS	Antenna	Structure, Multibeam Antenna	Component	Uncrewe	458
	ACTS	Communication	Amplifier, Traveling Wave Tube	Component	Uncrewed	464

Description of the First Pound Cost estimating methodology

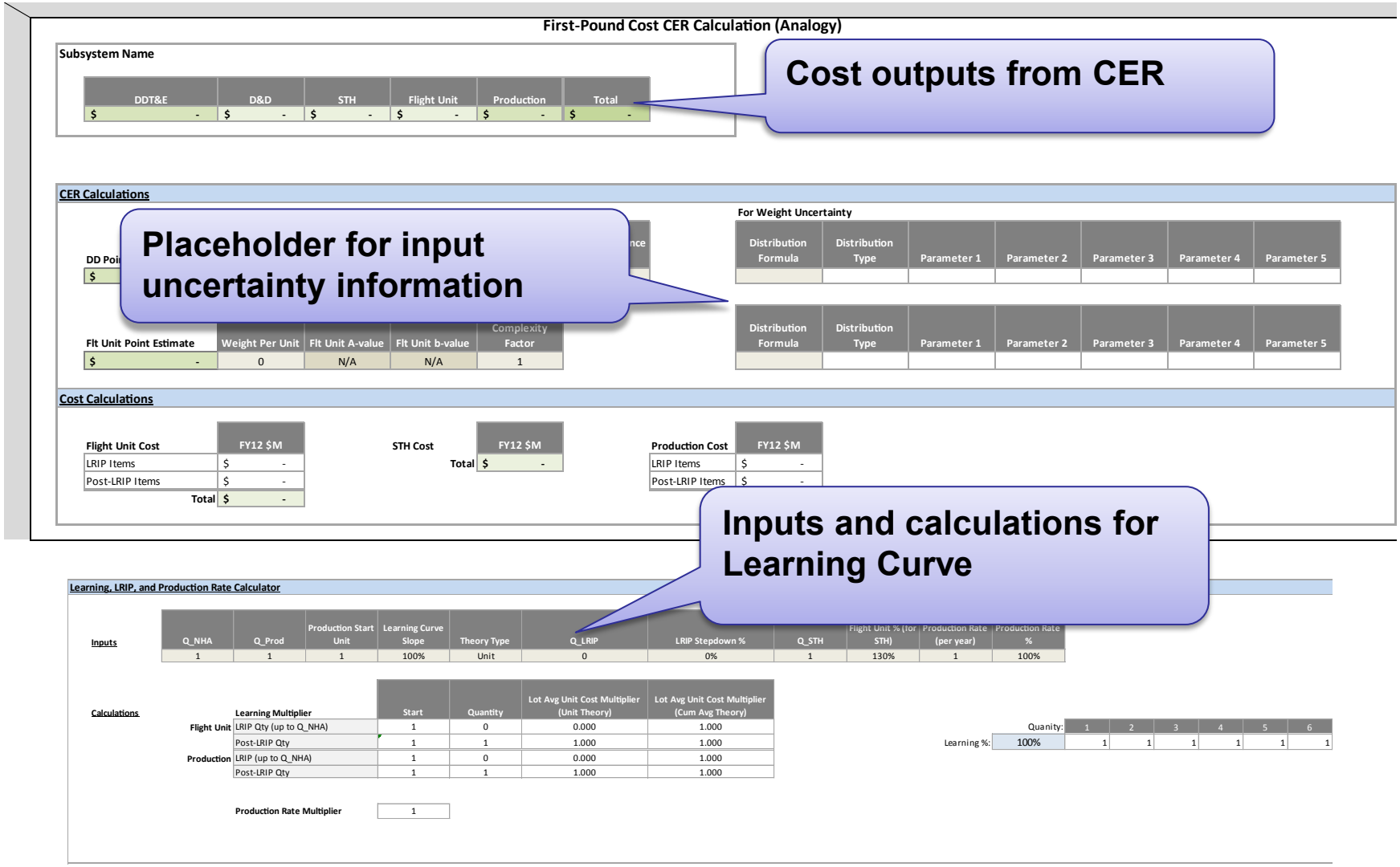
Calculations for equation parameters (A and b-values)

Instructions for using this worksheet

Table of hardware from which to select one or more analogous data points

PCEC CER Library
First Pound Cost (2 of 2)

Engineering Cost Office



PCEC CER Library
System Integration (1 of 2)

Engineering Cost Office

System Integration Cost CER Documentation (Analogy)

Overall CER description:

This CER provides a relationship that can used to estimate the cost of a System Integration cost element using spacecraft hardware c
***A-value**: Calibrated value of the coefficient for the mission calculated by inputting the mission's actual SI Cost, Weight, and b-value*
the y-intercept of the regression line in log space.
***b-value**: Exponent for the equation SI Cost = A * HardwareCost ^ b for the element being modeled. Computed based on regression c*

Description of System Integration estimating methodology

Design and Development & Flig

CER Information

Instructions for using this worksheet

CER:
*DD FY12 = A * Cost^b*
*FU FY12 = A * Cost^b*

Variable Definitions:

A = The geometric m
b = The average of t
Cost = Spacecraft Ha

Calculations for equation parameters (A and b-values)

1. Input total spacecraft costs (D&D, STH, Flt Unit, Prod.) in the "CER Calculations" section to the right (or link to WBS)
2. Select analogous mission(s) in the table below
3. Input any additional factors you wish to apply to the costs in the section to the right
4. Link cost results in "System Integration Costs" section at right to your WBS summary worksheet

Average Values Based on Selection

	DDT&E A-value	DDT&E b-Value	Flt Unit A-value	Flt Unit b-Value
IACO	N/A	N/A	N/A	N/A
STO	N/A	N/A		
GSE	N/A	N/A		
SE&I	N/A	N/A	N/A	N/A
PM	N/A	N/A	N/A	N/A
LOOS	N/A	N/A		

Spacecraft Cost to Use

DDT&E	Flt Unit
STH	Flt Unit
D&D + STH	
D&D + STH	
D&D + STH	Flt Unit
D&D + STH	Flt Unit
D&D + STH	

Note: If "N/A" appears in a cell above, please select at least one element with a non-zero value

Select one or more entries in the table by entering an "X" in the "Selected Mission" column to include that mission in the A- and b-value calculations for the CER equations

Elements Selected 0

Table of hardware from which to select one or more analogous data points

Selected Mission	Mission	Hardware Class	Orbit	Spacecraft Class	Estimating Level						Flt Unit A-value - STO	Flt Unit B-Value - STO
	ACTS	Uncrewed	Earth Orbiting	Communication	System							
	AE-3	Uncrewed	Earth Orbiting	Scientific	System							
	AEM-HCMM	Uncrewed	Earth Orbiting	Scientific	System							
	ALEXIS	Uncrewed	Earth Orbiting	Scientific	System							

PCEC CER Library
System Integration (2 of 2)

Engineering Cost Office

System Integration Costs

	DDT&E	D&D	STH	Flight Unit	Production	Total
IACO	$ -			$ -	$ -	$ -
STO	$ -					$ -
GSE	$ -					$
SE&I	$ -			$ -	$ -	$ -
PM	$ -			$ -	$ -	$ -
LOOS	$ -					$ -

Cost outputs from CER

CER Calculations

Spacecraft Cost Inputs

Link to WBS T

CER Calculations

IACO	$ -	$ -	N/A	N/A	1.00	$ -	$ -	N/A	N/A	1.00	$ -
STO	$ -	$ -	N/A	N/A	1.00						
GSE	$ -	$ -	N/A	N/A	1.00						
SE&I	$ -	$ -	N/A	N/A	1.00	$ -	$ -	N/A	N/A	1.00	$ -
PM	$ -	$ -	N/A	N/A	1.00	$ -	$ -	N/A	N/A	1.00	$ -
LOOS	$ -	$ -	N/A	N/A	1.00						

PCEC Interface

PCEC Interface Templates

Structured for CER Inputs
CER Output Summary for DDT&E, D&D, STH, Flight Unit, Production and Total Cost

PCEC Power Distribution

DDT&E	D&D	STH	Flight Unit	Production	Total
$ 11.021	$ 11.021	$ -	$ -	$ -	$ 11.021

Structured for CER Inputs
Multivariable CER FU and DD sections with variable input information and CER formula references in place

CER Calculation

PCEC Power Distribution DD	Weight Per Unit	Launch Vehicle	Crewed	New Design	DD Management Rating	Manufacturing Methods	Engineering Management
$ 11.021	1000	1	1	0.75	0.534	0.8	0.56
	9.8593E-06	1.00602E-05	0.018137938	0.000862701	0.050984275	---	---
	pounds, 0+	1 if No, =EXP(1) if Yes.	1 if No, =EXP(1) if Yes.	0-100% (Decimal in [0-1])	0-100% (Decimal in [0-1])	0-100% (Decimal in [0-1])	0-100% (Decimal in [0-1])
	Uncertainty Adj. Prediction	SSE Adjusted	Adjustment Factor	SEE	T-Distribution	Degrees of Freedom	
	11.02053177	0.690063994	1.071588041	0.643963881		31	

Notes:

PCEC Power Distribution FU	Weight Per Unit	Launch Vehicle	Crewed	New Design	Planetary Rating	FU Management Rating	Manufacturing Methods
$ -	1000	1	1	0.75	1	0.738	0.8
	4.66569E-05	0.03926264	0.005373827	0.026690061	0.091531793	0.924792728	---
	pounds, 0+	1 if No, =EXP(1) if Yes.	1 if No, =EXP(1) if Yes.	0-100% (Decimal in [0-1])	1 if No, =EXP(1) if Yes.	0-100% (Decimal in [0-1])	0-100% (Decimal in [0-1])
	Uncertainty Adj.	SSE Adjusted	Adjustment Factor	SEE	T-Distribution	Degrees of	
	#NUM!	#NUM!	#NUM!	0.621478963		30	

Notes:

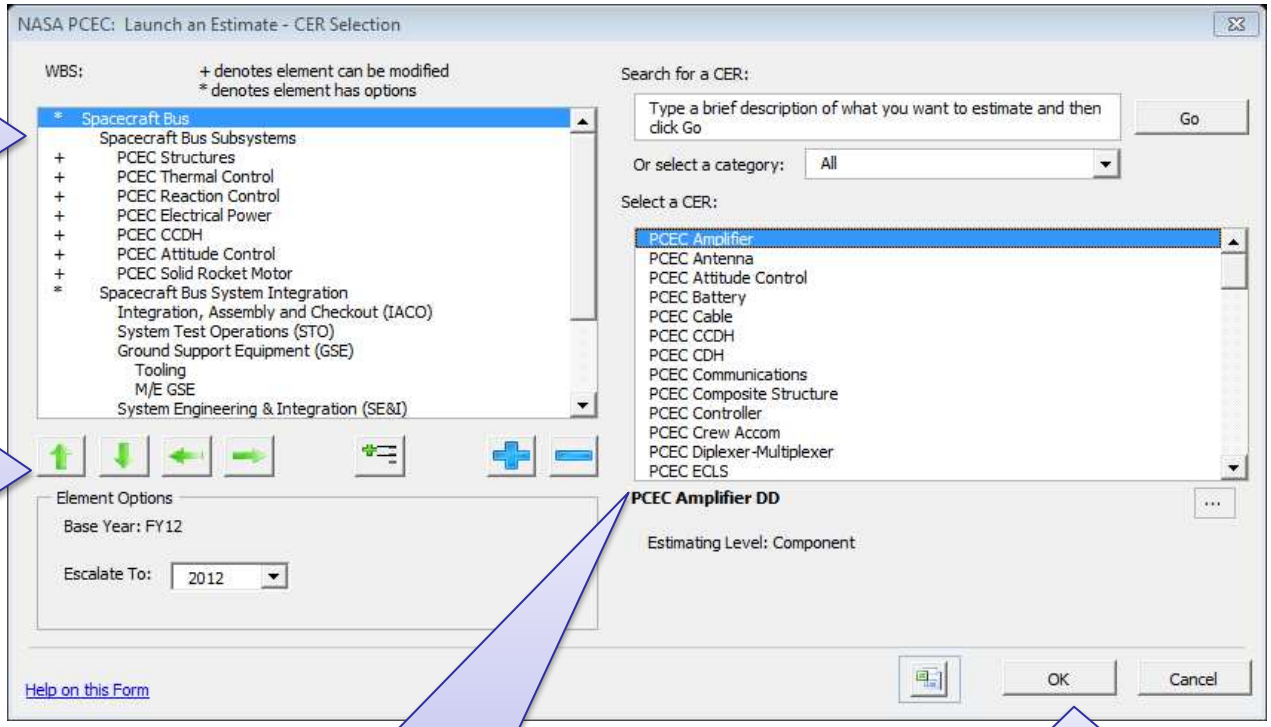
Additional Calculation Sections
Sections for calculating Learning, LRIP, and Production Rate based on CER inputs

PCEC Interface
Launch an Estimate

Engineering Cost Office

Modify WBS Elements
Add and remove CERs from WBS Hardware sections

Tailor WBS Hierarchy
Create summary elements and sub-elements to tailor WBS



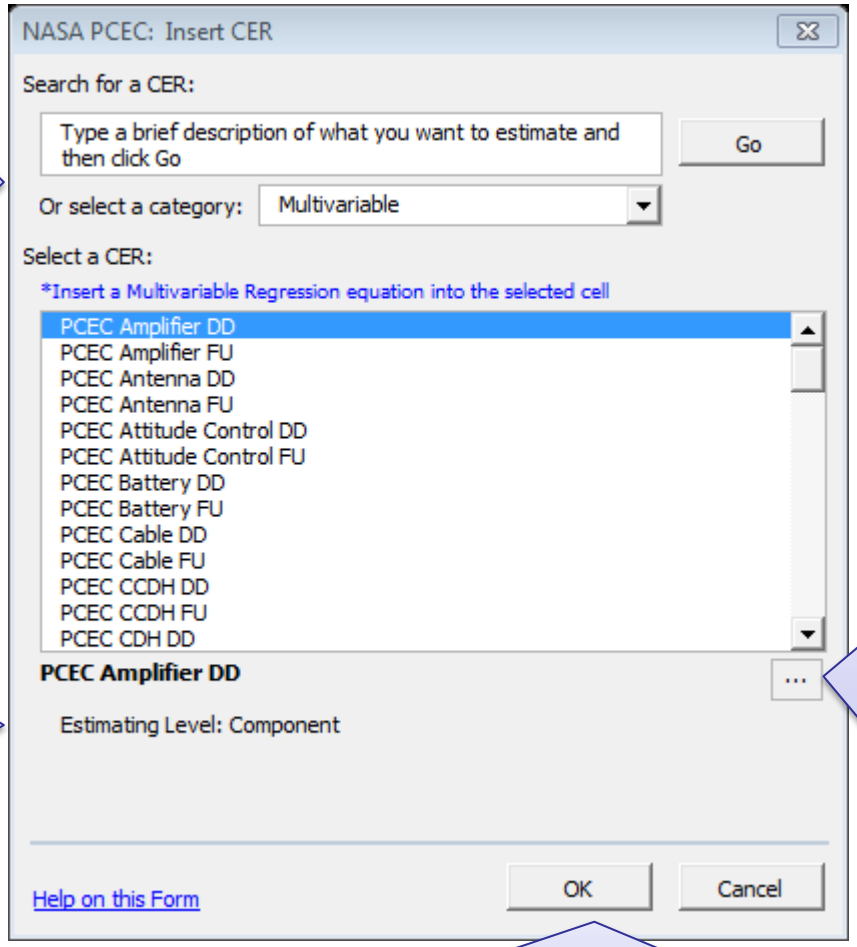
CER Search
Search PCEC CERs by keyword or category for inclusion in WBS

Launch an Estimate
Create estimate that includes the created WBS with links to the selected CERs

PCEC Interface
Search CER Library

Engineering Cost Office

CER Search
Search PCEC CERs by keyword or categories such as: Level, WBS, or Methodology



CER Description
See detailed information about the selected CER

Multivariable CER Info
View detailed info about CER including statistics and documentation

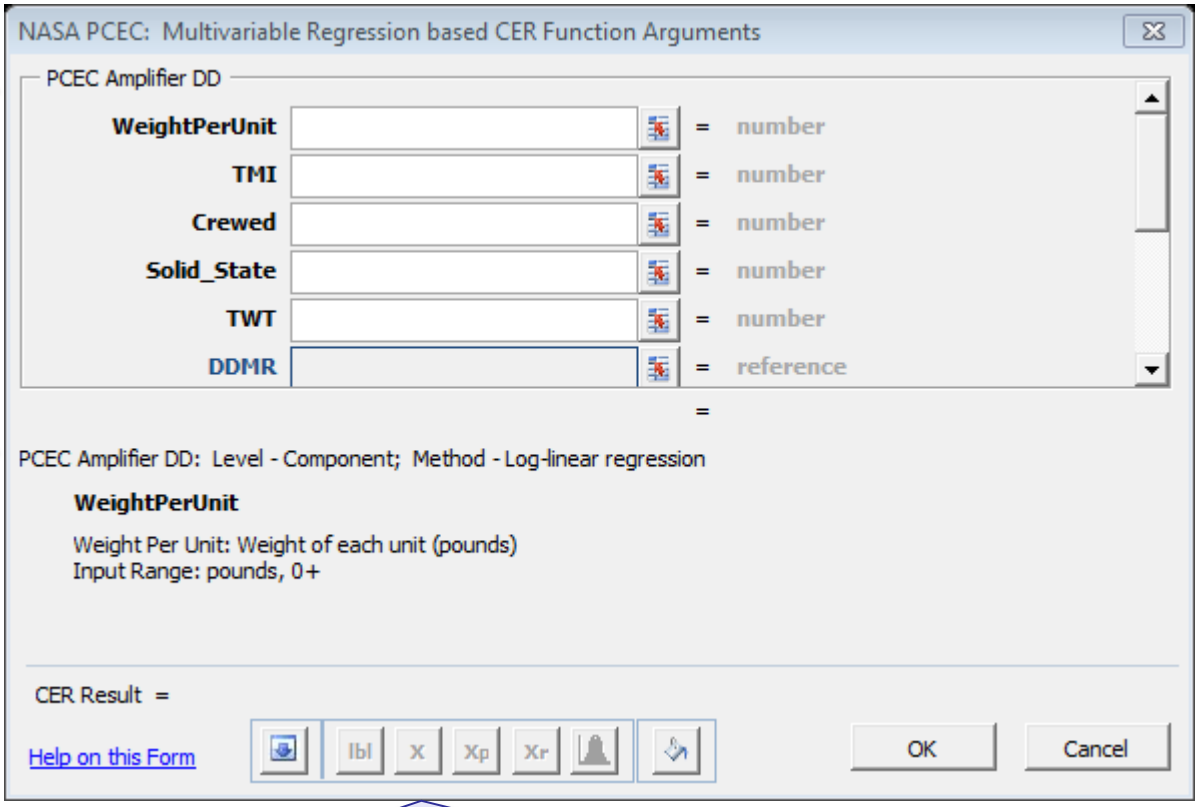
CER Description
Proceed to the next step in entering a CER into your model

PCEC Interface
Insert Multivariable CER

Engineering Cost Office

Multivariable CER Inputs
Input values into CERs as values or references to cells

Input Descriptions
View context sensitive information about the selected input variable



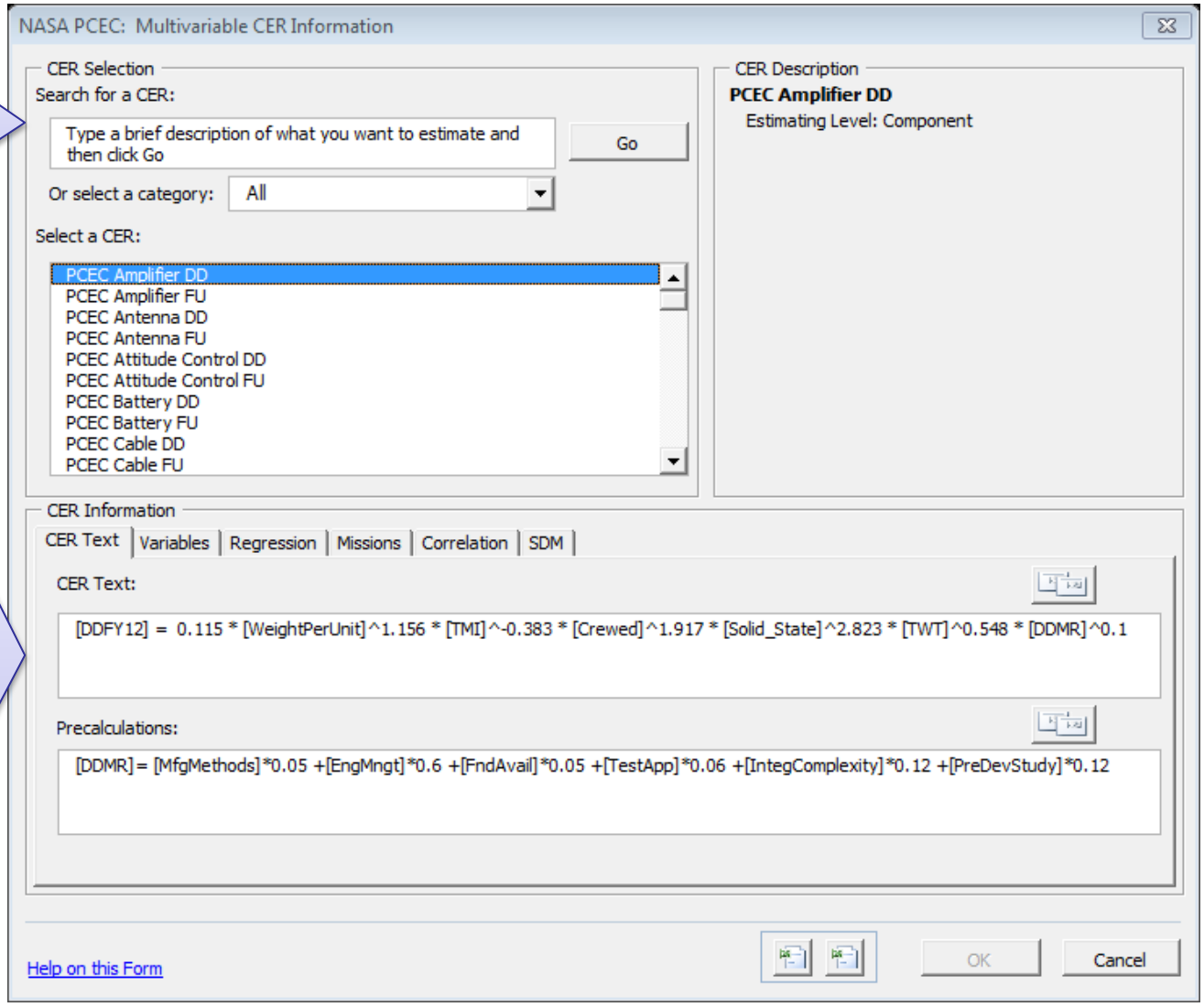
Output Options
Specify what information to output with the CER as well as format choices and uncertainty calculations

PCEC Interface
CER Details

Engineering Cost Office

CER Search
Search PCEC CERs by keyword or category

CER Information
View detailed information for Multivariable CERs including: Equation Text, Variable Info, Regression Statistics, Included Missions, Variable Correlation, and Uncertainty Info

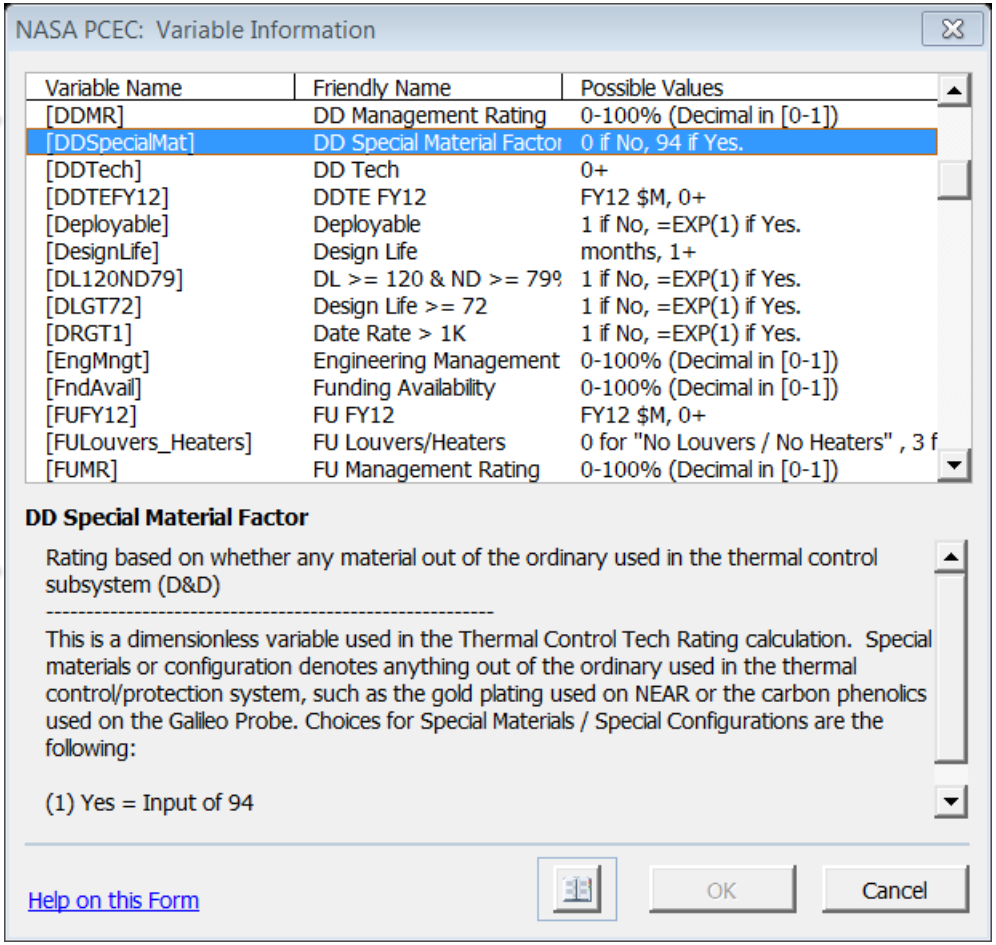


PCEC Interface
Variable Information

Engineering Cost Office

Variable Information
View critical information about CER variables such as Name, Friendly Name, and range of possible input values

Variable Description
View variable definition and a detailed description of how input Values impact a CER output



PCEC Interface Document Workbook

Engineering Cost Office

CER Document Table
View a table of all CERs included in the workbook. The table contains links to CER Documentation and the CER's cell location in the workbook

Estimating Relationship Documentation Report created at: 5/12/2014 3:55:15 PM

Estimating Relationship Name	Worksheet	Address	Valid
PCEC Amplifier DD	Sheet1	B2	TRUE
PCEC Structures DD	PCEC Structures CER	C13	TRUE
PCEC Structures FU	PCEC Structures CER	C35	TRUE
PCEC Thermal Control DD	PCEC Thermal Control CER	C13	TRUE
PCEC Thermal Control FU	PCEC Thermal Control CER	C35	TRUE
PCEC Reaction Control DD	PCEC Reaction Control CER	C13	TRUE
PCEC Reaction Control FU	PCEC Reaction Control CER	C35	TRUE
PCEC Electrical Power DD	PCEC Electrical Power CER	C13	TRUE
PCEC Electrical Power FU	PCEC Electrical Power CER	C35	TRUE
PCEC CCDH DD	PCEC CCDH CER	C13	TRUE
PCEC CCDH FU	PCEC CCDH CER	C35	TRUE
PCEC Attitude Control DD	PCEC Attitude Control CER	C13	TRUE
PCEC Attitude Control FU	PCEC Attitude Control CER	C35	TRUE
PCEC Solid Rocket Motor DD	PCEC Solid Rocket Motor CER	C13	TRUE
PCEC Solid Rocket Motor FU	PCEC Solid Rocket Motor CER	C35	TRUE
PCEC Power Distribution DD	PCEC Power Distribution CER	C13	TRUE
PCEC Power Distribution FU	PCEC Power Distribution CER	C35	TRUE

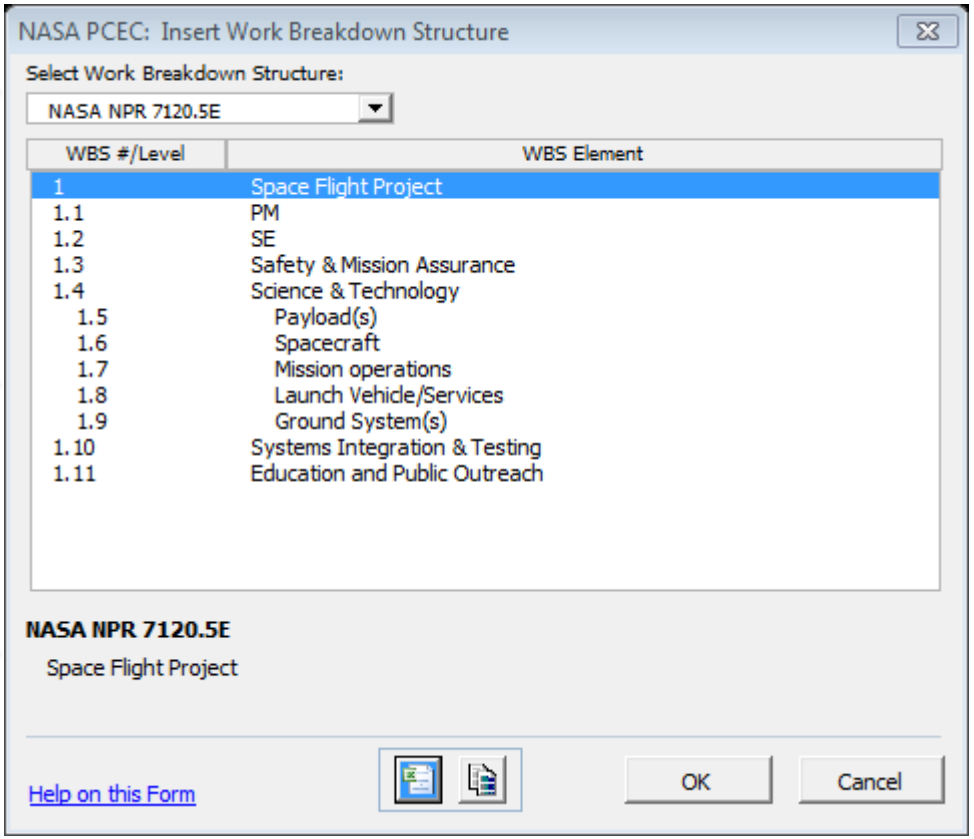
CER Documentation
CER documentation contains the following information about Multivariable CERs: CER Description, Equation Text, Variable Information, Regression Statistics, and Descriptive Statistics,

PCEC Interface
Insert WBS

Select WBS
Select WBS from all WBS available in the PCEC library

WBS View
View the elements of the selected WBS

Element Description
View the elements of the selected WBS



Insert WBS
Insert WBS as a new worksheet or as a list of values in a specified location

PCEC Interface Inflation

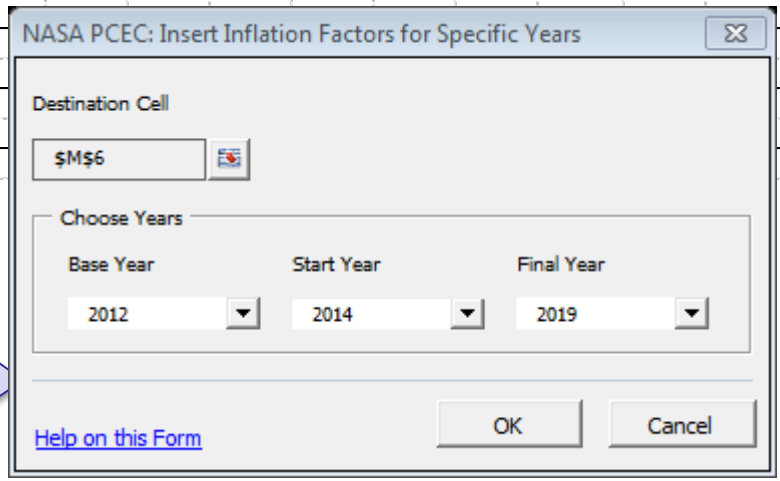
Engineering Cost Office

NASA NEW START INFLATION INDEX--(ACTUALS THRU September 2013)

YEAR	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	TQ	1977
INFL.RATE	4.0%	4.3%	3.2%	4.0%	3.5%	4.5%	3.4%	6.0%	4.9%	5.4%	5.7%	6.9%	6.3%	5.7%	5.7%	7.2%	10.8%	9.0%	2.1%	8.5%
FACTORS	1.040	1.043	1.032	1.040	1.035	1.045	1.034	1.060	1.049	1.054	1.057	1.069	1.063	1.057	1.057	1.072	1.108	1.090	1.021	1.085

Inflation Table
Insert the NASA NEW START INFLATION INDEX table as a new worksheet in the workbook

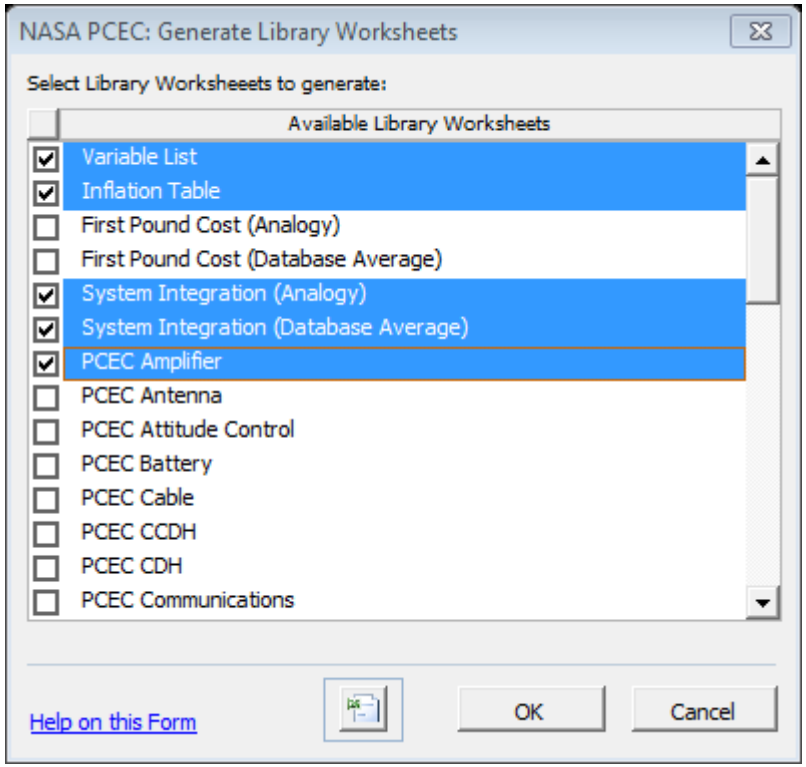
Inflation Factors
Specify a range of years to return a subset of the inflation table



PCEC Interface
Insert Library Worksheets

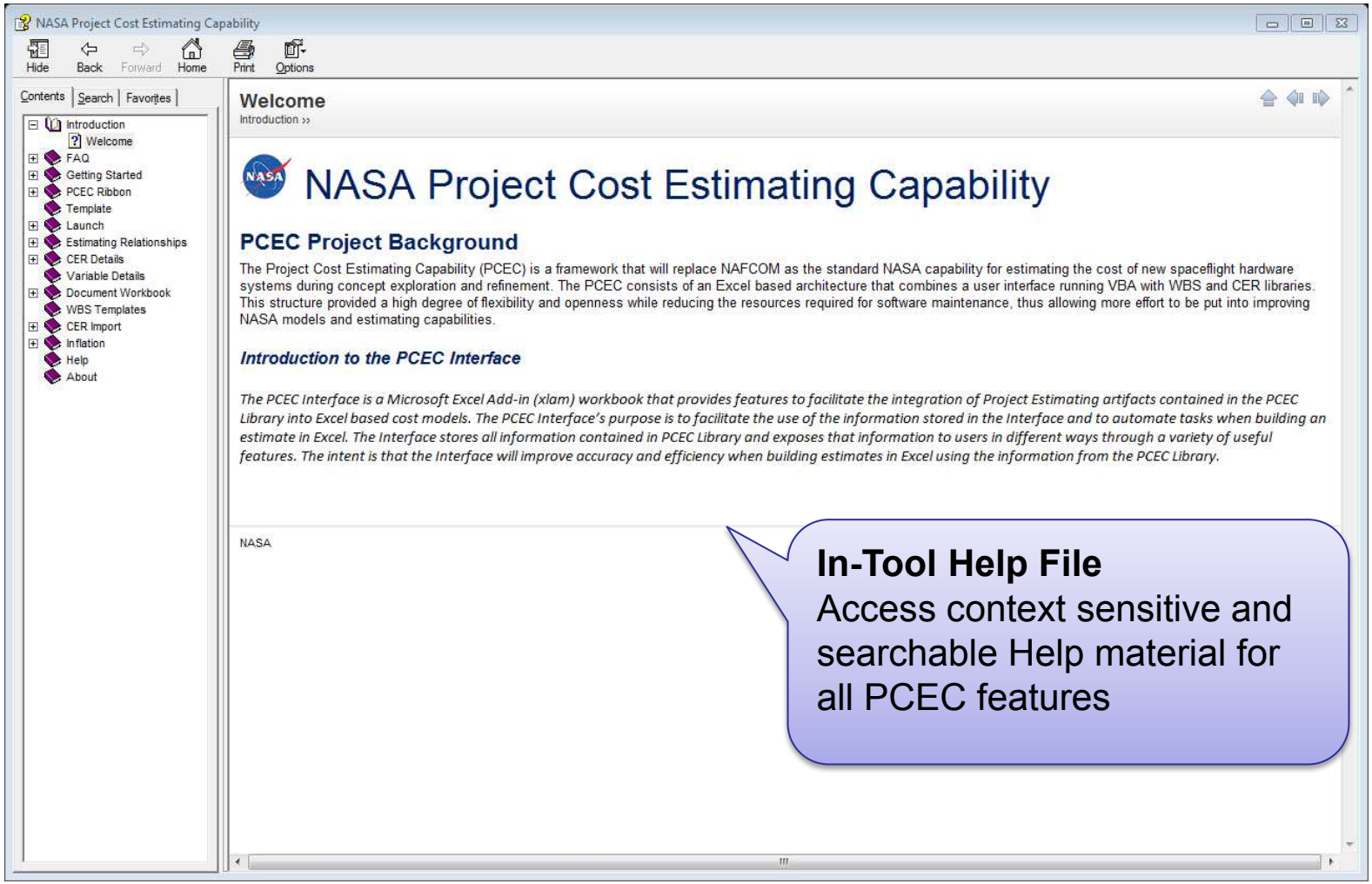
Engineering Cost Office

Library Worksheets
Generate PCEC Library worksheets as new worksheets in the workbook or as worksheets in a new workbook



PCEC Interface
In-Tool Help File

Engineering Cost Office



In-Tool Help File
Access context sensitive and searchable Help material for all PCEC features