

# Development of a Project Cost Estimating Capability

ICEAA

June 12, 2014

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## Outline




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- Overview of the NASA/Air Force Cost Model (NAFCOM)
- Rationale for Developing a New Project Cost Estimating Capability (PCEC)
- Overview of the Requirements and the Architecture for the PCEC
- Demo of PCEC (Library and Interface)




## NASA Air Force Cost Model (NAFCOM)



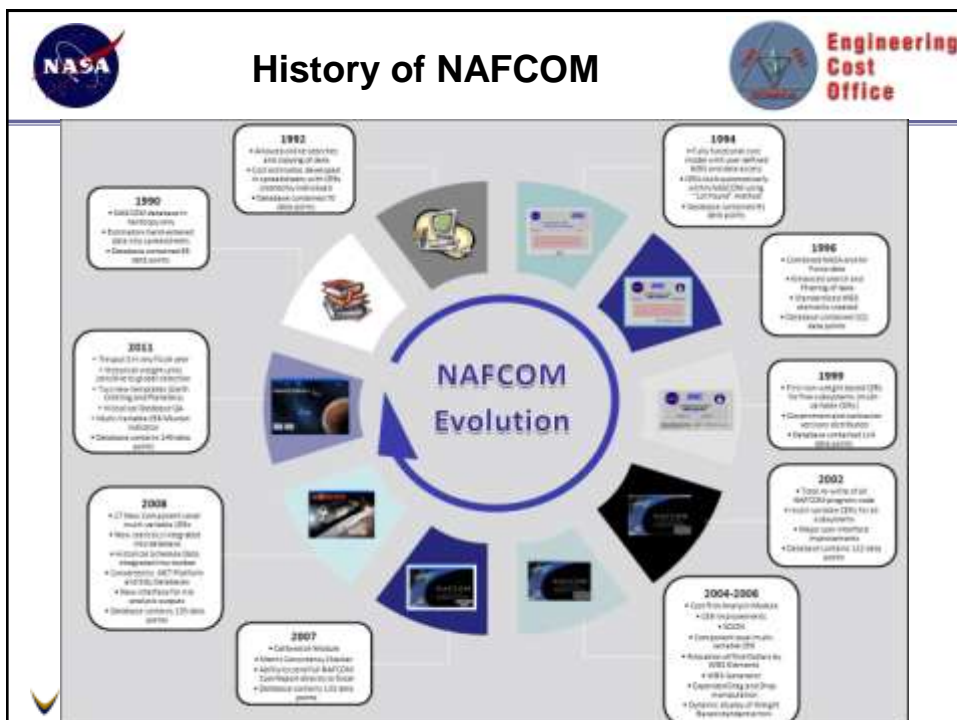
- Utilization**
  - Cost estimating tool for launch vehicles, robotic spacecraft, human spacecraft, landers, rovers, and other flight hardware systems
  - Used by over 1000 Government and Contractor employees
- Overview**
  - Parametric cost model based on over 155 NASA and Air Force space flight hardware projects.
  - Developed over the past 19 years with 12 major releases providing increased accuracy, data content, & functionality.
  - Two cost estimating methodologies are available:
    - Multi-Variable CERs**
    - Weight/Analogy based CERs**
  - Incorporates Liquid Rocket Engine Cost Model (LRECM) and Space Operations Cost Mode (SOCM)
  - Allows user input CERs and thru-put costs
  - Performs probabilistic risk analysis using FRISK
- Versions of NAFCOM**
  - Government version** that includes modeling capability and underlying data
  - Contractor version** that includes all Government version capability (CER's, etc) but no underlying cost data (SBU, Proprietary, etc)







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## Changing World




- **New Agency Requirements (e.g., JCL and Life-Cycle Cost Estimating)**
- **NASA Standard WBS**
- **Shrinking Budgets**
- **Distributed IT Infrastructure**
- **IT Security Requirements**
- **Sophistication of the NASA Cost Community**
- **New and Challenging Estimating Requirements**

Unfortunately, the NAFCOM software as it stands today is not well-suited to adapt to these new estimating needs of the NASA cost community




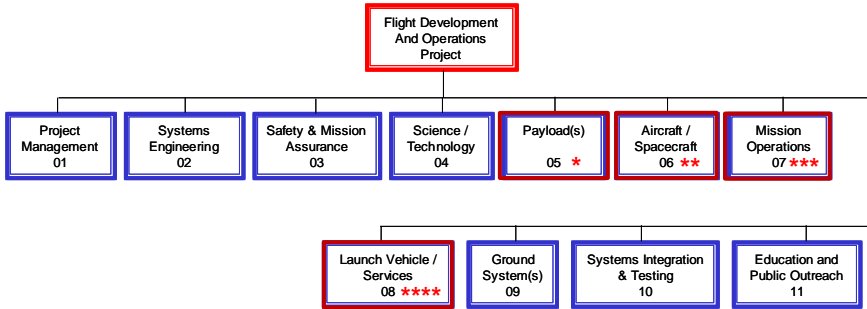
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## NAFCOM and the NASA Standard WBS








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\* Analogy estimates based on old data

\*\* Spacecraft only



\*\*\* Robotic spacecraft

\*\*\*\* New launch vehicle developments



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## Why PCEC?

The Project Cost Estimating Capability (PCEC) modeling construct was envisioned to adapt to this new environment:

- Address **all elements** of the NASA Standard WBS as defined in NPD 7120.5E
- Change the focus of the NASA investment portfolio from **automation** centric to **research** centric
- Create an environment that addresses the **diverse estimating and analysis requirements** across NASA
- Enable the entire NASA cost community to have **ownership** and **add value** to an Agency-wide capability
- Emphasize **good analysis** as a critical component of credible cost estimating (problem driven analysis vs. tool driven analysis)

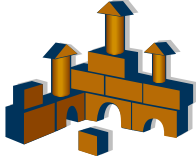
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## PCEC Philosophy

- Simple, Robust, Transparent
- Focus on Flexibility and Capability versus Ease of Use
- Don't Duplicate Existing Capabilities / Models (NICM, LRECM)
- Use Existing Software to the Greatest Extent Possible (e.g., Argo, @Risk, Crystal Ball)
- Expect NASA Cost Analysts to Know how to Use Spreadsheets and other Desktop Applications
- Keep the Data behind the NASA Firewall
- Modular, Open Source Architecture




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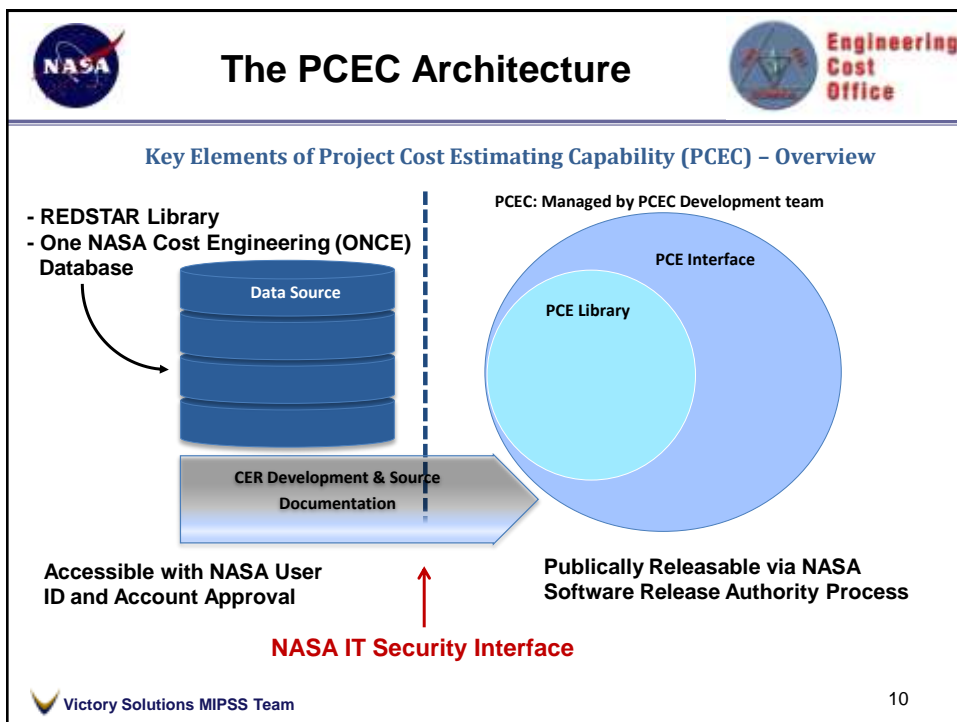



## PCEC Requirements

- **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*


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## 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 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




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## CER Library Organization






- **Introduction**
- **General Information**
  - Variable List
  - Variable Influence Tables
  - Mission Information
  - WBS Dictionary
  - Inflation Table
  - CER Documentation Help
- **Recommended CERs**
  - System Level
  - Group Level
  - Subsystem Level
  - Component Level
- **Legacy CERs**
  - Group Level
  - Subsystem Level
  - Component Level

- **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

**Contents of Each CER Tab**

- CER Documentation
- Cost Calculation
- Risk Calculations


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### 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:**

<b>Models/Estimate</b>	<b>Inform/Document</b>	<b>Tools/Help</b>
<ul style="list-style-type: none"><li>– Load and save model templates</li><li>– Launch an Estimate to get started quickly with a custom model</li><li>– Insert individual CERs as a few lines or entire preformatted worksheets</li></ul>	<ul style="list-style-type: none"><li>– Learn more about CERs and variables</li><li>– Document and validate CERs used in your workbook</li></ul>	<ul style="list-style-type: none"><li>– Insert WBS templates, Library worksheets and Inflation information into your workbook</li><li>– Use the in-tool Help file to learn more about what the PCEC can do for you</li></ul>


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### PCEC Development


- **PCEC has been under development since September, focusing on development and staggered roll-out of the Library and Interface**
- **PCEC Release Plan/Terminology**
  - V0 – Beta version (for review & comment)
  - V1 – Release version (for reproducing core NAFCOM features)
  - Incremental releases (v1.x) will follow development sprints to fix bugs, introduce additional capabilities, and update data/CERs
- **Development Milestones to Date:**
  - Mid Dec 2013: PCEC Library v0
  - Late Feb 2014: PCEC Library v1
  - Late Mar 2014: PCEC Interface v0
  - Early May 2014: PCEC Interface v1 & Library v1.1

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**PCEC Path Forward**

- **PCEC Distribution**
  - Will be managed through the MSFC Software Release Authority
  - Currently undergoing review by Export Control and working through the software release process
  - Limited distribution only to NASA personnel at this time; will be publicly releasable upon completion of review (DoD, FFRDC, other Gov't Agencies, Industry, Academia)
  - Requests for v1 by NASA users can currently be made by e-mailing the PCEC support desk: [MSFC-PCEC@mail.nasa.gov](mailto:MSFC-PCEC@mail.nasa.gov)
- **Future Development**
  - Sprints will be occurring this summer to incorporate new capabilities (e.g., phasing, First Pound/System Integration risk) and the use of other tools (NICM, SOCM, LRECM, etc.) in PCEC models
  - V2 of Library and Interface (planned for fall release) will update modeling construct and CERs to align to NASA Standard WBS

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**Backup**

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## PCEC Library




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## PCEC CER Library

### CER Documentation (1 of 3)



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**PCEC Antenna CER Documentation**

**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 categorization four main types can be identified: wire, horn, reflector and array antennas. For spacecraft applications, wire antennas operate chiefly at VHF and UHF frequencies.*

**Design and Development CER**

**CER Information**

**CER:**

$$[DDFY12] = 48.257 * [WeightPerUnit]^{0.49} * [CommSC]^{-0.395} * [ReconSC]^{-1.032} * [TM]^{-1.586} * [Crewed]^{1.279} * [DDMR]^{0.5} * [Deployable]^{1.708}$$

**Pre-calculations:**


$$[DDMR] = [MfgMethods]^{0.05} * [EngMngt]^{0.6} * [FndAvail]^{0.05} * [TestApp]^{0.06} * [IntegComplexity]^{0.12} * [PreDevStudy]$$

**Methodology:**

Log-linear regression

**UID:**

016-01-01-01



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# PCEC CER Library

## CER Documentation (2 of 3)

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### Variables

Name	Constant	WeightPerUnit	CommSC	ReconSC	TMI	Crewed	DDMR	NewDesign	Deployable
Coefficient	3.877	0.490	-0.395	-1.032	-1.586	1.279	0.098	1.651	
SE	0.922	0.066	0.2336954	0.36861582	0.34973144	0.48633191	0.3090261	0.24181501	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

Coefficients and associated regression information

### Regression Statistics

Logspace	Unit space
R <sup>2</sup>	0.868
Adj R <sup>2</sup>	0.849
F-Stat	44.455
F-Stat P-V	0.000
PING Fact	1.241
SPE	1.06227925
Regression DF	179.037
Residual DF	5964.2
Total DF	27.185
8 SSR	5888.8
54 SSE	206.222
62 SST	15426.5
SEE	0.710
V_Bur	10.445
CV	0.129
Pearson's C	6.190
	5.495
	1.687
	0.932
	0.81476191

Regression analysis information and statistics

### Descriptive Statistics

Name	DDFY12	WeightPerUnit	CommSC	ReconSC	TMI	Crewed	DDMR	NewDesign	Deployable
Min	0.017	0.300	1.000	1.000	4.000	1.000	0.245	0.250	0.698
Max	91.068	155.900	2.718	2.718	12.000	2.718	0.797	1.000	2.718
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
SD	15.774	32.004	0.847	0.468	2.732	0.468	0.160	0.249	0.326
									9.727

Data descriptive statistics

### Correlation Matrix

	DDFY12	WeightPerUnit	CommSC	ReconSC	TMI	Crewed	DDMR	NewDesign	Deployable
DDFY12	1.0000	0.5415	0.1109	-0.3090	-0.6315	0.5275	0.2716	0.6988	0.3116
WeightPerUnit	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	-0.2498	-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	-0.2498	0.1614	1.0000	-0.5564	-0.2324		
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	0.6988	0.0339	-0.0243	0.0652	-0.2347	0.3682	0.3056	1.0000	0.2141
Deployable	0.3116	0.1533	-0.0115	-0.0648	0.0657	0.3682	0.4243	0.2141	1.0000

Data correlation matrix

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

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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-SD	GPSMVP	NATO III	TDRSS
AMPTE-CCC	DMSP-SD3	HEAO-1	OMV	TOKER
Apollo LM	DSCS-II	INTELSAT-IV	OSO-8	UFO
ATS-6	DSCS-IIIA	LRO	P78	
Chandra	DSP	MARISAT	SMS-1	
CRRES	GPS-IR	Mars Pathfinder	TACSAT	

Missions whose data was used for regression

### Variable Descriptions

#### INPUTS:

Name	Brief Description	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	
HighMethods	Manufacturing Methods: Rating that denotes the degree of use of advance manufacturing techniques	0-100% (Decimal in [0-1])
EngMgmt	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 to 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 Description	Possible Values
DDFY12	DDFY12: Design & Development (DD) 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	144.138187	4.99999664	-46.202783				
WeightPerUnit	117.48375	375.449975	64.4989148	1.6140661	260.121996	8.31594564	-88.307155				
CommSC	24.9999832	64.4989148	24.9999664	0	64.46038716	4.99999664	-46.202783				
ReconSC	4.99999664	1.6140661	0	4.99999927	12.4245249	0	-5.0580763				
TMI	144.138187	260.121996	54.4618716	12.4245249	337.932302	8.05069797	-107.51333				
Crewed	4.99999664	8.31594564	0	0	6.02080797	4.99999927	-1.8516955				
DDMR	-46.202783	-88.307155	-16.594409	-5.0580763	-107.51333	1.8516955	41.2446466				
NewDesign	-34.16088	-62.248428	-13.879504	-2.231434	-81.040663	0	27.8883275				
Deployable	7.97083671	0.99999865	0	6.44958287	0	-1.7987906	-0.3302715				

Uncertainty information


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Missions whose data was used for regression


Variable descriptions

Uncertainty information



## PCEC CER Library

### CER Calculation (1 of 2)




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#### PCEC Antenna Cost Calculation


Value Name	Input/ Calculation			
<b>Major Inputs</b>				
<b>Weight</b>				
Total Weight				
<b>Thrputs</b>				
Design & Development				
System Test Hardware				
Flight Unit				
<b>Common Multivariable Inputs</b>				
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
<b>PCEC Antenna Component Specific Inputs</b>				
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

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




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## PCEC CER Library

### CER Calculation (2 of 2)



**Engineering  
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#### Other Inputs

Quantity Next Higher Level		1	1
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#### CER Methodology

Multivariable Type	(6) Shuttle Calibrated
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#### 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




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## PCEC CER Library Uncertainty Calculations



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

**Uncertainty Adjusted Cost Estimate**

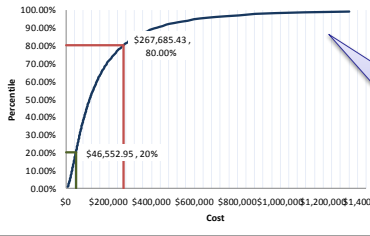
Estimate from the Cost Calculation section and a probability distribution function to generate a range of cost values. This can be used directly in a Monte Carlo simulation.

Distribution type:	T-Distribution
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

**A calculating version of modeling uncertainty.**

**Outputs can be used in directly in a Monte Carlo model**

**Estimating Uncertainty (No Inputs Uncertainty)**





Percentile	Cost \$FY12
20%	\$ 46,552.9
80%	\$ 267,685.4

**Takes point estimate from previously discussed Cost Calculation section**


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

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


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## PCEC CER Library First Pound Cost (1 of 2)



**Instructions for using this worksheet**

**First-Pound Cost CER Documentation**

**Overall CER description:**

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

**A-value:** Calibrated value of the coefficient for the individual mission calculated by inputting the mission's actual Cost, Weight, and 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.

**Description of the First Pound Cost estimating methodology**

**Design and Development & Flight**

**CER Information**

**CER:**

DD P12 - A \* Weight<sup>b</sup>

PU P12 - A \* Weight<sup>b</sup>

**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.

**Calculations for equation parameters (A and b-values)**


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

Selected Element	Percentage Element	Team	Estimating Element	Component	Uncertainty	Weight	Cost	Weight	Cost
Antenna			Antenna	Component	Uncertain	0	461	0	461
Antenna			Antenna	Component	Uncertain	0	473	0	473
Antenna			Antenna	Component	Uncertain	0	485	0	485
Antenna			Antenna	Component	Uncertain	0	498	0	498
Antenna			Antenna	Component	Uncertain	0	510	0	510
Antenna			Antenna	Component	Uncertain	0	522	0	522
Antenna			Antenna	Component	Uncertain	0	534	0	534
Antenna			Antenna	Component	Uncertain	0	546	0	546
Antenna			Antenna	Component	Uncertain	0	558	0	558
Antenna			Antenna	Component	Uncertain	0	570	0	570
Antenna			Antenna	Component	Uncertain	0	582	0	582
Antenna			Antenna	Component	Uncertain	0	594	0	594
Antenna			Antenna	Component	Uncertain	0	606	0	606
Antenna			Antenna	Component	Uncertain	0	618	0	618
Antenna			Antenna	Component	Uncertain	0	630	0	630
Antenna			Antenna	Component	Uncertain	0	642	0	642
Antenna			Antenna	Component	Uncertain	0	654	0	654
Antenna			Antenna	Component	Uncertain	0	666	0	666
Antenna			Antenna	Component	Uncertain	0	678	0	678
Antenna			Antenna	Component	Uncertain	0	690	0	690
Antenna			Antenna	Component	Uncertain	0	702	0	702
Antenna			Antenna	Component	Uncertain	0	714	0	714
Antenna			Antenna	Component	Uncertain	0	726	0	726
Antenna			Antenna	Component	Uncertain	0	738	0	738
Antenna			Antenna	Component	Uncertain	0	750	0	750
Antenna			Antenna	Component	Uncertain	0	762	0	762
Antenna			Antenna	Component	Uncertain	0	774	0	774
Antenna			Antenna	Component	Uncertain	0	786	0	786
Antenna			Antenna	Component	Uncertain	0	798	0	798
Antenna			Antenna	Component	Uncertain	0	810	0	810
Antenna			Antenna	Component	Uncertain	0	822	0	822
Antenna			Antenna	Component	Uncertain	0	834	0	834
Antenna			Antenna	Component	Uncertain	0	846	0	846
Antenna			Antenna	Component	Uncertain	0	858	0	858
Antenna			Antenna	Component	Uncertain	0	870	0	870
Antenna			Antenna	Component	Uncertain	0	882	0	882
Antenna			Antenna	Component	Uncertain	0	894	0	894
Antenna			Antenna	Component	Uncertain	0	906	0	906
Antenna			Antenna	Component	Uncertain	0	918	0	918
Antenna			Antenna	Component	Uncertain	0	930	0	930
Antenna			Antenna	Component	Uncertain	0	942	0	942
Antenna			Antenna	Component	Uncertain	0	954	0	954
Antenna			Antenna	Component	Uncertain	0	966	0	966
Antenna			Antenna	Component	Uncertain	0	978	0	978
Antenna			Antenna	Component	Uncertain	0	990	0	990
Antenna			Antenna	Component	Uncertain	0	1002	0	1002
Antenna			Antenna	Component	Uncertain	0	1014	0	1014
Antenna			Antenna	Component	Uncertain	0	1026	0	1026
Antenna			Antenna	Component	Uncertain	0	1038	0	1038
Antenna			Antenna	Component	Uncertain	0	1050	0	1050
Antenna			Antenna	Component	Uncertain	0	1062	0	1062
Antenna			Antenna	Component	Uncertain	0	1074	0	1074
Antenna			Antenna	Component	Uncertain	0	1086	0	1086
Antenna			Antenna	Component	Uncertain	0	1098	0	1098
Antenna			Antenna	Component	Uncertain	0	1110	0	1110
Antenna			Antenna	Component	Uncertain	0	1122	0	1122
Antenna			Antenna	Component	Uncertain	0	1134	0	1134
Antenna			Antenna	Component	Uncertain	0	1146	0	1146
Antenna			Antenna	Component	Uncertain	0	1158	0	1158
Antenna			Antenna	Component	Uncertain	0	1170	0	1170
Antenna			Antenna	Component	Uncertain	0	1182	0	1182
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Antenna			Antenna	Component	Uncertain	0	1206	0	1206
Antenna			Antenna	Component	Uncertain	0	1218	0	1218
Antenna			Antenna	Component	Uncertain	0	1230	0	1230
Antenna			Antenna	Component	Uncertain	0	1242	0	1242
Antenna			Antenna	Component	Uncertain	0	1254	0	1254
Antenna			Antenna	Component	Uncertain	0	1266	0	1266
Antenna			Antenna	Component	Uncertain	0	1278	0	1278
Antenna			Antenna	Component	Uncertain	0	1290	0	1290
Antenna			Antenna	Component	Uncertain	0	1302	0	1302
Antenna			Antenna	Component	Uncertain	0	1314	0	1314
Antenna			Antenna	Component	Uncertain	0	1326	0	1326
Antenna			Antenna	Component	Uncertain	0	1338	0	1338
Antenna			Antenna	Component	Uncertain	0	1350	0	1350
Antenna			Antenna	Component	Uncertain	0	1362	0	1362
Antenna			Antenna	Component	Uncertain	0	1374	0	1374
Antenna			Antenna	Component	Uncertain	0	1386	0	1386
Antenna			Antenna	Component	Uncertain	0	1398	0	1398
Antenna			Antenna	Component	Uncertain	0	1410	0	1410
Antenna			Antenna	Component	Uncertain	0	1422	0	1422
Antenna			Antenna	Component	Uncertain	0	1434	0	1434
Antenna			Antenna	Component	Uncertain	0	1446	0	1446
Antenna			Antenna	Component	Uncertain	0	1458	0	1458
Antenna			Antenna	Component	Uncertain	0	1470	0	1470
Antenna			Antenna	Component	Uncertain	0	1482	0	1482
Antenna			Antenna	Component	Uncertain	0	1494	0	1494
Antenna			Antenna	Component	Uncertain	0	1506	0	1506
Antenna			Antenna	Component	Uncertain	0	1518	0	1518
Antenna			Antenna	Component	Uncertain	0	1530	0	1530
Antenna			Antenna	Component	Uncertain	0	1542	0	1542
Antenna			Antenna	Component	Uncertain	0	1554	0	1554
Antenna			Antenna	Component	Uncertain	0	1566	0	1566
Antenna			Antenna	Component	Uncertain	0	1578	0	1578
Antenna			Antenna	Component	Uncertain	0	1590	0	1590
Antenna			Antenna	Component	Uncertain	0	1602	0	1602
Antenna			Antenna	Component	Uncertain	0	1614	0	1614
Antenna			Antenna	Component	Uncertain	0	1626	0	1626
Antenna			Antenna	Component	Uncertain	0	1638	0	1638
Antenna			Antenna	Component	Uncertain	0	1650	0	1650
Antenna			Antenna	Component	Uncertain	0	1662	0	1662
Antenna			Antenna	Component	Uncertain	0	1674	0	1674
Antenna			Antenna	Component	Uncertain	0	1686	0	1686
Antenna			Antenna	Component	Uncertain	0	1698	0	1698
Antenna			Antenna	Component	Uncertain	0	1710	0	1710
Antenna			Antenna	Component	Uncertain	0	1722	0	1722
Antenna			Antenna	Component	Uncertain	0	1734	0	1734
Antenna			Antenna	Component	Uncertain	0	1746	0	1746
Antenna			Antenna	Component	Uncertain	0	1758	0	1758
Antenna			Antenna	Component	Uncertain	0	1770	0	1770
Antenna			Antenna	Component	Uncertain	0	1782	0	1782
Antenna			Antenna	Component	Uncertain	0	1794	0	1794
Antenna			Antenna	Component	Uncertain	0	1806	0	1806
Antenna			Antenna	Component	Uncertain	0	1818	0	1818
Antenna			Antenna	Component	Uncertain	0	1830	0	1830
Antenna			Antenna	Component	Uncertain	0	1842	0	1842
Antenna			Antenna	Component	Uncertain	0	1854	0	1854
Antenna			Antenna	Component	Uncertain	0	1866	0	1866
Antenna			Antenna	Component	Uncertain	0	1878	0	1878
Antenna			Antenna	Component	Uncertain	0	1890	0	1890
Antenna			Antenna	Component	Uncertain	0	1902	0	1902
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Antenna			Antenna	Component	Uncertain	0	1926	0	1926
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Antenna			Antenna	Component	Uncertain	0	2010	0	2010
Antenna			Antenna	Component	Uncertain	0	2022	0	2022
Antenna			Antenna	Component	Uncertain	0	2034	0	2034
Antenna			Antenna	Component	Uncertain	0	2046	0	2046
Antenna			Antenna	Component	Uncertain	0	2058	0	2058
Antenna			Antenna	Component	Uncertain	0	2070	0	2070
Antenna			Antenna	Component	Uncertain	0	2082	0	2082
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Antenna			Antenna	Component	Uncertain	0	2214	0	2214
Antenna			Antenna	Component	Uncertain	0	2226	0	2226
Antenna			Antenna	Component	Uncertain	0	2238	0	2238
Antenna			Antenna	Component	Uncertain	0	2250	0	2250
Antenna			Antenna	Component	Uncertain	0	2262	0	2262
Antenna			Antenna	Component	Uncertain	0	2274	0	2274



## PCEC CER Library

### First Pound Cost (2 of 2)



**First-Pound Cost CER Calculation (Analogy)**

**Subsystem Name**

DOTRE	D&D	STH	Flight Unit	Production	Total
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -

**CER Calculations**

Placeholder for input uncertainty information

**Cost Calculations**

Flight Unit Cost	STH Cost	Production Cost
FY12 \$M	FY12 \$M	FY12 \$M
Unit Items	Unit Items	Unit Items
Post-LRP Items	Post-LRP Items	Post-LRP Items
Total	Total	Total

**For Weight Uncertainty**


Distribution Formula	Distribution Type	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Parameter 5

**Inputs and calculations for Learning Curve**

**Learning, LRP, and Production Rate Calculator**


Q-Start	Q-Prod	Production Start Date	Learning Curve Slope	Theory Units	Q-Start	LRP Start Date	Q-Prod	LRP End Date	LRP Units	LRP Rate	Production Rate
1	1	1	100%	1	1	1	1	1	1	100%	1

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## PCEC CER Library

### System Integration (1 of 2)



**System Integration Cost CER Documentation (Analogy)**

**Overall CER description:**

This CER provides a relationship that can be used to estimate the cost of a System Integration cost element using spacecraft hardware.

**A-value:** Calibrated value of the coefficient for the mission calculated by inputting the mission's actual SI Cost, Weight, and b-value.

**b-value:** Exponent for the equation SI Cost = A \* HardwareCost \* b for the element being modeled. Computed based on regression.

**Design and Development & Flight CER Information**

**CER:**

DD FY12 = A \* Cost<sup>b</sup>

FU FY12 = A \* Cost<sup>b</sup>

**Variable Definitions:**

A = The geometric mean of the cost of the hardware

b = The average of the cost of the hardware

**Instructions for using this worksheet**

1. Input total spacecraft costs (D&D, STH, Flight 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

**Calculations for equation parameters (A and b-values)**

**Average Values Based on Selection**

DOTRE A-value	DOTRE b-value	FR Unit A-value	FR Unit b-value
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A

**Spacecraft Cost to Use**

DOTRE	FR Unit
STH	FR Unit
D&D + STH	FR Unit
D&D + STH	FR Unit
D&D + STH	FR Unit
D&D + STH	FR Unit

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

Selected Mission	Hardware Class	Orbit	Spacecraft Class	Estimating Level
ACTS	Uncrewed	Earth Orbiting	Communication	System
AE-3	Uncrewed	Earth Orbiting	Scientific	System
AIM-HCM	Uncrewed	Earth Orbiting	Scientific	System
ALEXIS	Uncrewed	Earth Orbiting	Scientific	System

**Description of System Integration estimating methodology**


**Test Operations**

FR Unit b-value - STH	FR Unit b-value - STH


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## PCEC CER Library System Integration (2 of 2)



**Engineering  
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**System Integration Cost CER Calculation (Analogy)**

**System Integration Costs**

	DOT&E	D&O	STH	Flight Unit	Production	Total
IACO	\$ -			\$ -	\$ -	\$ -
STD	\$ -					\$ -
GSE	\$ -					\$ -
SEMI	\$ -			\$ -	\$ -	\$ -
PM	\$ -			\$ -	\$ -	\$ -
LOOS	\$ -			\$ -	\$ -	\$ -

**Cost outputs from CER**

**CER Calculations**


	Spacecraft Cost Inputs					Link to WBS	Production Point Estimate
	DOT&E Point Estimate	Cost Input (STH or D&O + STH)	DOT&E A-Value	DOT&E b-Value	DOT&E Complexity Factor		
IACO	\$ -	\$ -	N/A	N/A	1.00	\$ -	\$ -
STD	\$ -	\$ -	N/A	N/A	1.00	\$ -	\$ -
GSE	\$ -	\$ -	N/A	N/A	1.00	\$ -	\$ -
SEMI	\$ -	\$ -	N/A	N/A	1.00	\$ -	\$ -
PM	\$ -	\$ -	N/A	N/A	1.00	\$ -	\$ -
LOOS	\$ -	\$ -	N/A	N/A	1.00	\$ -	\$ -

**CER Calculations**




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## PCEC Interface



**Engineering  
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# PCEC Interface





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## PCEC 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


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## PCEC Interface Templates





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

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




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


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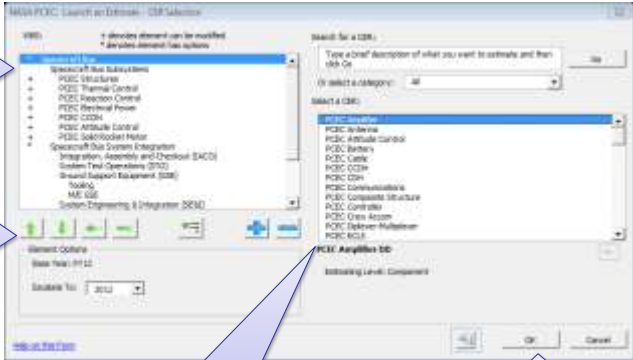


## PCEC Interface Launch an Estimate




**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


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## PCEC Interface Search CER Library




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

**CER Description**  
See detailed information about the selected CER




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

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



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## PCEC Interface

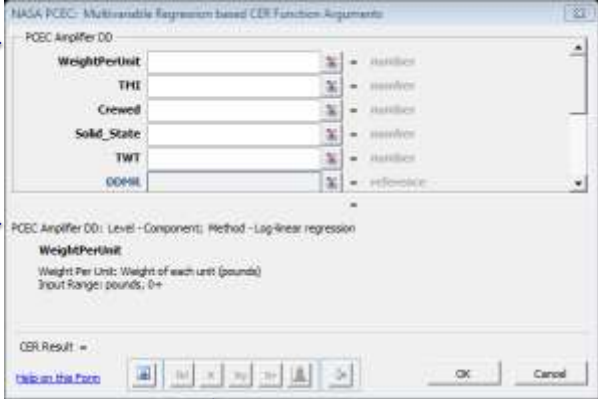
### Insert Multivariable CER





**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





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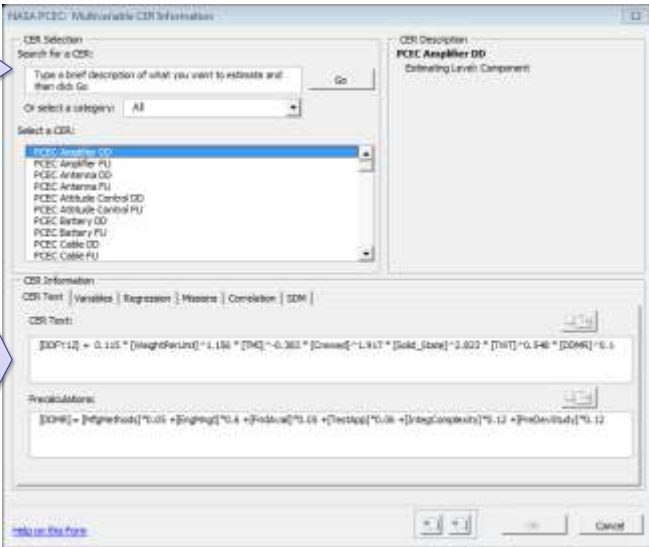
## PCEC Interface


### CER Details




**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




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## PCEC Interface Variable Information



**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






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## PCEC Interface Document Workbook



**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


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






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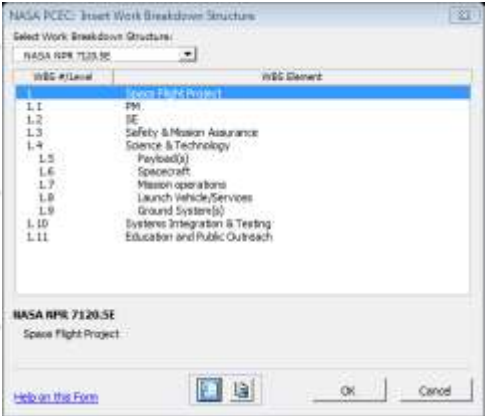
## PCEC Interface Insert WBS




**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




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## PCEC Interface Inflation





**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
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%
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
FROM 1959	1	1.043	1.0764	1.1194	1.159	1.2107	1.2519	1.327	1.39205	1.4672	1.5509	1.6579	1.762	1.863	1.969	2.111	2.339	2.549
FROM 1960		1	1.032	1.0733	1.111	1.1608	1.2003	1.2723	1.33466	1.4067	1.4869	1.5895	1.6897	1.786	1.888	2.024	2.242	2.444
FROM 1961			1	1.04	1.076	1.1248	1.1631	1.2329	1.29328	1.3631	1.4408	1.5402	1.637	1.731	1.829	1.961	2.173	2.368
FROM 1962				1	1.035	1.0816	1.1183	1.1854	1.24354	1.3107	1.3854	1.481	1.5743	1.664	1.759	1.886	2.089	2.277
FROM 1963					1	1.000	1.045	1.0805	1.1454	1.20148	1.2664	1.3385	1.4309	1.521	1.608	1.699	1.822	2.019
FROM 1964						1	1.034	1.096	1.14975	1.2118	1.2809	1.3693	1.4556	1.539	1.626	1.743	1.932	2.105
FROM 1965							1	1.06	1.11194	1.172	1.2388	1.3243	1.408	1.488	1.573	1.686	1.868	2.036
FROM 1966								1	1.049	1.1056	1.1687	1.2493	1.328	1.404	1.484	1.591	1.762	1.921
FROM 1967									1	1.054	1.1141	1.1909	1.266	1.338	1.414	1.516	1.680	1.831
FROM 1968										1	1.054	1.1141	1.1909	1.266	1.338	1.414	1.516	1.680
FROM 1969											1	1.054	1.1141	1.1909	1.266	1.338	1.414	1.516
FROM 1970												1	1.054	1.1141	1.1909	1.266	1.338	1.414
FROM 1971													1	1.054	1.1141	1.1909	1.266	1.338
FROM 1972														1	1.054	1.1141	1.1909	1.266
FROM 1973															1	1.054	1.1141	1.1909

**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






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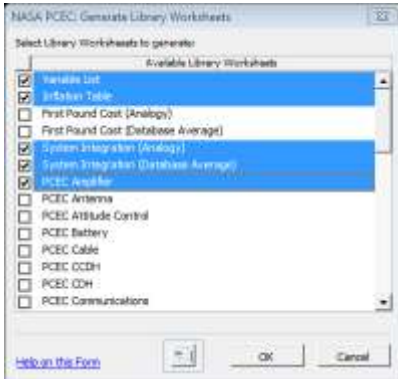
## PCEC Interface


### Insert Library Worksheets



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






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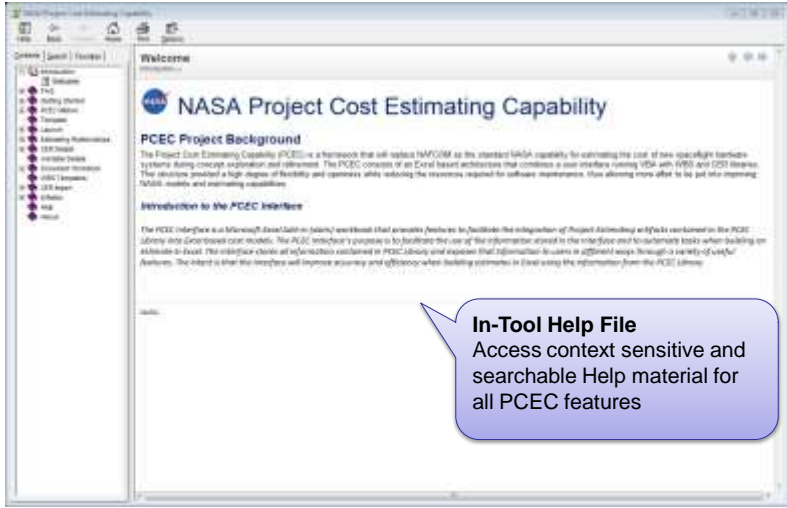


## PCEC Interface


### In-Tool Help File



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



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