

Development of a Project Cost Estimating Capability

NASA Carpe Diem

May 15, 2014

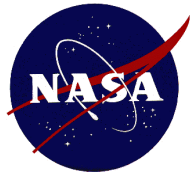
Andy Prince – MSFC/Engineering Cost Office

Brian Alford – Victory Solutions MIPSS Team/Booz Allen Hamilton

Blake Boswell – Victory Solutions MIPSS Team/Booz Allen Hamilton

Matt Pitlyk – Victory Solutions MIPSS Team/Booz Allen Hamilton

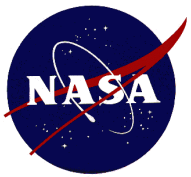
Mark Pedigo – Victory Solutions MIPSS Team/Booz Allen Hamilton



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Booz | Allen | Hamilton

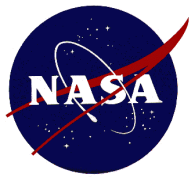


Outline



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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)



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Utilization

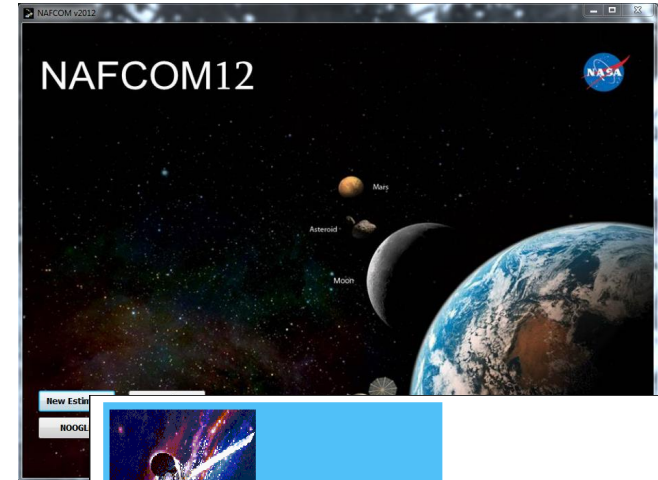
- Primary cost estimating tool for launch vehicles, CEV, landers, rovers, and other flight hardware elements.
- Used by over 1000 Government and Contractor employees.

Background

- 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 estimating** is data driven, statistically based and allows users to document estimating assumptions rather than using complexity factors - supportable, repeatable and verifiable.
 - **Weight based estimating** is valuable early in the estimating process when an analyst may only have a WBS and mass statement - also useful if estimating hardware very analogous to a mission in the historical database.
- Probabilistic risk analysis capability incorporated to account for cost and technical uncertainty.

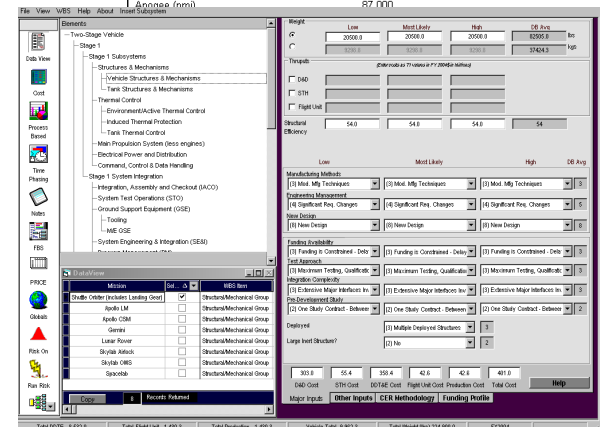
NAFCOM Distribution and Access

- Currently there are two 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 specific data (SBU, Proprietary, etc)

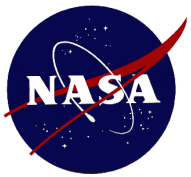


Chandra

MANAGEMENT CENTER: MSFC
 CONTRACTOR: TRW
 LAUNCH DATE: July 1999
 LAUNCH WEIGHT (LBS):
 SUBSYSTEM DRY WEIGHT (LBS):
 DESIGN LIFE: 5-10 years
 LAUNCH VEHICLE: Space Shuttle
 DESIGN APPROACH: Protflight
 ORBIT PARAMETERS:
 Apogee (nm): 87,000



July of 1999, is the very regions of the known as AXAF, the instruments and a spacecrafter comes a features are: an order for high spectral



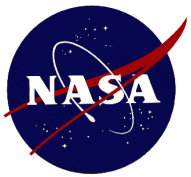
Changing World



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- **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



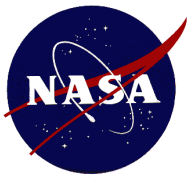
Why PCEC?



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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)

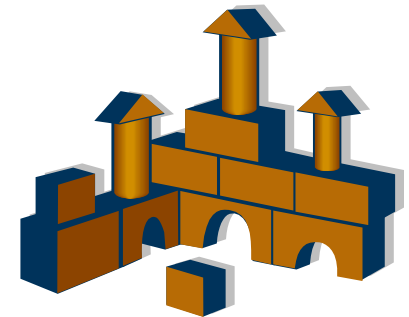


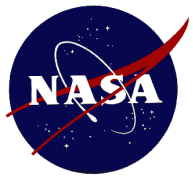
PCEC Philosophy



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- **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**





PCEC Requirements

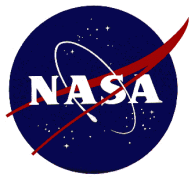


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- **The PCEC team formed a PCEC Steering Committee to guide, define, and develop core requirements**
 - Total of 25 Requirements Spread over 3 Levels
- **Key Attributes:**
 - Transparent and Customizable
 - Meet all NASA IT Security Requirements
 - 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*

NAFCOM Capabilities

| | | |
|----------------------------|---------------------|-------------------|
| WBS Templates | CER Statistics | Weight-Based CERs |
| Multivariable CERs | Learning Curve | Reports |
| Systems Test Hardware Cost | Schedule Estimating | Time Phasing |



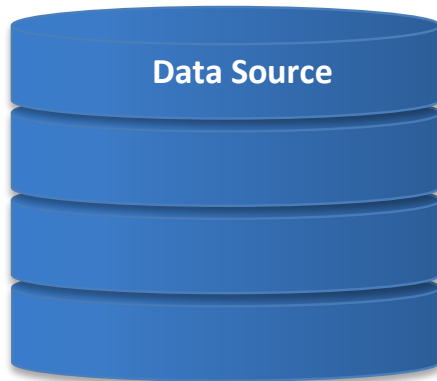
The PCEC Architecture



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

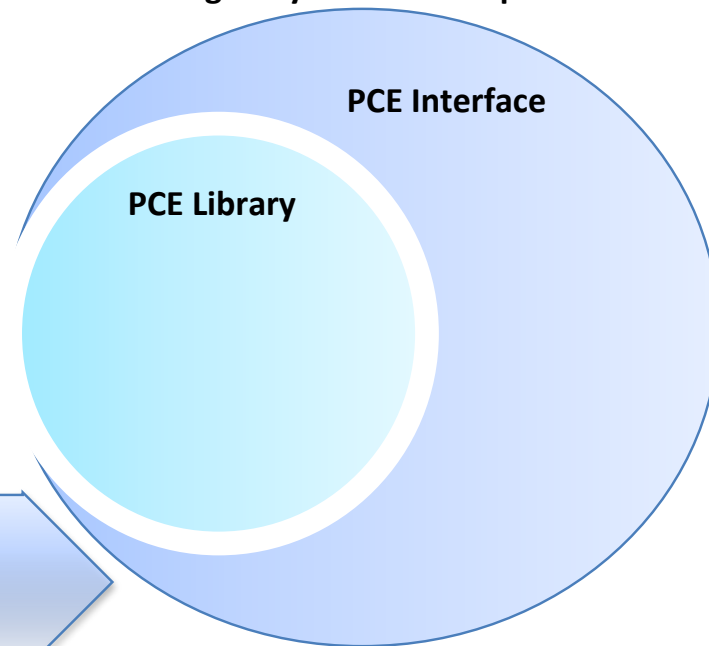
- REDSTAR Library
- One NASA Cost Engineering (ONCE) Database



CER Development & Source
Documentation

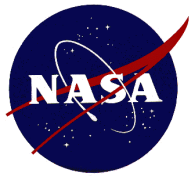
Accessible with NASA User
ID and Account Approval

PCEC: Managed by PCEC Development team



Publically Releasable via NASA
Software Release Authority Process

NASA IT Security Interface



PCEC Elements



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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:
 $[AttConDDTech] = [HorizonSensors]^2 * [SunSensors]^1 * [StarTrackers]^2 * [Gyro]^{1.1} * [Magnetometers]^2 * [RadarAltimeter]^1 * [RendezvousRadar]^{1.0}$
 $[DDMR] = [MfgMethods]^{0.05} * [EngMngt]^{0.6} * [FndAvail]^{0.05} * [TextApp]^{0.06} * [IntegComplexity]^{0.12} * [PreDevStudy]^{0.12}$

Methodology:
 Log-linear regression

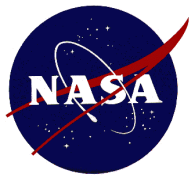
UID:
 005-01-01-02

Variables

| Name | Constant | DDMR | NewDesign | TMI | WeightPerUnit | Planet | LV | Crewed | SpinStab | AttConDDTech |
|-------------|----------|-------|-----------|-----------|---------------|-----------|-----------|----------|-----------|--------------|
| Coefficient | 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 | 0.1473218 | 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

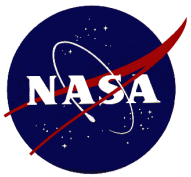


PCEC Development



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- 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



PCEC Path Forward



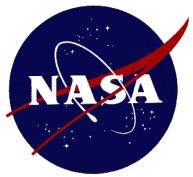
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- **PCEC Distribution**

- 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

- **Future Development**

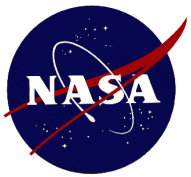
- Sprints will be occurring this summer to incorporate new capabilities (e.g., phasing, First Pound/System Integration risk) and the use of other tools (NICM, SOCM, LRECM, etc.) in PCEC models
- V2 of Library and Interface (planned for fall release) will update modeling construct and CERs to align to NASA Standard WBS



PCEC Demo



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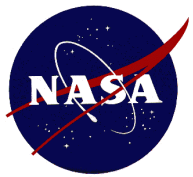


Summary



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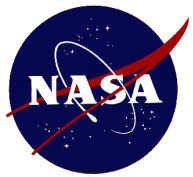
- **NAFCOM has had a Long and Successful Run**
 - Known and Appreciated across the Aerospace and Academic Communities
- **Resource Constraints, IT Security Requirements, NASA Standard WBS, and Several other Reasons Signal it is **Time for a Change****
- **PCEC will Meet these Demands and Provide Greater Capability to a more Sophisticated User Community**



Backup

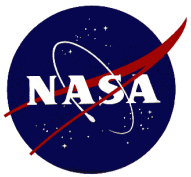


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PCEC Library



PCEC CER Library

CER Documentation (1 of 3)



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PCEC Antenna CER Documentation

CER Name and description of what is being estimated

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:

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

Text versions of the CER and any precalculations

Pre-calculations:

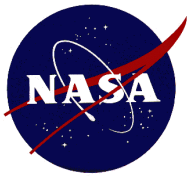
$$[DDMR] = [MfgMethods]^{0.05} + [EngMngt]^{0.6} + [FndAvail]^{0.05} + [TestApp]^{0.06} + [IntegComplexity]^{0.12} + [PreDevStudy]^{0.12}$$

Methodology:

Log-linear regression

UID:

016-01-01-01



PCEC CER Library

CER Documentation (2 of 3)



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Variables

| Name | Constant | WeightPerU | CommSC | ReconSC | TMI | Crewed | DDMR | NewDesign | Deployable |
|-------------|----------|------------|------------|------------|------------|------------|------------|------------|------------|
| Coefficient | 3.877 | 0.490 | -0.395 | -1.032 | -1.586 | 1.279 | 0.098 | 1.651 | 1.279 |
| 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 |

Coefficients and associated regression information

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 Co | 0.932 | 0.81476191 |

Regression analysis information and statistics

Descriptive Statistics

| Name | DDFY12 | WeightPerU | CommSC | ReconSC | TMI | Crewed | DDMR | NewDesign | Deployable |
|--------|--------|------------|--------|---------|--------|--------|-------|-----------|------------|
| 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 |
| 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 |

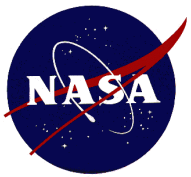
Data descriptive statistics

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 | 0.0652 |
| TMI | -0.6315 | -0.2452 | -0.2488 | 0.1614 | 1.0000 | -0.5564 | -0.2324 | -0.2947 | 0.0657 |
| Crewed | 0.5275 | -0.0376 | -0.2381 | -0.0862 | -0.5564 | 1.0000 | 0.3118 | 0.3682 | 0.0423 |
| DDMR | 0.2716 | -0.0633 | 0.1652 | -0.2393 | -0.2324 | 0.3118 | 1.0000 | 0.3056 | 0.0423 |
| 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 |

Data correlation matrix

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



PCEC CER Library CER Documentation (3 of 3)



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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-III | 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 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 | |
| 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 Description | 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

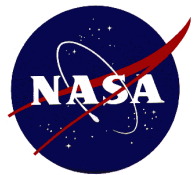
Prediction Interval Distribution

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 | -88.307181 |
| CommSC | 24.9999832 | 64.4989148 | 24.9999664 | 0 | 54.4618716 | 0 | 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 |
| NewDesign | -34.16088 | -62.248428 | -13.879504 | -2.231434 | -81.040663 | 0 | 27.8983275 |
| FndAvail | 27.8983275 | 30.3028771 | 7.97083671 | 0.99999865 | 0 | 6.44958287 | -0.3302715 |
| TestApp | 30.3028771 | 0.3302715 | 0.99999865 | 0 | 6.44958287 | 0 | -1.7987906 |
| IntegComplexity | 0.3302715 | -0.3302715 | 0 | 0 | 6.44958287 | 0 | 2.48045032 |

Uncertainty information



PCEC CER Library

CER Calculation (1 of 2)

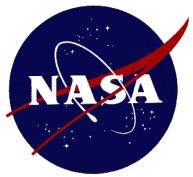


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PCEC Antenna Cost Calculation

| <i>Value Name</i> | <i>Input/ Calculation</i> | | | |
|---|--|-----------|-----------|-------------|
| Major Inputs | | | | |
| <i>Weight</i> | | | | |
| Total Weight | | | | |
| <i>Thruputs</i> | | | | |
| 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 anc | | | 12 |

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



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 | |

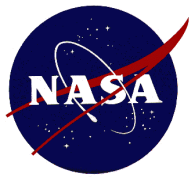
| Globals | | |
|-------------|-----------|------|
| Flight Year | 2015 | 2015 |
| Units | Thousands | 1000 |

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

Additional CER inputs

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

CER outputs



PCEC CER Library Uncertainty Calculations



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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 |
| Degrees of Freedom: | 54 |
| 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 |

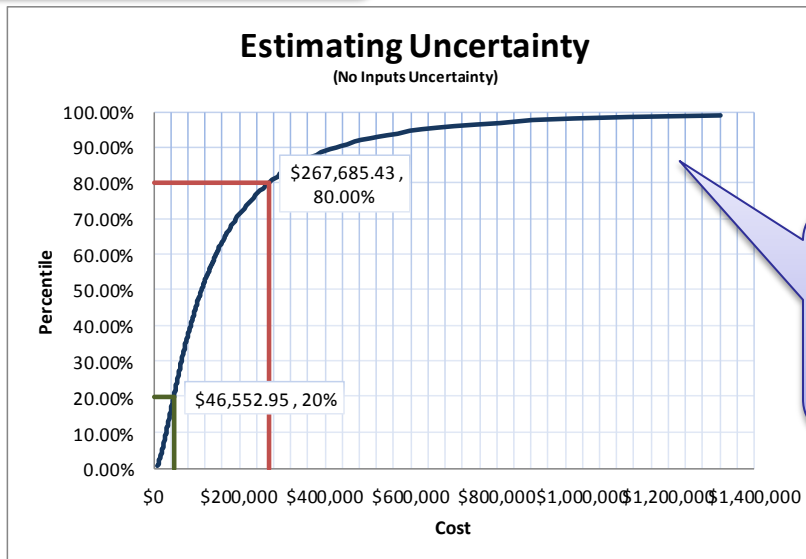
A calculating version of modeling uncertainty.

Takes point estimate from previously discussed Cost Calculation section

Outputs can be used in directly in a Monte Carlo model

Session Error Cumulative Distribution Function

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



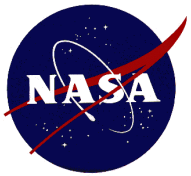
S-Curve Percentiles

| | |
|-----|--------------|
| 20% | \$ 46,552.9 |
| 80% | \$ 267,685.4 |

Percentile Cost \$FY12

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

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



PCEC CER Library

First Pound Cost (1 of 2)



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Description of the First Pound Cost estimating methodology

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 Complexity.

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.

Calculations for equation parameters (A and b-values)

Instructions for using this worksheet

Design and Development & Flight

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

1. Input element weight (and uncertainty, if desired) and complexity factors in "CER Calculator" section 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

Average Values Based on Selection

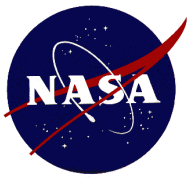
| D&D | | Fit Unit | |
|-------------|-------------|------------------|------------------|
| D&D A-Value | D&D b-value | Fit Unit A-value | Fit Unit b-value |
| N/A | N/A | N/A | N/A |

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 equation

| Selected Element | Mission | Subsystem Element | WBS Item | Estimating Level | Hardware | Unit | Hardware ID |
|------------------|---------|-------------------|--------------------------------|------------------|----------|------|-------------|
| | ACTS | Antenna | Antenna | Component | Uncrewed | 0 | 462 |
| | ACTS | Antenna | Antenna | Component | Uncrewed | 0 | 471 |
| | ACTS | Antenna | Antenna, Multibeam | Component | Uncrewed | 0 | 465 |
| | ACTS | Antenna | Structure, Multibeam Antenna | Component | Uncrewed | 0 | 458 |
| | ACTS | Communication | Amplifier, Traveling Wave Tube | Component | Uncrewed | 0.80 | 464 |

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



PCEC CER Library

First Pound Cost (2 of 2)



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First-Pound Cost CER Calculation (Analogy)

Subsystem Name

| DDT&E | D&D | STH | Flight Unit | Production | Total |
|-------|------|------|-------------|------------|-------|
| \$ - | \$ - | \$ - | \$ - | \$ - | \$ - |

Cost outputs from CER

CER Calculations

Placeholder for input uncertainty information

For Weight Uncertainty

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

| Fit Unit Point Estimate | Weight Per Unit | Fit Unit A-value | Fit Unit b-value | Complexity Factor |
|-------------------------|-----------------|------------------|------------------|-------------------|
| \$ - | 0 | N/A | N/A | 1 |

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

Cost Calculations

| Flight Unit Cost | FY12 \$M |
|------------------|-------------|
| LRIP Items | \$ - |
| Post-LRIP Items | \$ - |
| Total | \$ - |

| STH Cost | FY12 \$M |
|--------------|-------------|
| Total | \$ - |

| Production Cost | FY12 \$M |
|-----------------|----------|
| LRIP Items | \$ - |
| Post-LRIP Items | \$ - |

Inputs and calculations for Learning Curve

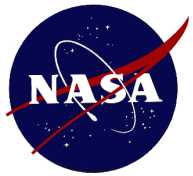
Learning, LRIP, and Production Rate Calculator

| Inputs | Q_NHA | Q_Prod | Production Start Unit | Learning Curve Slope | Theory Type | Q_LRIP | LRIP Stepdown % | Q_STH | Flight Unit % (for STH) | Production Rate (per year) | Production Rate % |
|--------|-------|--------|-----------------------|----------------------|-------------|--------|-----------------|-------|-------------------------|----------------------------|-------------------|
| | 1 | 1 | 1 | 100% | Unit | 0 | 0% | 1 | 130% | 1 | 100% |

| Calculations | Learning Multiplier | Start | Quantity | Lot Avg Unit Cost Multiplier (Unit Theory) | Lot Avg Unit Cost Multiplier (Cum Avg Theory) |
|--------------|------------------------|-------|----------|--|---|
| Flight Unit | LRIP Qty (up to Q_NHA) | 1 | 0 | 0.000 | 1.000 |
| | Post-LRIP Qty | 1 | 1 | 1.000 | 1.000 |
| Production | LRIP (up to Q_NHA) | 1 | 0 | 0.000 | 1.000 |
| | Post-LRIP Qty | 1 | 1 | 1.000 | 1.000 |

Production Rate Multiplier:

| Quantity: | 1 | 2 | 3 | 4 | 5 | 6 |
|-------------|------|---|---|---|---|---|
| Learning %: | 100% | 1 | 1 | 1 | 1 | 1 |



PCEC CER Library

System Integration (1 of 2)



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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 as 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 analysis.

Description of System Integration estimating methodology

Design and Development & Flight

CER Information

CER:

$$DD\ FY12 = A * Cost^b$$

$$FU\ FY12 = A * Cost^b$$

Variable Definitions:

A = The geometric mean

b = The average of the

Cost = Spacecraft Hardware

Instructions for using this worksheet

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

Calculations for equation parameters (A and b-values)

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

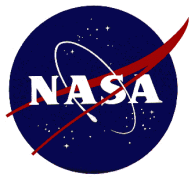
| DDT&E | Flt Unit |
|-----------|----------|
| STH | Flt Unit |
| D&D + STH | |
| D&D + STH | |
| D&D + STH | Flt Unit |
| D&D + STH | Flt Unit |
| D&D + STH | |

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 | | | | | | Test Operations | | |
|-------------------|----------|----------------|----------------|------------------|------------------|------------------------|------------------------|--|
| Selected Mission | Mission | Hardware Class | Orbit | Spacecraft Class | Estimating Level | Fit Unit A-value - STO | Fit 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 | | | |

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



PCEC CER Library System Integration (2 of 2)



**Engineering
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System Integration Cost CER Calculation (Analogy)

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

| D&D | STH | Flight Unit | Production |
|-----|-----|-------------|------------|
| | | | |

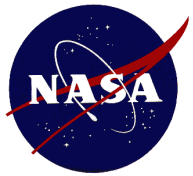
Link to WBS

CER Calculations

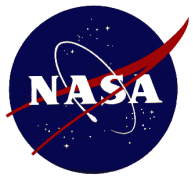
| | DDT&E Point Estimate | Cost Input (STH or D&D + STH) | DDT&E A-Value | DDT&E b-Value | DDT&E Complexity Factor |
|------|----------------------|-------------------------------|---------------|---------------|-------------------------|
| IACO | \$ - | \$ - | N/A | N/A | 1.00 |
| STO | \$ - | \$ - | N/A | N/A | 1.00 |
| GSE | \$ - | \$ - | N/A | N/A | 1.00 |
| SE&I | \$ - | \$ - | N/A | N/A | 1.00 |
| PM | \$ - | \$ - | N/A | N/A | 1.00 |
| LOOS | \$ - | \$ - | N/A | N/A | 1.00 |

| | | | | |
|------|------|-----|-----|------|
| \$ - | \$ - | N/A | N/A | 1.00 |
| \$ - | \$ - | N/A | N/A | 1.00 |
| \$ - | \$ - | N/A | N/A | 1.00 |
| \$ - | \$ - | N/A | N/A | 1.00 |

| Production Point Estimate |
|---------------------------|
| \$ - |
| \$ - |
| \$ - |
| \$ - |



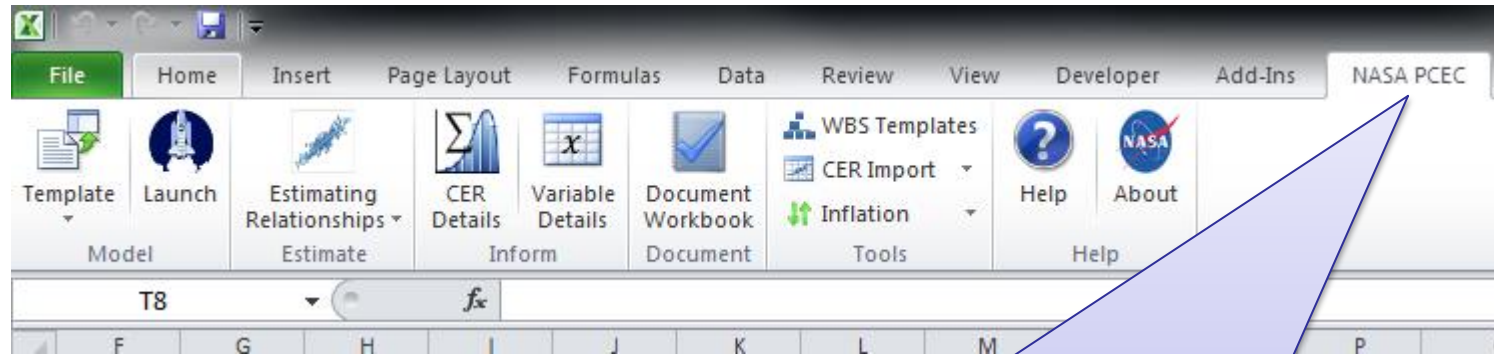
PCEC Interface



PCEC Interface Ribbon

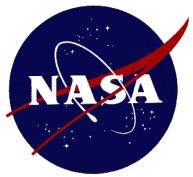


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The PCEC Ribbon Tab provides ease of access to all PCEC features, including:

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



PCEC Interface Templates



**Engineering
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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

| <u>PCEC Power Distribution DD</u> | 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, O+ | 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 | |

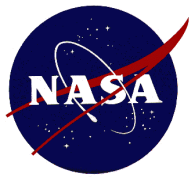
Notes:

| <u>PCEC Power Distribution FU</u> | 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, O+ | 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 Freedom | |
| | #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



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Modify WBS Elements

Add and remove CERs from WBS Hardware sections

Tailor WBS Hierarchy

Create summary elements and sub-elements to tailor WBS

WBS: + denotes element can be modified
* denotes element has options

Search for a CER:
Type a brief description of what you want to estimate and then click Go
Or select a category: All

Select a CER:
PCEC Amplifier
PCEC Antenna
PCEC Attitude Control
PCEC Battery
PCEC Cable
PCEC CCDH
PCEC CDH
PCEC Communications
PCEC Composite Structure
PCEC Controller
PCEC Crew Accom
PCEC Diplexer-Multiplexer
PCEC ECLS

Element Options
Base Year: FY12
Escalate To: 2012

PCEC Amplifier DD
Estimating Level: Component

Help on this Form

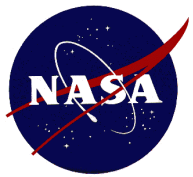
OK Cancel

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



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CER Search

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

CER Description

See detailed information about the selected CER

NASA PCEC: Insert CER

Search for a CER:

Type a brief description of what you want to estimate and then click Go

Go

Or select a category: Multivariable

Select a CER:

*Insert a Multivariable Regression equation into the selected cell

- PCEC Amplifier DD
- PCEC Amplifier FU
- PCEC Antenna DD
- PCEC Antenna FU
- PCEC Attitude Control DD
- PCEC Attitude Control FU
- PCEC Battery DD
- PCEC Battery FU
- PCEC Cable DD
- PCEC Cable FU
- PCEC CCDH DD
- PCEC CCDH FU
- PCEC CDH DD

PCEC Amplifier DD

Estimating Level: Component

Help on this Form

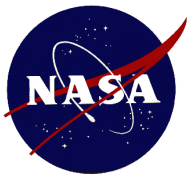
OK Cancel

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



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

Input Descriptions
View context sensitive information about the selected input variable

NASA PCEC: Multivariable Regression based CER Function Arguments

PCEC Amplifier DD

| | | | |
|----------------------|----------------------|---|-----------|
| WeightPerUnit | <input type="text"/> | = | number |
| TMI | <input type="text"/> | = | number |
| Crewed | <input type="text"/> | = | number |
| Solid_State | <input type="text"/> | = | number |
| TWT | <input type="text"/> | = | number |
| DDMR | <input type="text"/> | = | reference |

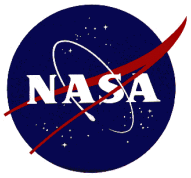
PCEC Amplifier DD: Level - Component; Method - Log-linear regression

WeightPerUnit
Weight Per Unit: Weight of each unit (pounds)
Input Range: pounds, 0+

CER Result =

[Help on this Form](#)

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



PCEC Interface CER Details



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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

NASA PCEC: Multivariable CER Information

CER Selection

Search for a CER:

Type a brief description of what you want to estimate and then click Go

Go

Or select a category: All

Select a CER:

- PCEC Amplifier DD
- PCEC Amplifier FU
- PCEC Antenna DD
- PCEC Antenna FU
- PCEC Attitude Control DD
- PCEC Attitude Control FU
- PCEC Battery DD
- PCEC Battery FU
- PCEC Cable DD
- PCEC Cable FU

CER Description

PCEC Amplifier DD

Estimating Level: Component

CER Information

CER Text | Variables | Regression | Missions | Correlation | SDM

CER Text:

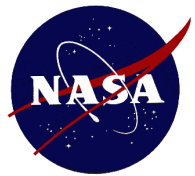
$$[DDFY12] = 0.115 * [WeightPerUnit]^{1.156} * [TMI]^{-0.383} * [Crewed]^{1.917} * [Solid_State]^{2.823} * [TWT]^{0.548} * [DDMR]^{0.1}$$

Precalculations:

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

[Help on this Form](#)

OK Cancel$$



PCEC Interface Variable Information



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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

NASA PCEC: Variable Information

| Variable Name | Friendly Name | Possible Values |
|---------------------|----------------------------|--------------------------------------|
| [DDMR] | DD Management Rating | 0-100% (Decimal in [0-1]) |
| [DDSpecialMat] | DD Special Material Factor | 0 if No, 94 if Yes. |
| [DDTech] | DD Tech | 0+ |
| [DDTEFY12] | DDTE FY12 | FY12 \$M, 0+ |
| [Deployable] | Deployable | 1 if No, =EXP(1) if Yes. |
| [DesignLife] | Design Life | months, 1+ |
| [DL120ND79] | DL >= 120 & ND >= 79% | 1 if No, =EXP(1) if Yes. |
| [DLGT72] | Design Life >= 72 | 1 if No, =EXP(1) if Yes. |
| [DRGT1] | Date Rate > 1K | 1 if No, =EXP(1) if Yes. |
| [EngMngt] | Engineering Management | 0-100% (Decimal in [0-1]) |
| [FndAvail] | Funding Availability | 0-100% (Decimal in [0-1]) |
| [FUFY12] | FU FY12 | FY12 \$M, 0+ |
| [FULouvers_Heaters] | FU Louvers/Heaters | 0 for "No Louvers / No Heaters", 3 f |
| [FUMR] | FU Management Rating | 0-100% (Decimal in [0-1]) |

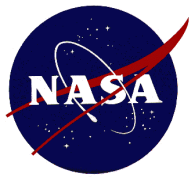
DD Special Material Factor

Rating based on whether any material out of the ordinary used in the thermal control subsystem (D&D)

This is a dimensionless variable used in the Thermal Control Tech Rating calculation. Special materials or configuration denotes anything out of the ordinary used in the thermal control/protection system, such as the gold plating used on NEAR or the carbon phenolics used on the Galileo Probe. Choices for Special Materials / Special Configurations are the following:

(1) Yes = Input of 94

[Help on this Form](#) [OK] [Cancel]



PCEC Interface Document Workbook



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Office

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

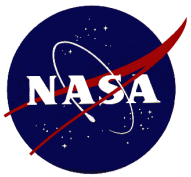
CER Document Table

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 Name | Worksheet | Address | Valid |
|--|-----------------------------|-------------------------|-------|
| PCEC Amplifier DD | Sheet1 | \$B\$2 | TRUE |
| PCEC Structures DD | PCEC Structures CER | \$C\$13 | TRUE |
| PCEC Structures FU | PCEC Structures CER | \$C\$35 | TRUE |
| PCEC Thermal Control DD | PCEC Thermal Control CER | \$C\$13 | TRUE |
| PCEC Thermal Control FU | PCEC Thermal Control CER | \$C\$35 | TRUE |
| PCEC Reaction Control DD | PCEC Reaction Control CER | \$C\$13 | TRUE |
| PCEC Reaction Control FU | PCEC Reaction Control CER | \$C\$35 | TRUE |
| PCEC Electrical Power DD | PCEC Electrical Power CER | \$C\$13 | TRUE |
| PCEC Electrical Power FU | PCEC Electrical Power CER | \$C\$35 | TRUE |
| PCEC CCDH DD | PCEC CCDH CER | \$C\$13 | TRUE |
| PCEC CCDH FU | PCEC CCDH CER | \$C\$35 | TRUE |
| PCEC Attitude Control DD | PCEC Attitude Control CER | \$C\$13 | TRUE |
| PCEC Attitude Control FU | PCEC Attitude Control CER | \$C\$35 | TRUE |
| PCEC Solid Rocket Motor DD | PCEC Solid Rocket Motor CER | \$C\$13 | TRUE |
| PCEC Solid Rocket Motor FU | PCEC Solid Rocket Motor CER | \$C\$35 | TRUE |
| PCEC Power Distribution DD | PCEC Power Distribution CER | \$C\$13 | TRUE |
| PCEC Power Distribution FU | PCEC Power Distribution CER | \$C\$35 | 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



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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

NASA PCEC: Insert Work Breakdown Structure

Select Work Breakdown Structure:
NASA NPR 7120.5E

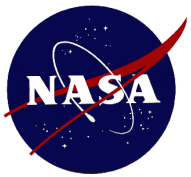
| WBS #/Level | WBS Element |
|-------------|-------------------------------|
| 1 | Space Flight Project |
| 1.1 | PM |
| 1.2 | SE |
| 1.3 | Safety & Mission Assurance |
| 1.4 | Science & Technology |
| 1.5 | Payload(s) |
| 1.6 | Spacecraft |
| 1.7 | Mission operations |
| 1.8 | Launch Vehicle/Services |
| 1.9 | Ground System(s) |
| 1.10 | Systems Integration & Testing |
| 1.11 | Education and Public Outreach |

NASA NPR 7120.5E
Space Flight Project

[Help on this Form](#)  

Insert WBS

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



PCEC Interface Inflation



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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 | | | | | 1.000 | 1.045 | 1.0805 | 1.1454 | 1.20148 | 1.2664 | 1.3385 | 1.4309 | 1.521 | 1.608 | 1.699 | 1.822 | 2.019 | 2.200 | |
| 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 | | | | | | | | | | | | | | | | | | | |
| FROM 1969 | | | | | | | | | | | | | | | | | | | |
| FROM 1970 | | | | | | | | | | | | | | | | | | | |
| FROM 1971 | | | | | | | | | | | | | | | | | | | |
| FROM 1972 | | | | | | | | | | | | | | | | | | | |
| FROM 1973 | | | | | | | | | | | | | | | | | | | |
| FROM 1974 | | | | | | | | | | | | | | | | | | | |

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

NASA PCEC: Insert Inflation Factors for Specific Years

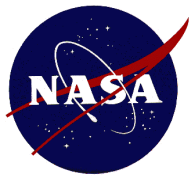
Destination Cell

Choose Years

Base Year Start Year Final Year

2012 2014 2019

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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

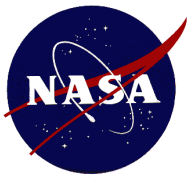
NASA PCEC: Generate Library Worksheets

Select Library Worksheets to generate:

Available Library Worksheets

- Variable List
- Inflation Table
- First Pound Cost (Analogy)
- First Pound Cost (Database Average)
- System Integration (Analogy)
- System Integration (Database Average)
- PCEC Amplifier
- PCEC Antenna
- PCEC Attitude Control
- PCEC Battery
- PCEC Cable
- PCEC CCDH
- PCEC CDH
- PCEC Communications

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PCEC Interface In-Tool Help File



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NASA Project Cost Estimating Capability

Hide Back Forward Home Print Options

Contents Search Favorites

- Introduction
 - Welcome
- FAQ
- Getting Started
- PCEC Ribbon
- Template
- Launch
- Estimating Relationships
- CER Details
- Variable Details
- Document Workbook
- WBS Templates
- CER Import
- Inflation
- Help
- About

Welcome

Introduction >>

NASA Project Cost Estimating Capability

PCEC Project Background

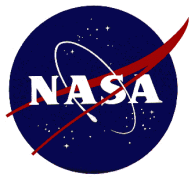
The Project Cost Estimating Capability (PCEC) is a framework that will replace NAFCOM as the standard NASA capability for estimating the cost of new spaceflight hardware systems during concept exploration and refinement. The PCEC consists of an Excel based architecture that combines a user interface running VBA with WBS and CER libraries. This structure provided a high degree of flexibility and openness while reducing the resources required for software maintenance, thus allowing more effort to be put into improving NASA models and estimating capabilities.

Introduction to the PCEC Interface

The PCEC Interface is a Microsoft Excel Add-in (xlam) workbook that provides features to facilitate the integration of Project Estimating artifacts contained in the PCEC Library into Excel based cost models. The PCEC Interface's purpose is to facilitate the use of the information stored in the Interface and to automate tasks when building an estimate in Excel. The Interface stores all information contained in PCEC Library and exposes that information to users in different ways through a variety of useful features. The intent is that the Interface will improve accuracy and efficiency when building estimates in Excel using the information from the PCEC Library.

NASA

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



History of NAFCOM



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NAFCOM Evolution

1990

- NASCOM database in hardcopy only
- Estimators hand-entered data into spreadsheets
- Database contained 65 data points

1992

- Allowed online searches and copying of data
- Cost estimates developed in spreadsheets with CERs created by individuals
- Database contained 70 data points

1994

- Fully functional cost model with user defined WBS and data access
- CERs built automatically within NASCOM using "1st Pound" method
- Database contained 91 data points

1996

- Combined NASA and Air Force data
- Enhanced search and filtering of data
- Standardized WBS elements created
- Database contained 102 data points

2011

- Thruput \$ in any fiscal year
- Historical weight units sensitive to global selection
- Two new templates (Earth Orbiting and Planetary)
- Historical Database QA
- Multi-Variable CER Mission indicator
- Database contains 149 data points

1999

- First non-weight based CERs for five subsystems (multi-variable CERs)
- Government and contractor versions distributed
- Database contained 114 data points

2008

- 17 New Component Level multi-variable CERs
- New statistics integrated into database
- Historical Schedule Data integrated into toolbar
- Converted to .NET Platform and SQL Databases
- New interface for risk analysis outputs
- Database contains 135 data points

2002

- Total re-write of all NAFCOM program code
- multi-variable CERs for all subsystems
- Major user interface improvements
- Database contains 122 data points

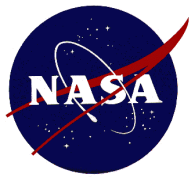
2007

- Calibration Module
- Matrix Consistency Checker
- Ability to send full NAFCOM Cost Report directly to Excel
- Database contains 133 data points

2004-2006

- Cost Risk Analysis Module
- CER Improvements
 - SOCM
- Component level multi-variable CER
- Allocation of Risk Dollars by WBS Elements
 - WBS Generator
- Expanded Drag and Drop manipulation
- Dynamic display of Weight Based standard errors





Major NAFCOM Components



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Data

Engineering Cost Model

- Spacecraft
- Launch Vehicles
- Crewed Vehicles
- Landers
- Etc.



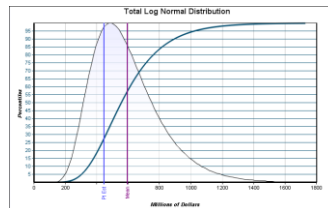
**Liquid Rocket Engine
Cost Model (LRECM)**
Victory Solutions MIPSS Team



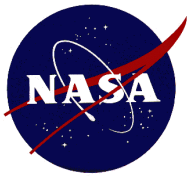
Space Operations Cost Model (SOCM)

Scientific Instrument Cost Model (SICM) Data

ca. 1998



**FRISK Based
Risk Analysis**



Requirements



Level 1

1. Shall enable the use of Cost Estimating Relationships (CERs).
2. Shall enable the use of Work Breakdown Structures (WBSs).
3. Shall facilitate the ability to do, but not perform, risk analysis.
4. Shall not contain sensitive, controlled, or proprietary data.
5. Shall not provide access to or have software dependencies on any databases or libraries external to the PCEC Architecture as defined in the PCEC Architecture document.
6. Shall implement the agreed upon list of NAFCOM functionalities outlined in the NAFCOM Functionalities to PCEC document.
7. Shall include documentation covering the use of all capabilities and features.
8. Shall include documentation and statistics of CERs.
9. Shall show complete transparency of calculations being performed.
10. Shall produce estimates that are traceable to the NASA Standard WBS.
11. Shall be compliant with all NASA IT security requirements.
12. Shall be compatible with MS Office 2010 for Windows and later versions.
13. Shall be transparent to, open to, and modifiable by all users.
14. Shall enable an estimator to develop an estimate with links to PCEC data, CERs, or WBS

Level 2

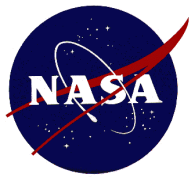
1. Shall allow use of preloaded CERs contained in the PCE Library. (1)
2. Shall allow use of custom CERs. (1)
3. Shall allow user to modify preloaded CERs contained in the PCE Library. (1)
4. Shall contain all statistics relevant for assessing the CER. (8)
5. Shall contain all necessary information to perform risk analysis. (3, 8)
6. PCE Library releases shall be separate from PCE Interface releases. (7)
7. Shall allow use of preloaded WBS(s) contained in the PCE Library. (2)
8. Shall allow customization of WBS(s). (2)

Level 3

1. PCE Interface shall allow users to manually adjust the parameters of preloaded CERs.(3)
2. The PCE Interface and PCE Library shall each have their own release version and release schedule. Each release of the PCE Interface shall come preloaded with the latest PCE Library. New releases of the PCE Library shall be able to be loaded into the current version of the PCE Interface by users. This separation shall 1) simplify the process of distributing updated CERs and 2) allow users to load previous CER releases (i.e. previous PCE Library versions) into the most current version of the PCE Interface. (5)
3. WBS templates shall be stored in the PCE Library and users shall have the ability to modify the templates to produce a customized WBS. (6, 7)

Key Attributes:

- Transparent and Customizable
- Meet all NASA IT Security Requirements
- Include Documentation and Statistics for all CERs
- Traceable to NASA Standard WBS
- Separate CER Libraries and Software
- No Data or Links to Databases

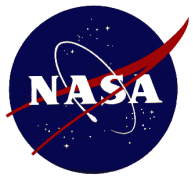


Key NAFCOM Features



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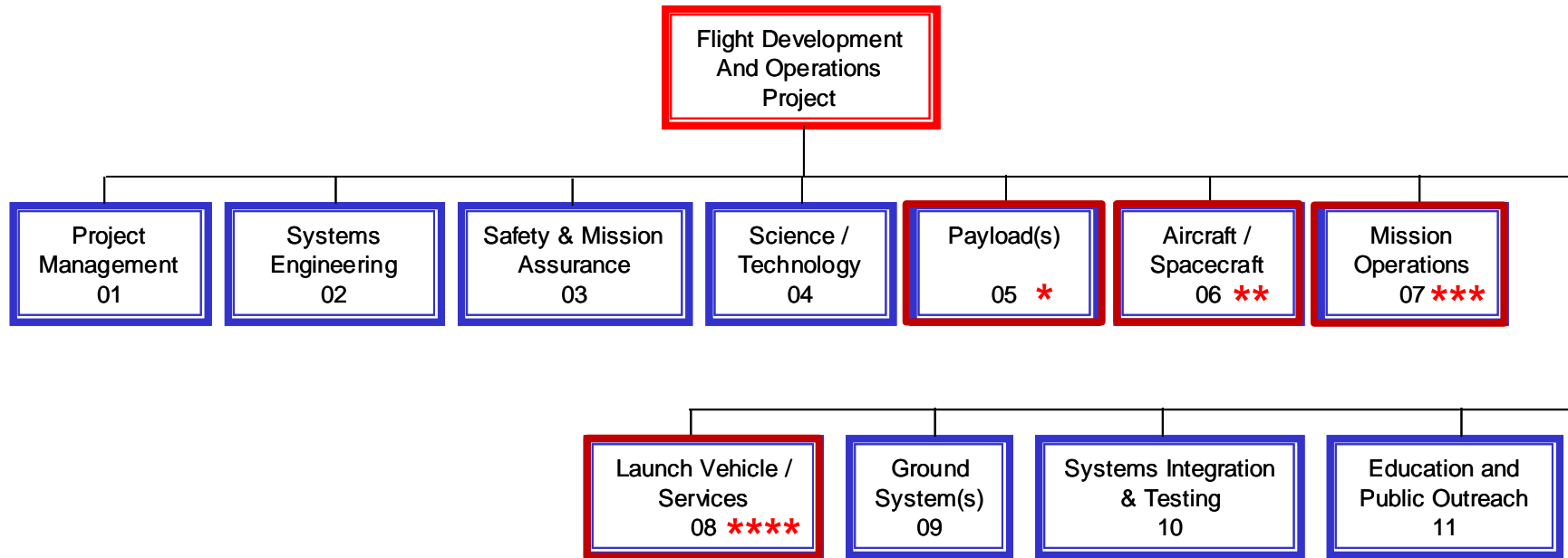
- **CER Selection**
- **Sort & Search Data**
- **WBS Development/Manipulation**
- **Cost Phasing**
- **Inflation**
- **Thru-put Costs**
- **Input user developed CERs**
- **Project Resumes/Data Sheets**



NAFCOM and the NASA Standard WBS

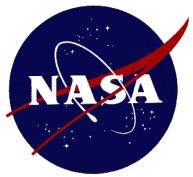


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=

- * Analogy estimates based on old data
- ** Spacecraft only
- *** Robotic spacecraft
- **** New launch vehicle developments

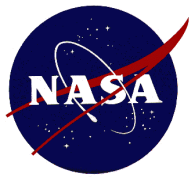


What Happens to NAFCOM?



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- NAFCOM's Primary Capabilities will be Captured by the PCEC
- In the Near Term *Limited Technical Support* is being Provided to Current NAFCOM12 Users
- PCEC Library v0 is being Provided on a Case by Case Basis
- Once the PCEC becomes Operational, all Support for NAFCOM will End



CER Library Organization



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- **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**