How much does this cost?

Source: US Navy – Released 2012 (120919-O-GR159-007)
https://www.flickr.com/photos/usnavy/8043212532/in/photostream/

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Estimation Methodologies

- **Engineering Judgment**
  - The engineering build-up method develops the cost estimate at the lowest level of the WBS, one piece at a time, and the sum of the pieces becomes the estimate.

- **Analogy**
  - An analogy uses the cost of a similar program to estimate the new program and adjusts for differences.

- **Parametric: basic CERS ($/lb.) to Complex Models (multi-variant)**
  - A cost estimating methodology using statistical relationships between historical costs and other program variables such as system physical aspects.

- **Others**
  - Actual Costs
  - Expert Opinion
  - Extrapolation
  - Learning Curves
  - …
Purpose of Program Affordability

- Minimize Total Life Cycle Costs to the Customer, While Meeting all Requirements

- To Track Cost As a Technical Performance Measure (TPM) of the Deliverables

- Assist the Program in Achieving a Proper Balance Among Technical Performance, Affordability (Development, Production, Operating and Support), and Producibility.
Affordability Goal Setting

Customer Mandate

- Program affordability targets shall be treated by the program manager as a Key Performance Parameter (KPP).
- Affordability targets:
  - Total Development Cost
  - Average Unit Acquisition Cost
  - Average Annual Operating and Support cost per unit.

Raytheon Guideline

- Cost Technical Performance Measure (TPM) is an Affordability Metric
- Gate Reviews: Program Reviews the Affordability / DTC
- Program Performance Reviews
  - Issues / Accomplishments
  - System DTC Variance
  - Cost Reduction Roadmaps
  - Future Plans (Short to Long Term)

Program Affordability spans the entire life cycle of every program
The concept phase is when the trades between alternatives that affect affordability can be made and maximum cost savings achieved.

The longer you wait, the more difficult it is to optimize cost.

Program Affordability spans the entire life cycle of every program.
Traditional Cost Management

- Focus on meeting customer’s requirements.
  - Cost is seen as a **Dependent** variable
  - Cost is a result of functionality, features, and performance.

Cost is considered late in process, causing cost to be higher than desired.
Dealing with Uncertainty

Figure 4: Cone of Uncertainty

1. Uncertainty about cost estimate is high

2. Uncertainty is low

Cost estimate baseline

Estimate becomes more certain as program progresses
Estimate tends to grow over time as risks are realized

Concept refinement gate
Technology development gate
Start of program and start of system integration gate

Source: GAO

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Market Driven Cost Management

1. Market Driven Pricing
   - Product oriented to customers needs and affordability

2. Cost is an Independent variable
   - Cost is treated early and driver when defining hardware/software requirements

3. Proactive
   - Cost is actively worked on during the product and process development

When done early, there is alignment between the cost and the technical solution maximizing the win probability.
Cost as a Requirement

Product-based bidding: Top Down ➔ Lower Cost, Higher Quality

Formal Proposal Development Engine

Development: Technical Offering Trade Assessment of Financial Cost Volume

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Formal Proposal Development Engine

Development: Technical Offering Trade Assessment of Financial Cost Volume
Price to Win Overview

What is Price to Win?

Price to Win (PTW) is the recommended bid price at which the customer will select the our solution instead of competitors’ solutions in a competitive procurement process.

THE GOAL OF PTW ANALYSIS

- Develop a **market-based price** for a competitive pursuit based on a deep understanding of both the **customer** and the **competitors**
  - what customers want and what they are willing to pay
  - what is the competitor’s solution, and what will they bid
- The PTW recommendation provides a pivotal data point from which to develop the **pricing strategy** for our solution

THE PTW PROCESS IS...

- ...an analytical method of estimating the price a competitor will bid using multiple approaches
- ...grounded in a foundation of solid **Competitive Intelligence (CI)** collected throughout the pursuit
- ...started very early in the capture process, and is **updated continually** through the Final Proposal Revision (FPR) phase, as useful CI improves the fidelity of the PTW estimate

Timeline

<table>
<thead>
<tr>
<th>Milestones</th>
<th>PTW Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Contact</td>
<td>Phase 1: Coarse “Should Cost”</td>
</tr>
<tr>
<td>PTW Kickoff</td>
<td>Phase 2: Low Confidence “Could Cost”</td>
</tr>
<tr>
<td>Competitive Assessment</td>
<td>Phase 3: Bid Strategy Shaping</td>
</tr>
<tr>
<td>Black Hat 1</td>
<td>Phase 4: High Confidence Price to Win</td>
</tr>
<tr>
<td>Gate 2</td>
<td>Pink Team</td>
</tr>
<tr>
<td>Black Hat 2</td>
<td>Gold Team</td>
</tr>
<tr>
<td>Gate 3</td>
<td>White Glove</td>
</tr>
<tr>
<td>Red Team</td>
<td>Gate 4</td>
</tr>
</tbody>
</table>

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“Pricing is the moment of Truth”: E.R. Corey (Harvard Business School) - 1962

- A PTW always should always begin with plan to research the customer, the competition, and the proposed solution.
- A good PTW should be independent from the capture team, so that it will provide an alternative approach (one developed from the competitor’s viewpoint), thereby challenging the capture team to develop the best win strategy.

```
PTW

Contract Performance

Competitor Intelligence

Customer Intelligence

Requirements, Landscape, Source Selection Criteria

What is their propensity? What drives their decisions?

What is their win strategy? Who will they work with? What will they offer?

What assessments will be used? Will complexity allow for risk?

How do we maximize our strengths? Can we minimize our deficiencies?
```
PTW Methodology – The Nine

1. Customer Available Budget Analysis
2. Competitor Bid-to-Budget Analyses
3. Competitor Solution Definition
4. SME Should Cost RTN and Competitors
5. Bottoms Up: RTN and Competitors
6. Parametric Models: RTN and Competitors
7. Similar Programs: RTN and Competitors
8. PTW Analysis
9. Independent PTW

Analysis | Who | Description
--- | --- | ---
1. Customer Available Budget | BD | An analysis to determine the amount of money from the customer available to a program.
2. Bid-to-Budget | BD | A comparison of past competitor bids relative to the customer’s available budgets for similar programs.
3. Solution Definition | SME | A technical definition of the competitor’s architecture. The should cost and bottoms up will be based on this architecture. It will likely be refined over time.
4. Should Cost | SME | A gross, rough order of magnitude cost estimate for a system by major WBS element. Based primarily on engineering judgment from SMEs who are knowledgeable about that system. Purpose is to get a quick estimate of system cost. Also called “Delphi” or “Component Substitution.”
5. Bottoms Up | PTW | A detailed cost estimate of the architecture using specific geographic locations of work, escalation over time, BOEs, a BOM, vendor quotes, types of labor, teaming arrangements, etc. It is to be an accurate representation of the cost of the system.
6. Parametric Model | PM | A metric by which one can compare similar systems. Example: Cost per pound, cost per kilowatt, etc.
7. Similar Programs | PM | A cost comparison of similar past or existing programs to the one defined in item 3. Validates or contrasts to provide additional perspective. May also be called “similar to” analysis.
8. PTW Analysis | PTW | A gathering of data into a cohesive story for each competitor’s likely prices and a price target range for RTN to bid in order to win.
9. Independent PTW | TBD | A PTW performed by a group that are outside the Capture.

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1/9/2020 | 14
Affordability Model Attributes

Cost Modeling will allow IPTs to compare cost projections against cost targets under a variety of scenarios.
Affordability Modeling

Input Data: Use Est. Values (Historical, Predicted, etc.) to populate initial Cost Models.

- As the program matures, Model is continually updated

Estimates, Quotes, *ROMs, etc. → Current Cost Model → Up-to-Date Affordability Reports, Projections, etc.

Actuals, Updates

- To Improve cost projection accuracy, the Cost Model should consider the following inputs:

  • Detailed Indented Parts Lists
  • Part Quantities
  • Price Estimates
  • Supplier Price Quotes
  • Price Actuals
  • Labor Hours, Standards & Realization Factors
  • Requirements and IPT Summary
  • Rates and Factors
  • Support Pools and Burdens
  • Six Sigma Worksheets
  • Assembly Process Flow (Including Engineering Troubleshooting and Assistance)
  • Assembly and Test Yields
  • Rework, Attrition and Scrap
  • Batch Sizes and Amortized Set-up Costs
  • Material Allowances
  • Negotiation Allowances
Industry Parametric Modeling: SEER®

- SEER® software uses:
  - Parametric algorithms
  - Built-in Knowledge Bases
  - User Defined Unique Knowledge Bases
    - Which Capitalize on existing Data
    - Calibration tools are built in so it can be customized to user defined experience and expertise

- “Top Down” Parametric approach:
  - Employs cost estimating relationships (CERs) or equations
  - Built-in CER Mapping Database
    - Employs cost estimating relationships or equations
  - Allows estimation based on measurement of key parameters that drive time and effort
    - Technical or physical characteristics of the product, personnel, and development environment
  - Once relationships are known, parameter values can be changed and the effects evaluated
What is SEER – H® (Hardware) ?

- SEER-H® is a parametric hardware estimation model
- Estimates development, production, operations and support cost as well as reliability of the hardware
- Utilizes:
  - Mapping Database
  - Knowledge Bases
  - Estimating Equations
- Bases estimates on a variety of cost driving parameters
  - Product description: What is Being Built ?
  - Mission description: How it Must Perform ?
  - Program description: How it Will Be Built ?
  - Maintenance description: Who/Where/How will be done ?
- Reports cost and reliability estimates in a variety of formats
SEER Integrated Tool Suite

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SEER® Cost Modeling Inputs

- **Program Schedule:**
  - Development = 1/6/2014
  - Production = 1/4/2016
  - Base Year = 2014

- **Quantity**
  - Development
    - Demo Systems
    - Types of Demonstration and EMD Units
  - Production
    - QTY
    - Build Plan number per year (or Month)

- **Product Breakdown Structure**
  - This is how the system will be put together
  - Prior to starting it is important to have a plan of how the team wants to group costs (across the Should Cost, PTW and RTN Cost)
  - Where items are being built (which facility will be responsible for which item)
  - The overall build and test plan
  - Useful Inputs SWAP and BOMs

- **What kind of Contract? CP or FF**

- **The Major Questions:**
  - **Application:** overall hardware function (CPU, structure...) Separate sets for mechanical and electronic elements
  - **Platform:** operating platform (space, ground...)
  - **Acquisition:** development and production scenario (make, buy, outsource, shared development, CFE ...)
  - **Standards:** specifications and standards used in product development and production
  - **Reuse:** Percentage of design effort required to complete development and design effort.
  - **Product Description:**
    - Mechanical: Weight, Size, Material Type
    - Electrical: # of PCB, Board Size, Composition (if unknown size of box and % electronics)
    - Optical: Size, number, type
    - Software: Number of CSCIs, SLOC count for NEW, Modified Reused, including Purchased

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SEER® Cost Modeling Outputs

- With Good Inputs the model can reflect the program and the data can be analyzed:
  - Development vs Production.
  - Cost Drivers
  - System Level Costs: PM, SE, IAT
  - Confidence on the data
  - ...

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This is not a Magic 8-Ball!

Garbage In is Garbage Out!

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Deterministic vs. Monte Carlo Model

- **Point Estimate**
  - Every Input variable is known.
  - Output Variables are the combination of those inputs.

- **Stochastic Approach**
  - Each input variable has a probability distribution.
  - Output variables have new distribution based upon thousands of recalculations of the input variables variation.
WBS Mapping Initiative Objectives

- Develop a program cost catalog for Space programs inclusive of program bio, cost collection assumptions, major milestone dates
- Utilize the MIL-STD-881 Space Systems WBS to map program actuals and to use in bidding process
- Provide a consistent cost collection system for robust comparative analysis across Space programs
  - All functions looking at the same source data
  - Currently going thru data validation with functional stakeholders to get buy in
- Reduce proposal/ROM cycle time by having the data available at all times
  - Avoid pulling the same data for each proposal
- Collaborate the CIPT on data collection
How Does SEER® Help?

SEER® can answer the following questions

- **Does X system cost $10M or $100M?**
  - This is the question often asked to make early business decisions
  - Architectural solution usually very rough

- **Does X System cost $10M or $20M?**
  - High level architectural studies
  - Internal ROMs
  - ICE

- **Does X System cost $10M or $12M?**
  - Requires highly experienced tool users
  - Requires historical validation
  - Requires minimum “guesstimation”
Validation Run-Rules

- **Validation Project Description**
  - Use SEER-H and SEER-SYS tools to model labor hours for a variety of space and airborne products and systems
    - Goal to understand the model prediction vs actuals
  - Establish a Validation Team
    - Ensure independence between SEER Tool users and senior cost estimator and financial analyst responsible for correlating EAC and Actuals to common WBS
  - Create SEER Tool User Guidelines
    - Model Inputs are based on design and requirements
      - Weight, component count, material type, quantity
    - Nominal Kbase setting will be used for all subjective inputs i.e. skill level and experience

Independence between SEER Model Implementation and Actual/EAC correlation is key to validity of validation effort.
Airborne SEER-H® EAC Update

- Status updated on XXXX SEER-H® Prediction
  - Compare SEER-H prediction from 1Q-17 EAC and 4Q-17 EAC
  - 4Q Net increase of 6000 hours from previous EAC
    - Test Issues
    - Changes to text fixture design
    - Unanticipated change request from suppliers
    - Firmware development productivity lower than planned
  - SEER-H® confidence curve and risk
    - Estimate now aligns with a probability typically used to capture bids with low risk or higher confidence
    - Model has not utilized the Least/Likely/Most for design element parameters to capture risk
      - Potential model improvement would be to include

<table>
<thead>
<tr>
<th>WBS Item</th>
<th>1Q17 EAC CEU Labor Hours</th>
<th>4Q17 EAC CEU Labor Hours</th>
<th>SEER® Labor Hours (50% Confidence)</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW Element EMD</td>
<td>191082</td>
<td>199572</td>
<td>193565</td>
<td>3 %</td>
</tr>
<tr>
<td>Contract Subtotals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SEER-H® aligns well with actual program cost and program execution
Integrated Support Electronics (ISE)

- Validation effort performed for both the Phase A and Phase B portion of the program through first article sell-off
- SEER Inputs
  - Level 3: Unit, ISE
    - Platform: Space-unmanned, Standard: Military Full
  - Level 4: Modules
    - Platform: Space-unmanned, Standard: Military Full
  - Level 5: Components
    - Applications: Varied, Platform: Space-Unmanned, Standard: Military Full, Acquisition Category: Varied (Design Maturity)

<table>
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<th>SEER® Labor Hours (50% Confidence)</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISE (Includes System Engineering Hours)</td>
<td>313939</td>
<td>319263</td>
<td>2%</td>
</tr>
</tbody>
</table>

Results obtained with only changing quantitative values on component counts and Development quantities.
Cost as a Requirement

Product-based bidding: Top Down ➔ Lower Cost, Higher Quality

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Setting Cost Requirements

Choosing a cost depends on TPMs, schedule, contract type, & risk tolerance.

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**Cost Engineering's Mission is balance the customer’s needs with what they can afford!**
A Successful Effort

4/15 RFI
ROM = $99M

$116M Customer budget @ 7/12 Industry Day

$98M Customer budget @ 10/7 DRFP update

9/15 1st PTW with inputs from DDR leads
10/7 SEIT refined to bottom-up
10/18 SEIT refined to bottom-up
10/13 Cost K/O Mfg.
9/29 and 10/6 Director challenges to Centers to reduce cost
9/20 Initial price roll-up
10/21 Should cost and < $90M price championed by SR VP
10/28 Latest tech baseline updates
10/27 Leadership driven results
11/1 Input to Corp. investment review
11/16 Cost volume submittal

Failure to Manage Costs Leads to Losing the Program, a Difficult Path to Completing a Bid, or an Issue Riddled Program.

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Winners Understand & Anticipate Customer’s “Best” Value

“Better, Faster, & Cheaper”

Cost Realism

Customer Funding

Program Objective

Program Threshold

Bid Price

Winners

Losers

Performance