Overcoming Challenges in Estimating Advanced Technology Programs

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Abstract: During the Source Selection process, many different types of cost analysis are required by both the Source Selection Board (Government) and the Contractor (Performer). This includes analysis such as Cost Realism, Analysis of Alternatives, Ghosting the Competition and Growth Estimating. Often times, both Government and Contractors have no consistent, repeatable and traceable way of performing these types of analysis. This leads to poor and/or inconsistent decision making during the Source Selection process. However, using parametric methods, these types of analysis are easily accomplished in a fraction of the time of traditional methods.

This presentation will discuss and demonstrate best practices for using parametric cost estimating methods for long range, advanced technology under uncertainty. One key question often asked is how a commercially available parametric model can accurately predict the costs of advanced technology ten or more years into the future. This presentation examines the difficulty of analyzing and estimating costs for systems that incorporate advanced technology in relation to mature systems where cost history exists. We will also discuss the need for data driven parametric estimating and the importance of developing cost estimating relationships based on actual cost data.

Introduction

The objective of this paper is to discuss the challenges in estimating advanced technology programs and discuss best practices gained through practical experience. As any good cost estimator knows, future programs are usually extrapolated by using historical data as a starting point. This can take the form of Cost Estimating Relationships (CERs) analogies, detail time and material estimates or any combination other methods.

Parametric models are also used to extrapolate technology, performance and cost parameters to determine new programs. While one can argue that all future programs are relatable to past technologies and thus data-driven, there are instances where prior historical data is not adequate to describe the advances in technology required, say ten to fifteen years into the future. Programs in this timeframe are usually considered high risk and may be undertaken by agencies such as DARPA. Although these programs may produce revolutionary changes if successful, there are many challenges in the estimating the advanced technology required.

Challenges in Estimating Advanced Technology Programs

Cost estimating for programs in the near term (1-5 years) often relies on established databases, advanced technology programs are usually thought of as having Initial Operating Capability of 10-15 years in the future. Extrapolation of cost databases and CERs are often used for up to 10 years in the future, there is substantial risk of underestimating the program or mismatching cost and performance data.

In fact, the data required for successful estimation of advanced technology programs may not be sufficient to extrapolate beyond the 5 year mark without substantially increasing the risk of understating cost estimates, leading to large program overruns. Thus, estimating by techniques such as analogy, while appropriate for near term projects where data can be reasonably extended, often proves disastrous in estimating advanced technology programs.

The same applies for development of cost estimating relationships where the independent variables, such as performance and technical characteristics (weight, thrust and speed), are highly uncertain. Often, performance parameters are subject to volatility as the program matures and even if cost data can be extrapolated, results can be highly skewed due to changes in these variables. Thus the level of confidence in advanced technology estimates is a major concern.

In March 2011, the US GAO examined some of these factors, especially the ones relating to Nunn-McCurdy breaches[1]. These breaches occur when the unit cost of a program exceeds a certain threshold. While there are a number of different criteria for Nunn-McCurdy cost breaches, the GAO points out that “since 1997, there have been 74 Nunn-McCurdy breaches involving 47 major defense acquisition programs.” Figure 1, from the GAO report, points out the trend and number of critical and significant breaches between 1997 and 2009.

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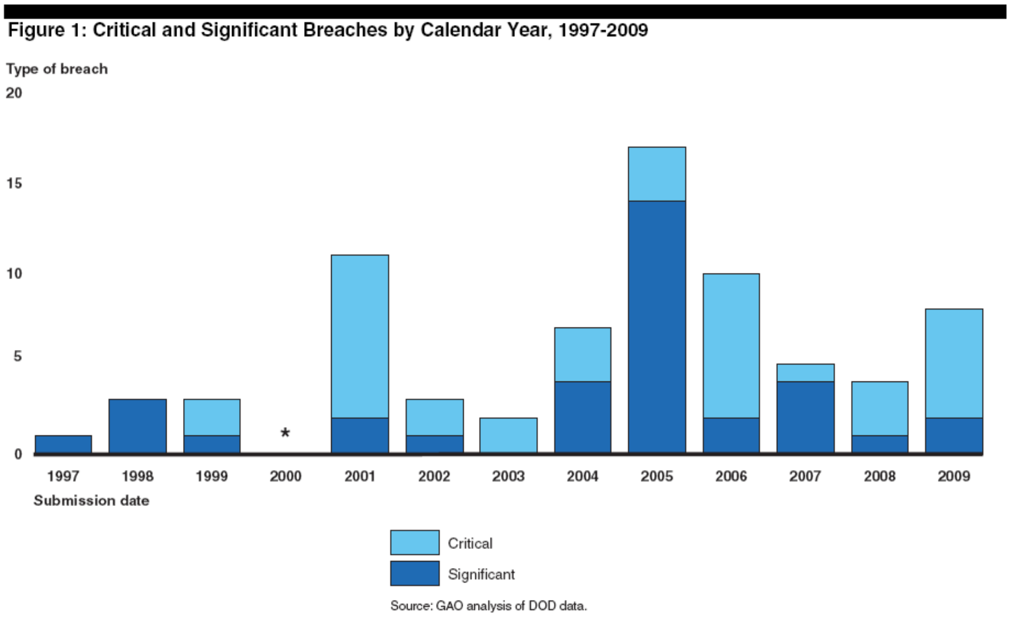
[1] GAO “DoD Cost Overruns: Trends in Nunn-McCurdy Breaches and Tools to Manage Weapon Systems Acquisition Costs”, GAO-11-499T



Source: GAO analysis of DOD data.

Figure 1 Nunn-McCurdy Cost Breaches 1997-2009[2]

Of the 47 programs GAO found that aircraft, satellite and helicopter programs experienced the largest number of breaches. The most interesting aspect of the GAO study is the underlying factors of what causes the breaches: surprisingly, GAO's analysis of DoD data reveals that the number of breaches caused by engineering/design issues are the highest cited. Figure 2 presents the GAO research analyzing the factors that are cited in the Selected Acquisition Reports (SAR).

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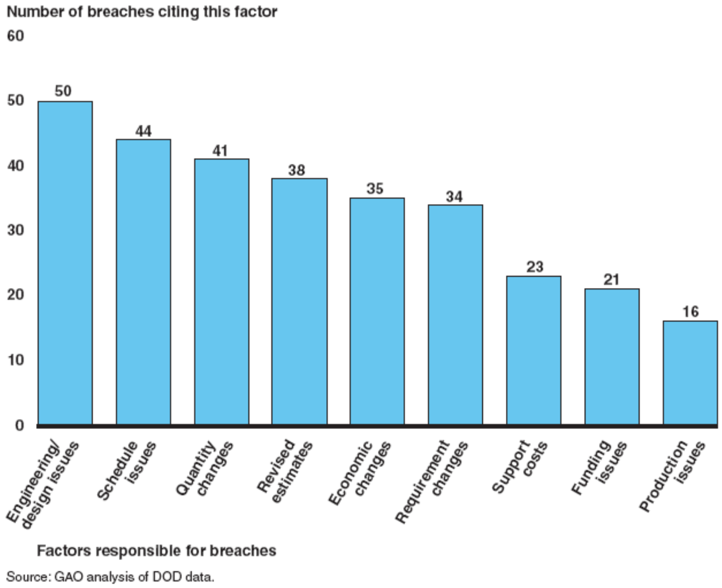
[2] GAO "DoD Cost Overruns: Trends in Nunn-McCurdy Breaches and Tools to Manage Weapon Systems Acquisition Costs", GAO-11-499T, page 3



Source: GAO analysis of DOD data.

Figure 2 Factors Cited in SARs as being Responsible for Nunn-McCurdy Breaches[3]

Figure 2 raises some interesting points related to the cost estimating of advanced technology programs. For example, GAO cites the example of programs such as the Space Based Infrared System High (SBIR) "that began with immature technologies and was based on faulty and overly optimistic assumptions about software reuse and productivity levels, the benefits of commercial practices, management stability, and the level of understanding of requirements."[4]

The report goes on to discuss using knowledge-based acquisition practices to help minimize the risk of cost overruns. In particular, the GAO study recommended early and continued systems engineering analysis.

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[3] GAO "DoD Cost Overruns: Trends in Nunn-McCurdy Breaches and Tools to Manage Weapon Systems Acquisition Costs", GAO-11-499T, page 5

[4] GAO, "Defense Acquisitions: Despite Restructuring, SBIRS High Program Remains at Risk of Cost and Schedule Overruns", GAO-04-48

Specifically “robust AoAs and preliminary design reviews (PDR)….ensure that new programs have a sound, executable business case that represents a cost-effective solution to meeting warfighters’ needs”.[5]

However, while there are SPDR/CCDRs for R&D programs of record, little data is known for advanced technology programs, which presents challenges in estimating. Although research indicates that engineering and design issues are the number one factor for Nunn-McCurdy cost breaches, and GAO calls for early and continued system engineering analysis, we want to examine several other approaches for cost estimating of advanced technology programs. Table 1 summarizes some of the major methodologies, including pros and cons, used in the estimation of advanced technology programs.

Table 1 Approach to Estimating Advanced Technology Programs

Approach	Pros/Cons
Subject Matter Expert (SMEs)	• Pro: Using appropriate SMEs from a variety of disciplines leverages a vast body of collective knowledge and can rapidly produce an estimate • Con: Hard to substantiate results, key program elements often missed
Delphi Method	• Pro: Similar to SME, but uses a more structured approach through written questionnaires and several rounds of polling. Uses four distinct phases including exploration, reaching understanding, evaluation of differences and final evaluation • Con: While a more formal approach, not all perspectives may be explored, and expert opinion may not adequately forecast cost of future technology
Cost Estimating Relationships (CERs)	• Pro: Analyzes relationship between cost and non-cost data such as range, payload, speed and technology. Highly correlated CERs useful in projecting future costs • Con: Extrapolating CERs well beyond reasonable forecasting time periods and technology. Advanced technology programs may require development of new technology that is revolutionary, not evolutionary
DoD Parametric Models	• Pro: CERs are based on extensive DoD data • Con: Same problem noted in CERs above, plus DoD models may not be available to all performers

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[5] GAO “DoD Cost Overruns: Trends in Nunn-McCurdy Breaches and Tools to Manage Weapon Systems Acquisition Costs”, GAO-11-499T, page 7

While all of the methodologies above are useful in estimating advanced technology programs, acceptance of the results will vary based on the quality of the data and the time period of the forecast. For example, extending CERs or a parametric model to forecast completely new technology 10-15 years in the future (even if data-driven) can lead to erroneous results if the technology and/or performance parameters are not well understood. The same applies to SME/Delphi methods where extrapolation of expert opinion, even though formalized, is inadequate to envision the cost/performance impacts expected in an advanced technology program.

Given that all current cost estimating methodologies carry inherent risk of “unknown-unknowns” the best way to estimate advanced technology programs is to use more than one approach. In our experience, often using a combination of SMEs, data-driven CERs and commercially available parametric models yields the best results. Disagreement between the estimating approaches is a useful tool in “triangulating” an estimate; and disagreement between an SME and a parametric model can lead to a better understanding of the inherent cost/performance risk.

For example, during a recent estimate of an advanced technology program, we developed a parametric model for a technology 10 years into the future. The prevailing wisdom from the SMEs was that the parametric model would severely underestimate the technology since the new technology was extremely advanced. In order to verify the estimate, our team blended the SME experience along with the parametric and data-driven approach to derive the triangulated estimate based on more than one methodology.

We found that SME input was critical to discuss qualitative factors such as requirements stability, engineering complexity, systems integration, etc. Once a triangulated estimate approach/methodology is in place, it can be used to develop a range of early stage estimates useful for advanced technology programs. Table 2 below summarizes the types of early stage analysis and estimates that should be artifacts of advanced technology programs.

Table 2 Types of Early Stage Estimates

Type	Description
Analysis of Alternatives	Is proposed technical baseline cost-effective against other competing alternatives in meeting both performance and cost?
Cost Realism	Are the performers bidding within an accurate range based on past experience?
Data Driven Estimating	Are the performers bidding based on appropriate, traceable historical data points if applicable?
Independent Cost Estimate (ICE)	Using the performer’s technical configuration, what does a completely independent look say about the performer’s bid?
Risk Analysis	Is the bid over conservative, what is the risk profile and how much cost exposure can we absorb?

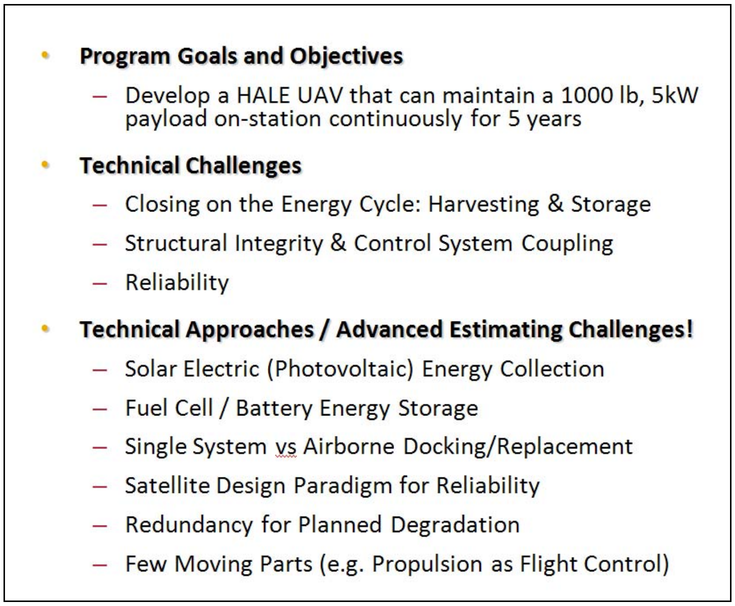
Schedule Estimating	Can we really do the job within the schedule constraints?
Growth Estimating	What other configurations, materials or technologies might we consider

We found that one of the most useful early stage estimates for advanced technology programs is the Analysis of Alternatives (AoAs). The AoA is useful in early conceptual stages where a decision is required for using one type of technology versus another. For instance, the AoA may look at cost/performance trades of using an existing technology against developing an entirely new technology. This is often dependent on projected mission profiles and requires good integration between operational effectiveness and cost models. Another use of the AoA for advanced technology program estimating is during source selection where each performer's technical solution is evaluated against a mission profile and existing technology solutions. In this way, solutions that do not meet mission profiles or operational effectiveness figures of merit are not pursued.

To demonstrate how an AoA is effectively used for cost/performance decisions on advanced technology programs, we will demonstrate the use of an AoA for a High Altitude Long Endurance (HALE) Unmanned Air Vehicle (UAV). It is important to note that all sources of data used to demonstrate this AoA are in the public domain and approved for release by DARPA. The full DARPA presentation containing the public domain data is "Vulture Program, May 20, 2009, IDGA Summit" – distribution unlimited.

Analysis of Alternatives - High Altitude Long Endurance (HALE) UAV

We will use the conceptual Vulture HALE UAV Program as an example to effectively demonstrate how the AoA is used for cost estimating and operational effectiveness metrics. This AoA will evaluate current technology solutions against three Vulture candidates. Cost estimates are not enough to determine the best alternative. The analysis must be coupled with the projected lifecycle mission profile to fully evaluate the applicability of developing new, expensive technology against cheaper, existing technologies. Figure 3 describes the program goals/objectives, technical challenges/approaches to the Vulture UAV.



- **Program Goals and Objectives**
  - Develop a HALE UAV that can maintain a 1000 lb, 5kW payload on-station continuously for 5 years
- **Technical Challenges**
  - Closing on the Energy Cycle: Harvesting & Storage
  - Structural Integrity & Control System Coupling
  - Reliability
- **Technical Approaches / Advanced Estimating Challenges!**
  - Solar Electric (Photovoltaic) Energy Collection
  - Fuel Cell / Battery Energy Storage
  - Single System vs Airborne Docking/Replacement
  - Satellite Design Paradigm for Reliability
  - Redundancy for Planned Degradation
  - Few Moving Parts (e.g. Propulsion as Flight Control)

Figure 3 Vulture Program Overview[6]

To achieve the program goals and technical challenges, three performers, Aurora Flight Science, Lockheed-Martin and Boeing have developed radically different concepts for the Vulture HALE UAV as displayed in Figure 4.

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[6] DARPA, Vulture Program, May 20, 2009 IDGA Summit, Page 2, distribution unlimited

Figure 4 Vulture Performer Designs[7]

For the demonstration of this AoA, we plan to perform an early stage, pre-milestone A concept estimate to determine the cost/effectiveness of Vulture against the existing alternatives of Global Hawk and Global Observer. At this stage the program is conceptual with very little detail known. The existing physical and performance data is available only at a high level. DARPA is the lead agency for development of Vulture.

Taken together, this presents many estimating challenges. First, the advanced technology required for solar electric and fuel cells to support a five hear HALE mission has not yet been developed. Advances in these technologies will require new cost estimating paradigms. Given that very little data does exist, it is still possible to construct a viable AoA using a parametric modeling approach. To accomplish this, the AoA will consider four Measure of Effectiveness (MOEs): range (how far to target), loiter (how long the UAV must stay on target), quantity (how many UAVs are required) and cost (seven year LCC). These will be used to evaluate Vulture against the current technology solutions. Figure 5 summarizes the mission profile and number of aircraft required for the HALE UAV objective.

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[7] DARPA, Vulture Program, May 20, 2009 IDGA Summit, Page 8, distribution unlimited

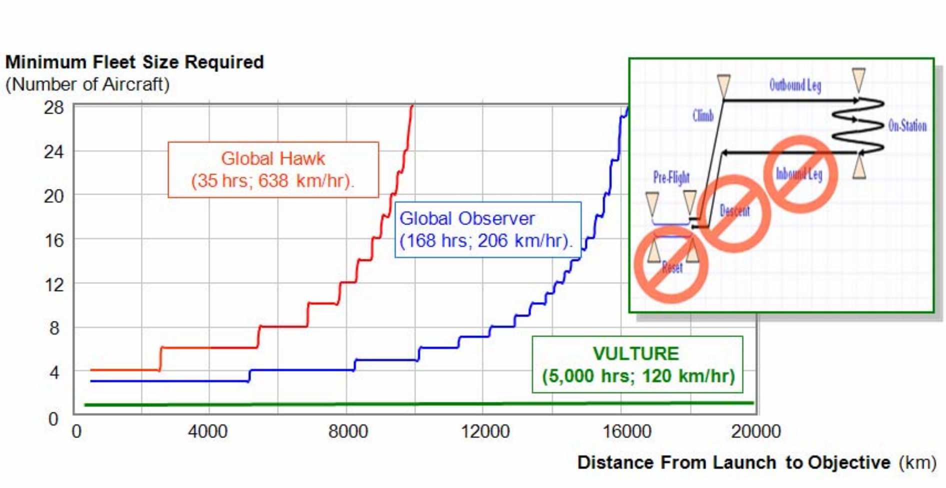

Figure 5 HALE UAV Mission Profile[8]

From the mission profile displayed in Figure 5, we can now develop the quantity of aircraft needed to support the mission profile. This particular profile has both a distance and loiter requirement i.e., after the aircraft reaches its objective, it must be able to stay on station for a fixed period of time. This is a key driver for determining the number of aircraft needed to accomplish the mission. Figure 6 below displays the number of aircraft that are needed to accomplish the mission within a particular distance range.

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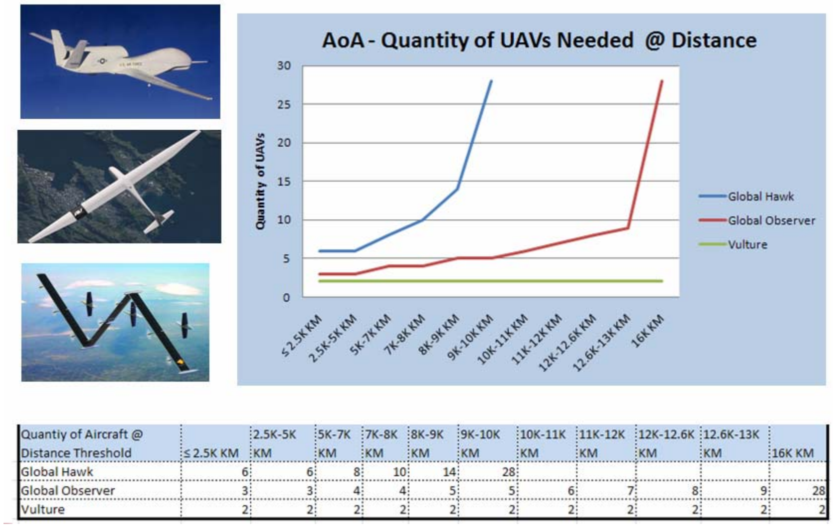
[8] DARPA, Vulture Program, May 20, 2009 IDGA Summit, Page 3, distribution unlimited



Quantiy of Aircraft @ Distance Threshold	≤ 2.5K KM	2.5K-5K KM	5K-7K KM	7K-8K KM	8K-9K KM	9K-10K KM	10K-11K KM	11K-12K KM	12K-12.6K KM	12.6K-13K KM	16K KM
Global Hawk	6	6	8	10	14	28					
Global Observer	3	3	4	4	5	5	6	7	8	9	28
Vulture	2	2	2	2	2	2	2	2	2	2	2

Figure 6 AoA - Quantity of UAVs Needed @ Distance

From a cost modeling standpoint, we will be estimating the advanced technology Vulture HALE UAV against Global Hawk and Global Observer using a conceptual parametric model since little data is known. We have selected the TruePlanning Concepts model.

The TruePlanning for Concepts models were built in partnership between PRICE Systems and the United Kingdom (UK) Ministry of Defence (MOD) Defence Equipment and Support (DE&S) organisation. Figure 7 is a screen shot of the TruePlanning for Concepts catalogue. Each Cost Object, represented by a software icon, within the catalogue is a specific System estimating model. Currently ten Cost Objects exist with the ability to predict parametrically the cost and schedule of specific Systems using high level cost drivers deemed to be available during pre-concept and concept phases of a project's life cycle[9]

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[9] 42nd DODCAS 2009 "Implementing Early Concept Cost Models" Mr. Shermon, PRICE Systems)

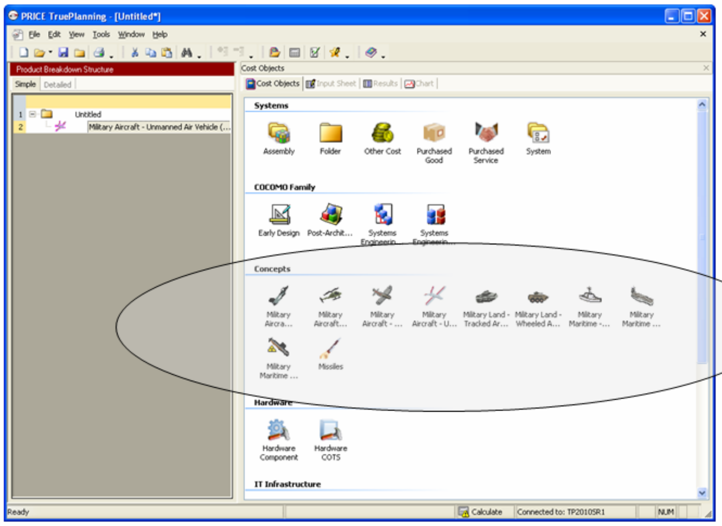
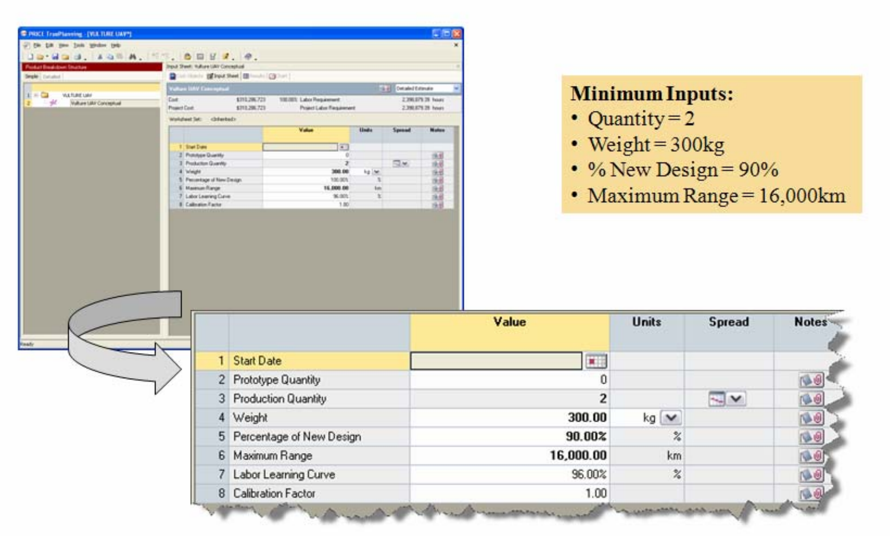


Figure 7 TruePlanning for Concepts

Using the TruePlanning for Concepts model, we can produce a high level estimate of the Vulture UAV using only the parameters quantity, weight, % new design and range. These parameters are well suited for estimating our Vulture UAV at the early concept stage and obtaining a reliable estimate using data-driven metrics. Figure 8 demonstrates the modeling of the Vulture UAV in the TruePlanning for Concepts model.

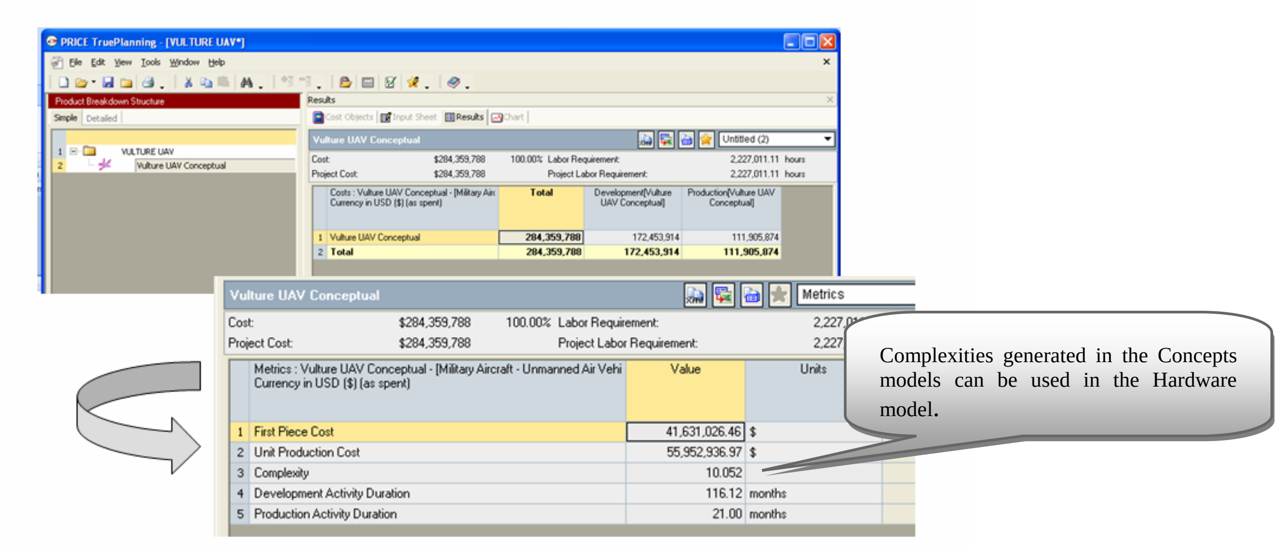


Minimum Inputs:
- Quantity = 2
- Weight = 300kg
- % New Design = 90%
- Maximum Range = 16,000km

		Value	Units	Spread	Notes
1	Start Date				
2	Prototype Quantity	0			
3	Production Quantity	2			
4	Weight	300.00	kg		
5	Percentage of New Design	90.00%	%		
6	Maximum Range	16,000.00	km		
7	Labor Learning Curve	96.00%	%		
8	Calibration Factor	1.00			

Figure 8 Vulture HALE UAV Modelled in TruePlanning for Concepts

As a demonstration, consider the movement of our Vulture HALE UAV in TruePlanning for Concepts to the more detailed TruePlanning for Hardware model. One of the outputs of the Concepts model is the Complexity of the system (as seen in Figure 9), which is a significant and necessary cost driver in the Hardware model. This allows us to both model the Vulture HALE UAV along slide Global Hawk and Global Observer as well as the full life cycle cost profile.



Vulture UAV Conceptual

Cost: $284,359,788 100.00% Labor Requirement: 2,227,011.11 hours
Project Cost: $284,359,788 Project Labor Requirement: 2,227,011.11 hours

	Costs : Vulture UAV Conceptual - [Military Air Currency in USD ($) (as spent)	Total	Development[Vulture UAV Conceptual]	Production[Vulture UAV Conceptual]
1	Vulture UAV Conceptual	284,359,788	172,453,914	111,905,874
2	**Total**	**284,359,788**	**172,453,914**	**111,905,874**

Vulture UAV Conceptual

Cost: $284,359,788 100.00% Labor Requirement: 2,227,0
Project Cost: $284,359,788 Project Labor Requirement: 2,227

	Metrics : Vulture UAV Conceptual - [Military Aircraft - Unmanned Air Vehi Currency in USD ($) (as spent)	Value	Units
1	First Piece Cost	41,631,026.46	$
2	Unit Production Cost	55,952,936.97	$
3	Complexity	10.052	
4	Development Activity Duration	116.12	months
5	Production Activity Duration	21.00	months

Complexities generated in the Concepts models can be used in the Hardware model.

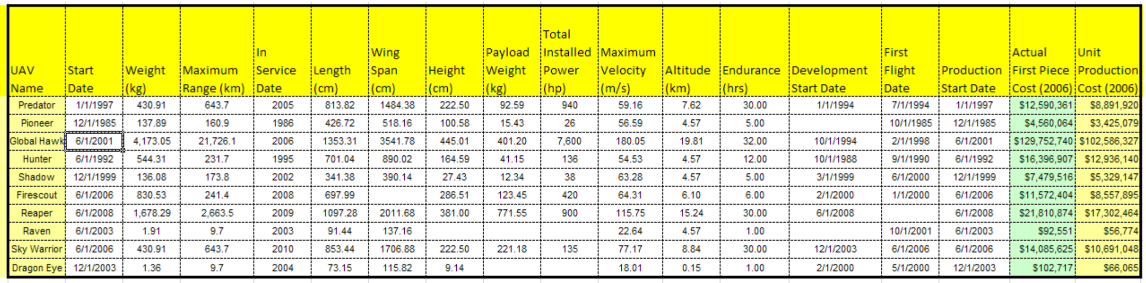
Figure 9 Vulture UAV complexity value from TrueConcepts

Now that we have estimated Vulture HALE UAV in TruePlanning Concepts model and generated a complexity value, we can now include it in TruePlanning for Hardware model along with Global Hawk and Global Observer to produce full lifecycle cost estimates. At this point it is possible to refine the estimate further and consider breaking down the hardware elements into sub-systems or equipments as the definition of the systems becomes more detailed. As the project life passes, the appropriate estimating methodology is used with the appropriate project phase.

In addition, we can also take a data-driven approach to help triangulate our estimate. The TruePlanning 2010 SR1 parametric model has the capability of creating custom CERs based on your own specific cost history. Some of the benefits of this approach are having both your own custom CERs and data integrated into the TruePlanning framework for additional analysis allowing side-by-side comparison with other PRICE methodologies.

For example, Table 3 shows historical cost/performance data for UAV's as found in the US Military Aircraft Data Book 2008 Thirtieth Edition section 5.

Table 3 UAV Historical Data[10]



UAV Name	Start Date	Weight (kg)	Maximum Range (km)	In Service Date	Length (cm)	Wing Span (cm)	Height (cm)	Payload Weight (kg)	Total Installed Power (hp)	Maximum Velocity (m/s)	Altitude (km)	Endurance (hrs)	Development Start Date	First Flight Date	Production Start Date	Actual First Piece Cost (2006)	Unit Production Cost (2006)
Predator	1/1/1997	430.91	643.7	2005	813.82	1484.38	222.50	92.59	940	59.16	7.62	30.00	1/1/1994	7/1/1994	1/1/1997	$12,590,361	$8,891,920
Pioneer	12/1/1985	137.89	160.9	1986	426.72	518.16	100.58	15.43	26	56.59	4.57	5.00		10/1/1985	12/1/1985	$4,560,064	$3,425,079
Global Hawk	6/1/2001	4,173.05	21,726.1	2006	1353.31	3541.78	445.01	401.20	7,600	180.05	19.81	32.00	10/1/1994	2/1/1998	6/1/2001	$129,752,740	$102,586,327
Hunter	6/1/1992	544.31	231.7	1995	701.04	890.02	164.59	41.15	136	54.53	4.57	12.00	10/1/1988	9/1/1990	6/1/1992	$16,396,907	$12,936,140
Shadow	12/1/1999	136.08	173.8	2002	341.38	390.14	27.43	12.34	38	63.28	4.57	5.00	3/1/1999	6/1/2000	12/1/1999	$7,479,516	$5,329,147
Firescout	6/1/2006	830.53	241.4	2008	697.99		286.51	123.45	420	64.31	6.10	6.00	2/1/2000	1/1/2000	6/1/2006	$11,572,404	$8,557,895
Reaper	6/1/2008	1,678.29	2,663.5	2009	1097.28	2011.68	381.00	771.55	900	115.75	15.24	30.00	6/1/2008		6/1/2008	$21,810,874	$17,302,464
Raven	6/1/2003	1.91	9.7	2003	91.44	137.16				22.64	4.57	1.00		10/1/2001	6/1/2003	$92,551	$56,774
Sky Warrior	6/1/2006	430.91	643.7	2010	853.44	1706.88	222.50	221.18	135	77.17	8.84	30.00	12/1/2003	6/1/2006	6/1/2006	$14,085,625	$10,691,048
Dragon Eye	12/1/2003	1.36	9.7	2004	73.15	115.82	9.14			18.01	0.15	1.00	2/1/2000	5/1/2000	12/1/2003	$102,717	$66,065

Using TrueAnalyst, this data can be used to develop custom data-driven cost objects using the cost/performance parameters directly from the EXCEL spreadsheet. Figure 10 below shows ten historical UAV point's data directly built into custom cost objects in TruePlanning.

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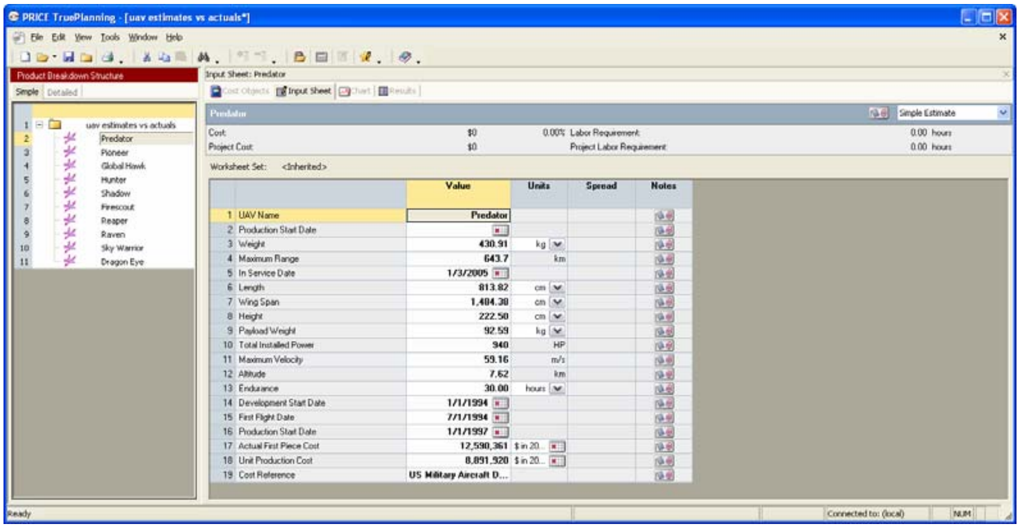
[10] US Military Aircraft Data Book, 2008 Thirtieth Edition, Section 5

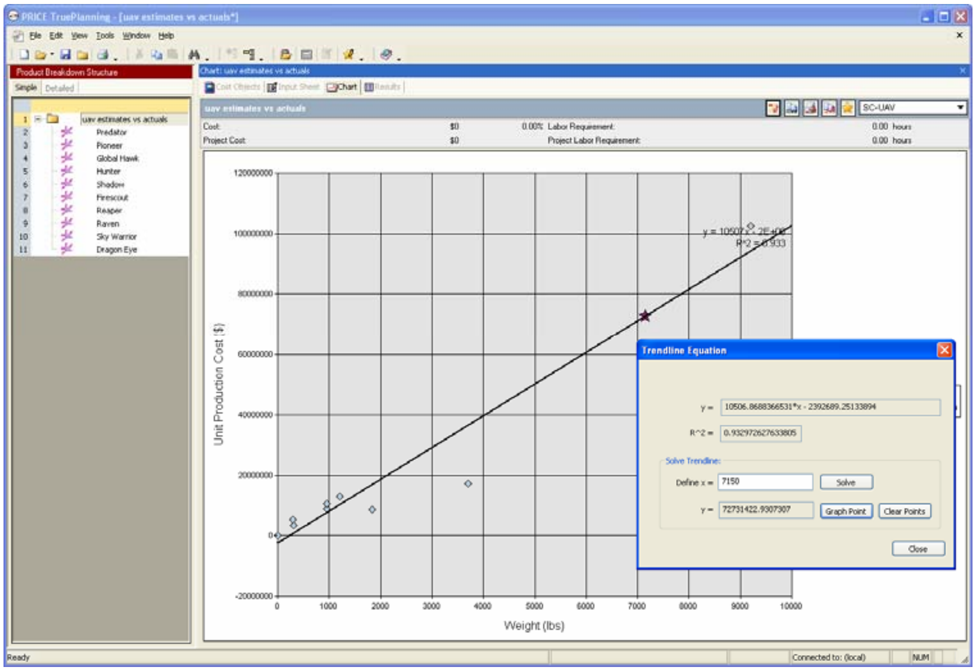


Cost: $0 0.00% Labor Requirement: 0.00 hours
Project Cost: $0 Project Labor Requirement: 0.00 hours
Worksheet Set: <Inherited>

		Value	Units	Spread	Notes
1	UAV Name	Predator			
2	Production Start Date				
3	Weight	430.91	kg		
4	Maximum Range	643.7	km		
5	In Service Date	1/3/2005			
6	Length	813.82	cm		
7	Wing Span	1,404.30	cm		
8	Height	222.50	cm		
9	Payload Weight	92.59	kg		
10	Total Installed Power	940	HP		
11	Maximum Velocity	59.16	m/s		
12	Altitude	7.62	km		
13	Endurance	30.00	hours		
14	Development Start Date	1/1/1994			
15	First Flight Date	7/1/1994			
16	Production Start Date	1/1/1997			
17	Actual First Piece Cost	12,590,361	$ in 20...		
18	Unit Production Cost	8,891,920	$ in 20...		
19	Cost Reference	US Military Aircraft D...			

Figure 10 UAV Data-Driven Cost Objects in TruePlanning

Once the data-driven custom cost objects are built into TruePlanning, we can use the scatter plot capability to develop the trend line equation based on the data. Figure 11 shows the results of our historical UAV scatter plot analysis including the trend line for weight vs. unit production cost. Note R^2 is displayed along with the ability to “solve” for any defined weight.



y = 10506.8688366531*x - 2392689.25133894

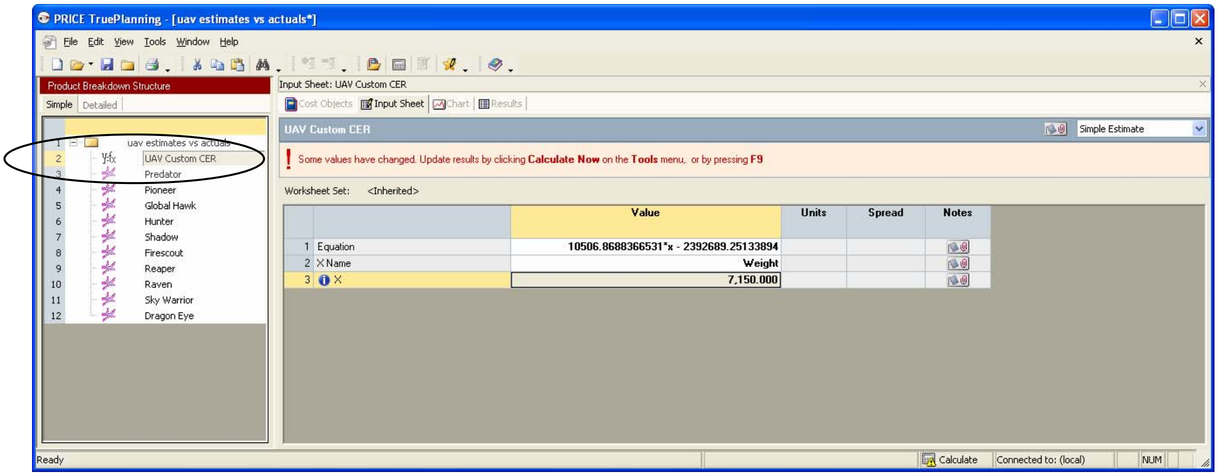
R^2 = 0.932972627633805

Define x = 7150

y = 72731422.9307307

Figure 11 UAV Data Driven Trendline in TruePlanning

Once we have developed the trendline equation, we can now develop a custom CER cost object in TruePlanning by simply copying the equation into a single variable equation cost object and defining the X variable as weight.



Input Sheet: UAV Custom CER

UAV Custom CER

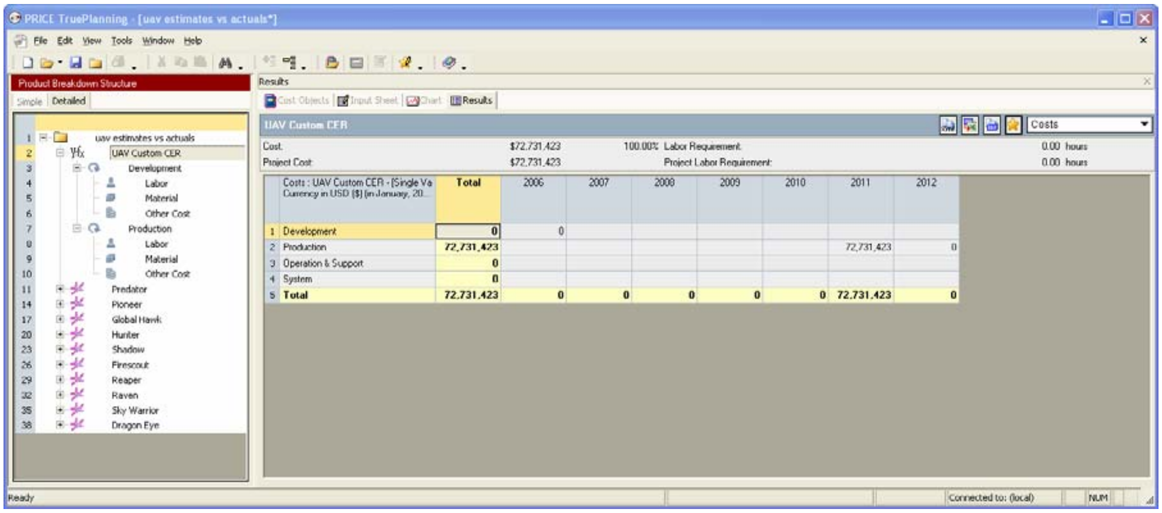
! Some values have changed. Update results by clicking **Calculate Now** on the **Tools** menu, or by pressing **F9**

Worksheet Set: <Inherited>

		Value	Units	Spread	Notes
1	Equation	10506.8688366531*x - 2392689.25133894			
2	X Name	Weight			
3	X	7,150.000			

Figure 12 UAV Custom CER Based on Historical Trendline Analysis

Then we can simply enter the weight of the UAV and our predictive data-driven equation will forecast production cost as shown in Figure 12.



Results

UAV Custom CER

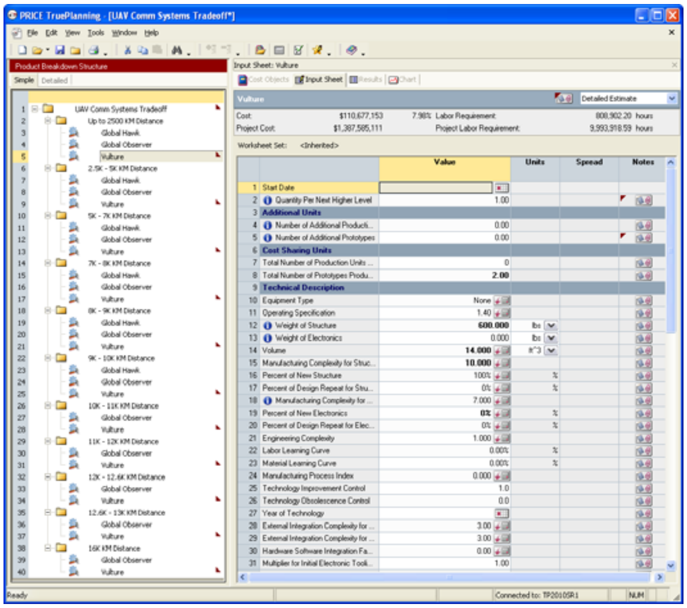
Cost: $72,731,423 100.00% Labor Requirement: 0.00 hours
Project Cost: $72,731,423 Project Labor Requirement: 0.00 hours

	Costs : UAV Custom CER - [Single Va Currency in USD ($) (in January, 20...	Total	2006	2007	2008	2009	2010	2011	2012
1	Development	0	0						
2	Production	72,731,423						72,731,423	0
3	Operation & Support	0							
4	System	0							
5	**Total**	**72,731,423**	**0**	**0**	**0**	**0**	**0**	**72,731,423**	**0**

Figure 13 UAV Custom CER Data-Driven Results

We now have several ways of estimating our HALE VULTURE UAV, either by using the TruePlanning for Concepts model, or using the custom cost object to develop a trendline equation and then using that equation as a custom CER. We could also build up a more detailed view of the HALE Vulture UAV using the TruePlanning for Hardware model if enough data is known and available. The strength of this approach is that several methodologies (PRICE Research, Custom CERs and detailed build-up) are available side-by-side in the TruePlanning framework for “triangulation” of the estimate.

At this point, we can now construct the AoA within the TruePlanning Hardware model. As displayed in Figure 14, we construct the AoA consistent with the mission distance and quantity of aircraft required. The AoA considers 11 different distance requirements and the quantities of each aircraft required to meet each of the distance requirements. For example, the distance requirement of 9K to 10K miles requires 28 Global Hawk or 5 Global Observers or 2 Vultures. Additional concept designs of Vulture can be evaluated in the True Planning for Concepts model and then included in the Hardware model.



1 UAV Comm Systems Tradeoff
2 Up to 2500 KM Distance
3 Global Hawk
4 Global Observer
5 Vulture
6 2.5K - 5K KM Distance
7 Global Hawk
8 Global Observer
9 Vulture
10 5K - 7K KM Distance
11 Global Hawk
12 Global Observer
13 Vulture
14 7K - 8K KM Distance
15 Global Hawk
16 Global Observer
17 Vulture
18 8K - 9K KM Distance
19 Global Hawk
20 Global Observer
21 Vulture
22 9K - 10K KM Distance
23 Global Hawk
24 Global Observer
25 Vulture
26 10K - 11K KM Distance
27 Global Observer
28 Vulture
29 11K - 12K KM Distance
30 Global Observer
31 Vulture
32 12K - 12.6K KM Distance
33 Global Observer
34 Vulture
35 12.6K - 13K KM Distance
36 Global Observer
37 Vulture
38 16K KM Distance
39 Global Observer
40 Vulture

Vulture

Cost: $110,677,153 7.98% Labor Requirement: 808,902.20 hours
Project Cost: $1,387,585,111 Project Labor Requirement: 9,993,918.59 hours

Worksheet Set: <Inherited>

		Value	Units	Spread	Notes
1	Start Date				
2	Quantity Per Next Higher Level	1.00			
3	**Additional Units**				
4	Number of Additional Producti...	0.00			
5	Number of Additional Prototypes	0.00			
6	**Cost Sharing Units**				
7	Total Number of Production Units ...	0			
8	Total Number of Prototypes Produ...	**2.00**			
9	**Technical Description**				
10	Equipment Type	None			
11	Operating Specification	1.40			
12	Weight of Structure	**600.000**	lbs		
13	Weight of Electronics	0.000	lbs		
14	Volume	**14.000**	ft^3		
15	Manufacturing Complexity for Struc...	**10.000**			
16	Percent of New Structure	100%	%		
17	Percent of Design Repeat for Stru...	0%	%		
18	Manufacturing Complexity for ...	7.000			
19	Percent of New Electronics	**0%**	%		
20	Percent of Design Repeat for Elec...	0%	%		
21	Engineering Complexity	1.000			
22	Labor Learning Curve	0.00%	%		
23	Material Learning Curve	0.00%	%		
24	Manufacturing Process Index	0.000			
25	Technology Improvement Control	1.0			
26	Technology Obsolescence Control	0.0			
27	Year of Technology				
28	External Integration Complexity for ...	3.00			
29	External Integration Complexity for ...	3.00			
30	Hardware Software Integration Fa...	0.00			
31	Multiplier for Initial Electronic Tooli...	1.00			

Figure 14 HALE UAV AoA in TruePlanning

The TruePlanning Hardware model is constructed to evaluate each of the alternatives on a seven year operational profile. We found the best way of determining the parameters required to run the life cycle model is through structured meetings with Subject Matter Experts or Delphi methods. In this way, each of the Vulture proposed designs can be evaluated and modelled for their specific operational profile. Figure 15 shows the results of modelling the Vulture HALE UAV proposed design against Global Hawk and Global Observer.

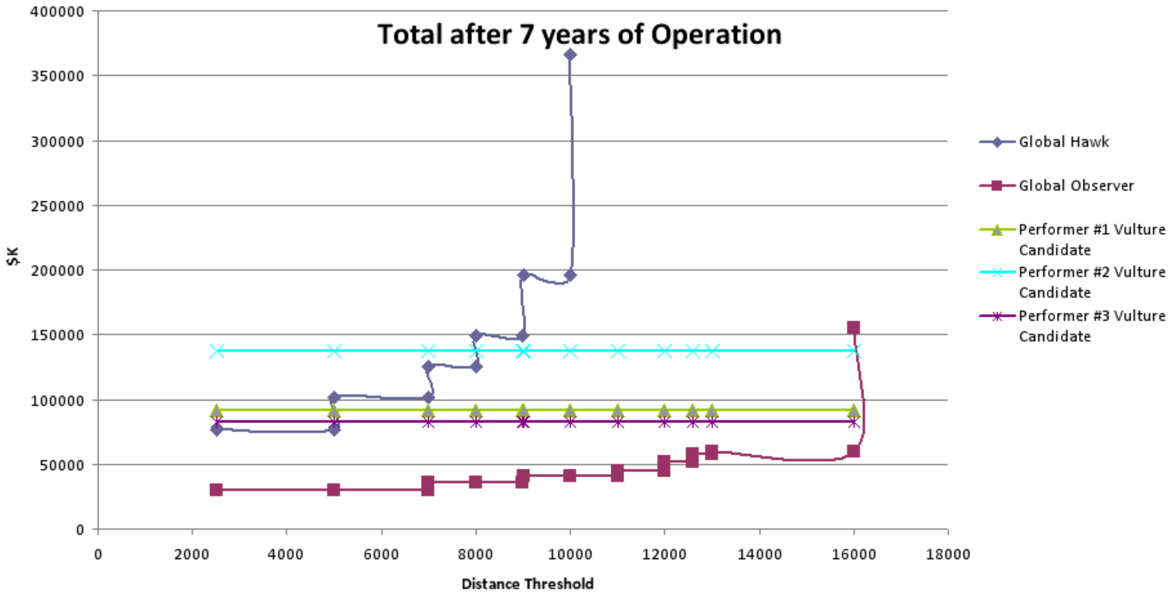


Figure 15 HALE UAV AoA Results

As seen in Figure 11, greater distance thresholds favor Vulture UAV over Global Hawk and Global Observer. The AoA clearly demonstrates that the amount of investment and risk in developing the Vulture UAV is highly dependent on the correct interpretation of the mission profile. As we can see in Figure 15, Global Hawk is not a viable option past 10k kilometers because of the quantity of aircraft vs. cost. Global Observer remains a viable alternative to Vulture up to the 16k kilometer range where the quantity of aircraft vs. cost makes it an ineffective alternative. We also found that concepts of operation and maintenance are critical: the greater the operational intensity, the greater the advantage seems to be for Vulture UAV. Overall, the AoA demonstrates that while Vulture HALE UAV costly for shorter missions, it is most cost-effective for the 16k kilometer missions.

This AoA clearly shows that investment in the Vulture program is highly dependent on the mission profile vs. other alternatives. The AoA is used to evaluate each performer's solution (competing Vulture designs) against the mission profile as well. For this AoA, TruePlanning for Concepts and TruePlanning for Hardware allowed for rapid evaluation of the alternative using a combination of CERs, data-driven research and SME input.

Analysis of Alternatives (AoA) is a key tool for early estimating of Advanced Technology Programs. However, the AoA must take into account not only performance, but the entire lifecycle cost impact. Advanced Technology Program estimating may be difficult when no comparable technology exists. ATP estimates should be “triangulated” by using several cost estimating techniques (parametric, SME, bottom-up). The AoA, when coupled with systems’ engineering analysis is a key tool in evaluating new technology development against competing current alternatives.