Five Questions a Project Manager Should Ask About Every Estimate

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TruePlanning® by PRICE® Systems

Every day, project managers make decisions based on estimates.

- How much will it cost?
- How long will it take?
- How much can we do in 6 months?
- How much can we do for $3M?

Why are we overrunning our budget?

Why does the deliverable not meet all requirements?

Why didn't you tell me that it was such a big change at the time?

Project Managers must be good estimators to be successful.

Importance of Estimation
The key to successful project completion is a rational cost and schedule estimate. These estimates are the foundation for trade-off studies and management decisions regarding project lifecycle planning.

Stanford Business Research Foundation
http://www.sbrf.org/estimation.htm

David Cottengim, an accountant at the Defense Finance and Accounting Service, said a study of 250 complex, software-intensive projects identified only 25 as successful in achieving their initial cost, schedule and performance objectives. He defines a failed project as one that is six months over schedule and 15 percent over its cost estimate.
The successful projects all made good use of:

- Project planning
- ***Cost estimating***
- Measurement techniques
- Milestone tracking.

http://www.fcw.com/article102817-05-28-07

To be good estimators, project managers must….

- **develop personal estimating Rules of Thumb**
  - When quick decisions are required
  - To challenge the rationale and assumptions behind estimates
  - To build confidence and become and “educated consumer” of estimates
- **support rigorous cost, schedule, & risk models and databases**
  - To develop rigorous, accurate metrics over time
  - To establish estimating credibility
  - To establish corporate knowledge
- **ask <u>five</u> questions about <u>every</u> estimate to establish a baseline for estimating rules of thumb and rigorous models**

What are rules of thumb, metrics, models, and the five questions?

- Rules of Thumb
- Mathematical Models
- Project Management Triangle
- Five Questions

Rules of Thumb

A **rule of thumb** is a principle with broad application that is not intended to be strictly accurate or reliable for every situation. It is an easily learned and easily applied procedure for approximately calculating or recalling some value, or for making some determination. A simple model.

- **Tailor Rule of Thumb** A simple approximation that was used by tailors to determine the wrist, neck, and waist circumferences of a person through one single measurement of the circumference of that person's thumb. The rule states, typically, that twice the circumference of a person's thumb is the circumference of their wrist, twice the circumference of the wrist is the circumference of the neck, and twice around the neck is the person's waist. For example, if the circumference of the thumb is 4 inches, then the wrist circumference is 8 inches, the neck is 16 and the waist is 32. An interesting consequence of this is that — for those to whom the rule applies — this simple method can be used to determine if trousers will fit: the trousers are wrapped around the neck, and if the two ends barely touch, then they will fit. Any overlap or lack thereof corresponds to the trousers being too loose or tight, respectively.
- **Marine Navigation** A ship's captain should navigate to keep the ship more than a thumb's width from the shore, as shown on the nautical chart being used. Thus, with a coarse scale chart, that provides few details of nearshore hazards such as rocks, a thumb's width would represent a great distance, and the ship would be steered far from shore; whereas on a fine scale chart, in which more detail is provided, a ship could be brought closer to shore.
- **Etiquette** In a formal place setting, the silverware and the dinner plate should be set back from the edge of the table a length equal to the distal phalanx of the thumb.

http://en.wikipedia.org/wiki/Rule_of_thumb

Mathematical Models

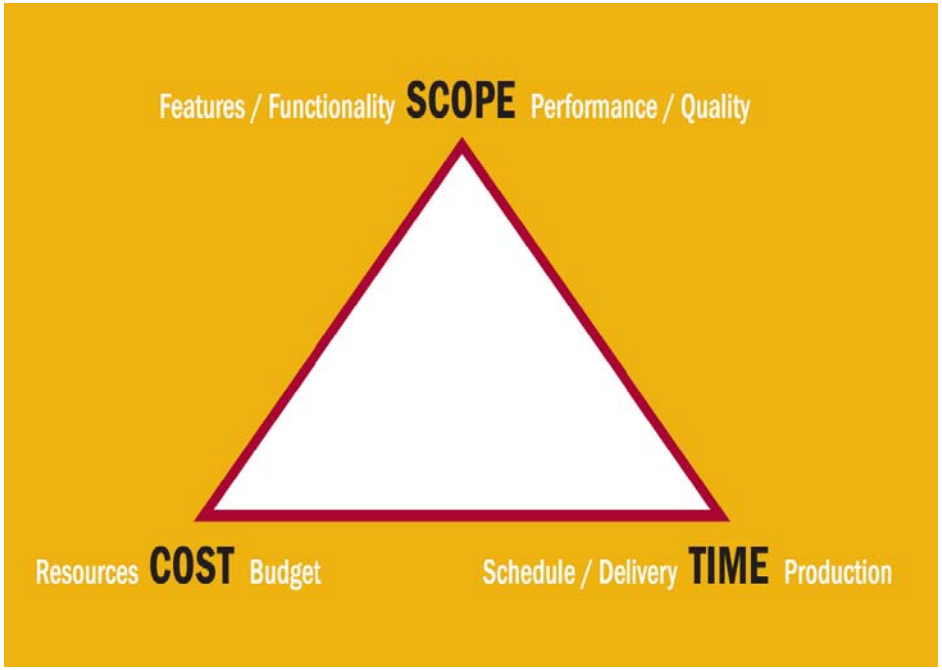
- A mathematical model is an abstract model that uses mathematical language to describe a system. Mathematical models are used particularly in the natural sciences and engineering disciplines (such as physics, biology, and electrical engineering) but also in the social sciences (such as economics, sociology and political science); physicists, engineers, computer scientists, and economists use mathematical models most extensively.
- Eykhoff (1974) defined a mathematical model as 'a representation of the essential aspects of an existing system (or a system to be constructed) which presents knowledge of that system in usable form'.
- Mathematical models can take many forms, including but not limited to dynamical systems, statistical models, differential equations, or game theoretic models. These and other types of models can overlap, with a given model involving a variety of abstract structures.
- Examples
  - The Malthusian Growth Model, $P(t) = P_0 e^{rt}$

    where P0 = Initial Population, r = growth rate, t = time
  - Learning Curve Model $Y_x = Kx^{\log_2 b}$

    where K = first unit cost, Y_x = cost for xth unit, x = unit number, and b = learning percentage

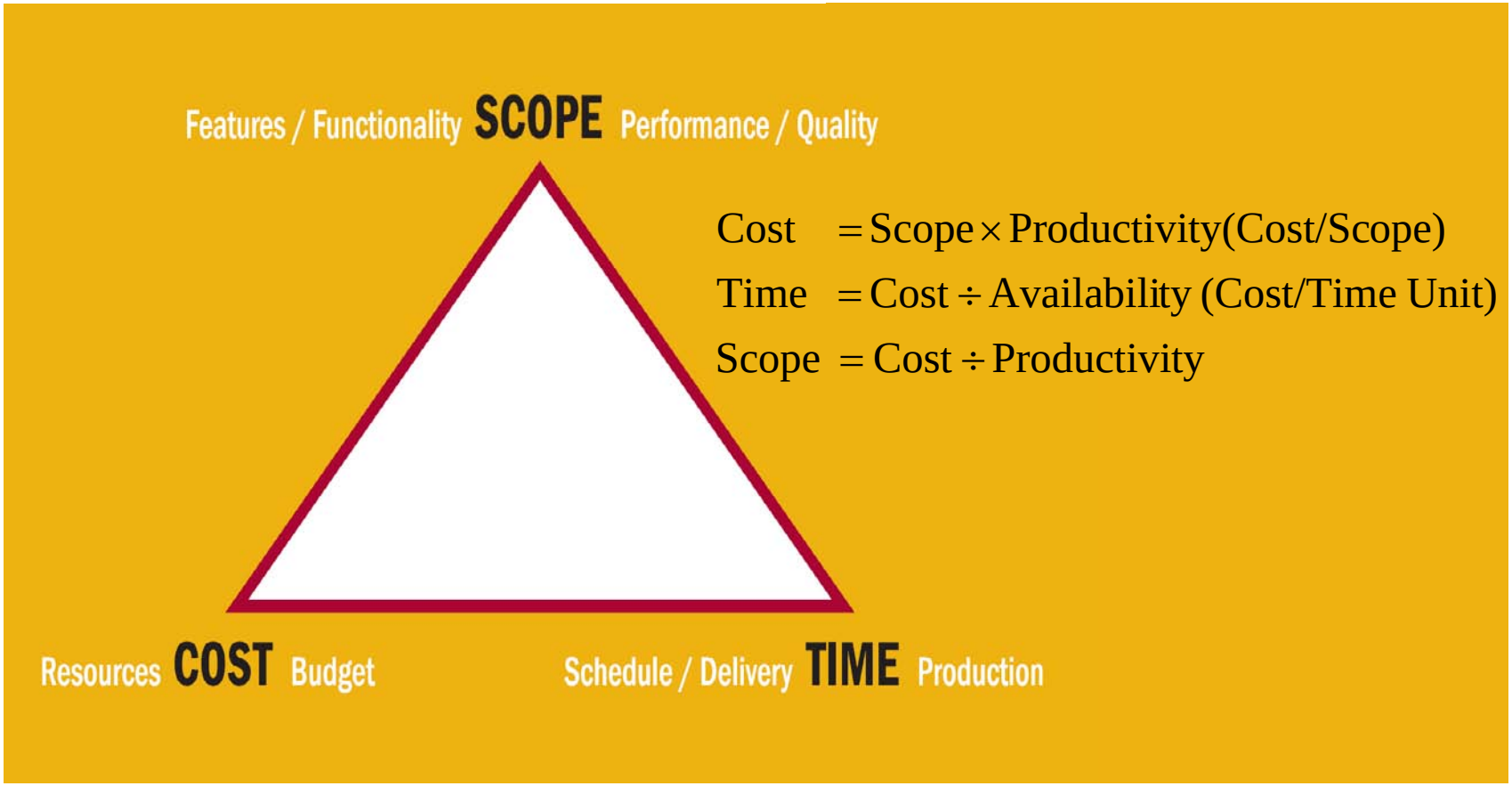
Wikipedia (various sources)

The Project Management Triangle



Each side represents a constraint. One side of the triangle cannot be changed without impacting the others.

The points of the triangle are connected by simple relationships

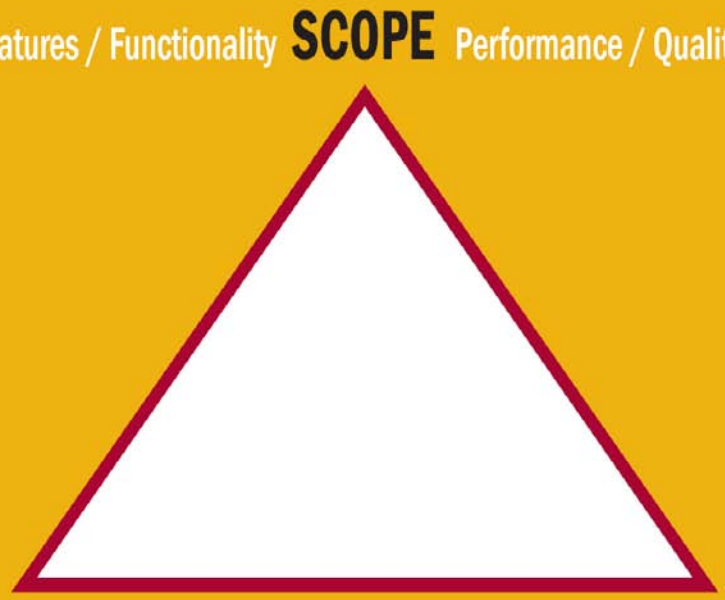


$$\text{Cost} = \text{Scope} \times \text{Productivity (Cost/Scope)}$$

$$\text{Time} = \text{Cost} \div \text{Availability (Cost/Time Unit)}$$

$$\text{Scope} = \text{Cost} \div \text{Productivity}$$

Project Managers use the Triangle's simple relationships to make decisions.



•Example

$$\text{TtlHours} = \text{TtlSLOC} \times (\text{Hours/SLOC})$$
$$\text{TtlMonths} = \text{TtlHours} \div (\text{Hours/Month})$$
$$\text{SLOC} = \text{TtlHour} \div (\text{Hours/SLOC})$$

so, if

SLOC = 10,000, and

Productivity = .09 Hours per SLOC; and

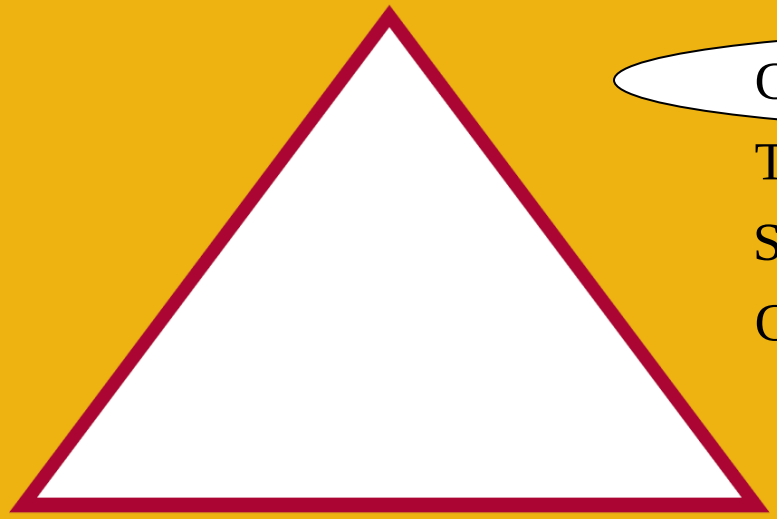
Availability = 468 Hours per Month;

then

Cost = TtlHours = 900; and

Time = TtlMonths = 1.92

The most challenging relationship is Cost as function of Scope.



$$\text{Cost} = \text{Scope} \times \text{Productivity}$$

$$\text{Time} = \text{Cost} \div \text{Availability}$$

$$\text{Scope} = \text{Cost} \div \text{Productivity}$$

$$\text{Cost} = \text{Availability} \times \text{Rate} \times \text{Time}$$

Project Managers must develop Rules of Thumb and utilize Rigorous Models for *Cost = f(Scope).*

Rigorous Cost, Schedule, and Risk Estimating Models

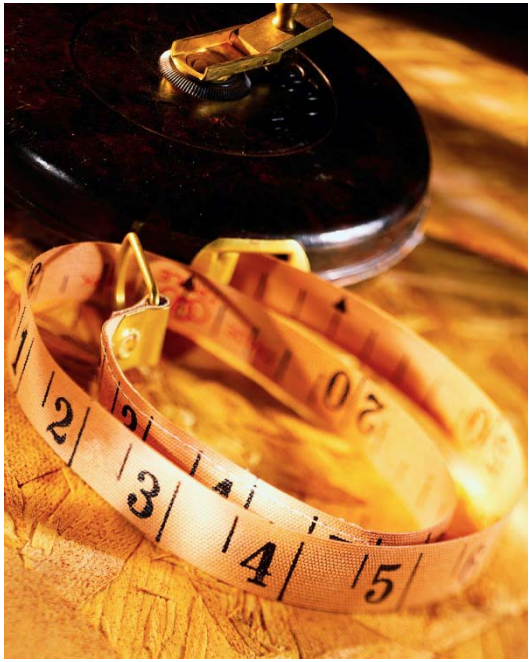
Rules of Thumb

$$\text{Cost} = \text{Scope} \times \text{Productivity} \times \text{Reality Factors}$$

Rules of Thumb are simple models based on averages, while Rigorous Models take into account several other Reality factors. Reality factors help you normalize data to determine better Rules of Thumb.

Project Managers must identify the metrics of which they are most comfortable for their models.

- **Scope metrics**
  - Hardware – Weight, Objects, Parts
  - Software – SLOC, FPs, OPs, Use Cases
- **Productivity metrics**
  - Hardware – Cost/Weight,, Cost/Object
  - Software – Hours/SLOC
- **Reality Factor metrics**
  - Hardware – Complexity, features, quantities, delivery rate, schedule compression, learning rate,
  - Software – language, application, complexity, memory utilization
  - General – reuse, engineering maturity, operating environment, quality

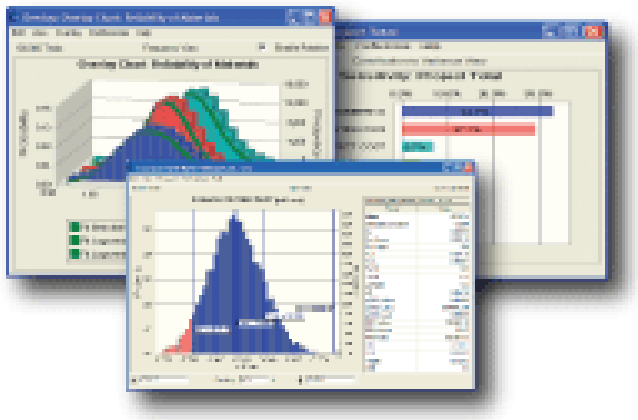


Project Managers must know the risk associated with an estimate.

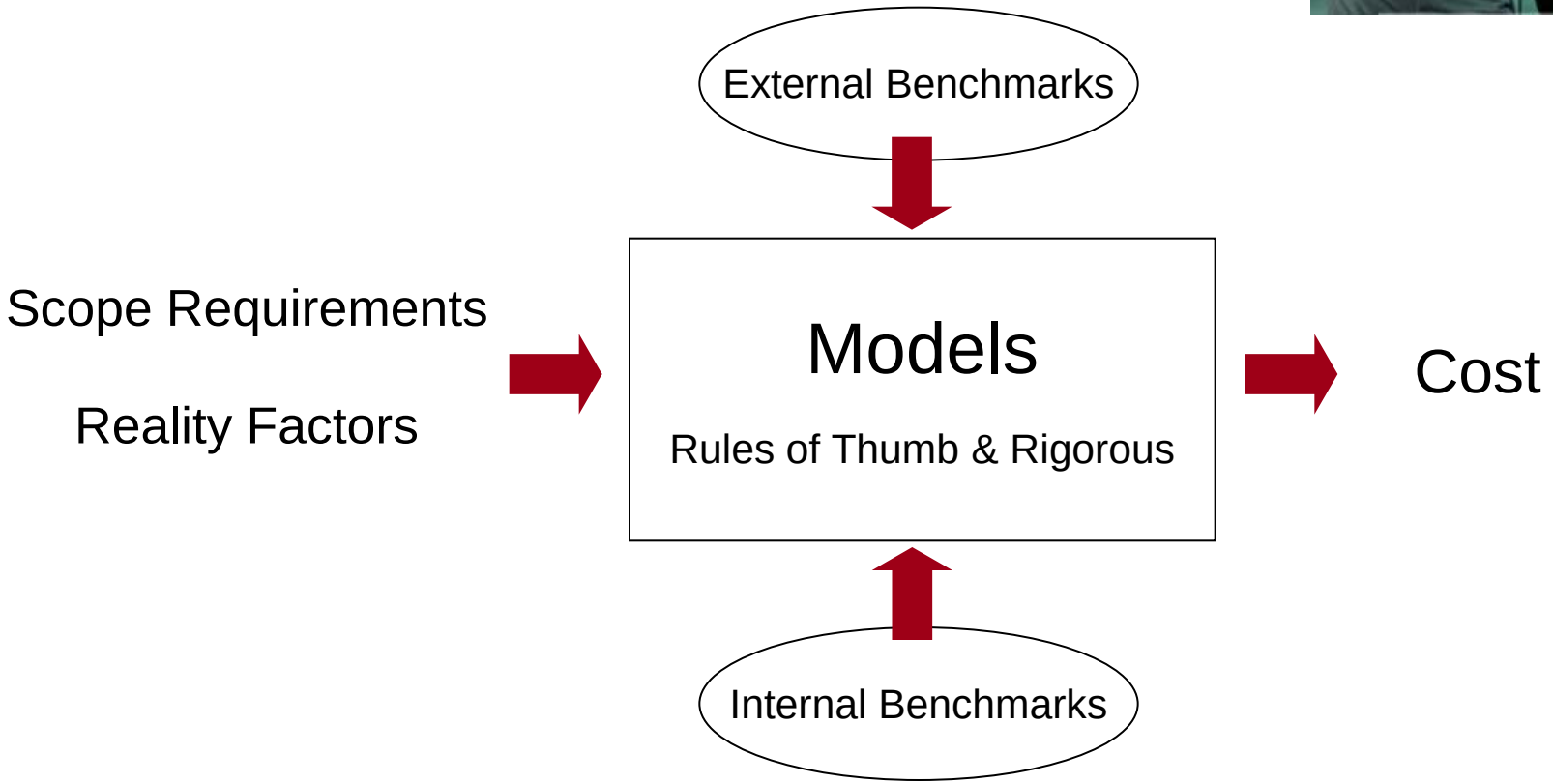
Rule of Thumb

$$\frac{(\text{BestCase} + (4 \times \text{MostLikely}) + \text{WorstCase})}{6}$$

Rigorous Model



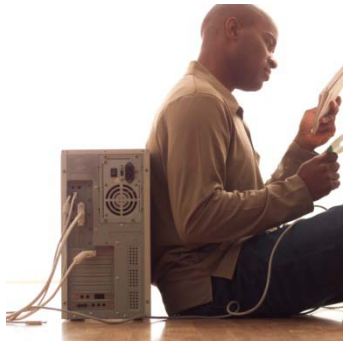
Project Managers should develop Rule of Thumb Models and Rigorous Models from internal and external benchmarks for credibility



External Benchmarks

Table 1: Rules of Thumb Based on LOC Metrics for Procedural Languages (Assumes 1 work month = 132 work hours)

Size of Program in LOC	Coding LOC per Month	Coding Effort (Months)	Testing Effort Percent	Noncode Effort Percent	Total Effort (Months)	Net LOC per Month
1	2500	0.0004	10.00%	10.00%	0.0005	2083
10	2250	0.0044	20.00%	20.00%	0.0062	1607
100	2000	0.0500	40.00%	40.00%	0.0900	1111
1,000	1750	0.5714	50.00%	60.00%	1.2000	833
10,000	1500	6.6667	75.00%	80.00%	17.0000	588
100,000	1200	83.3333	100.00%	100.00%	250.0000	400
1,000,000	1000	1000.0000	125.00%	150.00%	3750.0000	267



http://www.compaid.com/caiinternet/ezine/capers-rules.pdf

Table 3

REGRESSION EQUATION, DATA, AND RESULTS FOR AIRCRAFT CHARACTERISTICS CASE

Equation[a]

$$COST = 1.38\ WEIGHT^{1.44}\ e^{(.14\ FSTFLT + 1.41\ ALLWTHR)}$$

$$(.01)\ (.01) \qquad (.01)$$

Where:
- ALLWTHR = All weather capability (Yes=1/No=0)
- COST = Estimated total avionics suite cost ($K-78)
- FSTFLT = Aircraft first flight data minus 62
- WEIGHT = Aircraft empty weight (K-lbs)
- ( ) = Significance of regression coefficient (one-tailed t-test)

Statistics[b]

$R^2 = .99$ SEE = .14 F = 144, Significant at < 1%

An Analysis of Combat Aircraft Avionics Production Costs, RAND

External Benchmarks …Call a Friend? …Ask the Audience?

costhelper what people are paying

Search over 800 topics on CostHelper.com

How much does Google™ Custom Search cost? Search

BROWSE ALL TOPICS >> | babies & children | cars & car maintenance | education | health & personal care | home & garden | personal finance | pets & pet care | small business | weddings

CostHelper.com > Home & Garden > New Roof

New Roof Cost

How Much Does a New Roof Cost?

Average: $11,209-$17,060

High: $20,000-$25,000

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Roof Repair
Slate Roofing
Roof Estimate
Shingle Roofing

A roof is your home's topmost protective layer against the elements, but it can also be a design statement. Wood shakes are a traditional American roofing material, but are vulnerable to fire and mold, and must be replaced fairly frequently. Because of their relative low cost and ease of installation, asphalt shingles are now the most common roofing material in the US. However, many people choose a tile or metal roof because they are so long-lasting and stylish.

Typical costs:

- Do-it-yourself materials to install an asphalt shingle roof on an average one-story ranch-style home (with a gently sloping roof of 1,700-2,100 square feet) can run **$680 -$3.700**, depending on the quality of the materials. Having the old roofing materials removed and new asphalt shingles professionally installed is about **$1,700 -$8,400** on a typical ranch-style home, depending on materials and location.
- Wood shingles or shakes are beautiful but require ongoing maintenance, can be prone to fires and don't last as long as other roofing materials. Installing natural wood shingles or shakes on an average one-story, ranch-style home (1,700-2,100 square feet of gently sloping roof) costs around **$6,800 -$20,000** or more. Re-roofing the same home with high-quality, fire-resistant materials of recycled rubber or plastic molded to look like wood runs around **$12,600 - $18,900** or more.
- A tile roof is distinctive, durable, fire-resistant and impervious to insects or rot. Installing a concrete tile roof can run **$7,650 -$21,000** for a basic roof on a ranch-style home. Roofing the same surface with ceramic clay tiles can be **$11,900 -$2,100** for standard shapes and colors in lower-grade tile, and **$17,000 -$60,000** for more custom shapes and colors, or complex installations.
- A metal roof is lightweight, durable, fire-resistant and does not rot. A professionally installed steel roof can be **$5,100 -$22,000** for steel roofing on a simple one-story ranch-style house; aluminum runs **$11,900 -$24,200** for the same roof; and copper jumps to **$25,500 -$39,600**.
- A slate roof is one of the most long-lasting roof materials available. Installing natural slate tiles can run **$17,000 -$84,000** for a 1,700-2,100 square foot roof, or **$27,000 -$120,000** for a 3,000-square-foot roof, depending on the quality of the slate and the complexity of the installation process. Roofing with synthetic slate tiles (recycled rubber or plastic molded to look like slate) is about **$11,900 -$18,900** for an average ranch house with a 1,700-2,100 square foot roof; or

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Philadelphia Coupons
1 ridiculously huge coupon a day. It's like doing Philly at 90%

Recent Posts

Amount: $2.90 **ROOFING SERVICES**
Posted by: FD HANDYMAN SERVICES in san diego, CA. **Purchased:** August, 2009
Type: any **Sq Ft of Roof:** any
Contractor: FD HANDYMAN SERVICES
We are a handyman company with plenty of roofing knowledge. We have done many roofing projects, commercial and residential in the san diego area. We are experienced, efficient, and with good prices. Our average cost for removing and installing shingles runs for about $2.9/ sq. ft. This price includes supplies/materials. However, to give an accurate estimate we have to give a quote from the place where the project needs to be completed.
Was this post helpful to you? yes no Report prohibited or spam

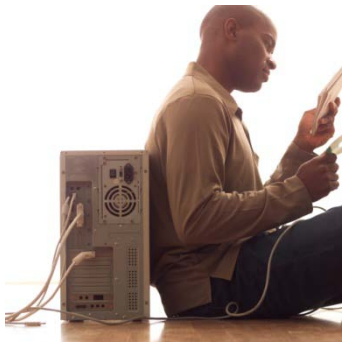
Amount: $12,000.00 **Getting roof re-done**
Posted by: San Jose Home Owner in San Jose, CA. **Purchased:** October, 2009
Type: asphalt shingles **Sq Ft of Roof:** 1700
Getting our roof done with new gutter, trim, and thicker asphalt shingles.
Was this post helpful to you? yes no Report prohibited or spam

Amount: $1,500.00 **Roof completed under 1000 bucks**
Posted by: frank lancaster in lancaster, PA. **Purchased:** January, 2008
Type: singles **Sq Ft of Roof:**
Contractor: friends references
I bougnt a home and the inspector told us the roof was in good condition but it may require maintenace in the next two year, i decide to shop around for advice. friend told me that he could get someone to re roof my home for a 1000 dollars, i spent 500 on materials, the person did complete the job, but now I have leaks and he has not shown his face to fix this problems...
nevere ever would listen to cheap advise, I will only do contract with professionals...
: (
Was this post helpful to you? yes no Report prohibited or spam

Amount: $0.00 **help with shingle quality**
Posted by: comnav in mesa, AZ. **Purchased:** December, 2009
Type: asphalt **Sq Ft of Roof:** 4200
bank hired out of state roofer to replace roof
on house we intend to purchase
it looks cheap, how do we know if the material is decent quality or not
won\t show us an invoice, as bank purchesed the new roof
3 tab fiberglass comp. 20 year
Was this post helpful to you? yes no Report prohibited or spam

External Benchmarks

Phase No.	Percentage	Phase	or	Phase No.	Percentage	Phase
1.	10 %	Requirements Analysis		1.	11 %	Requirements Analysis
2.	30 %	Requirements Specification		2.	11 %	Anforderungs-Specification
3.	30 %	DP-Concept		3.	5%	Logical System Specification
4.	25 %	Coding		4.	10 %	Physical Design
5.	5 %	Delivery		5.	46 %	Coding and Module Test
				6.	5 %	Implementation
				7.	12 %	System Test



http://www.compaid.com/caiinternet/ezine/bundschuh-est.pdf

Task	Rule Of Thumb
Project Management	A full time Project Manager is required for every six staff assigned to the project. A typical MIS project requires the equivalent of 2/3 full time staff. Applying this rule of thumb suggests that the Project Manager should be assigned between 33% and 50% or the duration of the project.
Business Analysis	Allow a figure of 20% of the time allowed for the technical tasks to complete the business specification.
Systems Analysis and Design	Allow a figure of 25% of the time allowed for the technical tasks to complete the design specification.
Infrastructure Support	Allow a figure of 10% of the time allowed for the technical tasks.
Peer Testing	Allow a figure of 10% of the time allowed for the technical tasks.
Integration Testing	Allow a figure of 15% of the time allowed for the technical tasks.
Acceptance Testing	Allow a figure of 15% of the time allowed for the technical tasks.
Deployment	Allow a figure of 5% of the time allowed for the technical tasks.

http://www.projects.ed.ac.uk/areas/research/RAE/RES018/EstimationGuidelines.shtml

Internal Benchmarks

•Tailor's Rule of Thumb

$\times 2.3 =$

$\times 2.3 =$

$\times 2.3 =$

Measuring actual results and calibrating models builds accuracy, confidence and credibility

Personal experience, Anthony A. DeMarco, PRICE Systems, LLC

Internal Benchmarks

		Q1	Apr	May	Jun	* Jul *	Aug	Sep	Oct	Nov	Dec	Avg.
PRICE	Orders											
	Best Case	16.582	16.911	17.539	17.992	17.372	17.397	17.162	16.517	16.126		17.066
	Most Likely	15.596	15.716	15.995	16.481	16.529	16.071	15.815	15.757	15.620		15.953
	Worst Case	14.312	14.762	14.489	14.756	15.514	15.122	14.899	15.017	15.022		14.877
		15.546	15.756	16.001	16.445	16.500	16.134	15.887	15.760	15.605		15.959
		14.897	*15.679*	*15.618*	*15.952*	*16.261*	*15.959*	*15.735*	*15.690*	*15.666*		15.718
Division 1	Orders											
	Best Case	5.561	6.029	6.488	6.700	6.658	6.618	6.658	6.633	6.554		6.433
	Most Likely	5.417	5.529	6.231	6.477	6.416	6.385	6.354	6.326	6.383		6.169
	Worst Case	5.346	5.329	6.080	6.300	6.340	6.233	6.213	6.183	5.980		6.001
		5.525	*5.909*	*6.421*	*6.638*	*6.602*	*6.557*	*6.583*	*6.557*	*6.480*		*6.363*
Division 2	Orders											
	Best Case	5.952	5.896	5.992	5.570	5.565	5.492	5.230	4.843	4.742		5.476
	Most Likely	5.319	5.234	5.301	5.270	5.161	5.089	4.917	4.757	4.643		5.077
	Worst Case	4.322	4.808	5.019	4.871	4.884	4.959	4.701	4.527	4.643		4.748
		4.585	*4.959*	*5.145*	*4.981*	*4.980*	*5.026*	*4.775*	*4.582*	*4.653*		*4.854*
Division 3	Orders											
	Best Case	5.069	4.986	5.059	5.722	5.149	5.286	5.273	5.041	4.830		5.157
	Most Likely	4.860	4.953	4.462	4.735	4.953	4.597	4.543	4.674	4.594		4.708
	Worst Case	4.644	4.625	3.390	3.585	4.290	3.930	3.986	4.307	4.399		4.128
		4.787	*4.811*	*4.052*	*4.333*	*4.680*	*4.377*	*4.377*	*4.552*	*4.534*		*4.500*

VP 1 $$\frac{(8\times \text{BestCase} + \text{MostLikely} + \text{WorstCase})}{10}$$

VP 2 $$\frac{(\text{BestCase} + \text{MostLikely} + 8\times \text{WorstCase})}{10}$$

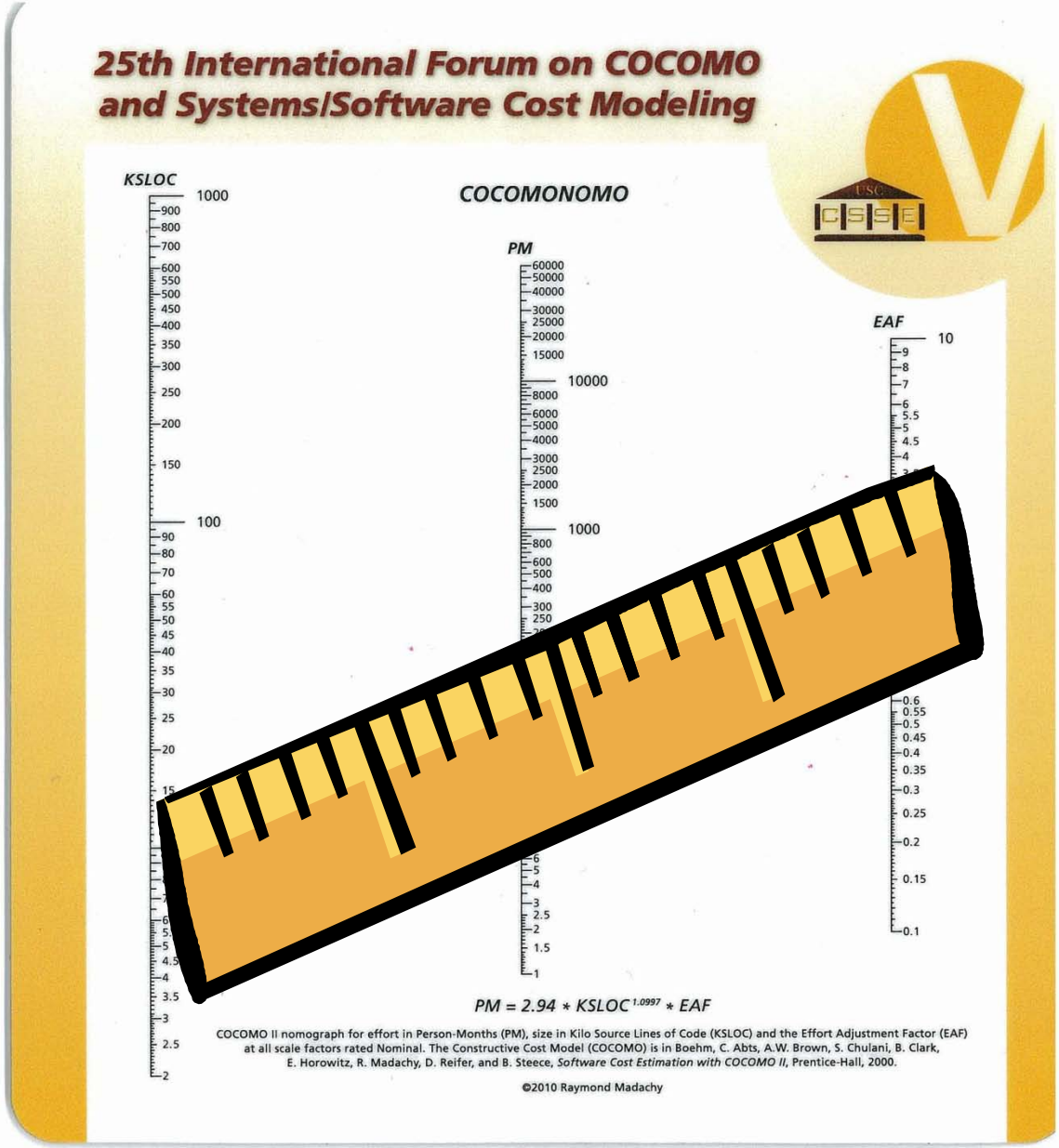
VP 3 $$\frac{(\text{BestCase} + (4\times \text{MostLikely}) + (4\times \text{WorstCase})}{9}$$

Measuring actual results and calibrating models builds accuracy, confidence and credibility

Personal experience, Anthony A. DeMarco, PRICE Systems, LLC

COCOMO-NOMO
(Nomogram)

Internal & External Benchmarks



Project Managers should develop Rule of Thumb Models and Rigorous Models from internal and external benchmarks for credibility

External Benchmarks

Scope Requirements

Reality Factors

Models

Rules of Thumb & Rigorous

Cost

	Weight		Cost	Complexity	Maturity
Project 1	1000	$	167,857	4	1
Project 2	3983	$	2,318,704	3	7
Project 3	200	$	217,630	2	8
Project 4	567	$	846,268	6	5
Project 5	50	$	206,166	10	4
Project 6	768	$	348,844	5	2

Internal Benchmarks

Project databases that include technical parameters, programmatics and cost are necessary for internal benchmarks

Project Managers should ask five questions about every estimate.

1. **What is the measure of scope?**
2. **What is the productivity?**
3. **What is the resource availability assumption?**
4. **What are the most significant reality factors making this different than the norm?**
5. **What is the uncertainty of the parameters and the risk in the estimate?**

The five questions will drive the estimating cultural and behaviors that you desire

Example – PM Rules of Thumb for Software

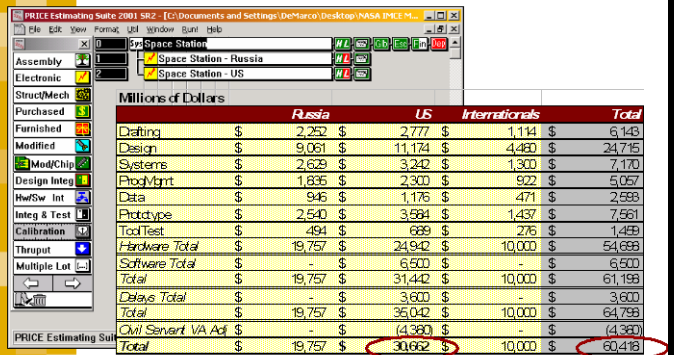
- **Scope = SLOC**
- **Productivity = 0.10 hours per SLOC**
- **Risk** = $\frac{(\text{BestCase} + \text{MostLikely} + (4 \times \text{WorstCase})}{6}$
- **Reality**
  - = Manned Space 3x
  - = Unmanned Space 1x
  - = Studies 0.5x
  - = Mature Tech 1x
  - = Immature Tech 3x
- **Buildup =**

Requirements Analysis	5
Requirements Specification	10
Design	20
Code	30
Test	30
Delivery	5

…or $Code x 3.3

International Space Station Example

2. Initial Estimate of $17.4B was over optimistic, based on heroic assumptions



Millions of Dollars

	Russia	US	Internationals	Total
Drafting	$ 2,252	$ 2,777	$ 1,114	$ 6,143
Design	$ 9,061	$ 11,174	$ 4,480	$ 24,715
Systems	$ 2,629	$ 3,242	$ 1,300	$ 7,170
ProgMgmt	$ 1,835	$ 2,300	$ 922	$ 5,057
Data	$ 946	$ 1,176	$ 471	$ 2,593
Prototype	$ 2,540	$ 3,584	$ 1,437	$ 7,561
TestTest	$ 494	$ 689	$ 276	$ 1,459
Hardware Total	$ 19,757	$ 24,942	$ 10,000	$ 54,698
Software Total	$ -	$ 6,500	$ -	$ 6,500
Total	$ 19,757	$ 31,442	$ 10,000	$ 61,198
Delays Total	$ -	$ 3,600	$ -	$ 3,600
Total	$ 19,757	$ 35,042	$ 10,000	$ 64,798
Civil Servant VA Adj	$ -	$ (4,380)	$ -	$ (4,380)
Total	$ 19,757	$ 30,662	$ 10,000	$ 60,418

PRICE

FASTER DECISIONS. BETTER DECISIONS.™

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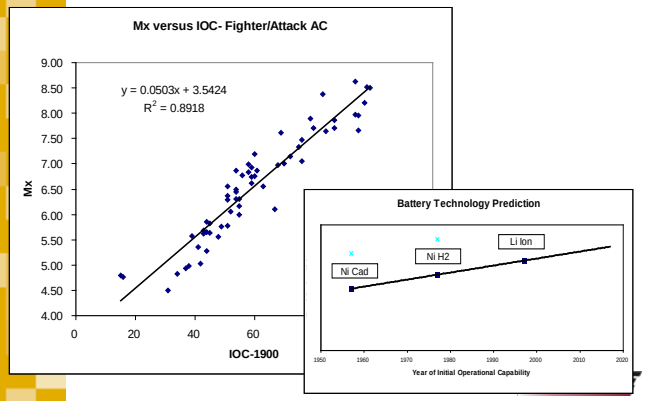
Advanced Concepts
Technology Cost & Risk Forecasting



FASTER DECISIONS. BETTER DECISIONS.™

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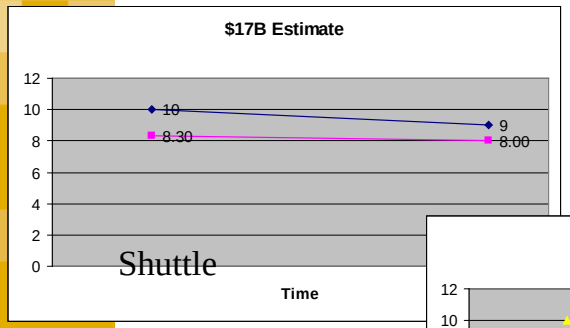
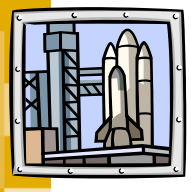
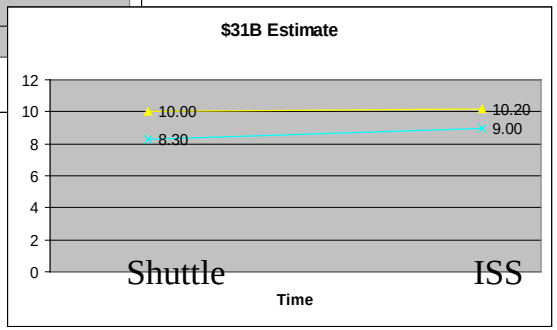
Heroic Assumption – New ways of doing Business will reverse historic trend?







PRICE

FASTER DECISIONS. BETTER DECISIONS.™

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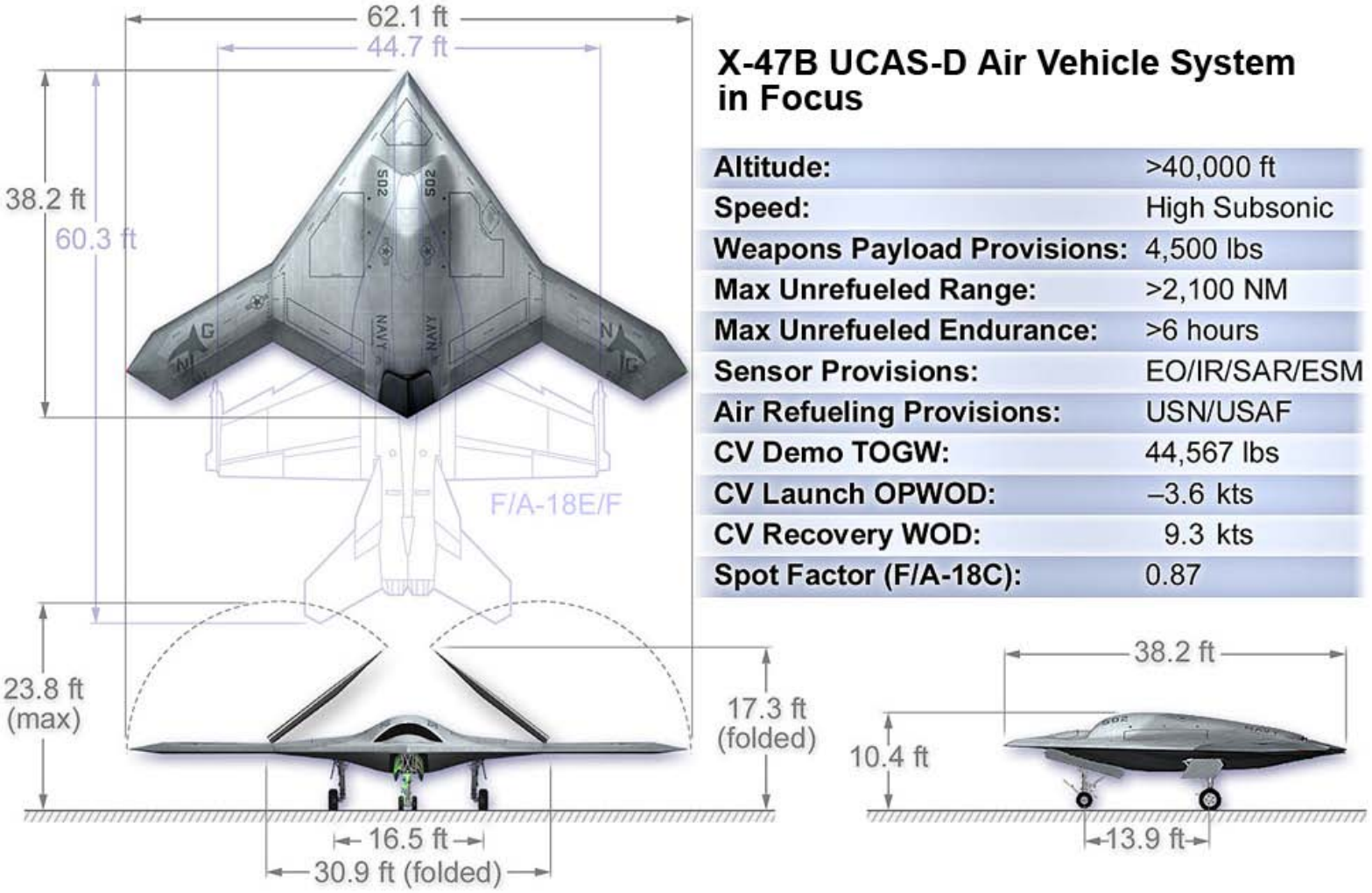
Analysis performed with IMCE Task Force (Young), Anthony A. DeMarco, PRICE Systems, LLC

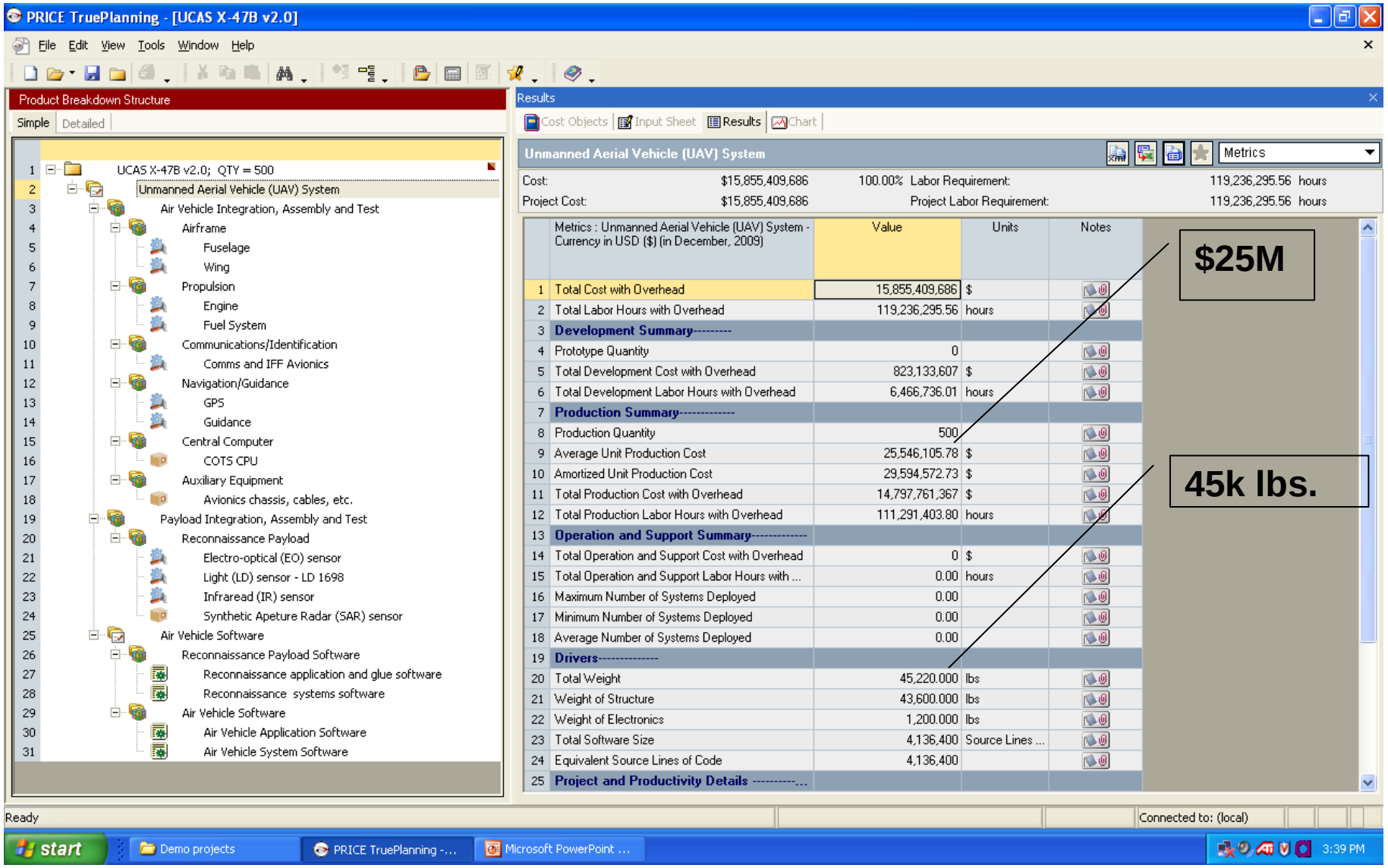
Navy UCAS



X-47B UCAS-D Air Vehicle System in Focus

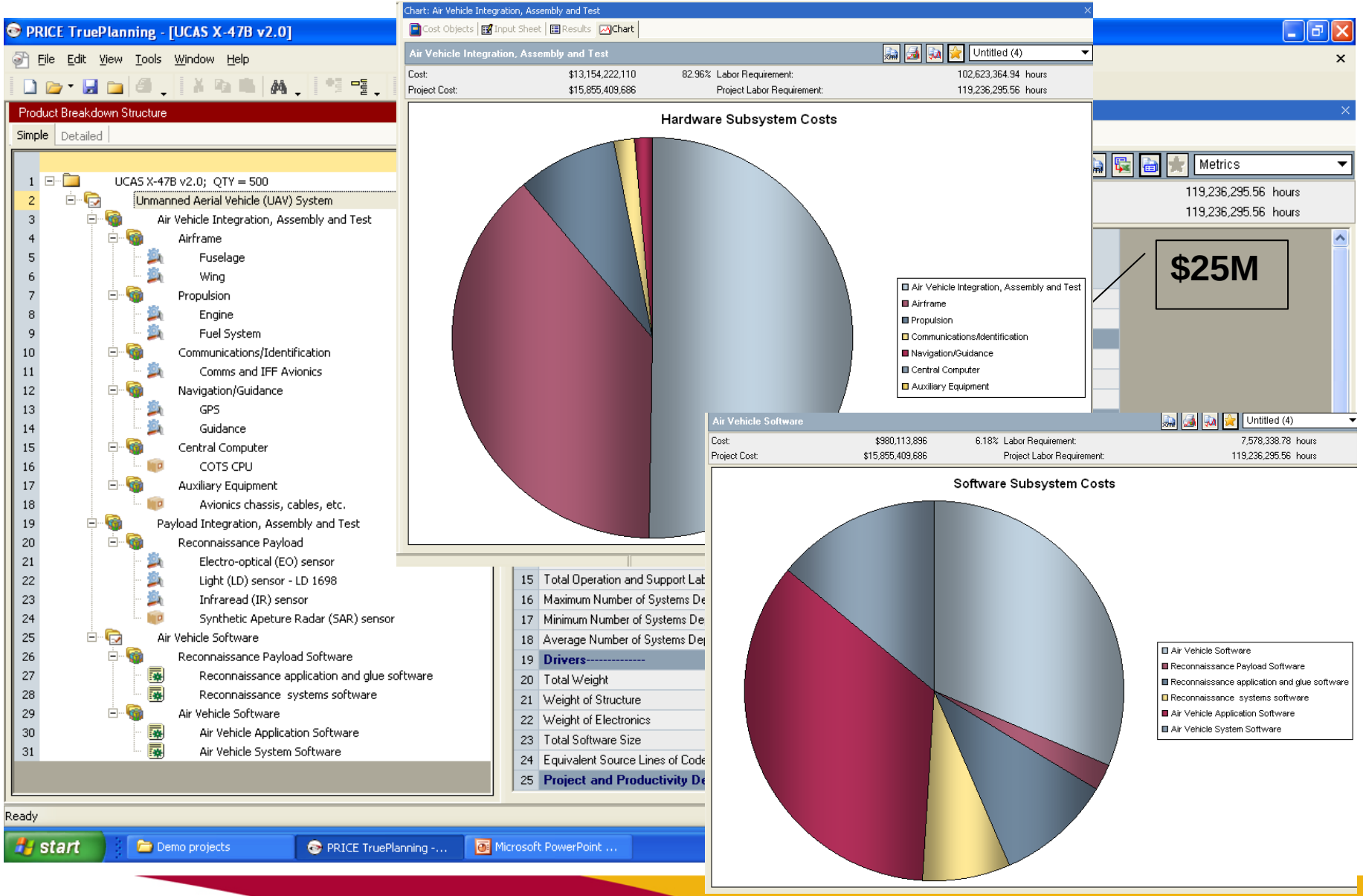
Altitude:	>40,000 ft
Speed:	High Subsonic
Weapons Payload Provisions:	4,500 lbs
Max Unrefueled Range:	>2,100 NM
Max Unrefueled Endurance:	>6 hours
Sensor Provisions:	EO/IR/SAR/ESM
Air Refueling Provisions:	USN/USAF
CV Demo TOGW:	44,567 lbs
CV Launch OPWOD:	–3.6 kts
CV Recovery WOD:	9.3 kts
Spot Factor (F/A-18C):	0.87

PRICE TruePlanning Estimate



TruePlanning® by PRICE® Systems

PRICE TruePlanning Estimate



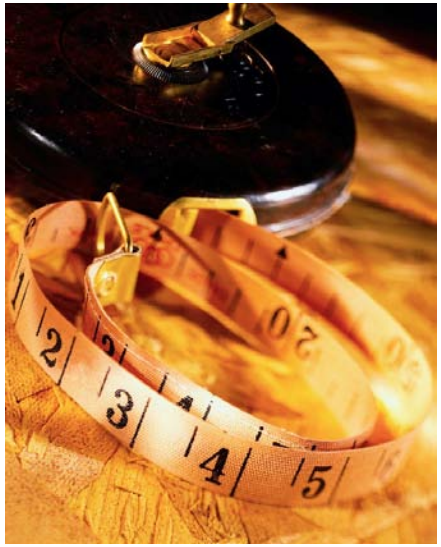
TruePlanning® by PRICE® Systems

What 5 questions will the Program Manager ask?

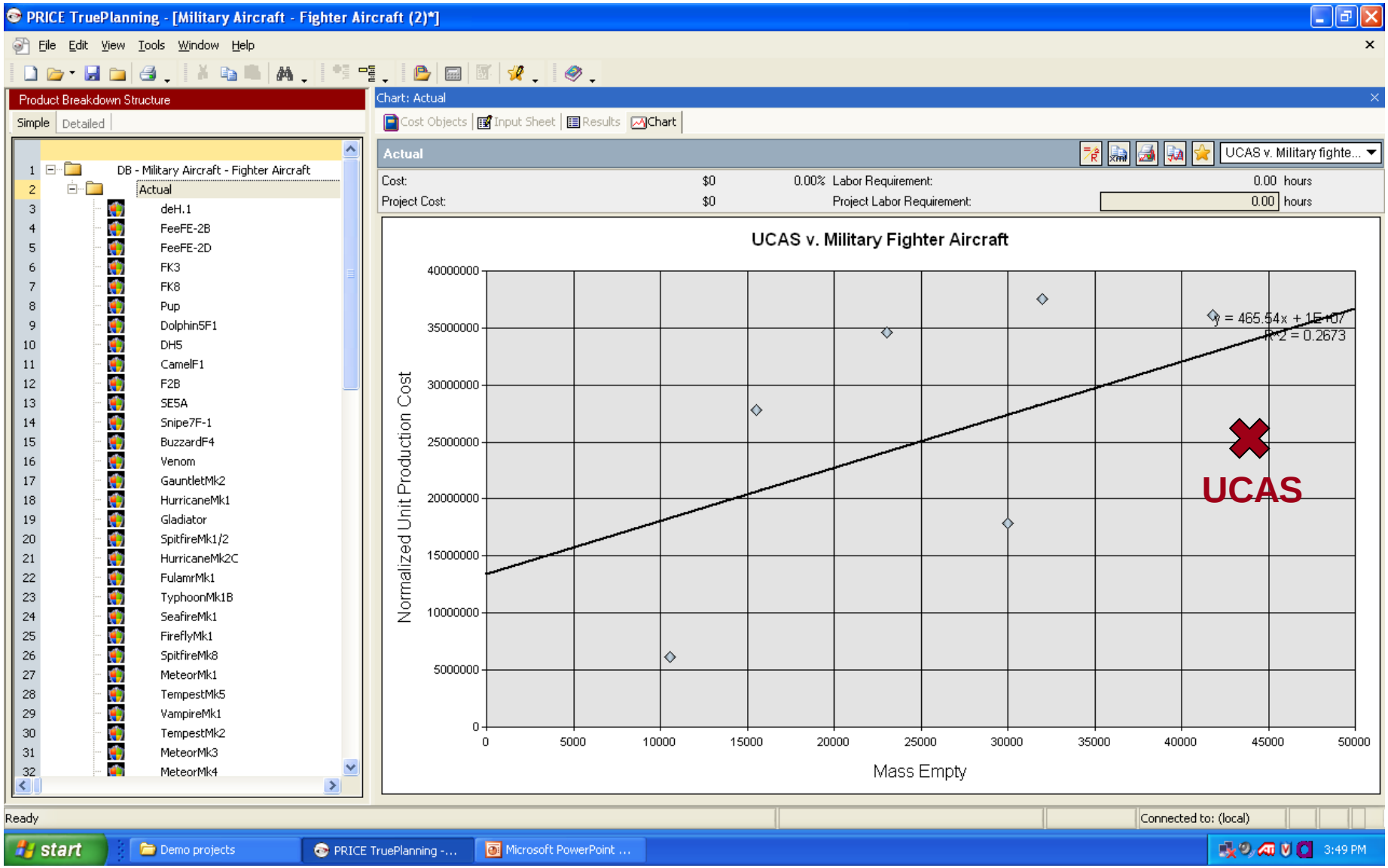
How will AFCAA look at this?

How will the CAPE look at this?

How will the GAO look a this?



TruePlanning Estimate Validation



TruePlanning® by PRICE® Systems

Every day, project managers make decisions based on estimates.

So create your estimating culture and be prepared!

- **How much will it cost?**
- **How long will it take?**
- **How much can we do in 6 months?**
- **How much can we do for $3M?**

Thank you for evaluating the risk. We should not do this.

I understand we can't get everything we want and your plan addresses the top priorities.

I am happy we stayed on schedule and did not add that seemingly small requirement.

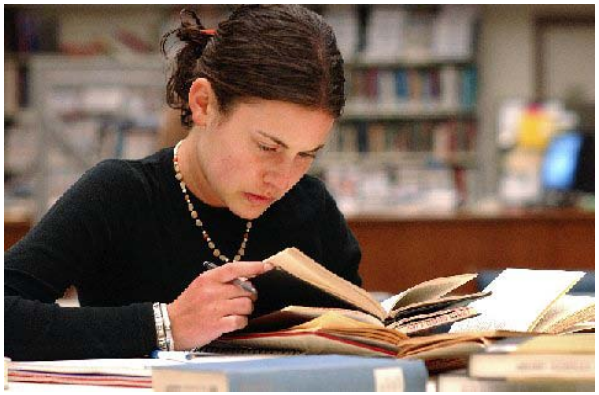
You really know how to establish realistic expectations and deliver.

You have a lot of credibility

Summary
To be successful, project managers should…

- **Develop personal estimating Rules of Thumb from external and internal benchmarks**
- **Utilize rigorous estimating models and enterprise databases**
- **Ask five questions about every estimate to judge its credibility and to fortify your personal Rules of Thumb and estimating models and databases**

References



- **Cost Helper** http://www.costhelper.com
- **Rules of Thumb** http://www.rulesofthumb.org
  http://www.rulesofthumbs.com
- **TruePlanning** http://www.pricesystems.com

Thank you for your time

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