



Using Public Data for Validation

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Problem Statement



Why do we need to expand our verification options?

- The burden of proof is on the analyst
- Overspends remain a major organisational issue
- A lot of models remain rubbish-in, rubbish-out

This Presentation



How this will help you...

- Identify public data to assist validation
- Measure the data properly
- Convert measurements to actionable intelligence

Validation Definition



Validation is the process, or act, of demonstrating the complex model's ability to function as a credible estimating tool. Validation ensures: ¹

1. The model is a good predictor of costs
2. Estimating system policies and procedures are established and enforced
3. Key personnel have proper experience and are adequately trained.

¹ Parametric Estimating Handbook (2008). International Society of Parametric Analysts



Theory Overview

Using Public Data

Multiple Estimating Methods

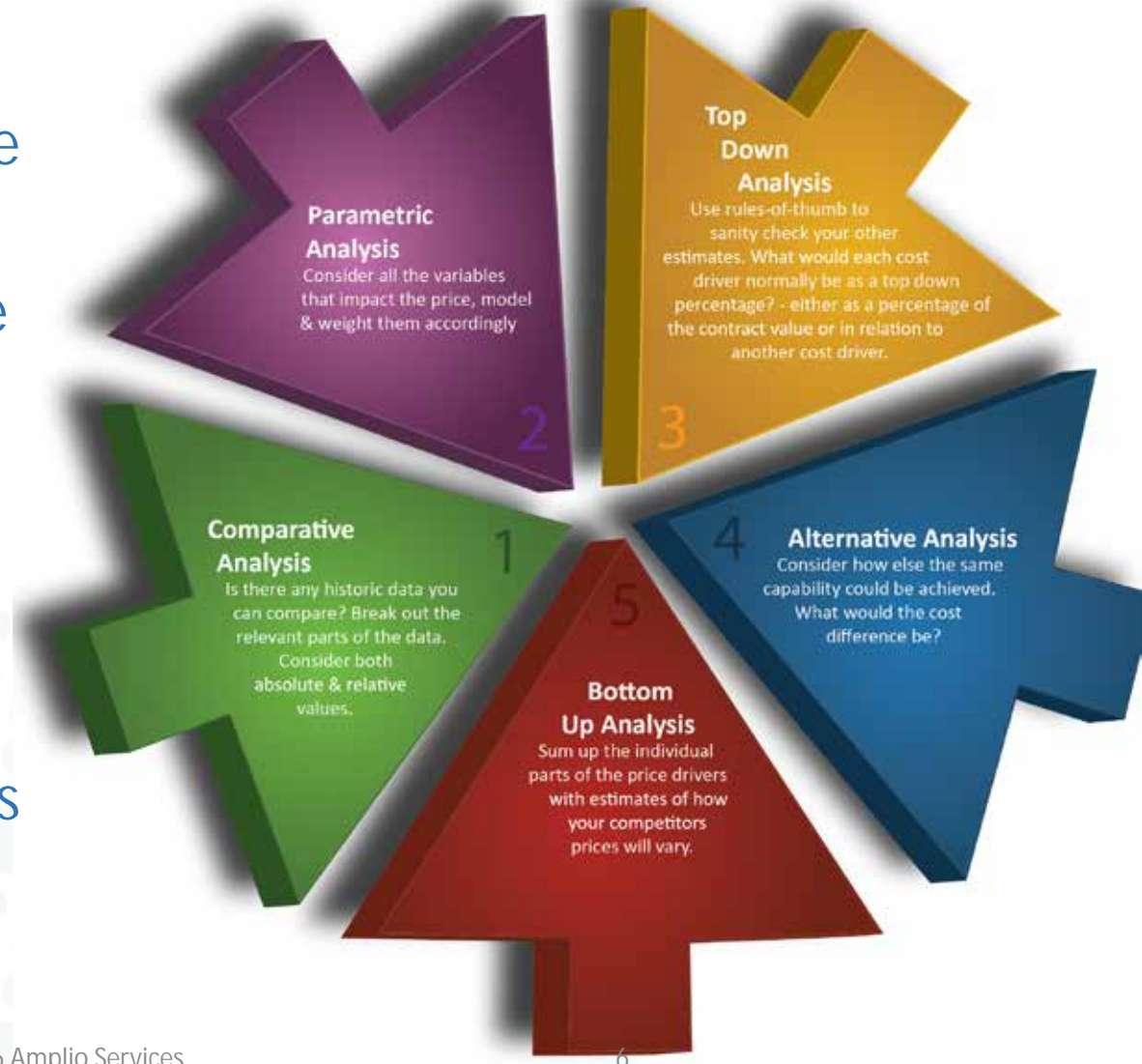
If your bottom up estimates are 70% accurate. That means there they are 30% inaccurate.

If parametric estimates are 85% accurate and show a similar prediction, the combined accuracy is now 95.5%.

Add a comparative estimate with 60% accuracy that also supports our answer and our combined accuracy is now 98.2%.

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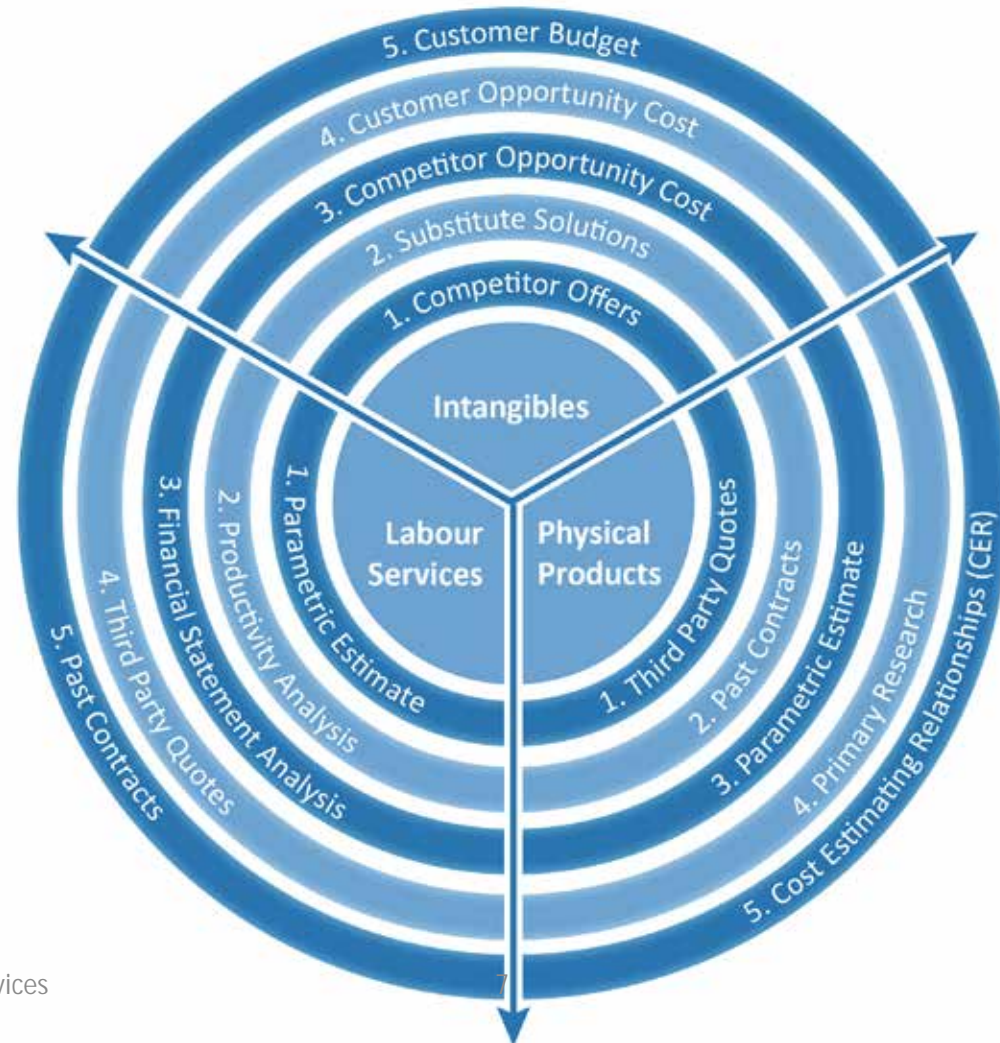
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Finding Data



There is a hierarchy of data that we look for when producing estimates.

The best quality data is shown nearer the middle of the circle, however we usually gather as much as possible.

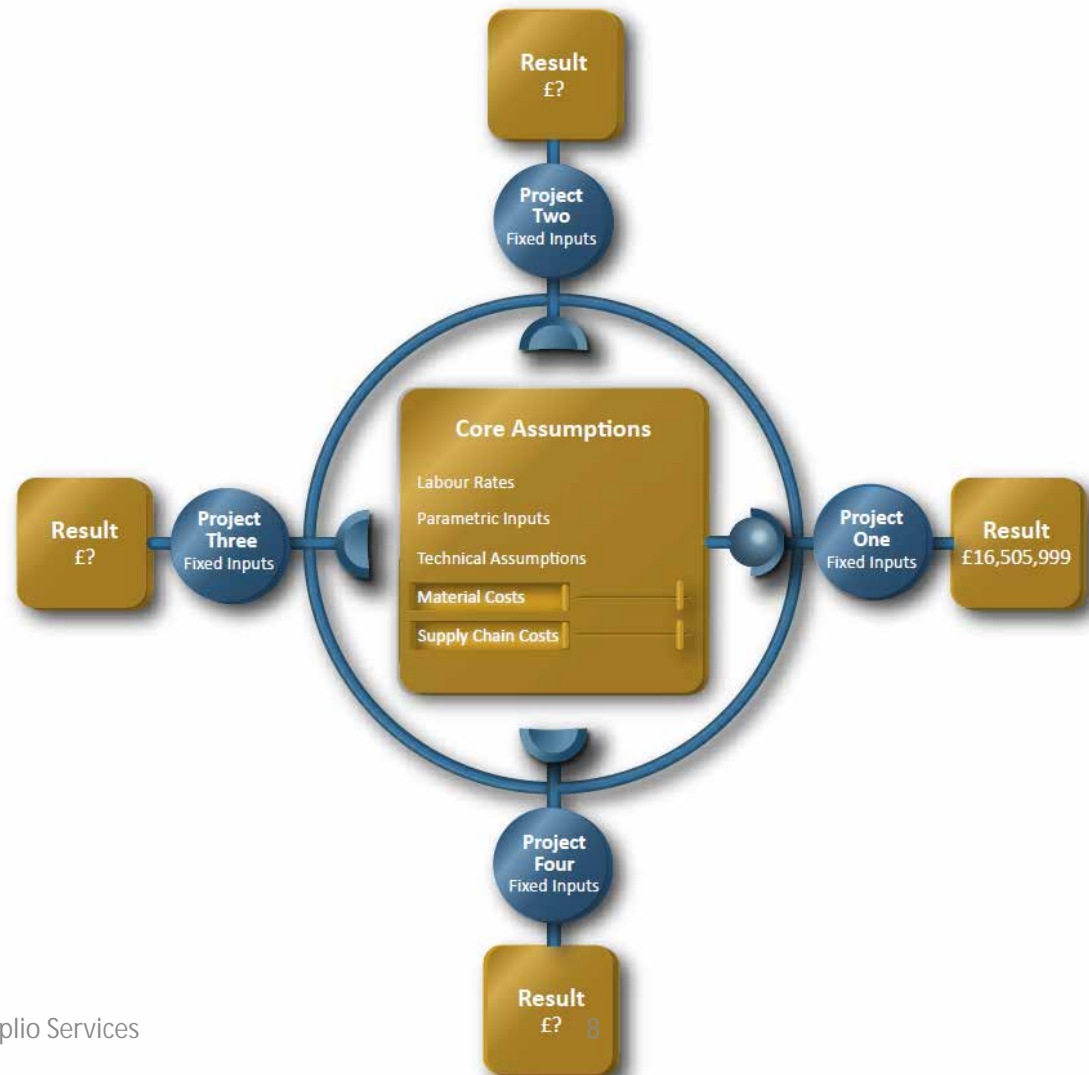


Data Pivoting



Data pivoting allows us to check for errors by re-using assumptions throughout multiple projects.

By maintaining a set of core assumptions, but varying project based inputs; we can identify potential errors.





UAV Example

Validation Example

Parametric Estimate



If we have a parametric estimate, we are required to estimate inputs that have high uncertainty

Product Breakdown Structure

Simple Detailed

- 1 Unmanned Air Vehicle in 881C Template S1_A
- 2 UA_1.0_1.6_1.7_1.10 UAV System_System Engineering_Pro...
- 3 UA_1.5 UAV System Integration, Assembly, Test and Che...
- 4 UA_1.4 UAV Software Release
- 5 UA_1.1_1.1.7 Air Vehicle_Air Vehicle Integration, Ass...
- 6 UA_1.1.1_1.1.1.1 Airframe_Airframe, Integration, ...
- 7 UA_1.1.1.2 Fuselage Assembly Object
- 8 UA_1.1.1.3 Wings
- 9 UA_1.1.1.4 Empennage Assembly Object
- 10 UA_1.1.1.5 Nacelle Assembly Object
- 11 UA_1.1.2 Propulsion System Object
- 12 UA_1.1.3_1.1.3.1 Vehicle Subsystems_Vehicle ...
- 13 UA_1.1.3.2 Flight Controls
- 14 UA_1.1.3.3 Auxiliary Power System
- 15 UA_1.1.3.4 Hydraulic System
- 16 UA_1.1.3.5 Electrical System
- 17 UA_1.1.3.6 Environmental Control System
- 18 UA_1.1.3.7 Fuel System
- 19 UA_1.1.3.8 Landing Gear System
- 20 UA_1.1.3.9 Rotor Group
- 21 UA_1.1.3.10 Drive System
- 22 UA_1.1.3.11 Vehicle Subsystems Software ...
- 23 UA_1.1.4_1.1.4.1 Avionics_Avionics, Integration...
- 24 UA_1.1.4.2 Communication/Identification
- 25 UA_1.1.4.3 Navigation/Guidance

Input Sheet

Cost Objects Input Sheet Attributes Results Chart

UA_1.1.1.3 Wings

Cost:

Project Cost:

Phase Set: A <Inherited> Worksheet Set: A <Inherited>

	Value	Units
1 Start Date		
2 Quantity Per Next Higher ...	2.00	
3 Additional Units		
4 Number of Additional Prod...	0.00	
5 Number of Additional Prot...	0.00	
6 Technical Description		
7 Equipment Type	None	
8 Operating Specification	1.600	
9 Weight of Structure	236.7000	lbs
10 Weight of Electronics	2.0000	lbs
11 Manufacturing Complexity for ...	7.165	
12 Percent of New Structure	50.00%	%
13 Manufacturing Complexity for ...	6.633	
14 Percent of New Electronics	50.00%	%
15 Engineering Complexity	1.000	
16 External Integration Complexity...	2.00	
17 External Integration Complexity...	2.00	

US Procurement Reports



The US Department of Defence publishes some very detailed cost information that we can use as a **comparative estimate**

UNDER SECRETARY OF DEFENSE
(COMPTROLLER)

Search OUSD Cor

ABOUT OUSD(C) FMR BUDGET MATERIALS BUDGET EXECUTION FINANCIAL

OFFICE OF THE UNDER SECRETARY OF DEFENSE (COMPTROLLER)

DoD Budget Request

2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 19

The Department's Budget request for the Department of Defense sustains the President's commitment to invest in America's security and prepare for the future by funding a high state of military readiness and ground force strength; strengthening combat capabilities of America's Armed Forces; and deter and defeat future threats to the Nation's security; and improving the quality of life for service members and their families.

- ...
- ...
- Budget Documents
- ...
- Budget Materials

- Budget Material
- Budget Material

Defense Budget Materials - FY2017

Press Releases

Press Release - Defense Budget

Budget Briefing

Transcripts:

- Briefing by Under Secretary Of Defense (Comptroller) Mike McCord; Lt. Gen. A. Director, Force Structure, Resources and Assessment, Joint Staff (J8)

Summary Budget Documents



Overview - FY2017 Defense Budget

Performance Improvements



Program Acquisition Costs by Weapons System

11



Financial Summary Tables

US Procurement Reports



Whilst we need to adjust for labour rates, currency, inflation & quantities – the upside is the sheer depth of data available in the US

UNCLASSIFIED

Exhibit P-5, Cost Analysis: PB 2014 Army										Date: April 2013									
Appropriation / Budget Activity / Budget Sub Activity:					P-1 Line Item Nomenclature:					Item Nomenclature (Item Number - Item Name, DODIC):									
2031A: Aircraft Procurement, Army / BA 01: Aircraft / BSA 10: Fixed Wing					A00005 - MQ-1 UAV					A00005 - MQ-1 UAV									
Resource Summary	Prior Years	FY 2012	FY 2013 [#]	FY 2014 Base	FY 2014 OCO ^{##}	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	To Complete	Total							
Procurement Quantity (Units in Each)	55	29	19	15	-	15	15	-	-	-	-	133							
Gross/Weapon System Cost (\$ in Millions)	895.501	550.798	518.088	518.460	-	518.460	232.321	1.000	14.000	100.334	-	2,830.502							
Less FY Advance Procurement (\$ in Millions)	-	-	-	-	-	-	-	-	-	-	-	-							
Net Procurement (P1) (\$ in Millions)	895.501	550.798	518.088	518.460	-	518.460	232.321	1.000	14.000	100.334	-	2,830.502							
Plus CY Advance Procurement (\$ in Millions)	-	-	-	-	-	-	-	-	-	-	-	-							
Total Obligation Authority (\$ in Millions)	895.501	550.798	518.088	518.460	-	518.460	232.321	1.000	14.000	100.334	-	2,830.502							
<i>(The following Resource Summary rows are for informational purposes only. The corresponding budget requests are documented elsewhere.)</i>																			
Initial Spares (\$ in Millions)	-	-	-	-	-	-	-	-	-	-	-	-							
Gross/Weapon System Unit Cost (Units in Thousands)	16,281.830	18,993.030	27,267.780	34,564.000	-	34,564.000	15,488.067	-	-	-	-	21.282							
[#] FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012 ^{##} The FY 2014 OCO Request will be submitted at a later date																			
Cost Elements († indicates the presence of a P-5A)	ID CD	All Prior Years			FY 2012			FY 2013			FY 2014 Base			FY 2014 OCO			FY 2014 Total		
		Unit Cost (\$ K)	Quantity (Each)	Total Cost (\$ M)	Unit Cost (\$ K)	Quantity (Each)	Total Cost (\$ M)	Unit Cost (\$ K)	Quantity (Each)	Total Cost (\$ M)	Unit Cost (\$ K)	Quantity (Each)	Total Cost (\$ M)	Unit Cost (\$ K)	Quantity (Each)	Total Cost (\$ M)	Unit Cost (\$ K)	Quantity (Each)	Total Cost (\$ M)
Flyaway Cost																			
Recurring Cost																			
† Aircraft		4,406.000	55	242.347	4,206.000	29	121.964	5,286.000	19	100.429	5,396.000	15	80.944	-	-	-	5,396.000	15	80.944
Ground Control Station (GCS)		3,172.000	10	31.724	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Portable Ground Control Station (PGCS)		1,128.000	4	4.511	631.000	6	3.785	942.000	4	3.768	-	-	-	-	-	-	-	-	-
Universal Ground Control Station (UGCS)		3,202.000	15	48.037	2,757.000	14	38.593	4,060.000	8	32.478	3,537.000	8	28.296	-	-	-	3,537.000	8	28.296
Ground Data Terminal (GDT)		1,229.000	14	17.207	-	-	2,871.000	8	22.969	-	-	-	-	-	-	-	-	-	-
Universal Ground Data Terminal (UGDT)		1,189.000	15	17.842	1,218.000	21	25.585	-	-	-	-	-	-	-	-	-	-	-	-
Portable Ground Data Terminal (PGDT)		379.000	4	1.517	-	-	2,034.000	4	8.137	-	-	-	-	-	-	-	-	-	-
Automatic Take-Off & Landing Sys (ATLS)		713.000	16	11.412	815.000	7	5.704	1,535.000	4	6.138	1,046.000	6	6.274	-	-	-	1,046.000	6	6.274
Satellite Ground Data Terminal (SGDT)		1,632.000	17	27.739	1,719.000	7	12.030	2,947.000	4	11.786	2,205.000	8	17.640	-	-	-	2,205.000	8	17.640
Ground Support Equipment Kits (GSE)		2,554.000	6	15.325	2,127.000	7	14.886	2,974.000	4	11.896	2,768.000	6	16.608	-	-	-	2,768.000	6	16.608

UK NAO Reports



Again, if we adjust our models for the same settings, we can compare to a similar UK system. However, the level of detail here is generally lower

Watchkeeper

The Capability

Watchkeeper will provide the operational commander with a 24-hour, all weather, intelligence, surveillance, target acquisition and reconnaissance capability supplying accurate, timely and high quality imagery to support decision making. The system will consist of unmanned air vehicles, sensors, data links and ground control stations. Watchkeeper is planned to be delivered through an incremental programme to allow the system to benefit from both existing and developing sensors and air vehicle technology.



Overview of Cost, Time and Performance

	Approved	Forecast/Actual	Variation	IY Variation
Cost of Assessment Phase	£52m	£65m	+£13m	-
Cost of Demonstration & Manufacture Phase	£847m	£839m	-£8m	-£4m
Cost of Support Phase	£55m	£53m	-£2m	+£3m
Duration of Assessment Phase		68 months		
In-Service Date	June 2010	February 2012	+20 months	+12 months
Support Contract Go-Live	January 2010	January 2010	0 months	0 months
Support Contract End	May 2013	September 2014	+16 months	+16 months

UK Financial Statements



Where the UK does offer more information than the US is that private company financial statements are freely available.

In this instance, a joint-venture company carried out the contract. So the project revenue & company revenue are the same.

Profit and loss account for the year ended 31 December 2014

	Notes	2014 £000	2013 £000
Turnover	2	46,684	61,787
Cost of sales		(31,199)	(46,841)
Gross Profit		15,485	14,946
Administrative expenses		(953)	(999)
Operating Profit	3	14,532	13,947
Interest receivable and similar income	6	23	46
Profit on ordinary activities before taxation		14,555	13,993
Tax	7	(2,653)	(3,392)
Profit for the financial year	12	11,902	10,601

All amounts relate to continuing activities.

UK Financial Statements



Usually, the notes to the accounts show the labour costs which further allows us to cross-reference labour / material split assumptions

5. Staff costs

	<i>2014</i>	<i>2013</i>
	<i>£000</i>	<i>£000</i>
Wages and salaries	4,632	5,886
Social security costs	475	551
Other pension costs	153	169
	<u>5,260</u>	<u>6,606</u>

The average monthly number of employees (excluding executive directors) for the year was:

	<i>No.</i>	<i>No.</i>
Programme	66	91
Administration	6	7
	<u>72</u>	<u>98</u>

Labour Rates Example



Financial Statements provide many of the inputs we need to calculate labour rates. However, we still need to make assumptions about other inputs. We can measure the standard deviation of the errors to show how good our assumptions really are.

Company A	CY 2012	CY 2013	CY 2014	Average
Implied Wages and Salaries	£173,628,832	£209,371,748	£202,970,111	£195,323,564
Delta from Actual	-8.3%	0.0%	-5.4%	-4.6%
Implied Wages of Contractors	£20,954,387	£25,287,496	£24,499,157	£23,580,346
Implied COGS	£919,966,380	£932,833,624	£1,077,984,767	£976,928,257
Delta from Actual	1.3%	1.6%	2.0%	1.6%
Implied Revenue	£980,928,169	£1,076,482,521	£1,057,488,135	£1,038,299,608
Actual Revenue	£994,917,691	£970,449,535	£1,164,712,010	£1,043,359,745
Delta from Actual	-1.4%	10.9%	-9.2%	0.1%
Variance of Effort				0.2%
Standard Deviation of the Error				1.6%

Labour / Material Split



Even if the top-level results of our data pivoting appear correct, we may dig into deeper analysis to cross-reference assumptions. The split between labour and materials is very useful and informs our 'value added ratio'

Results				
Cost Objects Input Sheet Attributes Results Chart Metrics Schedule Unce				
Unmanned Air Vehicle in 881C Template S1_A				
Cost:		\$1,135,068,502		
Project Cost:		\$1,135,068,502		
Phase Set: A		Worksheet Set: A		
Costs : Unmanned Air Vehicle in 881C Template S1_A - [System Folder] Currency in USD (\$) (as spent)	Total	Labor	Material	Other Cost
1 Development	241,699,973	235,847,314	3,868,938	1,983,721
2 Production	893,368,529	622,336,901	268,344,052	2,687,576
3 Operation & Support	0	0	0	0
4 Total	1,135,068,502	858,184,215	272,212,990	4,671,297



Metrics

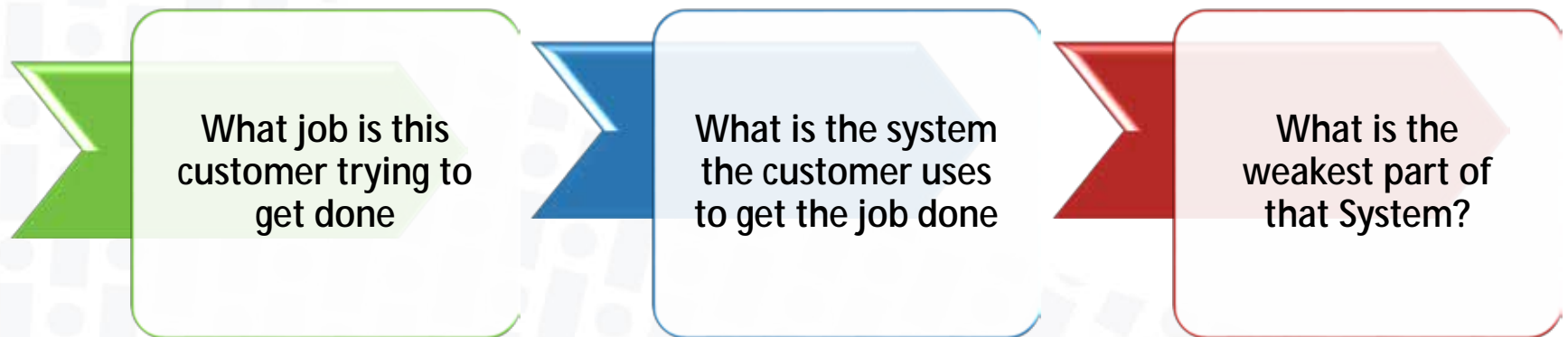
Using data in innovative ways

The Jobs-to-be-done Framework



This framework from Clayton Christensen provides a framework for the parameters we measure in order to quantify value

“ Customers aren’t interested in buying products or services per se. They have problems they want to solve and goals they want to achieve. These are jobs they want to do ” ³



³ The Innovator’s Solution (2003). Clayton Christensen

The Jobs-to-be-done Framework



Transport for London (TfL) is investing in several major projects including HS2, Crossrail & Northern Line Extension

What job are they trying to get done?

Currently, the Docklands Light Railway service operates driverless trains but it:

'Improved' capacity

For the first time on deep-level sections of the Tube, the 250 trains, which are a mechanised air-cooling system built in.

They will also have improved accessibility, with step-free access from the platform.

London Underground said the trains would improve capacity by:

- The Central line by 25% (the equivalent of up to 12,000 customers per hour)
 - The Bakerloo line by 25% (the equivalent of up to 8,000 customers per hour)
 - The Waterloo & City line by 50% (the equivalent of up to 9,000 customers per hour)
 - The Piccadilly line by 60% (the equivalent of up to 19,000 customers per hour)
- It is hoped that the trains will remain in service for more than 40 years.

London Overground capacity

VOR

We are extending most London Overground trains from four to five cars. The five-car fleet will roll out from late 2014.

- ▼ Longer trains
- ▼ Next steps
- ▼ Managing the impact of work
- ▼ Gospel Oak to Barking
- ▼ Contact us

Since we took over the network in 2007, London Overground passenger numbers have quadrupled. To meet this increasing demand we plan to introduce longer trains, to provide an additional 25% capacity and reduce crowding.

Value Add Ratio



Added Value

- § Finished Goods
- § Software as a Service
- § Raw Materials
- § Capability Enhancement

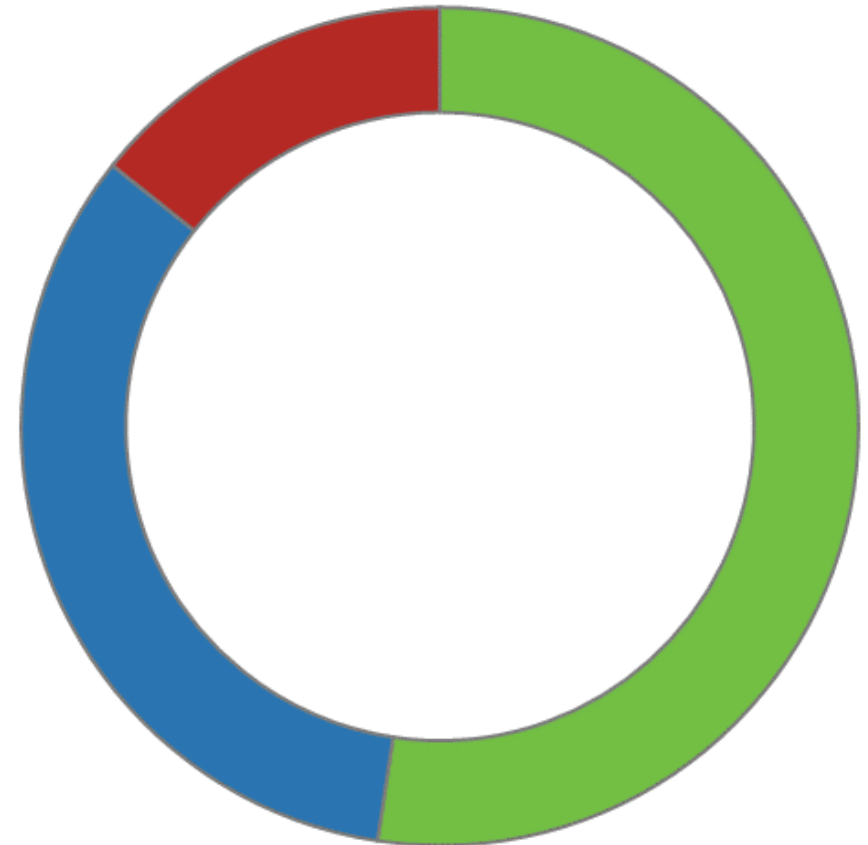
Overheads

- § Project Management
- § Training
- § Certification
- § Design Engineering

Waste

- § Rework
- § Inefficient Yields
- § Emergency Maintenance
- § Risk

■ Added Value ■ Overheads ■ Waste



COSYSMO



The Constructive Systems Engineering Cost Model (COSYSMO) is a method of quantifying system size and complexity, it was developed by Ricardo Valerdi

A	B	C	D	E	F	G	H	I	J
	Easy	Weight Easy	Nominal	Weight Nominal	Difficult	Weight Difficult	Weight of Category		Size for Category
Number of System Requirements	100	0.1	300	0.8	100	0.1	25.00%		65
Number of System Interfaces			30	1			25.00%		8
Number of System Specific Algorithms	100	0.4	280	0.5	200	0.1	25.00%		50
Number of Operational Scenarios			8	1			25.00%		2
Size of System:	125								
Calibration Constant A =	1.3								
Economy/Desiconomy of Scale E=	0.5								
Person Months:	12								



We have first determined the correlation between the average profit of the company for the last years and the win of a major contract, using Pearson product-moment correlation coefficient:

$$r = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2} \sqrt{\sum_{i=1}^n (y_i - \bar{y})^2}}$$

Then we have made a prediction model to determine the probability for a company with certain profit margin to win the major contract using the least squares normal equation:

$$C = (X^T X)^{-1} X^T Y.$$

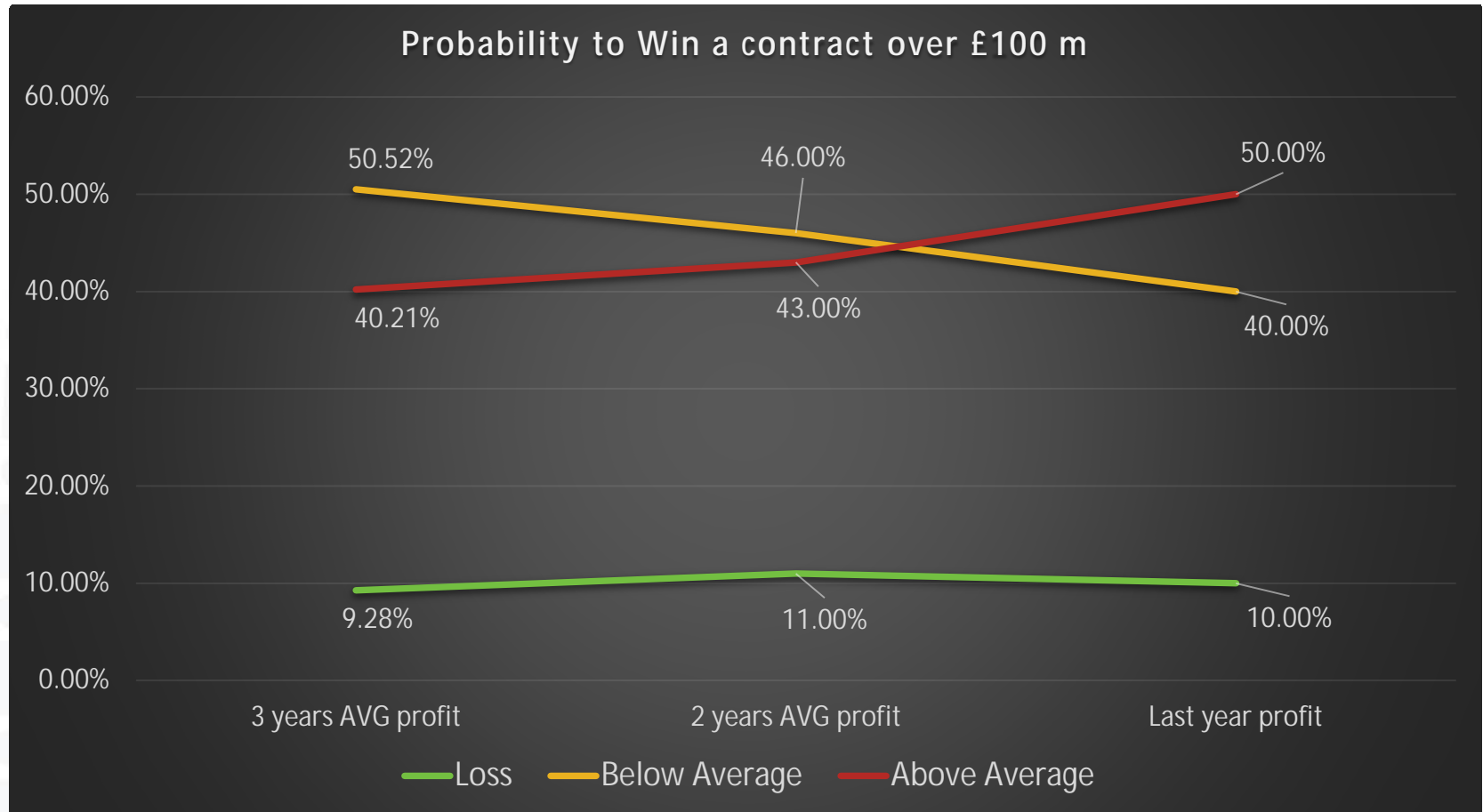
Where:

C is the model coefficients vector,

X is the data matrix and

Y is the result vector.

We have obtained the following probabilities:





Interpretation Issues

The challenge of how to read your data!

Aligning Terminology



Parametric Estimate:
‘Development’

Department of Defense:
“RDTE”

Ministry of Defence:
“Concept, Assessment,
Demonstration”


Costs - UA_1.1.1.3 Wings - (Hardware Component) Currency in USD (\$) (in spent)	Total	Development	Production	Operation & Support
1 Design Engineering	1,300,880	1,341,378	24,976	
2 System Engineering	68,761	68,761		
3 Support Engineering	4,245,109	688,052	3,557,057	
4 Test Engineering	4,682,400	0	4,682,400	
5 Assembler	3,991,201	0	3,991,201	
6 Material	8,756,561	0	8,756,561	
7 Tooling and Test Engineering	102,324	0	102,324	
8 Tooling and Test Material	654,456	0	654,456	
9 Manufacturing Engineering	242,936		242,936	
10 Fabricator	2,737,831		2,737,831	
11 Test Equipment	0		0	0
12 Spares	0		0	0
13 Contractor Services	0		0	0
14 Shipment Services	0		0	0
15 Operator	0		0	0
16 Technician	0		0	0
17 Amount for Initial Supply Administration	0		0	0
18 Amount for Support Supply Administration	0		0	0
19 Support Equipment Rear Space Charges	0		0	0
Total	25,846,467	2,086,172	24,750,295	0

supporting, and providing for Gray Eagle and its variants through program and support items.
Prime Contractor: General Atomics-Aerospace Systems Inc., San Diego, CA

MQ-1 Predator / Gray Eagle						
	FY 2012**		FY 2013**		FY 2014	
	\$K	Qty	\$K	Qty	\$K	Qty
13788						
Predator BSA	11.6	9.0	-	-	9.0	2.3
Gray Eagle BSA	171.8	74.4	-	-	74.4	18.9
SOEOR	3.8	1.8	-	-	1.8	2.1
Subtotal	187.2	85.2	-	-	85.2	23.3
Procurement						
Predator BSA	181.3	18.9	-	-	38.9	9.7
Gray Eagle BSA	497.8	19	749.6	19	349.6	416.2
SOEOR	3.7	4.8	-	-	4.9	38.4
Subtotal	682.7	29	754.5	19	794.5	445.3
Total	870.0	39	858.7	19	879.7	468.6

** FY 2012 includes Base and O&D funding. ** As/After the FY 2013 President's Budget Request. ** Includes support for test and dev on handover.

Watchkeeper
The Capability



Watchkeeper will provide the operational commander with a 24-hour, all-weather, intelligence, surveillance, target acquisition and reconnaissance capability supplying accurate, timely and high quality imagery to support decision making. The system will consist of unmanned air vehicles, sensors, data links and ground control stations. Watchkeeper is planned to be delivered through an incremental programme to allow the system to benefit from both existing and developing sensors and air vehicle technology.

Overview of Cost, Time and Performance

	Approved	Forecast/Actual	Variation	FY Variation
Cost of Assessment Phase	£25m	£66m	+£41m	=
Cost of Demonstration & Production Phase	£847m	£939m	+£92m	+£2m
Cost of Support Phase	£35m	£23m	-£12m	+£23m
Duration of Assessment Phase		68 months		
In-Service Date	June 2010	February 2012	+20 months	+12 months
Support Contract Go-Live	January 2010	January 2010	0 months	0 months
Support Contract End	May 2013	September 2014	+16 months	+16 months

Interpreting Terminology



If parametric algorithms are based on a database of actual historical data. What should we assume about the results for a bid?

Product Breakdown Structure

Simple Detailed

- 1 Zumwalt DDG 1000 Destroyer in 881 C
- 2 SS_1.1_1.2_1.3_1.6 Ship_System Engineering_Program Mana...
- 3 SS_1.1.8 Total Ship Integration/Engineering
- 4 SS_1.1.1 Hull Structure
 - 5 Main Hull
 - 6 Support and Protection
- 7 SS_1.1.2 Propulsion Plant
 - 8 Propulsion Units
 - 9 Transmission and Propeller
 - 10 Engine Support Systems
 - 11 Propulsion Subsystem Software Release
- 12 SS_1.1.3 Electric Plant
 - 13 Power Generation
 - 14 Distribution and Lighting
 - 15 Electric Plant Software Release
- 16 SS_1.1.4 Command, Communications and Surveillance
 - 17 Navigation Lighting
 - 18 Navigation Identification and Management Systems

Results

Cost Objects Input Sheet Attributes Results Chart Metrics Schedule Uncertainty Analysis

Zumwalt DDG 1000 Destroyer in 881 C

Cost: \$15,694,560,108 100.00% Labor Requirement:

Project Cost: \$15,694,560,108 Project Labor Requirement:

Phase Set: A Worksheet Set: Buy Level

Costs - Zumwalt DDG 1000 Destroyer in 881 C - [System Folder] Currency in USD (\$) (as spent)	Total	Labor	Material	Other Cost
1 Development	981,659,700	961,898,679	12,839,511	6,921,510
2 Production	14,712,900,408	10,394,401,446	4,278,972,775	39,526,188
3 Operation & Support	0	0	0	0
4 Total	15,694,560,108	11,356,300,125	4,291,812,286	46,447,697

Gaps in the data



We use terms like 'risk' but 'risk' is not a category you will find on a company balance sheet.

Balance sheet at 31 December 2014

	Note	2014 £000	2013 £000
Non-current assets			
Property, plant and equipment	8	90,835	93,266
Intangible assets	7	334,573	331,181
Investments in subsidiaries	9	200,459	189,968
Retirement benefit asset	18	208,675	95,506
Deferred tax asset	27	1,594	417
		836,136	710,338
Current assets			
Inventories and contracts in progress	10	101,733	136,248
Construction contracts	11	61,700	76,294
Trade and other receivables	12	190,330	160,676
Derivative financial instruments	20	4,307	8,623
Financial assets	13	186,917	112,941
Cash and cash equivalents		30,043	23,478
		575,030	518,260
Total assets		1,411,166	1,228,598
Current liabilities			
Trade and other payables	19	244,875	224,208
Advances from customers	11	164,050	156,027
Derivative financial instruments	20	9,747	2,167
Financial liabilities	14	177,142	190,710
Current tax liabilities	15	7,554	7,787
Provisions for liabilities and charges	17	24,852	23,319
		628,220	604,218
Non-current liabilities			
Non-current financial debts	14	27	124
Deferred tax liabilities	27	55,195	33,788
		55,222	33,912
Total liabilities		(683,442)	(638,130)
Net assets		727,724	590,468
Equity			
Ordinary shares	16	270,000	270,000
Retained earnings		462,431	316,467
Cash flow hedge reserve	16	(4,707)	4,001
		727,724	590,468
Total equity	28	727,724	590,468

Explaining the Results



Most people in our organisations do not think probabilistically!
Some people even object to it!

At best, most people have three understandings of probabilistic results:
"it will happen, it won't happen, it might"



Summary



Using the lessons in this presentation, you should

- Be able to identify sources public data to assist validation and improve your estimates
- Use measures such as data pivoting, the jobs-to-be-done framework, COSYSMO and 'Value Added Ratio' to convert data to actionable intelligence
- Anticipate some of the interpretation challenges you will encounter when you practice these skills