Presented at the 2016 International Training Symposium: www.iceaaonline.com/bristol2016

Using Public Data for Validation

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October 2016

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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

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This Presentation

How this will help you…

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

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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]

- The model is a good predictor of costs
- Estimating system policies and procedures are established and enforced
- 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.

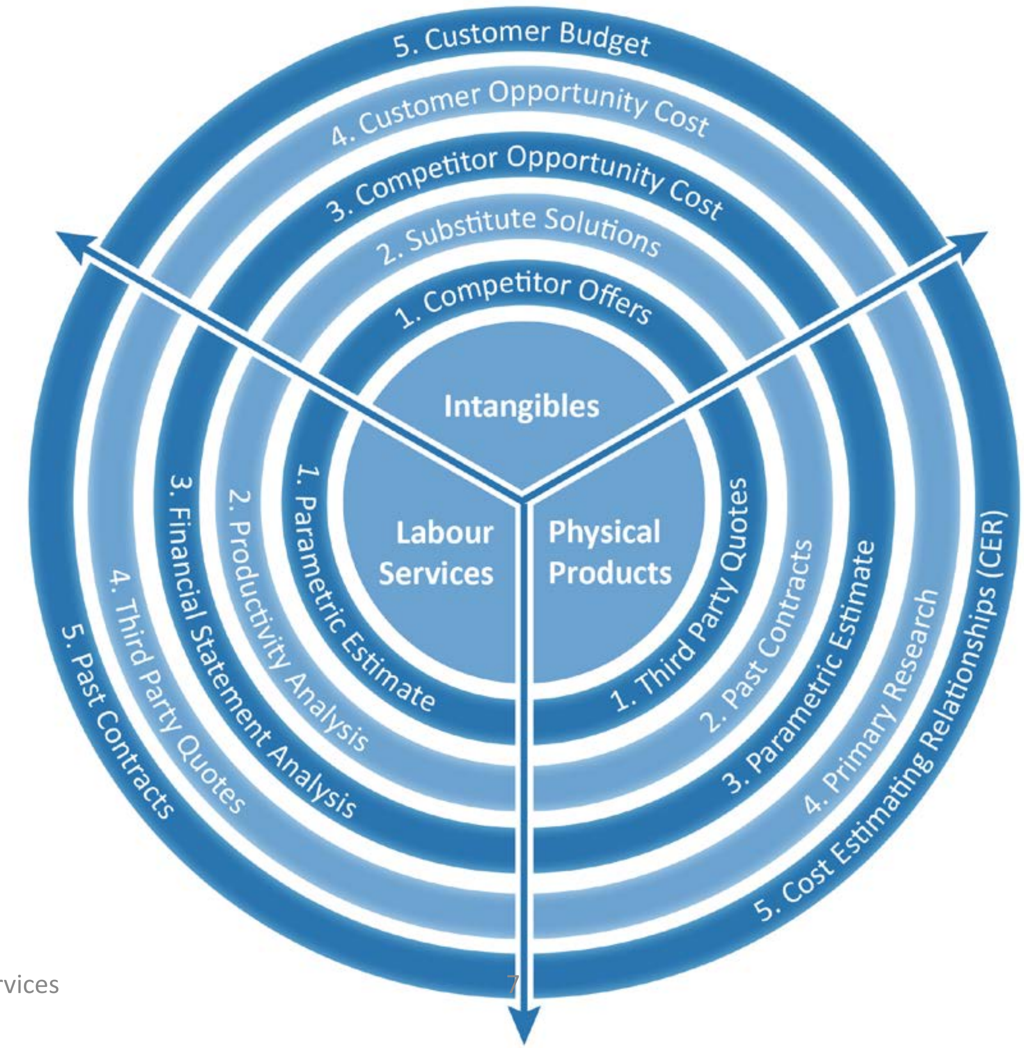
If parametric estimates are 85% accurate and show a similar prediction, the combined accuracy is now 95.5%.

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

Finding Data

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

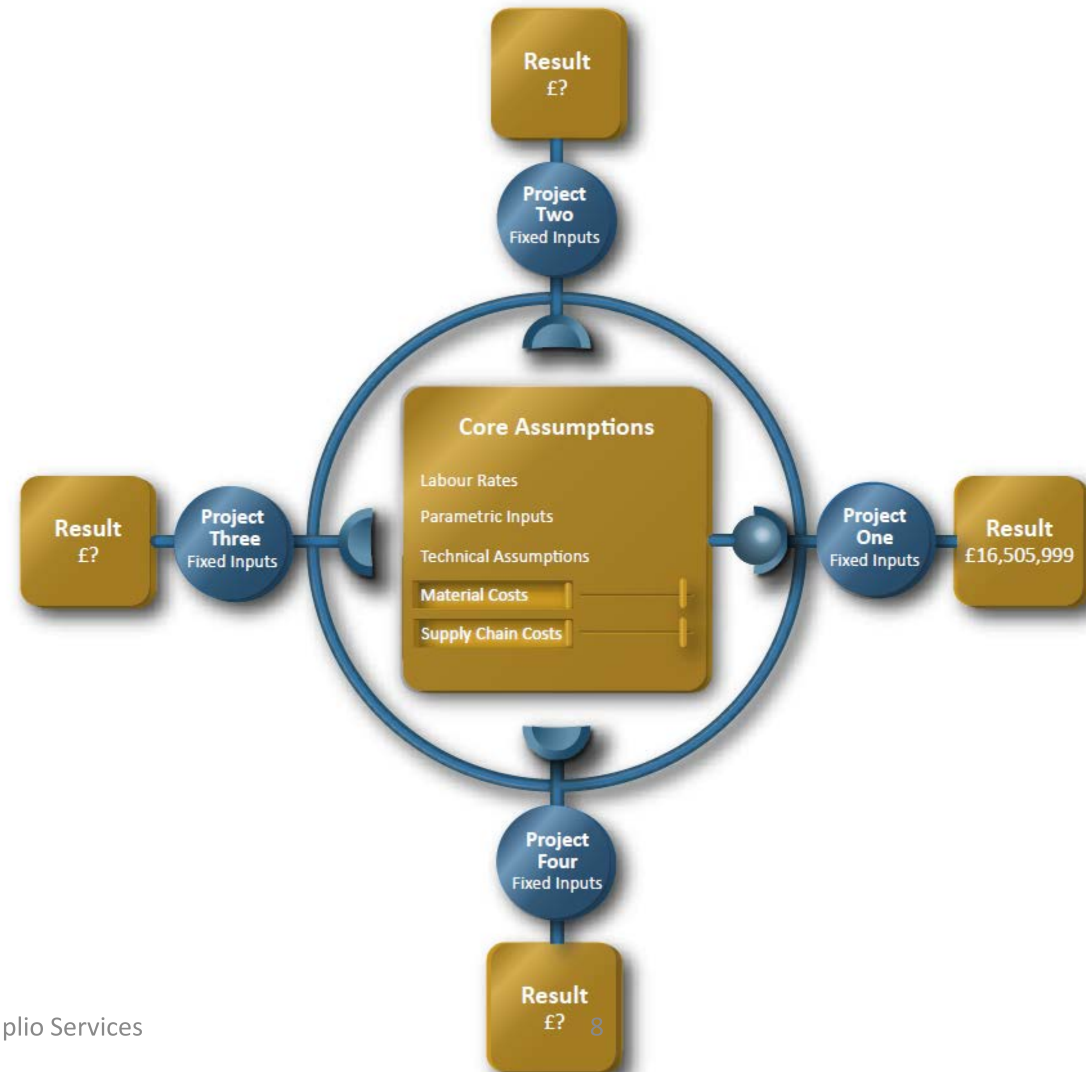
The best quality data is shown nearer the middle of the circle, however we usually gather as much as possible.



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.



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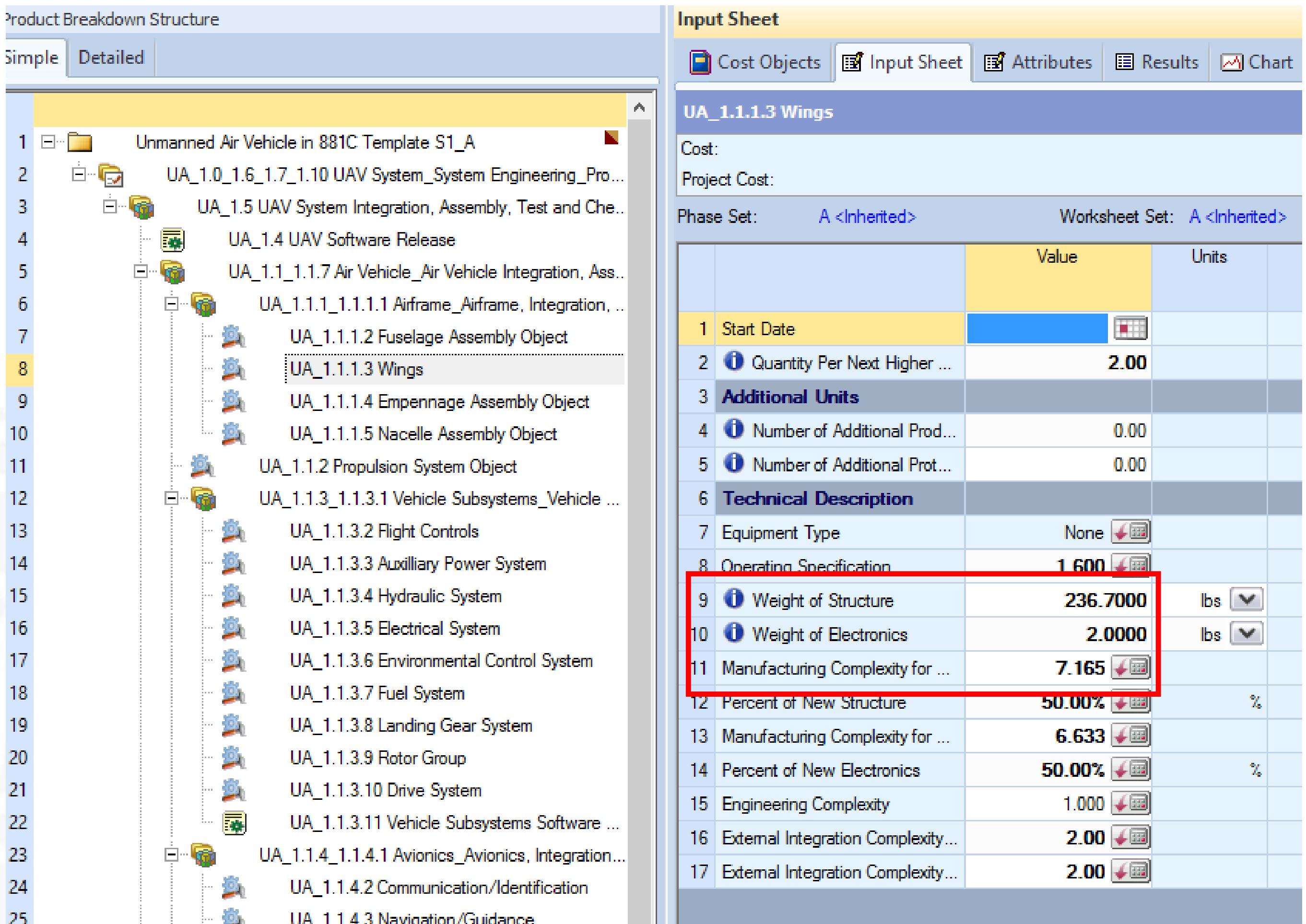
UAV Example

Validation Example

Parametric Estimate

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



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US Procurement Reports

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

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: 2031A: Aircraft Procurement, Army / BA 01: Aircraft / BSA 10: Fixed Wing

P-1 Line Item Nomenclature: A00005 - MQ-1 UAV

Item Nomenclature (*Item Number - Item Name, DODIC*): 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 PY 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**
(The following Resource Summary rows are for informational purposes only. The corresponding budget requests are documented elsewhere.)												
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

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UK NAO Reports

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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.

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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

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

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

	No.	*No.*
Programme	66	91
Administration	6	7
	72	98

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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%**

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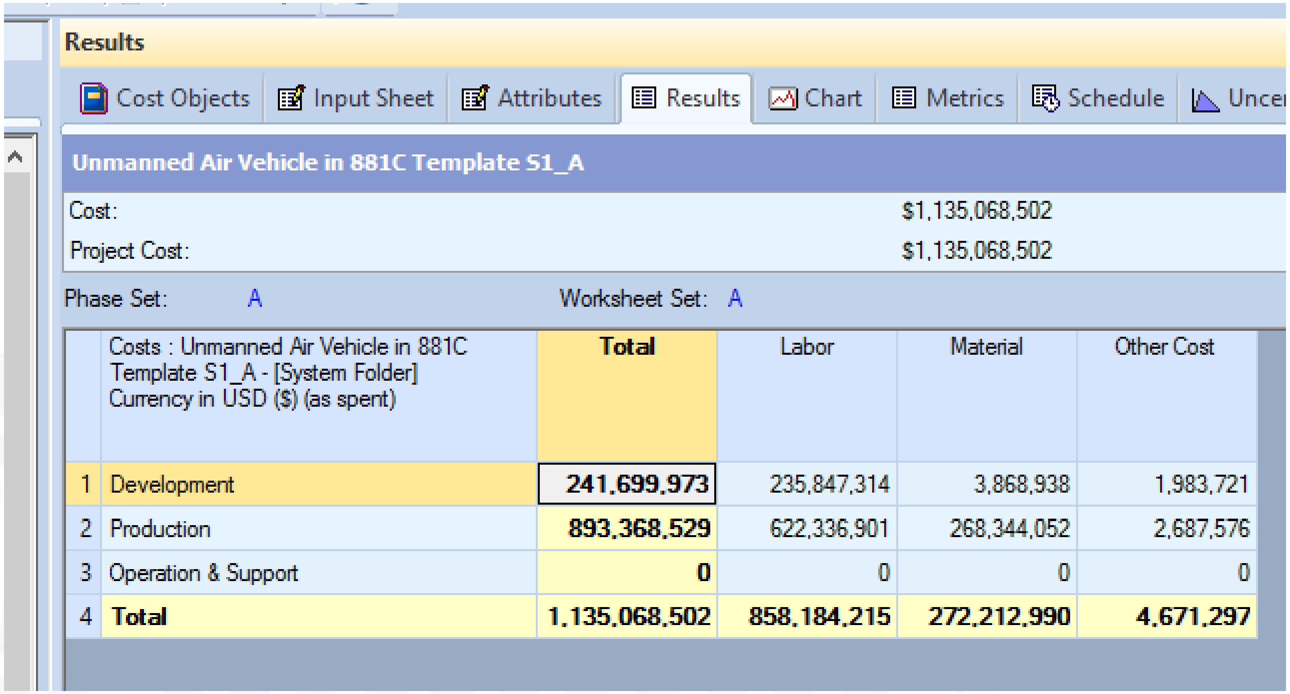
Labour / Material Split

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**’



	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]

What job is this customer trying to get done

What is the system the customer uses to get the job done

What is the weakest part of that System?

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

The Jobs-to-be-done Framework

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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 its

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

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

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

vo

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

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

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

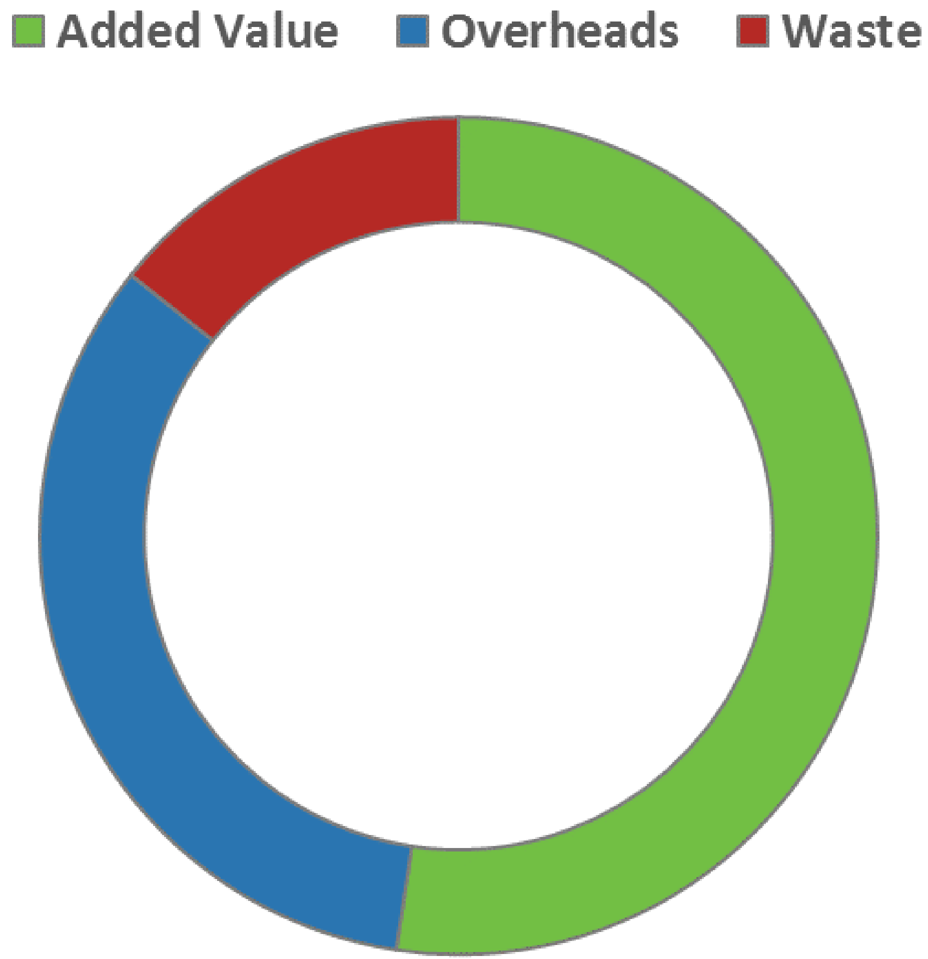
- Finished Goods
- Software as a Service
- Raw Materials
- Capability Enhancement

Overheads

- Project Management
- Training
- Certification
- Design Engineering

Waste

- Rework
- Inefficient Yields
- Emergency Maintaince
- Risk



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COSYSMO

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

	Easy	Weight Easy	Nominal	Weight Nominal	Dificult	Weight Dificult	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:

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

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:

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

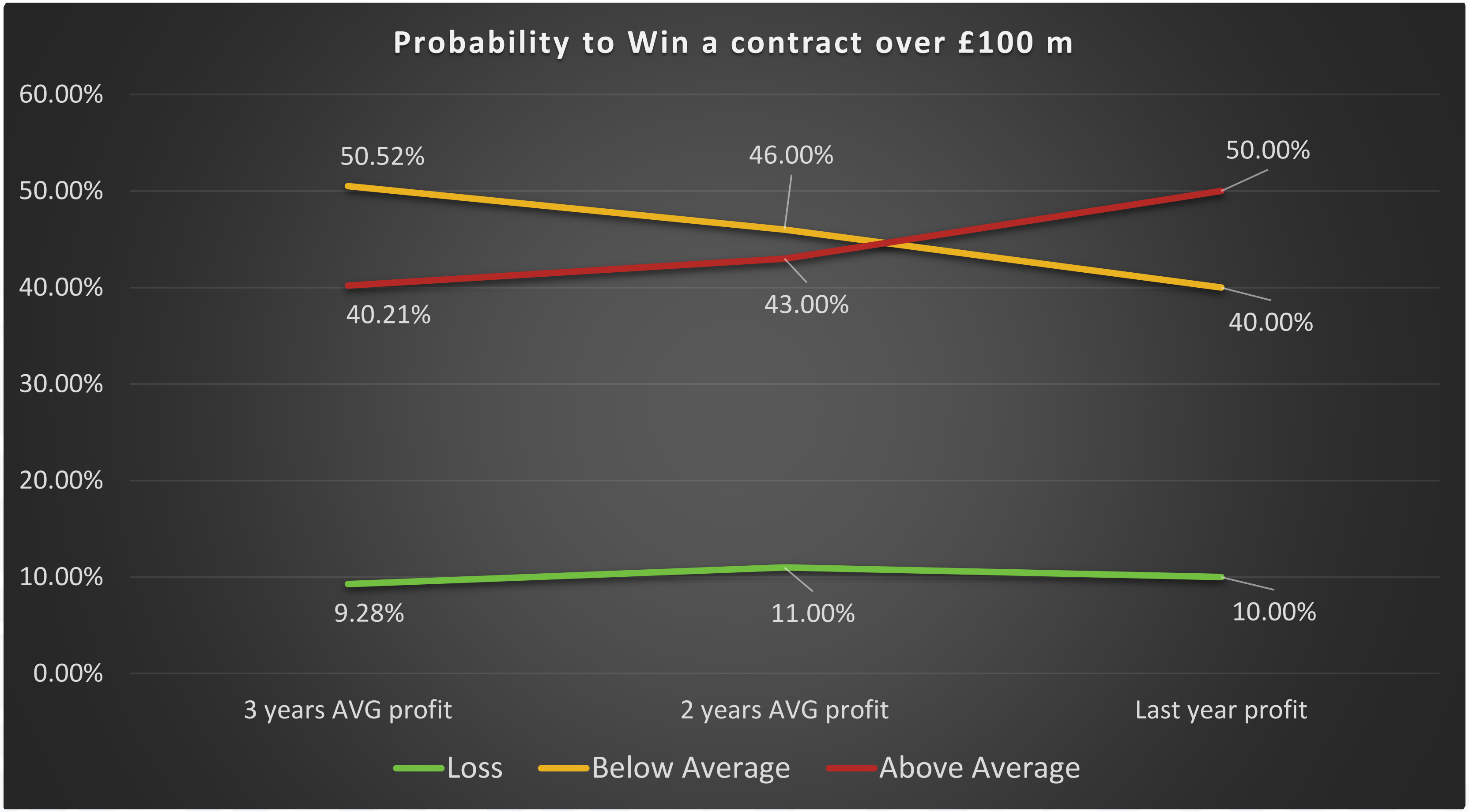
Where:

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

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Parametric Estimate: 'Development'

Department of Defense: "RDTE"

Ministry of Defence: "Concept, Assessment, Demonstration"

UA_1.1.1.3 Wings

Cost: $26,846,467

Project Cost: $1,135,068,502

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

	Costs : UA_1.1.1.3 Wings - [Hardware Component] Currency in USD ($) (as spent)	Total	Development	Production	Operation & Support
1	Design Engineering	1,365,888	1,341,318	24,570	
2	System Engineering	68,761	68,761		
3	Support Engineering	4,245,109	686,092	3,559,017	
4	Test Engineering	4,682,400	0	4,682,400	
5	Assembler	3,991,201	0	3,991,201	
6	Material	8,755,561	0	8,755,561	
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
14	Shipment Services	0			0
15	Operator	0			0
16	Technician	0			0
17	Amount for Initial Supply Administration	0		0	
18	Amount for Support Supply Administration	0			0
19	Support Equipment Floor Space Charges	0			0
20	**Total**	26,846,467	2,096,172	24,750,295	0

capability, and procures 15 Gray Eagle aircraft and three modular platoon sets of equipment.

Prime Contractor: General Atomics–Aeronautical Systems Inc., San Diego, CA

MQ–1 Predator / Gray Eagle

	FY 2012*		FY 2013**						FY 2014	
			Base Budget		OCO Budget		Total Request			
	$M	Qty	$M	Qty	$M	Qty	$M	Qty	$M	Qty
RDT&E										
Predator USAF	51.6	-	9.1	-	-	-	9.1	-	3.3	-
Gray Eagle USA	121.8	-	74.6	-	-	-	74.6	-	10.9	-
SOCOM	3.0	-	1.4	-	-	-	1.4	-	2.1	-
Subtotal	176.4	-	85.1	-	-	-	85.1	-	16.3	-
Procurement							-	-		
Predator USAF	161.2	-	30.9	-	-	-	30.9	-	9.7	-
Gray Eagle USA	697.8	29	749.6	19	-	-	749.6	19	616.2	15
SOCOM	3.7	-	4.0	-	-	-	4.0	-	20.6	-
Subtotal	862.7	29	784.5	19	-	-	784.5	19	646.5	15
Total	1,039.1	29	869.6	19	-	-	869.6	19	662.8	15

* FY 2012 include Base and OCO funding

** Reflects the FY 2013 President's Budget Request

Numbers may not add due to rounding

1-2 AIRCRAFT

Watchkeeper

The Capability

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Support Contract End	May 2013	September 2014	+16 months	+16 months

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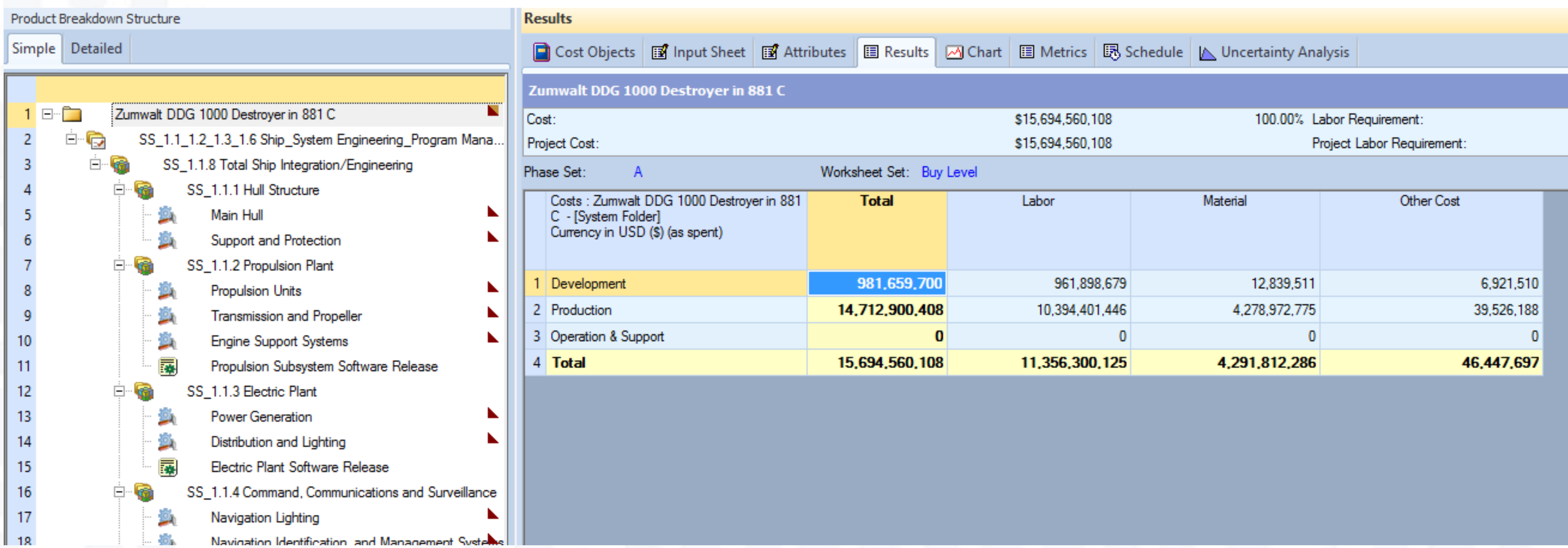
Interpreting Terminology

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



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Gaps in the data

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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
Total equity		**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"

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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

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