Cost Benefit Optimisation to achieve Affordable Force Structures

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Abstract: This paper will describe the application of parametric cost models to the problem of selecting the optimum Force Structure when limited defence budgets impose considerable restrictions on the shape and magnitude of the armed forces.

The use of Cost Benefit analysis by means of a Combine Operational Effectiveness and Investment Appraisal (COEIA) has been a methodology used to select alternative Force Structures in many procurement agencies. It is now possible to optimise this process through the linkage of parametric models and optimisation tools such as Phoenix Integration's ModelCenter.

The objective of this study is to develop the optimum Force Structure, within a specified budget, which provides the most benefit in terms of the measure of effectiveness.

This paper will describe the methods and processes used to establish the measure of effectiveness and cost estimate for each of the systems under consideration. It will demonstrate practical usage of the parametric models and linkage to optimisation tools such as ModelCenter including techniques resulting from this study so far and planned future research.

The technique is transferable and equally applicable to other situations where multiple trade-off of cost and benefit exist.

Introduction

The objective of this paper is to demonstrate the enterprise capability of a 3rd Generation parametric cost model like TruePlanning® in two ways. Firstly, to demonstrate its capability to provide Through Life Estimating (TLE) over time by the seamless transition of cost estimating methodologies; TruePlanning for Concepts to TruePlanning for Hardware, within a single cost framework. Secondly, to demonstrate the interface capability with other software applications, in this case ModelCenter, due to TruePlanning's modern software architecture built on a Microsoft SQL database.

Both of these attributes will be observed through a case study which will clearly show the principle of generating a Combine Operational Effectiveness and Investment Appraisal (COEIA). The case study will show obvious efficiencies that can be achieved through the use of such tools.

It must be noted that this case study is for demonstration only. The data contained within it is example data only and does not represent any current or future projects of any nation. The names reflect types of platforms with typical costs and weights and do not reflect anything other than 'gross' order of magnitudes.

TruePlanning® for Concepts

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 1 is a screen shot of the TruePlanning for Concepts catalogue version 36. 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 life cycle[1],[2].

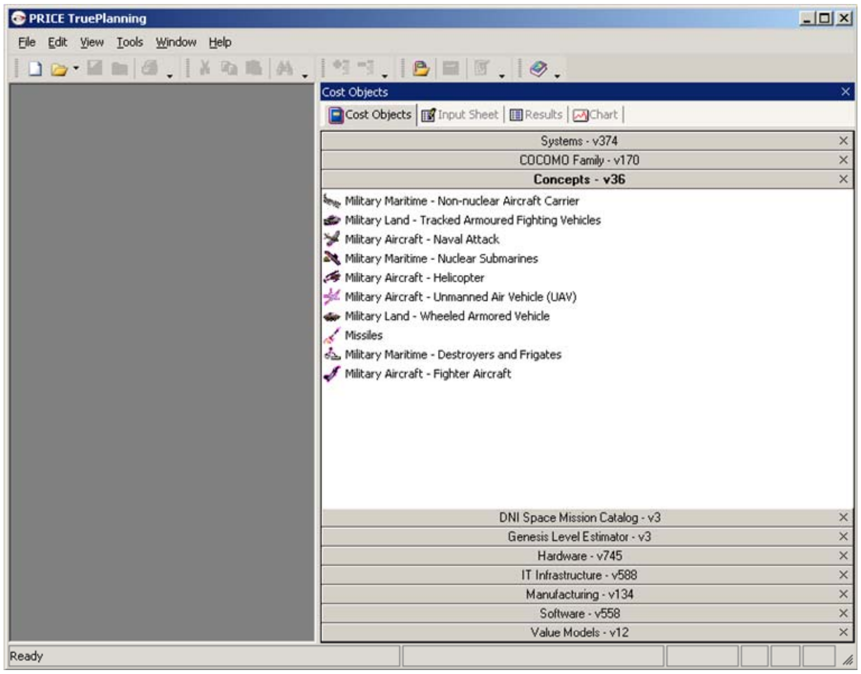


Figure 1 - UK MoD and PRICE Systems Custom built conceptual models

An efficient way to populate the model and thereafter create an estimate is to import a Product Breakdown Structure (PBS) from Microsoft Excel. It is possible to see from Figure 2 that the Cost Object tab within such a spreadsheet only needs to have the Cost Objects identified on each row and the specific Cost Object cost drivers specified and populated on each column to be capable of being imported by the TruePlanning software.

This type of interface makes the life of the Parametrician much easier. They only need to set up the template and request that it is populated by the relevant subject matter expert (SME) to enable them to quickly build the project.

The spreadsheet in this case study has been populated with a high level Force Structure for the Freedonia armed forces. The structure is divided into land, sea and air by folders as convenient summation points in the PBS.

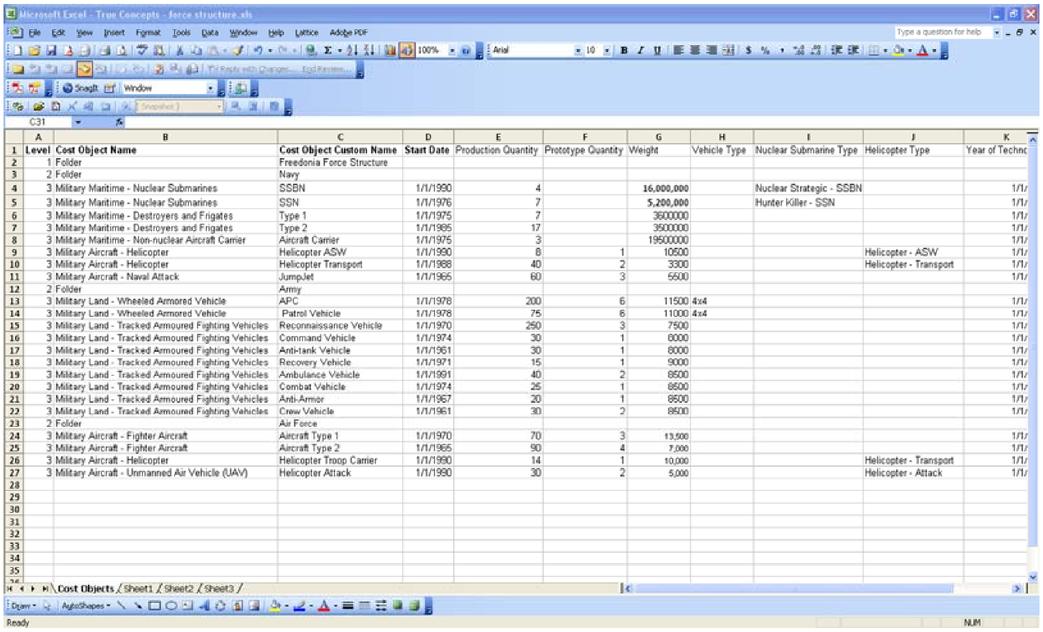


Figure 2 - Populating TruePlanning for Concepts from Excel

On retrieving the file from the SME the spreadsheet can be imported into TruePlanning to create the identical Product Breakdown Structure (PBS). The PBS is populated with all the mandatory input parameters, as shown in Figure 3.

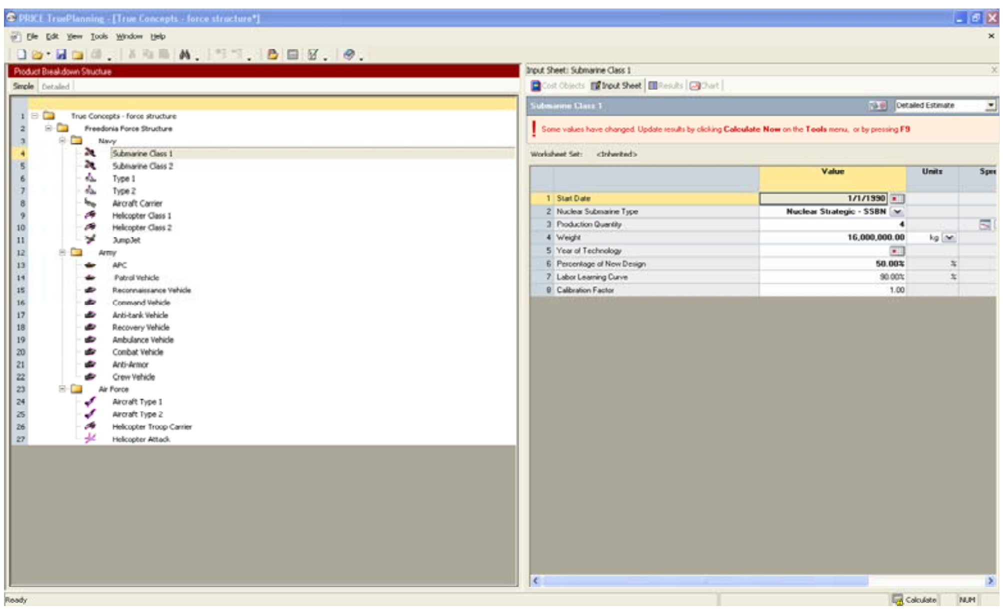


Figure 3 - High level Force Structure built as a Product Breakdown Structure (PBS)

At this stage it is simply a mater of calculating the total Force Structure estimated cost by selecting the 'Calculate now' menu option or pressing the calculator icon on the tool bar.

Through Life Estimating (TLE)

A significant challenge for a Parametrician or Cost Engineer is moving from one estimating methodology to another. As you can observe in Figure 4 different cost estimating methodologies align with different phases of the equipment or system's life. This Through Life Estimating (TLE) problem arises due to the use of multiple tools; spreadsheet, parametric models, simulation tools, etc. When transitioning between these tools it is difficult to make an auditable and justified explanation about why the costs might have changed.

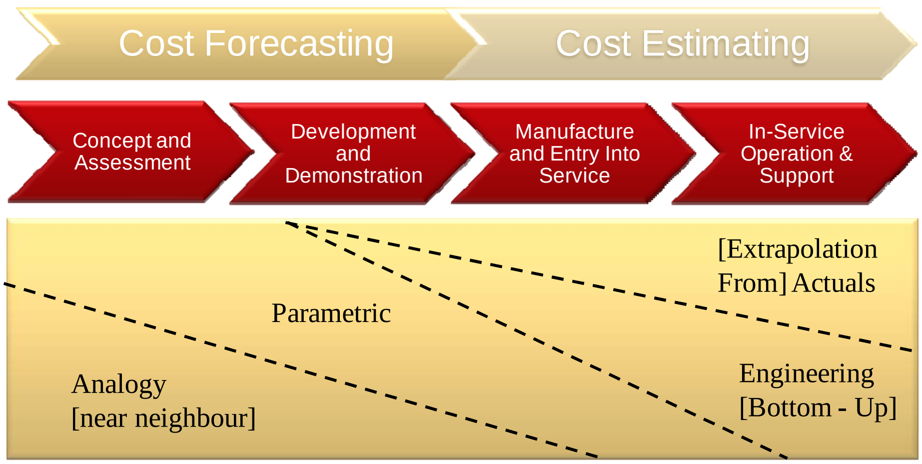


Figure 4 - Appropriate methodology for project phase

An advantage of a 3rd Generation parametric cost model results from its framework structure enabling multiple models (or catalogues) to work together and roll-up together. Figure 5 indicates the cost models which are available from PRICE Systems, but it is also possible to add your own custom models to this mixture. Using all these methodologies within one framework means that labour rates and escalation tables are consistently applied between models. It also means that the approach to risk analysis and capacity analysis are consistent and reconcilable.

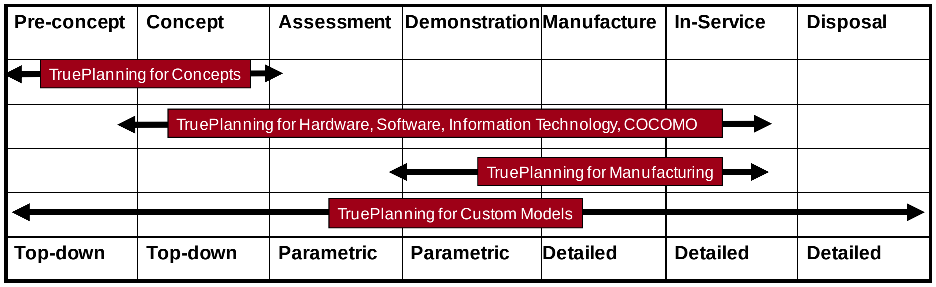


Figure 5 - Adopting the right model for the correct phase in a single framework

As a demonstration, consider the movement of our Force Structure in TruePlanning for Concepts to the more detailed TruePlanning for Hardware model. One of the outputs of the Concepts model in the "Metrics" Results is the Complexity of the system (as seen in Figure 6) this is a significant and necessary cost driver in the Hardware model.

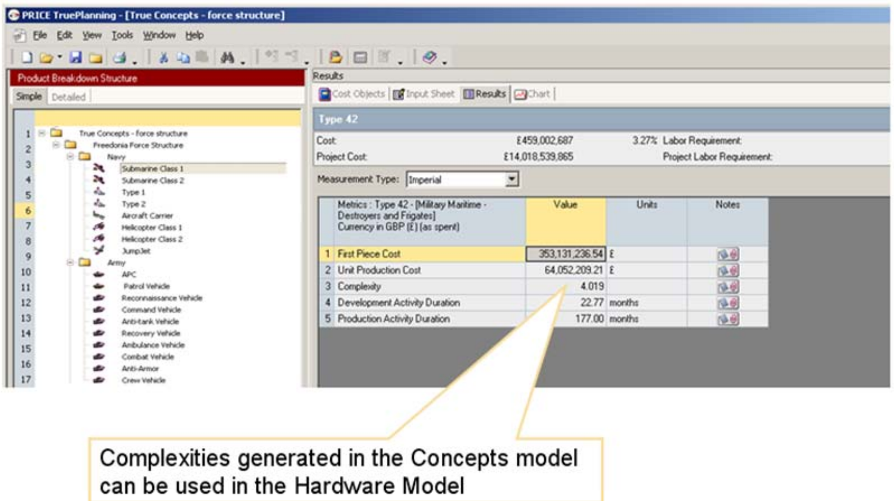
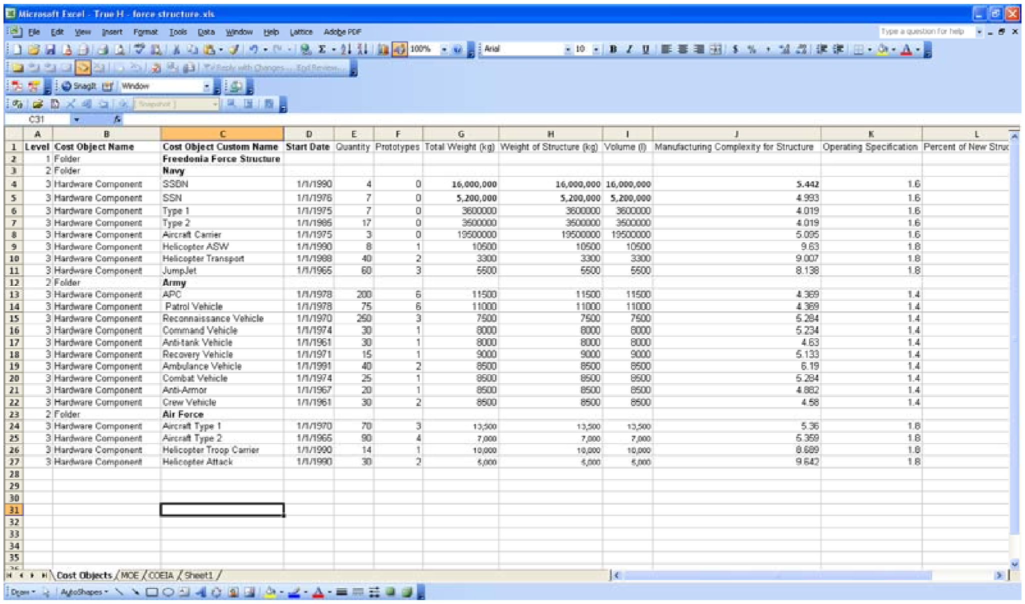


Figure 6 - Complexity generation in TruePlanning for Concepts

This output can be used in a modified spreadsheet to populate an identical Force Structure PBS, but using Hardware Cost Object instead of Concepts Cost Objects, as seen in Figure 7.



	Level	Cost Object Name	Cost Object Custom Name	Start Date	Quantity	Prototypes	Total Weight (kg)	Weight of Structure (kg)	Volume (l)	Manufacturing Complexity for Structure	Operating Specification	Percent of New Struc
2	1	Folder	**Freedonia Force Structure**									
3	2	Folder	**Navy**									
4	3	Hardware Component	SSDN	1/1/1990	4	0	16,000,000	16,000,000	16,000,000	5.442	1.6	
5	3	Hardware Component	SSN	1/1/1976	7	0	5,200,000	5,200,000	5,200,000	4.993	1.6	
6	3	Hardware Component	Type 1	1/1/1975	7	0	3600000	3600000	3600000	4.019	1.6	
7	3	Hardware Component	Type 2	1/1/1986	17	0	3500000	3500000	3600000	4.019	1.6	
8	3	Hardware Component	Aircraft Carrier	1/1/1975	3	0	19500000	19500000	19500000	5.095	1.6	
9	3	Hardware Component	Helicopter ASW	1/1/1990	8	1	10500	10500	10500	9.63	1.8	
10	3	Hardware Component	Helicopter Transport	1/1/1988	40	2	3300	3300	3300	9.007	1.8	
11	3	Hardware Component	JumpJet	1/1/1965	60	3	5500	5500	5500	8.138	1.8	
12	2	Folder	**Army**									
13	3	Hardware Component	APC	1/1/1978	200	6	11500	11500	11500	4.369	1.4	
14	3	Hardware Component	Patrol Vehicle	1/1/1978	75	6	11000	11000	11000	4.369	1.4	
15	3	Hardware Component	Reconnaissance Vehicle	1/1/1970	250	3	7900	7900	7900	5.284	1.4	
16	3	Hardware Component	Command Vehicle	1/1/1974	30	1	8000	8000	8000	5.234	1.4	
17	3	Hardware Component	Anti-tank Vehicle	1/1/1961	30	1	8000	8000	8000	4.63	1.4	
18	3	Hardware Component	Recovery Vehicle	1/1/1971	15	1	9000	9000	9000	5.133	1.4	
19	3	Hardware Component	Ambulance Vehicle	1/1/1991	40	2	8500	8500	8500	6.19	1.4	
20	3	Hardware Component	Combat Vehicle	1/1/1974	25	1	8500	8500	8500	5.284	1.4	
21	3	Hardware Component	Anti-Armor	1/1/1967	20	1	8500	8500	8500	4.882	1.4	
22	3	Hardware Component	Crew Vehicle	1/1/1961	30	2	8500	8500	8500	4.58	1.4	
23	2	Folder	**Air Force**									
24	3	Hardware Component	Aircraft Type 1	1/1/1970	70	3	13,500	13,500	13,500	5.36	1.8	
25	3	Hardware Component	Aircraft Type 2	1/1/1965	90	4	7,000	7,000	7,000	5.359	1.8	
26	3	Hardware Component	Helicopter Troop Carrier	1/1/1990	14	1	10,000	10,000	10,000	8.689	1.8	
27	3	Hardware Component	Helicopter Attack	1/1/1990	30	2	5,000	5,000	5,000	9.642	1.8	

Figure 7 - Platform complexities from the TruePlanning for Concepts model

When importing the Excel spreadsheet into TruePlanning for a second time the result is the same PBS built from Hardware Cost Object (Figure 8). However, it is now populated using the complexities which were derived from the output of the Concept model.

What is the advantage? Well, from at this point it's possible to refine the estimate further and consider breaking the hardware elements down 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.

Naturally this can be a hybrid solution with part of the Force Structure represented as Concept Cost Objects and the more mature elements represented by Hardware Cost Object. It does not need to be one model or the other. TruePlanning will roll-up all the estimates to provide an overall Force Structure cost estimate.

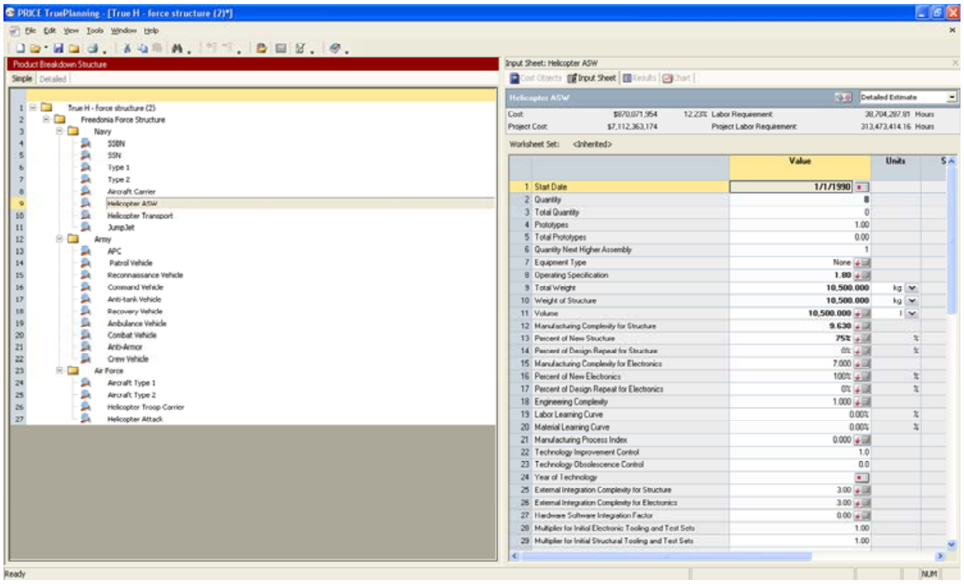


Figure 8 - TruePlanning for Hardware – Complexity inputs

How do the results compare? Well, the two projects have an almost identical estimate of £14bn in both cases. However, as observed in Figure 9, the cost profiles are similar, but not the same. This is due to the different techniques used to populate the production quantity in the TruePlanning for Hardware and Concepts Cost Objects. It could be argued that this is sufficiently accurate for a high level exercise of this nature and the cost accuracy would mature further as the systems became better defined and detailed.

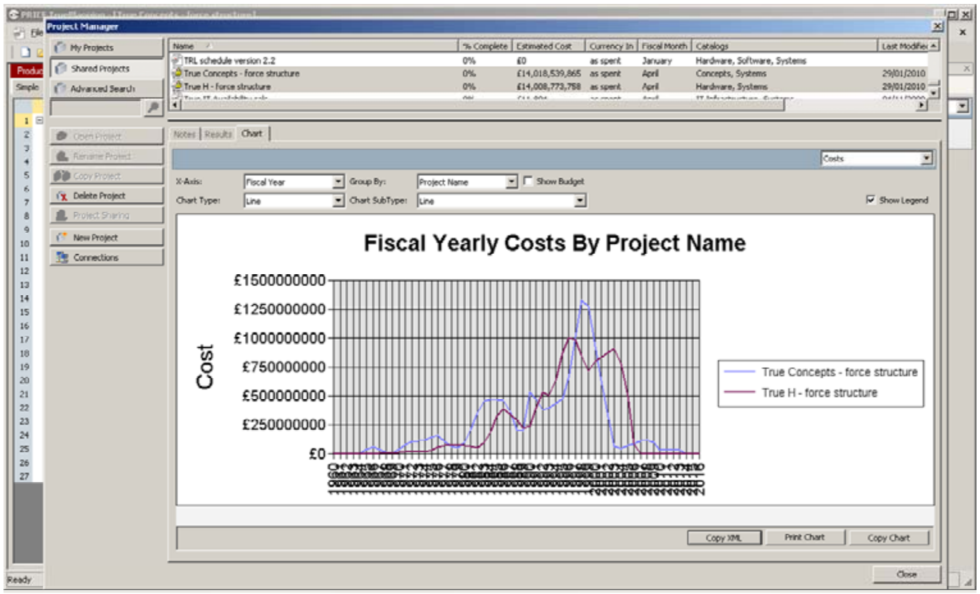


Figure 9 – Through Life Estimating; Comparison of TruePlanning for Concepts and TruePlanning for Hardware

Model Centre and TruePlanning®

With TruePlanning at the centre of your Cost Management solution it is easy to implement enterprise connectivity. The TruePlanning architecture is built on the MS-SQL database which has web services capable for interfacing with other Microsoft applications and third party tools as those seen in Figure 10.

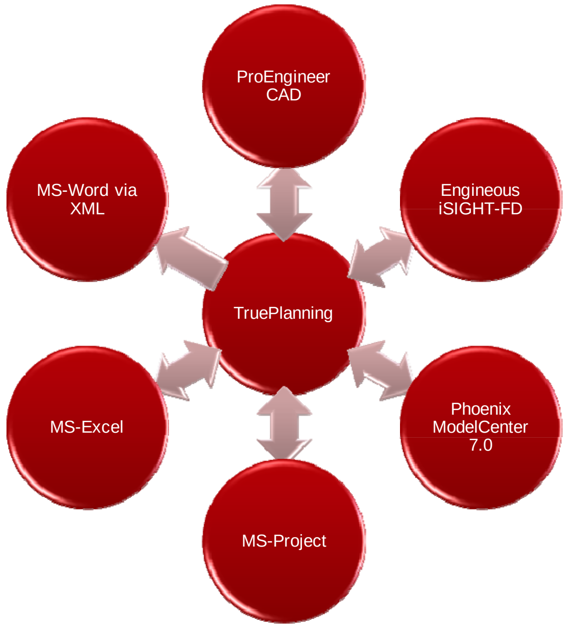


Figure 10 – TruePlanning Enterprise capability

This connectivity can lead to a Global Deployment of the parametric model enabling more departments to benefit from integrate business applications and solutions[3]. To demonstrate this capability this paper will utilise the Phoenix ModelCenter tool.

TruePlanning® and Economic Analysis (EA)

To enable sensible investment decisions to be made, most businesses will conduct an Investment Appraisal (IA) or cost benefit analysis. An Economic Analysis (EA) which will review the magnitude of the financial income and outgoing expenditure to determine the Return on Investment (ROI) and assess whether an option is an economically prudent investment. Net Present Value (NPV), ratios and payback periods are all established tools for this type of consideration.

Unfortunately, the defence business cannot use such standard tools to make a decision because its outcome is not financial, rather the suppression of the enemy or opponent. As a result it is necessary to consider the outgoing cost of procuring and maintaining systems against a Measure of Effectiveness (MOE) in terms of their defensive or offensive worth. Many defence procurement agencies use this type of analysis; the United Kingdom (UK) Ministry of Defence (MOD) uses a COEIA as described here;

Combined Operational Effectiveness Investment Appraisal (COEIA) is a formal comparison of acquisition options on a cost versus effectiveness basis to satisfy a User Requirement. The COEIA is an integral part of the Investment Approvals Board (IAB) procedure. The COEIA may be considered an Investment Appraisal, used to assess the *effectiveness of differing acquisition options in an objective and where possible, quantitative way. Its purpose is to select one of the acquisition options, before proceeding further[4].*

At the heart of the COEIA there is a diagram, like Figure 11, which plots cost versus effectiveness. It is common for these charts to have boundaries; threshold and objective. The threshold and objective boundaries tend to eliminate options easily. In this example the top-right quadrant indicates an area of unaffordable cost and the bottom-left quadrant indicates an area of unacceptably low MOE. Any options which fall into these quadrants can be automatically eliminated. The options which fall into the centre quadrant are optimal and can be considered viable solutions.

Automating the process of populating this diagram with higher and lower quantities of larger and smaller systems would make the process more efficient.

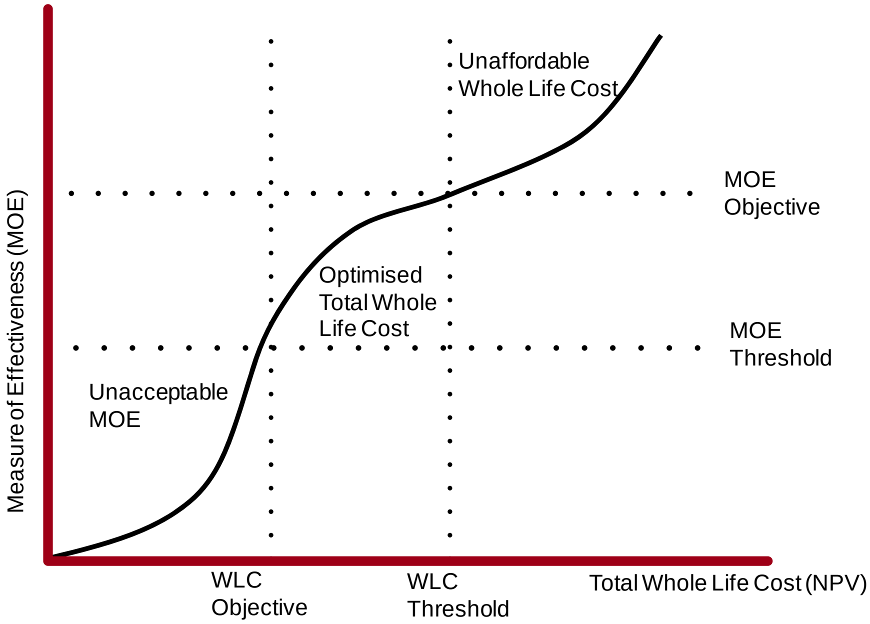


Figure 11 - Combine Operational Effectiveness and Investment Appraisal (COEIA)

The shape in the centre quadrant is often referred to as the “knee of the curve”. Interpreting the best cost per MOE option can often be difficult. One solution which is often used is to make one dimension a constant. This will result in a constant cost or constant effectiveness chart which is easier to interpret. This process involves, for example, selecting one project cost and then matching all the desired combination of systems (size and quantity) which would result in that cost. Then taking all these system combinations and calculating their various measures of effectiveness. A Balance of Investment (BOI) study would typically consider different systems that can provide an equivalent capability at different performance levels and at different costs.

The results can be plotted in the same way, but instead of a curve the result is a straight line and the candidate solution is easier to choose, see Figure 12.

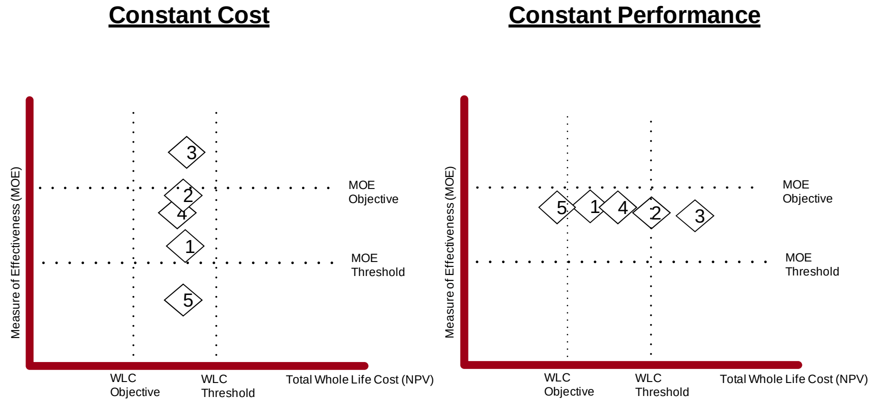


Figure 12 - Simplifying the analysis

TruePlanning will calculate the Net Present Value (NPV) required for this type of analysis together with other EA statistics such as Internal Rate of Return (IRR), Payback period and Benefit-Cost Ratio. All these figures can be seen in the "Metrics" Results at the System Folder of the PBS, as seen in Figure 13.

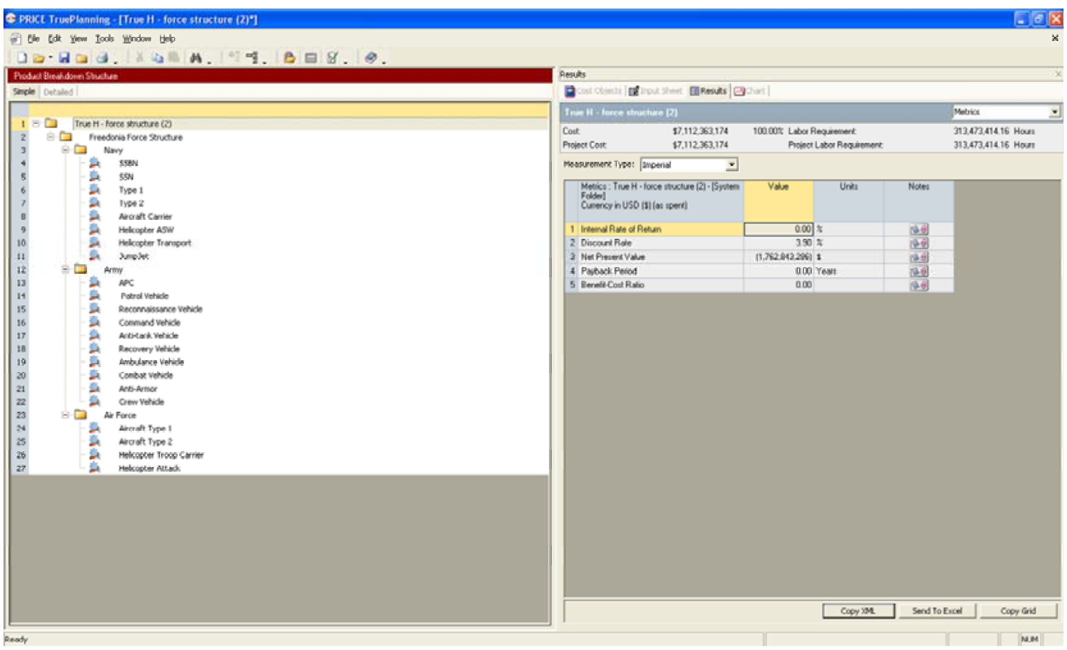


Figure 13 - TruePlanning calculates Business Case statistics including the Net Present Value (NPV)

What is not included in TruePlanning is the Measure of Effectiveness (MOE) calculation which will typically be produced as a result of Operation Analysis (OA) research.

Optimisation Case Study – COEIA

In this Case Study it is assumed that the Freedonia Defence department has exceeded the budget for equipment acquisition. It has a need to reshape the structure of its acquisition program within a number of constraints;

1. It should be able to fight a small conflict outside its borders within Freedonia's maximum achievable MOE objective of 8,000
2. Total Force Structure should not exceed £13bn in acquisition cost

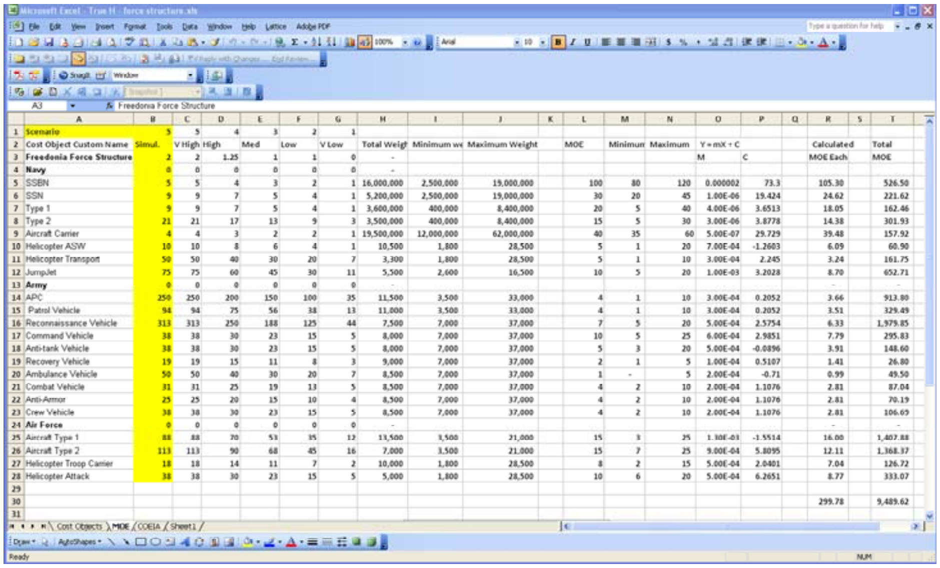
These constraints will form the quadrants in the COEIA chart which will be seen in the results.

Operational Analysis (OA) is the technical and scientific analysis of the military environment that helps to identify, analyze and provide solutions to problems, such as the Operational Effectiveness of equipment. The MOE can be derived by OA using a range of models[5];

- Wargames – using military expertise to fight 'paper' wars
- Simulations – using computer-based techniques
- Synthetic environments – where models and real equipment can be tested in a range of virtual surrounding, also reducing the need for experiments at different locations
- Field trails – using real equipment and personnel to validate research

In this Case Study a simulation has been used. The SSBN was taken to be the most lethal system and ranked with a MOE index of 100. Other systems were judged relative to the SSBN based upon a Delphi voting process and given a MOE index. Each system also had a size (weight) characteristic which could be varied in the analysis. Consequently a simple relationship was established between the size of the systems and the MOE index.

This simple calculated MOE index could then be used with the size and quantity of each system selected by the ModelCenter software to calculate the total Force Structure MOE for a given scenario (see Figure 14).



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	Scenario	5	5	4	3	2	1													
2	Cost Object Custom Name	Simul.	V High	High	Med	Low	V Low	Total Weigh	Minimum we	Maximum Weight		MOE	Minimum	Maximum	Y = mX + C			Calculated		Total
3	Freedonia Force Structure	2	2	1.25	1	1	0	-							M	C		MOE Each		MOE
4	Navy	0	0	0	0	0	0	-												
5	SSBN	5	5	4	3	2	1	16,000,000	2,500,000	19,000,000		100	80	120	0.000002	73.3		105.30		526.50
6	SSN	9	9	7	5	4	1	5,200,000	2,500,000	19,000,000		30	20	45	1.00E-06	19.424		24.62		221.62
7	Type 1	9	9	7	5	4	1	3,600,000	400,000	8,400,000		20	5	40	4.00E-06	3.6513		18.05		162.46
8	Type 2	21	21	17	13	9	3	3,500,000	400,000	8,400,000		15	5	30	3.00E-06	3.8778		14.38		301.93
9	Aircraft Carrier	4	4	3	2	2	1	19,500,000	12,000,000	62,000,000		40	35	60	5.00E-07	29.729		39.48		157.92
10	Helicopter ASW	10	10	8	6	4	1	10,500	1,800	28,500		5	1	20	7.00E-04	-1.2603		6.09		60.90
11	Helicopter Transport	50	50	40	30	20	7	3,300	1,800	28,500		5	1	10	3.00E-04	2.245		3.24		161.75
12	JumpJet	75	75	60	45	30	11	5,500	2,600	16,500		10	5	20	1.00E-03	3.2028		8.70		652.71
13	Army	0	0	0	0	0	0	-										-		-
14	APC	250	250	200	150	100	35	11,500	3,500	33,000		4	1	10	3.00E-04	0.2052		3.66		913.80
15	Patrol Vehicle	94	94	75	56	38	13	11,000	3,500	33,000		4	1	10	3.00E-04	0.2052		3.51		329.49
16	Reconnaissance Vehicle	313	313	250	188	125	44	7,500	7,000	37,000		7	5	20	5.00E-04	2.5754		6.33		1,979.85
17	Command Vehicle	38	38	30	23	15	5	8,000	7,000	37,000		10	5	25	6.00E-04	2.9851		7.79		295.83
18	Anti-tank Vehicle	38	38	30	23	15	5	8,000	7,000	37,000		5	3	20	5.00E-04	-0.0896		3.91		148.60
19	Recovery Vehicle	19	19	15	11	8	3	9,000	7,000	37,000		2	1	5	1.00E-04	0.5107		1.41		26.80
20	Ambulance Vehicle	50	50	40	30	20	7	8,500	7,000	37,000		1	-	5	2.00E-04	-0.71		0.99		49.50
21	Combat Vehicle	31	31	25	19	13	5	8,500	7,000	37,000		4	2	10	2.00E-04	1.1076		2.81		87.04
22	Anti-Armor	25	25	20	15	10	4	8,500	7,000	37,000		4	2	10	2.00E-04	1.1076		2.81		70.19
23	Crew Vehicle	38	38	30	23	15	5	8,500	7,000	37,000		4	2	10	2.00E-04	1.1076		2.81		106.69
24	Air Force	0	0	0	0	0	0	-										-		-
25	Aircraft Type 1	88	88	70	53	35	12	13,500	3,500	21,000		15	3	25	1.30E-03	-1.5514		16.00		1,407.88
26	Aircraft Type 2	113	113	90	68	45	16	7,000	3,500	21,000		15	7	25	9.00E-04	5.8095		12.11		1,368.37
27	Helicopter Troop Carrier	18	18	14	11	7	2	10,000	1,800	28,500		8	2	15	5.00E-04	2.0401		7.04		126.72
28	Helicopter Attack	38	38	30	23	15	5	5,000	1,800	28,500		10	6	20	5.00E-04	6.2651		8.77		333.07
29																				
30																		299.78		9,489.62
31																				

Figure 14 - Freedonia Measure of Effectiveness (MOE) Simulation

Once the Excel spreadsheet calculating the MOE for a given Force Structure is established, a Scenario Based Model (SBM) is developed representing any number of given scenarios. Recognizing that each SBM will have a calculated MOE and a calculated acquisition cost for the given Force Structure, the challenge is to automatically evaluate each SBM in TruePlanning.

Each SBM needs to be logical in terms of its structure; it should not be a random number generation exercise. For example, a Force Structure which calculates several aircraft carriers but no aircraft is not logical. Likewise, an army structure with many offensive vehicles, but no recovery or repair vehicles is equally flawed as a Force Structure.

Typically, a cost estimator builds and evaluates each scenario in TruePlanning, running the model and then plotting the estimated cost against the MOE. While this is effective for a small number of SBM, it is impractical for a larger data set representing dozens or even hundreds of scenarios. In this case, we need to use a System Engineering tool such as Phoenix Integration’s ModelCenter which allows a direct link of the MOE spreadsheet to TruePlanning to conduct the optimization.

The goal is to establish an environment allowing each SBM to be run directly through TruePlanning, calculate the cost estimates and associated MOEs then automatically plot the results. The following analysis demonstrates the methodology using five SBMs, but larger data set can be easily established.

For example, Figure 15 displays five SBMs representing potential types of conflicts that may present themselves to the Republic of Fredonia.

	A	B	C	D	E	F	G
1	Scenario	5	5	4	3	2	1
2	Cost Object Custom Name	Simul.	V High	High	Med	Low	V Low
3	**Freedonia Force Structure**	2	2	1.25	1	1	0
4	**Navy**	0	0	0	0	0	0
5	SSBN	5	5	4	3	2	1
6	SSN	9	9	7	5	4	1
7	Type 1	9	9	7	5	4	1
8	Type 2	21	21	17	13	9	3
9	Aircraft Carrier	4	4	3	2	2	1
10	Helicopter ASW	10	10	8	6	4	1
11	Helicopter Transport	50	50	40	30	20	7
12	JumpJet	75	75	60	45	30	11
13	**Army**	0	0	0	0	0	0
14	APC	250	250	200	150	100	35
15	Patrol Vehicle	94	94	75	56	38	13
16	Reconnaissance Vehicle	313	313	250	188	125	44
17	Command Vehicle	38	38	30	23	15	5
18	Anti-tank Vehicle	38	38	30	23	15	5
19	Recovery Vehicle	19	19	15	11	8	3
20	Ambulance Vehicle	50	50	40	30	20	7
21	Combat Vehicle	31	31	25	19	13	5
22	Anti-Armor	25	25	20	15	10	4
23	Crew Vehicle	38	38	30	23	15	5
24	**Air Force**	0	0	0	0	0	0
25	Aircraft Type 1	88	88	70	53	35	12
26	Aircraft Type 2	113	113	90	68	45	16
27	Helicopter Troop Carrier	18	18	14	11	7	2
28	Helicopter Attack	38	38	30	23	15	5

Figure 15 - Scenario Based Model - Force Structure

Each SBM represents a complete Force Structure ranging from “Very Low” to “Very High” along with the appropriate quantities of each system within the Force Structure. As shown in Figure 14, the Excel spreadsheet calculates the MOE for each given Force Structure in the yellow highlight column. Using a series of nested “IF” statements, any of the five scenarios can be “called in” to the highlighted column by simply typing in the number of the scenario (1 through 5) in the cell named Scenario (B1).

When complete, the aim is to automatically transfer the SBM parameters to TruePlanning to derive its cost estimate and repeatedly plot the results against the calculated MOE. For this analysis Phoenix Integrations’ ModelCenter is used. ModelCenter contains several optimization tools and the ability to ingrate with Excel along with other engineering tools such as MATLAB, MathCAD, CATIA and Pro/E.

Figure 16 below shows ModelCenter integrating both Excel and TruePlanning through its visual interface.

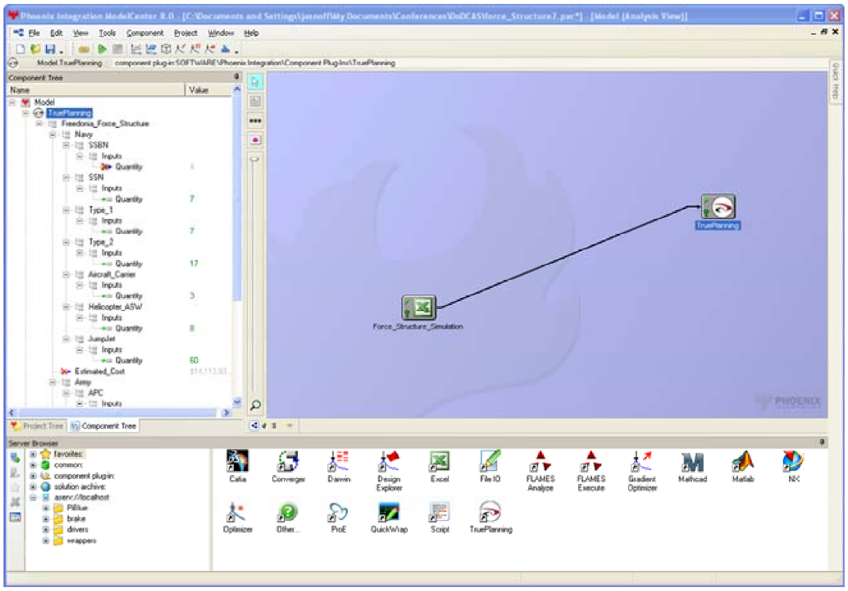


Figure 16 - Force Structure Simulation - ModelCenter - TruePlanning Plug-in

Once Excel has been linked with TruePlanning, the link editor in ModelCenter is used to map the cells in Excel to the input parameter values in TruePlanning. By linking the yellow highlighted column in Excel, the current Force Structure under evaluation, to the input quantities in TruePlanning we can automatically conduct simulation analysis.

Figure 17 below shows the link editor in ModelCenter and the visual "drag and drop" wiring diagram which maps the Force Structure in Excel to TruePlanning. Note that this mapping is done at a detailed level. As ModelCenter is capable of exposing all inputs and outputs data elements within the TruePlanning cost objects, any variety of optimization analysis may be conducted.

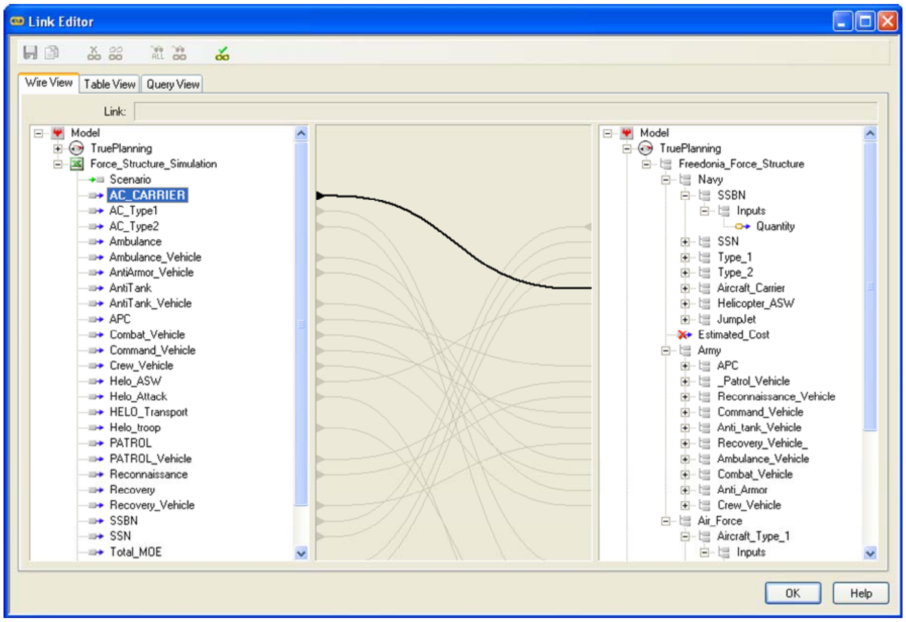


Figure 17 - Scenario Linkage between Excel Force Structure and TruePlanning model

For our Republic of Fredonia case study, the Parametric Study Tool (as shown in Figure 18) has been selected to conduct the analysis. This tool is located within ModelCenter and is one of several optimization tools integrated within the software. The tool is set up to iterate the cell in Excel named "Scenario" for each of the five defined SBMs.

The tool is initialized to use the design variable *Model.Excel.Scenario* with a starting value of 1 and ending value of 5 utilising 5 samples and a step size of 1. As the cell "Scenario" is iterated, the "IF" statements in Excel alters the Force Structure parameters associated with it. At that point, ModelCenter then transfers those values to the mapped inputs parameters in TruePlanning, runs the TruePlanning model and returns the cost estimate results.

Efficiency saving can be made within the COEIA process when approached in this way. This can result in either less time taken to complete all the SBMs or the same time take to complete more SBMs. If more SBMs are conducted then there will be a finer granularity to the analysis results with greater chance of determining the optimum solution.

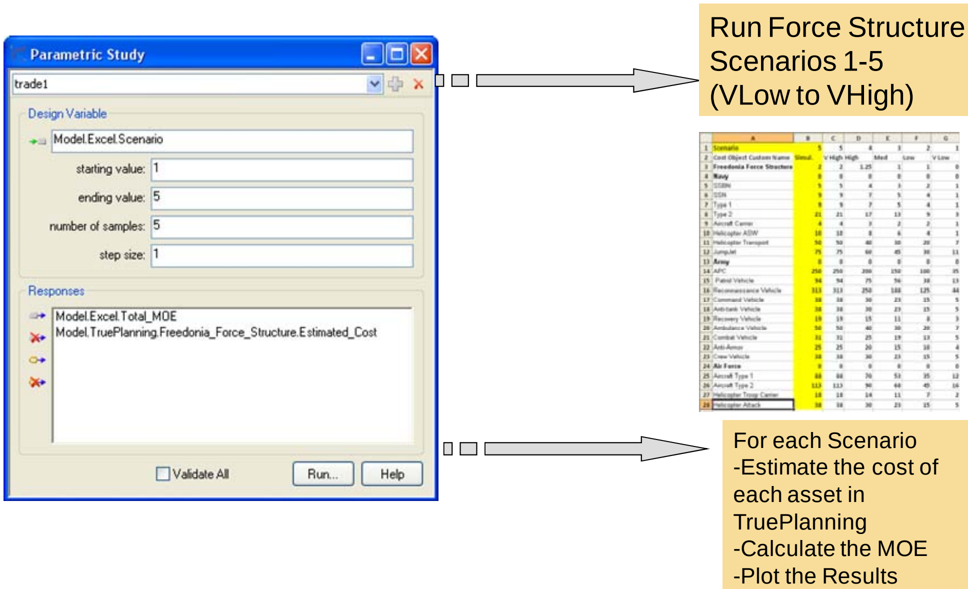


Figure 18 - ModelCenter Parametric Simulation Tool

As each of the scenario iterations are imported ModelCenter estimates the cost in TruePlanning and the MOE calculations in Excel, it then plots the estimated cost of the Force Structure against the MOE.

The outcome of this combined process produces the COEIA chart shown in Figure 19 below. This chart is automatically produced by ModelCenter.

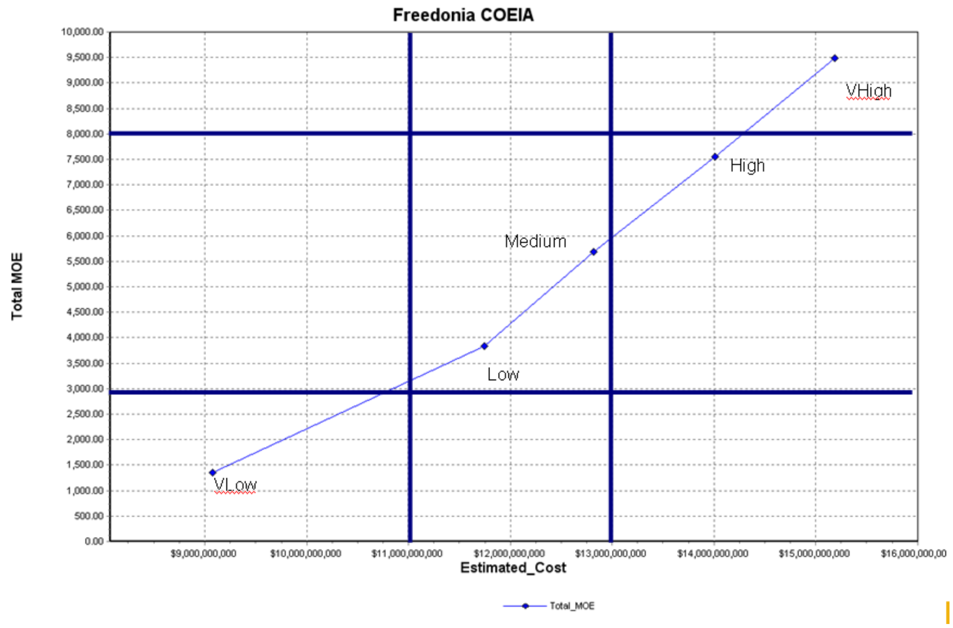


Figure 19 - Parametric Simulation Tool – Results

As shown in Figure 19, it is possible to overlay the MOE objective of 8,000 and a MOE threshold of 3,000 on top of the results to make the interpretation of the conclusions easier. We assume that any MOE values below 3,000 would not constitute the necessary critical mass for the simplest of armed forces or could be resolved through diplomatic means. Values above 8,000 are not achievable or would infer global war which would require different assumptions and analysis. In terms of estimated cost, we have overlaid the cost threshold of $13bn and cost objective of $11bn.

With objective and thresholds defined, we can now consider conclusions within several regions identified as follows:

- VHigh – While above the MOE, the scenario exceeds the threshold for cost.
- VLow – While below the objective for cost, the scenario is below the MOE of 3,000 and may not require a military response.
- High – This scenario while within the threshold MOE threshold / objective exceed the cost threshold and therefore not viable.
- Medium / Low – Both of these scenarios are within the thresholds and objective for cost and MOE and thus viable solutions.

ModelCenter also has other formats useful for displaying results as shown in Figure 20 below.

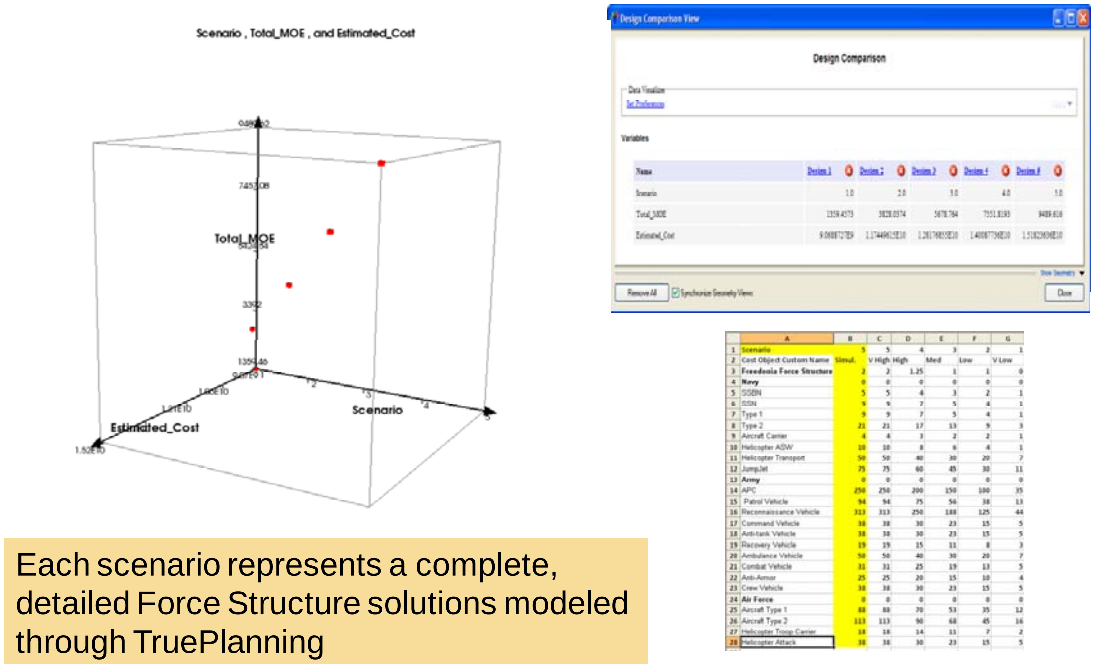


Figure 20 - Scenario Analysis

As shown in Figure 20, ModelCenter provides several other displays useful for evaluation. These displays include 3D modelling of MOE versus Cost versus Scenarios. In addition ModelCenter also provides a design comparison tool.

Summary

The conclusion of the Freedonia COEIA exercise shows thet evaluation of the five Force Structure scenarios through ModelCenter simulation and TruePlanning reveals:

- Freedonia is only capable of supporting low to medium conflicts given achievable MOE and budget constraints.
- Supporting a High Level Conflict Freedonia can achieve the MOE, but exceeds the budget.
- Supporting a Very High Level Conflict, Freedonia cannot achieve the desired MOE or budget.

This paper has hopefully stimulated thoughts about optimising and automating the COEIA process by linking parametric cost models and optimisation tools with the associate efficiency savings. The paper has provided evidence that;

- The TruePlanning for Concepts Catalogue is applicable methodology for early program costing estimating

- TruePlanning for Concepts generation of Complexities can feed the TruePlanning for Hardware demonstrating the benefits of the Through Life Estimating capability
- 3rd Generation TruePlanning has significant enterprise capability including the quick optimisation capability of Phoenix ModelCenter with TruePlanning
- Demonstration of an optimised Combine Operational Effectiveness and Investment Appraisal (COEIA)

Planned future research

It is recognised that this initial study demonstrates a unique methodology which will need to mature. Future research will be focused upon;

- Additional TruePlanning for Concepts models to enable further systems (Battle Tanks, RFA, LPD, etc) to be estimated. The UK MOD has indicated a desire to continue their partnership with PRICE Systems. At the present time these gaps can be filled through the use of the TruePlanning for Hardware cost model.
- It is recognised that the Operational Analysis (OA) conducted in this case study is simplistic, although it demonstrates the underlying principles. Future research would seek a competent OA research organisation complementary to the parametric skills in PRICE Systems to refine the MOE element of the COEIA.

References

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