

The following presentation was given at:

The SCAF 2015 Cost Estimating Challenge

*Tuesday 14th April 2015
BAWA Centre, Bristol*

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SCAF Workshop Balance of Investments 14th April 2015

AMIT ARYA
AMY CLOAK



- **Introduction**
- **The Project**
- **The Approach**
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- **Model Run Through**
- **Scenario Analysis**
- **Risk**
- **Summary**
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Thales UK Bid Finance

- 30 people support all Thales UK Business Units (Air, Land, Sea, Rail)
- Key function in supporting bid submission, estimating, costing and pricing
- Understand all financial aspects of each individual bid
- Business case support
- Risk support



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The Project

The Objective

- Determine a plan of action for SCAFland to help its dependant territory, Freedonia, during a period of conflict

The Task

- Develop a BOI model to run and experiment with different scenarios to help Freedonia during conflict and to provide the best strategy for the government

Data Sources



www.parliament.uk

The Approach



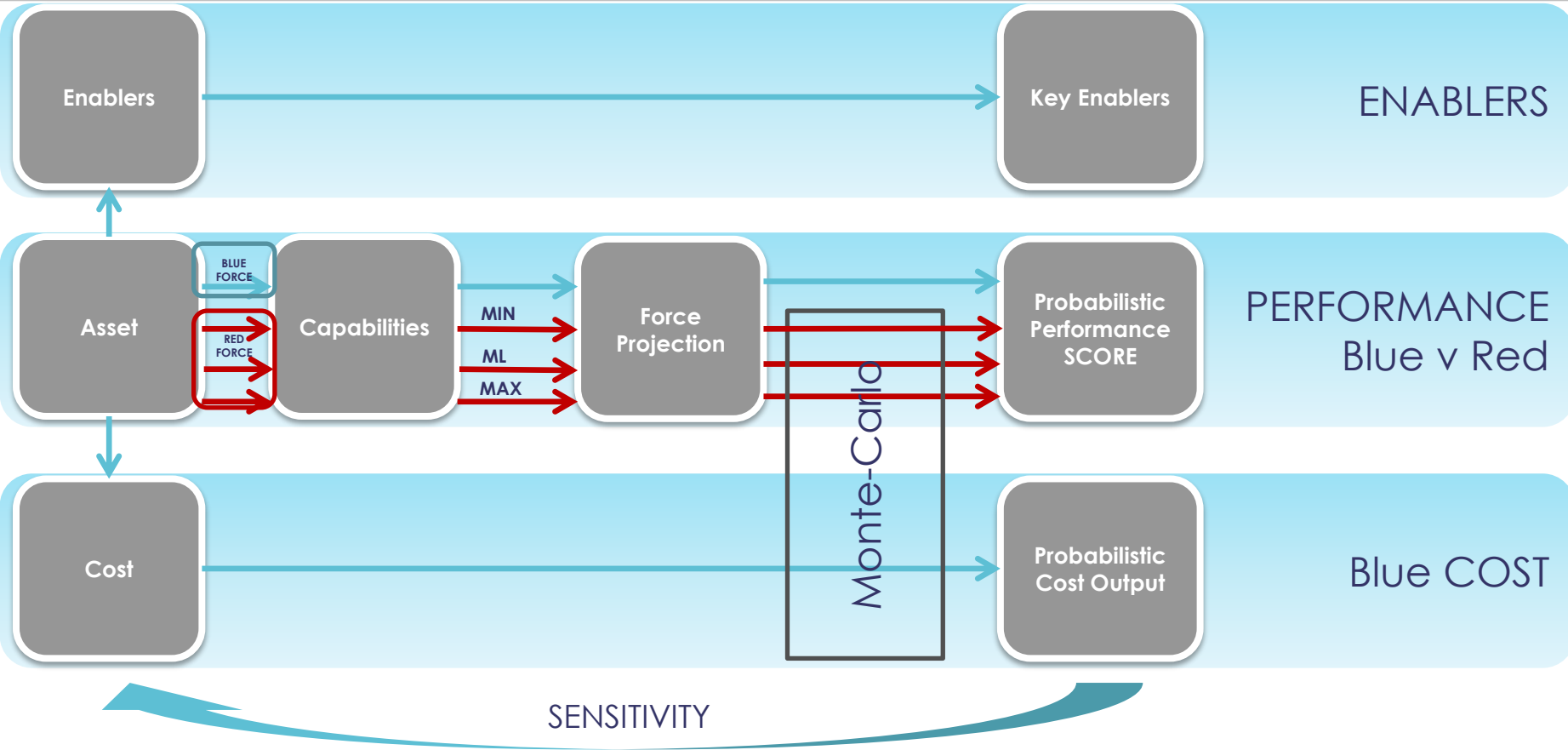
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Assumptions

- 3 Month conflict
- SCAFLAND (Blue force) is based on UK assets
- Attack force (Red force) is based on an assessment of the enemy Asset
- Only OPEX costs are considered, CAPEX costs considered sunk
- Assumes chosen assets will be used equally in duration i.e. Full time on task
- Does not include the cost of ammunition
- Assumes no attrition
- Assumes Red Force Asset pool is a Constant

The Balance of Investment Model

Model Structure



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Assets

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Blue Force				
Asset	Description	QTY	Total In service	
Land	Infantry Regiment	Units	7	20
Land	Tanks	Challenger 2	20	407
Land	Armoured Personnel carriers	Bulldog, Schimitar	25	1676
Land	Infantry combat vehicles	Warrior, Stormer	30	781
Land	Self propelled guns	AS90, GMLRS	20	145
Land	Tank destroyers	N/A	0	0
Land	Self propelled anti ac gun	Starstreak HVM	0	62
Land	Towed Artillery	Light Gun L118	20	138
Land	Supply vehicles	MAN, Leyland, Bedford	40	5000
Land	Recognition vehicle	Jackal, Sparten, Coyote, Warthog, Viking, Wolfhound	10	592
Land	Anti AC System	Rapier, Starstreak LVM	10	150
Land	Light Support Vehicle	Foxhound, Huskey Panther, Snatch 2 RVMIK Landrover, vector	25	2000
Land	Heavy Support Vehicle	Mastiff	10	776
Land	Anti armour system	MBT LAW, Javin, ILAW	10	138
Air	Attack helicopters	Apache, Wildcat	17	66
Air	Transport helicopters	Lynx, Chinook, Merlin	22	362
Air	Air Defence Air Craft	Tornado F3, No longer in service	0	0
Air	Ground Attack Aircraft	Tornado GR4, JSF	0	85
Air	Transport Air craft	C17, C130, A400	0	338
Air	Recognition air craft	Watchkeeper, Defender, Sentre, senintal	3	30
Air	Multi-role aircraft	Typhoon	0	178
Sea	Destroyers	Type 45	1	6
Sea	Frigates	Type 23	3	13
Sea	Mine warfare vessel	Sandown, Hunt	0	16
Sea	Patrol vessel	River	0	4
Sea	Cruisers	N/A	0	0
Sea	Aircraft carrier	QE Class	0	0
Sea	Corvettes	N/A	0	0
Sea	Amphibious assault ship	Ocean	1	3
Sea	Amphibious land dock	Albion Class	1	1
Sea	Ballistic missile submarine	Vanguard	0	4
Sea	attack submarine	Astute, Trafalger	2	6
Sea	Guided missile submarine	N/A	0	0
Sea	Commando regiment		2	4

Red Force					
Asset	Description	Min	ML	Max	Total In service
Infantry Regiment		7	10	12	
Tanks	TAM	15	30	44	293
Armoured Personnel carriers	M113, AMX 13	30	60	90	600
Infantry combat vehicles	Panhard, AMX 13, VCTP	11	22	33	216
Self propelled guns	VCA Palmara, SLAM	7	13	20	128
Tank destroyers		0	0	0	
Self propelled anti ac gun	Roland	1	1	1	3
Towed Artillery	155 Howitzer	14	28	42	280
Supply vehicles	Various	14	28	42	280
Recognition vehicle	Various	3	5	8	47
Anti AC System	Bofors, A90, RBS 70	8	15	23	147
Light Support Vehicle	Various	80	160	240	1600
Heavy Support Vehicle	Various	0	0	0	
Anti armour system		15	29	44	289
Attack helicopters		0	0	0	0
Transport helicopters	Bell 412, Bell 212	5	10	15	95
Air Defence Air Craft	Mirage III, M18, MD500	3	6	8	52
Ground Attack Aircraft	A4, IA58	3	6	8	53
Transport Air craft	737, 757, C130, Fokker	5	10	15	100
Recognition air craft	Learjet	1	1	1	3
Multi-role aircraft	Mirage P5	1	1	2	8
Destroyers	Almirante Brown	1	1	1	4
Frigates		0	0	0	0
Mine warfare vessel		0	0	0	0
Patrol vessel	Intrepida	1	1	2	8
Cruisers		0	0	0	0
Aircraft carrier		0	0	0	0
Corvettes	Espora, Drummand	1	1	2	9
Amphibious assault ship	Type 42, costa sur	0	0	0	0
Amphibious land dock		0	0	0	0
Ballistic missile submarine		0	0	0	0
attack submarine	Santa Cruz	1	1	1	3
Guided missile submarine		0	0	0	0
Commando regiment		1	1	1	0

Asset Capability

Ranked assets against their capabilities on a scale 0 to 9

Ranks multiplied by the quantity of assets to gain a “score” against each capability

Capabilities	Assets												
	Infantry Regiment	Tanks	Armoured Personnel carriers	Infantry combat vehicles	Self propelled guns	Tank destroyers	Self propelled anti ac gun	Towed Artillery	Supply vehicles	Reconnaissance vehicle	Anti AC System	Light Support Vehicle	
Personnel Protection	0	3	3	3	0	0	0	0	0	3	0	3	
Ground Combat	5	7	0	3	7	7	7	0	0	0	0	0	
Short Range Personnel mobility	0	0	7	0	0	0	0	0	0	0	0	0	
Medium Range Personnel Mobility	0	0	7	0	0	0	0	0	7	0	0	5	
Long Range Personnel Mobility	0	0	0	0	0	0	0	0	0	0	0	0	
Short Range Attack	5	7	0	3	3	3	0	3	0	0	0	0	
Medium Range Attack	0	5	0	3	7	7	0	0	0	0	0	0	
Long Range Attack	0	0	0	0	0	0	0	0	0	0	0	0	
Tactical Ground Attack	3	0	0	3	3	0	0	0	0	0	0	0	
Strategic Ground Attack	0	0	0	0	0	0	0	0	0	0	0	0	
Anti AC systems	0	0	0	0	0	0	7	0	0	7	0	0	
Anti Ship Systems	0	0	0	0	0	0	0	0	0	0	0	0	
littoral Defence	0	0	0	0	0	0	0	0	0	0	0	0	
Amphibious Landing	0	0	0	0	0	0	0	0	0	0	0	0	
Intelligence & Surveillance	0	0	0	0	0	0	0	0	5	0	0	0	

Capabilities	Assets																																				
	Infantry Regiment	Tanks	Armoured Personnel carriers	Infantry combat vehicles	Self propelled guns	Tank destroyers	Self propelled anti ac gun	Towed Artillery	Supply vehicles	Reconnaissance vehicle	Anti AC System	Light Support Vehicle	Heavy Support Vehicle		Anti armour system	Attack Helicopters	Transport helicopters	Air Defence Air Craft	Ground Attack Aircraft	Transport Air craft	Reconnaissance air craft	Multi-role aircraft	Destroyers	Frigates	Mine warfare vessel	Fleet vessel	Cruisers	Aircraft carrier	Corvettes	Amphibious assault ship	Amphibious land dock	Ballistic missile submarine	Attack submarine	Guided missile submarine	Commando regiment		
Medium Range Personnel Mobility	0	0	175	0	0	0	0	280	0	0	125	50	0	0	110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	740		
Ground Combat	63	140	0	90	140	0	0	140	0	0	0	0	0	0	70	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	712		
Personnel Protection	0	60	225	90	0	0	0	0	30	0	75	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	510		
Medium Range Attack	0	100	0	90	140	0	0	0	0	0	0	0	0	0	152	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	486		
Short Range Attack	35	140	0	90	60	0	0	60	0	0	0	0	0	0	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	446		
Tactical Ground Attack	35	0	0	90	60	0	0	0	0	0	0	0	0	0	85	66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	346		
Short Range Personnel mobility	0	0	175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	175		
Long Range Personnel Mobility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	154	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	172		
Anti AC systems	0	0	0	0	0	0	0	0	0	70	0	0	0	0	66	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	143	
Long Range Attack	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85	0	0	0	0	0	0	3	9	0	0	0	0	0	0	0	0	0	0	0	0	97	
Intelligence & Surveillance	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	
Anti Ship Systems	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	21	0	0	0	0	0	0	0	0	0	0	0	0	48	
Amphibious Landing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	
Littoral Defence	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	14	26
Strategic Ground Attack	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

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Force Projection

- Ranked the capabilities against the different environments chosen within combat
- Ranks multiplied by the score given to asset capability
- The relative strength of Blue score against Red score for each environment was compared and calculated as a percentage

Force Projection	Capabilities														
	Personnel Protection	Ground Combat	Short Range Personnel mobility	Medium Range Personnel Mob	Long Range Personnel Mobility	Short Range Attack	Medium Range Attack	Long Range Attack	Tactical Ground Attack	Strategic Ground Attack	Anti AC systems	Anti Ship Systems	Litoral Defence	Amphibious Landing	Intelligence & Surveillance
Blue Force	510	757	175	760	198	491	628	235	411	0	168	73	29	33	77
Air Supremacy	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Land Supremacy	3	3	3	3	3	5	5	3	3	0	0	0	0	0	0
Open Sea Supremacy	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Coastal waters Supremacy	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0
Intelligence Supremacy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5

Force Projection	Capabilities													Score	%			
	Personnel Protection	Ground Combat	Short Range Personnel mobility	Medium Range Personnel Mob	Long Range Personnel Mobility	Short Range Attack	Medium Range Attack	Long Range Attack	Tactical Ground Attack	Strategic Ground Attack	Anti AC systems	Anti Ship Systems	Litoral Defence			Amphibious Landing	Intelligence & Surveillance	
Blue Force																		
Air Supremacy	0	0	0	0	0	0	0	0	0	0	840	0	0	0	0	0	840	78%
Land Supremacy	1530	6813	525	2280	594	2455	3140	1175	1233	0	0	0	0	0	0	19745	66%	
Open Sea Supremacy	0	0	0	0	0	0	0	0	0	0	0	365	0	0	0	365	22%	
Coastal waters Supremacy	0	0	0	0	0	0	0	0	0	0	0	0	145	165	0	310	22%	
Intelligence Supremacy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	305	305	157%	

Monte Carlo

- Used on both Cost and Performance analysis
- Simple Min, Medium and Max analysis
- Ran 2000 samples
- Parameters set between the minimum and maximum score of asset projection assigned to the combat environments

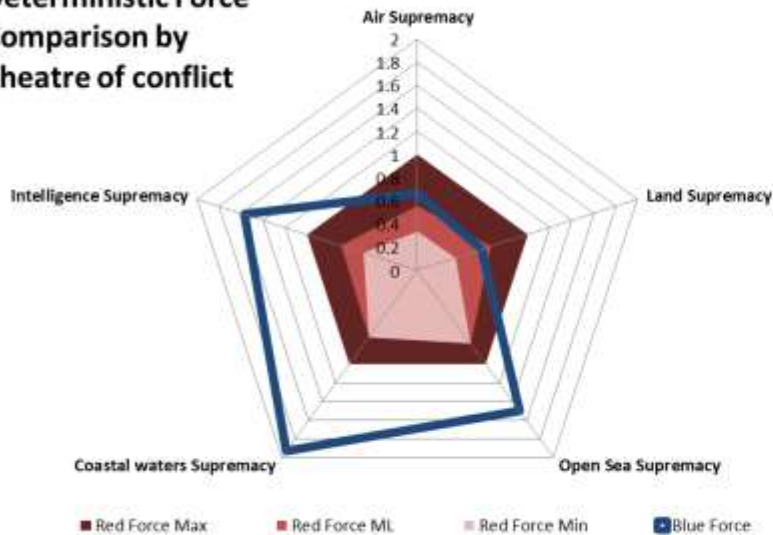
OUTPUTS

- Calculates total operational cost for the Blue Force
- Calculates total force projection of Red Force

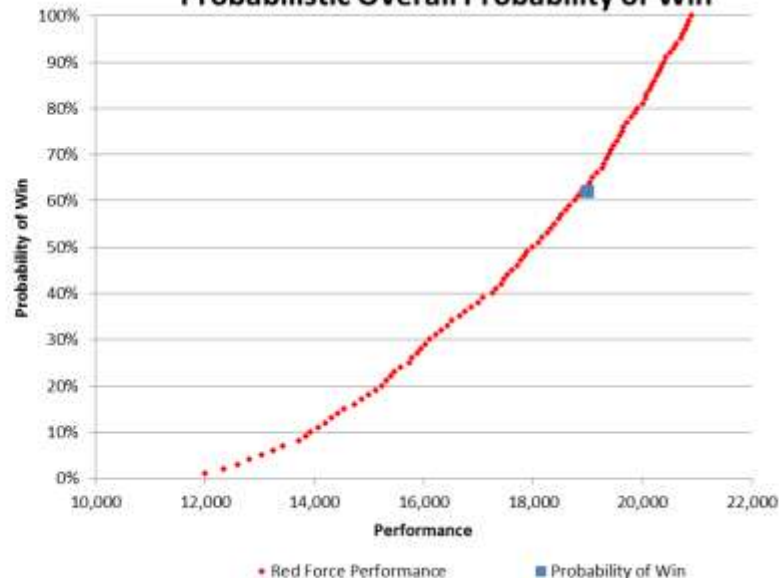
Force Projection

Spider Diagram to demonstrate Blue and Red Army power by environment

Deterministic Force Comparison by Theatre of conflict



Probabilistic Overall Probability of Win

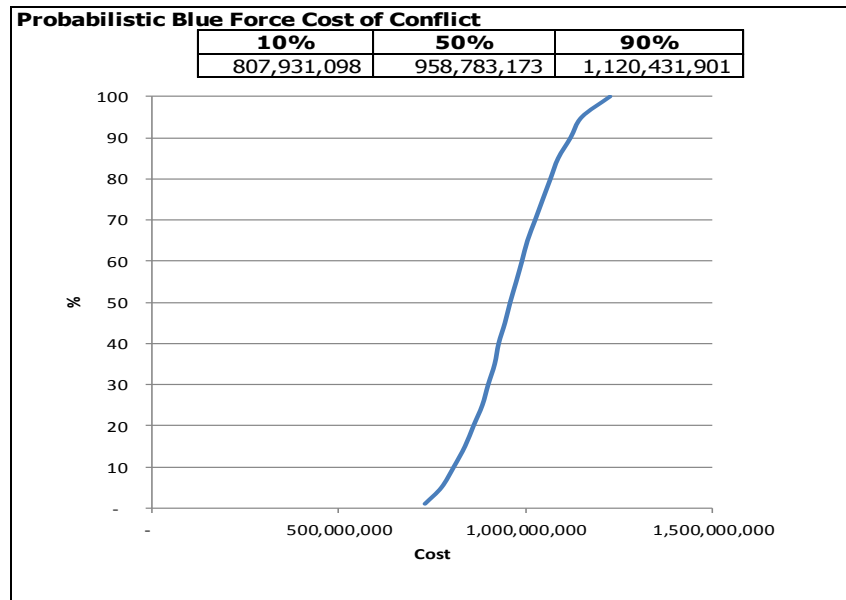


TOTAL PROBABILITY OF WIN: 60%

Cost

Operation duration (Days):	90	Total Campaign cost of Asset			Notes	Total cost for number of assets		
	Assets	QTY	Min	ML		Max	Min	ML
Tanks	20	203,558	227,438	275,198	See Calcs	4,071,156	4,548,756	5,503,956
Attack helicopters	17	14,135,760	25,200,000	29,183,760	Based on hourly running costs of Lynx and Apache, MoD capitation rates	240,307,920	428,400,000	496,123,920
Destroyers	1	9,000,000	11,250,000	13,500,000	Based on a daily running cost of a Type 45, 36.5M per vessel per year 3rd party source	9,000,000	11,250,000	13,500,000

Challenger Tank Daily cost							
Min	ML	MAX					
1,592	1,592	1,592	Fuel capacity				
160	300	340	Range				
0	0	0	MPG				
796	1,061	1,592	usage per day	Assumed 0.5, 0.75 & 1 tank of fuel used of fuel used			
796	1,061	1,592	Cost of fuel				
370	370	370	Crew				
1,096	1,096	1,096	Maintenance	10% of UPC			
2,262	2,527	3,058	Per day				



Costs based on a day rate and based on operational costs

Built up according to min, medium and max level

Run through a Monte Carlo Simulation

“Enablers” – items that have a strong relationship with an asset

Enablers	Most Likely	Assets							
		Infantry Regiment	Tanks	Armoured Personnel carriers	Infantry combat vehicles	Self propelled guns	Tank destroyers	Self propelled anti ac gun	
		7	20	25	30	20	0	0	
Command HQ		3	3	3	3	3	0	3	
Communications		3	3	3	3	3	0	3	
Command vehicles		3	3	3	3	3	0	3	
Radar station		0	0	0	0	0	0	0	
Logistics vehicles		3	0	0	0	0	0	0	
Engineering Vehicle		0	3	3	3	3	0	3	
Ground crew		0	0	0	0	0	0	0	
Air Operators		0	0	0	0	0	0	0	
Airfield		0	0	0	0	0	0	0	
Hospital ship		0	0	0	0	0	0	0	
Forward repair ship		0	0	0	0	0	0	0	
Replenishment ships		0	0	0	0	0	0	0	
Tankers		0	0	0	0	0	0	0	
Landing craft		0	0	0	0	0	0	0	
Cargo Vessel		0	5	5	5	5	0	3	
Refuelling A/C		0	0	0	0	0	0	0	

Key Enablers	
RANK	Item
1	Cargo Vessel
2	Command HQ
2	Communications
2	Command vehicles
5	Engineering Vehicle
6	Radar station
7	Airfield
8	Ground crew
8	Air Operators
10	Logistics vehicles
10	Refuelling A/C
12	Forward repair ship
12	Replenishment ships
12	Tankers
15	Hospital ship
15	Landing craft

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Sensitivity

Sensitivity		20%					
Rank	Asset	QTY	New QTY	%	62%		
3	Infantry Regiment	7	8.4	67%	62%	5.000%	

- Uses an adjustment factor to factor up quantities
- Simulation increases each asset type the factor and records the change to % win
- Compares against the original percentage to show how sensitive each asset is

Sensitivity Analysis: Key Asset		
% Sensitivity adjustment: 20%		
Rank	Asset	+%
1	Tanks	7%
2	Light Support Vehicle	6%
3	Infantry Regiment	5%
3	Transport helicopters	5%
3	Amphibious land dock	5%
6	Self propelled guns	4%
6	Towed Artillery	4%
6	Attack helicopters	4%
13	Armoured Personnel carriers	3%
13	Infantry combat vehicles	3%
13	Air Defence Air Craft	3%
17	Recognisance vehicle	2%
17	Anti AC System	2%
17	Corvettes	2%
17	Amphibious assault ship	2%
25	Tank destroyers	1%
25	Anti armour system	1%
25	Ground Attack Aircraft	1%
25	Multi-role aircraft	1%
30	Supply vehicles	0%

Note: Values less the 5% are negligible due to monte-carlo simulation variability

OPTIONS ANALYSIS

Scenario 1

Asset Compilation	
Infantry Regiment	7
Tanks	20
Armoured Personnel carriers	25
Infantry combat vehicles	30
Self propelled guns	20
Towed Artillery	20
Supply vehicles	40
Recognisance vehicle	10
Anti AC System	10
Light Support Vehicle	25
Heavy Support Vehicle	10
Anti armour system	10
Attack helicopters	20
Transport helicopters	25
Recognisance air craft	3
Destroyers	1
Frigates	1
Amphibious assault ship	1
Amphibious land dock	1
Attack submarine	1
Commando regiment	2

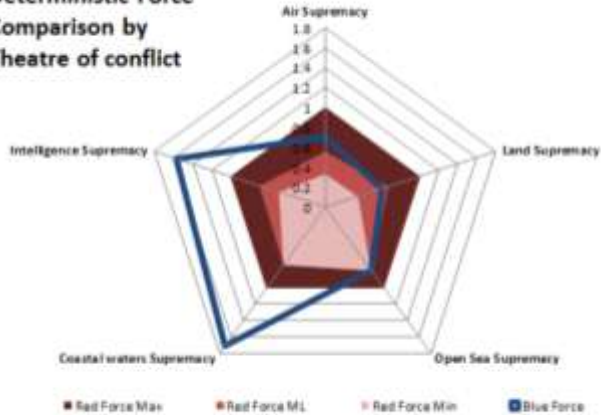
Probability of Winning: 70%

- **Baseline Scenario**
- **Small amount of sea assets as great supremacy and cost the most**
- **Probability of winning that you would be comfortable with**
- **Reasonable cost for the probability**

Scenario 1

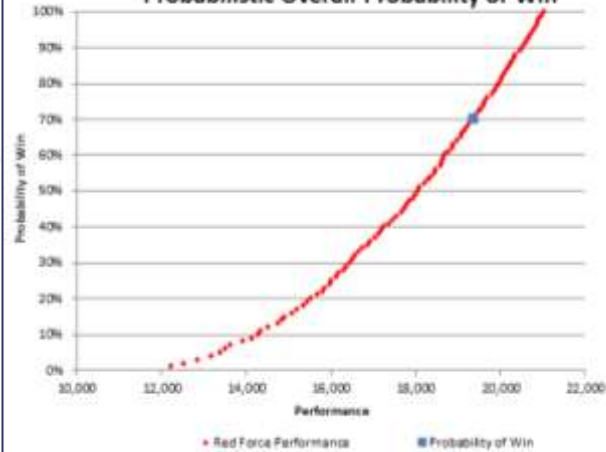
Probability of Winning: 70%

Deterministic Force Comparison by Theatre of conflict

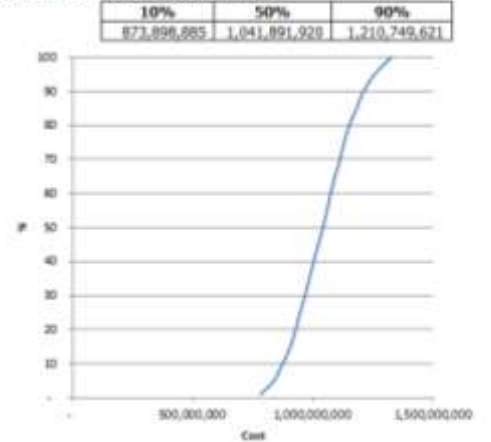


Note: Values denote % capability against Red Force, where 1 = Maximum Red force capability

Probabilistic Overall Probability of Win



Probabilistic Blue Force Cost of Conflict



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Risk & Uncertainty

Risk	Probability	Cost	Performance	Mitigation
Key enabling asset lost on route	Medium	High	High	Spread cargo on other transport
Weather on route and during conflict	High	Low	Medium	Check weather forecasts and plan movements
Adverse environment causing crucial land vehicles to fail	Low	Low	High	Multi task other capable vehicles. Ensure tested before combat to ensure reliability
Operational plans leaked/intercepted	Low	Medium	Medium	Tight security

Schedule Risk

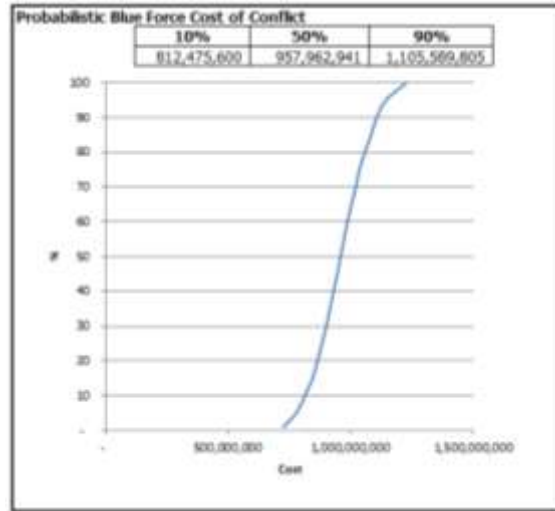
- Overarching risk of Conflict lasting longer than estimated
90 > 120 days = 400M increase to campaign cost

Uncertainty of Red force asset build up and usage

Scenario 2

- Reduce most expensive assets: air and sea
- Reduce helicopters by 6
- Reduce ships by 3

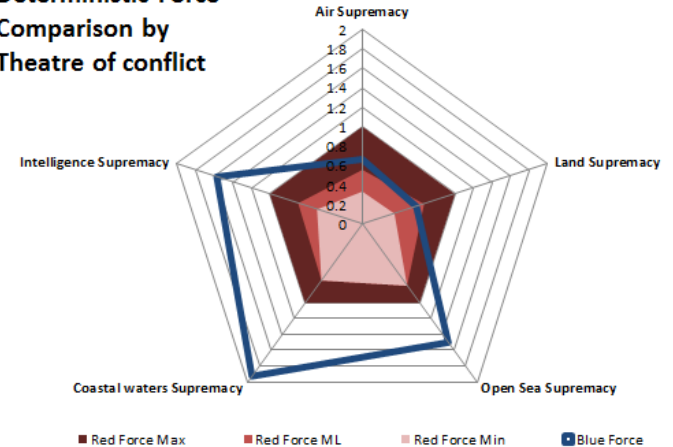
Probability of Winning: 60% -(10%)



Cost saving = 100M @
90%

PERFORMANCE

Deterministic Force
Comparison by
Theatre of conflict



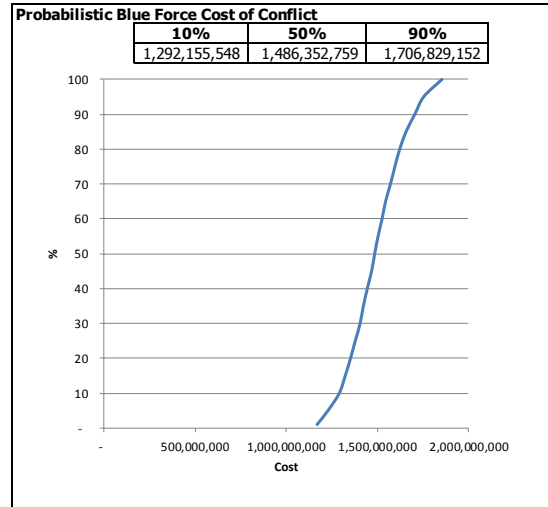
Scenario 3

■ Certain win

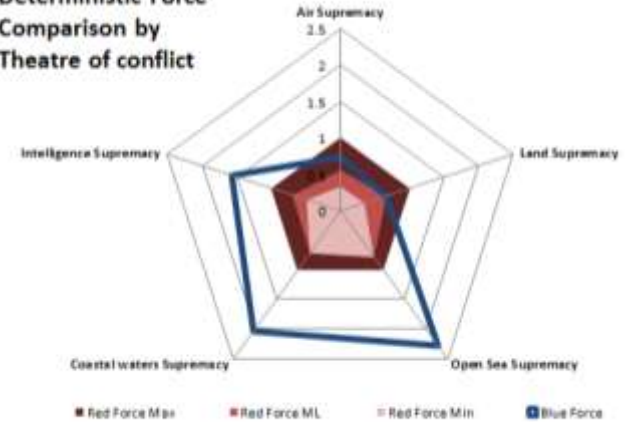
■ Improve land positioning

■ Reasonable cost

Probability of Winning: 100% (+30%)



Deterministic Force Comparison by Theatre of conflict



Note: Values denote % capability against Red Force, where 1= Maximum Red force capability

**Cost increase = 500M
@ 90%**

Scenario 4

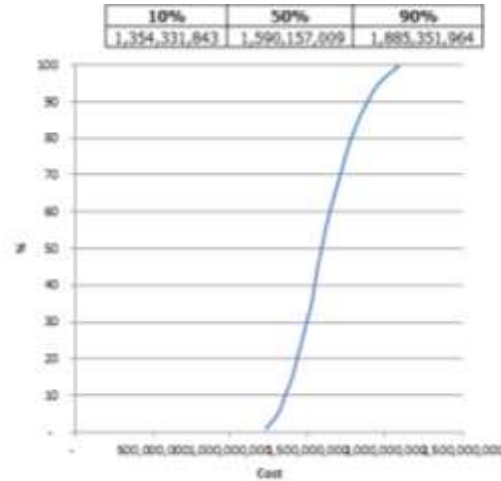
Probability of Winning: 100% (+30%)

■ Certain win

■ Increased aircrafts and aircraft carriers

■ Easier to transport

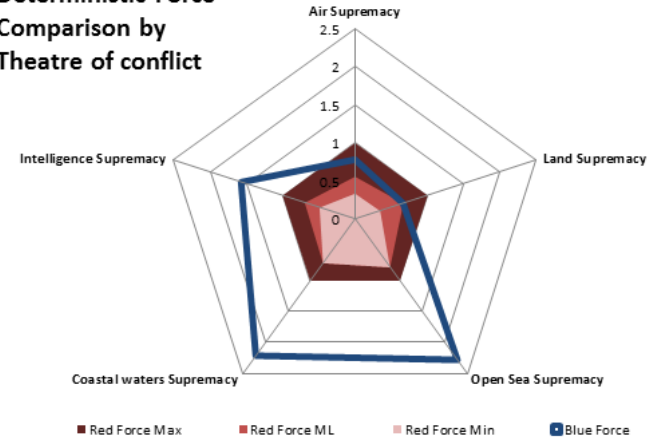
■ Greater cost



**Cost increase = 600M
@90%**

PERFORMANCE

**Deterministic Force
Comparison by
Theatre of conflict**



Summary

- Scenario 1 – 70% chance of winning
- Reasonable cost against strong probability
- Budget restrictions led a sensible look on cost
- Still a high chance of success
- Drew on strengths of pre-existing assets

Lessons Learnt

- **Better use of Monte Carlo simulation based on each asset line instead of the sum**
- **Use of a proper modelling tool**
- **Quantify the risks rather than use a qualitative measurement**
- **Engage with stakeholders for a better view**
- **Small changes make big differences in analysis**
- **Ability to work outside of a “comfort zone” in a fragmented team with people we do not normally work with**

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Thank you!
Questions?

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