

Measuring the Relationship between Energy Use and Military Capability - Historical Perspectives

Presentation at ISMOR 2014

Tel: 023 9225 9930

info@polarisconsulting.co.uk

Practical Solutions to Complex Problems

www.polarisconsulting.co.uk

Cranfield
UNIVERSITY

defence 
economics

Requirement

DSTL commissioned this study to answer the following broad requirement

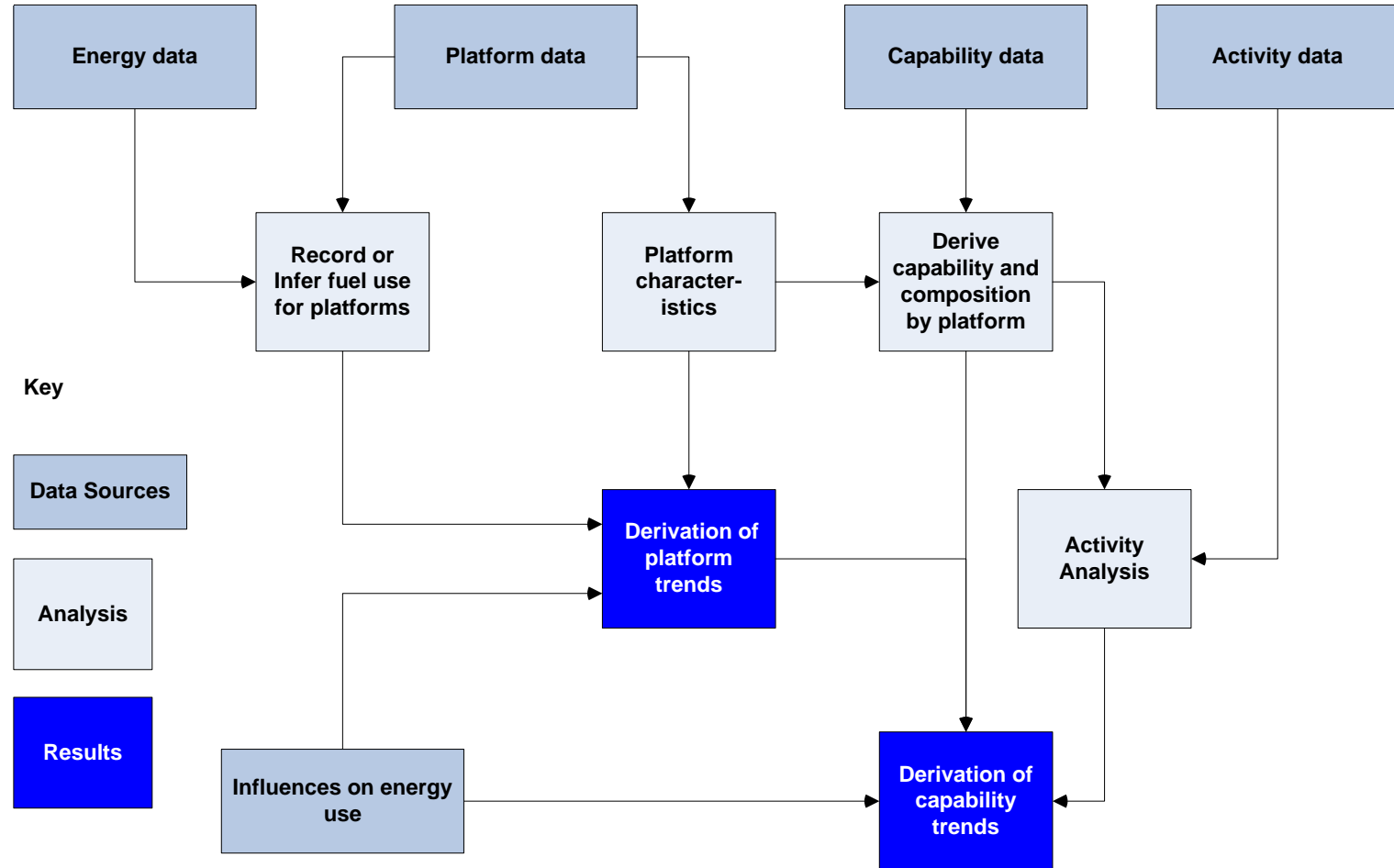
“UK MOD are interested in determining whether there is a quantifiable relationship between energy consumption and capabilities / platforms past and present (foreign and domestic), and then use this to forward project energy consumption for future capabilities / platforms”

“Understanding past and current energy consumption trends will allow for better assessment of the comparative energy efficiency of future platforms/ capability. Determining whether there are energy related historical trends for military capabilities and platforms will enable the MOD to plan and manage energy as a capability.... This will contribute to the MOD delivering against its target to reduce the reliance of the Armed Forces on fossil fuel by 18% by 2020/21”.

This study has developed a method to map the energy consumption of specific military capabilities over time

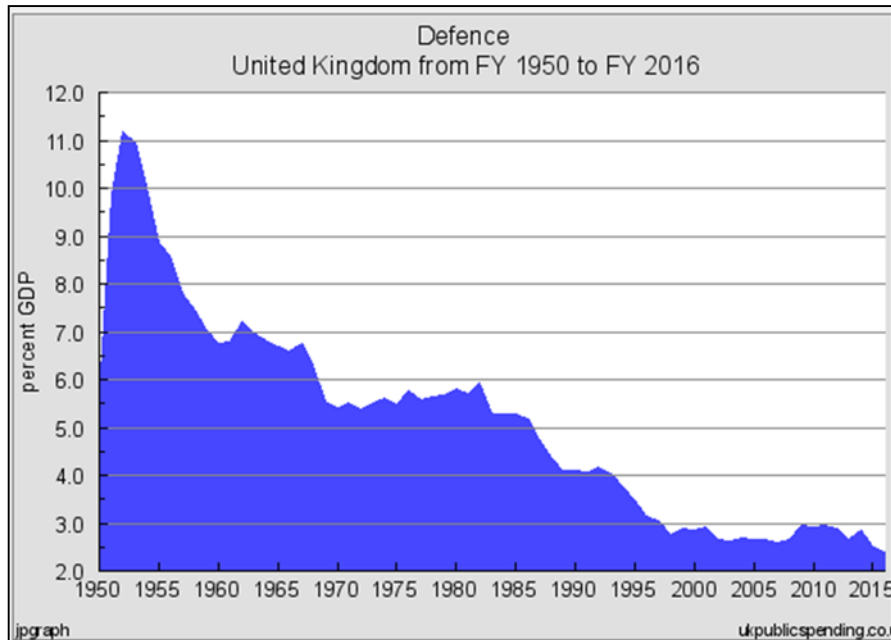
- The method was developed through two case studies of specific capabilities: Carrier Strike and Armoured Battlegroup (BG); but can be applied to other military capabilities
- Unit Acquisition Cost (UAC) was used as a proxy for capability on the basis of previous research and the difficulty of measuring capability through judgement
- Data on physical characteristics and fuel data were gathered from MOD or open sources; or proxies used where required
- The method looks across a 50-60 year timescales and inferences need to be made on data
- The key finding is that absolute Capability has grown faster than *fuel use* but at around the same rate as *fuel cost*

Polaris
CONSULTING

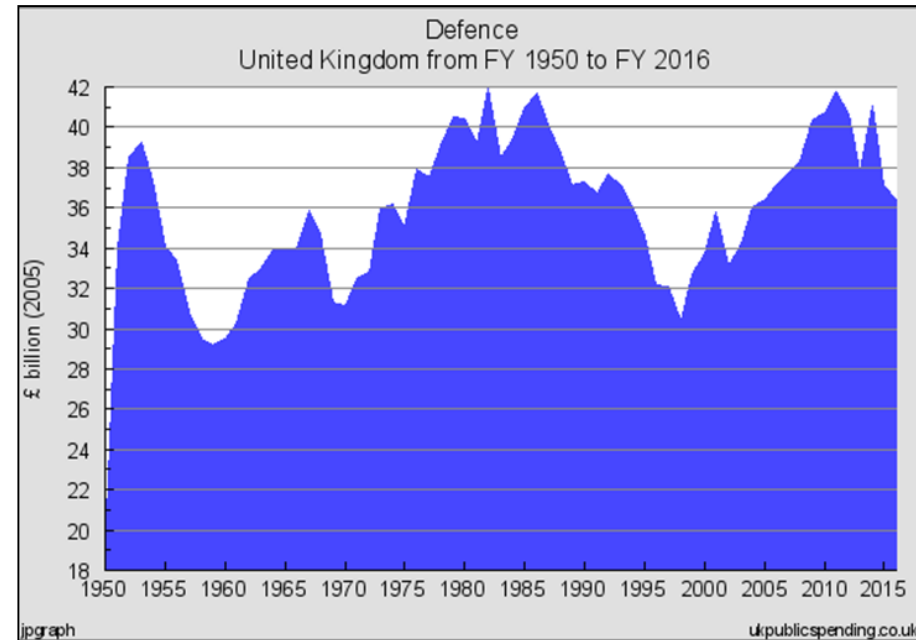


Defence Spending

Over the past 50 years or so, the UK defence budget has been largely stable in real terms, with the growth in GDP offsetting the decline in the share defence takes of that GDP



UK Defence Spending as a % of GDP



UK Defence Spending in 2005 £s

UAC as a Proxy for Capability (1)

The original intention was to base capability measurement on the results of Capability Audit, but this proved impractical

- Military capability, as defined by the UK (and US) is relative to the effectiveness of the opposing forces; it is not an absolute measure
- Capability Audits can provide effectiveness for different Epochs and could be used to infer absolute capability, although it would be still represent a proxy
- Similarly, the use of Future Force Development (FFD), other modelling and/or Military Judgement Panels could deliver a proxy for absolute capability
- These approaches rely, however, on potentially sensitive information and Capability Audit results are only available from c. 2000

UAC as a Proxy for Capability (2)

Unit Acquisition Cost (UAC) offers an alternative proxy for capability

- Studies of intergenerational equipment cost have concluded that the major driver for cost escalation is improved capability
- This is because defence equipment represent 'tournament goods' whose sole utility is being superior to the opposition
- UAC therefore represents a proxy measure of absolute capability which may readily be calculated as an indicator of relative capability for comparing with growth in other cost factors. This is not discounted but deflated to a constant price
- There are complications from other cost drivers:
 - Higher costs through reduced production numbers
 - Reduction in competitive pressures between companies AND
- Handling Mid Life Upgrades (MLUs)
- Overall, however, UAC is useful so long as 'like is compared to like'

Carrier Strike is a strategic, high profile capability which has been the subject of numerous UK Strategic Defence Reviews

- Carrier Strike comprises an aircraft carrier, its air group, escorts (destroyers and frigates), RFAs and submarine(s)
- The UK had the 2nd largest aircraft carrier fleet in the world in the 1960s, but the emphasis shifted to ASW operations in the 1970s
- The Falklands War meant that Carrier Strike was reprieved with a limited capability until the 1998 SDR, when the CVF (Queen Elizabeth class) was conceived with full expeditionary capability
- Budgetary realities in the 2010 SDSR removed the UK's Carrier Strike capability until c.2020, but retained the aspirations of the 1998 SDR
- Defence policy and budgetary pressures have dominated Carrier Strike planning over the past 50 years

Proxy and inferred data has been used for UAC and fuel data, based around 4 Carrier Strike groups from different Epochs

- Epoch mid-1960s: Audacious Class Carrier, 3 cruisers, 3 destroyers and 5 RFAs
- Epoch mid-1970s: Audacious Class Carrier, 4 destroyers, 6 frigates and 2 RFAs
- Epoch 2000s: Invincible Class Carrier, 3 destroyers, 5 frigates and 2 RFAs
- Future Force 2020: Queen Elizabeth Class Carrier, 2 destroyers, 3 frigates and 5 RFAs
- Lack of fuel data precluded the inclusion of air groups

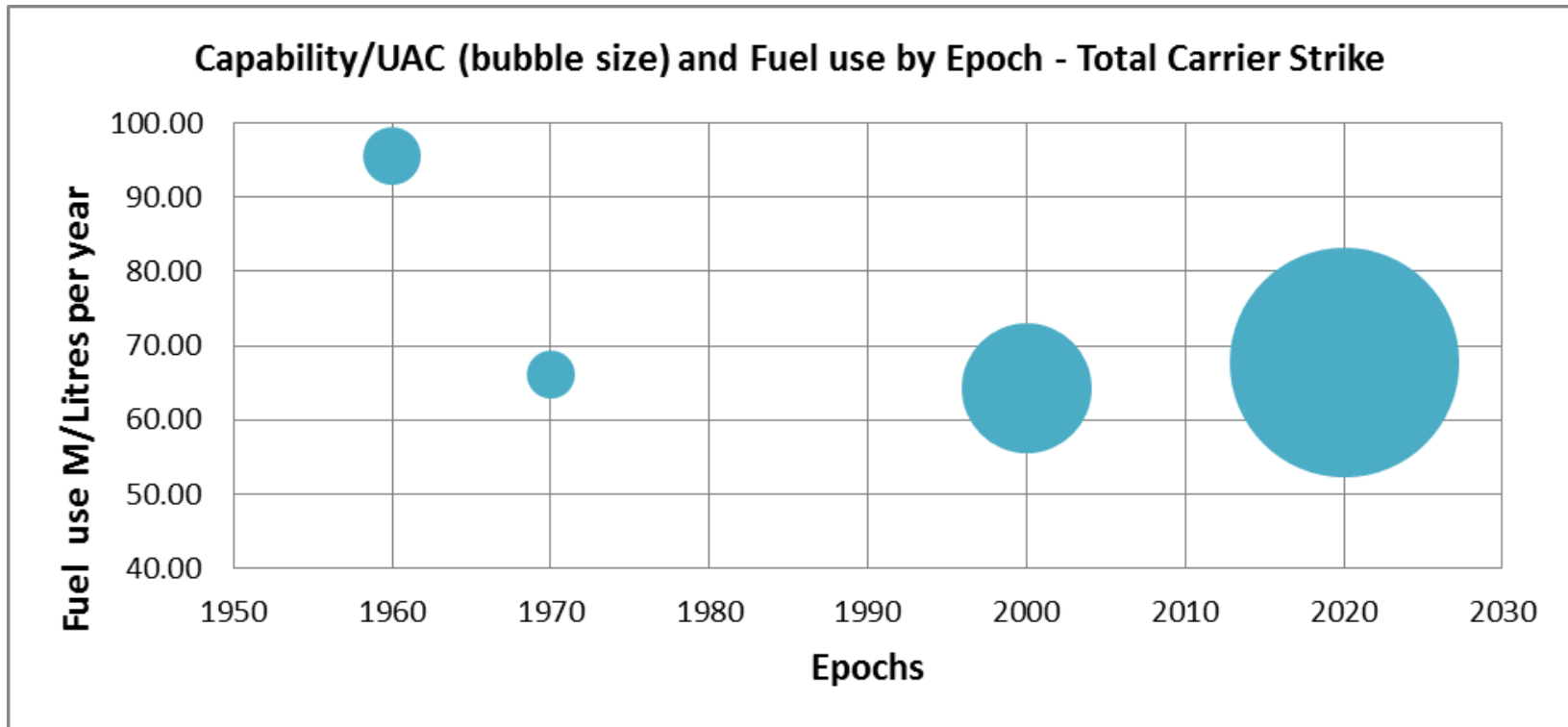
Fuel and Capability (UAC) Data

This chart summarises fuel and UAC data for the 4 Epochs
Fuel is in millions of litres/year

Platform	Epoch							
	1960		1970		2000		2020	
	Fuel	UAC	Fuel	UAC	Fuel	UAC	Fuel	UAC
Carrier	20.36	£80m	20.36	£80m	14.10	£476m	29.18	£2,770m
Destroyers	14.59	£128m	19.45	£171m	17.79	£417m	13.74	£1,950m
Frigates	25.67	£141m	7.38	£45m	18.18	£544m	10.66	£883m
RFAs	35.33	£73m	32.10	£63m	13.78	£529m	32.70	£959m
Total	95.94	£423m	79.29	£359m	63.85	£1,966m	86.28	£6,562m

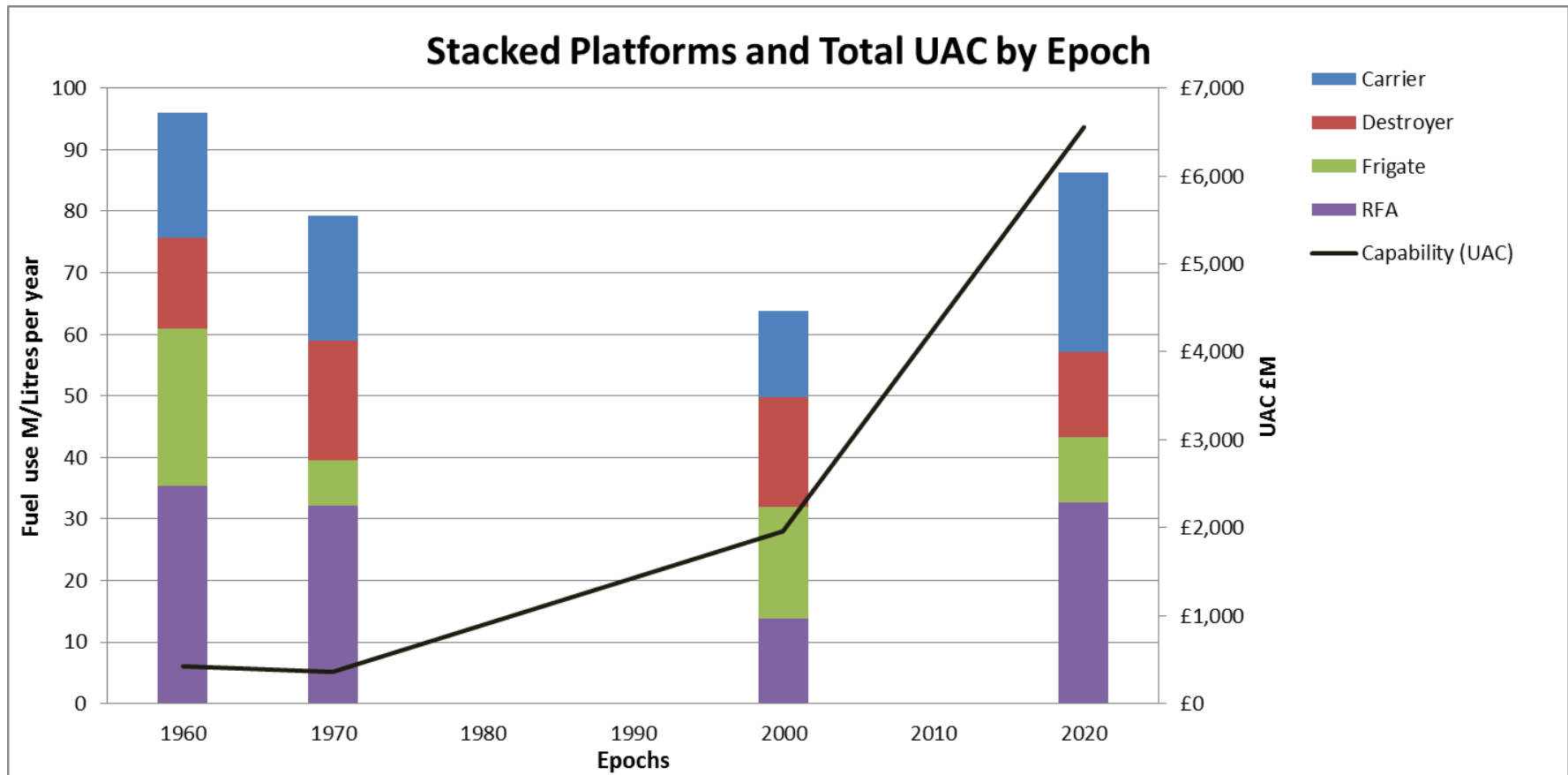
Capability & Fuel by Epoch

This chart shows capability (UAC; as bubble size) against fuel use for the 4 Epochs



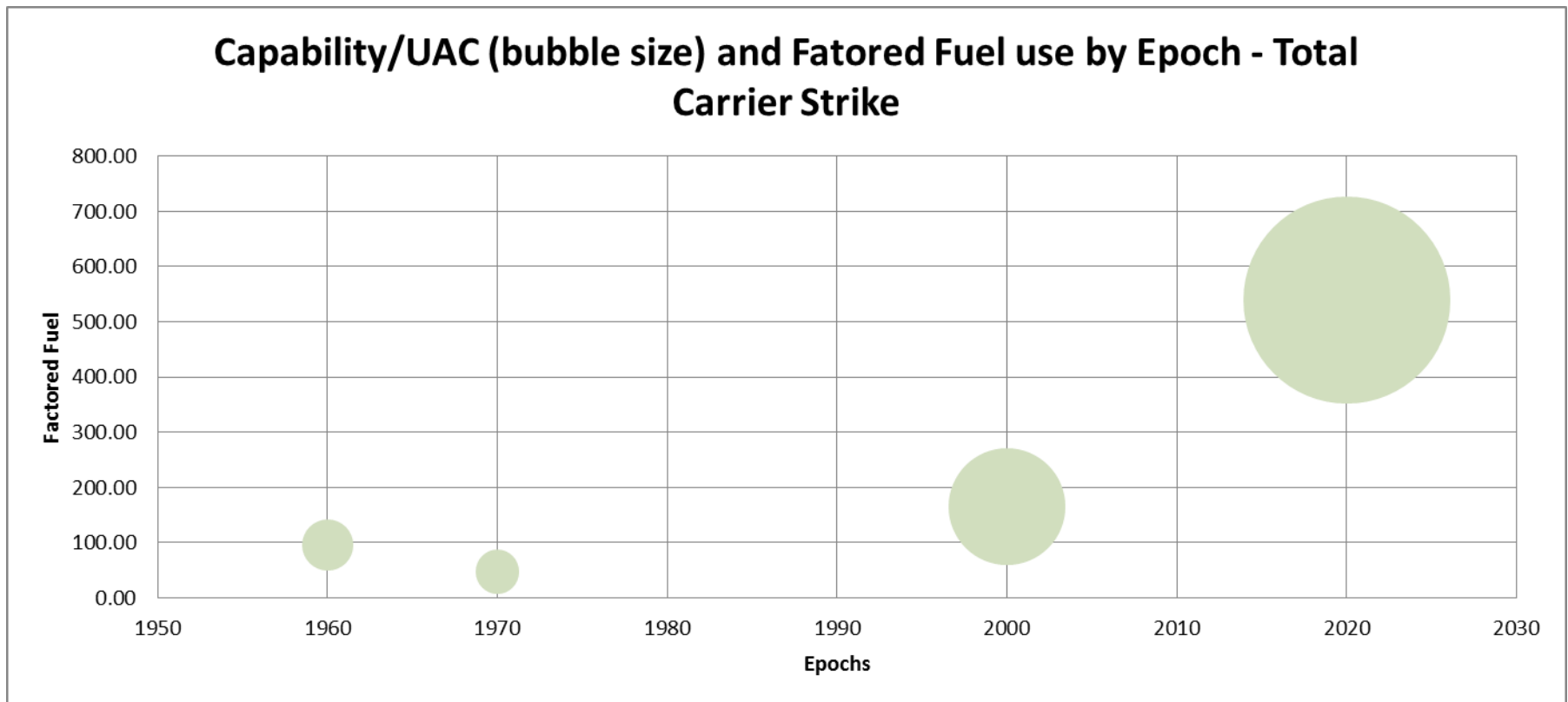
Fuel Breakdown by Epoch

This chart shows the fuel breakdown by type of ship for the 4 Epochs, with capability shown (on a different scale) as a line



Fuel Cost by Epoch

This chart shows capability (UAC; as bubble size) against fuel cost for the 4 Epochs



Carrier Strike Conclusions

The ratio of capability to fuel use has increased 17 fold from 1971 to 2020; the ratio of capability to fuel cost has increased 3 fold

- Fuel use has remained broadly similar from 1960 to 2020
- Absolute capability has increased 16.6 times from 1960 to 2020
- The ratio of capability to fuel use has increased 17.3 times from 1960 to 2020
- However, the ratio of capability to fuel cost has only increased 2.8 times from 1960 to 2020
- Absolute Capability has grown much faster than fuel use and faster than fuel cost
- Hence fuel use compared to/deflated by Relative Capability has been on a declining trend. This is still true in regard to fuel cost, but much less so.

The Main Battle Tank (MBT) is central to this capability but it never operates in isolation, and always as part of the Battlegroup (BG).

- The Armoured BG as a capability comprises a number of tanks, along with associated Infantry Fighting Vehicles, Armoured Personnel Carriers, along with Recce and support vehicles
- The purpose of the British Army of the Rhine (BAOR), and NATO forces as a whole in Germany was to act as a deterrent against Soviet action with its capability centred on mobile, armoured warfare to slow or stop an incursion across the border.
- Like Carrier Strike, the evolution of UK armoured capability has been dominated by defence policy and budgetary realities.
- The basic composition of an armoured battlegroup, in terms of the number of vehicles and their broad type, has remained remarkably constant for 50 years, albeit with an increase in capability.
- What has changed is the number of battlegroups available to the Army, as a result of conflict becoming more expeditionary in character with 6 being available today compared to 24 in 1980.

Armoured BG Epochs (1)

Proxy and inferred data has been used for UAC and fuel data, based around 3 Armoured BGs from different Epochs

	Epoch 1 1971	Epoch 2 1997	Epoch 3 2003
MBT type	Chieftain (CH)	Challenger 1 (CR1)	Challenger 2 (CR2)
Years in service	1966-1995	1983-2000	1998-present
Engine type	Leyland L60 2 stroke, 6 cylinder (multi fuel)	Rolls Royce/Perkins Condor CV12 (diesel)	Perkins CV12 V12 (26 litre diesel)
Engine power	Up to 750 bhp at 2100 rpm	1200 bhp at 2300 rpm	1200 bhp

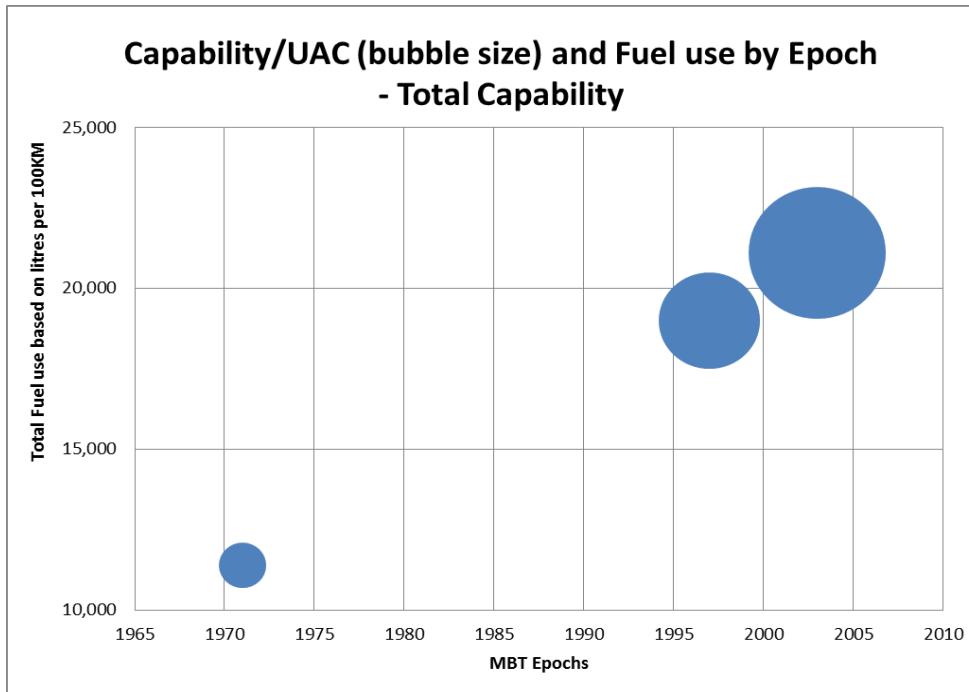
Armoured BG Epochs (2)

This chart summarises the data gathered for the 3 Epochs

Role	1971				1997				2003			
	Fuel - litres per 100km	UAC	Unit numbers	Weight (ton)	Fuel - litres per 100km	UAC	Unit numbers	Weight (ton)	Fuel - litres per 100km	UAC	Unit numbers	Weight (ton)
MBT	6755.56	£28.80	32	55	9117.18	£109.20	26	62	10745.78	£182.00	28	67
IFV	472.92	£2.05	5	31	2743.33	£10.96	21	107	2559.52	£61.26	19	34
APC	1102.39	£1.47	12	48	410.00	£2.31	5	13	1263.33	£8.67	13	43
Recce	533.33	£2.49	17	5	1334.06	£19.63	12	32	1334.06	£25.63	12	33
Support	1217.31	£6.58	10	260	4412.56	£37.23	29	316	4339.39	£56.66	20	226
Wheeled	1317.48	£0.83	40	25	969.47	£10.98	58	47	863.34	£19.51	49	53
Total Capability	11398.97	£42.20	116	426	18986.60	£190.31	151	577	21105.43	£353.74	141	455

Capability and Fuel by Epoch

This page shows capability (UAC; as bubble size) against fuel use for the 3 Epochs, and the factor of increase in UAC and Fuel across the Epochs

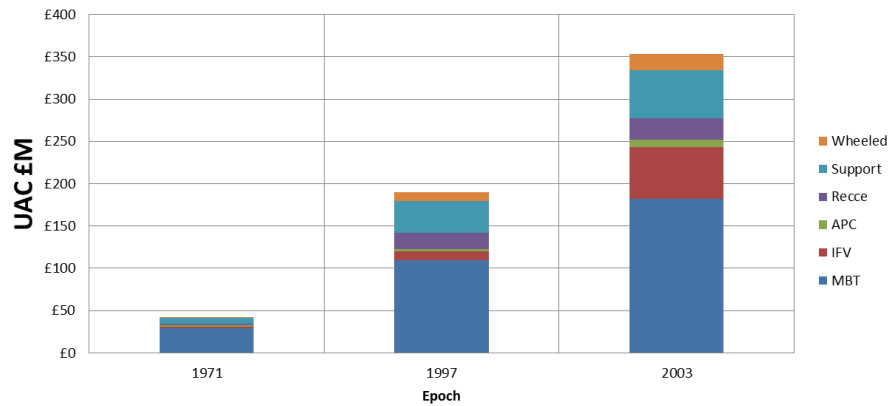


Role	Baseline		Factor of increase compared to 1971			
	1971		1997		2003	
	UAC	Fuel	UAC	Fuel	UAC	Fuel
MBT	£28.80	6756	3.79 x	1.35 x	6.32 x	1.59 x
IFV	£2.05	473	5.36 x	5.8 x	29.94 x	5.41 x
APC	£1.47	1102	1.57 x	0.37 x	5.92 x	1.15 x
Recce	£2.49	533	7.9 x	2.5 x	10.31 x	2.5 x
Support	£6.58	1217	5.66 x	3.62 x	8.62 x	3.56 x
Wheeled	£0.83	1317	13.25 x	0.74 x	23.55 x	0.66 x
Total	£42.20	11399	4.51 x	1.67 x	8.38 x	1.85 x

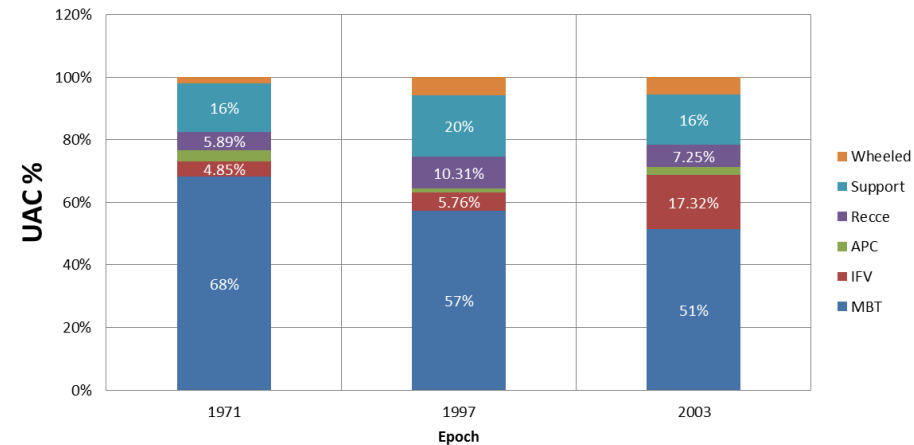
Capability by Role and Epoch

This page shows UAC by Role, and the proportion of each roles UAC for the 3 Epochs.

Role UAC by Epoch

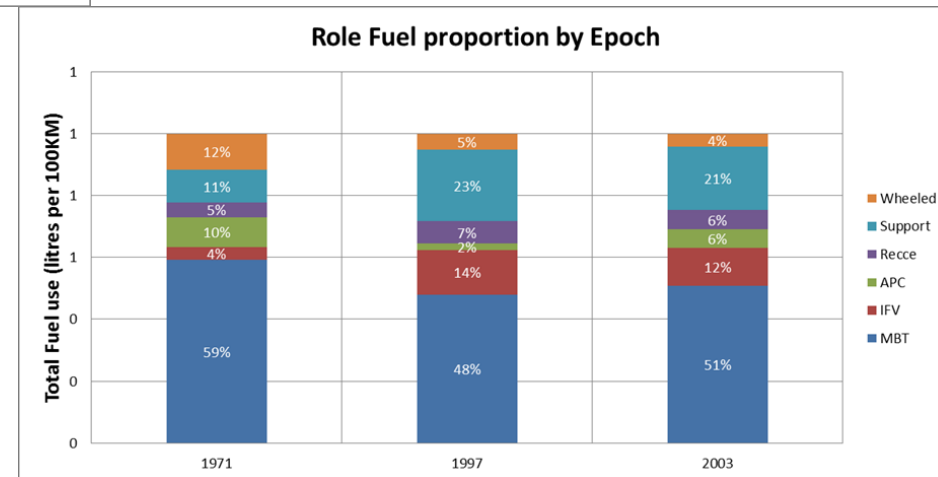
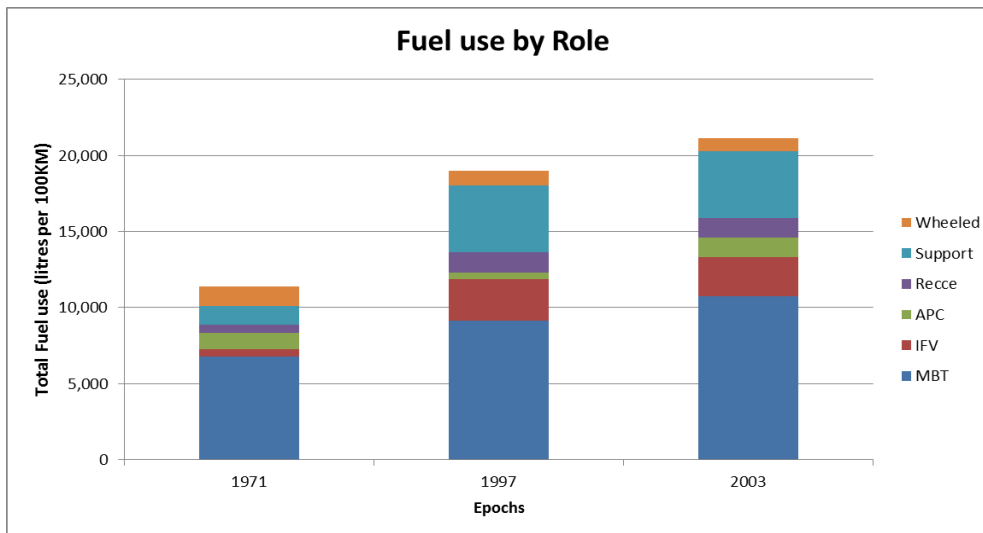


Role % of total Capability based on UAC



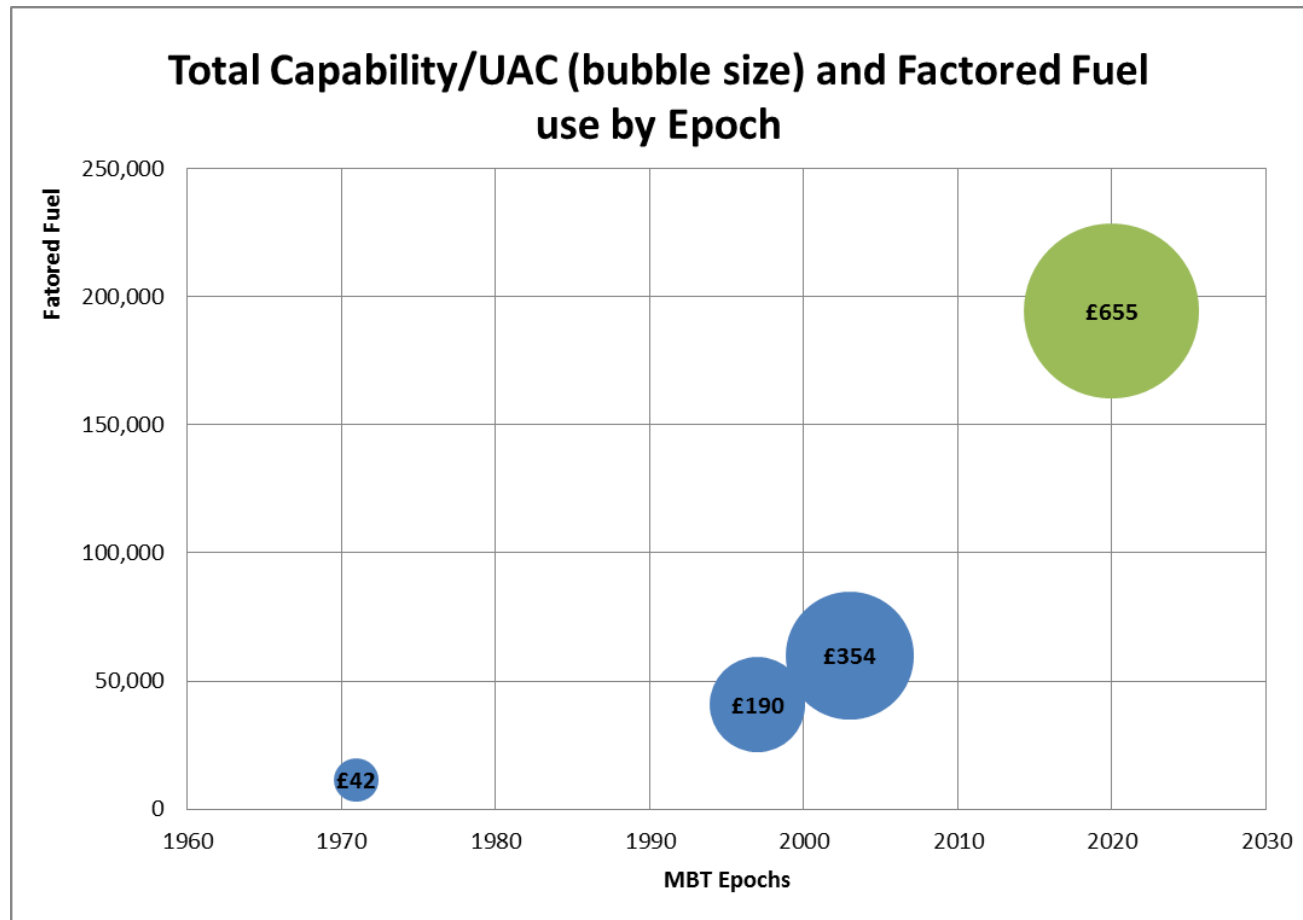
Fuel Breakdown by Epoch

This chart shows the fuel breakdown by role, and the proportion of total fuel used by that role for the 3 Epochs



Fuel Cost by Epoch

This chart shows capability (UAC; as bubble size) against fuel cost for the 3 Epochs and a 2020 Epoch



Armoured BG Conclusions

The ratio of capability to fuel use has increased 4 fold from 1971 to 2020; the ratio of capability to fuel cost has decreased slightly

- Fuel use increased by 1.9 times from 1971 to 2003
- Absolute capability has increased 8.4 times from 1971 to 2020
- The ratio of capability to fuel use has increased 4.5 times from 1971 to 2020
- However, the ratio of capability to fuel *cost* has decreased to 91% between 1971 to 2020
- Absolute Capability has grown faster than fuel use but at around the same rate as fuel cost
- Fuel *use* deflated by relative capability has reduced and fuel *cost* deflated by relative capability has risen slightly

Overall Conclusions

The method has successfully mapped the way in which capability and energy have changed over time for two capabilities

- The method is now proven and may be applied to other capabilities
- The different results from Carrier Strike and Armoured BG show that each capability should be treated separately
- With the two case studies, absolute capability has increased much more rapidly than fuel use, but the increase in fuel cost is closer to the increase in absolute capability
- Individual platforms tend to increase in size and therefore energy use, but increasing UAC means that there are less of them
- The major drivers are the reducing number of platforms as UAC rises and the increasing cost of fuel

Questions

We are happy to take questions from the floor