

The Contribution of OR in the UK Equipment Capability Audit

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Introduction

In the UK MOD, the Equipment Capability Customer (ECC) is responsible for delivering a balanced, coherent and affordable Equipment Programme (EP) to meet MOD strategic and policy requirements and the needs of HM forces. But how do we assess whether the EP is meeting those needs and requirements?

The answer to this question is the process known as the ECC Capability Audit. This paper outlines the Capability Audit process and in particular the part played by OR within it.

The Equipment Capability Customer¹

The role of the Equipment Capability Customer (ECC) is:

- a) To develop a balanced, coherent and affordable equipment programme;
- b) Strategic oversight of the capability of equipment already in service;
- c) To manage the Approvals process;
- d) To design the research programme in support of capability development.

The current ECC structure is given at Figures 1 to 3.

The Joint Capability Board (JCB) (Figure 1) provides strategic leadership and direction to the ECC in delivering a balanced, coherent and affordable Equipment Programme. The JCB is chaired by the Deputy Chief of Defence Staff (Equipment Capability) (DCDS(EC)). Its members are the Capability Managers, the Director General of Equipment (DGE) and the Director General of Research and Technology (DG(R&T))².

¹ This section is largely drawn from the ECC Capability Handbook, 2005 edition.

² DG(R&T) is based in the Chief Scientific Advisor's area.

Joint Capability Board Members

Deputy Chief of Defence Staff (Equipment Capability)

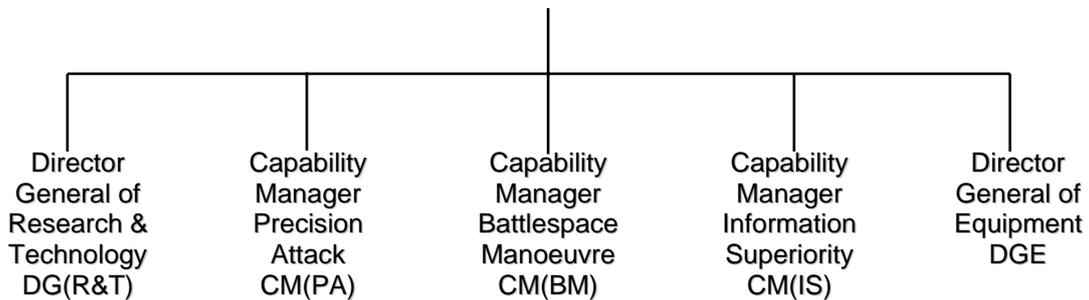


Figure 1: ECC Top Management Structure – the JCB

Equipment Capability is broken down into a number (currently eleven) of areas, each of which is the responsibility of a Director of Equipment Capability (DEC) (Figure 2). It is the job of each DEC to analyse the specific military needs within their capability area, determine when and where gaps in capability will occur and formulate plans to close those gaps.

Deputy Chief of Defence Staff (Equipment Capability)

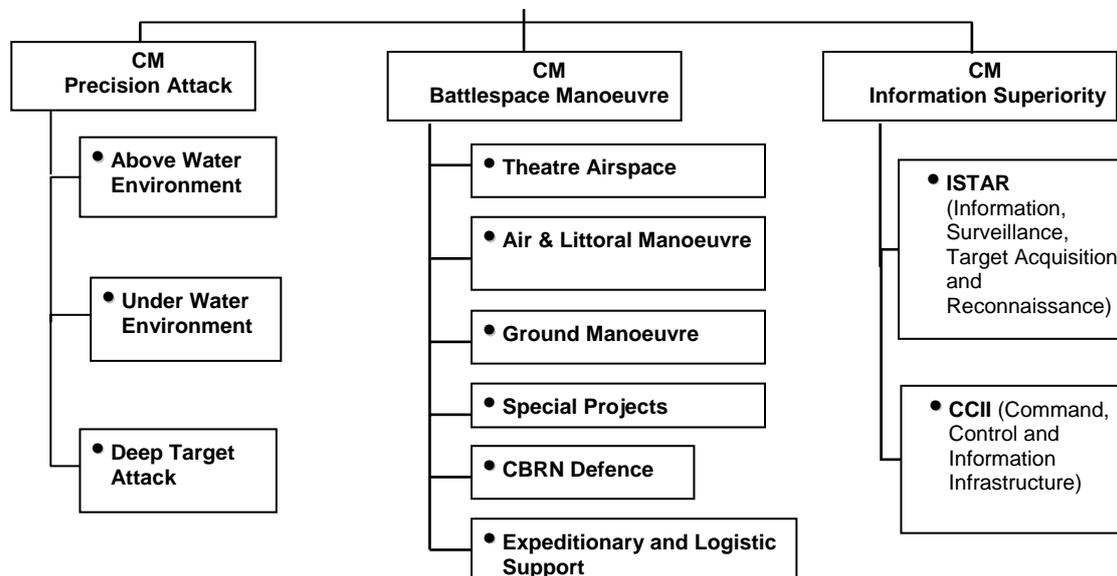


Figure 2: ECC – the DEC Structure

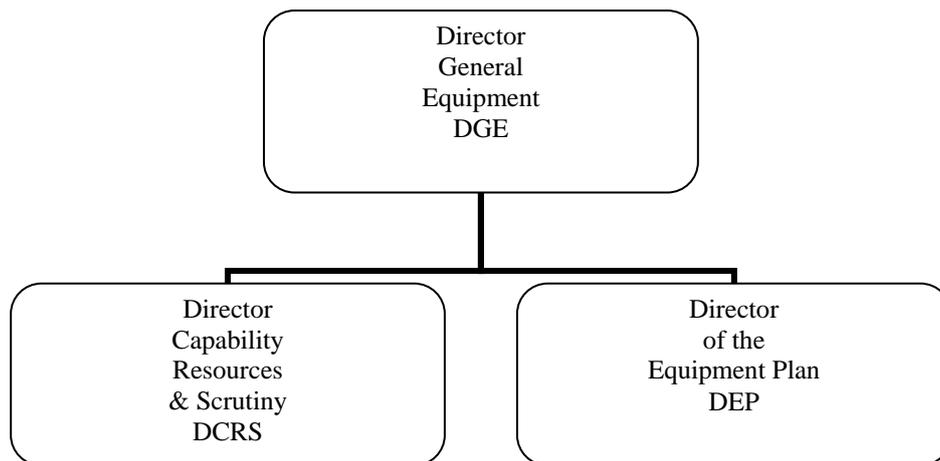


Figure 3: ECC – the DGE's organisation

The Director General of Equipment's organisation (Figure 3) provides support and guidance across the ECC, providing balance and a broader perspective than the individual DsEC.

- a) The Director Capability Resources and Scrutiny (DCRS) provides financial planning and programming advice to the ECC to ensure coherency and affordability. His organisation also establishes the validity of the requirement and value for money of business cases, as well as general scrutiny requirements and information to other parties.
- b) The Director of the Equipment Plan (DEP) is responsible for the production of the Equipment Plan (EP). His organisation also develops and manages the processes to support the EP, including Decision Conferencing, High Level Operational Analysis and the *Capability Audit*.

What is the Capability Audit?

The Capability Audit is the ECC's process for assessing the expected collective operational capabilities of UK Forces employing the equipment being procured or continued in service under the current and projected Equipment Plan. It is thus designed:

- a) to determine whether the current plan will enable the UK's armed forces to fulfil the tasks required of them by policy;

and

- b) hence to inform decisions on any required changes to the plan.

Capability is broken down into a Capability Taxonomy, each area of which is assigned to a particular DEC. Each DEC leads an Audit of his area of responsibility to determine whether the current EP is meeting their capability objectives, as defined by policy.

The Audit uses a set of planning scenarios to provide the context in which to assess whether or not the EP will deliver the capabilities that UK forces will require to meet the range of operational tasks which policy requires that they be able to do in the future. The Audit also assesses the ability to conduct concurrent operations, again as defined by policy.

Why an “Audit”?

The term “Capability Audit” was adopted for this process to emphasise the following aspects of the approach:

- a) That it should identify *surpluses* in capability as well as shortfalls.
- b) That it is intended to be *quantitative* rather than qualitative.
- c) That it measures the expected output of the *current* plan. It identifies areas where change may be needed but this process does not propose options for implementing that change.

Given the breadth, complexity, dynamic nature and sheer size of the EP, a meaningful and effective audit of it is not a simple task. Achieving it requires an organised approach using a structured common framework.

The Capability Measurement Framework

The capability measurement framework provides just such a single common framework, applicable across the ECC, within which the capability audit is conducted. It promotes consistency in approach and facilitates comparison and balancing across capability areas.

The framework has three axes: Capability, Operation Type and Timeframe; in other words, *what we can achieve, within what operational contexts and when.*

- a) The Capability axis focuses on *effects*³ not means. It must be expressed purely in capability terms and not confused with platforms, systems or operation types.
- b) The Operation Type axis is expressed in terms of endorsed planning scenarios drawn from the current SAG set⁴.
- c) The Timeframe axis allows audit of the EP as it develops over time, to take account of the changing EP and emerging/changing threat, by examining the situation in at least two future timeframes.

Capability

I have made extensive use here of the term “capability” – but what exactly is “capability”? My dictionary defines “capable” as:

“having the power or fitness or the necessary wickedness for; able, competent.”⁵”

Leaving aside “necessary wickedness”, our capability is our power, fitness, ability and competence to do what is required of us; our ability to achieve our objectives.

More specifically, military capability can be defined⁶ as the ability to:

- a) Bring together maritime, ground and air components into coherent joint forces under unified command and fully capable of achieving the required objectives;

³ Currently defined by DCDC as: “*The consequence of one or more activities that contribute to one or more objectives.*” (*The UK Military Effects-Based Approach*, JDN 1/05, September 2005. p1-4)

⁴ Studies Assumptions Group, *The SAG Book v6.2*, September 2005.

⁵ *Pocket Oxford Dictionary*, OUP, London.

⁶ Based on Beare, G & Taylor, B, *Measuring Capability*, Paper to International Symposium of Military Operational Research, 2001.

- b) Deliver appropriately motivated, manned, trained and equipped force packages, at the required level of readiness and with the necessary support, sustainability and deployability, to achieve the full range of required military tasks.

Military Capability thus encompasses all Lines of Development (LOD). The ECC’s Capability Audit is primarily concerned with Equipment Capability, since that is our area of responsibility⁷. However, DEC’s should note in their audit reports where developments in other LODs are anticipated to have a potential effect on our future capability.

Military operations encompass a broad range of activities and requirements. The capabilities required to achieve them are similarly broad, complex and varied. For assessment of the UK’s military capabilities to be both meaningful and manageable, these capabilities need to be subdivided into a structure of discrete, identifiable (and measurable) pieces. Such a structure is known as a taxonomy. It needs to be comprehensive – to capture all relevant capabilities – and discrete – to avoid duplication.

A hierarchical capability taxonomy has been developed and refined over several years. The top-level equipment capabilities and the DEC’s currently responsible for them are shown in Table 1.

Each top-level capability is the responsibility of one – and only one – DEC. Since there are linkages and dependencies between capabilities, however, it is essential that DEC’s should work closely together. In particular, there needs to be agreement on common assumptions.

Capability	Lead DEC
Command, Control, Communications and Computing	CCII
Force Readiness	DEP
Strategic Mobility	ELS
Intra-Theatre Mobility	ALM
Intelligence, Surveillance, Reconnaissance & Info Ops	ISTAR
Control & Denial of Above Water Battlespace	AWE
Control & Denial of Under Water Battlespace	UWE
Control & Denial of Theatre Airspace	TA
Control & Denial of Land Close Battlespace	GM
Deep Attack	DTA
CBRN Defence	CBRN
Counter-Terrorism	SP
Logistic Support	ELS

Table 1: Allocation of Capabilities to Lead DEC’s

⁷ Although a recent MOD study – *Enabling Acquisition Change* – recommends expanding the ECC’s role in other LODs.

Operation Type

Whether the forces generated and the force packages delivered are actually capable of achieving the required tasks and objectives obviously depends upon the circumstances they are in, including the opposition faced. Capability is *relative* not absolute. For it to be assessed meaningfully, it needs to be placed into an operational context.

A set of scenarios, drawn from the SAG book, provides the operational context for the Audit. This set is designed to enable adequate coverage of policy priorities, combined with suitably – but not unrealistically - challenging tests of our military capabilities. For practical purposes, this set is also constrained to be the minimum number feasible for these purposes.

The scenario set is divided into a *mandated* set, which all DEC's are required to use, and a *recommended* set, which are recommended and supported by DEP for DEC use, if required to augment the mandated scenarios.

Common campaigns, drawn from High Level Operational Research studies are used for the audit scenarios. This is to ensure commonality and consistency between DEC's. Teams of Operational Research analysts and military officers, supported by expertise from intelligence, international relations and other relevant disciplines, construct meticulous campaigns, taking into account Blue, Red and other perspectives. These are modelled in campaign level simulation models – or by other approaches where these are more appropriate – to establish a baseline campaign. This baseline campaign provides the benchmark for each scenario; a common standard against which variations, excursions and – in the Capability Audit – planned capabilities can be assessed.

Timeframe

Our capability develops over time as new equipment enters service and old is withdrawn. Other developments, such as upgrades, enhancements and changes in the other LODs also have an effect. Since capability is relative, changes over time in the capabilities possessed by our potential opponents also need to be taken into account. Since, therefore, our capability will inevitably alter over time, a single timeframe assessment is insufficient.

The basic requirement is for audit of one near-term timeframe and one ten years subsequent to it. Additional timeframes can be audited by DEC's if they consider that these would provide important additional information.

For convenience, and consistency with other long-term assessment work, years which are a multiple of 5 (e.g. 2010, 2015) are used.

Capability Goals

The capability framework has thus far:

- a) Broken down the concept of military capability into more defined and manageable categories (the capability taxonomy).
- b) Set the operational context in which those capabilities are utilised (the scenarios).
- c) Determined when the state of development of these capabilities are to be assessed (the timeframes).

This leaves to be determined the level of each capability that is actually required. This is a three-stage process:

- a) *Capability Goal*. The first stage⁸ is to identify a form of words that represents the effect that the capability is intended to achieve – its *goal* - and does so in generic terms, for example:

“Air vehicles entering the Air Component Commander’s (ACC) Area of Interest (AoI) are detected and tracked at the resolution necessary to permit engagement by own air defence systems.”

This generic form should be applicable to a range of scenarios and timeframes.

- b) *Measure of Effectiveness*. The second stage is to identify a relevant Measure of Effectiveness (MoE) for the goal. An example might be:

“The percentage of air vehicles entering the ACC’s AoI that are detected and tracked at the resolution necessary to permit engagement by own air defence systems.”

This should also be generic and applicable to different scenarios and timeframes.

- c) *Benchmark*. The third stage requires quantification of the *goal*, using the *MoE*, in the context of a single *campaign* and *timeframe* to establish the *benchmark* level. At this stage, it is necessary to identify the ‘greatest demand’ or ‘most stressing’ time for the capability in question. To pursue the previous example, this might be the time at which the ACC’s AoI is at its greatest extent or perhaps the time when the largest number of threat platforms are simultaneously within the area. The result could be along the lines of:

“80% of the air vehicles entering the ACC’s AoI during Phase X of Scenario Y in Timeframe Z are detected and tracked at the resolution necessary to permit engagement by own air defence systems.”

The principle here is that if the capability can deliver its hardest task then it can deliver easier ones. The numerical value set, 80% in our example, is the *minimum*⁹ level required to achieve a result at least as good as that achieved in the baseline campaign modelled by High Level OR. Those developing the benchmarks will need to assure themselves that they have identified a sufficiently demanding test and the appropriate level to be achieved in it.

Example benchmarks might include a rate at which ammunition must be supplied to artillery units or the minimum probability of defeating enemy anti-ship missiles to keep losses to acceptable levels. Benchmarks should not simply measure equipment performance as an end in its own right but must be driven by the achievement, in a joint coalition context, of the required *effect(s)* - those that contribute to achieving the objective(s).

Benchmarks are likely to differ between scenarios, as the threats and operational contexts may differ. They may also vary between timeframes as the threat capabilities and own available equipment change over time. Changes in our capabilities or force

⁸ Perhaps confusingly, “Capability Goals” is the term generally used to refer to the whole process, as well as just the first stage.

⁹ It is important to emphasise the *minimum* nature of capability benchmarks. We do not plan to achieve overkill.

structures may also mean that our campaign plans will vary between timeframes. The capability goal process may need to take account of this.

If all relevant capability goals are met to their benchmark levels, then the outcome of the campaign, as assessed by high-level analysis, should be achieved. If some capability goal benchmarks are not met, then there should be a risk that the desired campaign outcome would not be achieved¹⁰. If a capability can fall short of its benchmark with no ensuing risk then it has probably been set too high.

In practice, this process is a difficult and sometimes contentious task. Lower level Operational Research has a key role to play here in providing an objective and rational means of setting appropriate goals, MoEs and benchmarks, as well as in assessing whether we can achieve them.

For each cell of the framework (i.e. each cell of the capability taxonomy, in each scenario, in each timeframe):

- a) A goal, MoE and benchmark is set for the required capability (the benchmark will be specific to that cell; the goal and MoE probably not);
- b) All of the contributing systems are mapped into that cell to build an assessment of the forecast achieved level of capability. Where possible, this should be an objective assessment supported by OR;
- c) This forecast achieved level is compared with the benchmark level to determine whether there is a shortfall, sufficiency or affluence in that capability in that timeframe and scenario;
- d) Where a shortfall exists, the associated risk is assessed, including possible options for mitigation or acceptance.
- e) Affluences and sufficiencies may need to be examined to determine whether there is scope for savings, possibly through taking risk.

The results from the individual cells are subsequently aggregated up to give an overall picture of capability development over time.

Concurrency Analysis

The Capability Goals process tests our capability within specific operational contexts. Concurrency Analysis tests whether there would be sufficient numbers of equipments available to meet the capability requirements of a number of concurrent operations.

The concurrency sets used are derived from current policy, as laid out in Defence Strategic Guidance. The concurrency sets give guidance on the combinations of operation types which UK forces should be able to mount concurrently. Concurrency analysis generates such sets of scenarios drawn from a large range of approved scenarios – a much larger range than those used within the Audit for assessment of Capability Goals – and tests whether we have the forces available to mount them. This analysis is conducted over time, taking into account such factors as build-up, draw-down and recuperation of forces, providing a dynamic analysis more reflective of operational reality than a simpler static analysis would be.

¹⁰ This does not necessarily mean outright campaign failure but a poorer outcome than the baseline campaign. This could mean, for instance, that the strategic objectives are achieved but at increased casualties.

Dstl's Operational Researchers have developed a Concurrency Analysis modelling capability for use in the Capability Audit. Space precludes describing it in detail here, but, in outline, the analysis uses one model, DIDO, to generate demand streams of operations over time and another, AENEAS, to assess our ability to provide suitable forces to meet the requirements of those operations.

Output

The results of each DEC's Capability Audit should be summarised using a 'traffic light' scheme, as follows:

	Capability delivered exceeds goal by 25%
	Capability goal met and exceeded by up to 25%
	Capability shortfall of up to 25%
	Capability shortfall of more than 25%
	Not Assessed

Figure 4: Capability Score colour system.

The degree of objectivity employed in the generation of each score is also indicated, using the following scheme:

A	Assessment achieved by means of subjective judgement only
B	Assessment achieved by means of subjective judgement informed by objective evidence
C	Assessment achieved by means of judgmental interpretation of existing objective evidence
D	Assessment drawn directly from objective evidence

Figure 5: Capability Score objectivity system

Figure 6 gives an illustration of how results could look for a generic capability area.

			Scenario 1		Scenario 2		Scenario 3		Peace	
	Level 1	Level 2	Year X	Year Y	Year X	Year Y	Year X	Year Y	Year X	Year Y
Top level Capability Area	Sub-area	Sub-area	C	B	C	B	C	B	C	B
		Sub-area	D	A	D	A	D	A	D	A
		Sub-area	C	A	C	A	C	A	C	A
		Sub-area	D	A	D	A	D	A	D	A
		Sub-area	D	A	D	A	D	A	D	A
	Sub-area	Sub-area	D	A	D	A	D	A		
		Sub-area	D	B	D	A	D	A	A	A
		Sub-area		A		A		A		
		Sub-area	D	B	D	B	D	B	D	D

Figure 6: Example Capability Score Output

The outputs from individual taxonomy levels and sub-levels inform individual DEC capability planning and are also synthesised by DEP into a consolidated overall ECC Capability Audit report for consideration by the JCB.

The JCB reviews the Audit and provides direction and prioritisation for more detailed capability investigations, Balance of Investment (BOI) studies and other measures to determine the changes required to the EP, taking account of the balance of capabilities and requirements across the ECC as a whole.

The Capability Audit, therefore, provides the means of identifying and assessing, as objectively and authoritatively as possible, shortfalls and surpluses in currently planned capabilities and bringing these to the attention of the JCB for potential action.

Contribution of Operational Research

During the course of this paper, I have touched upon various contributions made by Operational Analysis/Research to the Capability Audit.

- a) High Level OR develops and assesses the scenario campaigns which provide the operational context for the audit.
- b) Lower level OR can assess whether particular benchmarks can be achieved within those campaigns.
- c) Concurrency Analysis assesses our ability to meet the demands of concurrent operations.

The Audit is intended to be quantitative rather than qualitative; objective rather than subjective. This is its core strength; integral to its value as a tool supporting our decision-making within the ECC – and helping explain those decisions to the Treasury.

The principal means of providing the objective evidence the Audit requires is through well-designed and conducted Operational Research studies. This implies that Operational Research should be used in support of the Audit, wherever feasible.

But OR is, I would argue, more than just a support function to the Capability Audit. The Audit is a structured, objective, scientifically-based approach to aiding senior decision-makers faced with a complex real-world problem. Whether or not all those involved in it would necessarily see it as such, I would argue that the Capability Audit is, in itself, Operational Research.