Operational Analysis: Historical Perspectives and Future Challenges

Dr Roger A Forder
Defence Science and Technology Laboratory
Portsdown West
Hampshire PO17 6AD
UNITED KINGDOM

raforder@dstl.gov.uk

ABSTRACT

The development of operational research and analysis has depended both on the demands generated by a changing defence environment and on the availability of relevant expertise, tools and techniques from within the contemporaneous scientific environment. On the demand side, defence transformations have often figured prominently in stimulating analytical developments. However, despite the current availability of a wide-ranging tool-set built up over many years, some important challenges remain for analysts seeking to support the current transformational process within NATO and the nations.

1.0 INTRODUCTION

In preparing this paper, I was very happy to accept the Symposium Committee's suggestion that I should spend a little time looking back over the history of operational research and analysis[1] to review where our current tool-set came from. In fact, my thesis will be that advances in operational analysis have often been stimulated by periods of defence transformation, or at least substantial strategic change. I will then suggest a few of the challenges that still face us in supporting the current defence transformation within NATO.

There are several official definitions of transformation used by NATO and the nations, but they all seem rather too specific to the current, post-Cold-War environment. For the purposes of this paper, the following more generic alternative is suggested:

> "A defence transformation is a major change in a nation's or alliance's defence posture that substantially affects all or most defence lines of development"

'Defence lines of development' (DLoD) is the UK terminology - broadly equivalent to the US DoD's DOTMLPF - for the set of generic elements that have to be brought together to generate a defence capability, namely:

- Training
- Equipment
- Personnel
- Information
- Doctrine (and concepts of operation)
- Organization

[1] A note on terminology is in order here. Usage of the terms 'operational analysis' (OA) and 'operational research' (OR), for what is essentially the same activity, varies across the NATO nations. In the UK defence community 'OA' has been used in preference to 'OR' since the mid-1960s. This paper will broadly follow this usage, reserving the 'OR' label for the original activity that developed before and during World War II and referring to 'OA' thereafter.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
APR 2010	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Operational Analysis: Historical Perspectives and Future Challenges	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Defence Science and Technology Laboratory Portsdown West Hampshire PO17 6AD UNITED KINGDOM**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADA564688. Analytical Support to Defence Transformation (Le soutien analytique a la transformation de la Defense). RTO-MP-SAS-081

14. ABSTRACT
The development of operational research and analysis has depended both on the demands generated by a changing defence environment and on the availability of relevant expertise, tools and techniques from within the contemporaneous scientific environment. On the demand side, defence transformations have often figured prominently in stimulating analytical developments. However, despite the current availability of a wide-ranging tool-set built up over many years, some important challenges remain for analysts seeking to support the current transformational process within NATO and the nations

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**12**	

- Infrastructure
- Logistics

The order here is not necessarily a logical one, but generates the useful mnemonic acronym TEPIDOIL. Actually, a ninth - interoperability - is sometimes added, although this is really an aspect that needs to be considered in the context of each of the others, rather than as something separate. My suggestion that, by definition, defence transformations substantially affect all or most of these elements is intended to distinguish transformations from, for example, just a major re-equipment programme (although even this would invariably have an impact beyond simply the equipment DLoD).

Although the term 'defence transformation' seems to have come into use specifically to describe the far-reaching changes to national and NATO's defence postures set in motion by the end of the Cold War, transformations that fall within the definition proposed above have, in fact, been fairly common over the centuries. Many of the great national leaders and great commanders have carried them through, as indeed have some of those on whom the verdict of history is less favourable.

2.0 DEFENCE TRANSFORMATIONS: AN HISTORICAL PERSPECTIVE

2.1 Alfred the Greats' Defence Transformation

As far as the history of my own nation is concerned, the first recorded defence transformation is that instigated by Alfred the Great, who was king of the Anglo-Saxon Kingdom of Wessex from 871 to 899. Although he never himself ruled the whole of what is now England, he can be regarded as the godfather of the English nation. His reign was much troubled by the Danish Vikings, who were not only already in control of lands in the east of England, including London, but were still making attacks across the North Sea with further conquests in mind. In response, Alfred made major changes to his defence capability both on land and at sea [1].

At sea, he ordered the construction of a fleet of longships that were much larger than anything the English had possessed up to that point and twice the size of Viking warships. The idea was to intercept raiding fleets before they landed, which - odd as it may seem to us - had never been tried before. On land, he made major changes in organization. Up to that point, the only land forces he had available were those raised locally and temporarily in each county, which could only be used in that county. He changed all that and organized a permanent, mobile field army that could be used across the kingdom. Finally, he ringed Wessex with some thirty fortified and garrisoned towns. These could act as secure bases from which to harry the Danes; or if the Danes attacked, they could hold out until the new cavalry arrived. Taken as a whole, Alfred's initiatives involved major changes in organization, doctrine, personnel, equipment and infrastructure and no doubt logistics as well. In general, it worked, at least in the medium term: the Danes were halted, the tide was turned and their boundaries driven back.

2.2 Demand and Supply in Operational Analysis

So, defence transformations are not new. However, we can be fairly certain that, despite being a very progressive monarch, Alfred did not call on the services of any operational analysts. This may seem a rather obvious, indeed facetious, statement. However, it does bring home the point that for OA to be employed, there needs to be a source of supply as well as demand. The situation can be summed up as in Figure 1, which posits that the employment, nature and achievements of OA are a function of

- the demand for its services, as generated by the culture, people, policy and priorities of the prevailing defence environment (and these may well, of course, include the needs of a defence transformation process);

- the contemporaneous scientific environment (culture, people, methods and tools) that can supply those services.

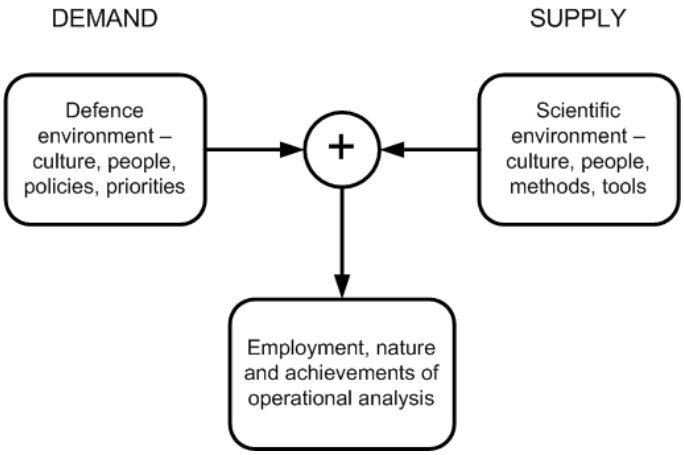

Figure 1: Supply and demand in operational analysis

For Alfred, the defence need was there but the scientific environment that could support it was not. In what follows, therefore, the evolution of the supply side will be examined as well as changing defence needs.

2.3 World War II: The Origins of Operational Research

Whilst, over the centuries, it is possible to point to isolated instances where talented individuals have thought about military operations in a way that we would now recognise as operational research, we need to move forward to the late 1930s before we come to any institutionalised applications within the official defence community.

It is well documented [2][3] that operational research, both as a term and as a recognised discipline, first came into use in the UK during the run-up to World War II, when radar scientists became involved in the analysis of air defence exercises, a major aim of which was to investigate the use and value of the new technology that they had been developing. This activity then drew them into issues of overall system design, operating procedures and tactics which had hitherto been the preserve of the military. This involvement was seen as highly beneficial and, when war broke out, a small team of these scientists was seconded to HQ Royal Air Force Fighter Command and the world's first OR group was born.

Now, it is certainly possible to argue that the situation at the beginning of World War II represented the result of a defence transformation, probably in several respects. One of the most notable was the way in which air power had come of age. In particular, the bomber was now the most feared weapon of war and one that was expected to give a future conflict a quite different character from anything that had gone before. The evolution of the Royal Air Force since its establishment in 1918 had involved major efforts along every line of development, and during the 1930s the provision of capabilities to counter the bomber threat had become top priority. For some years, the prospects of genuinely effective air defence had seemed slim, and emphasis had been placed on deterrence through the threat of retaliatory action. However, the advent of radar offered fresh hope, if only the new technology could be turned into an operational system.

Air power as a threat and air power as defence were therefore major new factors in warfare. OR came about initially to support air defence and, although it spread quickly to all the Services, its most effective area of application was still in air power, or defence against air power, in all its manifestations - in RAF

Fighter Command, in the Army's Anti-Aircraft Command, in RAF Bomber Command and in RAF Coastal Command's crucial contribution to the Battle of the Atlantic against the U-boats [4]. It can therefore be argued that the defence transformation represented by the advent of serious air power in the 1930s helped to spawn OR.

But what about the supply side of the equation: the scientific environment? What was that in the late 1930s? Well, to start with, there was a scientific environment. For the first time in history, science was now an established profession with a critical mass of professional scientists, including a significant number in government service. In the UK, at least, this was a result of the substantial government support of science that had been put in place since World War I, in both the civilian and defence environments. The qualified people, with the right mental outlook, were there to invent OR and apply it. There weren't, of course, any specialised 'OR methods', but the universal stock-in-trade of the scientist - the basic scientific approach supported by the common tools of mathematics, particularly statistics - was enough at this stage. So when the need for support and the availability of that support coincided, OR was born.

2.4 The Early Cold War Years

By the end of World War II, the important role of science in war was now recognised as never before, and OR was a small but undisputed part of the success story, having spread rapidly during the early 1940s from the UK to other Allied nations. OR organizations became a permanent part of the defence establishment both in the UK and US. New areas of activity were opened up; for example, the US Army had not really embraced OR during the war but established an Operations Research Office in 1948 [5]. In Canada, an OR activity was slowly reconstituted after the return of many wartime staff to civilian life [6].

All this seemed very natural. But where did it leave the characterisation of OR groups as described by Patrick Blackett, the most prominent of the UK pioneers [7]:

> "The main field of their activity is clearly the analysis of actual operations, using as data the material to be found in an operations room, e.g. all signals, track charts, combat reports, meteorological information, etc." ?

With the war ended, so, to a large extent, had operations. So what was the role of OR? Obviously, there was a vast quantity of wartime data that could still be analysed to extract useful insight into tactical and equipment issues relevant to traditional types of warfare. But these issues were not the most pressing ones. Almost as soon as the war ended, we found ourselves in what might well be considered another defence transformation, initiated by the advent of atomic and then thermonuclear weapons.

These weapons dominated thinking in the late 1940s and the 1950s. A whole new 'strategic theology' was established, codified in the early 1960s by writers such as Herman Kahn [8], bringing together the ideas of deterrence, mutually assured destruction, first and second strikes, and so on. In the US, the priorities were to put in place its own nuclear delivery systems and to evolve some sort of defence, as far as it was possible, against those of the enemy. It was very much a cross-DLoD effort: organization, equipment, people, training, infrastructure, logistics. All this was the stimulus and the seedbed of the next major development in OR. Rather than making sense of real, day-to-day operations, analysts now had to be concerned with hypothetical circumstances; hypothetical enemy reactions; and the pros and cons of equipment as yet unprocured, perhaps even undeveloped. Some sort of major paradigm shift would have to happen.

What was the scientific environment? Well, science was now big, much bigger than it had ever been. Science had helped win the war, now it was going to help win the peace. It was natural for the military to turn to science and analysis, even though the context was quite different from wartime OR. There were plenty of new ideas around and new techniques were providing inspiration: for example, linear

programming, game theory and Monte Carlo methods[2]. However, it was probably at the RAND Corporation in the US where it all came together for the first time, and it happened under a new label: 'systems analysis' [9][10]. Although wartime OR was certainly one of the inspirations for systems analysis, there were others: for example, general systems ideas, such as, systems engineering, with its focus on the whole as more than the sum of its parts, and economic analysis [11], with its emphasis on maximising outputs for a given set of inputs (Figure 2).

One of the results of all this was that we started to think more explicitly in terms of 'models'. I am not sure that the World War II pioneers ever used the term 'model'. But in fact their analysis of day-to-day operational experience, and its expression in simple mathematical terms, did give them a model - a simplified representation of reality on which to make predictions about the effects of alternative courses of action. Systems analysis generalised the idea of a model to *any* logical or mathematical simplification of the real world. A model synthesised all available inputs - planning assumptions, engineering assessments and military judgement as well as data. Systems analysis also stressed the importance of treating uncertainty in a full and explicit way.

Whilst the term 'systems analysis' is not so commonly used in the sense discussed here, except (almost!) in the title of the SAS Panel, the general approach and philosophy lives on in OA today. Whilst the label 'systems analysis' never displaced 'operational analysis', it changed its character and reoriented it for the later post-War world (Figure 2).

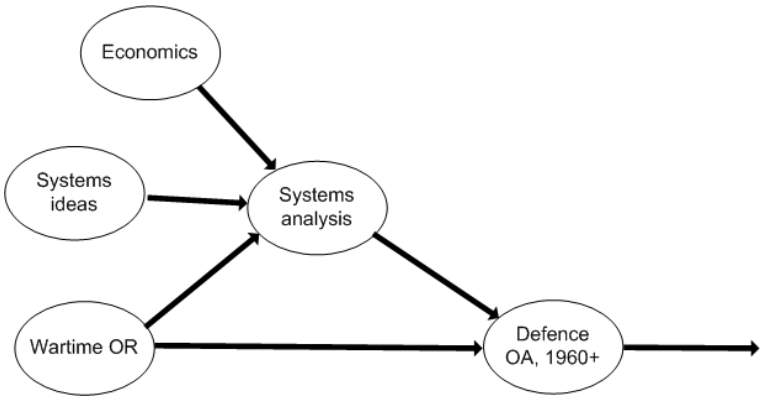

Figure 2: OR, systems analysis and OA

2.5 The Change to Flexible Response

The next development that changed the nature of the demand for OA was in the mid-1960s when NATO moved away from the doctrines of Tripwire and Massive Retaliation to that of Flexible Response. Rather than assuming, and threatening, that any move against NATO by the Warsaw Pact would inevitably lead rapidly to strategic nuclear exchange, the aim was to react conventionally, or at least sub-strategically, in a way that would extend the time available for negotiations that could avoid Armageddon. This was undoubtedly a major change in policy and doctrine and it could certainly be argued that, over the subsequent few years, its implementation amounted to a defence transformation.

As far as analysis was concerned, the effect was to put the spotlight on examining the size and shape of forces needed to fight big and relatively prolonged conventional wars in Europe and the Atlantic. What did the scientific and analytical environment have to offer that could meet this new challenge? The

[2] Monte Carlo methods had been used in the atom bomb project and their use was not necessarily dependent on the availability of a computer. A RAND Corporation book, *A Million Random Digits with 100,000 Normal Deviates*, published in 1955, proved a best-seller as an aid to 'manual' application of the Monte Carlo approach.

answer was large, discrete-event simulations, which were themselves made possible by the advent and rapid evolution of the mainframe digital computer - the iconic technical development of the 1960s.

The combination of military need and the advent of the mainframe computer was a powerful one. Discrete-event simulation proved a very flexible tool, enabling models to exploit increasing computer power by embracing ever greater levels of detail, for which there was unending appetite from the military customer. For good or ill - and many analysts felt uncomfortable with these developments - large combat simulations dominated defence OA for about two decades, underpinning innumerable studies addressing, Primarily, issues of equipment, logistics, doctrine and overall force structure.

2.6 The End of the Cold War

At around the turn of the 1990s, the mould described above was decisively broken by the end of the Cold War. The characteristics of the new defence environment are very familiar and are, indeed, the driver of the transformation addressed by this symposium:

- the move away from territorial defence to a much wider range of scenarios, with an emphasis on expeditionary operations, ranging from 'small' conventional wars, through counter-insurgency and peace support, to humanitarian operations;
- the new logistics, force generation and readiness issues which the change to an expeditionary posture throws up;
- flexible and adaptable concepts of operations, particularly those exploiting new information-based concepts such as network-enabled capability (the 'information-age battlefield');
- achievement of results through influence ('hearts and minds') as well as traditional military action;
- the demand for low casualties and low collateral damage;
- for many nations, profound changes in personnel policies and structures.

What was the scientific and analytical environment that could supply the OA tools needed to address this wealth of new issues? Just as the change to Flexible Response broadly coincided with the advent of the mainframe computer, so the end of the Cold War came about not long after the microcomputer revolution had started to deliver desktop computing power exceeding that of the earlier mainframes. Perhaps even more importantly, along with powerful desktop PCs came the PC software with which we are now so familiar. In particular, it would now be difficult to envisage an analytical landscape without the flexibility, power and convenience of PC-based spreadsheets and databases. But, in addition to such general-purpose software, there was soon a widening range of powerful commercial, off-the-shelf packages for many of the more specific OA techniques, such as discrete-event simulation, system dynamics, linear programming, multi-criteria decision analysis (in a variety of guises) and cognitive mapping. As the last of these exemplifies, the growing list included not only 'hard' quantitative techniques but also the methods of 'soft OR' (sometimes called problem-structuring methods) of which, hitherto, defence analysts had made relatively little use. Increasing use of these methods to address some of the less well-defined problems of the new defence environment would be another notable feature of the 1990s.

There was, therefore, a wealth of capability that could be used to widen the repertoire of defence OA in response to the widened problem space. Naturally, different nations had different priorities in using this capability. The following describes some features of the UK experience over the last 20 years [12]:

- Starting with the 1991 Gulf War, the increased tempo of actual operations that the new environment brought with it led rapidly to a revival in direct OA support to frontline commanders. The now ubiquitous laptop computer featured strongly in this development.

- Working closely with colleagues, both military and civilian, in the policy and planning branches of the Ministry of Defence, we put a great deal of effort into establishing a coherent approach to specifying, controlling and using multiple scenarios as a basis for our analysis. As well as calling up many *ad hoc* methods, this has given a new lease on life to our use of linear programming for formal optimisation across a scenario set.
- Our use of simulation changed its character in many respects:
  - increasing computer power reached the stage where we were able to use it to make simulations easier to use and understand, not just more complex;
  - using a number of new approaches, we were able to develop war-fighting simulations to address the more fluid battlefield [13] and to model command and control [14];
  - often using commercial desktop packages, we used simulation for a wide range of new, or revived, applications, not just combat modelling. For example: deployment of forces to theatre; logistic supply chains and associated information systems; equipment maintenance; recuperation after operations; information processing systems; casualty evacuation chains and the operation of field hospitals.
- We made some first, rather modest, steps towards addressing infrastructure and personnel planning issues.
- Last but certainly not least, we tried to tackle the influence - 'hearts and minds' - issue (of which more below).

It can be seen, therefore, that modern analytical methods and models can address, and have addressed, many of the issues that arise in the defence transformation that NATO nations are engaged in. But where is our toolbox deficient? What are the challenges? The first one that I want to discuss is the last bullet mentioned above: the influence issue.

3.0 FUTURE CHALLENGES

3.1 Challenge #1 : Understanding Influence

It is now generally accepted that if we want to relate the outcome of peace support and counter-insurgency operations to the military resources that we use and the way in which we use them, then we are highly dependent on understanding (modelling) human perception and behaviour and the ways by which they can be influenced. Depending on the problem in hand, this may mean the perception and behaviour of humans in any one or more of a very wide range of circumstances and combinations: individuals, crowds, military units, factions, regimes, populations.

In the UK we have adopted a multi-pronged approach to this issue.

- We have widened the analytical discipline base: the Dstl Strategic Analysis Group now includes psychologists, anthropologists, sociologists and graduates in strategic studies.
- We have developed our exploitation of historical and current operational data into this new area. This has certainly been useful in, for example, reaching broad conclusions about factors affecting success of CT/COIN [15][16]. However, we should like to achieve much more pull-through from current operations.
- We have used experimental gaming, where we try to provide participants with sufficient 'wrapping' to enable them to play out of their own personality and culture [17][18].
- We do our best to keep up with possibly applicable theoretical approaches, such as complex adaptive systems theory, and with what other nations are doing in this field, through activities such as the SAS-074 task group.

Nevertheless, although progress has been made, we recognise that we still have not cracked the problem in a really substantial way. What are the prospects for doing much better? The challenge is a major one, since, to put it colloquially, "we've been trying to work out how the other guy ticks for millennia" and have not succeeded very well. There are many reasons for this: humans come in an infinite variety, as far as their experience, beliefs and priorities are concerned; in any given real-life situation there are innumerable, unobserved (perhaps unobservable) contextual variables which may well be crucial in determining how people react; and whatever assessments we might make can be upset by chance events over which we have no control.

The questions therefore arise: What if we can't predict human perception and behaviour? Where does it really matter? More specifically, does it matter for analysis to support transformation? Let me be potentially provocative here and say that perhaps it does not matter quite so much for force structure and capability acquisition problems, which are, of course, among the main issues in planning defence transformation. My rationale in suggesting this is that we cannot do everything by influence, so we shall inevitably need a range of lethal and non-lethal force at our disposal. Our focus must therefore be on providing options which enable commander to deal with variety of events and human responses. To identify such options we can draw on past experience about the sorts of situations that have arisen and the sorts of options commanders needed; and we can use gaming, which is good at exposing possibilities even if it is not very good at prediction. But we do not need models that can predict the outcome of actions in specific, hypothetical situations.

My thesis is, therefore, that achieving the right sort of influence is not so much about what you have in the way of capabilities but how you choose to use them in specific circumstances 'on the day'. What this means is that understanding influence is crucially important when trying to provide analytical advice to commanders in planning and executing operations. However, this is not directly a transformation issue and is therefore a discussion for another day, but I will remark that there is an advantage in having a real operational context that is specific and (in principle) data-rich, rather than one that is generic with lots of unknown but important parameters.

So if, as my thesis suggests, analysis of force structure and capability acquisition issues is not greatly dependent on our ability to model influence, are there other transformational issues that do require us to understand influence better? I believe that there are and that they are ***doctrine*** - how we plan to go about operating in the new environment - and ***training*** - how we train our people to give reality to that doctrine. I suspect that the more important of these is training. If commanders and the personnel under their command are going to operate effectively in the new environment, they must be comfortable with the idea of considering both the physical and the influence aspects of their proposed actions. This is a really fundamental change from the old attritional, Cold War days.

We must therefore think more clearly where influence modelling really matters and focus our efforts in those directions. My firm belief is that, in the absence of a theoretical breakthrough, we must continue to try to make the most of empirical data from ongoing operations.

3.2 Challenge #2 : Training

Having raised the issue of training in this particular context, I now want to generalise it. I believe that the whole training enterprise is still a big challenge for analysis. Training, retraining if you like, is critical to transformation, but we analysts seem to be able to offer relatively little insight into the key training questions: how much is enough; the trade-off between investment in training and investment in other lines of development; the trade-off between live and synthetic training; what factors affect the value of training, whether live or synthetic; the significance of skill fade and the value of experience; and so on. Training is, perhaps, the line of development that offers the greatest challenge to analysis in terms of what we feel we could do, compared with what we have been able to do.

3.3 Analytical Support to DLoDs - An Overview

In the light of these comments, it is interesting to put together a table that attempts to compare the potential contribution of analysis with current analytical capabilities for each line of development. The result is shown in Table 1. Reflecting what has been said above, training is in the high-potential, low-capabilities box. No attempt will be made here to discuss all the assignments made: they are best regarded as an interesting basis for discussion. But I believe that personnel also scores high potential for a contribution from analysis, but with analysis capabilities still less than we would wish. The high-potential, high-capabilities box is, of course, occupied by equipment and logistics.

Table 1: Potential contribution of analysis to understanding seven of the Defence Lines of Development, compared with current analytical capabilities

POTENTIAL CONTRIBUTION OF ANALYSIS	LOW	MEDIUM	HIGH
HIGH	Training	Personnel	Equipment Logistics
MEDIUM	Doctrine	Infrastructure Information	
LOW			

CURRENT ANALYTICAL CAPABILITIES

The reader will probably already have observed that there is one line of development missing from Table 1, namely *organization*. I was not at all clear where it should go. It is important not to confuse organization with force structure. A lot of good analysis is undertaken to advise on force structure, in terms of what force elements are needed at what readiness to meet the needs of defence policy, at either national or NATO level. But, even here, we tend not to look very much at how the overall force structure should actually be organized, as distinct from what it consists of or specific management issues such as deployment cycles. In any case, force structure is very far from being the whole of a defence organization.

3.4 Challenge #3 : Putting it all Together

These considerations therefore led me to my third challenge: "putting it all together". If we are making changes across the lines of development, as we are in carrying through a defence transformation, then we are likely to want to look at each in some detail, with specific, tailored models. But, in the end, we want to achieve a single coherent defence posture, a single coherent defence organization. This is not just a military organization, of course, but one which starts with top-level political direction and includes a wide range of both military and civilian elements, bringing together policy-making, finance, acquisition, operational planning, and so on, in a coherent and efficient manner.

I am not sure that we are very good at taking this holistic view and assisting our senior political and military decision-makers in this final synthesis, although I know that some of the other papers in this

symposium will address it. Perhaps we can learn from some of the so-called 'strategic OR' that goes on in the commercial and industrial sectors. But, in any case, I think that it's a major challenge that we can too easily forget.

3.5 Challenge #4 : Making a Difference – Engaging the Senior Decision-Maker

This paper was originally going to end with Challenge #3 above, since "putting it all together" did indeed seem an appropriate end-point. But my mention in the preceding paragraph of the really key players in transformation, namely our senior political and military decision-makers, suggested one further, overarching challenge. Discussion of models and methods is all very well, but if we want to make a difference then we have got to engage the attention our senior decision-makers and to convince them that we have something useful, and usable, to say. In other words, they have got to 'buy into' our analytical efforts.

If we are going to achieve this, then we have both longer-term and shorter-term challenges. First, we have to create a receptive environment for the use of analysis, in which decision-makers have been encouraged, and not disappointed, in the belief that we have something useful to say, and in which trust can build up. Inevitably, this takes time. Then, in addressing the topic of the moment - whatever it is - we have got to understand rapidly the issues as they are seen by the senior stakeholders; scope and structure our analysis appropriately; make sure it is ready when it's needed; and communicate it in the right way. If we don't, then we are wasting our time, however technically sound our work might be.

So this is my final challenge: how to engage senior decision-makers with our analysis and ensure that it's of value. I suspect that this is the biggest of them all, so is an appropriate point on which to end.

4.0 REFERENCES

[1] Stenton, F M. *Anglo-Saxon England*. 3rd edition. Oxford University Press (1971). Pp 263-265. See also the *Wikipedia* article on Alfred the Great, http://en.wikipedia.org/wiki/Alfred_the_Great.

[2] Air Ministry. The Origins and Development of Operational Research in the Royal Air Force. Air Publication 3368. London: HMSO (1963).

[3] Kirby, M W. *Operational Research in War and Peace: The British Experience from the 1930s to 1970*. London: Imperial College Press (2003).

[4] Waddington, C H. *OR in World War II: Operational Research against the U-Boat*. London: Elek Science (1973).

[5] Shrader, C R. *History of Operations Research in the United States Army, Volume I: 1942-1962*. Washington DC: Office of the Deputy Under Secretary of the Army for Operations Research (2006). Obtainable from the US Government Printing Office, Washington DC.

[6] Morton, N W. A brief history of the development of Canadian military operational research. *Operations Research* **4**, 187-192 (1956).

[7] Blackett, P M S. Scientists at the operational level (1941). Reprinted in: Keys, Paul (ed). *Understanding the Process of Operational Research: Collected Readings*. Chichester: John Wiley & Sons (1995).

[8] Kahn, H. *On Thermonuclear War*. Princeton University Press (1960).

[9] Smith, B L R. *The RAND Corporation*. 1st edition. Cambridge, Massachusetts: Harvard University Press (1966).

[10] Quade, E S (ed). *Analysis for Military Decisions: The RAND Lectures on Systems Analysis*. 1st edition. Chicago: Rand McNally (1964).

[11] Hitch, C J, and McKean, R N. *The Economics of Defense in the Nuclear Age*. 1st edition. Cambridge (Mass): Harvard University Press (1960).

[12] Forder, R A. Operational research in the UK Ministry of Defence: an overview. *Journal of the Operational Research Society* **55**, 319-332 (2004).

[13] Taylor, B, and Lane, A. Development of a novel family of military campaign simulation models. *Journal of the Operational Research Society* **55,** 333-339 (2004).

[14] Moffat, J. *Command and Control in the Information Age: Representing its Impact*. London: The Stationery Office (2002).

[15] Irwin, C, and Morley, A. Drawing lessons from the past: historical analysis of stabilization operations. *Journal of the Royal United Institution for Defence Studies* **150** (1), 49-53 (February 2005).

[16] Hossack, A D, and Sivasankaran, K. Success factors in CT/COIN campaigns: preliminary results arising from current research. In: Woodcock, A E R, and Rose, G (eds). *The Cornwallis Group X: Analysis for New and Emerging Societal Conflicts.* Cornwallis, Canada: The Canadian Peacekeeping Press (2006), pp 469-491. Online at: http://www.thecornwallisgroup.org/workshop_2005.php (accessed 15 April 2010).

[17] Bolland, B, and Purvis, M. *Coercive Operations and their Influence on the Equipment Programme.* Presentation given at the 20th International Symposium on Military Operational Research, 2003. http://ismor.cds.cranfield.ac.uk/ISMOR/2003/bolland.ppt (accessed 15 April 2010).

[18] Bolland, B. Re-thinking coercion. *Journal of the Royal United Institution for Defence Studies* **151** (4), 42-46 (August 2006).

5.0 COPYRIGHT AND DISCLAIMER

The views expressed in this paper are those of the author and do not necessarily reflect those of Dstl or any other part of the UK Ministry of Defence.