NORTH ATLANTIC TREATY ORGANISATION

RESEARCH AND TECHNOLOGY ORGANISATION

RTO PUBLICATION **SAS-087**

NATO Guide for Judgement-Based Operational Analysis in Defence Decision Making

(Guide OTAN pour l'analyse opérationnelle basée sur le jugement dans la prise de décision de défense)

Client-Oriented Volume

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Preface

The System Analysis and Studies (SAS) Panel, which is one of the technical panels within NATO's Research and Technology Organisation, commissioned a Task Group (TG-034, SAS Activity 087) to write a Guide for judgement-based Operational Analysis (OA). After an exploratory phase in 2009 which addressed, at the Panel's request, the issues surrounding use of judgement in Operational Analysis, the TG formally started its work Spring 2010 and finalised the code at the end of 2011.

The defence environment is complex and dynamic. The nature of modern conflict, rapidly changing technology, changed attitudes to risk, and the sheer diversity of actors from different cultural backgrounds are factors in that environment. Defence decision makers are confronted with an increasing operational complexity which has strategic implications. Purely mathematical methods of analysis may not be helpful in these circumstances; increasing use needs to be made of methods which rely upon the structured elicitation and synthesis of judgements.

Judgement-based OA (called 'soft' OA in the academic world to contrast with 'hard', mathematics-based OA) is increasingly used to support defence and security decision making both at national and NATO levels. Such decisions need to be defensible when subject to scrutiny and decision makers must have confidence that the material presented to them is the best available so that the decision risk is contained. However, judgement-based analysis cannot be subjected to conventional tests of mathematical rigour, so an alternative strategy is needed.

This volume is directed to the clients of such judgement-based OA studies. These include decision makers, study sponsors, end users and other stakeholders. Its purpose is to:

- Create an understanding of what judgement-based OA is, and what it can offer;
- Identify the requirements for the client group in sponsoring and guiding judgement-based OA studies; and

- Show how a judgement-based OA study is carried out in order to maximise the validity, credibility and acceptance of the study and its outcomes.

The analyst-oriented volume of the Guide ("Code of Best Practice for 'Soft' Operational Analysis", the CoBP itself) describes the overall study methodology, the study process, the 'actors' involved and their roles and responsibilities, the achievement of validity, credibility and acceptance, and the communication with the client. The TG proposes that its work be complemented by an education program to introduce the opportunities offered by judgement-based OA to decision-making bodies within NATO and Partner Nations, and to show how to make best use of it. It is expected that once published, the CoBP will be reviewed and revised in the light of experience in practice. A third volume is a brief summarising brochure for (high-level, 'executive') decision makers explaining key aspects.

The adoption of the Guide is expected to increase significantly the acceptance of judgement-based studies within the military and defence-oriented operational analyst communities. This will, in turn, be beneficial to the quality of defence decision making through the enhancement of the versatility of OA support, to both operations and in longer term support of strategy and defence planning.

The analyst-oriented volume describes the TG's working procedure, and provides additional background information and account. The TG has restricted itself in referencing the material in the main text of the analyst and client-oriented volumes in order to not distract the reader too much from the content. By its nature, the Guide is a work of review and representation of relevant ideas. References are given where appropriate and are not designed to be exhaustive, or even comprehensive. The analyst-oriented volume contains lists of references; the client-oriented volume only to a few key ideas. The last page of this volume lists some references recommended to interested clients.

The TG acknowledges with gratitude the contribution by reviewers from both academia and defence organisations of drafts of the Guide. Reviewers of this client-oriented volume were: Dr. R.A Forder (formerly at Defence Science & Technology Laboratory, United Kingdom); Lt.Col. J-H. Pay (Norwegian Defence Research Establishment FFI, Norway); Cpt.Cdr. F.S. Ordean and Lt.Col. I. Psomas (Joint Assessment Branch, Joint Force Command Brunssum, NATO).

SAS-087 Task Group Membership List

AUSTRALIA	N.J. Curtis (main author)
CANADA	M. Halbrohr
FRANCE	O. de Baysier (until Autumn 2010)
GERMANY	G. Mihelcic C. Wittmann
NETHERLANDS	I.C.L. Bastings D.J.D. Wijnmalen (Chair)
SWEDEN	J. Frelin
UNITED KINGDOM	S.M. Lord G.A. Pickburn
UNITED STATES	Y.H. Wong (as from December 2010)
NATO/ACT	A. Smethurst S. Collins

Executive Summary

Judgement in different guises has been used by military staff whenever assessing problematic situations and making decisions. NATO practitioners have determined that approaches within Operational Analysis (OA) that are predominantly based on human judgement, are an increasingly critical capability needed to support defence decision making. Wider acceptance and employment of judgement-based OA would enable the defence community to enhance its capability to deal with complex, high priority problem issues for which this type of analysis is particularly suited.

The development of the "NATO Guide for Judgement-Based Operational Analysis in Defence Decision Making" was commissioned by the System Analysis and Studies Panel within NATO's Research and Technology Organisation. Its purpose is:

- To create an understanding of what judgement-based OA is;
- To clarify what judgement-based OA can do to help address problematic situations, and what people can expect from it; and
- To provide guidance on how a judgement-based OA study should be carried out to maximise validity, credibility and acceptance of the study and its outcomes.

The Guide is published as three volumes: an analyst-oriented document (the "Code of Best Practice for 'Soft' Operational Analysis") setting rules of the road for analysts, this client-oriented document, and a brief summarising brochure for (high-level, 'executive') decision makers explaining key aspects. This volume aims at familiarising decision makers and their staff with the potential of judgement-based OA. It addresses the following questions:

- What is judgement-based OA?
- Which problematic situations require judgement-based OA?
- How does judgement-based OA add value?
- What does a judgement-based OA study look like?
- What is expected of me, the client?

- What does the analyst bring to achieve validity, credibility and acceptance?
- How can a Code of Best Practice protect the client from threats to the study?

Synthèse

Les états-majors ont utilisé le jugement sous différents aspects, à chaque fois qu'ils ont évalué des situations problématiques et pris des décisions. Les professionnels de l'OTAN ont établi que les approches utilisées lors de l'analyse opérationnelle (AO), qui sont principalement basées sur le jugement humain, représentent une capacité critique croissante indispensable au soutien des prises de décision de défense. Une meilleure acceptation et une meilleure utilisation de l'AO permettraient à la communauté de la Défense d'améliorer sa capacité à traiter des problèmes complexes et hautement prioritaires pour lesquels ce type d'analyse conviendrait particulièrement.

L'élaboration du « Guide OTAN pour l'analyse opérationnelle basée sur le jugement dans la prise de décision de défense » a été soutenue par la commission sur les études et l'analyse de systèmes de l'Organisation pour la Recherche et la Technologie de l'OTAN. Son objectif est de :

- Sensibiliser à l'AO basée sur le jugement ;
- Clarifier la manière dont l'AO basée sur le jugement peut aider à traiter des situations problématiques, et ce que les personnes peuvent en attendre ; et
- Fournir des orientations sur la manière dont une étude par AO basée sur le jugement doit être menée afin d'optimiser la validité, la crédibilité et l'acceptation de ladite étude et de ses résultats.

Le guide est constitué de trois ouvrages : un document d'analyste (le « Code de bonnes pratiques pour une analyse opérationnelle 'en douceur' ») définissant les règles à suivre par les analystes, le présent document orienté « client », ainsi qu'un court résumé sous forme de brochure à l'attention des décideurs (de haut niveau, de « l'exécutif ») expliquant les principaux aspects de cette analyse. Le présent ouvrage a pour but de familiariser les décideurs et leurs états-majors avec le potentiel de l'AO basée sur le jugement. Il aborde les questions suivantes :

- Qu'est-ce que l'AO basée sur le jugement ?
- Quelles situations problématiques requièrent une AO basée sur le jugement ?

- En quoi l'AO basée sur le jugement est-elle source de valeur ajoutée ?
- A quoi ressemble une étude par AO basée sur le jugement ?
- Qu'attend-t-on de moi, le donneur d'ordres ?
- Que réalise l'analyste pour apporter à l'étude validité, crédibilité et acceptation ?
- De quelle manière un code de bonnes pratiques peut-il rassurer le donneur d'ordres contre les craintes que suscite l'étude ?

Chapter 1 – WHAT IS JUDGEMENT-BASED OA?

The science of assisting decision makers to find and compare options so that capability development or operational decisions may be made is known to the NATO community as Operational Analysis (OA) and in the academic world as Operational Research or Operations Research. No distinction of application is implied by the substitution of 'Analysis' for 'Research'. Although definitions of OA abound, below are two examples of clear and concise descriptions:

- '… the application of scientific methods to assist executive decision makers' – *NATO Code of Best practice for CJTF and Component Commanders*; and
- '… the discipline of applying advanced analytical methods to help make better decisions' or more simply as 'the science of better' – *UK Operational Research Society*.

For the specific purpose of this document, the following description of OA is used to encapsulate the common features:

- An interdisciplinary science which assists better decision making through identification and comparison of change options designed to improve problematic situations.

All decisions made by decision makers will involve judgement to some extent. However, this is distinct from the notion that, in some cases, the material used by the decision makers will be derived from a methodical process that uses human judgement and predominantly non-mathematical models: judgement-based OA.

Judgement-based OA is used to inform those decisions where the real issues at stake and the factors to be taken into account are incompletely understood, where many and possibly conflicting viewpoints are involved, or where our understanding of the actual interactions involved is limited. Many real-world issues such as those found in the military and security domains can be described in this way (*see the case study on Page 2 for an example*). The term 'soft' is used in the academic community to denote the methods used in such OA studies as often much of the input and output comprises qualitative/ subjective information.

Case Study – A Real-World Example: Advice to the Deployed Commanders in East Timor

The deployed commanders in East Timor following the 1999 independence referendum were faced with a challenging issue – what *could* be the effect of the deployments on the local populations? This was clearly an area outside their usual expertise and experience as it involved non-military considerations, an unfamiliar physical and human environment and it was not feasible to reduce all the issues to a single quantitative measure that the commander could manage. Instead a study was made to investigate the triggers and causes that led to disruptive events in that country's 400 year history. The findings were used to forecast possible events that could occur as the population reacted to the changed socio-political environment. While the source material and analytical process was well documented it was primarily based on interpretation and judgement of material collected by the analyst. Similarly the use made of the material was to guide the commander's judgement in his decisions on *possible* courses of action.

Cases where judgement-based OA is used to understand issues described above can be contrasted to cases where most of the issues of a problematic situation are known and there is a mathematical or logical process to derive more quantitative insights. The term 'hard' is often used here, though in reality there is no rigid distinction and most decisions comprise both 'hard' and 'soft' elements. An easy way to understand the differences in emphasis is to note that 'hard' OA is more likely to be based on verifiable *facts* and numerical *data* via objective modelling whereas 'soft' OA is predominantly founded on *judgement* and more likely to lead to a body of evidence allowing exploration and comparison of *possibilities* though incorporation of subjectivity. Many real-world issues belong to the latter category; particularly high-level questions relating to strategy, capability development and major system acquisitions.

The aim of judgement-based OA is to harness and exploit the latent knowledge and judgement of all stakeholders in a decision in a coherent and auditable way. Once that has been achieved by means of the study methods addressed by the Guide, the findings of the study can be laid before the responsible executive decision maker as evidence to assist his final sovereign judgement.

The output of a 'hard' OA study will always have a quantitative aspect, though it may not be couched in terms of a single solution as sensitivity and 'what if' issues should be included. In other cases, competing options without a common reference point may be encountered. For instance, decision makers may address

an issue in terms of cost versus reliability where the data has been presented based on strong 'hard' and verifiable mathematical OA principles. In this case the two measures to be traded (cost and reliability) can be realistically optimised (respectively minimised and maximised) as single solutions. However, the relative value of these two measures is a matter of debate between the decision makers.

The output of a judgement-based OA study may also have some quantitative flavour, depending on the methods used, but in other cases it may be a body of well-structured evidence that allows the decision maker to move his thinking forward. In the extreme cases of judgement-based OA, neither the options nor the means of comparing them will be known in the first instance. A mathematical solution is extremely unlikely as is the notion of optimisation. Considerable judgement will be required even in the formulation of the issues and further subjective techniques will be required as the study unfurls. Nevertheless, decision makers still need to have material on which to base their decisions and thus the analyst and client community must have a sound strategy to deal with these cases.

In fact, there is a continuous spectrum of study types and many studies are distinctly hybrid in nature. In particular, most 'hard' OA studies benefit from an initial judgement-based problem-structuring phase to bring out divergent stakeholder perceptions, clarify issues and objectives, identify a full range of options, etc., while some inputs to 'hard' models will inevitably fall more into the category of judgement but this does not mean that they become a judgement-based study.

For the client of the analysis, the critical issue is not so much the detail of the judgement-based OA methods used in a study but more the validity, credibility and acceptance of the results and how they are used by decision makers. Where there is measurable data, established procedure and, critically, verifiable mathematics, the material presented to the decision makers can be readily and precisely explained and defended. In judgement-based studies there is a danger that the method will be the subject to as much scrutiny by the decision makers as the results. This may be particularly apparent where those involved in the decision have an engineering, mathematics or science background and feel uncomfortable with the style of judgement-based OA. Such perceptions may lead to delay or rejection of a proposal that the clients intimately involved in the study are proposing. For judgement-based studies an analyst-oriented Code

of Best Practice (CoBP; published as a separate volume of the Guide) is needed to ensure that the best possible advice was presented to the decision makers.

This volume of the Guide aims to show clients how to commission, guide and use judgement-based studies with confidence, resulting in less decision risk to military procedures, organisations and acquisitions. It is intended as a reference to provide guidance to potential clients. This volume therefore describes:

- The nature and scope of judgement-based OA;
- Potential uses of judgement-based OA;
- How a judgement-based study will progress;
- The requirements on and obligations of the client;
- The expectations and needs of the analyst; and
- Potential pitfalls and their avoidance.

Three key aspects of judgement-based OA should be noted:

1) It enables progress to be made for some otherwise intractable and complex decisions.
2) It involves a creative journey of discovery and learning that can be used to the advantage of decision makers.
3) The inherent uncertainty of complicated decision situations that the defence sector faces, leads the client for judgement-based OA to what are perhaps his most pressing concerns – its validity, credibility and acceptance. Study methods must therefore be well documented to withstand scrutiny.

Judgement-based OA is in many ways a collaborative adventure involving subject-matter experts, clients, analysts, and facilitators of workshops with stakeholder groups. Good practice therefore requires that all are aware of their roles and responsibilities. This volume of the Guide is focused on issues regarding general aspects of judgement-based OA, particularly from the client's viewpoint, and on how that contributes to rigorous and auditable quality control of both process and content.

The Guide does not compare, assess or recommend individual methodologies or methods and techniques. Many textbooks and articles that attempt to do that

already exist and the companion analyst-oriented volume (see its Annex B) gives a selective list and a brief summary of methods and techniques.

In summary, judgement-based OA is characterised by its methodical use of human judgement and predominantly non-mathematical models. It is used where there are real-world problematic situations that cannot be solved by the application of predominantly mathematics-based sciences.

Chapter 2 – WHICH PROBLEMATIC SITUATIONS REQUIRE JUDGEMENT-BASED OA?

There is no prescribed single way to identify if and when a judgement-based analysis is needed. If there is uncertainty or disagreement about the real issues at stake and the factors and interactions that need to be taken into account or if there are several potential ways to approach the issues, then, at the very least, some sort of initial, judgement-based analysis to structure the problem is required. If, having defined the issues and structured the problem, one then needs to analyse interactions where understanding of the real world is insufficient to construct explicit, mathematics-based cause and effect models, then deeper judgement-based analysis can be used to progress the study.

The check-list in Table 1 expands on these basic principles. It should be stressed that 'ticking' several of the items on the list should not be seen as a failing; it is just a recognition of reality. As will be seen, the list can be used to advantage by the client.

Table 1: Indicators of the Need for a Judgement-Based OA Study[1].

❑ Not much is initially known about the nature of the problematic situation and its boundaries (what matters and what does not).
❑ Not much is initially known about defining elements of the problematic situation and how they may be interrelated.
❑ Not much is initially known about who the stakeholders are and in what manner they may be directly or indirectly affected, their viewpoints and what they are worried about.
❑ Not much is initially known about goals, objectives and measures of effectiveness or merit that may be relevant.
❑ Not much is initially known about what can and should be changed towards improvement, and under what conditions or according to what criteria a change will be regarded as an improvement.
❑ Not much is initially known about the data needed, its relevance, availability and reliability.
❑ Not much is initially known about the way in which changes in context will affect the problematic situation, its improvement and the study design to achieve it.
❑ Power, emotion, politics and ethics will most likely come into play, but not much is initially known about how and to what effect.
❑ Different people say different things (or express different views) about the same issue.
❑ Not much is known about key interactions of human cognition, beliefs and behaviour.
❑ Not much is known about the context of grand-scale issues that have no clear end-points, transcend specific domains, and have significant political or public policy implications (e.g. counter-terrorism).
❑ Not much is known about where any possible resolution will most likely have side-effects attached to them that are undesirable by stakeholders.

[1] Based on: Eden, C. and Ackermann, F., "Viewpoint – Where next for problem structuring methods", Journal of the Operational Research Society, 57, 2006, 766-768; Franco, L.A. and Montibeller, G., "Facilitated modelling in operational research", European Journal of Operational Research, 205, 2010, 489-500; Mingers, J., "Soft OR comes of age – but not everywhere!", Omega, 39, 2011, 729-741; Pidd, M. (Ed.), "Systems modelling, theory and practice", Wiley, 2004, ISBN 0-470-86731-0; Pidd, M., "Tools for thinking – Modelling in management science", Wiley, 1996, ISBN 0-471-96455-7; 3rd Edition October 2009 (©2010 ISBN 978-0-470-72142-1).

Examples where judgement-based analysis can assist decision makers include complex, often high-priority, problem issues such as:

- Broad issues that are at an early stage of formulation (e.g. policy development);
- A wide range of concepts to replace an old capability being examined, thus avoiding premature adoption of a particular solution;
- Completely new areas to examine (e.g. to address newer forms of conflict such as irregular/asymmetric warfare);
- Acquisition where there are aspects of capability which may need to be traded-off (e.g. mobility versus lethality); or
- Planning of military-led campaigns that need to be identified and examined within a Whole of Government or comprehensive approach context where 'hearts and minds' issues are a major factor (e.g. counterinsurgency or Nation-building in failing states).

In such cases, the use of judgement-based analysis may be a necessity rather than an option if progress is to be made (*see key aspect 1 in Chapter 1).* Any attempt to treat the issue as something that can be logically addressed, formulated and solved in a purely mathematically way will be fundamentally flawed, and, more critically for the client, will lead to rejection or delay of a decision.

Cases where a judgement-based approach is not required, at least after the problem-structuring phase, include areas where clear objectives and associated quantitative measures of effectiveness can be defined and where our knowledge base allows explicit, objective modelling of the key interactions. Examples include: inventory management and scheduling of replacement parts or consumables, maintenance regimes, workforce planning or optimum search patterns. But even in these 'clear-cut' cases, there will always, at some level of the hierarchy of client decision makers or at some stage of the study process, be different interpretations of data, results or findings; there will be experts providing estimates based on judgement; and there will be group discussions to arrive at a consensus about, for example, the problem formulation to begin with. All these matters require approaches that are based on judgement and thus fall into the broad category of judgement-based OA.

It is important to place judgement-based OA in context. A helpful taxonomy of describing issues is to use the established terms of puzzles, problems and messes (Table 2)[2]. Together, these three terms describe what is referred to as the 'problematic situation', though the term 'problem' is often used to denote both a specific case or any issue examined in an OA study. Short descriptions of these areas follow, though it should be noted that these terms are selected points across a spectrum, not discrete cases. Nevertheless, it is a useful concept and many studies seem to deal with a problematic situation that falls naturally into one column or another:

- '*Puzzles*' – These are cases where: (1) The issue is clear; (2) There is probably an agreed way of addressing the issue; and (3) A limited number of relevant, well defined and understood measures can be evaluated by verifiable mathematics. In general, the formulation of the issues will be readily agreed by the client and analyst and the results will be easy to validate.
- '*Problems*' – These are cases where: (1) The intent of the study is clear though there might be several ways of addressing it; (2) There will be generally established ways to design the study; and (3) Quantitative results will be generated using reasonably well-understood measures though there will be some judgement and therefore subjectivity involved in their determination. The analyst and client will be able to agree on a way to address the study ('agreeable') though the client may claim flexibility as to the actions that may be taken in exploiting its results. This latter point is not necessarily a bad thing.
- '*Messes*' – These are cases where: (1) There is a perceived need to investigate an area though it is not clear what the issue is or indeed how to even describe the decision context, possibly involving stakeholders who have multiple perspectives and disagree about what needs to be done; (2) There is no obvious way of tackling the issue; and (3) Judgement will be used extensively in developing and describing possible ways forward which may include extensive qualitative statements. Involvement of the many stakeholders means that agreement on the formulation of issues is not guaranteed and the results of the study may lead to wide but healthy debate.

[2] What follows is to a large extent based on M. Pidd's work and references therein (see footnote 1).

Table 2: Characteristics of Puzzles, Problems and Messes.

	Puzzle	Problem	Mess
Description	Well-defined issue with a specific solution that can be worked out.	Well-defined issue, but with no single solution or approach.	Complex issue which is not well defined.
Formulation of the Issues	Agreed objectives achieved through logical analysis.	Agreeable after negotiation between clients and analysts, and input by other interested parties.	The lack of clarity and agreement of the issues themselves will make formulation disputed.
Typical Advice	Optimal solution.	Preferred option based on ranking.	Possible courses of action.
Validity of the Advice	Accepted after scrutiny of mathematics and calculations.	Even though the results are reached by agreed methods, the conclusions can be disputed thus leading to informed debate about the actions to take.	The advice will lead to an informed debate about the pros and cons of several possibilities for the way ahead.

The need to use judgement-based OA will increase towards the right-hand side of Table 2.

Figure 1 shows that when moving from puzzles to messes, the clear-cut nature of the problematic situation will diminish, whilst reliance on judgement will increase.

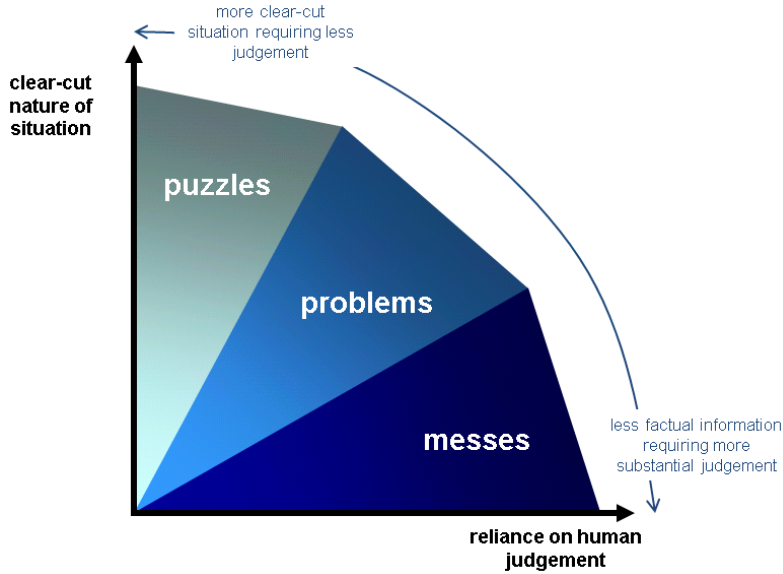

Figure 1: A Spectrum of Problematic Situations and Their Clear-Cut Nature versus Reliance on Human Judgement.

The initial design of a judgement-based approach should be left to the analyst though the client will need to understand and agree the way ahead. The material in this volume will help to identify the likely course of action that the analysts will take and thus will inform initial discussions, provide a foretaste of the approach to be taken and guide client actions and expectations. The companion analyst-oriented volume will provide greater detail of how the study may be conducted.

Considerable value may be added by adopting elements of a judgement-based approach, even for a study which may appear at first glance to be puzzle-like. The client is advised to use the check list given in Table 1 to see if consideration of any of the points provides better insights.

Finally it should be noted that Chapter 1 already pointed out that there is a continuous spectrum of study types and many studies are distinctly hybrid in

nature. A predominantly judgement-based approach may include therefore some 'hard' or quantitative elements. This is referred to as 'complementarity': 'soft' and 'hard' methods and techniques complement each other. It is often the case that the analyst needs to dig deep into a problem to, for example, test feasibility or consequences of adopting a particular option.

In summary, a judgement-based OA approach should be taken when the issues are not initially clear or agreed, where multiple perspectives across stakeholders have to be dealt with, or there is no obvious and clear way to conduct the study owing to an insufficient understanding of the real world.

Chapter 3 – HOW DOES JUDGEMENT-BASED OA ADD VALUE?

Judgement-based OA is in itself conducted as a creative journey of discovery and learning (*see key aspect 2 in Chapter 1*). This results from the needs imposed by the nature of 'problems' and 'messes' as opposed to 'puzzles'. Judgement-based OA uses models both for visualisation of the issues and for manipulation to explore possible changes or evaluate options. Such models may include the beliefs, insights and expectations of people who wish to use the model as a means of communication and stimulus of debate and reflection (i.e. support their thinking) to create or improve a mutual understanding of each other's viewpoints and positions. This creation or improvement of mutual understanding is part of the learning process.

As such, judgement-based OA adds value through:

- An improved shared understanding, through a recognition to consider all sides of the issue;
- An enhanced sense of common purpose;
- A greater commitment to a general way forward;
- The discovery and consideration of alternative options;
- The development of acceptable solutions or ways forward to improve the problematic situation;
- Harnessing of latent knowledge and the systematic gathering and analysis of information; and
- The use of an approach that recognises people's different cognitive viewpoints and belief systems.

All of these items contribute to the development of a shared common picture of the issues, even if there is disagreement on detail. Thus an informed climate of debate is developed (*see case study on Page 14*).

Case Study: Creative and Cooperative Issue Exploration – The Army of Tomorrow Study

A Seminar War Game (SWG) on the 'Army of Tomorrow'' examined military operations of the future by incorporating both military and civilian (e.g. police, diplomats, aid agencies, scientists, and others) judgements and perspectives. It provided a means to 'meld' these diverse judgements together in order to produce insights into future operational challenges and opportunities.

The judgement-based OA approach provided a means to engage stakeholders who came from different cultures and had very different points of view.

Key elements of judgement-based OA that must be justified and explained include:

- The methodology used (defined as *'the particular combination of methods or techniques used in the study'*).
- The particular methods or techniques used (each is *'a structured set of guidelines or rules or algorithms to achieve some clear well-defined purpose'*).
- Models used in the study (each is *'a representation of (a part of) reality as seen by a number of people who wish to use the model to understand, manage, or improve that reality'*).

In this context we refer to a model as an abstraction of reality that supports an OA study. Use of models lies at the heart of all types of OA, but they may not necessarily involve mathematics. Famously, they may even not be right! (*see text box below*).

'All models are wrong!'

It is only meaningful to debate validity of a method at the point of application, i.e. in the context of the decision problem being addressed.
"All models are wrong, but some are useful."[1]

Types of judgement-based OA models that can add value include the following:

- Rich pictures allowing a visual representation of the issues on a single sheet of paper.

[1] G.E.P. Box, N.R. Draper, "Empirical Model-Building and Response Surfaces", Wiley, 1987.

- Discrete-event linked diagrams showing the stages involved in a process of change and development.
- Influence diagrams showing how discrete elements in a system are linked (sometimes as cause-effect relationships in 'causal maps') and the trade-offs that may be required.
- Mind maps (or 'concept maps') to explore concepts and to identify and classify issues.
- SWOT matrices pairing Strengths and Weaknesses with Opportunities and Threats.
- Hierarchical diagrams of concepts and their relationships.
- Maps of benefits and their mechanisms of generation.

When considering the types of problematic situation we may wish to address, the differences between the 'puzzle' and 'mess' ends of the spectrum in Table 2 identify benefits that can be exploited using a judgement-based approach (Table 3).

Table 3: Benefits of Taking a Judgement-Based Approach Based on the Differences between Predominantly Judgement-Based and Predominantly Mathematics-Based OA[2].

	Differences: 'Mess' vs. 'Puzzle'	Benefits of Judgement-Based Approach
Study Outcomes	Explorative and qualitative leading to insights and learning rather than seeking statistically valid outputs.	Allows management of the way forward rather than finding *the* solution.
Study Purpose	Must be discussed and reviewed after much analysis rather than deduced through problem analysis.	Avoids going too early to a solution.
Problematic Situation	Mental construct formulated in terms of a manageable 'problem' or 'mess' rather than a logical process to reach a solution.	Encourages longer-term thinking and the ability to reconcile different objectives, perspectives and values.
Process – Study	Stages emerge as appropriate instead of in a planned and sequential manner.	Iterative interpretation.
Process – People	Clients (and other stakeholders) contribute by participation and informed judgement (sometimes affected by power and emotion), in addition to (possibly sparse) hard data.	Biases are identified and accommodated, with clients identifying creative options.
Methodology	Predominantly interpretative and subjective instead of predominantly factual and objective.	Allows freedom to explore possibilities through an interpretative approach.
Models	Representations of the problematic part of the *perceived* world rather than the *real* world.	Conceptual visualisation.
Data	More observer-dependent and subjective (affected by a broader range of sources of uncertainty) than observer-independent and objective.	Uncertainty is treated in a creative, explorative manner, allowing 'what if' thinking.

[2] Partly based on M. Pidd's work (references listed under Chapter 2's footnote 1 on Page 7).

Many of the positive aspects mentioned so far stem from the need in judgement-based OA for a divergent discovery phase (Figure 2) where all aspects of the issue are discussed and explored. The divergent phase enables stakeholders to minimise the risk of pre-conceived notions becoming dominant before the 'problem' has been derived from the 'mess'. This should be compared with the case for more structured issues where there will be steady convergence from the start. The client must expect and be comfortable with this initial divergent problem structuring stage and be ready to realise the value it might add.

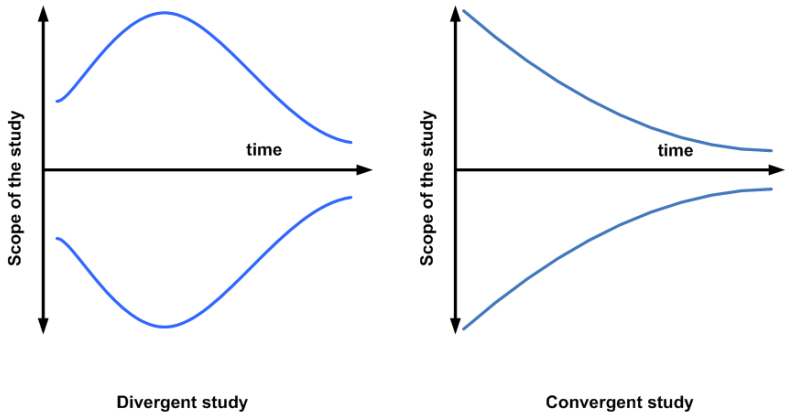

Figure 2: Comparison of the Divergence and Convergence in Judgement-Based (left) and Mathematics-Based (right) OA Studies.

In summary, judgement-based OA provides value-adding and explorative methods to identify possible ways to tackle ill-defined issues. The value added includes: harnessing of latent knowledge, the involvement of stakeholders, the exploration and formulation of the problematic situation, and the creation of a model of that situation which can be agreed on and exploited to inform decisions.

Chapter 4 – WHAT DOES A JUDGEMENT-BASED OA STUDY LOOK LIKE?

Although judgement-based OA studies will follow the same general principles, none will be alike as each investigation will tend to be unique. The variable factors are, typically: the subject matter, the desired outcome and the dynamic relationships of the combination of the client and analyst. In general, any OA study will follow the formula of:

- Identify the stakeholders;
- Achieve consensus on the issues;
- Describe the system of interest to the stakeholders and benefits they seek from it;
- Identify the system measures of performance and benefit;
- Generate change options; and
- Model the system of interest, so that change options can be evaluated for the benefits each will deliver.

An OA study follows an iterative process which allows the study team (i.e. the clients, the analysts and other stakeholders) to work collaboratively towards a developing goal. Decision makers, faced with a need to formulate a plan of action, will express their predicament as a problematic situation to which some structure should be given. Analysts are asked to suggest a design for a study of the problematic situation; the design evokes methods, models and data in an iterative, and hopefully convergent, programme of analysis which may include objective knowledge from the worlds of science, mathematics and engineering. This process can be described through a four-phase process[1] of:

- Appreciation;
- Analysis;
- Assessment; and
- Action.

[1] Based on Mingers, J. and Brocklesby, J., "Multimethodology: Towards a framework for mixing methodologies", Omega 25, 1997, 489-509.

This process is in many ways akin to the military OODA loop process of Observe, Orient, Decide and Act. Figure 3 shows the iterative process of a judgement-based OA study, where the goal of the study may not have been apparent at the start and indeed may change several times during the process. During the process there are also key deliverables that have to be agreed upon by clients (i.e. their decision makers).

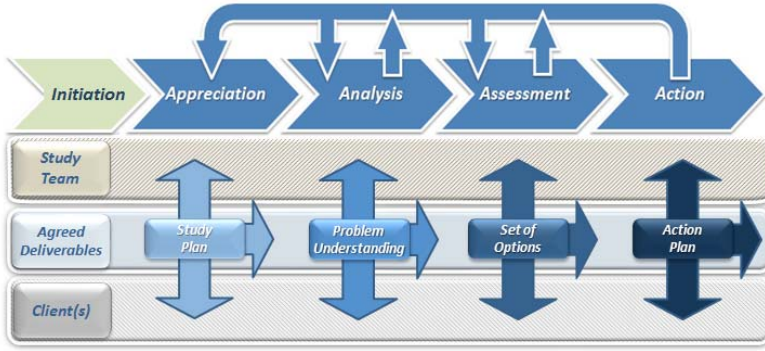

Figure 3: The Iterative Judgement-Based OA Study Process.

Within these guidelines many possible paths may be taken for any given study (Table 4), involving various methodologies or methods, all of which will inform the client and, ultimately, be useful to a decision maker. The key aspects are the continuing dialogue between the client and the analysts and iterative revision of the models and options. The four phases should therefore be used in an iterative and complementary manner. While Figure 3 is also applicable to a 'hard' OA study, the degree of iteration, reinterpretation and revision is likely to be much higher for a judgement-based one because of the inherent uncertainty.

Table 4: Typical Elements of a Judgement-Based OA Study.

Appreciation:

- Hold workshops with stakeholders (possibly including subject-matter experts) to gather their views of the problematic situation.
- Interview clients (including those affected by the study's outcome), actors (participants) and owners (those with power).
- Draw rich pictures based on the views expressed by the stakeholders and agree a common picture.
- Identify the vocabulary needed to describe the system of interest and changes to it.

Analysis:

- Identify relationships between the factors of relevance.
- Visually structure the factors in a diagram or some other type of (visual) model.
- Analyse the map and determine crucial factors for focus.
- Propose measures to characterise the benefits desired and explore some plausible contexts.
- Identify some issues of concern for further in-depth investigation (possibly in a more quantitative analysis).
- Define and use models to investigate and analyse specific problem issues.
- If required, exploit results of models and/or knowledge from standard science.

Assessment:

- Design possible options for changes to the system of interest.
- Do some 'what if' analysis to select a short list of possible options for further study.
- Compare options.

Action:

- Offer support to the client in preparing his preferred courses of action, compare pros and cons.

Figure 4 illustrates how each phase may include tasks (and methods) that are typical of other phases, in a varying intensity and most likely requiring a varying amount of time. Of course, at the global study level, the major emphasis will be on the tasks and the use of methods that are typical of a specific phase (i.e. the diagonal from the lower left corner to the upper right corner of Figure 4), but at the local study level within a phase there may be a similar sequence of study

phases. Consideration of the other phases will also ensure that the overall study goal is kept in mind while working at the specific phase.

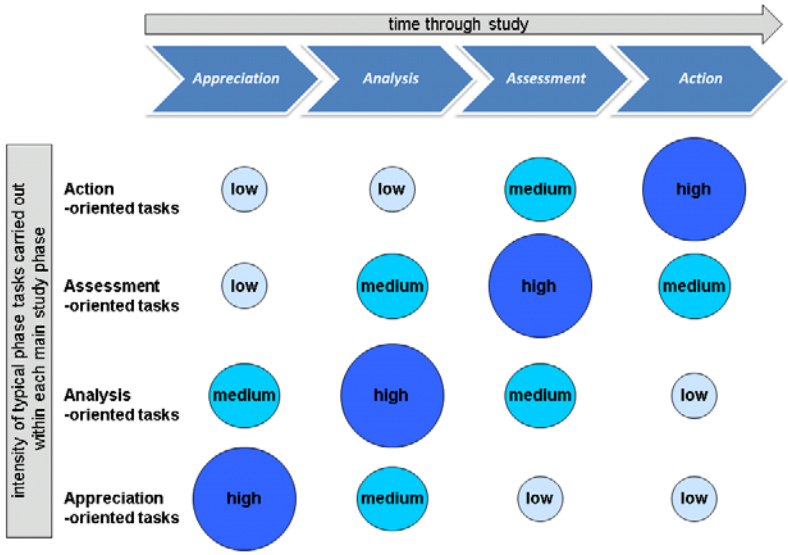

Figure 4: Each Main Phase Requires, in a Varying Intensity, Tasks that are Typical of All Phases.

In general, the appreciation phase is likely to be relatively longer for a judgement-based OA study than that for a more quantitative one. This does not necessarily mean that overall a judgement-based OA study will take longer than a quantitative one; it is just that the balance of formulation and resolution may differ. As a fundamental rule for the initial stage of the study, the analyst will be trying to identify what the real question is and for this reason, much of the initial work will concentrate on the appreciation phase (Figure 4). For this, the analyst has to establish a mutual understanding with the client, his backgrounds and value-sets. The influences of the other stakeholders also need to be catered for (see Chapter 5).

It is often the case that when faced with a ‘problem’ or ‘mess’, an intermediate report may be produced, termed a ‘front end’ or ‘scoping’ study. This is a

valuable way of providing an initial appreciation of the issues (*see case study on this page*). Agreement of a common picture of an issue is a sensible and necessary step (part of the appreciation phase) before work on solutions, options or ways ahead is taken further.

There are a number of methodologies available that can support a 'front end' problem formulation in a scoping study (*see the companion analyst's volume*). Experience has shown that a single technique is rarely enough for a typical study; instead methodologies are adapted or in some cases a multi-methodology approach (*see case study on Page 23*) is taken. The client should not request, let alone insist upon a specific methodology, but instead clearly articulate the aims and objectives of the study and work in partnership with the analyst to design an approach best suited to the study's aims.

Case Study: An Initial Study to Bound Future Work – Future Expeditionary Operations

In NATO a capability manager was asked to consider the future capabilities that might be needed for expeditionary operations. He took the NATO definition of Expeditionary Operations as his starting point; however he found it vague and all-encompassing and therefore not useful to direct or inform capability requirements analysis. Help was needed to delimit and more clearly define expeditionary operations before a study of requirements could begin.

Morphological analysis was used to identify common understanding about the key characteristics for expeditionary operations across various communities within NATO. It was ideal as a tool to deal with the multi-dimensional and non-quantifiable nature of the problem. The study resulted in a more detailed description of expeditionary operations that could be used as the basis for further requirements work.

Case Study: An Example of Multi-Methodology – Maritime Mine Countermeasures

A study conducted for a Nation's Navy on 'New Operational Concepts for Maritime Mine Counter Measures' involved addressing a multitude of aspects and drawing on many different areas of expertise. The study was conducted using a multi-methodology approach in a series of facilitated workshops:

- Methods used in the 1st work package were:
  scenario development and analysis, capability analysis.
- Methods used in the 2nd parallel work package were:
  technology survey and assessment.
- Methods used in the 3rd subsequent work package were:
  morphological analysis (for design), multi-criteria analysis (for evaluation).
- Methods used in the 4th subsequent work package were:
  additional technological analysis, in-depth multi-criteria analysis.

Facilitation played a key role in helping study participants stay focused while addressing the complexity of the problem. Facilitation also helped ensure that participants were aware of the particular perspective by which the current project stage was to be looked upon. The facilitator explained current discussion issue(s), repeated crucial current assumptions, clarified the current activity's position in the chain of activities being undertaken, ensured that conclusions were not adopted without analysing their rationale, managed expectations and managed the changing views regarding ways of structuring and using the base material. The facilitator worked closely with the analyst to progress the study.

Facilitated workshops (*see case study on this page*) are often-used tools in judgement-based OA to provide a venue for stakeholders to meet in order to inform each other, to agree on problem formulations and to create courses of action. A central requirement for conducting successful workshops is an independent, impartial facilitator. The facilitator should observe roles and role behaviour and needs to be aware of the power and politics that may affect the group. It is therefore noted that a facilitator is likely to play an important role by providing, for example:

- Help so that the participants can work together and focus the discussion;
- Management of the elicitation process in an unbiased manner; and
- Facilitation so that workshops are not dominated by individuals.

The typical conceptual environment in which judgement-based methods come into play is shown in Figure 5.

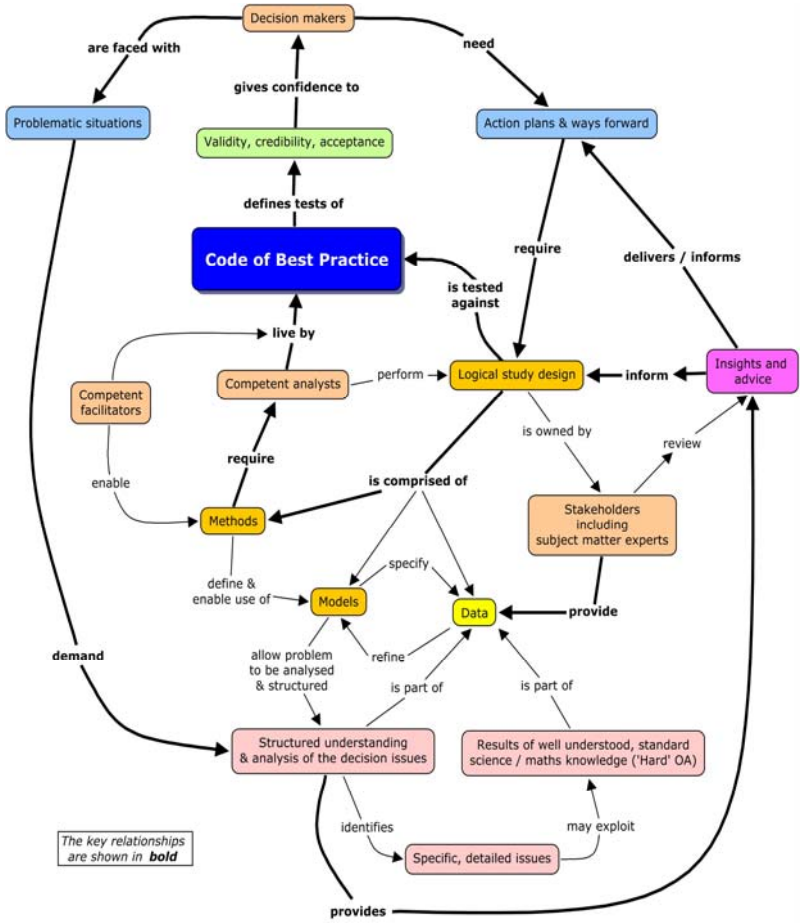

Figure 5: Judgement-Based OA and the Role of the Code of Best Practice.

Figure 5 is itself deliberately displayed as a diagram including relationships between concepts as this is one of the methods that analysts use to portray ('model') systems under study, particularly in cases like this where a process or action is followed. Identification of actions and related stakeholders, linkages, feed-back loops and the influences of each element provide a common picture of the issues involved. Its purpose is creating clarity, focus and enabling communication and debate. While the diagram is at first glance complicated, there are no difficult concepts and it contains all the necessary elements in an easily followed form. All judgement-based studies will follow this basic pattern of developing a model (or models), manipulating the model to explore changes and then proposing options and means to compare them.

As can be seen, the notion of a CoBP is expressed with the above environment in mind. For much of the analytical activity the client is either specifically involved at a node (e.g. 'Decision makers' and 'Stakeholders'), influences or is influenced by a neighbouring node. Thus the client, the problematic situation and the analyst are intimately involved. In this client-oriented volume, Chapters 2 and 7 describe the nature of problematic situations and the requirements of the decision makers; Chapter 3, how the study issues evolve and sometimes require a more quantitative analysis; Chapter 4, the methods used and their input; Chapter 5, the role of the analysts and clients and form of the output; and Chapter 6, study validation, credibility and acceptance.

In summary, despite the uniqueness of each study, there are common approaches that provide a methodical way to conduct judgement-based OA. Considerable emphasis is placed on problem definition or appreciation. The process is iterative and involves extensive interaction of the client and analyst groups.

Chapter 5 – WHAT IS EXPECTED OF ME, THE CLIENT?

In a judgement-based OA study, there may be many issues, each 'owned' by a stakeholder. The number of individuals and interest groups could therefore be significant. As shown in Figure 6, even the notion of 'client' has several meanings including decision makers, customers, sponsors and end users. Some of the clients may also have additional roles as subject-matter experts.

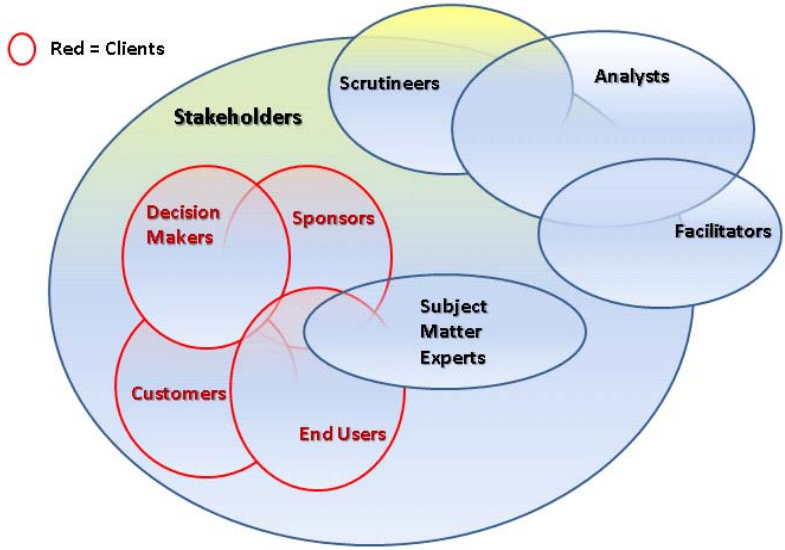

Figure 6: Individuals and Interest Groups Involved in a Judgement-Based OA Study.

The roles and responsibilities of each of the individuals involved should be defined. This is a full list of roles, and in some studies a single individual may take on more than one role. For instance, any of the individuals involved can be a stakeholder. Similarly, an analyst may also work as a facilitator in a study.

Potential participants in a judgement-based OA study are:

- Stakeholder – someone affected by, or involved with making, the decision.
- Clients:
  - Sponsor – the client who owns the study (and often the 'problem').
  - End users – the clients who will benefit from the study's outcomes.
  - Customer – the client who commissions the study and pays the bill.
  - Decision makers – the clients with influence and power to decide on issues and effect change.
- Others:
  - Subject-Matter Expert – someone who knows about the domain under study.
  - Scrutineer – someone who independently looks at the study process and results.
  - Facilitator – an impartial catalyst to draw knowledge from others and help people work together.
  - Analyst – someone who designs and conducts a study and knows what methods to use.

The mix of those involved in the study is rich and a balance needs to be struck between the divergent exploratory phase where the issues are developed, and the convergent phase of consensus and action where the insights from the study are developed (Figure 2). As can be inferred, not all of the 'client' group would be involved at any one time. The observation that almost half of the roles mentioned in the above list are labelled as 'clients' brings considerable responsibilities for that group. These responsibilities include:

- Adopting ownership of the study and its results;
- Providing insights on the problematic situation (e.g. current perception of the issues, of key individuals, of the sources of expertise that the study could draw on);
- Assisting the analyst in developing and evolving the study design as the study progresses;

- Approving the study design and changes to it;
- Providing, or helping ensure access to, subject-matter experts and some of the information, data, and documents needed during the course of the study; and
- Participating in and encouraging (possibly busy) other individuals to contribute to the study (e.g. by issuing invitations to participate in workshop sessions, by providing an introduction for the analyst to other stakeholders, by building a high level of visibility and support for the study within the client community).

Without intimate involvement of the client, particularly for access to observed data, any study is likely to be both shallow and narrow and likely to require rework when exposed to the decision makers. With such material, however, both the quality of the study and the trust in the results increases (*see case study on this page*).

Case Study: The Importance of Access to Data – Analysis of 'White' Shipping

In the development of NATO maritime capability, user requirements for monitoring 'white' shipping were not well understood. To improve understanding, a cognitive task analysis was conducted using critical incident inquiry to identify the specific cues that alert operators to suspicious behaviour.

Concept mapping was employed to record and analyse operator strategies and reasoning as they worked with systems to complete tasks. Performance and standard work load measures were also collected and combined with the concept maps to provide an overall assessment.

Expert and well-calibrated observational data was required for reasonable interpretation of the way operators use strategies. While some data collectors/observers were comfortable with the tools and methods being used, several were only available for two days before the execution to train and exercise. This caused some difficulty in the analysis, and necessitated a much greater amount of post experiment analysis. Even with a standard method for recording observational data, collectors need to have appropriate time and training to be familiar with the relevant methods and theoretical implications associated with behaviours being observed.

The final point to be made is that while the analyst has the lead in the design of the study, the client will strongly influence how the outputs should be presented.

The analyst can provide advice on this, of course, but the client should be more attuned to the use that would be made of the product, and the decision-making process. Whether for a more quantitative or more judgement-based OA study, it is probable, if not certain, that discussion material will be presented to the decision makers. For a more quantitative study the raw data will probably be reasonably clear-cut even though there may still be a contestable decision (e.g. the reliability versus cost issue described in Chapter 1). For a judgement-based OA study, the client and analysts should consider two issues: the form of the actual results and their presentation. If done badly, either of these aspects could render an otherwise excellent study worthless. In addition, the relationship between the analyst and the client can be damaged.

The *text box* on this page shows a generic acquisition study that will be used to illustrate many of the issues involved in the types of decision making using multiple criteria and likely to be found in judgement-based OA studies.

A Generic Acquisition Study

Study Purpose:

To compare three hardware options (A, B and C) for a capability acquisition.

Formulation:

Agree that 'capability' is a combination of criteria, e.g. 'lethality', 'mobility', 'survivability' and 'sustainability.

Method:

Find ways to measure or otherwise provide insight on these terms for each of the options.

Output:

A compilation of the pros and cons of the three options.

An example of presenting the data for this generic acquisition study is shown in Figure 7 (and its explanation in the text that follows). This illustrates several important learning aspects based on the notions of criteria, numbers and colours. It is worth discussing these aspects in detail as they provide several informative examples for the use and applicability of judgement-based OA.

Two ways of presenting the data are shown in the same table of Figure 7. The first is primarily based on a pictorial representation including colour based

on the use of underlying threshold values. The second includes quantitative tabulated data. The results can be interpreted in terms of the observation that Option C appears to have lower capability, though neither Option A nor Option B fulfils all the criteria.

The point being made with this example is that the final part of the judgement has been left to the decision maker – it is expected of him, in this particular example, to balance the relative strengths and weaknesses of the three options. Thus the nature of a judgement-based OA approach means that it should be presented in a way that supports decision making and that judgement and choice can still be applied by the decision makers and the raw results do not impose a strait jacket. The way of presenting results is primarily the analyst's responsibility, but requires involvement of the client; the client should therefore be prepared to be actually involved in the presentation and interpretation of the results.

In summary, the client is one of several stakeholders. The client should be actively involved in all stages of the judgement-based OA study, including problem definition, study planning and execution, data gathering, and design and form of the study outputs.

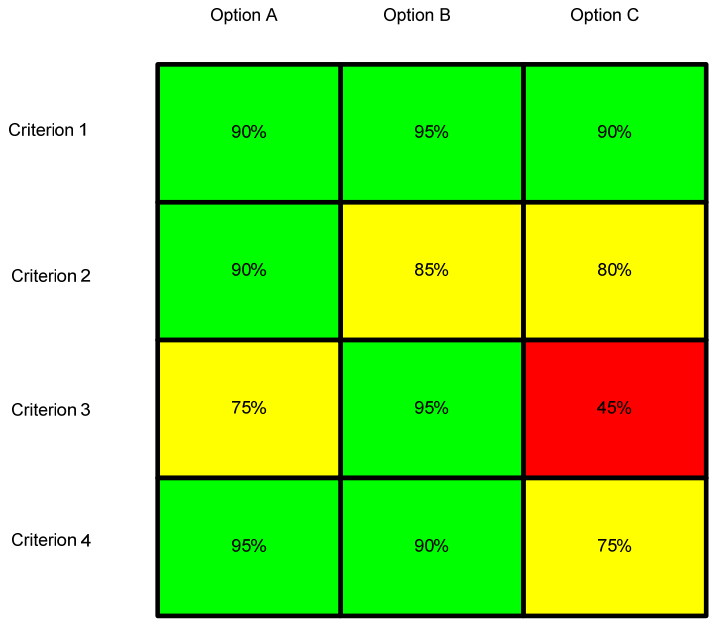

Figure 7: 'Traffic Light' to Compare Options Which Allows Freedom of Choice by the Decision Makers.

The use of four separate criteria allows freedom of action to the decision maker by leaving the final part of the judgement to the decision maker – it is expected of him, in this particular example, to balance the relative strengths and weaknesses of the three options A, B and C. To assist in this, analytical techniques have been developed that allow consensus on the relative importance of criteria to be converted to weighting factors and these can be used to identify a single value for each of the options. Sensitivity analysis would allow inspection of how susceptible these figures are to changes in relative weighting, which may in fact be considerable. It is critical that the decision maker is involved in this process and is left with room for manoeuvre. There would however be little room for manoeuvre if the material was merely presented in the form of a (equally) weighted average of the four criteria: option A 88%, B 91% and C 73%. Thus the nature of a judgement-based OA approach means that it should be presented in a way that supports decision making and that judgement and choice can still be applied by the decision makers and the raw results do not impose a strait jacket.

The use of numbers is a double-edged sword. Quantitative material can provide compelling evidence and can help in the scrutiny process. There may even be a perception that quantitative results take precedence over all other forms of input. However, the methods used in the study would ideally be based on an agreed plan of work and by necessity will include the use of approximations and subjective grouping of disparate elements to reach these numbers. It is also by no means certain that the criteria are even mathematically discrete. In such cases, the use of numbers is to inform the decision-making process rather than to provide definitive material. In the paragraph above, it was noted that a single figure could be calculated for each option, but then the richness in the study has been lost by this approach and the executive has not been given a complete picture on which to make a decision. There is a temptation to take the actual numbers too literally and prefer Option B over Option A even though the numbers should only be taken as indicative. The decision maker also loses the ability to prefer Option C which may be preferred when other factors are taken into account.

The third issue, colour, is possibly the most complex. As noted in Tables 1 and 3 emotion is an important part of judgement-based OA and such 'traffic light analysis' is likely to play a part in perceptions. An obvious question of Figure 7 is the basis of the colour coding – at what threshold value does an option achieve a green rating? This is something that should have been agreed between the analysts and client before the material was submitted to the decision-making process but should be transparent. For instance it could be based on a requirements analysis. The use of colour, however, does have benefits. For instance, options A and B both have three 'greens' and one 'yellow'. This presents the issue well to the decision maker – where do they want to take the 'yellow'? Similarly, the 'red' for option C flags a critical issue for further discussion.

Chapter 6 – WHAT DOES THE ANALYST BRING TO ACHIEVE VALIDITY, CREDIBILITY AND ACCEPTANCE?

The inherent uncertainty of a messy situation leads the client for judgement-based OA to what are perhaps his most pressing concerns – the need for validity, credibility and acceptance (*see key aspect 3 in Chapter 1*).

The analyst should be considered the expert in design, development and implementation of the study plan and methods. He will be guided by established practice, previous work and experience and by general skills in the area. One of these skills derives from his knowledge of how to ensure that a sound process has been followed in two respects:

- Was the approach taken appropriate for the maturity of the issue? *(was the right study done?).*
- Was 'due diligence' employed in carrying out the study? *(was the study done right?).*

Was the Right Study Done?

The analyst community recognises two seemingly distinct categories of problematic situation where a predominantly judgement-based study is appropriate: problems and messes (Table 1). When considering the defence sector, as a general rule it can be supposed that the position in the capability development cycle will impact on the type of problematic situation encountered and thus the style of study, as follows:

- *Needs or concept phase* – 'Mess' is most appropriate as there should be a need for a high-level examination of the issues from which concepts can be developed in the form of capability options. Typical examples of a needs phase study include policy or concept development, gap analysis and broad options for force structure change.
- *Requirements phase* – A 'mess' or a 'problem' is most appropriate as the capability options begin to take shape and more definition and specification is required. Typical examples of requirements phase study include option development and comparison, possibly leading to the start of an acquisition.

- *Acquisition phase* – Depending on the degree of certainty of the issues, a 'problem' or, less likely, a 'puzzle' approach would be appropriate. Typical examples where judgement-based OA is involved include comparison of operational concepts for different short-listed equipment options.
- *In-service* – Any fit-for-purpose approach is appropriate, particularly if there are time or other constraints such as in operations.

Figure 8 suggests a procedure that allows examination of problematic situations where there is initial uncertainty of how to proceed. Using the previously discussed material it is straightforward to separate a 'puzzle' from a situation where many of the elements in Table 1 in Chapter 2 were ticked. At this stage, it is useful to consider the situation as a 'perceived mess' but note that with examination by the analyst and client some cases may be turned into 'problems'. In these cases there will be a commitment to an agreed study plan developed jointly by the client and analyst. This conversion of a 'perceived mess' to a 'problem' is often considered as an important aim of judgement-based OA and is often referred to as 'problem structuring'. Typical elements of concern of any study of a problematic situation are:

- Setting initial boundaries in physical, organisational, social, time-related, etc., terms as they could affect the analysis approach;
- The nature of the options to choose among, and the ability of (semi-)-quantitatively evaluating and comparing them;
- The type(s) of model to be constructed and used, and the desired nature of the results and the outcome of the study as a whole;
- The participants in the study, the specific types of expertise needed, and the information each individual will bring in through their expertise; and
- The study design needed to achieve results.

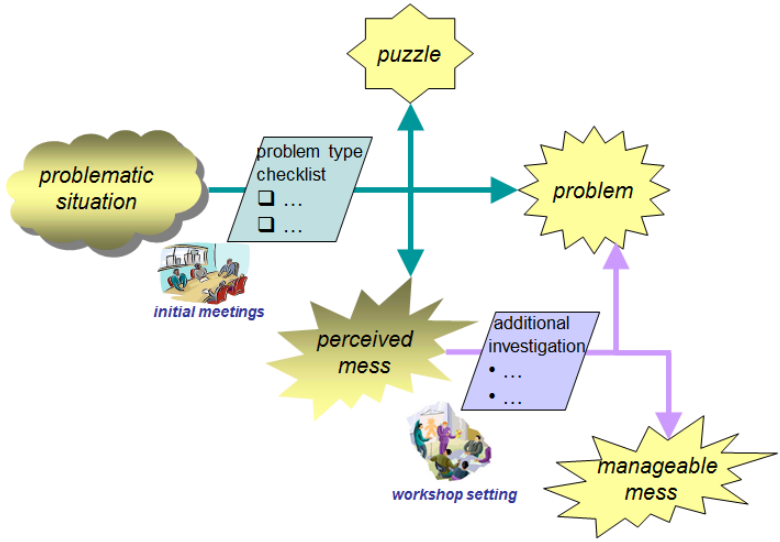

Figure 8: Methodology for Coping with Problematic Situations and Their Nature Where There is Initially Uncertainty of How to Proceed.

Other cases, however, will be better treated as messes. Some analysts believe that they are 'managed, not solved'. This leads to a different analytical course of action, for instance:

- A better understanding of aspects of the problem and the factors that influence it;
- Identification of problematic aspects that should be addressed and improved;
- A view of any boundaries to be set initially;
- The nature of the anticipated outcome of the study;
- The participants in the study, the specific types of expertise needed, and the information each individual will bring in through their expertise; and
- A general and flexible outline of the study design to achieve results.

The key message thus is *fitness for purpose*, or to put it in another way 'the right study is done'.

Was the study done right?

There are a number of possible challenges to the validity of a study.

Validity is a multi-faceted concept. Its aspects include:

- *Objectivity* (the quality of being based on rules grounded in theory or established practice and characterised by recorded argumentation and rationale and following an agreed and sound process accepted by all involved);
- *Rigour* (quality achieved through strict enforcement of rules and requirements);
- *Repeatability* (the quality of an outcome to occur again, given same starting conditions – it might be noted that this is a worthy goal but it may not occur as similarity, particularly when individuals or organisations are involved, can not be guaranteed);
- *Auditability and transparency* (the critical elements that allow scrutiny through validation and verification of the study approach and findings);
- *Independence* (the proactive steps taken to ensure lack of bias, whether intentional or unintentional);
- *Grounding and consistency* (a validation mechanism where studies are based on theory or established methods and can be checked against real or calculated data);
- *Understand-ability* (the removal of barriers to learning and involvement in the study achieved through the use of terms familiar to the clients and through explanation of the methods);
- *Explanatory power* (the depth and breadth of explanation of the system properties and behaviours inherent to the problematic situation as afforded by the OA method and its results);
- *Completeness* (demonstration that the methods adopted for the study address all aspects of a problematic situation, and if not, the limitations that are imposed);

- *Robustness under uncertainty* (the accommodation of incompleteness and variability and its implications); and
- Clear *separation of data from the method* which uses it (the quality of ensuring that data availability does not drive method selection and *vice versa*).

There is a need for rigour in the absence of verifiable mathematical methods. Thus a sound procedure, based on the CoBP, is followed to ensure that there is an audit trail showing how the issues have been addressed. The aim is to achieve, from use of the CoBP, sufficient rigour to render the entire process *objective*, even though individual elements of a judgement-based OA study may require *subjective* inputs. Put simply, the analyst and client have to work harder in a judgement-based OA study to develop a convincing case than they would if the results fell naturally from a mathematical process.

The professional analyst will have many attributes and skills to bring to the problematic situation (Table 5) which will enhance the likelihood that validity, credibility and acceptance will be manifest. He will be responsible for assembling an analytical team comprising the appropriate skill sets or access to computer-based or other resources. In a similar way to the client roles expressed in Chapter 5, the other defined roles of the analyst are:

- Help structure and define the nature of the problematic situation;
- Design the stages of the process used within the study;
- Suggest scientific ways to investigate and model the problematic situation and suggest the methodology and the method(s) to be used, the workshops (if any) to be held, and ways to report and interpret the study's outcomes;
- Provide facilitated modelling (generally through the use of workshops; including an integrated process of data gathering and model creation and analysis);
- Help develop agreed-upon outputs (e.g. better understanding of the problematic situation, identification of desirable and politically feasible options for improving the problematic situation);
- Report and interpret the study process (including participants), results and outcomes;

- Generally, provide a rational and logical analysis that aids in managing the complexity of the problematic situation, aids in recognising and managing uncertainty and risk, and adequately meets the overall study goals; and
- Remain thoroughly devoted to providing a credible, rigorous analysis and to ethical principles.

Table 5: Attributes of a Judgement-Based OA Analyst.

A competent judgement-based OA analyst:
• Is interested in practical solutions.
• Can take a broad holistic view of the issue under study.
• Possesses a high degree of initiative, energy, and maturity.
• Is a 'self-starter' who can work well individually and in a team.
• Has a high degree of general intelligence and enthusiasm for the work.
• Knows relevant judgement-based methods and their merits (pros and cons).
• Enjoys drawing knowledge from other disciplines.
• Has the right personality so as to be able to gain client confidence and effectively communicate study results to decision makers.
• Is devoted to scientific rigour and ethical principles.
• Has adopted and shows a fundamentally helpful attitude.

The correctness of a judgement-based OA study is hard to define and for this reason 'due diligence' guidance has been implemented by the Task Group as a CoBP. Similarly, it is difficult to define a specific study pattern of work. An approach based on principles or values is preferred over a rigid manual where every step has to be completed before the next can be started.

The primary dimensions of validity are objectivity and rigour (*see Page 36*); credibility and acceptance are not distinct qualities but are rather derived from validity and reinforced by the skills and expertise of the analyst.

Credibility is achieved when expertise is delivered with trustworthiness. The level of credibility a study method may have will depend on the amount of expertise available to apply it, and the perceptions of the client (and other stakeholders) of that expertise. Indeed, there are both subjective and objective components to credibility. In particular, the trustworthiness of an analyst will

itself be subjective and personal to clients. In order to gain credibility for those methods which have been validated through consideration of the above factors, it is necessary to also consider the acceptance of such models from the decision maker community.

Acceptance is a concept which is present throughout the study process. It starts at the point where the problematic situation is raised and is critical through to the end of the process, where the analysis will be exploited by clients. Communication between the analyst and the clients is critical throughout all aspects of the study process; often lack of communication with stakeholders can be missed until the very end of a study and so damage its acceptance. Acceptance can be gained through transparency and communication of the modelling process. This will help the analyst gain the trust and confidence of the decision makers in the method, and more importantly, the study outcomes so that these can be of most value.

The confidence a client has in an analyst can also be increased through adequate preparation. For example, training an analyst improves their own confidence which will then be more easily portrayed to clients.

Credibility and acceptance will be further reinforced by independent scrutiny.

In summary, the analyst will work with the client to ensure that an appropriate degree of validation has been applied to a judgement-based OA study. The analyst's skills and expertise are crucial in this respect. A study's validity and the (perceived) trustworthiness of an analyst's expertise will to a large extent determine that study's credibility, and, together with transparency and good communication throughout the study process, the acceptance of study outcomes by decision makers.

Chapter 7 – HOW CAN A CODE OF BEST PRACTICE PROTECT THE CLIENT FROM THREATS TO THE STUDY?

A judgement-based OA study will likely be only one input into a decision-making process. In contrast to the added value described in Chapter 3, a set of threats to a successful and valid judgement-based OA study can be codified. These threats to judgement-based OA, can be intentional or unconsciously directed by individuals' decision-making preferences or backgrounds. They could include:

- *Threat 1:* Disagreement with a specific part of the study leading to a dismissal of the rest of the material.
- *Threat 2:* Treating judgement-based OA study results with too much certainty (e.g. as a prediction).
- *Threat 3:* Too rapid a progression from an ill-formed concern to a rigid plan for change (e.g. an acquisition).
- *Threat 4:* Biased preference of some forms of evidence (e.g. quantitative sources).
- *Threat 5:* selective interpretation to support a specific argument.

Some of the threats (e.g. 1 and 5) hold for OA in general, but may be particularly likely to occur with judgement-based OA. Some of these threats will occur no matter the situation but the analyst (and where appropriate the client) can provide convincing arguments to address and mitigate most of the items on the list. There is probably little that can be done about *Threat 5*, except perhaps making different interpretations of parts of the model (e.g. in the form of a visual map of relevant concepts) so that they are represented in the results. The adoption of the principles of the CoBP will limit the impact of unhelpful criticisms that may occur in a real study.

Table 6 shows how a hypothetical situation relating to an acquisition based on military effectiveness may be challenged by these threats. Shown are mitigation strategies to counter the intent of *Threat 1* and also to address legitimate analytical scrutiny. It might be noted that the example in Table 6 contains far more technical detail than appears in the remainder of this volume. This is

introduced for illustrative purposes only but shows some of the issues that are likely to be found when judgement-based studies are done. It is only one way in which such a study may be conducted and is based on the generic study box in Chapter 5. The companion analyst volume contains more detail of such issues.

Table 6: Possible Challenges to an Acquisition-Focused Judgement-Based OA Study (Example) and Their Mitigation.

Issue	Mitigation by Analytical Approach	Formal Mitigation
Identification of Issues	Exploratory front-end (scoping) analysis for problem definition in the appreciation phase.	Terms of reference agreed by the customer.
Definition of Military Effectiveness	Military effectiveness is represented as a combination of, for example, lethality, mobility, sustainability and survivability.	Use previous studies as support and gain agreement of the client group.
Measurement of Terms (e.g. lethality)	Measure loss exchanges ratios through war-gaming.	Use previous studies as support and gain agreement of the client group.
Weightings	Hold workshops with stakeholders.	Good practice in facilitation using subject-matter experts where all opinions are heard with no domination by individuals.
Vignettes for Wargames (e.g. for lethality)	Identify a range of fit for purpose vignettes consistent with any prescribed scenarios.	Client group to endorse that they are suitable.
Sample Size/ Statistics	Emphasise quality of inputs rather than quantity and include material derived from different sources.	Client group to provide quality subject-matter experts. Validate through comparison of several different information sources.
Data	Use a combination of literature, commercial and client supplied data (informed opinion).	Client group to endorse material. Include sensitivity analysis.

Also to be noted in Table 6 is the frequent observation of required agreement between the client and the analyst, which may be informal (though recorded) or embodied in the terms of reference which form part of the study plan.

Threats 2 to 4 require dialogue between the analyst and members of the client group. The material in this volume lays the foundations for a robust defence against these threats. To some extent the position taken here involves two conflicting elements:

- Certainty that a good process has been followed; and
- Uncertainty in the results and outputs.

Reconciling the two might seem counterintuitive but that is the purpose of the required dialogue between the client group and the analyst. As described in Chapter 1, the three key aspects of judgement-based OA drive the study and should shape the use that is made of any study, such as to support advocacy. This debate may also be between the customer and the sponsor (see Chapter 5). The notion of a 'mess' where the resultant identification of management trajectories and progress indicators rather than a project approach may be alien to some decision makers, particularly those involved with short time scales.

Additionally, there is a need for expectation management where the threats to the study are caused by a fundamental difference in decision making and management. Those users that might want clear direction on the next stage may well be disappointed as the conclusion may be that (for instance) a firepower approach has more merit than one based on protection. It is quite possible that the study will end at this point with a recommendation for a follow-on study to be done, e.g. to address the possible options for firepower. Nevertheless, a well-founded decision will have been made, and critically, the basis will have been set for the criteria and approach to be taken.

Finally, the analyst and client may be pushed to use the study for predicting what is going to happen rather than forecasting what could happen, which again confuses the role of this sort of analysis.

For a study as a whole there will be a clear audit trail that will guide from appreciation of the issue through to analysis and definition of ways ahead. In the capability development process, for example, this will mean from the initial needs phase through to actual selection of a preferred option.

The CoBP is specifically directed to counter *Threat 4*, as implicit to any judgement-based study is the notion that while quantitative data may be used it will be used in specific cases to test an idea, or it might be applicable to a small part of the landscape. If the issue was a true 'puzzle' then the appropriate mathematics-based techniques would have been used. For 'problems' and 'messes' it is more likely that a mix of quantitative and qualitative data will be used and the skill is in melding it sensibly.

In summary, judgement-based OA is a key scientific activity that will add value for clients involved in decision making, allowing decisions to be made with less risk. However, potential threats to a judgement-based OA study exist and need to be managed through the application of the principles of the CoBP.

Annex – ADDITIONAL INFORMATION

NATO RTO, SAS-087, TG-034: "NATO Guide for Judgement-Based Operational Analysis in Defence Decision Making: Analyst-Oriented Volume ("Code of Best Practice")", available from this web site:

http://www.rto.nato.int/abstracts.aspx

NATO RTO, SAS-087, TG-034: "NATO Guide for Judgement-Based Operational Analysis in Defence Decision Making: Decision-Maker-Oriented Brochure", available from this web site:

http://www.rto.nato.int/abstracts.aspx

Web site of the UK Operational Research Society:

http://www.theorsociety.com/

The Society's web site for Operational Research, "The Science of Better":

http://www.scienceofbetter.co.uk

Handley A., "Guidance on the use of subjective Operational Analysis methods in support of acquisition decisions", DSTL/CR43706, March 2010. © Crown copyright 2010.