NORTH ATLANTIC TREATY ORGANISATION

RESEARCH AND TECHNOLOGY ORGANISATION

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RTO TECHNICAL REPORT **TR-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)

Analyst-Oriented Volume:

Code of Best Practice for 'Soft' Operational Analysis

This Report documents the findings of the Task Group TG-034 (System Analysis and Studies Panel) regarding best practices in judgement-based Operational Analysis.

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The Research and Technology Organisation (RTO) of NATO

RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote co-operative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective co-ordination with other NATO bodies involved in R&T activities.

RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also co-ordinates RTO's co-operation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of co-operation.

The total spectrum of R&T activities is covered by the following 7 bodies:

- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS System Analysis and Studies Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

These bodies are made up of national representatives as well as generally recognised 'world class' scientists. They also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

RTO builds upon earlier co-operation in defence research and technology as set-up under the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). AGARD and the DRG share common roots in that they were both established at the initiative of Dr Theodore von Kármán, a leading aerospace scientist, who early on recognised the importance of scientific support for the Allied Armed Forces. RTO is capitalising on these common roots in order to provide the Alliance and the NATO nations with a strong scientific and technological basis that will guarantee a solid base for the future.

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Glossary of Terms and Acronyms

Alternative	One of two or more possibilities that can be chosen for addressing, improving or (re)solving a problematic situation.
Analysis	A set of activities aimed at decomposing (physical, organisational, social) systems, problems, problematic situations, operations, etc., into their constituent parts, and at investigating their relationships and their meaning.
Analyst	An individual who conducts a study, and in this capacity designs the stages of the process, suggests scientific ways to investigate and model the problematic situation, the methodology(ies) and method(s) to be used, the workshops to be held, and ways to report and interpret the study's outcomes.
Client	This term denotes four specific types of stakeholders: - The *sponsor* who actually owns the study; - The *customer* who pays the bill for the study; - The *decision maker* who may make decisions regarding the problematic situation or concerning the recommendations by (outcomes of) the study in preparation of decisions by higher authority; and - The *end user* who is ultimately affected (either positively or negatively) by the study outcomes and related decisions. The various client types together are often referred to as 'client system' in the CoBP.
CoBP	Code of Best Practice
Credibility	The quality of being trusted and believed in or of being convincing or believable (based on The Oxford English Dictionary).
Customer	The individual who pays the bill for the study.
Data	Facts or other pieces of qualitative and/or quantitative information.
Decision	The result of making up one's mind regarding a choice between alternatives.
Decision maker	An individual who makes up his/her mind regarding the problematic situation or concerning the recommendations by (outcomes of) the study in preparation of decisions by a higher authority.
Delphi method	A structured communication technique, originally developed as a systematic, interactive forecasting method which relies on a panel of experts (http://en.wikipedia.org/wiki/Delphi_method; accessed on 18 October 2011).
Due diligence	An investigation based on agreed standards of the (true) worth of something.

End user	An individual who is ultimately affected (either positively or negatively) by the study outcomes and related decisions.
Expert (subject-matter expert)	An individual who has considerable relevant knowledge in a particular area without necessarily owning or otherwise being part of the problematic situation.
Facilitated modelling	A process where the analyst actively engages the client (group) to participate in all stages of a 'soft' OA study and thus acts as an facilitating analyst (often with the help of a supporting facilitator).
Facilitator	An individual who helps (i.e. supports, enables and encourages) individuals or a group or groups of stakeholders, clients, subject matter experts, and analysts work together through the stages of a study by managing procedure (the way the problem is tackled) and process (the way participants interact), whilst adopting an impartial attitude.
'Hard' Operational Analysis	OA based on well understood, standard science and mathematics.
Input	Data needed for setting up or running a model or influencing a process with the aim of affecting the results of that model or process.
Judgement	The result of the process of forming an opinion.
MA	Morphological Analysis
MC(D)A	Multiple Criteria (Decision) Analysis
Mess	Any problematic situation that requires or seems to require (re)solutions involving some action, although it is unclear initially what the issues are, what actions are required and/or who is or should be involved.
Method	A structured set of guidelines or rules to achieve some clear well-defined purpose.
Methodology	A particular combination of methods that possess a common set of characteristics and assumptions and are used in a study to achieve a purpose.
Model	A representation of (a part of) reality (i.e. a problematic situation) as seen by a number of people who wish to use the model to understand, manage, or improve that reality.
Morphological Analysis	A method for exploring all the possible solutions to a multi-dimensional, non-quantified problem complex (http://en.wikipedia.org/wiki/Morphological_analysis, accessed on 17 October 2011).
Multi-methodology	A combination of methods from possibly different methodologies.
Multiple Criteria (Decision) Analysis	A sub-discipline of OA that explicitly considers multiple criteria in decision-making environments (http://en.wikipedia.org/wiki/Multi-criteria_decision_analysis, accessed on 17 October 2011).

NATO	North-Atlantic Treaty Organisation
OA	Operational Analysis
Objective	*(adjective in connection with data)* Based on agreed, established, consensually observed facts. *(adjective in connection with an activity or process)* 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; *(noun)* Aim, purpose or goal.
Operational Analysis	The interdisciplinary science that focuses on how appropriate actions can be designed to change (i.e. towards improvement) or even (re)solve problematic situations.
Option	One of two or more possibilities that can be chosen for (re)solving a problematic situation.
OR	Operational Research (equal to Operational Analysis)
Outcome	This denotes what has been achieved by the study ('effect' or 'impact'), based on specific results and their analytic interpretation.
Primary client	The term 'primary client' refers to the single individual or (small) group of individuals who belong to the client system and who acts or are acting as a partner (first point of contact) to the analyst throughout the conduct of the study.
Problem	Any situation where there is a perceived gap between its current state and its desired or required state, which needs or seems to need a (re)solution involving some action, although it may often be unclear what (re)solution and what action are most appropriate.
Problem (proper)	A problematic situation in which it is not very clear initially what the issue is and how a solution can be found; could be positioned between 'Puzzle' and 'Mess' (ref. Chapter 2).
Problem structuring	The process of analysing a problematic situation in order to identify the issue(s) to be resolved.
Problem Structuring Methods	Methods developed for dealing with unstructured problematic situations that are characterised by multiple actors, their multiple perspectives and conflicts of interest, uncertain and unquantifiable factors, and designed to support groups in their decision making.
Problematic situation	Any situation that is characterised by the existence of one or more problems and requires or seems to require (re)solutions involving some action, although it may often be unclear initially what action.
Puzzle	A problematic situation in which it is fairly clear what the issue is and how a solution can be found.
Qualitative	Based on distinctions or descriptions in terms of characteristics, gradation or order.

Quantitative	Based on measurement in terms of numbers expressed on a numerical scale.
Repeatability	The quality of a phenomenon to occur again, possibly in different places and times, and observed by different people.
Requisite	The characteristic of something when relevant people have agreed on its adequateness and sufficiency for use.
Result	This denotes what has been produced by applying a model, method or methodology, or merely following a process.
Rigour	Quality achieved through strict enforcement of logical rules and doctrine.
Robustness	The quality of withstanding or overcoming adverse conditions (based on The Oxford English Dictionary).
SAS	System Analysis and Studies
Satisficing	A decision or strategy or (re)solution is satisficing if it is good enough (‘adequate’), but not necessarily optimal.
Scrutineer	An individual who provides an independent review of the study.
SME	Subject-Matter Expert (see under Expert)
SODA	Strategic Options Development and Analysis
‘Soft’ Operational Analysis	Operational Analysis exploiting methodologies and methods that are predominantly based on the rational (i.e. not intuitive) use of human judgement.
Soft Systems Methodology	An approach using ‘real world’ descriptions and systems engineering terms to structure messy problems where there may be divergent views about the nature and definition of the problem.
Sponsor	The individual who actually owns the study .
SSM	Soft Systems Methodology
Stakeholder	An individual who can affect or can be affected by the (resolution of the) problematic situation.
Strategic Options Development and Analysis	An approach using diagram-based visualisations to explore messy problems and capture individual and group views with the aim of reaching a shared understanding of the problem.
Study phase	A coherent and distinguishable part of a sequence or cycle of activities over time.
Subjective	Based on personal feelings or intuition or expertise.
System	A collection of organised things constituting a whole and the relationships between its constituent parts.

Technique	Denotes each of the specific algorithms or interviewing modes (etc.) which are part of a method.
TG	Task Group
Tool	Either a ‘Technique’ or the agent of a technique (e.g. a software program).
Transparency	The quality of being easy to perceive or detect, or open to public scrutiny (based on The Oxford English Dictionary).
Triangulation	The use and critical synthesis of different sources or perspectives or methods regarding a (usually) single issue.
Uncertainty	The absence of knowledge and the inherent variability of phenomena, both in varying degrees.
Validation	The activity of proving or demonstrating or supporting the truth or accuracy or value of something (based on The Oxford English Dictionary).
Validity	The quality of being logically or factually sound (‘cogent’) (based on The Oxford English Dictionary); fitness for purpose.
Wicked problem	A problem that is difficult or impossible to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognise. (http://en.wikipedia.org/wiki/wicked_problem; accessed on 2 November 2011). See ‘Mess’; this CoBP uses ‘mess’ rather than ‘wicked problem’.

Preface

The Task Group (TG-034, SAS Activity 087) was commissioned by the System Analysis and Studies (SAS) Panel to produce a code of best practice for judgement-based Operational Analysis. After an exploratory phase in 2009 which addressed, at the Panel's request, the issues surrounding use of judgement in Operational Analysis (OA), the TG formally started its work Spring 2010 and finalised the code at the end of 2011.

The TG began by identifying a number of topics that would have to be addressed and considering what the specific boundaries of a code of best practice would be. This included its readership. Inspired and informed by discussions at two academic conferences[1] about a number of challenging propositions regarding the subject proposed by the TG, the TG went on to identify and (re-)read relevant literature.

The TG decided to write a Guide consisting of three volumes: an analyst-oriented document (the "Code of Best Practice for 'Soft' Operational Analysis"), a client-oriented document, and a brief summarising brochure for high-level, 'executive' decision makers. The TG also decided to write the analyst-oriented document first, not only in view of the crucial role of the analyst, but also because the TG Members considering their background generally felt more comfortable with an analyst's perspective. The client-oriented volume was developed after a first full draft of the analyst-oriented volume and saw an addition of specific topics relevant to clients keeping mutual consistency in mind. The summary brochure was derived from the client-oriented volume.

The design and writing of the Guide's volumes was assigned individually to the following participating nations/agencies: NATO/ACT, Australia, Canada, Germany, Netherlands, Sweden, and the United Kingdom. The final set of volumes was submitted to the Panel in December 2011. Their common main title is "NATO Guide for Judgement-Based Operational Analysis in Defence Decision Making", referred to as 'the Guide'. The analyst-oriented volume however is the Code of Best Practice (CoBP) proper. The other two volumes have a more explanatory nature: one is directed to clients and is organised around seven key questions that clients are likely to ask, the other is a short summary of a few key aspects of (using) judgement-based OA and is written for executive decision makers explaining and promoting key aspects.

The TG used existing publications, including textbooks, edited collections (proceedings) and reviewed papers, in order to attempt to produce useful guidance, based on each TG Member's personal knowledge and experience. The TG did not always try to reconcile differing academic views but rather made an effort to synthesise all useful ingredients where possible and made informed choices where a synthesis appeared to be infeasible. This has all been done with the Guide's general and the CoBP's specific purpose in mind and creating, along the way, clarity and focus in the vast and rapidly further developing world of 'soft' OA.

In order to illustrate issues, the TG used a number of unclassified descriptions of case studies and derived short pieces of text from them each addressing a particular issue. They appear as illustrative text boxes in the main text of this volume. The TG decided on which issues would require clarification by text boxes and which aspects from the available case summaries would be appropriate. In addition, there are some clarifying text boxes that are not based on cases and text boxes at the start of most chapters, summarising their main points both as statements and as recommendations to the analyst. Different colouring is used to denote the three different text box types.

The TG has restricted itself in referencing the material in the main text in order to not distract the reader too much from the content. By its nature, the CoBP (in fact the entire Guide) is a work of review and representation

[1] ISMOR (30 August – 3 September 2010, New Place, Hampshire, UK): 27th International Symposium on Military Operational Research, with special theme 'The use of 'soft' methods in OR'.

OR52 (7 – 9 September 2010, Royal Holloway University of London, Egham, UK): 52nd Annual International Conference on Operational Research of the O.R. Society.

of relevant ideas. If a particular method for approaching a problem or issue was identified in an academic paper or book and adapted for use in the CoBP, a reference to the source is given. So, references are given where appropriate and are not designed to be exhaustive, or even comprehensive. Some chapters contain a short list of recommended publications for further reading. The references and the lists of publications for further reading encompass the literature that the TG have used for the CoBP and serve as a tribute to our major sources.

The TG very much appreciates the efforts made by external reviewers to review the documents. A draft version of the analyst-oriented volume was reviewed by two associate professors[2], amended based on this review and then finalised. A draft of the client-oriented volume was reviewed by three individuals[3] who belong to the Defence community, and finalised using their commentary. The TG acknowledges this support and thanks all reviewers for their most valuable advice. The Chair would like to thank all contributing nations and agencies for their effort in writing these documents which will be of benefit to all NATO Nations, PfP and Contact Nations, other Nations and organisations, and individuals.

Although the authors expect that the Guide will be useful as it is written, this work will clearly gain value from practical experience in working with it. The TG therefore recommends to the Panel that, in due course, an activity should be set up to see if the Guide, and especially the CoBP, needs adjustment based on the feedback that, hopefully, would have been brought to the Panel's or the authors' attention. That would be good practice.

[2] Dr. L.A. Franco (University of Hull, United Kingdom); Dr. E.A.J.A. Rouwette (Radboud University of Nijmegen, Netherlands).

[3] 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).

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

(RTO-TR-SAS-087)

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 (i.e. theories, methods, techniques, models) within Operational Analysis (OA) that are predominantly based on human judgement, are an increasingly critical capability needed to support defence decision making.

The field of judgement-based methodologies and methods within OA is usually known as 'soft' OA. It has a significantly more qualitative and subjective nature than the traditional, 'hard', OA methodologies which tend to be more quantitative and objective. 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. It is intended to increase the acceptance of judgement-based OA within the military and defence-oriented operational analyst communities. It provides pragmatic guidelines to enable this type of OA to be practised in a more rigorous and scientific manner, especially by those who are new to this type of approach. The Guide is also designed to be informative in the sense that it aims to clarify what judgement-based OA is, and when and how it can be used.

The purpose of the Guide is therefore:

- 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 in that respect; and
- To provide guidance on how a judgement-based OA study should be carried out to maximise the 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"), a client-oriented document, and a brief summarising brochure for high-level, 'executive' decision makers explaining key aspects.

This volume of the Guide sets the rules of the road for analysts who are new to this field of OA. It is expected that more experienced 'soft' OA analysts will also find it of value for educational or reference purposes whilst having developed their own views on how these kind of analyses should be carried out and perhaps even their own 'soft' methods or methodologies. The guidelines are offered as a means of assistance to analysts and are not meant to be too prescriptive in nature. They address:

- The nature of 'soft' OA and the type of problematic situations which require this type of analysis;
- How to achieve validity, credibility and acceptance of 'soft' OA studies;
- The roles and responsibilities of individuals involved in a 'soft' OA study;

- The design of a study, the design of the study's (multi-)methodology and how to recognise and cope with problematic situations;
- How to deal with data, subject matter experts, bias and aspects related to workshops; and
- How to communicate the results with the client.

The other two volumes explain to clients what judgement-based OA is, in what cases it may be useful to them, how their acceptance of a study's outcomes can be enhanced, and, when they are involved in a study, what their roles and responsibilities should be.

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

(RTO-TR-SAS-087)

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 (c.à.d. les théories, méthodes, techniques et modèles) 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.

La partie de l'AO dont la méthodologie et les méthodes sont basées sur le jugement est connue comme AO « en douceur ». Elle est, de manière significative et par nature, plus qualitative et subjective que l'AO classique (« *hard* ») dont la méthodologie est davantage quantitative et objective. 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. Il est conçu pour accroître l'approbation des analyses opérationnelles (AO) basée sur le jugement au sein des communautés militaires et d'analyse opérationnelle axés sur la défense. Il fournit des principes directeurs pragmatiques pour que ce type d'AO soit réalisé de manière plus rigoureuse et scientifique, particulièrement par ceux qui découvrent ce type d'approche. Ce guide est également à caractère informatif, car il vise à clarifier ce qu'est l'AO basée sur le jugement et où et quand en faire usage.

L'objectif de ce guide 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, un 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 volume de ce guide établit les règles à suivre pour les analystes qui découvrent ce champ d'AO. Il est fort probable que les analystes d'AO fonctionnelle plus expérimentés le trouvent également utile à des fins d'enseignement et de référence, bien qu'ils aient développé leurs propres opinions sur l'exécution de ce genre d'analyse et peut-être même développé leurs propres méthodes ou méthodologies fonctionnelles. Les principes directeurs sont proposés en guise d'aide aux analystes et ne sont pas prévus pour être trop normatifs de nature. Ils concernent :

- La nature des AO fonctionnelles et le type de situations problématiques qui nécessitent ce type d'analyse ;
- La manière d'établir la validité, asseoir la crédibilité et obtenir l'acceptation des études d'AO fonctionnelle ;
- Les rôles et responsabilités des personnes engagées dans une étude d'AO fonctionnelle ;
- La conception d'une étude, la conception de la méthodologie (multiple) d'une étude et la manière de reconnaître et d'affronter des situations problématiques ;
- La manière de traiter les données, les experts en la matière, la partialité et les aspects liés aux ateliers ; et
- La manière de communiquer les résultats au client.

Les deux autres volumes expliquent aux clients ce qu'est l'AO basée sur le jugement, dans quels cas elle peut leur être utile, comment améliorer l'acceptation des résultats d'une étude, et, lorsque les clients sont engagés dans une étude, quels devraient être leurs rôles et responsabilités.

Chapter 1 – INTRODUCTION

1.1 BACKGROUND

The defence environment is complex and dynamic. This is a result of, the nature of modern conflict, rapid changes in technology, the need to deal with uncertainty in the face of limited resources, changed attitudes to risk, and the sheer diversity of actors from different cultural backgrounds. Defence decision makers are confronted with an increasing operational complexity which has strategic implications. Decisions on defence policy and strategy are characterised by uncertainty and risk. Planning, conducting and evaluating missions also include indirect and non-kinetic effects, dealing with other (non-military) actors, social effects on the local population, public sentiment and other human factors. In addition, defence decision makers may be involved at any stage of the defence material cycle ranging from conceptual development, through to acquisition to use in conflict. Similarly, decisions need to be made in personnel-based activities such as career structures and training regimes.

All these decisions are made at strategic, operational or tactical levels. They may be aimed at the present or the far future, and may involve choices among tangible (materiel) and/or intangible (organisational structure, strategies, etc.) alternatives. Critically, many decisions are required where judgement rather than known facts plays a key role.

NATO practitioners have determined (e.g. [1]) that approaches (i.e. theories, methods, techniques, models) within Operational Analysis (OA) that are predominantly based on human judgement, are an increasingly critical capability needed to support defence decision making. Judgement in different guises has been used by military staff whenever assessing problematic situations and making decisions. The field of judgement-based methodologies and methods within OA is usually known as 'soft' OA. It has a significantly more qualitative and subjective nature than the traditional, 'hard', OA methodologies which tend to be significantly more quantitative and objective.

> In support of Australia's deployment to East Timor, a study was made of the triggers and causes that have led to disruptive events in that country's 400 year history. Importantly, the analyst was able to present the study in terms that could be readily used to forecast possible events that could occur as the population reacted to the changed socio-political environment. This enabled 'what-if' studies and campaign metrics to be devised.
> This type of study should be treated with confidence as in such cases the skill lies in the analysis not necessarily the domain area, as soft OA is applicable to many areas. The client should therefore exploit the fact that a military 'soft' operational analyst is able to provide useful insight into areas well outside of standard conflict analysis.

Military 'hard' OA has a long history. During World War I both the American and British governments established boards to support defence decision-making issues with mathematical methods [2]. (Military) OA as a formal discipline started to be recognised in the late 1930s and subsequent years by contributing to addressing, for example, air defence, bombing tactics, submarine/convoy war and logistic problems during World War II.

'Hard' OA predominantly relies on mathematically expressed relationships between variables derived from physical theory using quantitative data and seeks to identify quantitative (possibly optimal) solutions to problems, given a set of (well-defined) restrictions. 'Hard' OA consists of traditional OA approaches such as linear programming, queuing theory, computer simulation, etc., which are all characterised by their well-structured engineering-like nature and their reliance on mathematically expressed relationships between variables.

'Soft' OA started to be recognised in the early 1960s when the Rand Corporation first reported on the Delphi technique as an approach to achieving consensus among experts regarding bombing requirements [3]. In the late 1960s Churchman wrote an editorial [4] drawing attention to a type of ('wicked') problem

that was different from the problems usually addressed by OA [5]. Since the 1970s the UK originated a number of OA methods specifically designed for dealing with this type of problems; they are still in use today [6].

The strength of 'soft' OA lies in its ability to address complex (i.e. confusingly unstructured) situations in which what needs to be done and how to do it are both problematic, and to deal with the critical human aspects of the situation (e.g. differences in stakeholder perspectives and agendas, organisational politics, disagreement on ways forward, etc.). It is characterised by its use of human judgement in the form of (informed) opinions from experts and other stakeholders, thereby allowing more degrees of freedom and relying less on mathematical modelling in comparison with 'hard' OA.

The discussion of the limits of a purely mathematical, formal approach to OA is not new. In fact, even from within the 'hard' Operational Research (OR) community there have been critiques and examples of dissenters (e.g. [7]): one is faced with ill-structured, 'messy' situations in which decisions have to be made; yet one does not completely comprehend the situation. Here, 'soft' OA claims to help the decision maker either as an individual or within a group.

Look at the following two problematic situations:
1. Minimise the fuel cost of a regular repair resupply activity.
   → 'hard' OA: use dynamic programming to solve it.
2. Advise on the balance of maritime, land and sea capabilities for 2030.
   → 'soft' OA: but how would you do it?

Moreover, a problem definition does not present itself automatically. Before any type of model can be developed, the characteristics and boundaries of a problem, the objective(s), the multiple factors and their (critical) relationships and dependencies that are of relevance need to be identified and structured. And, at the end of even a 'hard' analysis, issues related to the interpretation of results and feedback often still involve judgement. Operational analysts therefore need to be familiar with both 'hard' and 'soft' OA if they are to be successful in addressing the diversity of military client tasking. Practice has shown that 'soft' and 'hard' OA can usefully complement each other. They need not be competing approaches.

Quote from report [2] of the Defence Science Board Advisory Group on Defence Intelligence:

"OR can significantly increase the decision-maker's insight and improve the quality of debate around key decision issues"

The application of 'soft' OA on defence problems is manifold and often successful, but success is not guaranteed. Although 'soft' OA has been accepted and successfully used by some analysts within NATO's defence communities for structuring problems, option design, option evaluation and action planning, it is perceived that there is still reluctance in some quarters to employ such methods. This lack of acceptance and use may be attributed to several reasons, including: a lack of affinity to using such methods by analysts who have been trained in 'hard' disciplines such as engineering and mathematics; philosophical disputes as to whether 'soft' OA truly is OA given its predominantly qualitative or semi-quantitative nature; and questions about its scientific rigour and quality control measures.

Progress has been made in laying the theoretical foundations for the rigorous use of 'soft' OA both in isolation and as part of a multi-methodological systems-type OA approach. In particular, approaches have been identified for problem structuring which can be used for analysing and transforming complex (or even 'chaotic') situations into problem abstractions one can work with. These approaches have to a large extent been grounded in theory and become established in practice [8]. Wider acceptance and employment of 'soft' OA would enable the defence community to significantly enhance its capability to deal with complex, high priority problem issues.

The development of a Code of Best Practice (CoBP) for 'soft' OA is intended to increase 'soft' OA's acceptance within the military and defence-oriented operational analyst communities. It will provide

pragmatic guidelines to enable this type of OA to be practised in a more rigorous and scientific manner, especially by those who are new to this type of approach.

Practice has shown that 'soft' OA adds value in problem structuring[1], option design and action planning. A CoBP should ensure that the value of 'soft' OA is maximised. On the one hand, a CoBP that addresses issues of validity will most likely increase credibility of study results which can therefore be trusted and accepted. On the other hand, a CoBP that also addresses what a client can and should expect from 'soft' OA, how to assess its results and how it leads to recommendable actions will also most likely increase understanding and appraisal of the relevance of such approaches. This will, in the end, be beneficial to the quality of defence decision making and the value and versatility of OA support, both in direct support of operations and in longer term support of (strategic) defence planning.

1.2 READERSHIP AND ORGANISATION OF THE GUIDE

The Guide is aimed at three different groups of *readers*:

- People who either own or are involved in the problematic situation or have stakes at or an interest in resolving the problematic situation and people who are otherwise involved in the process as providers of viewpoints, information, and other aspects of relevance, etc. (i.e. clients[2] and other stakeholders, subject-matter experts);
- People who conduct the study, suggest the methodologies and methods to be used, facilitate the study process or otherwise offer analytical support (i.e. operational analysts, facilitators) or scrutinise the study (i.e. scrutineers); and
- People who as executive or commanding officers have the burden of the final responsibility of having a problematic situation resolved, who have to agree on decision recommendations and actually take the final decision (i.e. executive decision makers).

Under the common header of "NATO Guide for Judgement-Based Operational Analysis in Defence Decision Making" the Guide has been organised in three separately published volumes in conformity with the three types of readers listed above.

1.2.1 An Analyst-Oriented Document

This document carries the sub-title "Code of Best Practice for 'Soft' Operational Analysis" and is in fact the Code proper and the most extensive volume of the three. It addresses the issues that the NATO Task Group felt would be important for analysts to know when new to the field of 'soft' OA; it sets the 'rules of the road' for analysts. Later sections of this chapter will introduce this document in more detail.

1.2.2 A Client-Oriented Document

This is a document which explains what 'soft' OA is in terms of judgement-based analysis and what one can expect from it. It is based on those elements of the first, analyst-oriented document that are relevant to clients. The document's chapters address the following questions:

[1] Although a large body of literature exists about what is known as 'Problem Structuring Methods' (which encompass some specific methods/methodologies), this CoBP has adopted the view that:

a) Problem Structuring Methods can do more than merely structure problems; and

b) There are quite a few other methods/methodologies (e.g. Multi-Criteria Analysis) that also enable problem structuring.

This CoBP will therefore not treat Problem Structuring Methods as a methodology of its own but as part of the broader family of modelling approaches that 'soft' OA comprises.

[2] Different types of people, their roles and responsibilities will be summarised in Section 1.6 and discussed further in Chapter 4.

- 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 CoBP protect the client from threats to the study?

1.2.3 A Document for the High-Level, 'Executive' Decision Maker

This document is a concise brochure carrying the sub-title "Judgement-Based Operational Analysis for Improved Defence Decisions". It summarises the client-oriented document and is written for executive decision makers, including high-ranked officers, and addresses the following issues:

- What is judgement-based OA?
- How can defence decision makers be supported?
- When should judgement-based OA be used?
- What can you do with facilitated workshops?
- What are the value and the benefits of judgement-based OA?

It also mentions the other volumes of the Guide and points out where more information can be found.

1.3 PURPOSE OF THE CODE OF BEST PRACTICE

A code of best practice captures and presents the peer consensus of the practitioners in a specific field of the behaviours, processes, information, and standards which constitute the current recommendable mode of action in that field. It aims to inform and guide practitioners in its field, both established and new, on the considered best ways of proceeding so as to complement and extend the existing knowledge base. It also defines the boundaries of accepted best practice, indicating where knowledge becomes weak or non-existent, and where further research may be required to extend the code.

A code of best practice may be derived from a consensus, formal or informal, or could be the product of a committee or a single mind. It gains its authority from peer review and the success of its application. The CoBP for 'soft' OA aims to inform, guide, validate, make credible and/or indoctrinate current practices for readers working to solve problems that require using 'soft' OA methods and techniques.

The CoBP for 'soft' OA aims to provide practical advice, and to set a benchmark for best practice to both clients and analysts in order to get the best out of the resources available. There should be some expectation that the analyst community uses this Code as guidance for best practice use of 'soft' OA methods (this volume). A client should use the Code to enable a better understanding of how 'soft' OA methods can help the client to make effective decisions (client-oriented volume, printed under separate cover). The Code aims to help an analyst and client cope with the issues of subjectivity that come with using 'soft' OA methods, and to cope with any analyst/client bias in the analysis process. It aims to provide guide to practitioners concerning the quality of subjective information and analysis, the transparency of the methods used and the credibility of the outputs.

The purpose of the CoBP is:

- **To create an understanding of what 'soft' OA is;**

- **To clarify what 'soft' OA can do to help address problematic situations, and what people can expect from it in that respect; and**
- **To provide guidance on how a 'soft' OA study should be carried out in order to maximise the validity, credibility and acceptance of the study and its outcomes.**

The CoBP is designed to be educational in the sense that it aims to clarify what 'soft' OA is, and when and how it can or should be used. The analyst-oriented volume, the actual Code, sets the rules of the road for analysts who are relatively new to this field of OA. It is however expected that more experienced 'soft' OA analysts will also find it of value for educational of reference purposes whilst having developed their own views on how this type of analysis should be carried out and perhaps their own methods or methodologies. The guidelines are offered as a means of assistance to analysts and are not meant to be too prescriptive in nature.

1.4 SCOPE OF THE CODE OF BEST PRACTICE

The purpose of decision support by 'soft' OA remains the primary scope of the CoBP. Within that context, the CoBP will look at 'soft' OA across the whole spectrum of applications. The CoBP will therefore deal with problem types that require a decision at some point, be it by an individual or by a group of people, be it a final decision or perhaps rather a recommendation for a decision, be it a short-term decision on, for example, operational contingencies or a long-term impact decision regarding some strategic issue. Typically, a great many workshop sessions are held and facilitated where a group of people meet to identify relevant knowledge or discuss some other issue of interest without identifying options that have to be decided upon. However, the CoBP will not address single session studies for, for example, mere knowledge elicitation. Facilitation methods exist which could be regarded as 'soft' and may be helpful for this type of limited-scope workshops, but these are not the types of studies or workshops that the CoBP addresses. The CoBP is not meant to be a guide to facilitation techniques or the organisation of workshops.

The CoBP does not describe, compare or assess individual 'soft' methods and techniques. There are textbooks and articles that do that. The CoBP is rather focused on issues of their usage and contribution to rigorous and auditable quality of both process and content. It does not recommend any of the existing formal methodologies or methods other than in a general sense. However, ideas of how to approach specific aspects have been adopted from existing (refereed) literature. Chapters 6 and 7 will mention some methods, by way of examples, to address specific issues.

Further, as stated previously, studies that require 'hard' OA usually have aspects that require human judgement and thus may benefit from 'soft' OA methods. The CoBP does not address 'soft' aspects of 'hard' studies (e.g. interpreting 'hard', numerical model results) as a particular phenomenon in itself. If those 'soft' aspects are substantial and are perhaps even supported by a method, then one is dealing with a mixed ('multi-methodology') approach (where 'soft' and 'hard' methods are combined) which will be discussed in Chapter 6.

The use of OA in an operational setting is explored by the NATO Technical Team SAS-089 "Operational Analysis Support to NATO Operations". Its aim is to elaborate a recommendation of an organisational structure, common procedures, technical training, and tools that improve effectiveness, interoperability, and sustainability of OA in support to operations in both NATO and national static and deployed HQs. The focus of the work of the team is on the provision of direct – especially deployed – OA support to NATO Operations. The purpose of such support is to improve the quality and pace in the decision-making process during all phases of operations. This subject will therefore not be addressed in this CoBP.

For pragmatic reasons the CoBP has adopted the term 'soft' even though it may be argued that this incorrectly suggests that a clear distinction between 'soft' and 'hard' exists. It has already been argued, and to be elaborated in Chapter 2, that even a 'hard' study has 'soft' elements. Similarly, such terms as

'qualitative' and 'quantitative', 'objective' and 'subjective' suggest distinctions that are not always warranted in practice. Initially, the authors of the CoBP attempted to introduce the term 'judgement-based' OA, since what the CoBP is about to describe is a type of analysis that is predominantly based on human judgement. Judgement-based OA applies the methods of 'Soft Operational Research' developed in academia. It has appeared, however, that the analytic community has become used to the term 'soft' OA to such a degree that the formal use of the term 'judgement-based' OA would have created unnecessary confusion. The CoBP uses 'judgement-based' where a special emphasis on the use of judgement is needed.

1.5 OVERVIEW OF THE CODE OF BEST PRACTICE

The chapters of the CoBP are organised according to four main themes put forward in the form of the following questions (ref. Figure 1-1):

- *What* is the CoBP about?
- *Why* was it written?
- *Who* is involved in a 'soft' OA study and what is expected of them?
- *How* should a 'soft' OA study be conducted?

Figure 1-1: Line of Reasoning Concerning the Flow of the Chapters.

Below follows an overview of the content of each chapter and the annexes of the CoBP:

- Chapter 1 presents an introduction to the subject, including scope, purpose, and meaning of the CoBP as well as some information on the working procedure. It also provides an overview of some key concepts that are used throughout the CoBP; many of these will be elaborated in specific subsequent chapters.
- Chapter 2 provides a general introduction to issues that are pertinent to the nature of 'soft' and 'hard' OA, including the phenomenon of uncertainty. It attempts to characterise 'soft' and 'hard' OA rather than provide a formal definition for each term. This chapter also addresses why one would do 'soft' OA in the first place.
- Chapter 3 discusses how a 'soft' study contributes to addressing a problematic situation as intended by the CoBP. It shows the line of reasoning of the CoBP and the philosophy of the use of methods, with a particular emphasis on aspects related to the purpose of writing the CoBP (e.g. validity, credibility and acceptance). This will be addressed again in later chapters, but more specifically in Chapter 8 where issues of interpretation and the use of study outcomes are discussed.
- Chapter 4 presents a discussion of the roles and responsibilities of the various actors involved in a 'soft' OA study, with a particular emphasis on the analyst and the facilitator. The use of subject-matter experts will be discussed in Chapter 7. Study success and acceptance largely depend on the quality of the process wherein the various actors interplay, and depends to a large degree on procedural rationality (i.e. the quality of how things are done and organised) in conjunction with substantive rationality (i.e. the quality of what is done).
- Chapter 5 presents an overview of the stages of the study process when conducting a 'soft' OA. It is an iterative cycle where products or findings of previous stages are reviewed based on new insights gained during later stages. The way in which the process is set up and actually conducted does in itself contribute to the validity, credibility and acceptance of a study. The chapter also addresses issues of parallel and sequential modelling activities, and divergent and convergent process stages.
- Chapter 6 addresses the modelling process in general and 'multi-methodology' in particular, which is the approach where various, possibly very different, methods are combined in one study. It provides guidelines as to the suitability of a combined approach and when to apply it. Many of the guidelines are also relevant to a single-methodology approach. The chapter also discusses the initial stages of a study where the nature of the problematic situation has to be assessed and upon which the design of the study methodology must be based.
- Chapter 7 presents an overview of the ways in which data can be collected, including elicitation of information from individual experts, sensitivity analysis, coping with data uncertainty, and dealing with subject-matter experts who are asked to provide information in a facilitated workshop setting. This chapter draws heavily from Chapter 4, as people (even experts) are often subject to biases when answering questions It stands in its own right as far as facilitation of groups of people is concerned, how data is gathered and interpreted using subject-matter experts, and how people work together to produce outcomes.
- Chapter 8 addresses how to communicate and report on the outcomes of a 'soft' OA study. This chapter draws on Chapter 7 about framing and biases, but also on Chapter 3 as far as validity, credibility and acceptance are concerned. Triangulation, sensitivity analysis and coping with bias all contribute to the validity of the results and are discussed in this chapter from a somewhat different perspective than previous chapters.
- Chapter 9 concludes with a summary of the essence of the CoBP and some final remarks.
- Annex A contains a list of key statements and recommendations that are taken from the initial summarising text boxes of each chapter and are especially important to the analyst (the 'rules of the road').

- Annex B contains a selective list of 'soft' OA methods and methodologies, quoted from [9].

1.6 KEY CONCEPTS

It is useful to discuss some key concepts that permeate throughout the CoBP. The definitions are based on [10], and more specifically [11], but have been adapted for the purpose of the CoBP:

- '*Methodology*' – Although the general philosophical meaning is that of 'the study of methods', the CoBP will regard 'methodology' as '*a particular combination of methods that possess a common set of characteristics and assumptions and are used in a study to achieve a purpose*'. That purpose may be the overall aim of the OA study or a part of it.
- '*Method*' – This term will be regarded as '*a structured set of guidelines or rules to achieve some clear well-defined purpose*' which may or may not involve mathematical calculations. Here, 'purpose' is meant to be a part of the aim of the study and its achievement will contribute to the overall study aim. The rules may be algorithmic in the mathematical sense, but could also be behaviour- or procedure-oriented, or a combination of both.
- '*Technique'* or '*Tool'* – These terms denote each of the specific algorithms or interviewing modes (etc.) which are part of a method. A difference could be made between the two where 'tool' would be regarded as the agent of a technique, e.g. a software program.
- '*Model*' – A model will be regarded as '*a representation of (a part of) reality (i.e. a problematic situation) as seen by a number of people who wish to use the model to understand, manage, or improve that reality*'. The model 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. Both setting up a model and using it (or, in 'hard' OA terms, even solving it) usually requires a method.

The definitions above suggest a clear difference between 'method' and 'methodology'. In practice, that difference is blurred and the two are used inter-changeably in the literature; there is no clear agreement in the literature about these terms. In the CoBP 'method' will be used to denote specific methods and 'methodology' will be used to denote a combination of methods or a general study approach where one or more methods are used.

In the light of the definitions above, 'soft' OA may be regarded as a '*meta-methodology*': a higher level of methodology, encompassing all 'soft' methods and methodologies. Note the distinction from the term '*multi-methodology*' which is a specific combination of different methodologies used in a study. A multi-methodology approach, based on a mix of appropriate ('hard' and/or 'soft') methods, has appeared to be very common and successful in practice and will be addressed in Chapter 6.

There are a number of additional key concepts that need to be discussed at the outset:

- '*Intervention*'[3] – This term denotes the process of challenging and changing people's thinking or an organisation's activities in order to achieve understanding and improvement and often, along the way, resolving problematic situations. The CoBP will avoid using intervention but rather use 'study' instead.
- '*Study*' – This term denotes a set of activities that is part of an intervention and usually refers to more specific actions of investigation and research, problem analysis and resolution.

[3] 'Intervention' will not be regarded as a military operation like in 'the intervention in Afghanistan' unless specifically indicated as such.

- '*Analysis*' – This term denotes a set of activities aimed at decomposing (physical, organisational, social) systems, problems, problematic situations, operations, etc., into their constituent parts, and at investigating their relationships and their meaning.
- '*Operational Analysis*' (term mostly used in the defence community, but equivalent to the term 'operational research' used in academia) is the interdisciplinary science that focuses on how appropriate actions can be designed to change (i.e. towards improvement) or even (re)solve problematic situations. The CoBP addresses 'soft' OA, an approach that uses methodologies and methods predominantly based on the rational (i.e. not intuitive) use of human judgement.
- '*Result*' – This term denotes what has been produced by using a model and applying a method, or merely following a process. It is rather more specific than 'outcome'. 'Results' constitute the ingredients for an 'outcome' (to be analytically interpreted), although in practice the distinction is not always crisp.
- '*Outcome*' – This term denotes what has been achieved with the study ('effect' or 'impact'), based on specific results and their analytic interpretation. It refers to what one can do with the results and what the meaning of the results is.
- '*Decision*' – This term refers to the result of making up one's mind regarding a choice between alternatives. The kinds of decisions that will be taken on the basis of a 'soft' OA study pertains to a choice between alternatives: ways forward ('actions'), (organisational) strategies, policy options, and the like.
- '*Alternative*' or '*Option*' – This term denotes one of two or more possibilities to be chosen for addressing, improving or (re)solving a problematic situation.
- '*Stakeholder*'[4] – This term denotes the person who affects or is affected by the (resolution of the) problematic situation. It encompasses rather different types of people who are, or have to be, involved in a study. Even 'analysts' and 'facilitators' (see below) may to some extent be regarded as 'stakeholders' as they, too, affect the study or are affected by it, e.g. their interest in its perceived success. The CoBP will address the way in which stakeholders should be involved in a study, and what roles they play.
- '*Client*' – This term denotes four specific types of stakeholders: the *sponsor* who actually owns the study, the *customer* who pays the bill for the study, the *decision maker* who may make decisions regarding the problematic situation and the *end user* who is ultimately affected (either positively or negatively) by the study outcomes and related decisions. All four together own in some way the problematic situation. The real client could, however, remain invisible, and could indeed be unknown. Note that situations can exist where there is not one single client but rather a group of clients ('client system') who may have (very) different interests in or views of the problematic situation, even if formally they adopt the same role. The 'primary client' is the first point of contact of the analyst; primary client and analyst are partners throughout the study.
- '*Subject-Matter Expert*' – This term denotes an individual who has considerable relevant knowledge without necessarily owning or otherwise being part of the problematic situation. He[5] is the expert in a particular area or topic and provides information; in doing so, he affects the study. The CoBP will specifically address issues concerning the elicitation of information from experts.
- '*Analyst*' – This term denotes a person who conducts a study, and in this capacity designs the stages of the process, suggests the methodology(ies) and method(s) to be used, the workshops to be held, ways to analyse and model the problematic situation and to report and interpret the study's outcomes. The analyst should work in cooperation with the client(s) and with a fundamentally helpful attitude, but at the same time he should be devoted to rigorous and ethical principles.

[4] The types of people that follow, including their roles and responsibilities, will be discussed further in Chapter 4.

[5] Throughout the CoBP the male form is used for simplicity's sake. This does, of course, in no way rule out any female actors.

- '*Facilitator*' – This term denotes a person who helps (i.e. supports, enables and encourages) individuals or a group or groups of stakeholders, clients, subject-matter experts, and analysts work together through the stages of a study by managing procedure (the way the problem is tackled) and process (the way participants interact), whilst adopting an impartial attitude. Facilitation is, similar to analysis, fundamental to the CoBP as the quality of a 'soft' OA study depends on it.

1.7 REFERENCES

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1.8 RECOMMENDED ADDITIONAL READING

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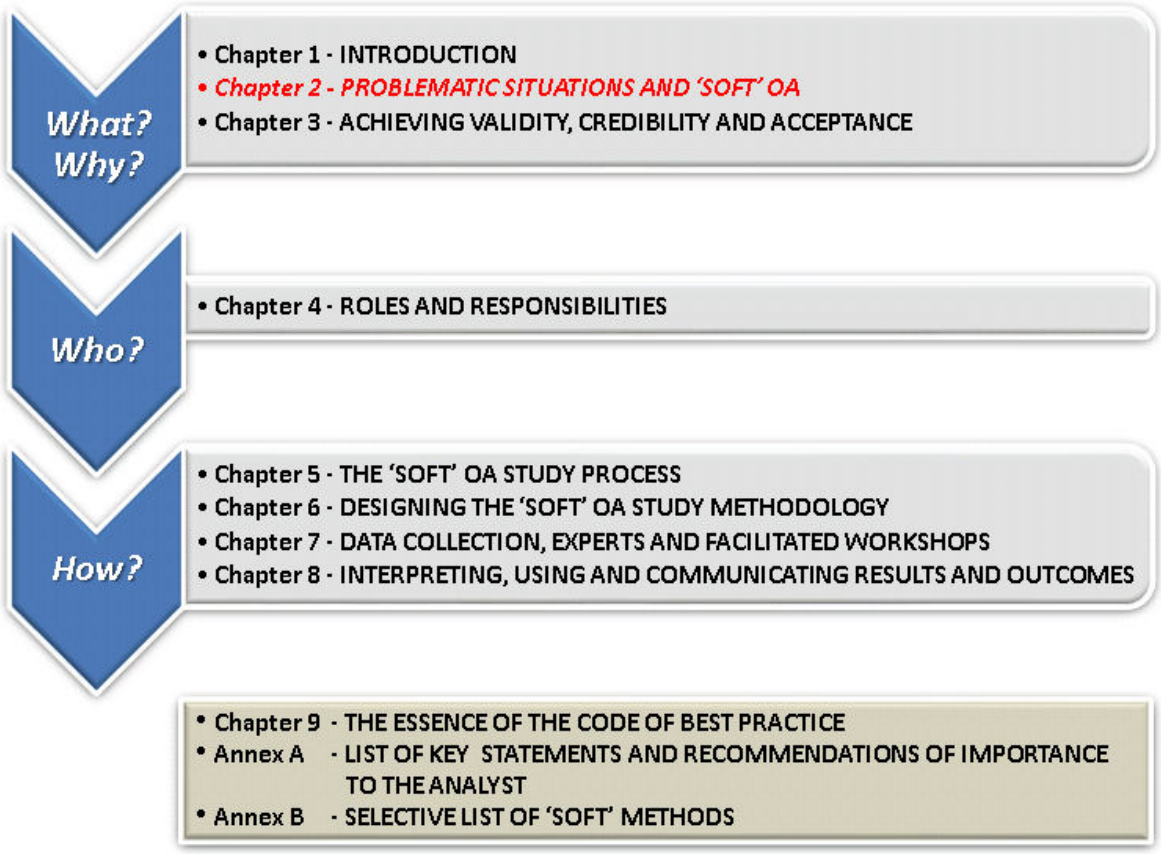
Chapter 2 – PROBLEMATIC SITUATIONS AND 'SOFT' OA



- Three types of a problematic situation can be distinguished: puzzle, problem (proper), mess. Each type is approached somewhat differently. 'Soft' OA tends to be more suitable for problems (proper) and messes.
- 'Hard' and 'soft' OA both support decisions regarding problematic situations. There are however numerous differences between them from a large number of perspectives, although in practice each perspective represents a spectrum.
- Uncertainty is one of the key phenomena that need to be addressed in a problematic situation as it characterises a problematic situation to a large extent.
- 'Soft' OA aims to structure problematic situations (with a focus on problems proper and messes), identify stakeholders and their interests and perceptions, include them in the study, use modelling primarily as a means to clarify issues and enhance communication but also to identify possible options for a most preferred way ahead in resolving the problematic situation.
- Messy problems cannot be fully resolved but should rather be managed.
- 'Soft' and 'hard' OA are in many respects complementary to one another; they are not competing OA approaches.

2.1 INTRODUCTION

This chapter introduces three types of a problematic situation that may be encountered. It then discusses the characteristics of 'hard' and 'soft' OA and points out similarities and differences. It focuses on the nature of data and models (and methods) and relates this to 'soft' and 'hard' OA. The chapter also discusses the phenomenon of uncertainty that to a large extent characterises the type of problematic situations addressed by OA (and specifically 'soft' OA in a defence context). This chapter ends by summarising why one would use 'soft' OA in a study.

2.2 PROBLEMATIC SITUATIONS

The term 'problem' has many meanings: it is used in this CoBP for any situation in which there is a perceived gap between its current state and its desired or required state, and which needs or seems to need a (re)solution involving some action, although it may often be unclear what (re)solution and what action are most appropriate. The term also has a specific meaning as one type of 'problematic situation' (see below).

For the purpose of the CoBP it is useful to distinguish between a few distinct problematic situations. The reason for this is that they usually require different approaches to address them. The literature suggests the following three problematic situation types summarised in Table 2-1 (ref. e.g. [1]):

- '*Puzzles*' – These are problematic situations where the issue is clear, what needs to be achieved is clear and the way in which this should be done (i.e. the model to be set up and the method to be applied) is also clear. Even in the case where these elements are not immediately clear, an agreement on their definition can be easily reached. Achieving a solution to a 'puzzle' may still be complicated but knowing how to build the model and which method to apply is a matter of education and expertise. The quality of the solution (e.g. its optimality) is usually testable.
- '*Problems*' – In this CoBP, problems have a more specific meaning and will therefore referred to as 'problem (proper)'. They denote situations where the issue may be more or less clear and structured and what needs to be achieved is (partially) clear as well. It is however not clear at the outset in what way a solution to a problem should be designed. Whereas the issue and the desired achievement may be readily agreed upon, achieving a solution is not a routine activity but will have to be negotiated depending on the views of the people (including analysts) involved and (often many) perspectives that are relevant. Therefore, it is not likely that an overall optimum solution will be produced. Rather a 'most preferred' (or 'satisficing'[1]) solution or set of solution options will be the result of the analysis, which will therefore require creativity in addition to education and expertise.
- '*Messes*' (or: '*Wicked Problems*')[2] – These are problematic (or even chaotic) situations that are ill-structured or do not seem to have any structure at all. The issues, and how they are interrelated, are not clear and considerable disagreement exists about them. Similarly, there is disagreement regarding what is to be achieved, who is to be involved and the steps that are to be taken towards some improvement or acceptable change of the situation. What is assumed, however, is that to some degree and with at least some people a sense of concern exists about the situation; something needs to be done, some decision must be taken in the end. What is also assumed is that it is possible to argue over the definition of the characteristics of the problematic situation. Messes are not solved, but managed [2]: coping with 'messes' requires considerable ingenuity and both analytical and social skills in addition to expertise with similar situations. No two 'messes' are the same.

[1] A decision or strategy or (re)solution is satisficing if it is good enough ('adequate'), but not necessarily optimal.

[2] Rittel and Webber formally introduced the term 'wicked problem' in [4], although they had first used it in the 1960s. Ackoff [5] introduced the term 'mess' or 'messy problem'. Although formally not identical, for practical purposes within this CoBP they denote a similar problematic situation type. This CoBP uses the term 'mess' or 'messy problem'.

Table 2-1: Main 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 problems or problematic situations that 'soft' OA seeks to address are usually the messy problems, and to some extent problems proper, that present no obvious solutions. Problem framing is thus the activity of trying to understand a problematic situation so that meaningful action can be taken (ref. Chapter 6).

When approaching a messy problem, it is usually clear that there is (at least initially) no agreed problem definition. Different stakeholders will have legitimately different and perhaps even contradictory views of its nature. In this context, problems have to be seen as socially constructed [3]. This means that there cannot be a correct problem definition, merely many possible definitions that may be useful for facilitating action. Moreover, the stated problem may not be the real or full problem and the problem statement should therefore be explored.

A well-defined problem is helpful for conducting a study, but in many cases it may not be possible to agree on a problem definition. In order to get a useful answer, it helps if you know what the question is. At the same time, the socially constructed nature of problems means that getting a useful problem definition has to involve some kind of negotiation. Often in 'soft' OA, in order to frame a problem, a facilitated process is used. Many of the more well-established methods in 'soft' OA are focused on problem definition.

It has also been argued (Chapter 1) that 'soft' OA will be of value in decision-making situations where the inputs in terms of data and information are not readily or reliably available[3], the decision consequences cannot be easily foreseen, or where decision options may even be undefined and clear inputs non-existent. Also for this reason, 'soft' OA and therefore reliance on human judgement will most likely be of value when facing 'messes' and perhaps 'problems' as well. 'Hard' OA will most likely be of value with 'puzzles' and to a lesser degree with 'problems'.

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 bound 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.

[3] This non-availability of data or its lack of reliability may also occur in a 'hard' OA study. In the latter, one would most likely resort to a parametric study.

Figure 2-1 illustrates[4] that puzzles represent clear-cut problematic situations where sufficient factual and complete information exists and little judgement is required. By contrast, messes represent complex problematic situations with incomplete and little factual information requiring substantial judgement. The potential usefulness of applying 'soft' OA increases when moving from the upper left corner of the diagram to its right lower corner.

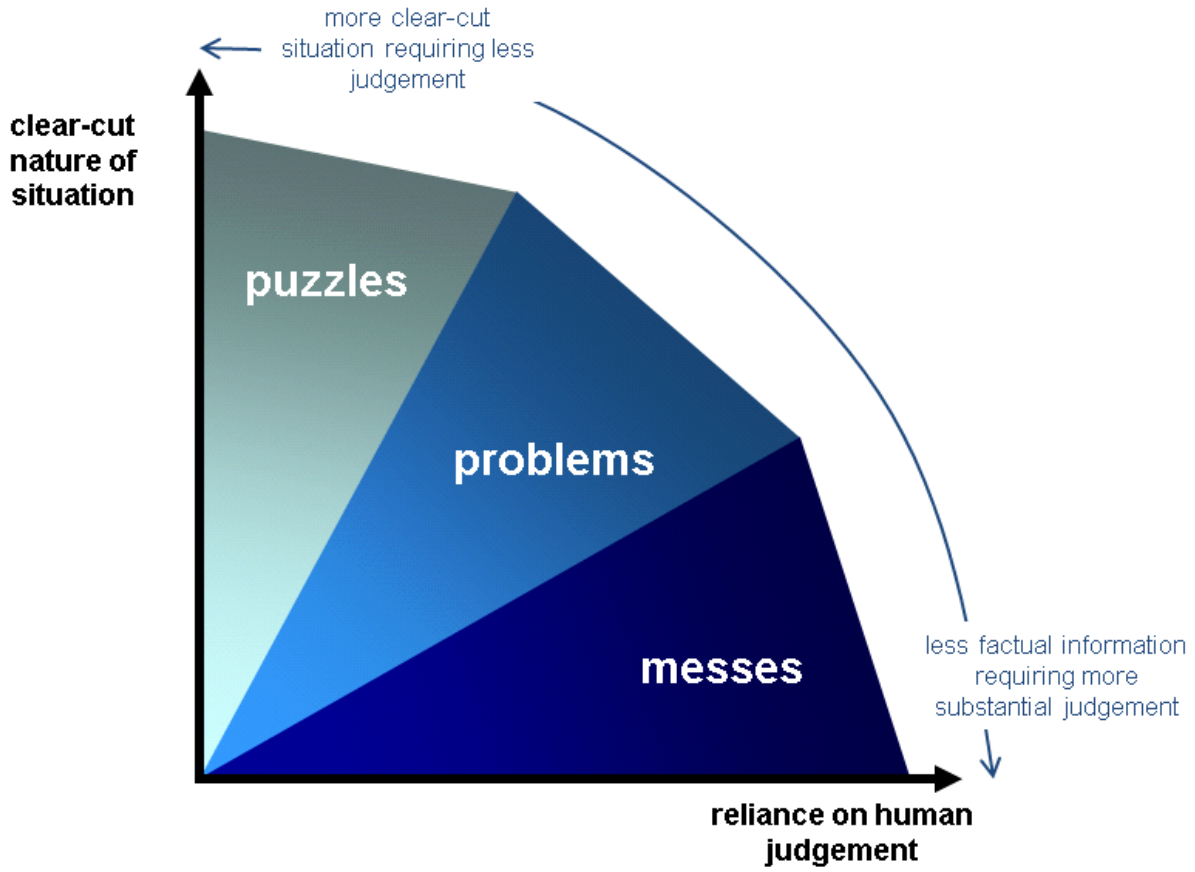


Figure 2-1: A Spectrum of Problematic Situations (Problem Types) and Their Clear-Cut Nature versus Reliance on Human Judgement.

2.3 ATTITUDES TOWARDS UNCERTAINTY

Defence problems almost always involve many kinds of uncertainty from a range of sources. Some of the uncertainty emanates from the characteristics of defence issues, and some of it is generally associated with the messy nature of problematic situations. For long-term defence issues, the main uncertainty is the development of the future operational environment, which determines the conditions within which a future capability is to be used. As new military capabilities require long lead-times, addressing this uncertainty is challenging. For near-term operational issues the key uncertainty is related to the intentions and capabilities of various actors in a complex conflict situation, and the character of the conflict in general.

Uncertainty in itself may call for 'soft' OA. In addition, messy problems show other forms of uncertainty. There is uncertainty regarding the objectives of action, closely connected to the uncertainty of intentions mentioned above. There is also uncertainty regarding the consequences of an action, emanating from a limited

[4] See [6] for an alternative way of illustrating this.

understanding of cause-effect relationships between factors of influence and unclear or debatable boundaries of problematic situations.

Fundamentally, there are two meanings of uncertainty which are related to its root causes: the *absence of knowledge* and the *inherent variability* of phenomena. In order to cope with uncertainty, three basic attitudes towards it may be distinguished, depicted in Figure 2-2. The corners of the triangle in Figure 2-2 represent basic 'primitive' attitudes, or types of bias, towards uncertainty:

- *Prediction* is the attitude that one should attempt to minimise uncertainty by trying to make as accurate predictions as possible.
- *Control* is the attitude that one should attempt to minimise uncertainty by seizing the initiative and taking control of the relevant bits of the environment.
- *Acceptance* is the attitude that one can never know what is going to happen, so there is no point in trying to predict or reduce uncertainty in any way.

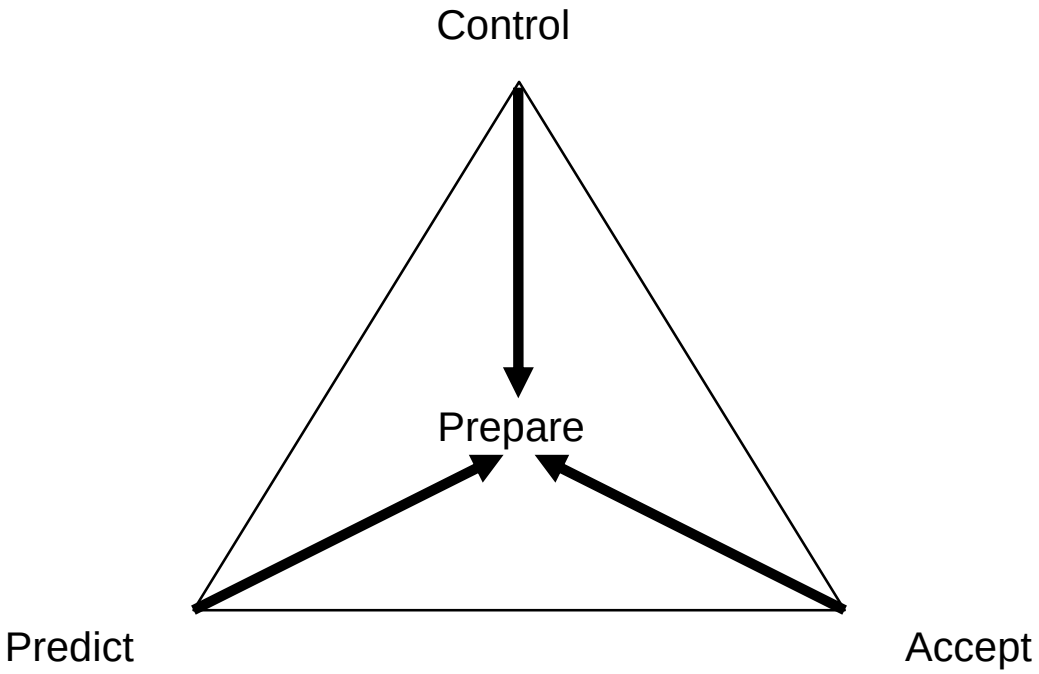


Figure 2-2: The So-Called Uncertainty Triangle, Denoting Basic Attitudes Towards Uncertainty (Extended from [7]).

Any of the three attitudes may lead to some form of *preparation.* This could range from focusing on those elements of uncertainty that can be predicted and design options accordingly, to designing, for example, a flexible, module-based response strategy in preparation of any contingency or challenge that might occur.

The idea behind the triangle is that a client should be aware of these attitudes, and that a proper mix of all three will be the most fruitful approach to preparing for uncertain events. For a messy problem, adopting only one of these attitudes is rarely sufficient.

It should be clear that it will not be sufficient to address uncertainty by merely varying a few of the parameters at the end of the study as part of a sensitivity analysis. The attitude towards uncertainty will shape the design of the study, specifically its problem framing stage and the stage where the *type* of options should be considered [7].

In subsequent chapters specific aspects of uncertainty will be discussed in more depth. For example, how the nature of the uncertainty affects the design of the study's ('soft') methodology is discussed in Chapter 6.

2.4 CHARACTERISTICS OF 'HARD' AND 'SOFT' OA

In the academic literature there has been some debate about the relationship between 'hard' and 'soft' OA. Some argue that they are two different ways of thinking, even two radically different paradigms[5] considering the differences in problematic situations for which they are most appropriate and the different methods they encompass. The CoBP adopts the view of others who argue that the two are complementary and can be used in series or in parallel, and even that 'hard' methods can be accommodated within a larger framework of 'soft' OA methods and vice versa. Even with 'puzzles' to be solved using some 'hard' OA technique there will always, at some level of the hierarchy of clients or at some stage of the study process, be different interpretations of data or results or validation findings. There will also be experts providing estimates based on judgement; and there will be group discussions in order to arrive at a consensus about, for example, the problem formulation to begin with. All these matters, also to be addressed in a 'hard' OA study, require approaches that are based on judgement and thus are related or even belong to the area of 'soft' OA. In addition, a 'soft' OA approach may turn to the use of some 'hard' method to solve a well-defined problem as part of a messy problematic situation[6]. This will be shown in the illustrative study scenario depicted in Figure 3-1 in Chapter 3.

In previous sections a large number of aspects of 'soft' and 'hard' OA have been addressed. They pertain to the nature of the problematic situation for which they are most suited, the purpose and outcome of a study, the people involved, etc. In the literature numerous taxonomies and tables can be found highlighting similarities and differences between the two types of OA. The most useful distinctions are summarised below in Table 2-2 instead of providing formal definitions of 'soft' and 'hard' OA. The descriptions tend to emphasise the differences and sometimes indicate extremes, but one should be aware that each aspect listed in Table 2-2 represents a spectrum of possibilities.

[5] A '*paradigm*' is a set of philosophical assumptions about what should be done and how (and the ethics of it) and about the nature of existing knowledge (and its validity) (based on [8]).

[6] As a further clarification: one of the methodologies that is often applied in a 'soft' OA is 'Soft Systems Methodology' [9]. The adjective 'soft' in SSM however refers to the way of dealing with problematic situations, not the nature of that situation itself. SSM can assist in addressing puzzles as well.

Table 2-2: Differences Between 'Hard' and 'Soft' OA as Extremes of a Spectrum (Based on e.g. [1], [3], [10]).

Aspects and Elements of the Study	'Hard' OA	'Soft' OA
Methodology	Based on generally accepted and theoretically grounded views of analysis. Predominantly factual and objective.	Based on thoroughly discussed arguments accepted by study participants. Predominantly interpretative, subjective, inductive. Proven value by experience.
Models	Shared representation of problematic part of the real world. Unambiguously linked to the study purpose and assumed to produce a problem solution. Utilise often (in addition to 'soft' representations) a formulaic representation of relationships between quantified concepts.	Representation of problematic part of the perceived world based on and shared by some or all study participants. Help understand study purpose and contribute to improving problem issues. Utilise the power of visualisation of concepts and their relationships often using well-chosen verbs and nouns.
Methods	Predominantly mathematics-based. Algorithmic.	Predominantly judgement-based, governed by guidelines and non-mathematical rules.
Data	Based on observer-independent measurement. Uncertainty treated stochastically.	Based usually on observer-dependent judgement. Uncertainty mostly treated qualitatively.
Study Outcomes	Based on rational, quantitative analysis. Based on clear results. Nature: 'solutions'. Search for the optimum. Repeatable.	Based on explorative, qualitative analysis. Based on insights and learning. Nature: 'ways forward'. Search for the requisite and accepted. Often not repeatable.
Study Purpose	Based on problem analysis. Clear at the outset and then taken as given.	Can become clear after problem analysis or even after one or more study stages.
Problematic Situation	Problematic situation is abstraction of the real world and can be delineated and engineered as a 'system' with its components. Usually short-term, operations-oriented. Single objective. Multiple objectives and perspectives can be modelled.	Problematic situation is often a mental construct and cannot easily or not at all delineated. Assembly of (partly) related 'concepts'. Usually long-term, strategy-oriented. Multiple objectives and perspectives exist, usually based on different stakeholder values that are difficult to reconcile.
Process – Study Stages	Can be designed ex-ante. Likely to be sequential.	Ex-ante design in general terms. Stages emerge as appropriate. Likely to be iterative.
Process – People Involved	Clients (and other stakeholders) provide input to problem analysis and model formulation. Power and emotion do not really matter. Analysts suggest and conduct the formal analysis, avoid biases, present solutions.	Clients (and other stakeholders) participate fully in process and can appear in a model-based representation of a problematic situation. Power and emotion matter. Analysts suggest and facilitate the process and any model usage, accommodate biases from different perspectives, engage clients in actively identifying options.

Although Table 2-2 suggests differences between the two approaches, the common denominator is the general posture of decision support.

The importance of Table 2-2 already arises at an initial stage of a study when the analyst has to negotiate the study approach with the client. Initial questioning based on the entries of that table will provide the analyst with information regarding for example (see Chapter 6 for further discussion):

- The nature of the problematic situation and the reason why it should be resolved;
- The people (or types of expertise) to be involved;
- The amount of effort required in getting a clear and shared picture among client and other stakeholders about what is to be achieved by the study, under what conditions an achievement is regarded as a success, and the nature of the information they can provide;
- The nature of the methodology/method to use (or even a combination of methodologies and methods), and the nature of data required;
- The study phasing; and
- The general attitude of the analyst and the client: a traditional expert mode (where the client can rely on the analyst to solve the problem), or a facilitated mode (where analyst and client/stakeholders work together to create satisficing options) [3].

Table 2-2 leads to four positive elements for a judgement-based approach over a purely quantitative one:

- The nature of the models involved lead to more of a conceptual approach, allowing more freedom in addressing the essence of the issue and thus avoiding, possibly unconsciously, adherence to the original paradigm;
- A creative use of uncertainty, allowing 'what if' considerations;
- A recognition of the need to consider all sides of the issue; and
- An appreciation of how to handle different viewpoints and belief systems.

This implied creativity leads to a divergent discovery phase where all aspects of the issue are discussed and explored. This is where completely new options or approaches may be discovered. This can be compared with the case for more structured issues (e.g. 'hard' OA) where there will be steady convergence from the start. The issue of divergence and convergence will be addressed again in Chapter 5 (Figures 5-8 and 5-9).

2.5 THE NATURE OF DATA AND MODELS IN 'SOFT' AND 'HARD' OA

It may be useful to focus on two prominent elements of an operational analysis: the data and the model and method for analysis. This discussion will not exactly define 'hard' and 'soft' OA more precisely than the previous section, which would be a daunting task, but may create a deeper understanding of the nature of both.

Figure 2-3 shows a scheme of different instances of the nature of data and models and methods and their combinations. In italics, some examples are offered to illustrate the general descriptions. Figure 2-3a shows the shaded parts of the scheme that are typical of 'hard' OA; Figure 2-3b shows the 'soft' OA parts. The combination of 'subjective' and 'quantitative' appears shaded in both. It depends on where one puts the emphasis: the elicitation of this type of data may use 'soft' methods, the result however is treated as input to a quantifiable, mathematical model, although some uncertainty may be involved. Even the degree of uncertainty, for example when expressed as a quantitative interval, may be used as numerical input to a mathematical model, although the elicitation of that interval is, again, essentially a judgement-based process[7]. All this illustrates that the distinction between 'hard' and 'soft' is not as sharply delineated as

[7] Another example would be the elicitation of input data for the Analytic Hierarchy Process (a decision-making methodology based on a hierarchy of multiple criteria, [11]) which requires a judgement-based elicitation process. However, the judgement data are processed by mathematical means to yield relative frequencies in the hierarchy.

suggested by the boxes in Figure 2-3; the boundaries between the boxes are rather blurred in practice and the arrows indicate that the scales are floating.

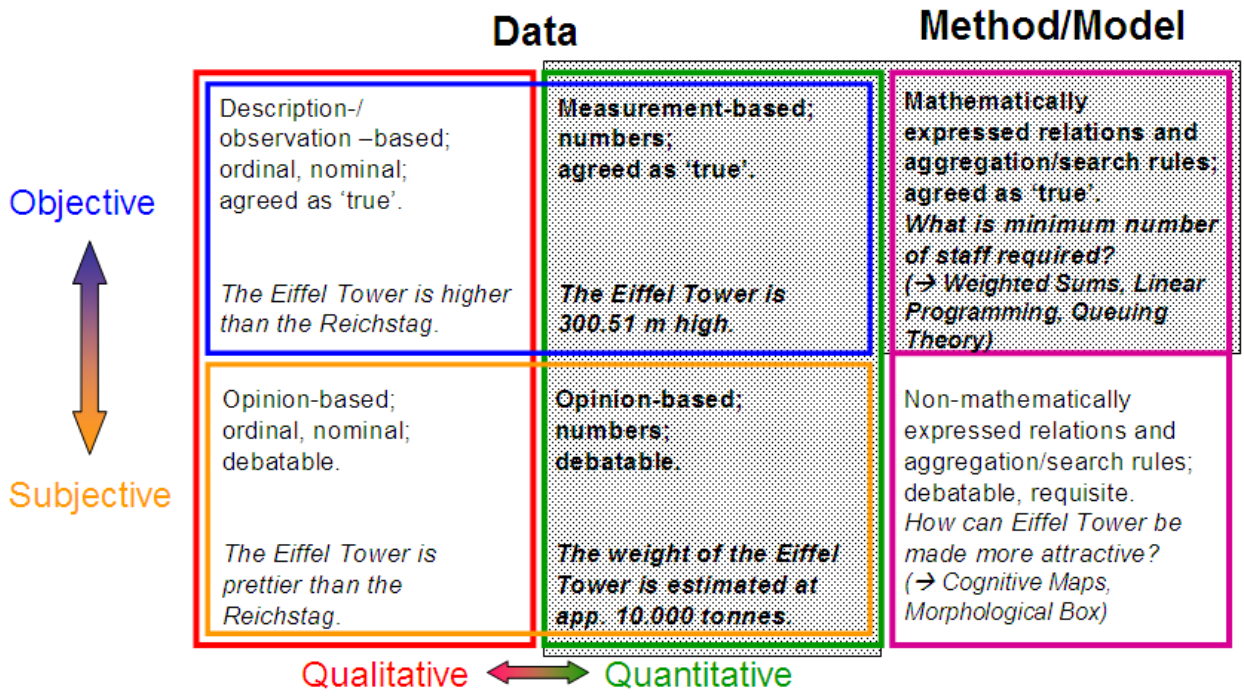


Figure 2-3a: Combinations of Data and Method/Model Types in 'Hard' OA (Shaded), with Examples.

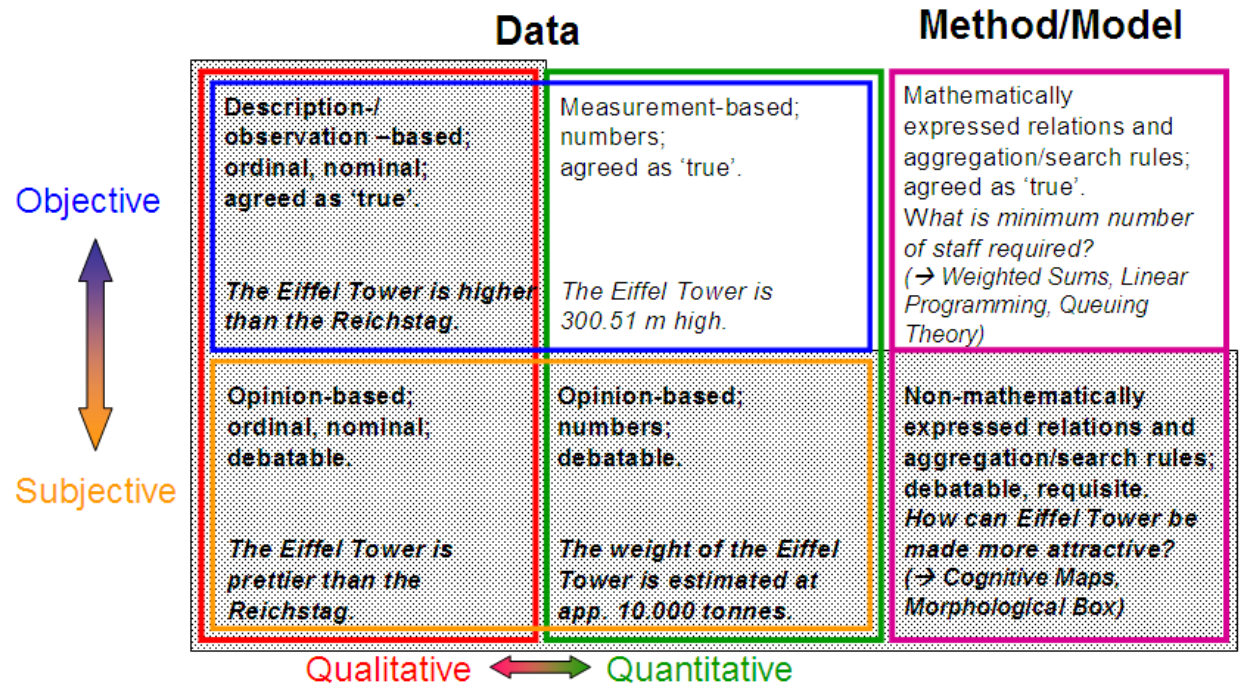


Figure 2-3b: Combinations of Data and Method/Model Types in 'Soft' OA (Shaded), with Examples.

Model-based decision support is the primary feature of OA and so it is of 'soft' OA. The type of models built and used (by using appropriate methods) in 'soft' OA, however, is different from that of traditional OA, as discussed in Section 2.4. The reason for this is that the nature of the problematic situation addressed by 'soft' OA is significantly different.

In general, building a model will enable (based on [3]):

- A convenient organisation (and most often visualisation) of the defining elements of the problematic situation and their interrelationships;
- A representation of a large amount of (qualitative and quantitative) information;
- Gaining a better understanding of the way in which factors influencing the problematic situation interact with the constitutive elements of that situation;
- Designing and investigating decision options and their consequences and determining which option(s) might be preferred over other options; and
- Enabling stakeholders to learn about the nature and root causes of a problematic situation by 'playing' with the model and thereby also gaining a better understanding of each other's viewpoints (i.e. the model is a learning tool).

A 'soft' OA model is, above all, a means to help people think about a problematic situation, understand and interpret its elements and factors of influence and their interrelationships, express and deal with views and opinions, identify crucial issues and come up with ways forward to address and cope with them.

By contrast, a 'hard' OA model is, above all, a means to search for an optimal solution to a well-defined problematic situation, or a 'satisficing' solution using mathematics-based heuristic algorithms.

2.6 BENEFITS AND OPPORTUNITIES OF DOING 'SOFT' OA

Now that the term 'soft' OA has been introduced and some key concepts and issues have been discussed, and before the guidelines for conducting a 'soft' OA study will be discussed in subsequent chapters, this chapter concludes by asking why one would use 'soft' OA in the first place.

There is a strong similarity between judgemental methods in operational research practice and a number of other modes of professional analytical practice. The closest relationship is perhaps with the domains of evaluation [12], social science (as described by SAS-074 [13]), business analysis, and elicitation (from experts) [14].

There are many issues when using traditional analysis techniques to analyse complex problems, as discussed earlier (e.g. in particular, understanding a system fully will assist in understanding the future behaviours of such a system). 'Soft' OA can incorporate multiple perspectives of the system and/or the problem and can help define boundaries and clarify assumptions and stakeholders' mental models.

'Soft' OA techniques can be used to try to make sense of these issues by bringing multiple stakeholders together to consider their multiple, often conflicting, views of the problem space. In particular, where there is a lack of clarity about the problem definition, disagreement and uncertainty about the issues and decision making, 'soft' OA techniques can play a large role in enabling stakeholders to make sense of the situation.

'Soft' OA techniques can help to manage the complexity within a problem space. They can consider both qualitative and quantitative data and information, including data that is incomplete or conflicting. Indeed 'soft' OA techniques are based on the judgement of stakeholders who are involved in the decision making.

For this reason, 'soft' OA techniques tend to be subjective in nature and hence multiple, and most likely conflicting, opinions of stakeholders could exist. But judgement can be treated as objectively as possible by following rules grounded in theory or established practice and by recording argumentation and rationale and agreeing on a sound process accepted by all involved.

In this remit, 'soft' OA can help to conceptualise and visualise the problem space and the issues, constraints and uncertainties within it. It starts to provide some structure to the problem to obtain a common understanding of the issues across stakeholders.

When using 'soft' OA techniques, there is often the need for a coherent and collaborative problem solving process because of the varied and conflicting stakeholder objectives and worldviews. A 'soft' OA analyst also needs to play the role of facilitator in order to achieve this successfully. Hence there is often the need for workshops and interviews in order to formally gather information. It is for this reason that 'soft' methods typically use subjective knowledge based on the judgement of stakeholders who are familiar with the problem space.

Stakeholders may have different priorities and different ways of working. 'Soft' OA can start to explore the disagreements and uncertainties that exist so that an agreed consensus can be developed and action can be taken. 'Soft' methods also enable individuals to consider other's points of view, and to consider how other people interpret the same experiences. When using these methods one can start to map out the relationships between individuals involved.

'Soft' OA can help one to start to make sense of the key issues and, although it often does not produce a perfect solution (there is no optimal solution to a messy problem), it can be a rather good approach to obtain a common understanding of the problem and the decision space, and to gain consensus amongst stakeholders on the way ahead.

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2.8 RECOMMENDED ADDITIONAL READING

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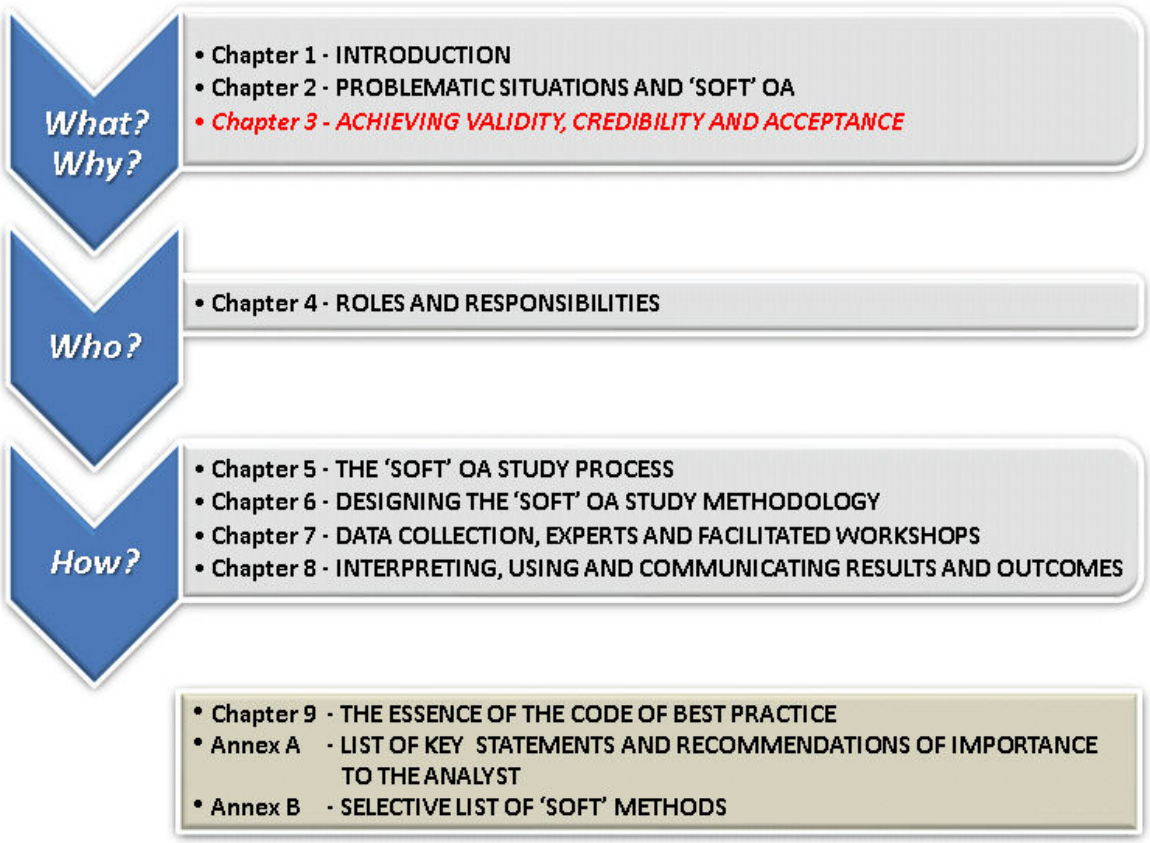
Chapter 3 – ACHIEVING VALIDITY, CREDIBILITY AND ACCEPTANCE



- The CoBP identifies how validity, credibility and acceptance can be achieved in a 'soft' OA study.
- The primary dimensions of validity are objectivity and rigour; credibility and acceptance are not distinct qualities but are rather derived from validity.
- The analyst's aim should be to make a clear distinction between the reality which is shared amongst the stakeholders, and the sectional perspectives which each may propagate for his own reasons.
- Gathering subjective judgements from experts exposes the analyst and his study to bias which can be motivational or cognitive in nature.
- The biggest threat to validity is ignorance at the design stage of what is likely to be important. This threat can itself be mitigated by creating an iterative design similar to that used in experimentation.
- An analyst needs to conduct activities in an ethical manner that deserves the confidence of all parties involved.
- Credibility and acceptance will be reinforced by independent scrutiny.

3.1 INTRODUCTION

The previous chapters of this Code have set out the aims and purposes of a Code of Best Practice and discussed the characteristics of 'soft' OA and judgement-based analysis. This chapter will describe the general context and process in which judgement-based methods are applied, and show where and why issues of validity have impact on the utility of the methods. The primary aspect of relevance to stakeholders in the use of these methods is validity. Credibility and acceptance of a method are not separable from validity but are rather derived from it. This chapter will discuss the nature of all three concepts and conclude with a discussion of ethical aspects of conducting a ('soft') OA study.

3.2 THE CONCEPTUAL ENVIRONMENT OF 'SOFT' METHODS

The typical conceptual environment in which 'soft' methods come into play is shown in Figure 3-1[1]. 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.

[1] This figure in itself is an example of 'soft' OA: a concept map where key concepts and their relationships are depicted in order to create a structured visual image of the 'problematic situation'. Its purpose is creating clarity, focus and enabling communication and debate.

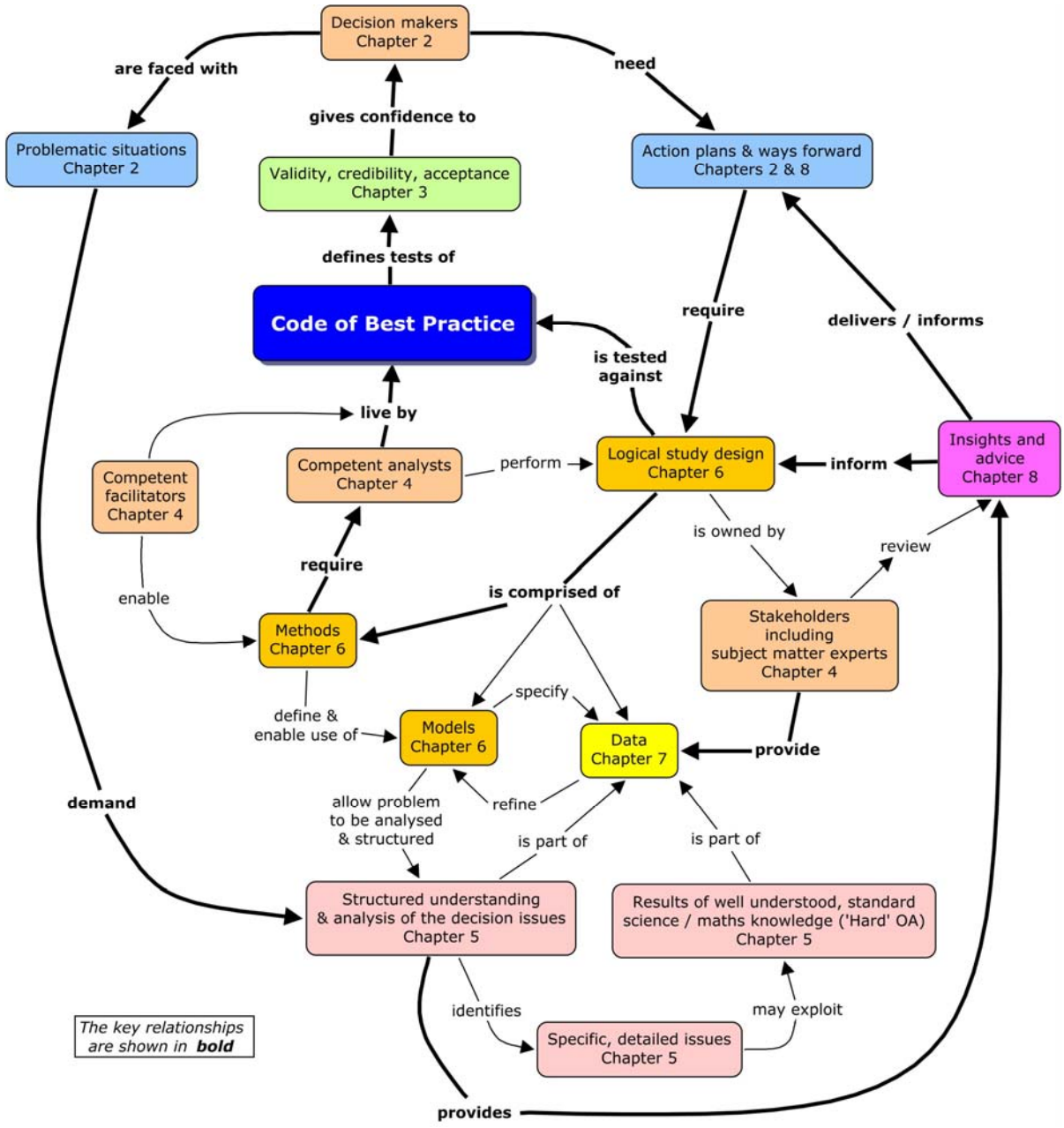


Figure 3-1: 'Soft' OA and the Role of the CoBP.

The CoBP is written with this environment in mind. Chapter 2 has explained the difficulties of defining complex problematic situations, discussed aspects that characterise them and related problematic situation types with 'soft' and 'hard' OA. It also explains why 'soft' OA can be helpful to a decision maker. Chapter 4 explains the roles and responsibilities of the clients, analysts, facilitators, and other stakeholders within a typical 'soft' OA study. Chapters 5, 6, and 7 discuss the action plans which will deal with complex problematic situations and detail the model building and analysis process which in the above diagram is represented as an iterative process combining stakeholder views, data collection, and analyst expertise in choosing the appropriate modelling approach. Chapter 8 of this volume explains how to engage the client (and other stakeholders) to best communicate results to them, ensuring the study outcomes are of most value. The concepts of validity, credibility and acceptance are incorporated into all aspects of this conceptual environment and each links naturally into the study design process.

Analysts should test their study design against this CoBP in order to establish the validity and credibility of their approach. The structured understanding which flows from the analysis forms the basis of insights and advice on the proposed courses of action to the decision makers.

This process is a re-expression in the decision-making context of the general approach to systematic enquiry and assessment. It therefore raises similar philosophical questions relevant to the issues of validity and credibility.

3.3 THE PHILOSOPHY OF METHODS

This is an extensive field which this CoBP cannot hope to address completely. However, it is important to understand the foundation ('grounding') of methods so that judgement-based approaches can be seen in relation to the conventional methods of science, engineering and mathematics.

Consideration of the philosophical foundations has more than general relevance; it may also be helpful in the conduct of individual studies in so far as the study domain is an instance of this general philosophical context.

The world view of the researcher can be expressed in terms of the three aspects to the philosophy of knowledge and the methods use to gain it: ontology, epistemology, and axiology (see also [1]):

What is the grounding of the techniques used in judgement-based analysis? A good analyst should always understand the philosophical foundation of his tools and methods.

- *Ontology* – What are the elements (constituents) of discourse and consideration, and do they endure? Are the elements objective ('real' or 'true'; see also Section 3.4.1) or are they constructed and so dependent for their meaning and interpretation on the cultural place in which they are posited?
- *Epistemology* – What meaning is to be drawn from a set of the elements and their relations? Are the meanings and relations objective ('real') and time independent, or are they (also) constructed and context-dependent? What enduring principles can be expressed in connection with the ontologically derived elements and can we, through reflection, reason about them? Such considerations bear upon the power of explanation which a method gives its users. It may also have effect through its aesthetic qualities, a more satisfying construct leading to enhanced explanatory power. Such considerations stray into the third aspect, axiology.
- *Axiology* – What is held to be worthy or of value? Axiology is concerned with the (ultimate) purpose of the research. Two perspectives are relevant: that of knowledge for its own sake, and that of knowledge which informs action. In practice, it may not be possible to decide in which category specific knowledge resides. Much, if not all, of the work conducted by the users of this CoBP will serve the second category of knowledge (i.e. which informs action). The worth or value of analysis practice and its products is also strongly dependent on the application of appropriate ethical principles. In particular, the general principles of good scientific practice, an analyst and client's honesty and openness, and the rigour of the study process are key considerations. Ethical considerations are discussed in more depth later in this chapter.

Each practitioner needs to establish his position in respect of these three philosophical aspects. Many find that a pragmatic, *critical realist* approach[2] is their natural position. A critical realist holds that knowledge is gained from the real world through the use of our senses assisted by our critical powers of reasoning. Knowledge can be both captured objectively by measurement, and constructed subjectively from the

[2] Implying also the capture of authentic knowledge, based on sense experience and empirical verification. A critical realist holds that science should be understood as an ongoing process in which scientists improve the concepts they use to understand the mechanisms that they study (Wikipedia). A further discussion of this subject can be found in Chapter 7.

expectations, world view, and values of the stakeholders in a decision situation. In essence, the aim of the critical realist should be to make a clear distinction between the reality which is shared amongst the stakeholders, and the sectional perspectives which each may propagate for his own reasons. Wide experience has shown this position to be feasible, not least because it is universally recognised by stakeholders.

3.4 THE NATURE OF VALIDITY

3.4.1 Dimensions of Validity

The primary dimensions of validity are *objectivity* and *rigour***,** as defined by the Concise Oxford English Dictionary (as below). In essence, objectivity refers to the ontological aspect of a method and its data, whilst *rigour* refers to their essential epistemological quality. Supplementary aspects of validity which reflect axiological considerations and so may be present in differing intensity according to the context in which a method is applied, include:

- Repeatability;
- Auditability/transparency;
- Independence and lack of bias;
- Grounding/consistency (in/with standards, and other data and methods);
- Understand-ability;
- Explanatory power;
- Completeness;
- Robustness under uncertainty; and
- Clear separation of data from the method which uses it.

The *dimensions* of *validity* can be accounted as follows.

- *Objectivity*. Analysis should be *objective* – i.e. 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. A good test of objectivity is whether an analysis is capable of debate amongst the stakeholders.
- *Rigour* is achieved through strict enforcement of logical rules and doctrine, such as this CoBP. Methods should be applied as proposed and documented, and any deviations should be justified and documented.
- *Repeatability* – sometimes called *reproducibility* or *replicability* – is the quality of a phenomenon to occur again, possibly in different places and times, and observed by different people. It is a key characteristic of the scientific study of phenomena, and may be difficult to achieve when (partly) relying on judgement as some conditions of the study domain (not least the expert stakeholders) may be beyond the control of the researcher. However, it should be regarded as a worthwhile objective. It is often the justification for the re-iteration of studies whose results have been challenged.
- *Auditability/Transparency*. Analysis should be *trustworthy*, with no undeclared assumptions or unstated simplifications (see *rigour*, above). Any given method needs to be both verified and validated. Verification tests whether the method works as it is specified to do, whilst validation results from a (satisfactory) comparison with a standard of behaviour external to the application to hand. Tests of verification and of validation, taken together, may be referred to as the execution of due diligence. Analysts have an obligation to monitor and report their own analytical processes, including those taken to establish the validation state of a method, e.g. through the use of method

logbooks. Transparency to enable repeatability may not be the only goal; transparency to demonstrate the legitimacy of the process undertaken is just as important. The assumptions and mental processes that underpin the design must be documented alongside the results so that they can be scrutinised together. Political and power factors may limit the transparency achievable in judgement-based OA; this is discussed further in Chapters 4, 6 and 7.

- *Independence and Lack of Bias*. For some, the analysis should be independent of vested interests [2]. For others, vested interests are part of the analysis and should be captured. The analyst must reflect on and deal carefully with bias, where possible mitigating or capturing it. Perceived objectivity of the analyst may be questioned. The relationship of the analyst with the customers, stakeholders and participants will be a factor. The role of the analyst within the method should form an explicit element of the study design. The analyst should regard himself as accountable for the quality of the analytical work; he needs to address arising issues with integrity, and in a neutral and impartial manner. Awareness of the political and social norms, values and power structure of the stakeholders is important in determining the perceived independence of the method and its analyst executors, and thus the entire validity of the design of a judgement-based study. Political issues in particular might be very difficult to accommodate into a study which seeks to meet criteria of validity. Issues of independence are discussed further in Chapter 4.
- *Grounding/Consistency (in/with standards, and other data and methods).* Methods should be based on solid theoretical and philosophical grounds. Also, where appropriate, they should be validated comparatively against real data gathered in designed experiments.
- *Understand-ability*. Questions to be addressed include: is the nature and methods of the enquiry or study fully understood by all stakeholders? Is the need for validation well understood and is the nature of the processes of validation inclusive? What is the impact of judgement biases and 'heuristics', as discussed below?
- *Explanatory Power.* What depth and breadth of explanation of the system properties and behaviours which the problematic situation embodies is afforded by the OA method and its results?
- *Completeness***.** Do the methods adopted for the study address all aspects of a problematic situation, and, if not, in what sense does their omission impact the study?
- *Robustness under Uncertainty.* The analysis should acknowledge uncertainty in data and method right from the outset, and a plan should be formed to reduce the impact of uncertainty and manage the residue so that the outcome of the analysis can be said to be robust, i.e. of known sensitivity to variations in the inputs, both structural and parametric. Issues of uncertainty are discussed more in-depth in Chapters 2 and 6.
- *Separation of Data from the Method which Uses it.* The overall methodology should strive to make a clear distinction between the methods adopted by the analysis, and the data those methods will employ. The distinction need not be fixed for the entire period of analysis; in general, even a method could be said to be a form of input 'data'. However, it is important for the stakeholders that as clear a distinction as possible should be made and managed as the analysis proceeds, lest the stakeholders lose confidence in the coherence and ultimate credibility of the analysis.

The determination of validity in any particular case will hinge upon *triangulation* of some or all of these dimensions. Validity will be judged greater as the correlation increases between the characteristics of the methods employed. Triangulation is discussed further in Sections 6.6.1 and 8.2.1.

There are human limits to validity in judgement-based OA, arising from the impact of biases and 'heuristics' in acts of judgement. When humans declare opinions, it can reasonably be assumed that their utterances will not be fully objective, but rather that they will be vulnerable to bias. Gathering subjective judgements from experts exposes the analyst and his study to possibilities of *two varieties of bias: motivational and cognitive.*

The first, motivational bias, arises when an expert's opinion is influenced by non-relevant circumstances, for example a drive to please the client of the study to which he is contributing. This bias can be conscious or unconscious; the expert may or may not realise that he has altered his view. The second is cognitive bias which can intrude when an expert does not follow rules or standards which are held to be objectively derived. An expert will often draw, consciously or unconsciously, upon 'heuristic' approaches to determination of, e.g. a variable's value. A good example is *anchoring*, i.e. the reluctance of an expert, perhaps for unconscious emotional reasons, to amend an initial view which might have been inadvertently suggested by a third party or even the analyst himself. Motivational bias may be very hard to detect and nearly impossible to eliminate. Much depends upon the attitudes and ethics of the analysts and the experts. Cognitive biases, by contrast, are better understood and have been studied experimentally, offering possibility that they can be eliminated or compensated for. The phenomenon of biases will be discussed further in Chapter 7.

It is helpful to make a clear distinction between *internal and external validity* in the application of subjective methods; internal validity refers to the logical grounding and coherence of the proposed methods, whilst external validity concerns the congruity of the methods to the area of application. Greater precision and control in the design and execution of the methods will increase its internal validity. Wider applicability of a method is an indicator of increased external validity. In this sense, *validity can be thought of as fitness for purpose*.

3.4.2 Achieving Validity

What are the threats to validity?

Internal validity is typically vulnerable to:

- Poorly defined measurement scales or categories;
- Statistical weakness resulting from very poor levels of participation by experts; and
- Inadequate recording methods.

External validity is threatened by:

- Poor understanding of the objectives and priorities of the analysis;
- Misunderstanding of the domain of expertise, robustness of the outputs to uncertainty, etc.; and
- The effects of human traits such as the biases introduced by heuristic reasoning (ref. Section 7.2).

Some of the internal factors will interact with the external factors and this must be considered in the study design. An example is the danger of mathematical artefacts in the outputs, particularly where statistical analysis has been carried out. Any analyst should be aware of these threats and make efforts to identify them, avoid them or cope with them.

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" [3].

Overall, a balanced, holistic view of validity is required, and some compromises will undoubtedly be needed in any practical design carried out within limited resources. Complete validation is probably not achievable in all applications, but, as with objective methods, it is something to be desired and aimed for. 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. Is the method to be used *sufficiently useful* for its purpose? Perhaps the biggest threat to validity is ontological: knowing at the design stage what is likely to be important. Only experience can tell you. This threat can itself be mitigated by creating an iterative design similar to that used in

experimentation. Having created a design based on a level one understanding of the issues and executed it, use the results to re-formulate priorities and expectations, redesign and re-execute.

3.4.3 Credibility and Acceptance

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 the client system[3]. 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 the client system. Communication between the analyst (i.e. the study team) and the client system 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. Transparency of judgement-based OA is discussed further in Chapter 8.

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 the client system. Also, ensuring resources and facilities are available can ease the model building and data elicitation process.

Credibility and acceptance will be further reinforced by independent scrutiny.

3.5 ETHICAL CONSIDERATIONS

An analyst needs to “conduct activities in an ethical manner that deserves the confidence of all parties involved” [4]. Ethical practice requires that the following action disciplines must be observed [5]:

- Act with skill and care, and keep skills up to date;
- Prevent corrupt practice and declare conflicts of interest;
- Respect and acknowledge the work of others;
- Ensure that research is justified and lawful; and
- Do not mislead – present evidence honestly.

Very similar ethical standards are promulgated by The Military Operational Research Society (of the USA) on its website [6]. Contributors to ‘soft’ OA-based studies should acknowledge these ethical guidelines and those of any professional organisation of which they are a member.

Note that these disciplines are as incumbent on the stakeholders in general as on the analysts, facilitators, etc., who are conducting the analysis. It is possible that some of the stakeholders may find the process of analysis and its results discomfiting. They should be content that they have been granted ‘*procedural*

[3] The term ‘client system’ refers to the (quite common) situation where there is no single individual acting as the client, but rather a group of individuals or (part) of an organisation. Figure 4-1 (Chapter 4) depicts the client system in red ovals.

justice': they have been involved, and can judge the fairness of the analysis process, even though they may not agree with its outcome, provided that there was initial agreement on the fairness of the rules followed during the collaborative process.

Many 'soft' methods require information and data to be taken directly from experts 'in the field'. The use of subjective methods could well be viewed as an *experiment*, particularly by the experts from who information is being captured. They are, in a sense, the subjects to which the methods are being applied; their involvement could be construed as a threat to their (mental) integrity. It is arguable, therefore, that the disciplines of ethical experimentation should be applied, at least in spirit, to many of the subjective methods. Considerations relevant to this perspective include:

- Accessibility of the methods to all stakeholders;
- The integrity of the participants themselves in their respective roles (chairman, member of workshop, stakeholder, analyst, client);
- The perceived validity of the method and its processes;
- The consent of participants;
- The utilisation of resources including participant/stakeholder time;
- Publication and distribution of results from the methods;
- Feedback for participants;
- Relationship with other contributing elements and parties to a domain being served by application of a 'soft' method; and
- Attitudes towards and actions taken by the client and other senior staff in power roles to participants in aftermath of an application of a subjective method.

The key test of the ethical validity of a method is whether it yields fresh knowledge; it would not be ethical to execute a study method which did not generate new data. It should be acknowledged that some of this knowledge is frequently of a sociological kind, reflecting prior ignorance on the part of some stakeholders of the perspectives and legitimate and well-founded preferences of other stakeholders.

3.6 REFERENCES

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3.7 RECOMMENDED ADDITIONAL READING

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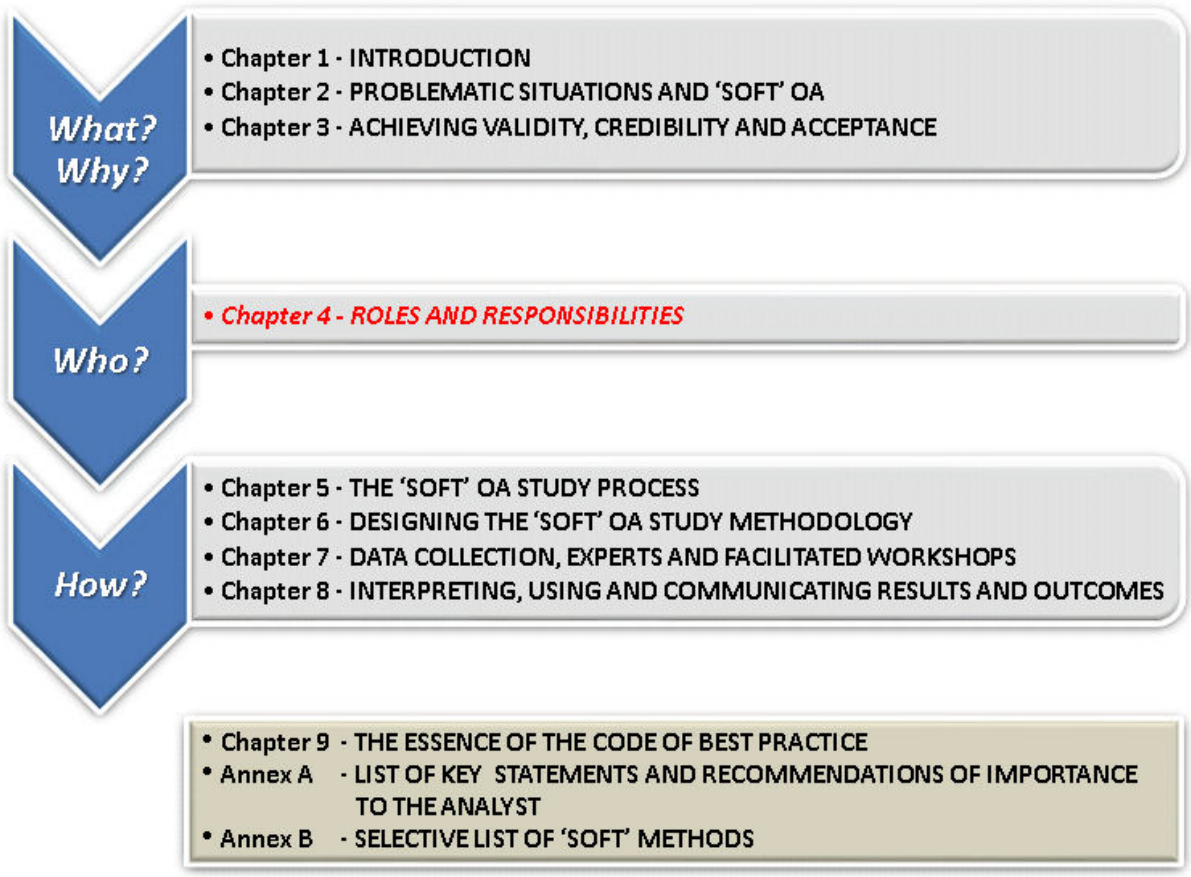
Chapter 4 – ROLES AND RESPONSIBILITIES



- Many roles and responsibilities are undertaken during the conduct of a 'soft' OA study. Moreover, one individual may adopt different roles involving different responsibilities. Each individual involved in the study contributes to its quality and success.
- The analyst, through his design and conduct of the study and through his reporting and interpretation of the study's outcomes, plays a key role in contributing to the study's validity, credibility and acceptance.
- The facilitator too, through his management of study process (the way participants interact), plays a key role in contributing to the study's validity, credibility and acceptance.
- The (primary) client has a responsibility towards the analyst in supporting the execution of the study and should act as a partner to the analyst.
- Good stakeholder management is the responsibility of the analyst and is critical to study success.

4.1 INTRODUCTION

This chapter discusses the roles and responsibilities of the significant actors who are associated with studies that apply 'soft' OA. While acknowledging that each study is unique, it nevertheless provides some guidelines to analysts. The guidelines are offered as a means of assistance and are not necessarily prescriptive in nature. In general, this chapter deals with the people involved in a study that employs 'soft' OA and with what those people do, whereas *how* those activities are carried out is discussed in the subsequent chapters of this CoBP.

4.2 INDIVIDUALS INVOLVED IN A 'SOFT' OA STUDY

Individuals associated with a study that applies 'soft' OA may play the roles of:

- *Analyst*: An individual who conducts a study, and in this capacity designs the stages of the process and suggests ways to investigate and model problematic situations, the methodology(ies) and method(s) to be used based on his knowledge and expertise, the workshops to be held, and the ways to report and interpret the study's outcomes.
- *Client*: This term denotes four specific types of stakeholders (who form a so-called 'client system'): the *sponsor* who actually owns the study, the *customer* who pays the bill for the study, the *decision maker* who may make decisions regarding the problematic situation or concerning the recommendations of the study in preparation for decisions by a higher authority and the *end user* who is ultimately affected by the study outcomes and related decisions. It should be noted that:
  - The customer hires the analyst to conduct the study and has discretion over funds. Sometimes, however, the party paying the bill for the study has no stake in the study outcome.
  - The decision maker is not necessarily in command of, or part of, the sponsor's organisation.
- *Expert* (also known as a Subject-Matter Expert (SME)): An individual who has considerable relevant knowledge in a particular area without necessarily owning or otherwise being part of the problematic situation. The SME may be considered to be a stakeholder since he affects the study through the provision of information. But, in general, in his role of SME, this individual does not necessarily own (part of) the problematic situation and need not otherwise be a part of the problematic situation.

  Some SMEs may be part of the 'client system'. End users may sometimes act as SMEs as well. In some security domains, the expertise is possessed by a limited number of individuals who will therefore find themselves in more than one of the sub-groupings of the stakeholders.
- *Facilitator*: An individual who helps (i.e. supports, enables and encourages) individuals or a group or groups of clients, subject matter experts, other stakeholders, and analysts to work together through the stages of a study by managing procedure (the way the problem is tackled) and process (the way participants interact) whilst adopting an impartial attitude.
- *Stakeholder*: An individual who can affect, or can be affected by the (resolution of the) problematic situation. The stakeholder system consists of individuals, groups and organisations that are affected by the problematic situation. In the military context, an enemy may also be a stakeholder. In such cases, the analyst should ensure that enemy perspectives and likely reactions are taken into account within the study context (e.g. through the use of Red Teaming). Even analysts and facilitators may, to some extent, be regarded as stakeholders as they too affect the study or are affected by it (e.g. due to their interest in the study's perceived success).
- *Scrutineer* (reviewer, auditor): An individual who provides an independent review of the study. Although the scrutineer does not act as an analyst, he may choose to perform his own analysis as part of his scrutineer function. The use of professional scrutineers contributes to study credibility and acceptance (see Section 3.4.3).

In designing and executing the study, the analyst should take into account the diverse nature of the client system. In particular, the analyst should appreciate that each client:

- Has a will, a purpose and resources, and may influence the study;
- Will perceive the problematic situation in a unique way, based on his own perspectives, commitments, objectives, interests, values, desires, and concerns;
- May have both a declared and an undeclared agenda; and
- May engage in organisational politics (which is not necessarily a bad thing, and not necessarily avoidable or to be avoided).

The analyst deals with members of the client system who may come from several different parts of an organisation or from several different (possibly external) organisations. Within each such organisation, the analyst's clients may hold different levels of responsibility within their respective organisations and belong to various levels within the organisational hierarchy. The analyst's clients may be staff at a high level (e.g. general/flag officers) or at a working level, and they may be military or civilian.

Each stakeholder will have different perceptions as to whether he and his organisation will benefit from study outcomes and hence will either be supportive, neutral or opposed to the study. Some stakeholders (even the clients among them) may actively attempt to subvert the study process and its outcomes (e.g. try to slow down or stop the study due to political issues, a power play, a hidden agenda, conflicting goals or an unwillingness to admit that there is a problem). Each client will have some degree of influence in determining whether the study succeeds, especially as it relates to whether the ideas or recommended changes emerging from the study will be accepted as being credible and hence whether they will be implemented.

The situation is further complicated by the reality that a particular role within the study may be undertaken by one or more individuals and may even be carried out by different individuals at different times. Additionally, an individual may take on one or more roles at any given time and his role(s) may change over time as the needs of the study change, as his perceptions of the problematic situation change, or as he moves out of his current position within the organisation (e.g. civilian promotion, military posting).

The analyst should try to understand the client system as it exists at the start of the study and as it evolves over time. He should try to deal appropriately with each of the individuals, groups and organisations involved directly in the study or having a significant stake in it. For example, in designing and conducting the study, the analyst should account for cases in which persons wear several 'hats' at the same time (e.g. a person who is the study sponsor but is also acting as a SME may be influenced by his interests as the study sponsor when providing his SME inputs during a workshop). As another example, in designing and conducting the study, the analyst should account for differences in culture (e.g. national, organisational, military/civilian) among the study participants. As well, he should be ready to deal with changes in the membership of the client system and with changes in the identity of the primary client[1], both of which are not uncommon during the conduct of a study.

Figure 4-1 graphically depicts individuals' roles and some of the possible relationships between the roles[2]. The figure is not definitive in nature; as noted above, changes in roles may take place over time. This aspect of the study should be managed by the analyst through the study design and by the facilitator during workshop sessions (e.g. an individual may be asked to put on just one of his several 'hats' when he participates in a facilitated session).

[1] The term 'primary client' refers to the single individual or (small) group of individuals who belong to the client system and who are acting as a partner to the analyst throughout the conduct of the study. The 'primary client' is the primary focus of attention for the analyst and is discussed in Section 4.3.2.

[2] The size of the oval areas within the figure and the size of their overlaps are purely illustrative.

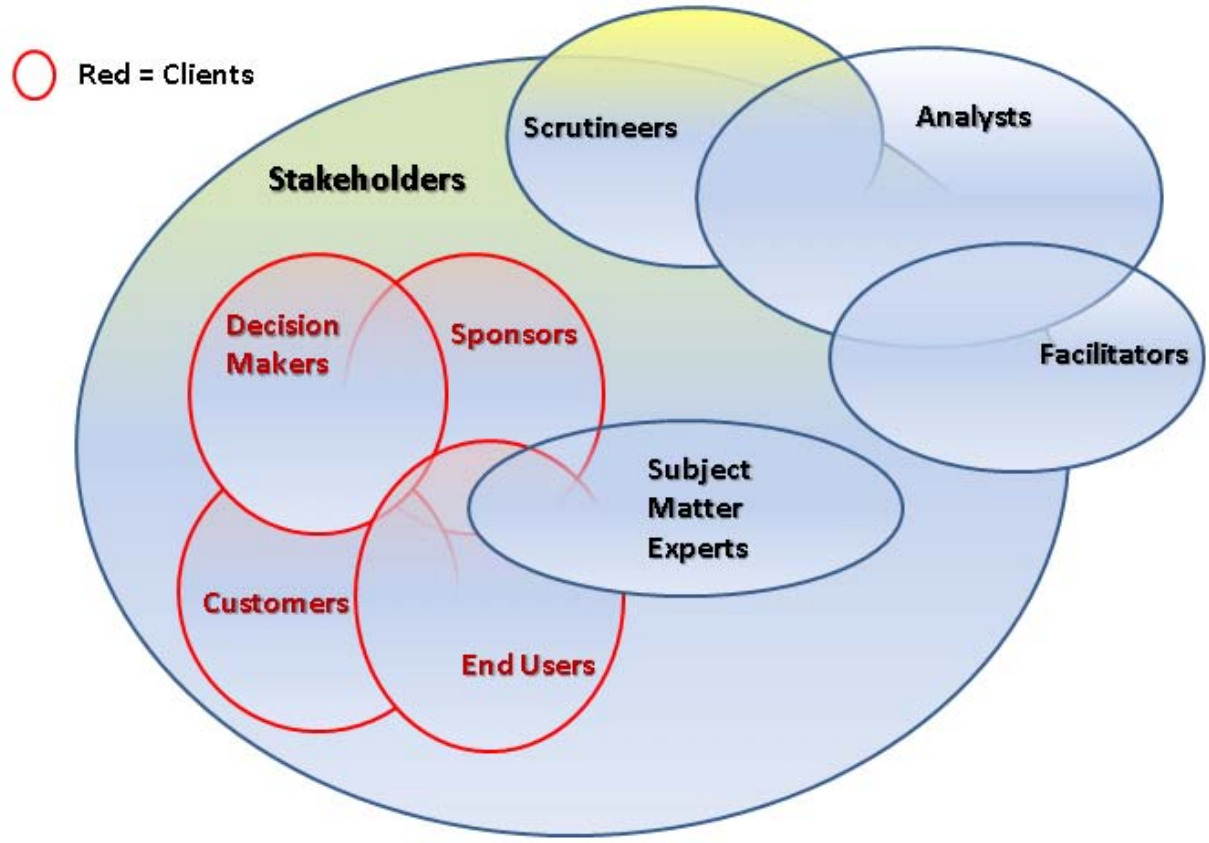


Figure 4-1: Roles of Individuals in a Study Employing 'Soft' OA and Their Relationships.

In the remainder of this chapter, discussion is focused primarily on the roles and responsibilities of the analyst and the facilitator. The roles of the other actors within the study are discussed where appropriate, and primarily from the viewpoint of the analyst.

4.3 THE ANALYST[3]

4.3.1 Analyst Task

The analyst [1] should take responsibility for the design, execution and scientific integrity of the study. In this capacity, he should:

- Help structure and define the nature of the problematic situation;
- Design the stages of the process used within the study;
- Suggest ways to investigate and model the problematic situation and suggest the methodology(ies) and method(s) to be used, the workshops (if any) to be held, and ways to report and interpret the study's outcomes;
- Provide facilitated[4] modelling (generally through the use of workshops; including an integrated process of data gathering and model creation and analysis [2]);

[3] Most of this section is relevant to all OA studies.

[4] This is a process where the analyst actively engages the client (group) to participate in all stages of a 'soft' OA study and thus acts as a facilitating analyst (often with the help of a supporting facilitator).

- Help develop agreed 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;
- 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 devoted to providing a credible, rigorous analysis and to ethical principles (as discussed in Chapter 3).

This section addresses analyst tasks, namely:

- Initial exploration and planning;
- Stakeholder analysis;
- The choice of an OA approach;
- The choice of study participants; and
- The general conduct of the OA study.

It also discusses:

- Dealing with uncooperative clients;
- Dealing with clients' participation requests;
- Building the analyst team;
- Balancing analyst responsibilities; and
- Analyst skills and training.

The information is provided from the analyst's perspective, concentrating on the activities that need to be carried out. Other chapters in this CoBP (and the literature) discuss *how* the activities should be carried out.

4.3.2 Initial Explorations in Cooperation with the (Primary) Client

When the analyst is called in for support, one of the first matters that he should consider is the nature of the task and the type of analysis that would be appropriate. Initially, he should gather some basic information on the problematic situation through consultations with some of the members of the client system. He should identify the primary client and should start to determine whether he is dealing with a puzzle, a problem (proper) or a *mess* (defined in Chapter 2) with the intent of using this characterisation to determine whether the task should be addressed through the use of 'hard' OA, 'soft' OA or a mixed approach (further discussed in Chapters 2 and 6). The analyst should recognise that, in the case of a *mess*, the initial characterisation will naturally be very limited in nature. In such a case, structuring and defining the problematic situation will become one of the key challenges in the study.

The analyst should also recognise that, in addressing a *messy* situation, there may be uncertainty over who the clients are and who should be chosen as the primary client. When identifying the clients of the study, the analyst should consider who would benefit from the study, who is seeking solutions to the same or similar problems, and who will be affected by possible study outcomes. The analyst may expect some members of the client system to self-identify to the analyst when they become aware of the study. However, others who will be affected by the study will be unaware of it and may not come forward on their own. Some may even actively seek to avoid it.

The analyst may identify clients by identifying the people involved in the area under investigation and approaching them to determine whether they are potential clients and whether they know of others who may be. The analyst should also ask the sponsor to help identify potential clients. He can then ask those who have been identified for additional leads. Through this type of procedure, the analyst should eventually identify the primary client and/or the initial client(s) he may work with. As more information is gathered, new members of the client system may be identified and their participation in the study negotiated. The analyst should conduct stakeholder analysis (discussed later in this section and in Chapter 6) in order to better understand the client system and to develop a plan for its management (e.g. whom to involve in the study and in which capacities, for example: problem scoping; analysing and designing options for addressing the problematic situation; workshop participant, data provider, contributor to the study's budget).

The analyst should try to communicate directly with potential clients as opposed to relying wholly on assumptions that are based on information gleaned from second-hand sources, when developing his understanding of the client system and his client management plan. It should be noted that the analyst may be subject to practical restrictions in his choice of whom to involve in the study, and how study participants may be dealt with. For example, the primary client may request that the analyst not contact other clients directly, but rather work through the chain of command when approaching others.

The analyst should focus on the primary client and should ultimately aim to satisfy the primary client's needs in terms of the study. He should also consider the welfare of all the members of the client system and should attempt to meet their collective needs in a fair and rigorous manner to the extent that it is reasonable and possible to do so.

Identifying the primary client may be a challenging task. The sponsor may be the primary client, but this is not always the case. For example, it may be difficult to select the primary client from within a client system that includes individuals with very different perspectives and agendas. As another example, the real primary client may be too senior to have the time to participate in the study, and an individual who can act as a surrogate for the real client may need to be found. Further, the real primary client may remain invisible to those directly involved in the study. Additional complications in terms of ensuring that the study meets its goals may arise when the person acting as the primary client is not the most senior person in his organisation and hence needs to 'sell' the study process and its outcomes to his seniors as well as to convince them that study resources are being well allocated. Despite these challenges, the analyst should identify the primary client early on in the study, possibly through use of the approach outlined in the preceding section. It is preferable that the primary client be an individual. If the choice of the primary client must consist of a group of individuals, then their number should be limited to a few. In this case, it is preferable that the analyst meet with the group members jointly, rather than individually, whenever decisions need to be made. This helps avoid placing the analyst in the position of trying to accommodate different, and possibly conflicting, interests while in the receipt of inconsistent guidance.

Once he has identified the primary client, the analyst should ensure that the primary client that has been identified actually understands and actually accepts the responsibilities that come with the primary client role.

In particular, the individual(s) chosen to act as the primary client should accept his obligation to act as a partner to the analyst. He should understand that it is crucial for him to fulfil his duties towards the analyst in order for the study to succeed. The analyst may ask the *primary client* to:

- Adopt ownership of the study and its results;
- Provide his insights on the problematic situation (e.g. his current perception of the issues, of key actors, of the sources of expertise that the study could draw on);
- Assist the analyst in developing and evolving the study design as the study progresses;

- Approve[5] the study design and changes to it;
- Provide, or help ensure access to, SMEs and some of the information, data, and documents needed during the course of the study;
- Participate in the study and encourage other, possibly busy, individuals to participate in 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); and
- Provide the analyst with adequate access to stakeholders and an adequate pool of study participants (both in quantity and quality) is critical for study success.

The first meeting with the primary client is important as it sets the tone for the primary client-analyst relationship. The analyst should build a relationship with the primary client that is based on mutual respect and trust. He should ensure that there is open communication and that the primary client feels free to ask questions, challenge assumptions, provide input and discuss contentious issues. The analyst should cooperate with the primary client and adopt a helpful attitude. He should use that initial meeting to develop a shared understanding of the primary client's current expectations with regard to the study (e.g. why the primary client wants the study initiated, what the primary client intends to do with the study outputs, what types of assessments decision makers would like the study to support, and what types of end products are desired). The analyst should also discuss what resources are available (e.g. personnel) and should ask about some of the study constraints (e.g. time, organisational culture, organisational politics, legal issues, physical issues, ethical issues). In designing the study, the analyst should consider the types of assessments the decision maker expects the study to help support and should also consult with end users to the extent possible and practical.

The analyst should recognise that, in the early stages of the study, the primary client's expectations may not yet be well formulated. The initial meeting will likely yield only partial answers to some of the analyst's questions. The analyst should put the client at ease by making it clear that he is not expected to have all the answers. The analyst should recognise that the primary client's expectations will likely mature and crystallise over time as the study progresses and new insights are developed.

After some investigation, the analyst should formulate a study plan (e.g. goals, scope, products, schedule, and resources), albeit with the caveat that the plan will need to be regularly revisited, and perhaps changed, as the study evolves (as discussed in Chapters 5 and 6). In the case of a *mess*, the analyst should ensure that clients appreciate and accept that a dynamic approach and study plan (further discussed in Chapters 5 and 6) may be needed. In order to help ensure that the study plan does not become a point of contention between the primary client and the analyst, the analyst should explain the necessity for flexibility and should negotiate expectations about what is to be done, why it is appropriate and what content and process milestones will be met [3].

The analyst should consult regularly with the primary client and should design the study so that it regularly delivers useful outputs to the client. These mechanisms should help minimise client concern about the need for study flexibility and the lack of a completely predetermined study plan. 'Soft' OA presents many opportunities for regular output delivery. Its involvement of the client community in the study process allows regular communication of study progress and results, unlike studies which release their recommendations only at the study's conclusion and the issue of the final report.

In developing the plan and in conducting the study, the analyst should also ensure that the primary client and other members of the client system appreciate the importance and value of both the *tangible* (e.g. set of recommendations) and the *intangible* (e.g. greater understanding and changed appreciation of key

[5] Note that others, for examples scrutineers, may be involved in approving the study design.

problematic issues gained through participation in the study) outputs that a study employing 'soft' OA may produce. Key actors who act as study participants should realise that the knowledge they gain as participants helps them not only deal better with the present, but also positions them to deal better with new related issues that will arise in the future.

From the initial meeting with the primary client and other stakeholders, the analyst should manage expectations. The expectation levels should correspond to what is actually attainable and agreed upon.

The analyst should be frank and open in his dealings. He should advise the primary client of the possible advantages that can arise from a chosen process and also of the possible disadvantages (e.g. an issue that the primary client wishes to keep dormant may be made public at a workshop by one of the participants, the primary client may not like some of the recommendations that are generated during a workshop).[6]

The analyst should also provide an opportunity for the primary client to air any fears or concerns that he may have about the study. For example, the primary client may:

- Be unsure about his ability to provide the types of inputs and judgements being sought from him;
- Be uncomfortable over the freedoms that may be granted to the analyst within his home organisation (and needed in order to enable the analyst to conduct the study);
- Question how the perspectives of those who have conflicting agendas will be incorporated into the study;
- Be afraid of losing control or power;
- Be concerned that hidden agendas will be uncovered; or
- Be concerned over budget reductions that may result from the study.

The analyst should address issues proactively and directly in order to ensure that client concerns do not adversely affect the study.

As stated earlier, the analyst should recognise that defining the problematic situation itself will be a challenge. The primary client may just have a vague sense that the problematic situation needs improvement but may not be aware of his objectives and/or priorities, and he may be hoping that the analyst will provide help in developing them. Or, the primary client may confuse a symptom that he is observing as being his real problem and may need the analyst to help uncover what the real issues are. Alternately, it may not be clear who the key actors are and who the analyst should involve in the problem structuring and definition. As well, the client system itself may be comprised of powerful individuals with conflicting interests and perspectives, presenting difficulties in client management and in meeting client needs. To address these issues, the analyst should consider the use of Problem Structuring Methods (PSMs) and stakeholder analysis (discussed in the following section).

4.3.3 Stakeholder Analysis

To apply 'soft' OA successfully, the analyst should develop a good understanding of the social system (i.e. roles, norms and values of the key actors) and the political system (i.e. how power is expressed, obtained, protected, preserved, passed on and relinquished; who holds power; explicit and hidden agendas) in which he is operating [4]. Finding out about the social aspects of the situation may be difficult as participants may not want to admit what their real norms and values are or they may not want the culture to change and so will not be willing to help with the analysis. Direct questions may result in participants providing politically correct answers or official myths rather than a true depiction of what is really

[6] A 'hard' OA study may have similar issues.

happening. Carrying out these activities constitutes stakeholder analysis and decisions on what to do with the stakeholders constitute the management plan.

The analyst should conduct the stakeholder analysis as discussed in Chapter 6 as part of the problem framing process. He should regularly update it during the study [3], preferably on a proactive basis. The need to regularly revisit and revise the stakeholder analysis, and hence also the stakeholder management plan (which is a product of the stakeholder analysis), stems from the stakeholder community not being static. As the study progresses through its lifecycle the members within the stakeholder community may change and/or the perceptions of individuals may change.

The analyst addresses the purpose, resources, intent, power and will of the stakeholders in order to make decisions on how to address the stakeholders within the study context. The analyst should use the stakeholder analysis to:

- Identify stakeholders;
- Gain an understanding of each stakeholder's motivations and how each stakeholder fits into the overall study context;
- Develop a plan as to how stakeholders should be engaged and managed during the study (e.g. how much attention to devote to each stakeholder, which stakeholders to invite to workshops, which stakeholders to include in formal communications regarding study outputs, how to manage pluralistic competing stakeholder demands); and
- Identify potential risks to the study (e.g. uncooperative stakeholders and their possible adverse effects on the study) and ways to address those risks.

Examples of management strategies that the analyst may choose to employ include, but are not limited to keeping a stakeholder informed, having a stakeholder actively participate in the study, trying to influence a stakeholder, and monitoring a stakeholder. When deciding which stakeholders to include as participants in workshops and/or other study aspects, the analyst should consider ethical, practical, legal, security and policy issues. For example, the analyst may decide to exclude adversarial stakeholders from participating in the study. However, the analyst should consider including some of the stakeholders with divergent interests as this may be useful in ensuring that the problematic situation is viewed holistically from multiple perspectives, that key issues are not missed and that study outputs are credible. The analyst may need to keep the stakeholder analysis private as the primary client may be uncomfortable with an explicit record. As well, the stakeholder plan may not be universally distributed as some stakeholders may not accept that they should be 'managed'. In conducting the stakeholder analysis, the analyst should identify stakeholders at a level of granularity (e.g. individual, organisation) at which they can be influenced and managed. The analyst should exercise good stakeholder management throughout the life of the study.

4.3.4 Choice of the OA Approach

The analyst should recognise that the choice of the OA approach may also present challenges. The analyst should accept that the final responsibility for that choice rests with him.

The analyst should make the choice of the OA approach based on the characteristics of the problematic situation and the study outputs that are to be produced. He should consider the pragmatic aspects of the situation such as whether the client culture supports the use of the proposed methods, the cognitive feasibility of the proposed methods (e.g. can study participants reasonably be expected to meet the cognitive task demands associated with the implementation of the proposed methods). He should also take into account analyst skills, analyst preferences, analyst experience, and analyst competencies [5]. The analyst should make the choice in consultation with the primary client and possibly other members of the client system, using the constructs described in Chapter 6. When dealing with a *mess*, the analyst may

sometimes organise a group discussion with select stakeholders regarding the choice of methodology and methods, and the pros and cons of the alternatives.

If a client suggests that a particular method be used, then the analyst should exercise caution. He should determine why this suggestion is being made and assess its merits. Is the method one which the person making the recommendation has used successfully in the past and trusts, or is there some reason for the suggestion other than the appropriateness of the method?

The analyst should make choices regarding the analytical approach at the study's outset, but should not consider them as fixed. Interventions change client perceptions and hence change the nature of the problem being addressed and the nature of the analysis required. The application of 'soft' OA tackles problems in a dynamic way in which the development of understanding and learning is episodic. As well, as methods are applied, new issues may arise that were not anticipated earlier.

The analyst should continually reflect on the different dimensions of the problem space (e.g. physical, social, individual), on the intellectual resources available, on the process (e.g. legitimacy, potential sources of error and bias) and on the outcomes in order to ensure that an appropriate combination of methodologies, methods and processes are being applied to address the situation at hand. He should evolve his choices (e.g. research design, data collection, data representation and process) based on critical reflection on what is happening during the course of the study and what remains to be accomplished in order to produce the types of outputs agreed to with the primary client and needed by the client system [6].

4.3.5 Choice of Study Participants

The analyst should recognise that decisions regarding study participants shape the study and the acceptance, credibility and validity of its outputs. The analyst should make decisions regarding the choice of study participants based on the topic being addressed and on participant knowledge, expertise, experience, availability and willingness to contribute. He should try to ensure that all key viewpoints are adequately represented within the study process. Overlooking and/or excluding key clients from the study risks study failure. Clients who are not properly engaged within the study context may not feel ownership (e.g. 'buy-in') towards study outcomes and may act against the implementation of any resultant recommendations. The analyst should try to ensure that client involvement is such that the mechanisms of interaction encourage adequate ownership of the study at the required levels of the client system hierarchy. As such, the analyst should carefully manage the type and extent of participation by each individual. He should consider regularly communicating study outputs to select individuals who choose not to participate more fully in the study process but whose relationship with the study is considered important.

The analyst should carefully consider:

- The number of SME participants that are required during each stage of the study;
- Which individual SMEs are best suited to act as study participants;
- The means to be used to elicit information from the SMEs; and
- How the SME-generated information is to be validated and used (further discussed in Chapter 7). For example, the analyst may ask a SME to participate in one or more of the following activities: gathering information, structuring issues, designing options, evaluating options and external review of the study as a whole or select aspects of it.

More specifically, the analyst may ask a SME to participate in one or more of the following activities:

- Provide his personal judgement;
- Act as a representative of his organisational group and hence provide judgements in terms of the group's official stance;

- Attempt to simulate the viewpoints of a select adversarial stakeholder (e.g. Red Teaming);
- Provide judgements based on the current state of affairs;
- Make predictions concerning the future;
- Act as a free thinker without considering policy or other constraints; and
- Provide judgements within the context of being bound by current policy or other select constraints.

For example, the analyst may ask a SME to contribute assumptions regarding future doctrine, performance data, force mixes, organisational structures, or force employment scenarios. A SME may be unwilling, or even unable, to perform some or all of the activities that the analyst asks him to engage in. Furthermore, a SME may sometimes believe that some of the activities that he is being asked to perform are in conflict. He may for these, or other reasons (e.g. lack of time to devote to the study), refuse to perform some or all of the roles that he is being asked to carry out.

In choosing SME participants, the analyst should recognise that while a SME does have detailed knowledge, it is not likely to be complete and could be biased, whether intentional or not (as discussed in Chapters 3 and 7).

Circumstances may dictate whether one or more SMEs should be employed in a study that uses ‘soft’ OA. In some cases, SMEs may be very busy and it may be a challenge to find SMEs to participate in a study (for example, due to the paucity of SME in some security domains). As such, analysts may sometimes be disappointed to find that the persons assigned to act as SMEs do not have the required knowledge, experience or expertise to carry out their designated task. They may also find it challenging if there is a need for continuity in the involvement of SMEs within the study context but different SMEs show up at each meeting. Sometimes, the analyst may find it necessary to bring in additional SMEs from the end user, customer or even analyst communities. The analyst should try to employ a mix of SMEs who together adequately represent the key viewpoints from which the topic under discussion may be considered and who are accepted by their peers as being experts in the field under consideration. Employing such a mix of SMEs may help alleviate some of the concerns regarding SME bias and impartiality by way of triangulation.

In general, the analyst’s design choices should encourage client ownership of the study. The analyst should attempt to build a good relationship with study participants and the members of the client system in general that is based on the clients’ confidence in the analyst’s integrity, honesty, skills, judgement and fairness. He should recognise that his study design choices, such as the choice of study participants and the manner in which judgements are elicited (discussed in Chapter 7), directly affect the quality of the study’s outputs [7].

4.3.6 Conducting the Study

The quality of a study relies, to a large extent, on the analyst’s qualifications, experience, perspective, training, track record, status, and presentation of self [8]. A skilled, experienced and mature analyst is more likely to make good choices of methodologies and methods for use in the study.

In designing and executing a study, the analyst should carry out the whole of the study jointly with the primary client. The analyst should meet regularly with the primary client. He should ensure that the primary client is kept satisfied in terms of the study’s progress, as well as the relevance and credibility of its outputs.

In conducting the study, the analyst should rely on the primary client’s problem domain knowledge and understanding of the context and on his own professional OA expertise and skills. He should use a process that is iterative in nature with repeated reformulation of the problematic situation and study approach as new

insights are gained. The analyst should typically employ the phased approach discussed in Chapter 5 (i.e. appreciation, analysis, assessment and action). He should orchestrate the elicitation and use of information and data from select stakeholders (discussed in Chapter 7) for the framing of the problematic situation and for the development of options for addressing the problematic situation, as well as for their communication and interpretation (discussed in Chapter 8).

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 'soft' OA approach provided a means to engage stakeholders who came from different cultures and had very different points of view.

The analyst should recognise that there may be no one right solution to the complex issues being addressed by the study. He should recognise that the use of subjectivity in generating recommendations is unavoidable [2]. Furthermore, in the case of a *mess*, the best one may hope for may be to better manage (rather than to solve) the *mess* that is being addressed.

The analyst should recognise that he plays a critical role in the study's credibility, validity and acceptance. He should accept his responsibility to provide a rational and logical analysis that aids in managing the complexity of the problematic situation and aids in recognising and managing uncertainty and risk. He should conduct the study in a way that accords to the best practices in the field (e.g. standards of practice set out by relevant scientific societies, professional bodies, his own organisation) and to ethical principles (further discussed in Chapters 3, 5 and 6). Many organisations have ethics boards to ensure that the research being undertaken conforms to standards and have documents to guide their researchers. Common quality issues that the analyst should address (discussed in Chapter 3) concern, but are not necessarily limited to ([9], [10]):

- Choice of participants;
- Handling of bias;
- Clear account of criteria used to select cases and data collection and analysis;
- Clear theoretical assumptions;
- Systematic data collection and record keeping;
- Documentation of the rationale behind the research design and data analysis;
- Clear discussion of models employed;
- Reference to accepted procedures for analysis;
- Detailed list of evaluative criteria (methods appropriate to question asked, connection to existing body of knowledge);
- Use of reliable data;
- Findings supported by data;
- Clear links between data interpretations and conclusions; and
- Clear distinction between data and its interpretation.

In conducting the study, the analyst should try to ensure procedural justice (i.e. agreement on the fairness of the rules followed during collaboration) and procedural rationality (i.e. the rationality of the means followed to achieve set goals) during the conduct of the study [3]. Generally the analyst should try to keep all the members of the client system satisfied, within reason. However in practice it may prove impossible, given differences in interests and values and conflicting personal agendas, to develop outputs from the study that satisfy everyone or it may even be undesirable to do so in the context of the adversarial positions of some of

the stakeholders. The analyst should, as a minimum, try to keep the primary client satisfied in terms of the execution of the study.

In conducting the study, the analyst should also aim for transparency. For example, he should ensure that the study process is well documented and auditable. The analyst should attempt, to the best of his ability, to act in an unbiased manner when addressing the differing perspectives and interests related to the problematic situation. Readers are referred to Chapters 3 and 8 for a discussion of analyst bias, study participant bias and study validity, credibility and acceptance. It is preferable for the analyst to be independent and to have no personal interest in the ultimate outcome of the study, but this is not always possible in practice. In the end, the study's credibility needs to be established among all stakeholders, with decision makers having enough confidence in the study's outputs to use them to inform the decisions that they make. The integrity of the analyst and his actions during the study directly affect the quality of the study.

During the planning and conduct of a seminar war game (SWG) concerning the 'Army of Tomorrow', the clients were intimately involved in all phases related to the operational employment of the SWG. The analysts acted as advisors. This approach resulted in the clients developing a feeling of ownership towards the SWG which, in turn, helped avoid many potential hazards. For example, this approach helped ensure that participants were well prepared to assume their assigned roles on the day of the SWG and made it more likely that the outputs of the SWG were viewed as being credible. The analysts were responsible for the rigour of the process. Analyst guidance was normally well accepted by the clients due to the need to ensure the credibility and acceptance of the SWG outputs in the eyes of outsiders.
The application of 'soft' OA was based on the mutual respect and trust between the clients and the analysts, and on the analysts striving to have the clients take as much ownership of the SWG process as possible.

As part of the conduct of the study, the analyst is also responsible for reporting and interpreting study results and outcomes. This activity is discussed in Chapter 8.

4.3.7 Dealing with an Uncooperative Client

On occasion, the analyst may need to deal with an uncooperative client. Several approaches are possible. In some cases, the analyst may decide to exclude the client from the study but to attempt to take his perspectives and possible actions into consideration, and to mitigate the damage that such an individual could do to the study. This may be done, for example, by having another knowledgeable client provide input on what the likely perspectives and reactions of the uncooperative client are. Alternately, the analyst may try to turn an uncooperative client into a neutral or supportive client through frank discussion, lobbying or negotiation.

The analyst should, however, be aware that some uncooperative clients may not be readily apparent. Analysts should be careful of clients who attempt to 'game' study activities in an attempt to force outputs to conform to their perspective of the problem (e.g. manipulation of weights when voting on options in a multiple criteria decision analysis context). When manipulations in voting are suspected, the analyst should document the study process to provide an audit trail and should consider conducting an analysis of the voting of sub-groups.

Analysts should also be careful of stakeholders who act as workshop participants in order to gather evidence that they intend to use to torpedo the study if their favourite issues show poorly. The analyst should also be careful of situations in which the primary client wants advocacy, especially since some clients with such intent may not make it explicit; the analyst needs to be firm with such clients. Negative stakeholders should be consciously addressed, even if the ultimate decision is to ignore them. Readers may wish to consult [11] for a further discussion about working with (difficult) groups (see also the discussion in Section 7.3 and its Table 7-1).

4.3.8 Dealing with Clients' Participation Requests

Occasionally, the analyst may encounter higher level clients (e.g. general/flag officers) who wish to participate on a part-time basis in a workshop. This allows these clients to gain, and contribute to, a much richer appreciation of the problematic situation without needing to make significant time commitments. It also provides them with an opportunity to confirm that the study is on time and on budget and to develop confidence in the study outputs. Furthermore, such limited participation may lead to the identification of others who may gainfully be brought into the study (e.g. a former commander, a representative from an Allied Service, an academic who has also been studying the problem).

Despite its advantages, the analyst should be aware that such participation may also negatively affect workshop dynamics (e.g. due to differences in rank among participants; further discussed in Chapter 7) if not handled properly. Normally, the analyst should encourage such participation but should manage it so that it benefits both the individual and the study. The facilitation style may need to be amended to mitigate some of the potential negative effects of such participation.

Occasionally the analyst may encounter a stakeholder who requests to attend a session purely as an observer. The analyst may discourage this practice as it can negatively affect the energy of the workshop and its ultimate success. Alternatively, the analyst may allow this practice but may carefully manage it in order to minimise its potentially adverse effects. For example, the analyst may manage such requests by scheduling all observers to attend only on a select day of a multi-day session.

4.3.9 Analysis Teams

The analyst may work alone or as a member of a team[7], on a full or part-time basis. He may provide both analytical and facilitation services, or may concentrate on the analysis (e.g. model creation and analysis) while working closely with one or more facilitators and/or other analysts. If the study calls for the use of specialised skills that the analyst does not have (e.g. specialised 'soft' OA methods expert), he should use the expertise of other analysts or step aside to be replaced by another analyst who has the required specialised skills. The size and nature of the task, and whether a mixed OA approach is required, should be used to determine whether the use of an analytical team, headed by a team leader, is appropriate. If external facilitators are to be used, then the analyst should consider bringing them into the study early on as this provides facilitators a better opportunity to provide direct and valuable input into the study design and execution.

4.3.10 Balancing Responsibilities

The analyst may find it challenging to transition between and balance his responsibilities as the analyst for the study, a researcher in the OA domain, a mentor of junior OA practitioners and, in some instances, as facilitator for the study's workshops. He should address this challenge by being a reflective practitioner and should act with pragmatism. He should continually review his own range of OA knowledge and skills and further his own methodological competence. He should dedicate himself to professional development, keeping abreast of new developments in his field and ameliorating his analytical 'toolbox' from the learning opportunities that arise. He should actively mentor and nurture the development of OA skills among more junior practitioners with the understanding that it is his professional responsibility to do so. His research should inform his practice, and his practice should inform his research. In this way, work undertaken in a study not only benefits the study's clients, but also supports the advancement of the OA profession including its theoretical underpinnings. Naturally, the analyst should always respect the client's privacy needs when determining how insights gleaned from real-world applications of 'soft' OA are published in scientific journals.

[7] The analyst team works in conjunction with the larger study team whose composition varies by study (and over time) according to the study's needs.

4.3.11 Analyst's Skills and Training

In common with many professions, there are no prescribed criteria stating the set of competencies that an analyst employing 'soft' OA should possess. However, general experience has provided insights on the skills that are required. The analyst employing 'soft' OA typically needs to have the skills of both analyst (modeller) and facilitator (although sometimes a study using 'soft' OA employs individuals purely in an analytical, or purely in a facilitative, role). Individuals who are good at 'applied scientific common sense' and in handling group dynamics will likely be good at 'soft' OA.

In terms of training, knowledge and skills, it is generally desirable that the analyst employing 'soft' OA ([1], [12]):

- Has training in some scientific discipline (though not necessarily in the exact sciences) and has a well-rounded scientific background (as 'soft' OA is based on the use of a scientific (and possibly a multi-disciplinary) approach);
- Has knowledge of some 'soft' methods and active experience with their application;
- Has the ability to use effectively a wide range of techniques to understand and support the social and cognitive needs of participants in a group situation in which a problem is being explored and solutions are being developed (e.g. active listening, chart-writing, managing group dynamics and power shifts, reaching closure);
- Has the ability to use software appropriate to the field of application;
- Can deal tactfully with the concerns of others; and
- Has strong oral and written communications skills.

In terms of interest, personality and conduct, it is generally desirable that the analyst employing 'soft' OA [1], [12]]):

- 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;
- Enjoys drawing knowledge from other disciplines (as OA is interdisciplinary and may draw solutions from engineering, psychology, and other social and political sciences);
- Has the right personality so as to be able to gain client confidence and effectively communicate study results to senior decision makers;
- Is devoted to scientific rigour and ethical principles; and
- Has adopted and shows a fundamentally helpful attitude.

It may also be useful if an analyst employing 'soft' OA has additional specialist training and knowledge appropriate to the field of application (e.g. advanced analytical methods such as mathematical modelling. However, this type of expertise may also be made available to a study through the involvement of an additional analyst who specialises in the required skill set.

Although much can be learned from books, 'soft' OA skills are best developed through practice and much is learned 'on the job'. Apprenticeship under a seasoned practitioner can be most beneficial to those new to the subject. Some well-founded 'soft' OA methodology schools exist, usually based at universities,

where training courses are offered. Many are found in the United Kingdom where aspects of 'soft' OA may form part of an OA university degree. An analyst, who starts out by conducting studies that employ 'hard' OA and who then acquires 'soft' OA skills may be well suited to conducting studies that use mixed methods and to leading a multi-disciplinary analysis team.

Different 'soft' methods have different approaches and styles of modelling. Practitioners tend to prefer certain types of OA approaches over others based on their background disciplines, personalities, skills and personal preferences. In practice, there are limitations in every OA practitioner's analytical 'toolbox' and there is a trade-off between breadth and depth of knowledge. Some practitioners are more able to be fluent in multiple genres of analysis than others. Particularly challenging is the ability to be adept at employing a mixed approach that combines the use of 'soft' and 'hard' OA.

4.4 THE FACILITATOR

4.4.1 Facilitator Task

Within 'soft' OA, it is accepted that problematic situations are socially constructed [2] though this may not be the perspective of the problem owners. That is, key actors negotiate about 'facts', social relationships and viable and acceptable means of addressing the problematic situation ([13], [14]). A study employing 'soft' OA typically uses a highly participative mode of engagement and typically, but not always, involves the use of facilitated sessions. Such sessions may use formal models to handle communication about content and to work with that content [2]. Workshops within the context of a study employing 'soft' OA may be used to help stakeholders reach agreement on what the problem is and on what the viable (satisfactory vice optimal) options for addressing it are. The facilitator, depending on the choice of methods, may work at the individual (e.g. interviews) or group (e.g. workshops) level.

The facilitator should serve as a catalyst who helps the study's (workshop) participants manage their tasks and achieve their objectives. In particular, over the conduct of a study the facilitator should manage process and procedure in a way that better enables participants to use their own competencies to:

- Develop a better understanding of the problematic situation;
- Generate options;
- Assess the options; and
- Formulate a set of recommendations or a strategy for the way ahead.

A study may involve several workshops, with each specific 'soft' OA workshop having a limited aim.

A study conducted for the 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 through the use of a series of project stages. 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.

The facilitator should also help participants develop commitment and ownership of the group's outputs. He should help them avoid reaching premature closure (e.g. 'groupthink') that may lead to unstable solutions. The facilitator should attend to content (the subject matter under discussion) only to the extent that process management needs to be informed by content. He should also manage the practicalities that are related to organising and running a group session.

The facilitator should attend to the personality, power and political issues that emerge during a facilitated session. For example, he should manage participation problems and protect individuals, such as in cases

when the group is attempting to suppress unpopular or minority views. Issues may arise, for example, if workshop participants are military officers of different ranks or if workshop participants belong to different levels of the organisation's hierarchy (e.g. one individual has direct power over the other). The facilitator may offer protection in the form of an intervention during a workshop setting or in the form of the workshop design (e.g. running separate workshops for higher and lower ranking individuals, using computers when gathering information and when carrying out voting over options in order to assure some degree of anonymity).

The facilitator should ask clarifying questions and address miscommunication within the group [15]. He should monitor both verbal and non-verbal cues and try to be sensitive to unexpressed feelings in order to determine where significant tension exists. He should help the group manage anxiety, frustration and tension in a constructive way.

It should be noted that the study outcome is affected not only by the amount of conflict present but also by the type of conflict present and by how the conflict is handled. Conflict may be the reason for starting a study and may be present throughout its conduct. The type of conflict present may be *affective conflict* (i.e. socio-emotional conflict, personal conflict) that is rooted in interpersonal relations within the group and/or it may be substantive or *cognitive conflict* that is related to the group task and generally involves differences of opinion or viewpoint [15]. The former may be more difficult to handle (e.g. individuals refuse to talk about issues or refuse to work together). The facilitator and analyst need to recognise that conflict is not always dysfunctional if it is handled properly. Further, they should recognise that sometimes positive change can only occur through conflict. In general, the facilitator should aim to do a good job in managing the emotional life of the group [16].

The remainder of this section addresses facilitator style and the facilitator's contribution to study credibility, validity and acceptance. It also discusses the building of the facilitator team and the requirements that the facilitator needs to meet in terms of content-related knowledge (i.e. knowledge about the subject matter under discussion). The discussion is provided from the analyst and facilitator perspectives, concentrating on the activities that need to be carried out and referring to other chapters in this CoBP for a discussion on *how* the activities may be carried out.

4.4.2 Facilitator Style

There is no one correct way to facilitate. There are many facilitative styles. The facilitator should adopt a situational approach: one which accommodates the task, the time available, the facilitator's own personality, the nature of the group, and the dynamics of the particular combination of participants. The facilitator should be flexible given the unpredictability of how a group session will evolve. He should act as a role model for group behaviour as his behaviour has a strong impact on how participants act individually and on the group dynamics. For a discussion on common workshop designs and facilitation techniques that may be used to address challenges in group dynamics, readers are referred to the vast literature on facilitation, including for example some of the references consulted in the writing of this section, namely ([10], [15], [16], [17], [18], [19]).

4.4.3 Facilitator's Contribution to Study Credibility, Validity and Acceptance

The facilitator's job is a challenging one. The facilitator may need to deal with heated debates between powerful personalities who have strongly divergent viewpoints and interests regarding the issues under discussion and who are blatantly resisting the facilitator's attempts to maintain control of the session. A badly facilitated session in which the facilitator loses credibility and the trust of the participants may not only fail to produce the required workshop output but may also destroy the primary client's confidence in the study. The facilitator's conduct has a direct impact on the success of a workshop and the study as a whole.

Whatever facilitative style is used, the facilitator should try to ensure that none of the participants have concerns over his impartiality. Hence, to the extent possible, the facilitator should:

- Perform his role in an unbiased fashion;
- Remain emotionally uninvolved;
- Keep an open mind;
- Not favour any participant;
- Encourage equal participation; and
- Refrain from contributing content, substantive knowledge or an opinion on the subject under discussion; this includes refraining from making verbal and non-verbal evaluations regarding content.

It is preferable that the facilitator have no stake in the ultimate outcome of the process (other than maintaining his professional credibility throughout that process).

The facilitator should regularly engage in critical reflection on the process and outcomes in order to adapt his approach to best suit the dynamically changing nature and needs of the group and better enable participants to manage their tasks and achieve their objectives.

4.4.4 Facilitator Team

Although the analyst (modeller) may typically act as facilitator during a study that employs 'soft' OA, this need not be the case. Sometimes, it is useful to split the analysis and facilitation tasks. This may be due to workload issues or a desire to address the semblance of impartiality in cases where the analyst belongs to one of the clients[8]. In such cases, it may be desirable to bring in one or more outside consultants to act as facilitators.

The facilitator may work alone or as part of a team of facilitators. He may be external or internal to the organisation to which the analytical team belongs. He may be supported during a workshop session by specially designated recorders. When the analysis and facilitation tasks are separated, the facilitator should cooperate closely with the analyst in the context of a facilitated modelling approach. It is not wise for the facilitator to be part of the client system due to possible concerns about the semblance of impartiality that may arise.

4.4.5 Facilitator's Content-Related Knowledge

The facilitator should ensure that he has enough knowledge about the subject matter being discussed and the acronyms to be used during a workshop so that he knows enough to keep track of the flow of the discussions, to ask the right questions and to effectively guide group processes and procedures. It generally helps, but is not absolutely necessary, for the facilitator to have significant content-related knowledge (provided that the knowledge does not compromise his impartiality as a facilitator). The facilitator should ensure that he has an adequate knowledge of modelling in order to be able to properly support the particular facilitated modelling approach that is being used during the workshop. The level of training needed, and knowledge of the subject matter being discussed, that is required for proper facilitation in support of the study should be considered by the analyst when he chooses the facilitator(s) to be employed by the study. Sometimes, there is a need for both a *technical facilitator* (i.e. knowledgeable about the subject matter (content) under discussion; or able to operate supporting software) and a *process facilitator* (i.e. knowledgeable in the application of a specialised OA method) in a group setting. The role of technical facilitator is often discharged by an expert who is

[8] Sometimes, if an analyst belonging to a client system is also chosen to act as facilitator, concerns over facilitator impartiality may be addressed by ensuring that workshop participants are chosen such that they adequately represent the diverse stakeholder views and interests.

imported to act as a technical guru and point of reference if technical uncertainties arise. This also allows the process facilitator to detach from the client in those cases where there are limited specialist personnel resources for the study.

4.5 SUMMARY OF THE ANALYST'S AND FACILITATOR'S RESPONSIBILITIES

The following sections provide a summary of the analyst and facilitator responsibilities that are discussed in this chapter.

4.5.1 Analyst Responsibilities

- Take responsibility for the design, conduct and scientific integrity of a study involving the use of 'soft' OA.
- 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.
- Continually reflect on the different dimensions of the problem space (e.g. physical, social, individual), on the intellectual resources available, on the process (e.g. legitimacy, potential sources of error and bias) and on the outcomes in order to ensure that an appropriate combination of methodologies, methods and processes are being applied to address the situation at hand.
- Identify one individual, or at most a small number of individuals, within the client system as the analyst's primary client.
- Encourage client ownership of the study.
- Build a relationship with the primary client that is based on respect, trust and open communication. Adopt a helpful attitude.
- Regularly update the stakeholder analysis and exercise good stakeholder management throughout the conduct of the study.
- Ensure that all key viewpoints are adequately represented within the study process.
- Ensure procedural justice (i.e. agreement on the fairness of the rules followed during collaboration) and procedural rationality (i.e. the rationality of the means followed to achieve set goals) during the study's conduct.
- Ensure transparency of the process and the analysis and ensure that the study process is well documented and auditable.
- Carefully consider which Subject-Matter Experts (SMEs) to involve as study participants, the means employed to elicit information from the SMEs, and how the SME-generated information is to be validated and used.
- Continually review own range of OA knowledge and skills and further own methodological competence.
- Use the expertise of other analysts if the study calls for the use of specialised, unfamiliar skills.
- Actively nurture the development of OA skills among more junior practitioners.

4.5.2 Facilitator Responsibilities

- Help (i.e. support, enable, encourage) study participants to work together through the stages of a study by managing procedure (the way the problem is tackled) and by managing process (the way participants interact).

- Perform this role in an unbiased fashion, remain emotionally uninvolved and refrain from contributing content or substantive knowledge on the subject under discussion. (It is recognised that every individual has biases. The guidance in this chapter refers to ultimate goals that an individual may aspire to achieve to the extent that the best of his abilities allows him to do so.)

- Act impartially and, preferably, have no stake in the ultimate outcome of the process.

- Prior to conducting a workshop, ensure having adequate knowledge about the subject matter being discussed, the acronyms that are likely to be used and the results that the analyst wishes to generate through the workshop.

- Use the expertise of other facilitators, if necessary. For example, a study may employ a team of two facilitators, one with extensive content-related knowledge (i.e. knowledge of the subject under discussion) and another who has specialised OA process skills.

- Address the personality, power and political issues that emerge during a workshop. Protect individual participants being singled out, for example in cases when the group is attempting to suppress unpopular or minority views.

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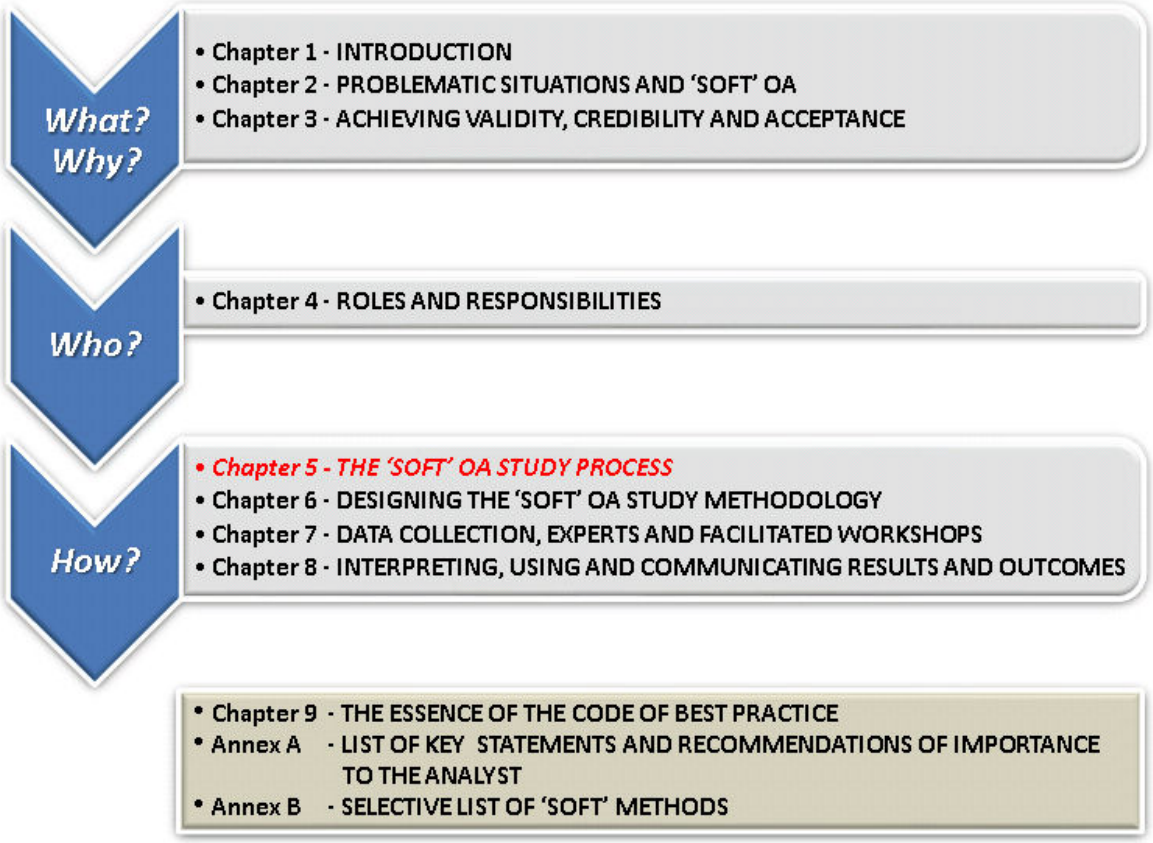
Chapter 5 – THE 'SOFT' OA STUDY PROCESS



- Consider designing the study as a process with the following phases:
  - *Appreciation* – 'What is happening'?
  - *Analysis* – 'Why and how is it happening'?
  - *Assessment* – 'How can it happen in a better way'?
  - *Action* – 'What needs to be done'?
- Ensure that the study team and the (group of) client(s) reach an agreement about the following concepts at the end of each of the 4A-phases:
  - *Study plan* (← Appreciation phase),
  - *Problem understanding* (← Analysis phase),
  - *Set of options* (← Assessment phase),
  - *Action plan* (← Action phase).
- Be aware that the people involved in the process belong to one of the following groups, though they should cooperate with each other:
  - *Study Team*: group of people who 'do the work' (e.g. the facilitator, the analysts, the SMEs, and subsets of other stakeholder types including clients);
  - *Client(s)*: group of decision makers (possibly including sponsors and customers).
- Be aware of the iterative (cyclic) and dynamic nature of the process and its phases.
- Recognise the divergent or convergent nature of subsequent phases and accommodate for it.
- Ensure that the plan for application of 'soft' methods is understood by participants and clients as part of their programme of progressive development. The same goes for the outputs and their utility.
- Provide a framework which allows decision makers to carry through their decision-making processes in a structured, auditable way.
- Create a roadmap depicting achievements and interrelations, perhaps in a facilitated workshop.

5.1 INTRODUCTION

This chapter recommends in the application of 'soft' OA that a study be conducted as a dynamic iteration cycle. As 'real-world problems' are inevitably multi-dimensional and therefore require a number of issues to be dealt with and a number of people to involve, a solution approach to these types of problems is usually not a single event but a process organised as a number of subsequent phases [1]. This chapter will address each of these phases. It will also address the iterative nature of the process and its stages of divergence and convergence.

5.2 HOW PEOPLE INFLUENCE THE 'SOFT' OA STUDY PROCESS

Processes that support human decision making within messy problem spaces and involve the participation of several decision makers, very often concentrate on satisficing rather than pure optimisation. Study procedures applied in these situations should support, in addition to the appreciation (ref. Section 5.3.1) and analysis (ref. Section 5.3.2) of the problematic situation [2]:

- The discovery of alternative options;
- The development of acceptable solutions or ways forward to improve the problematic situation;
- The systematic gathering and analysis of information; and
- The use of bounded rationality[1] that recognises people's cognitive limitations.

This implicates two central elements in problem resolution processes: negotiation and social relationships [2]. Personal interrelations as well as individually diverging agendas and objectives of the participants influence the problem resolving process and necessitate negotiation efforts in order to reach a satisfactory solution.

In general, the processes of using 'hard' and 'soft' OA approaches to problems are not necessarily fundamentally different from each other. The challenge of achieving an effective complementary approach that combines 'soft' and 'hard' OA methods lies within the blending of people, process, and analysis skills that suits the given problem structure and supports the achievement of a common understanding with and of the clients involved [2].

The choice of ('soft'/'hard') methods cannot be fixed at the beginning of a study but evolves from a critical reflection of the developments during the study [5].

Critical success factors for the study are the development among the analysts, clients, and further stakeholders involved into the problem resolving process of [6]:

- A shared understanding;
- A sense of common purpose; and
- A commitment to the way forward.

This intense involvement of a variety of people in the decision-making process coupled with the necessity for strong communication, coordination, and facilitation amongst them, may be regarded as one of the major differentiating characteristics between the application of 'soft' and 'hard' OA methodologies.

[1] The term 'bounded rationality' was introduced by Herbert A. Simon [3]. It describes the inability of human beings to optimise rationally their decisions due to the complexity, dynamics, and ambiguity of decision environments. For a certain (personal) constraint system, the decision maker will rather satisfice than optimise within his system due to a lack of important information concerning the definition of the problem or of relevant criteria [4]; he will stop his optimisation process when a 'satisficing' solution (that may not necessarily be the optimum) has been reached.

Defining an iterative decision cycle that synchronises the points of view of both the study team and the client team by making use of experienced facilitating analysts is an effective method to create useful approaches to solving problematic situations. Iteration in the process creates the flexibility to adapt the problem perception and to reconsider the methodological approach. Furthermore, it encourages the people involved in the decision-making process to rethink their approaches and perceptions.

Dealing with problematic situations that require the extensive use of human judgement in the decision-making process needs a process that is dynamic and open to changes caused by new insights or changing minds. An iterative process that supports the factors described above is elaborated in the following sections.

5.3 THE PHASES OF A 'SOFT' OA STUDY PROCESS

The analyst is responsible for developing the study design (e.g. process, stages, sessions, interviews) and for adapting (or fine-tuning) it as the study proceeds[2]. This includes making decisions regarding whether to apply a combination of 'soft' and 'hard' OA, and in what manner[3]. The clients' perceptions and reasons for commissioning the study influence choices regarding the study design. For example, some clients may express a preference that quantitative results should be part of the study outputs.

At the outset of 'soft' OA studies, analysts do not 'set in stone' the predetermined methods, techniques and procedures that will be applied in a pre-established order to address, or produce a solution to, the problematic issues under investigation. The application of 'soft' OA tackles problems in a dynamic way in which the development of understanding and learning is non-linear and which requires a flexible and adaptive approach to analysis. As such, the analyst continually and critically reflects on the different dimensions of the problem space, on the intellectual resources available, on the process (e.g. legitimacy, potential sources of error and bias) and on the outcomes in order to ensure that an appropriate combination of methodologies, techniques and processes are being applied to address the situation at hand and to find ways in which the process could be made even more efficient and effective. This is part of the iterative behaviour that the CoBP seeks to encourage.

In order to preserve the possibility of adapting the problem structure identified and with it the chosen methodological approach and model, an iterative decision support process is advised. This process is divided into phases that follow each other sequentially but not in a 'one-way' manner; if indicated, earlier phases can be repeated and will then influence the follow-up phases.

A distinction should be made between the following four main phases which helps design the study[4] (based on [1] and [7]). These '4 A-phases' (as referred to in this CoBP) are composed of:

- *Appreciation* – Activities to sense the problematic situation, identify all stakeholders and their viewpoints and assumptions, and other circumstantial factors ('what is happening').
- *Analysis* – Activities to actually analyse and structure the problematic situation, further develop and clarify all assumptions, aspects, perspectives and influencing factors and their (causal) relationships. It includes provision of information (data), possibly developing and relying on one or several models as representation constructs to create deeper understanding based on the model outputs ('why and how is it happening').
- *Assessment* – Activities to develop, investigate and compare ways of change and improvement and estimate/predict their consequences, and recommend one or more ways ahead ('what is the consequence of what is happening and how can it be changed to generate better consequences').

[2] A detailed analysis of the roles and responsibilities of the people involved in the 'soft' OA process is the subject of Chapter 4 of the CoBP.

[3] This issue is a central aspect of Chapter 6 of this CoBP.

[4] The four phases could help design any OA study.

- *Action* – Activities to arrive at a final conclusion (or even decision) and a recommendation of how implementation should be conducted ('what needs to be done').

The four phases listed above are similar to the (military) 'Observation, 'Orientation', 'Decision' and 'Action' loop (OODA loop[5]; Figure 5-1). The analyst should for each of these main phases determine its aim and what is required in terms of study activities. This should be based on the study's ultimate aim and in agreement with the client(s) including the key stakeholders.

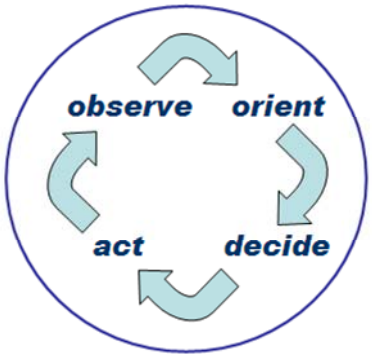


Figure 5-1: Military OODA Loop.

Figure 5-2 shows the iterative process model of 'soft' OA which – after initiating the study – consists of the four main phases described above and tasks which are assigned to either the 'study team' or the 'client(s)'. The process cycles between the two teams and relevant information and decisions are developed during facilitated meetings (see Chapter 7).

[5] Or 'Boyd cycle' after its inventor USAF COL J.R. Boyd; see also [8]. In the field of 'situational awareness' a similar planning cycle exists using three levels [9]:

1) Level 1 – perception of the elements in the environment (i.e. gather the elements to build up a model);
2) Level 2 – comprehension of the current situation (i.e. validate the model as reflecting the common picture of the present); and
3) Level 3 – projection of future status (use the model to forecast consequences of possible interventions).

As a last example, the 'soft' methodology 'Strategic Choice' distinguishes between: shape, design, compare and choose.

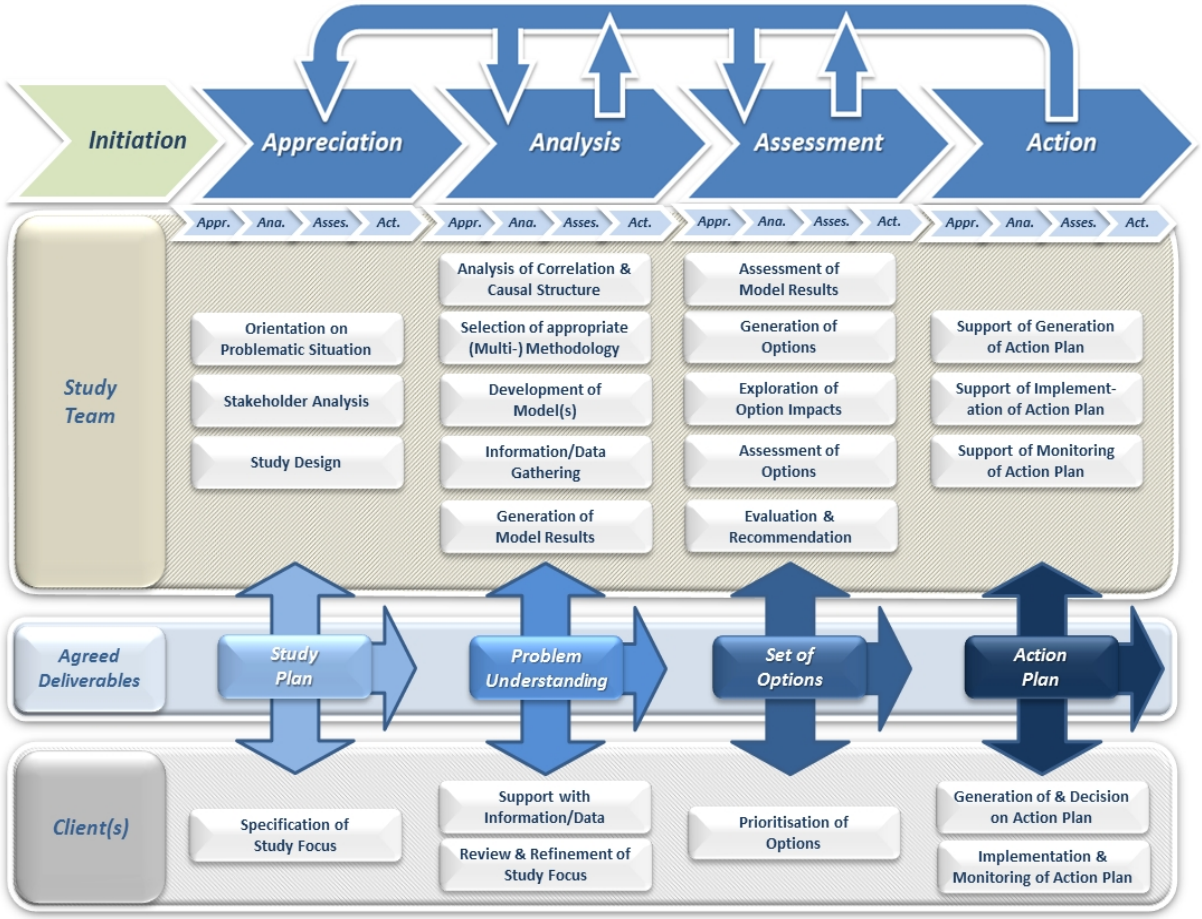


Figure 5-2: The Iterative 'Soft' OA Study Cycle.

The methodology of problem structuring ('Problem Structuring Methods', PSM), encompassing a large number of specific methods, is the predominant methodology used to understand a problematic situation, identify the concepts that are relevant and structure the relationships between them. They can therefore be used in the phases of appreciation and analysis. Although the term suggests that it stops at this point, many PSM allow progress toward the design of options and actions.

Decision making regarding problematic situations often involves a variety of stakeholders[6] (ref. Chapter 4); the iterative process depicted in Figure 5-2 considers this fact by assigning tasks to the study team and the client(s).

The study team (people who actually work on the problematic situation including participating clients and other stakeholders) and the client team (clients, particularly sponsors and other people from the client system, who have to make decisions about progress and deliverables) have to work collaboratively towards a common goal.

In each of the four A-phases of the process, both groups have to perform certain tasks that will at specific synchronisation points (milestones) converge into an agreement between the two; this agreement builds the basis for the further process work. If it is not possible to reach a common understanding between the two groups it may be necessary to return to an earlier phase and refine or reconsider the work done in that

[6] Analysts and facilitators are sometimes not considered to be part of the group of stakeholders within a decision-making process (ref. Chapter 4) but they are an integral part of the study team.

phase. Through this mechanism, the common decision-making process stays dynamic and iterative. This, on the one hand, may lead to a longer process turnaround time and increased complexity caused by the communication and coordination efforts. On the other hand, this approach supports the development of an exact and detailed problem understanding between the study team and the client(s) which is a necessary condition in order to generate an appropriate action plan as a result of the decision-making process.

The nature of the four A-phases is twofold (Figure 5-2). First, they are primary drivers to progress the study and provide waypoints for agreed deliverables. In addition, they should be used as activities within these phases to refine each of the phases in an iterative manner. Thus the Analysis phase may include the techniques applicable to the Appreciation, Assessment and Action phases in producing the agreed deliverable of the Analysis phase. This is illustrated in Figure 5-2 by the small-sized A-phases at the secondary level (Figure 5-6).The remainder of this section will discuss the main phases and the tasks that are carried out in each main phase. Section 5.4 will discuss the iteration and parallel processing aspects, also shown in Figure 5-2, more in-depth.

The first process step that starts off the (global) 'soft' OA process is the initiation-step. This process step is conducted just once, in contrast to the following process-steps that may be iteratively repeated. After the initiation of the process of 'soft' OA the following issues have become clear:

- A specific *problem* or a *problematic situation* exists and needs to be resolved;
- A (group of) *client(s)* exists who need(s) decision support;
- A *study team* has been contracted by the client(s); and
- A *study* will be conducted to provide decision support.

Having settled these initial issues, the 'study team' and the 'client(s)' enter the first phase of the 'soft' OA study process.

5.3.1 The Appreciation Phase

The first phase of the iterative process of 'soft' OA is the Appreciation phase. The central task within this phase is to orient on the problematic situation, thereby gaining an understanding of the people involved as well as the problem's environment.

For the study team, the Appreciation phase is divided into the three following tasks:

- Orientation on the problematic situation;
- Stakeholder analysis; and
- Study design.

The central task for the client(s) lies in providing the 'Specification of the study focus'.

This phase requires an intense interchange between the study team and the clients in order to create a clear picture of the problem environment as well as of the stakeholders involved.

As a result of this phase, a commonly agreed study plan should be developed which comprises the answers to the 'why?', 'what?', 'who?', and 'when?' of the study (adapted from [10]):

- *Why* is the problem addressed by the study?
- *What* tasks, work packages will be completed by the study?
- *Who* will be involved and what will be their responsibilities within the study?

- *When* will which tasks be performed and in which order? What is the study timeline?

The study plan is a formal, approved document used to guide both study execution and study control. The primary goal of the study plan is to document planning assumptions and decisions, to facilitate communication among stakeholder, and to document approved scope, cost, and schedule baselines (adapted from [11]). Although relevant to all studies, this is of special relevance to 'soft' OA studies considering the importance of communication and documentation of changed assumptions, etc.

Study plan as a central element of communication and coordination:

- guides study execution;
- documents study planning assumptions;
- documents study planning decisions regarding alternatives chosen;
- facilitates communication among stakeholders;
- organises and ensures communication between study and client teams;
- drafts a staged study plan;
- should document deviations from the original plan and give reasons why;
- provides a baseline for progress measurement and study control.

This phase requires the ability of the study team to capture and interpret the clients' knowledge and expertise as well as their attitude towards existing solutions and their effective involvement into the decision-making process [12]. This process may involve the conduct of interviews with the client(s). The results of these interviews may be visually presented as individual cognitive maps that will later on converge into a group map and will constitute the starting point for the development of a common understanding of the problem environment [12].

Another major aspect within this phase is the recognition of the nature, level and source of uncertainty; the decision on how to cope with the identified type of uncertainty is depicted in Figure 2-2 and affects the further study design in terms of, for example, choice of methodology. The basic approaches to dealing with (respectively prepare for) uncertainty are discussed in Section 2.3. Section 6.3 of this CoBP discusses approaches for the analysis and handling of uncertainty in detail.

At the end of the Appreciation phase the study team and the clients are expected to have a common understanding of the problem environment and of the next steps to undertake. This should be documented in the study plan. Furthermore, the study team will not only have a clear understanding of the structure of the client system and the stakeholders that comprise it, but will also have a strategy for coping with different types of stakeholders.

5.3.2 The Analysis Phase

After exploring the problem's environment and the outline of the problematic situation in the Appreciation phase, the problem itself moves to the centre of attention within the Analysis phase.

For this reason the major work of the study team consists of the following tasks:

- Analysis of correlation and causal structure;
- Selection of appropriate (multi-)methodology;
- Development of model(s);
- Information/Data gathering[7]; and
- Generation of model results.

[7] The 'Development of Model(s)' task may be separated from the 'Information/Data Gathering' task but this is not always necessary: e.g. drafting a diagram of all issues that define the problematic situation is in fact the development of a model and organisation of information at the same time.

For a successful conduct of the Analysis phase a close interaction with (part of) the clients is necessary. Therefore, the clients should provide time for the following tasks:

- Support with information/data; and
- Review and refinement of study focus.

As a central result of this phase, the study team and the clients have achieved and agreed to a common problem understanding that will be the basis for the selection of an appropriate (multi-) methodology.

After reaching a common understanding of the nature of the problem, the study team faces the task of defining an appropriate (multi-) methodology and with it the gathering of necessary information and data. This may take place during workshops conducted with (parts of) the (group of) client(s).

The amount of data and information accumulating while developing and processing some specific model approaches can be large and may at first appear unmanageable to the participants involved in the decision-making process. In these cases an approach to resolve this situation is to develop a road map that depicts the achievements reached so far as well as their interrelations [2]. Besides the improvement of the problem understanding, this approach supports the handling of the complexity of the problematic situation even if it cannot reduce it. It should be noted that reduction in complexity may negatively influence the effectiveness of the action plan chosen as a result of the iterative process.

Such roadmaps may not be easily understandable by those not directly involved in the study. Ownership of them is best allocated those who were closely involved in their creation [2]. It is therefore strongly recommended that its creation should take place in a facilitated workshop (ref. Chapter 7 on workshop facilitation) which equally involves the study team as well as (parts of) the (group of) client(s). This furthermore is a way to involve the client(s) in the model building process and to ensure a common problem understanding.

A crucial element in the choice of methodology as well as the modelling process itself is the handling of uncertainty factors which have been identified in the Appreciation phase. The impact of uncertainty attached to the data and information gathered in this phase has to be mitigated by choosing an appropriate methodology (ref. Section 6.3).

The validation of judgement-based models is rather of a qualitative nature. Particularly Chapters 2, 3 and 7 deal with issues of validation and verification. One important aspect of conducting 'soft' OA according to Phillips [13] (see also Section 5.4) lies in ensuring that everyone involved in the decision-making process approves of the methodological approach chosen and the respective model developed. Therefore, it is inevitable that the study team works closely together with the (group of) client(s) in a controlled and facilitated manner.

5.3.3 The Assessment Phase

Having generated a set of model results, the study team has to assess these results and generate action alternatives in regard to the shared understanding of the problem as well as the previously specified and agreed study focus. For this, the Assessment phase consists of the following tasks:

- Assessment of model results;
- Generation of options;
- Exploration of option impacts;
- Assessment of options; and
- Evaluation and recommendation.

The assessment of the model results may imply a variety of lines of action. The generation and assessment of these options and their impact is a major task for the study team within this phase. Furthermore, the effects of the choice of how to deal with the factors of uncertainty identified in the first phase and considered in the model development of the second phase manifest themselves in the Assessment phase.

Becoming aware in this phase that the approach to coping with the type of uncertainty initially assumed to belong to the problematic situation has been the wrong one, could necessitate the repetition of the second (reconfiguring the methodological approach) or even the first (reconsidering the initial assumptions) phase.

After defining and evaluating a set of action options, the study team identifies a recommended sub-set of these options. Consequently, the (group of) client(s) has to fulfil the task 'Prioritisation of options'.

As a result, a rated (sub-) set of options that may resolve (part of) the problematic situation is defined and builds the starting point for the following Action phase.

5.3.4 The Action Phase

The Action phase begins with the transformation of the set of prioritised options into a (number of) action plan(s) which is subsequently followed by the implementation of a chosen/agreed action plan. This task itself will involve the analysis and assessment of alternative action plans which may be organised similarly to the first two 'A-phases' of this chapter and which may require a small study on its own.

The study team could offer the following types of support to the client(s):

- Support of generation of action plan;
- Support of implementation of action plan; and
- Support of monitoring of action plan effects.

The following tasks have to be carried out by the (group of) client(s) in the Action phase, possibly supported by the study team:

- Generation of and decision on action plan; and
- Implementation and monitoring of action plan.

In a facilitated meeting, the study team together with the client(s) identify an action plan that is most likely to meet the requirements that have been specified throughout the iterative 'soft' OA study process. Subsequently, the action plan is implemented by the client organisation.

The implementation of the chosen action plan can produce effects that may not have been predicted or that may hint to a false analysis and assessment of the current problem and its environment. It may therefore be necessary to reconsider earlier phases (or tasks) of the iterative 'soft' OA study process or to repeat it entirely starting with the Appreciation phase.

5.4 ITERATIONS THROUGH THE 'SOFT' OA STUDY PROCESS

The application of mixed methods/methodologies is quite often the most promising way of meeting the demands of the multi-faceted nature of problematic situations. In addition, one or more of the four A-phases may have to be conducted more than once. Furthermore, this may take place sequentially or in parallel – where indicated and possible – and may lead to various combinations of iteration of 'soft' OA techniques.

Figure 5-3 gives an example of a sequential iteration through the 'soft' OA study process. Whereas earlier in this chapter the possibility of jumping back to preceding phases with respect to the application of a single methodology has already been indicated, Figure 5-3a shows the adaptation of this principle for two methods (one for each cycle) and Figure 5-3b shows that methods may be different per phase per cycle.

Figure 5-3a: Example of Sequential Phase Iteration (A Different Method Per Cycle).

Figure 5-3b: Example of Sequential Phase Iteration (A Different Method Per Phase Per Cycle).

If, however, for a specific problematic situation the application of two methodologies (e.g. mixed 'hard'/'soft' or 'soft'/'soft') may seem appropriate, a possible iteration may induce the parallel conduct of the Analysis and Assessment phases as depicted in Figure 5-4. Such possibilities should be taken into consideration when designing the study during the Appreciation phase.

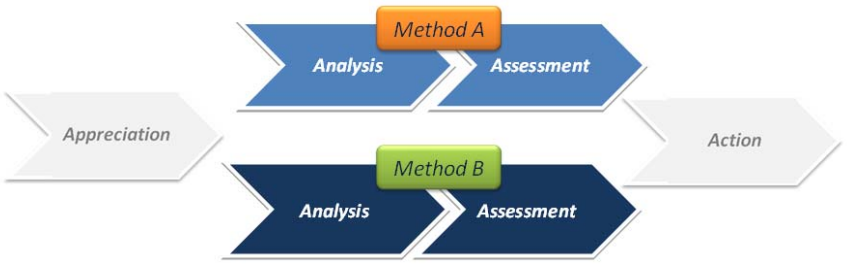


Figure 5-4: Example of Partially Parallel Phase Processing.

It may be necessary to run through all phases for each methodology, leading to a parallel two-threaded 'soft' OA study process as depicted in Figure 5-5.

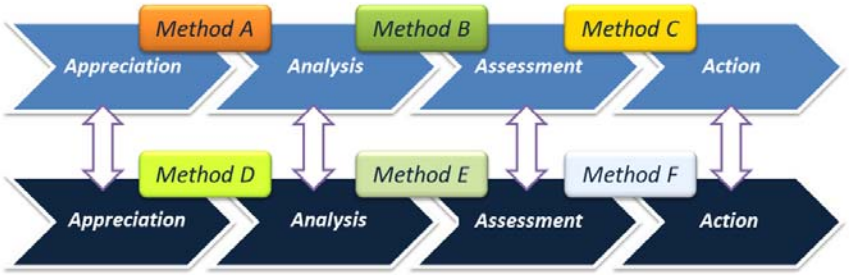


Figure 5-5: Example of Full Parallel Phase Processing with Different Methods.

The nature of the specific problematic situation, as well as the evaluation of the (group of) client(s), will help determine whether this setting should be dealt with in two separate studies or, if coherence requires, they are best treated by parallel execution. Chapter 6 discusses in detail the multi-methodological approach in the context of the application of 'soft' OA.

The four A-phases of the 'soft' OA study process describe the predominant activity in terms of the 'global' (or higher) problem level whereas at a 'local' (or lower) problem level (respectively at one smaller sub-set of the problematic situation) all four activities are conducted within the respective main phase before reaching the next main phase.

Figure 5-6 illustrates[8] how each main phase may include tasks (and methods) that are typical of other main 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 main phase (i.e. the diagonal from the lower left corner to the upper right corner of the diagram), but at the local study level within a main 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.

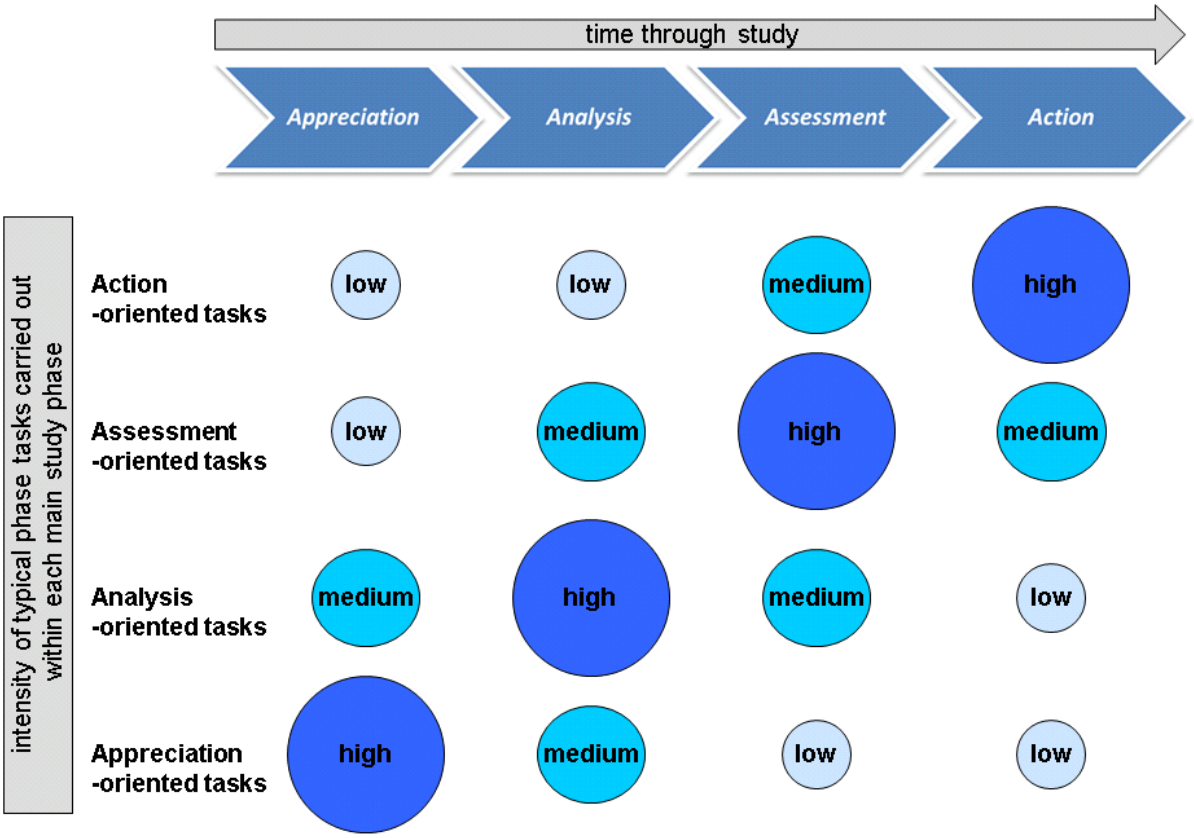


Figure 5-6: Each Main Phase Requires, in a Varying Intensity, Tasks that are Typical of All Phases.

An example within the Analysis phase may look like this:

- Appreciation of the problem's defining factors, including the selection of a suitable methodological approach for problem analysis (medium intensity in Figure 5-6).

[8] See [14] for an alternative way of illustrating this.

- Analysis of the problem's defining factors and their interrelationships (perhaps cause-effect relations) by developing and using a (causal) model and generating model results (high intensity in Figure 5-6).
- Assessment of the results (key concepts, key objectives, etc.) and the initially chosen methodological approach for the study (medium intensity in Figure 5-6).
- Action A: restart overall Analysis phase with different approach, or Action B: proceed to overall Assessment phase (low intensity in Figure 5-6).

In Figure 5-2, this correlation is depicted by a series of small-sized A-phases at a secondary level within a main phase (Figure 5-7).

Figure 5-7: Sequence of A-phases at the Secondary Level.

A 'hard' modelling approach often has a natural point where one can decide on its 'readiness' for use: a thorough verification (and validation) procedure will usually suffice. However, this may not be at all obvious when constructing judgement-based models. A judgement cannot easily be verified as 'correct'.

Phillips (e.g. [13]) introduced the useful concept of a *'requisite' model* which, assuming that it will serve as an aid to thinking and group learning, is *sufficient in form and content to resolve the issues at hand in the opinion of the group of people who construct the model*. Therefore, the model represents their collective view and shared understanding at that stage of the process.

The process of identifying a way ahead when a problematic situation has presented itself may be a matter of debate among a group of clients and other stakeholders. A requisite way ahead is one that is agreed by the group to be feasible and to sufficiently offer perspectives of improving or resolving that situation. The aim of the study may require a certain nature, precision or quality of data which may not be achievable with reasonable effort and costs. Again, an iterative process of reviewing and adjusting the initially chosen model type and method, and perhaps even the study's aim, can lead to a requisite approach based on debate and negotiation.

When building a model as a construct of concepts and relationships or as a criterion hierarchy for evaluation purposes or any other type of model based on judgement, the group will end the modelling process when it feels that 'requisiteness' has been achieved. That point has been reached when everybody feels comfortable with the model.

5.5 DIVERGENT AND CONVERGENT THINKING

The effect of opening up the problem space is referred to as divergence and describes the increase in complexity through adding new aspects to the problem.

'Divergence' is more often experienced in 'soft' OA rather than in 'hard' OA studies (Figure 5-8). The clear problem description typical of applications of 'hard' methods implies that a divergent stage is not needed.

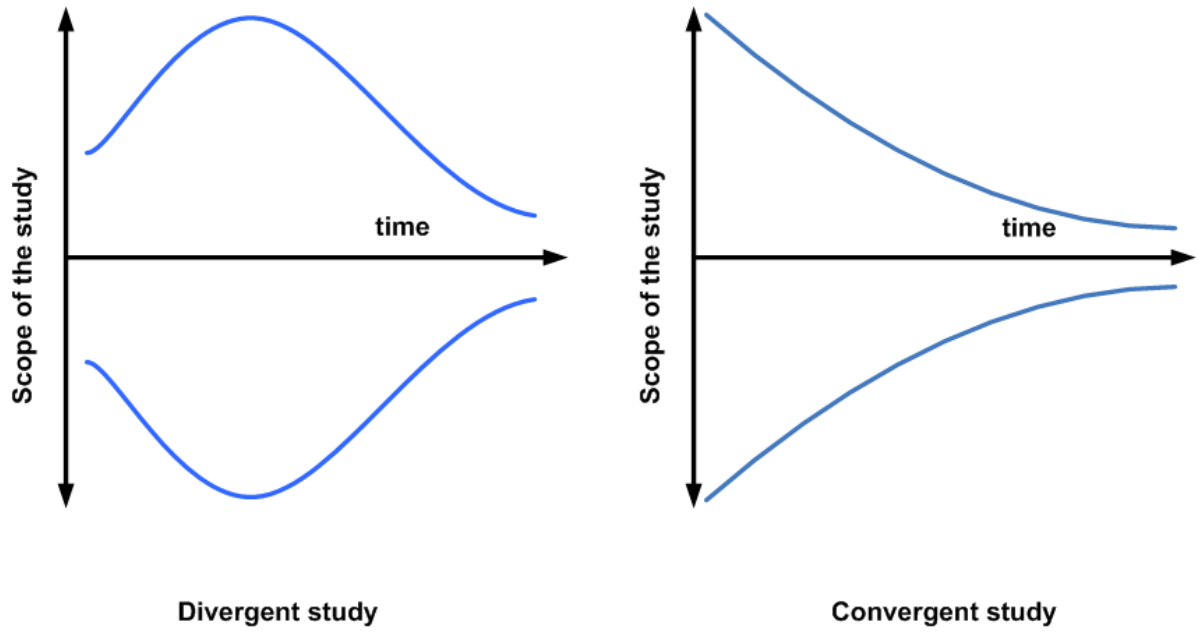


Figure 5-8: Comparison of Divergence and Convergence in ‘Soft’ and ‘Hard’ OA Studies.

‘Divergence’ opens up the problem space which quite often may be necessary and useful in order to let the ‘real’ problem emerge. Consequently, one of the major tasks of an experienced study team is to balance diverging and converging streams of thoughts throughout the ‘soft’ OA study process in order to reach a solution that addresses the right problem (or problematic situation) and that is understood and accepted by all stakeholders.

Divergence can appear in all phases of the process as a result of discussions (or brainstorming) between different people with different opinions (or agendas) and will increase complexity and turnaround time of the process. On the other hand, it may be necessary in order to identify the ‘real’ problem (or problematic situation) or to find the best possible solution or management approach to it.

Figure 5-9 depicts a cycle of divergent and convergent thinking. This figure illustrates that convergent lines of thinking may not always reach a satisficing end point at some stage of the process, for example End Point A, but rather Point B or Point C which may not be generally acceptable. In these cases iteration enables the rethinking of the current approach and provides an opportunity to get back ‘on track’ towards an end point that is more satisfactory.

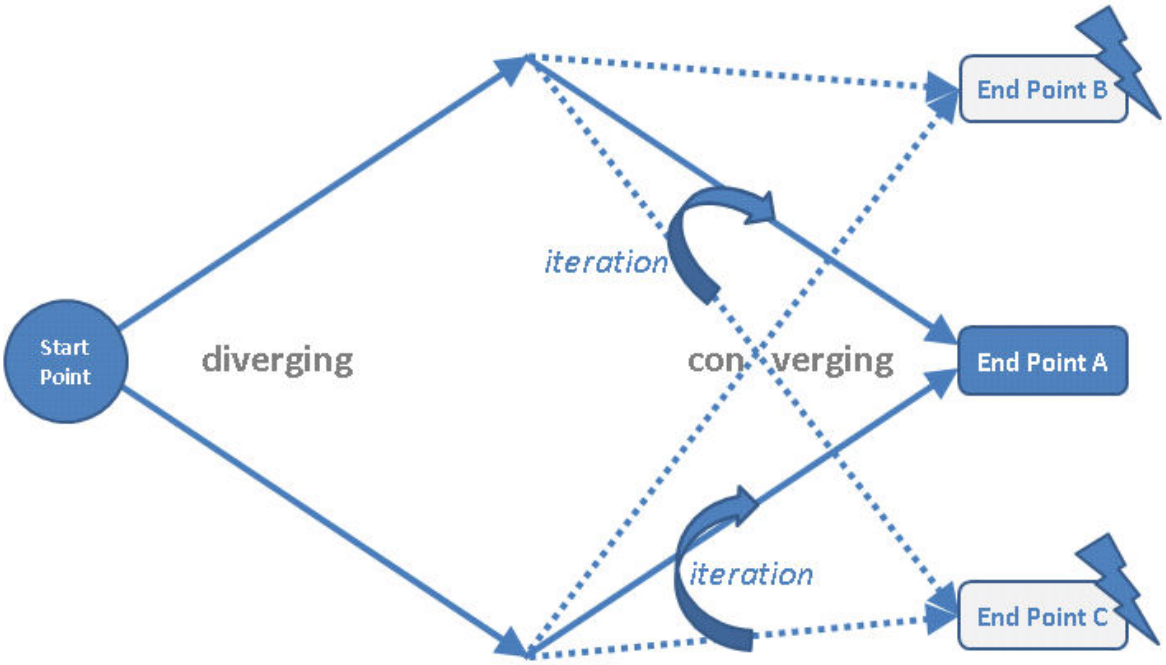


Figure 5-9: Iteration and Convergent Thinking.

Typical activities during stages of divergent and convergent thinking are given in Table 5-1.

Table 5-1: Divergent versus Convergent Thinking (taken from [15]).

Divergent Thinking		Convergent Thinking
Generating a list of ideas	vs.	Sorting ideas into categories
Free-flowing open discussion	vs.	Summarising key points
Seeking diverse points of view	vs.	Coming to agreement
Suspending judgement	vs.	Exercising judgement

An experienced facilitating analyst will encourage streams (or stages) of divergent and convergent thinking throughout the whole process in order to identify the most acceptable way ahead. The reader is referred to [15] fore more aspects of divergence and convergence in the context of working with groups.

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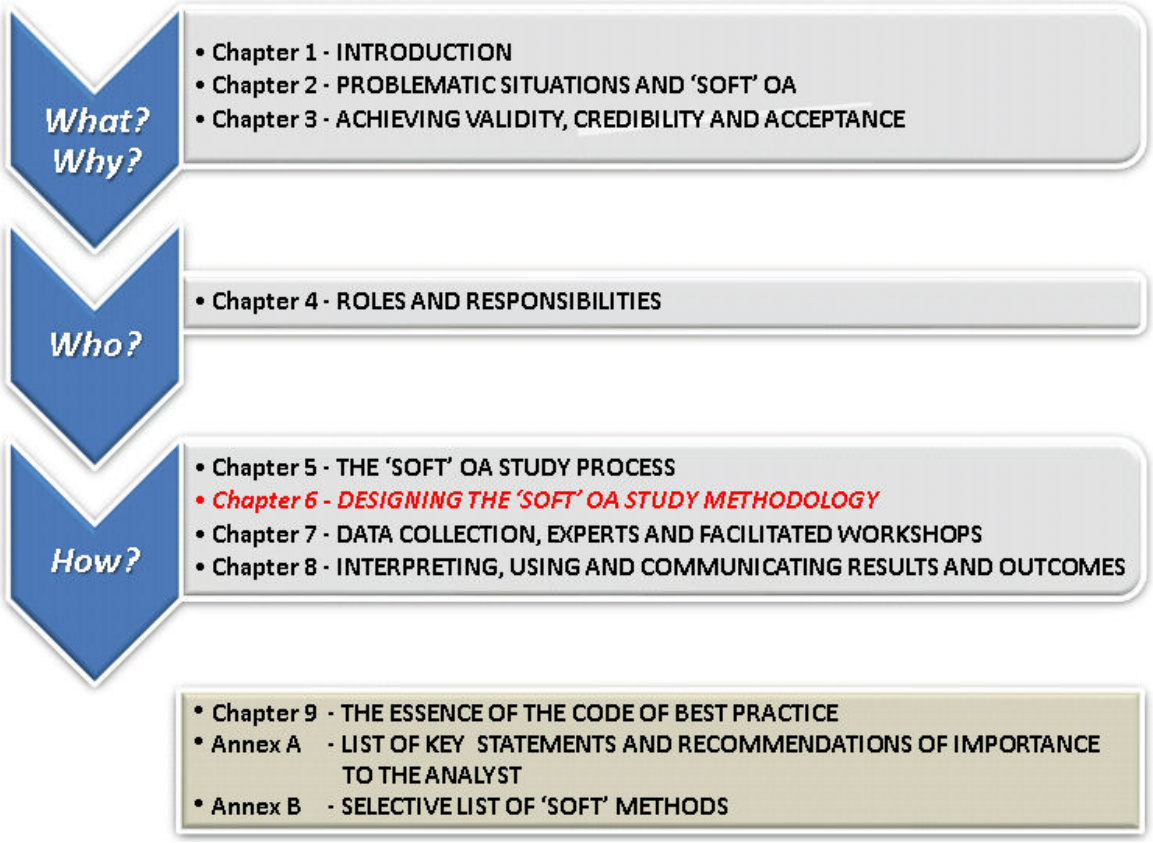
Chapter 6 – DESIGNING THE 'SOFT' OA STUDY METHODOLOGY



- Communicate with client(s) including key stakeholders and seek agreement on any assumption, action and delivery.
- Determine the most likely nature of the problematic situation by trying to shed light on key aspects.
- Decide on the appropriateness of a trajectory from perceived mess to either a problem proper or a manageable mess.
- Identify which type(s) of uncertainty exist(s) and contemplate on both the adequate attitude to uncertainty and ways of coping with it.
- Identify stakeholders and their interests and attitudes towards the study by conducting a stakeholder analysis.
- Decide on the appropriateness of a single or a multi-methodology study approach.
- Examine all methods on their merits to the problematic situation at hand and decide on the appropriateness of specific candidate methods. Recognise own limitations in knowledge/expertise and seek assistance.
- Decide on data and other resources needed including the use of software.
- Be aware of the danger of dissipation of results from 'hard' OA methods when interleaving 'hard' and 'soft' OA methods in a multi-methodology approach.
- Maximise objectivity and rigour, gauging the validity of the overall approach in terms appropriate to the problem domain being addressed.
- Document the argumentation and rationale for modelling decisions and keep a record.
- Document the argumentation and rationale for changes in the study's assumptions and aim (including aims of specific study phases), the definition (or, alternatively, the common understanding) of the problematic situation in order to ensure end-to-end integrity.

6.1 INTRODUCTION

This chapter addresses the design of the methodological approach of a study and in particular, whether and how different methods may be combined. As already stated in Chapter 1, the CoBP will not discuss specific methods but this chapter will provide general guidance to deciding on the choice of an appropriate study methodology and will give some examples of appropriate methods.

This chapter starts with guidelines as to how to determine the nature of the problematic situation since this will affect the methods and methodologies to be used. After that the chapter addresses the phenomenon of uncertainty in more depth than Chapter 2 by suggesting a typology which may be useful when designing the study methodology. The chapter then discusses stakeholder analysis and mapping as a follow-up on Chapter 4's discussion of the analyst's perspective on the stakeholders. The chapter goes on to address the modelling process and differentiates between a study approach based on a single methodology (usually for a small-scale study) and one that is based on multiple methods (usually for larger-scale studies). Collective experience (see e.g. [1]) has shown that most of the time, there is a need for a multi-methodology approach when addressing a mess. Much of what will be suggested regarding single-methodology studies – for example about choosing and designing a study methodology, about modelling issues, data requirements, use of experts, etc. – has a general validity and will therefore be valid for multi-methodology studies as well.

6.2 HOW TO COPE WITH PROBLEMATIC SITUATIONS AND RECOGNISE MESSES

When an analyst is called in for support, one of the first matters he has to consider is the nature of the problematic situation and the type of analysis that will be most appropriate.

Chapter 2 discusses three fundamental problem types that represent a broad spectrum of problematic situations: puzzles, problems (proper) and messes. At the outset of a study it may not be clear which type it is. Communication with the client(s) whilst referring to the main characteristics of the three problem types and to those listed in Table 2-2 should make matters clearer.

Below follows a step-wise approach which may help the analyst determine which type of problematic situation he is facing, before designing the study methodology: ask questions, follow a checklist, interpret the exploratory findings so far, decide on an additional trajectory to get things clearer in the case of a tentatively perceived mess.

The analyst must be able to discuss the client's initial statements (which could be ill-perceived) and identify which type should be assumed to be initially applicable. This could be done at an early stage of his involvement by asking questions regarding at least the following issues:

- Symptoms, possible causes, history (and: "is this all there is?": initially hidden problem behind stated problem);

Anonymous client quotation:
"I want to exclude unforeseen outcomes"

- Identification of stakeholders, and their backgrounds, interests, aims, and anticipated commitment; ("who is unhappy with the problem and why?", "who does and who does not want the problem to be resolved and why?", "who will and who will not be cooperating?", "when can the problematic situation be considered as 'improved'?");
- Uncertainties about the previous issues and resources needed and anticipated consequences of (not) addressing the problem, fear of these consequences, restrictions (and: "imposed by whom?");
- The relationship between the ultimate decision maker and the problem owner (and: "is there something to decide upon?", "is 'do nothing' a feasible option?", "why is this your problem?");

- Any deadlines, the time frame within which first deliverables are expected (and: "how urgent is this?"); and
- Payment and other administrative matters which however will serve as a means for the analyst to gain more insight into internal client relations ("who is paying?", "same person as problem owner?", "who is really willing to spend money"?).

When analysing the answers to the questions above, the following *checklist* (based on Chapter 2's Table 2-2 comparing 'soft' and 'hard' OA and its cited references, and also [2], [3]) will help the analyst determine if he is dealing with a messy situation, a problem (proper) or merely a puzzle:

- ☐ 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 the 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 the 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 of the problematic situation, 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.

The 'not much is (initially) known' part of the list above denotes that a large amount of uncertainty may exist: uncertainty about different aspects of a problematic situation and different types and levels of uncertainty. This will be discussed in Section 6.3.

The problematic situation may be regarded as a *puzzle* by the analyst if (virtually) none of the previous checklist items are ticked and if a search is required for a quantitatively underpinned outcome, preferably the best possible (the optimum), to inform the decision to be made. Some of the items listed in the checklist may require 'soft' methods to further delineate and define them. For example, there may be a need to interview stakeholders to agree the formulation of the model and the nature of the required solution, but this will be followed by a 'hard' modelling exercise in case of a puzzle.

The problematic situation may be regarded as a *problem (proper)* by the analyst if only a few of the previous items are ticked and there is a feeling amongst both the analyst and the client feel that agreement can be achieved in the formulation of the problem, the definition and (semi-)quantitative evaluation of the

potential solution options, and the procedure to achieve results. The study methodology will in this case most likely consist of a combination of 'hard' and 'soft' methods.

If most of the previous items are ticked the analyst will be wise to regard the problematic situation as a *mess*. In that case the CoBP suggests two ways forward: create a problem (proper) (i.e. a 'type 1 trajectory'), or, if that fails, continue to work in the mess space (i.e. a 'type 2 trajectory'). The two trajectories are discussed next.

A new combat boot had been introduced in Sweden when the number of foot injuries started rising alarmingly. The issue identified during the workshops using Morphological Analysis was a lack of knowledge of the range of injuries that had been sustained. A survey was conducted in order to map the issue. The survey was not part of the original study design, but an outcome of the acute lack of information the working group experienced. The morphological model was used the help shape the questions in the survey. Even though the study was not finalised as originally planned, the application of Morphological Analysis was valuable by transforming the combat boot issue from a mess to a problem, and by exposing the lack of data.

A *type 1 trajectory (perceived mess → problem proper)* should aim for a common agreement among the primary client and key stakeholders, before actually conducting the analysis proper, on at least:

- The formulation of the problem (creating a well-defined construct) one can work with;
- Setting initial restrictions[1] in physical, organisational, social, time-related, etc., terms as they could affect the analysis approach;
- The nature of the options and the ability to (semi-)quantitatively evaluate and compare them;
- The type(s) of model to be constructed and used, and the desired nature of results and the outcome of the study as a whole;
- Participants in the study (particularly in respect of specific types of expertise) and the information each individual will bring in (or give access to); and
- The internal phasing procedure of the study needed to achieve results.

A *type 2 trajectory (perceived mess → manageable mess)* should aim for a common desire, an initial commitment among primary client and key stakeholders, that something can and should be done to understand and change the current problematic situation. Along the way a clearer picture should be obtained of some key elements of the anticipated study, and thus turn the perceived mess into a mess that one can start working on:

- An identification and better understanding of aspects of the problem and the factors that influence it;
- The problematic aspects to be addressed and improved;
- A view of any boundaries to be set initially;
- The nature of the anticipated outcome of the study;
- Participants in the study (particularly in respect of specific types of expertise) and the information each individual will bring in (or may give access to); and
- An initial design of the internal phasing procedure of the study needed to achieve results.

Trajectory 1 could be a study in itself, the end of which could lead to the start of a problem (proper) solving study. Trajectory 2 will most likely be undistinguishable from the actual study, although one or two moments of reflection and a go/no-go decision could be built in.

[1] The definition of restrictions (i.e. boundaries to the study) at some stage of the study is important: how far to go back in history, for example, may determine whether or not some of the root causes of a conflict will be addressed.

Figure 6-1 illustrates the trajectory methodology for coping with problematic situations discussed above. A large part of it could be carried out in a facilitated workshop setting (ref. Chapter 7 on workshop facilitation) with key actors. Part of this process may be iterative (although not shown in the diagram) until a common understanding and agreement on the way ahead is achieved[2].

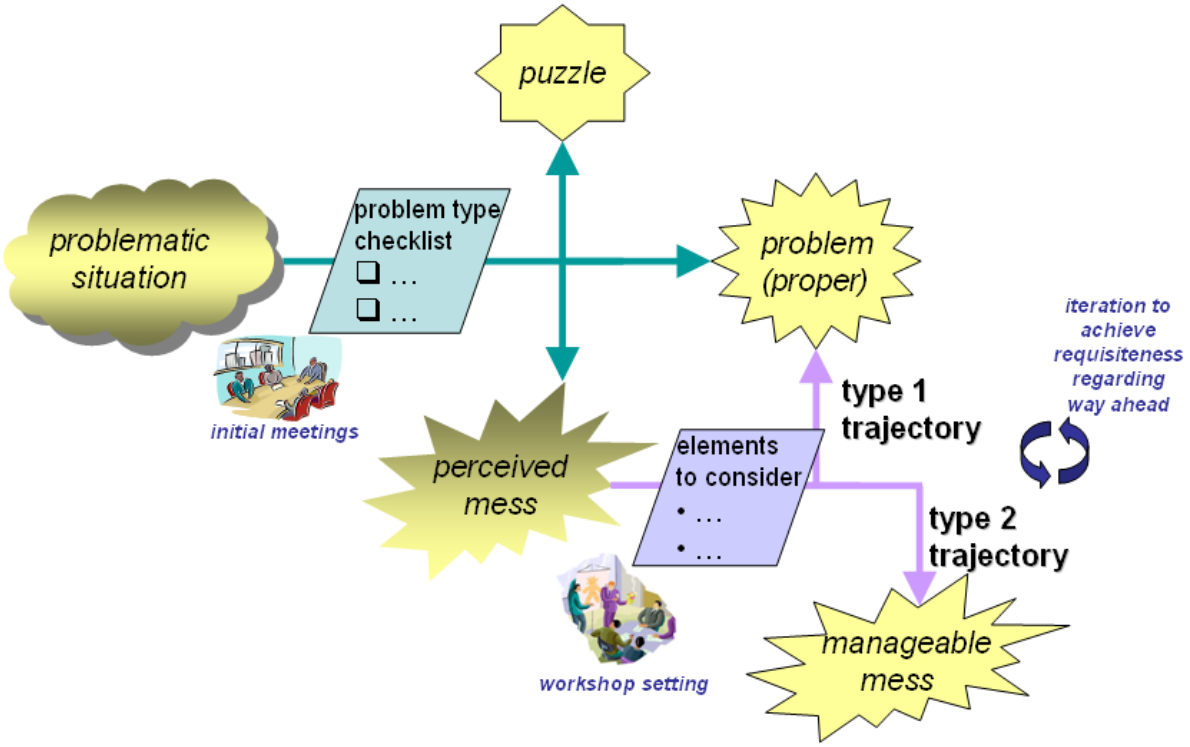


Figure 6-1: Procedure for Interpreting Problematic Situations and Identifying Their Nature.

Recall from Chapter 4 that the analyst very often has to 'prove' his competence in the methods and methodologies of 'soft' OA when a client's initial attitude is that of regarding the analyst as a technical scientist familiar with traditionally 'hard' analytical work. Adopting one of the two trajectories may be a way to show his skills at an early stage.

6.3 ANALYSING AND COPING WITH UNCERTAINTY

Uncertainty is a phenomenon that has to be coped with in any operational analysis as it is often the prime characteristic of the problematic situation. Chapter 2 discusses the concept of uncertainty in a general sense and suggests three different attitudes that one might adopt towards uncertainty. Each of them leads to some specific form of preparation for uncertain events. It is suggested in Chapter 2 that for coping with uncertainty related to the type of (messy) problems the CoBP is addressing, a mix of those attitudes will be most recommendable.

Before discussing the modelling process itself this section will discuss the various types of uncertainty in more depth with a view to the modelling consequences. This typology helps the analyst with identifying the nature of uncertainty that exists in the problematic situation he is dealing with and therefore with

[2] The concept of 'requisiteness' is usually applied to the modelling process (ref. Section 5.4), but it is also relevant to identifying a way ahead that is sufficient in form and content to resolve the issues at hand in the opinion of the group of people who will be involved in the study process.

determining which study methodology will be appropriate. At the end of this section some advice will be given regarding methods that are appropriate for certain types of uncertainty.

Much of what follows is based on Walker et al. [4] and Dreborg [5], which in turn are based on a large body of literature on uncertainty. That material has been adapted and extended for the purpose of the CoBP.

The list below constitutes a typology of uncertainty. A distinction can be made between the following dimensions and aspects.

- The *locations* of uncertainty; uncertainty may manifest itself in a number of elements of the modelling process:
  - *Model context*, which refers to the framing of the problem, the definition of problem boundaries, the identification of clients and other stakeholders and their perspectives, the identification of external sources of influence (e.g. adversaries, other threatening or non-threatening circumstances);
  - *Model structure*, which refers to the form of the model, the way in which concepts and relationships between concepts are defined, system behaviour;
  - *Model input and model parameters*, which refers to variables, data, values of parameters, description (expected behaviour) of external influence factors and the current system; and
  - *Model results*, which refers to estimates of outcomes/consequences, prediction error.

The other dimensions that follow are, in fact, characterisations pertinent to each of the uncertainty locations listed above:

- The *levels* of uncertainty; different degrees of uncertainty exist regarding the location of uncertainty, ranging from full knowledge (most likely quantitatively available) via partial (most likely only to some extent quantitatively and to some extent qualitatively available) to complete absence of knowledge:
  - *Stochastic uncertainty*, which derives from measurement issues such as imprecision and sampling error, and the inherent probabilistic nature of variables ('games against mother nature') – this type of uncertainty can usually be treated *quantitatively* as the event space will most likely be known.
  - *Scenario uncertainty*, which is uncertainty about the future external environment, the range of possible outcomes as a result of uncertain mechanisms although the probability values are unknown – two types of scenario uncertainty can be distinguished, both of which could be treated *quantitatively or qualitatively or as a mixture of both*:
    - *Intentional* (defence issues are normally characterised by the existence of adversarial actors, but this also includes situations where a number of stakeholders with divergent interests exist having the means to exercise influence); and
    - *Unintentional* (trends and developments to some extent autonomously leading to a future situation).
  - *Ignorance*, which ranges from 'known unknowns' when one still knows what one does not know, to 'unknown unknowns' when one even does not know what one does not know ('black swans') [6] – this type of uncertainty is usually *qualitative* and addressing it relies heavily on human judgement and imagination.
- The *nature* of uncertainty, which means that different sources (or perhaps rather: root causes) of uncertainty exist regarding the possible locations of uncertainty:

- *Imperfection of knowledge*, which may be reduced by more effort to gain missing knowledge (e.g. about adversaries, circumstances, stakeholders) or by involving subject-matter experts (who give informed estimates or their knowledgeable opinions) or perhaps merely by the passing of time as more information presents itself; and
- *Inherent variability*, which concerns social, economic and technological developments or natural events and may be caused by the inherent randomness (stochasticity) or dynamics of processes, technological surprises, and human behaviour and difference of opinion.

- The *time* dimension of uncertainty which means that the level or nature of uncertainty may or may not change over time:
  - *Dynamic uncertainty*, which is any uncertainty one will know more about *with time*, such as the weather, or the intentions of a specific adversary; it is essentially dynamic in relation to the degree of preparedness that exists with respect to a certain development, i.e. whether or not one knows in time what meaningful countermeasures to take; and
  - *Static uncertainty*, which essentially remains constant such as the probability of an accident occurring (assuming that no additional preventive precautions are taken as a preparation).

The analyst will need to distinguish between the dimensions and their underlying aspects in order to adequately design methods to cope with specific types of uncertainty. Figure 6-2 shows an uncertainty matrix (adapted and extended from Walker et al. [4]) with 'location of uncertainty' at its centre (vertical Y-axis), 'levels' and 'nature' at its right and left respectively (horizontal X-axis), and 'time' as the table's third dimension (Z-axis). The items on the X-axis characterise the items on the Y-axis. The items on the Z-axis characterise those on the X-axis for each of the location instances on the Y-axis. The result is a 3-dimensional matrix, where each cell may be elaborated further if that specific combination of location instance, level type, nature type and time aspect exists in the problematic situation the analyst is facing.

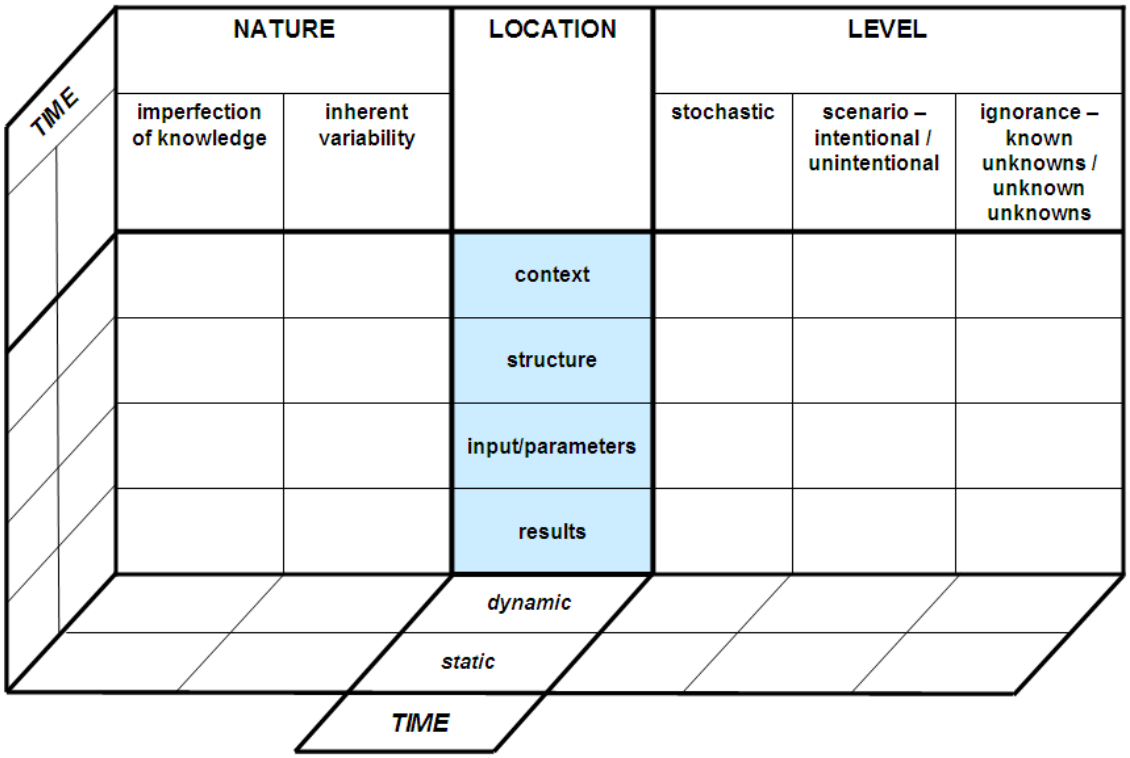


Figure 6-2: Table of Uncertainty Typology (3-dimensional) (Extension of a Table in [4]).

It must be noted that there are some relationships between 'Nature' and 'Level'; for example, imperfection of knowledge leads to ignorance. In addition, one could argue that 'static uncertainty' is an extreme case of 'dynamic uncertainty' as far as time is concerned. So, the dimensions are related to some extent.

The purpose of this table is to help the analyst find ways of dealing with uncertainty by:

- *Identifying* appropriate types of uncertainty in the preparatory pre-analysis phase of a study;
- *Choosing* appropriate methods in the Analysis phase (by examining their characteristics and relating these to the entries of the table in Figure 6-2) that are able to address identified types of uncertainty; and
- *Ex-post showing* that all relevant types of uncertainty have been dealt with by using the matrix as a quality control checklist.

In situations of uncertainty where a *quantitative* treatment would be appropriate, the following examples of methods would be useful:

- Risk management works well in a situation that is characterised by *stochastic* uncertainty, and can be used for *intentional* uncertainty as well. Risk management combines elements of all three attitudes towards uncertainty discussed in Chapter 2. Risk management needs to be supported by other approaches in situations of strong *qualitative* uncertainty.
- Game theory has been used successfully in situations where *intentional* uncertainty is strong, but it does require that the rules of the game be known quantitatively. Thus game theory is less suited were *intentional* uncertainty is combined with *qualitative* uncertainty.
- Decision trees are suitable for exploring situations of *dynamic* uncertainty, but again assume mainly *quantitative* uncertainty to work well.

If the situation is characterised by large elements of *qualitative* uncertainty, other, predominantly 'soft' approaches are called for. One important approach is scenario planning ([7], [8], [9]), which helps by imagining possible futures were different rules apply. In essence, scenario planning is used to explore bits of the event-space. Other methods can be used to similar effect, often in combination with scenario planning (e.g. Morphological Analysis [10]).

Early 2003, the Swedish Army leadership felt that the Army units no longer had a unified sense of purpose. As the focus of the Army had gradually shifted from homeland defence towards conducting missions abroad, the unity of purpose was gradually lost.

In order to address this challenge, a scenario planning approach was chosen. Workshops were assembled where a representative selection of Army personnel was present. They were tasked with brainstorming driving forces that could be regarded as important and uncertain. The key question was "Does Sweden need an Army in the future?". Based on the identified driving forces four scenarios were constructed, describing four 'worlds' in 2025 and addressing security issues. The scenarios were called "Democracy for all", "Renaissance for realpolitik", "Usama's triumph" and "Baltic focus".

The scenarios were used to show that some ground fighting capability would be required in all scenarios, but also that the conditions and requirements regarding that force would be very different in the four futures.

In situations where *intentional* and *qualitative* uncertainty is prevalent, various table top (war)gaming approaches have been successful (e.g. [11], [12]). By assuming the roles of potentially adversarial or co-operating actors one uses one's empathy and imagination to think of some of the novel moves the real actors might apply. A specific form of *qualitative* and *intentional* uncertainty is involved with identifying the possible consequences of actions one may take in order to address the problematic situation. In order to approach this issue gaming may be relevant as well.

When dealing with *dynamic* and *qualitative* uncertainty, one useful option is to use adaptive planning approaches, i.e. devise options that retain as much freedom of action as possible in the face of an uncertain future. The Strategic Choice Approach and Robustness Analysis (both in [13]) are helpful in these situations. System Dynamics, possibly in combination with Group Model Building [14], would be another

useful option for this type of uncertainty, but also for a situation where *dynamic* and *stochastic* uncertainty exists.

A rather different approach to addressing uncertainty is Assumption-Based Planning [15]. It is not limited to any particular type of uncertainty, but is used to revise and strengthen an already accepted plan. In essence, it is designed to identify critical assumptions in order to suggest shaping and hedging actions that will improve an existing plan.

The fundamental point about uncertainty is that it has to be managed properly in the study process, and while it cannot be eliminated its implications can be understood. Importantly, the analyst should not treat it as a commodity to hand on to the decision maker.

6.4 STAKEHOLDER ANALYSIS

At a (very) early stage of the study, the analyst, in partnership with the primary client and possibly other select members of the client system (ref. Chapter 4), normally conducts a stakeholder analysis exercise ([16], [17]). The objective is to:

- Develop a list of stakeholders;
- Identify the stakeholders' key characteristics;
- Identify potential risks to the study (e.g. uncooperative stakeholders and their possible adverse effects on the study); and
- Develop insight into how stakeholders should be engaged and managed during the study (e.g. how much attention to devote to each stakeholder, which stakeholders to invite to workshops, which stakeholders to include in formal communications regarding study outputs, how to manage pluralistic competing stakeholder demands).

The first of the following two sub-sections addresses what aspects of stakeholders should be analysed and what the challenges to this analysis are. The second sub-section will briefly discuss some examples of how an analysis can be conducted in the form of stakeholder mapping.

6.4.1 The Challenges of Analysing Stakeholders

A stakeholder analysis is conducted as part of the (initial) problem framing process. It is repeated regularly during the study on a (preferably) proactive or on a reactive basis. Revisiting and revising is required since the stakeholder community is not static (e.g. as the study progresses through its lifecycle the members within the community may change and/or the perceptions of individuals may change). The stakeholder analysis may need to be kept private as the primary client may be uncomfortable with an explicit record (see also Chapter 3).

For each stakeholder who is identified, assessments may be made of the following:

- The stake in the study;
- The awareness of the study;
- The interest in the study (e.g. why is he interested, what are his expectations and objectives, is he directly or indirectly affected);
- The perception regarding the study (e.g. does he believe that he will gain an advantage or be disadvantaged through the study);

- The position (e.g. internal or external actor, organisational membership, title or rank, place in the organisational hierarchy);
- The power and influence (e.g. ability to support or to sabotage the study process and resulting actions, ability to influence based on his network of relationships, his importance within his organisation, his resources);
- The relationships with other stakeholders (e.g. potential for conflict, potential to act as an opinion leader, which stakeholders have similar interests and views, possibilities for forming coalitions);
- The attitude towards the study (e.g. supportive, neutral, obstructive);
- The legitimacy in relation to the organisation;
- The urgency of the claim on the organisation (e.g. how important is the study to the stakeholder and how prepared is he to act (supportively or obstructively) to achieve his own desired outcomes); and
- The knowledge, experience and expertise in areas of interest to the study (e.g. how could he contribute to the study, participation possibilities).

A stakeholder analysis is by nature subjective and incomplete:

- There are uncertainties and inconsistencies in participant assessments;
- There is always a residual uncertainty about the will and purpose of the stakeholders (even involved stakeholders may choose not to disclose all their intentions);
- The information on external stakeholders in particular will be difficult to determine and will be incomplete (e.g. biased assumptions, use of stereotypes); and
- The stakeholder community is dynamic (e.g. members influence one another and change their stances, coalitions form and break up, new members enter and old ones leave, power shifts, interests change).

A seminar war game (SWG) on the Canadian 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. 'Soft' OA helps engaging stakeholders who come from different cultures and have very different points of view.

Addressing stakeholders within the study team is a matter of conducting effective facilitation that is trusted by the stakeholders. If the group of stakeholders that needs to be involved in a certain study phase is too large for conducting a single workshop, then a series of workshops may be conducted or other approaches may be found to engage all key actors (e.g. workshops supplemented by interviews). The benefit of involving stakeholders is that they may voice their concerns and find common ground in a problem definition, and ultimately be supportive of actions suggested by the study. Involving a larger number of stakeholders may also increase the quality of the problem definition, as each stakeholder brings in a new perspective on the issue. The drawback may be that stakeholders with sufficiently divergent interests may block any development of a common view and may get information that may benefit a contradictory purpose. Some may even attempt to bend the study to suit their own ends.

6.4.2 Stakeholder Mapping

Decisions have to be made on how to address the stakeholders within the study context. Using the analysis discussed in Section 6.4.1, a stakeholder mapping can be designed to help categorise stakeholders and identify ways of coping with them. Stakeholders with high power and high interest, for example, are likely to be critical to the implementation of the study's recommendations. Some of those stakeholders may perceive themselves to be winners, and others may perceive themselves to be losers, within the study context.

The stakeholder mapping provides a visual representation of some of the key parameters useful in characterising the stakeholders. Depending on the technique used, the mapping may be in tabular, graphical or pictorial format (see for example [16], [17] for a more in-depth analysis).

For example, a grid may be drawn with power (or influence; i.e. the capability to affect the study and achieve outcomes) along one axis and interest (in the study and its outcomes) along the other. The scale for power may, for example, be chosen to correspond to a high-low categorisation. The scale for interest may, for example, be chosen to be characterised as high-low or as similar-divergent. Stakeholders can then be placed within the quadrants based on their power and interest.

Other examples would include: opposing power to dynamism (predictability of a stakeholder's stance), or power to legitimacy (of the actions of the stakeholder in terms of desirability or appropriateness) and to urgency (the study's criticality and time-sensitivity as perceived by the stakeholder).

The clustering of the stakeholders provides an indication of possible stakeholder groupings in terms of their degree of importance to the study's success, and possible management strategies for each grouping. Examples of management strategies for each of the quadrants or combinations include, but are not limited to:

- Keep the stakeholder informed;
- Have stakeholders actively participate;
- Try to influence stakeholder; and
- Monitor stakeholders.

The analyst conducting the stakeholder mapping needs to consider his own roles, objectives and relationships with the stakeholders. Successful stakeholder negotiation needs to give due consideration to both voice (i.e. participation) and procedural justice (i.e. agreement on the fairness of the rules followed during collaboration).

6.5 CHOOSING THE METHOD

As far as the study methodology is concerned, there is a decision to be made if the study will use an approach based on a single method or methodology or a combination. The next two sections will address each type of approach separately. This section and its sub-sections will address the modelling process in general terms and those problematic situations where the study approach in fact relies on one single methodology or method. This will most likely be the case with problems having a narrow scope, a limited aim, or with separate (partial) studies each addressing a particular stage or activity of a larger-scale study. Practical experience suggests that multi-methodology (to be treated in Section 6.6) will be the more usual choice when facing messy problematic situations and certain more 'messy' instances of problems proper.

6.5.1 Deciding on the 'Soft' OA Method

The following *criteria* are suggested for consideration when deciding on which methodology/method is appropriate for addressing the problematic situation at hand (partly based on [18], [19], [20]):

- *Fitness for purpose* of the task to be conducted and the type of results desired. This includes the following aspects: the nature of anticipated outcomes, conformity with the divergent or convergent stage of the study[3], mental demands made of clients, but, most important and in fact integrating the previous aspects, appropriateness for developing and/or using the model to represent the problematic situation or support dealing with it.

[3] Particularly where group work is involved, there may be a need for facilitating both divergent and convergent thinking. As both types of thinking usually require different supporting methods, the notion of mixing methods ('multi-methodology') becomes natural (ref. Section 6.6 and [20]).

In each phase of the study (ref. Chapter 5) decisions have to be made concerning the general method and specific techniques to use for the different tasks in that phase; each of them should be fit for their purpose.

- *The nature and degree of uncertainty* involved and to what extent it should be coped with by the method. This criterion extends the previous one if uncertainty is a fundamental characteristic of the problematic situation the methodology/method is designed for.
- The degree to which a candidate method is accepted as *formally sound* or grounded in theory and/or proven to be successful in similar circumstances.

One of the factors considered in the choice of an analytical approach to examine issues related to the Canadian Army of Tomorrow was the cost of the study. Conducting a seminar war-game (SWG) required less resources and less time than simulation-supported experiments and field trials with military personnel. However, the SWG was able to contribute valuable insights for filtering out less promising alternatives, for structuring future studies and for determining who from the diverse stakeholder systems should have a role in those studies.
The SWG, as an example of 'soft' OA, is sometimes (but not always) a less resource intensive alternative.

- *Pragmatic reasons* based on, among others, time, budget and availability of people to be involved.
- *Data requirements* and other model-related resources such as availability of software and other supporting material.
- The *analyst's knowledge* of, *competence* in and *experience* with applying the (mechanics of the) method.
- The *facilitator's knowledge* of, *competence* in and experience with ways ('methods') in which groups should be guided and stimulated to achieve results, including coping with issues of dysfunction and disagreement, if the method requires group sessions. If not, are additional facilitators available and able to fit in the team?
- The degree to which the *clients* and other *stakeholders understand and feel comfortable* with the proposed method.
- The degree to which the *organisational culture* agrees with the proposed method.

Below follows an example showing how the nature of a problematic situation influences the nature of the methodology to be chosen.

Table 6-1: Relationship Between Problem Nature and Methodology (Adapted from [21]).

Nature of Problematic Situation	Nature of Methodology
Very complex and important to stakeholders.	Should increase quality of communication.
Very political where stakeholders have hidden agendas.	Should visualise and relate issues, impartially facilitated.
Very data rich where stakeholders aim for concrete options.	Should integrate opinions and data and create options and show consequences.

Creating a model which is a representation of the problematic part of (real or perceived) reality that people wish to deal with, requires a methodology or a method in itself. This (procedural) methodology or method is a structured set of guidelines or rules and will be applied by the analyst or by a group of people (in a 'facilitated modelling' mode). The application of different (procedural) methodologies/methods for setting up a model will most likely produce different models for analysis. None of them may be correct, but some of them will be more useful than others.

Some of the methods in the field of judgement-based OA are strongly associated with individual academic researchers and practitioners, often those who first characterised the method, exploited it and published their experiences of using it. Some methods are asserted to be exclusively useful for specific types of problematic situations, e.g. the exploration of strategic issues for organisations. Practitioners wishing to apply a specific method are advised to take an open approach and examine all methods on their merits in the problematic situation on hand before deciding which method to use. This state of affairs perhaps reflects the maturity of 'soft' OA. In a more established science, such as physics, there are standard approaches to tackling issues. This convergence has not yet emerged in 'soft' OA and while there are standard methods such as influence diagrams, there is still individual preference in choice of methodology.

The reasons why a particular method is chosen should be documented and accounted for. The same holds when it has become apparent that it is necessary to deviate from the formalities of a particular method or to adopt a multi-methodology approach.

6.5.2 Deciding on the Model's Resources

There are two related issues that must be dealt with when developing a model and applying a method: the nature and the origin of data. On the one hand, these two determine the way in which data is collected and used as input to a model. On the other hand, they depend on the type of model which, in turn, depends on the study's, or study activity's, purpose for which the model will be constructed and the type of results that are desired.

Figure 6-3 shows how a series of requirements originate from the aim of the study, leading to data resource requirements. The nature and origin of the data, in combination with other intrinsic data quality factors, affect, in turn, the model and its results and thus the achievement of the study aim. Also with the model and its results there are additional, more intrinsic, quality factors that affect the series of achievements, as shown. In the end, there may be a mismatch between what the study aim required and what could be achieved.

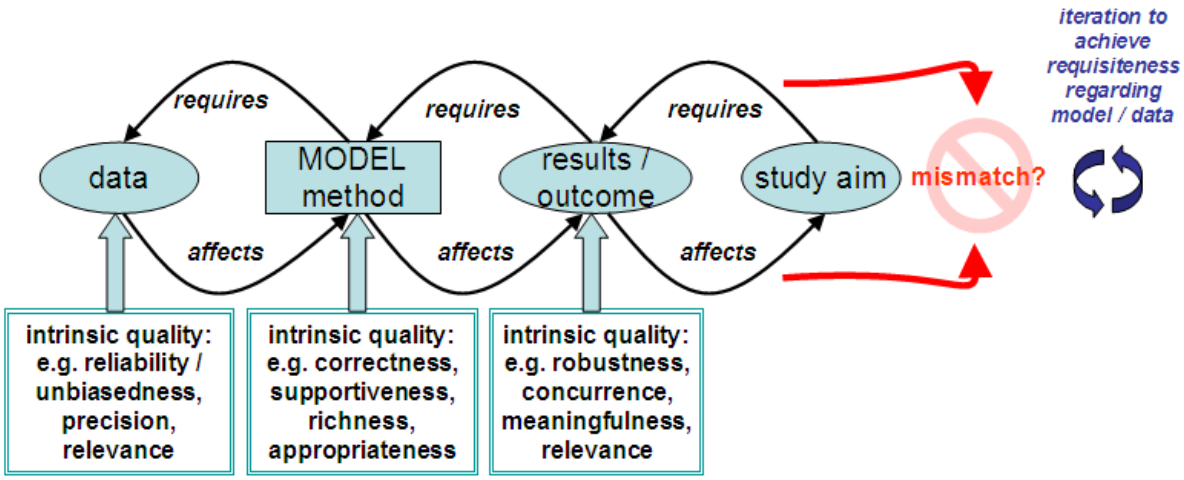


Figure 6-3: Data and a Possible Mismatch Between Requirements and Achievements, in Addition to Other Intrinsic Quality Factors Per Key Study Component (This may be an iterative process until requisiteness is achieved; ref. Section 5.4).

Figure 6-3 is valid for OA in general, but in 'soft' OA data largely depend on people and their judgements and much less on numbers and figures. This adds a particular dimension to the subject as these judgements represent people's beliefs and assumptions about the problematic situation, their preferences, and their estimates of otherwise unavailable numerical data. Chapter 2's Figure 2-3 makes a distinction between

quantitative and qualitative data, and between objective and subjective data. The nature of data can be manifold; commonly accepted theory however defines a limited number of formal scales on which data can be expressed and phenomena can be measured.

6.6 CHOOSING A COMBINATION OF METHODS – MULTI-METHODOLOGY

Experience has shown that a large number of problematic situations require combining different methodologies and/or methods.

While acknowledging the already multi-disciplinary nature of OA itself, any operational analyst should also be aware of possibly appropriate methods and methodologies from other fields of analysis: economics, psychology, sociology, political sciences, ethics, etc. This requires an open mind and out-of-the-box thinking by the operational analyst and an preparedness to call in or at least consult colleagues from those other fields.

Typically, as knowledge in a problem space is elicited and captured, the preferred methods become more focussed and specific, often creating opportunities for quantification of the problem space, with attendant statistical analysis.

Particular care needs to be taken where 'soft' and 'hard' methods are interleaved. In general, the relative simplicity of representation achievable by a 'soft' method can significantly degrade the credibility and resolution of predecessor 'hard' techniques. A 'hard' method can successfully address the interaction of distinct factors; if a 'soft' method is subsequently applied to the outputs of that 'hard' method, there is a danger that the impact of such interactions will be dissipated by the architecture of the 'soft' method. A final opinion-based step may be defensible especially if it involves the decision makers themselves. Difficulties arise in particular where a judgement-based step is planned between the application of two 'hard' methods.

Noting the caveat above, even when relying on 'hard' OA methods, 'soft' approaches may be helpful for the initial problem shaping and structuring tasks of the Appreciation and Assessment phases; perhaps for its subsequent Analysis and Action phases as well, in which, for example, a range of measures of effectiveness need to be embraced and interpreted together. The overriding requirement is to strive to maximise objectivity and rigour, gauging the validity of the overall approach in terms appropriate to the problem domain being addressed.

In supporting the development of new operational concepts for maritime mine counter measures a multi-methodology approach was designed:

- 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 concept design), multi-criteria analysis (for concept evaluation).
- Methods used in the 4th subsequent work package were: additional technological analysis, in-depth multi-criteria analysis.

The above is an example of a problematic situation requiring addressing multiple problem aspects and therefore applying a multitude of appropriate methods.

'Multi-methodology' is a rather ambiguous term as it can be understood as:

- A '*multi-method (or: 'mixed-method') methodology*': a combination of different methods from a single methodology (e.g. use of various aggregation methods all belonging to the methodology of value-based multiple criteria decision making); and
- A '*multi-method multi-methodology*': a combination of different methods from different methodologies (e.g. use of a mapping method belonging to the methodology of conceptual mapping and a value-based multiple criteria decision-making method). One of the methodologies may be dominant and will then be enhanced with suitable methods from one or more other methodologies.

The CoBP continues using the term 'multi-methodology' for both interpretations as has become customary in the 'soft' OA literature[4]. Some authors also account for the paradigm level (single versus multi-paradigm; ref. Section 2.4) when defining multi-methodology. The CoBP will not address that issue as it takes the stance that 'hard' and 'soft' OA are not really different paradigms.

6.6.1 Deciding on a Multi-Methodology Approach

There are three main reasons for *deciding to adopt* a multi-methodology approach ([22], [23]), which is a common and successful practice among experienced and knowledgeable practising analysts:

- The *problematic situation is multi-dimensional* (ref. Chapter 2): there are multiple problem aspects and/or distinguishable problem parts, multiple actors with multiple perspectives and multiple objectives, multiple types of information resources and sources of uncertainty, which may all require their own way of being coped with.
- The *study process is multi-phased*: each phase may have a different nature posing different tasks and activities and thus requiring its own dedicated methodology.
- The *usefulness of enhancement and triangulation*: different methods or even methodologies applied to the same issue may produce different results which can widen the scope of the study and open up the option space but can also be used for validation and for coping with weaknesses of particular methods. A particular example would be that requirements of one method uncover gaps in the analysis conducted with another method.

Sometimes, using different methods just happens as the study evolves and insights change.

It must further be noted that a multi-methodology approach can be designed as a serial or as a parallel process, or even a combination. A *serial multi-methodology* approach means that the combination of different methods and methodologies occurs across the different study phases or even across subsequent activities within a phase. Each subsequent phase or activity relies on a specific method or methodology. A *parallel multi-methodology* approach (although less common) means that different methods or methodologies are used in parallel within the same study phase (mainly for the purpose addressed by the third bullet above).

Taking the above-mentioned argument of usefulness further, a problematic situation which possesses more characteristics of a mess or even a problem proper than of a puzzle, will also be more appropriate for the use of different methods. Using different modelling methods will most likely produce different models thereby opening up different perspectives of the situation and stimulating discussion; this is an example of parallel multi-methodology. Section 5.4 also discusses serial and parallel approaches.

A UK study of the value for money of the *Falcon* communications system demonstrates the power of complementarity. The system has the potential to generate several benefits, each assessed by a different combination of techniques: military organisation *flexibility*, through a network model informed by a multi-criteria analysis; enhanced powers of *manoeuvre*, by logical analysis of interoperabilities; operational *pace and advantage* by a network efficiency model based on judgement; '*operational picture' completeness* through a 'hard' network simulation of data flows; and battle outcome from a simulation which drew on these parameters.

The diagram in Chapter 3 (Figure 3-1) shows that a problem structuring analysis may identify specific issues that need exploiting by methods from 'hard' OA. This would be a perfect example of 'soft' and 'hard' OA complementing each other.

[4] In addition, it should be noted that multi-methodology need not involve mixing whole methods. Elements of different methods may be taken together to, in fact, create an integrated new method. An existing method could be enhanced (enriched) by elements of another method.

There are also reasons for perhaps *not adopting* a multi-methodology approach if it is felt that the challenges listed below cannot be coped with ([1], [22], [24]):

- Some schools of thought (at companies, advisory or academic institutions) advocate their own *preferred methodology* and will not be prepared to use another methodology. If they are part of the same study team, this may pose a cultural and organisational barrier to a multi-methodology approach. This has to be identified and negotiated at as early a stage as possible.
- Some theorists point at *theoretical difficulties* with combining certain methodologies, especially when they feel that methodologies belong to different paradigms. In practice this means that it may not be clear how results from one method could or should be used as input to a subsequent method. Some adjustment or interpretation may be necessary, which has to be recorded. In addition, that same practice shows that this theoretical issue is of minor importance with the exception of the issue of interleaving 'hard' and 'soft' methods (discussed earlier in this section).
- Along similar lines as the previous reason: moving from one methodology to another may pose *cognitive difficulties* to *analysts* as this movement may require not only an altogether different analytical attitude but also specific practical skills. There may exist cognitive difficulties for *clients* as well who have to adapt themselves to, for example, different representations of problem issues. The analyst therefore needs not only to explain what is expected of clients but also to seek assistance if his expertise/knowledge seems insufficient.

6.6.2 Designing a Multi-Methodology Approach

Recall from Chapter 5 the four main activity-oriented *phases* of a study: appreciation, analysis, assessment and action. They can also be used to design a multi-methodology approach assuming that each phase's nature and tasks call for its own dominant methodology (or method).

Add to this set of phases three 'worlds' in order to create a full matrix of different dimensions which might act as a framework to design and appreciate the elements of a multi-methodology approach. These 'worlds' (material, social, personal) are based on the work by Habermas [25], but will for the purpose of the CoBP be loosely interpreted as the following respective *domains*:

- The objective, observable domain ('what we see');
- The inter-subjective, participatory domain ('what goes on in groups we participate in'); and
- The subjective, individual domain ('what we think and experience ourselves').

Table 6-2 shows the matrix-like framework, very similar to the one Mingers suggested [19][5]. Each cell contains a few phrases characterising the specific combination of phase and domain and suggesting the nature of the methodology(ies) to consider. The actual choice does, of course, depend on the key ingredients of any study design (ref. Chapter 5): the problematic situation itself, the people involved, the nature of the decision to make, the nature of the data and information required to produce outcomes that can inform the decision.

[5] An alternative approach for choosing a combination of methodologies is 'Total Systems Intervention' developed by Flood and Jackson [27]. Mingers' approach fits more closely with the terminology and study phasing adopted in this CoBP.

Table 6-2: Framework for Designing a Multi-Methodology Approach Using the General Study Phasing of Figure 5-2 (Adapted from [19] and [22]).

Study Phases→ Domains ↓	Appreciation of:	Analysis of:	Assessment of:	Action to be Taken:
Objective/Observable	(Physical) circumstances; organisational demands.	Correlations and causal structures; external influences.	Alternative options and their impacts.	Select and implement.
Intersubjective/-Participatory	Power relations; group dynamics.	Conflicts; common interests.	Alternative (social) structures.	Generate consensus and mutual empowerment.
Subjective/Individual	Emotions; beliefs; meanings.	Perspectives; perceptions; rationality.	Alternative conceptualis-ations.	Generate agreement and commitment.

The following steps will usually have to be followed for making that choice [23]:

- *Review* the problematic situation and the state and progress of the study;
- *Determine* what is required to make a further step toward the next study phase (and thus toward the aim of the study);
- *Be aware* of the methods and methodologies that are available for what is required and understand which of them are useful and in what ways; and
- *Choose* the most appropriate methods taking into account not only criteria related to the issues mentioned in the previous steps and to identified uncertainty types, but also to study constraints (budget, time, agenda, etc.) and analytical or other requirements (skills and experience, cognitive demands, cultural barriers, etc.).

Attempting to position candidate methods in the cells of this framework will not only show which study aspects can be covered but also which cannot and thus remain open (the reader is referred to [26] for examples). A discussion should be organised between analyst and client about what to do with a 'white spot' and whether or not it might be acceptable or whether a new, possibly modified, method or methodology should be designed.

The most important matter of attention for an analyst proposing a multi-methodology approach should be to explain and discuss the proposed methodology and gain commitment with the primary client and preferably with other involved key individuals as well.

From practice [1] it must be concluded that the choice of methods evolves during a study based on reflections along the way and can therefore not be fixed at the study's beginning. In addition, the choice of the methods and methodologies to be combined largely depends on the knowledge, experience and competence of the analyst as noted earlier. Any analyst must consciously reflect on his methodological decisions and be prepared to consult with colleagues; he should even ask them to join the team if and when the success of a study (and the satisfaction of the client) does so require.

6.6.3 Applying a Multi-Methodology Approach

Applying a multi-methodology approach needs continuous reflection on at least the following four issues (inspired by [20], [28], [29]):

- The *division of roles* between the analyst(s) and the facilitator(s), and among analysts and among facilitators if there are more than one.

  Refer to Chapter 4 for remarks on the differences between an analyst and a facilitator. Each has his own role to play, in principle, but the roles can be played by one single individual. Although there can be one principal analyst or facilitator who is most familiar with a particular method used within the study, it is wise to have basic knowledge of that method present with all analysts/facilitators. Knowledge overlap will contribute to informed assessment of the suitability of the elements of a multi-methodology approach, the successful integration of the results, and help ensure that informed support (e.g. technical support, use of software) can be provided by the non-principal analyst/ facilitator.

- The *translation of results* from one method to another.

  The results of one method may not be in the correct format for or may be otherwise unsuitable as input to another method. For example, a causal map structure containing cycles of influence cannot be used as such as a formal value-based multi-criteria model which usually cannot cope with cycles. So, there has to be a translation of one to the other. This is a non-obvious task to be carried out by skilful analysts, but surprisingly little reported on in the literature.

- The *combination of results* from different methods to the overall study outcome.

  Although the initial design may be a serial approach (each subsequent study phase requiring its own single method contributing to the overall study aim), it can happen that for reasons of enrichment or triangulation or challenging or opening up the options space (ref. Section 6.5.1), a parallel approach is adopted. The different methods applied in a single study phase, all contributing to the anticipated outcome of that phase may pose a challenge as to the nature of the combined results.

  At the results level of the individual methods there can be mutual confirmation, i.e. results all point to the same direction, but also contradiction (see also Figure 6-3). In the latter case, there has to be some degree of reconciliation at the outcome level (outcome based on the results) in order to allow study progress. This can be achieved by a discussion of the pros and cons, meanings and consequences, and reliability and other caveats of the various findings.

- The *validity of the end-to-end integrity* of the study.

  Moving from study phase to study phase and subsequently applying methods may lead to new insights along the way, but also to the danger of loosing sight of the over-arching study philosophy and its initial assumptions (e.g. about the features of the problematic situation). Adjustment of these defining elements according to the new insights, for example by updating an initial cognitive map, will help prevent losing the study's end-to-end integrity and provide a record of the study's progress.

6.7 COMPUTER SUPPORT

'Soft' OA can be conducted using high, medium or low technology approaches. When computers are used, they may be used interactively during sessions with the participant(s) (e.g. interactively building and refining models visualising and structuring the problematic situation) or after such sessions in an analysis mode. A specialised use of computers in facilitated workshops (ref. Chapter 7 on workshop facilitation) has arisen through the use of keyboard-entered, rather than oral, contributions. Anonymous contributions may be made, allowing speculative thinking and avoiding domination by senior military officers.

Computers, because they are useful for storing, retrieving, manipulating and communicating information, can be a powerful tool that helps the facilitator and the group to accomplish their tasks [30]. Computers may also be used in modes that provide anonymity to participants and so help manage personality issues

and pressures resulting from military rank differentials among participants. However, their use should not be allowed to intrude too much on group interaction. Participants concentrating too much on computer screens rather than on each other may neglect building the group relationships and dynamics that are critical for the development of robust solutions.

At all stages of a study there may be an opportunity for or even a need for computerised support of the modelling process[6]. This however requires considering very thoroughly the aspects discussed in Sections 6.5.1, 6.6.1 and 6.6.3 (see also [32]), as computerised models can not only be helpful and enhance process efficiency and effectiveness but can also be constraining to some degree. It should not be taken for granted that some model software perfectly matches the requirements of a problematic situation. In addition, in a multi-methodology approach, usually some effort is required to transfer output from one computer model to input for another. Moreover, some technical knowledge may be required to operate the software; a technical facilitator will usually be needed for support. Nevertheless, problem structuring, visualising models, executing calculations for those parts of the analysis that require some 'hard' OA techniques, comparing options, investigating their (possibly time-dynamic) consequences and synthesising information, visualising results, all may and indeed have proven to benefit from computer support (e.g. see [10] for computer-supported problem structuring and scenario creation using Morphological Analysis). The level of computer support may vary considerably though; some 'soft' approaches rely almost exclusively on it [32].

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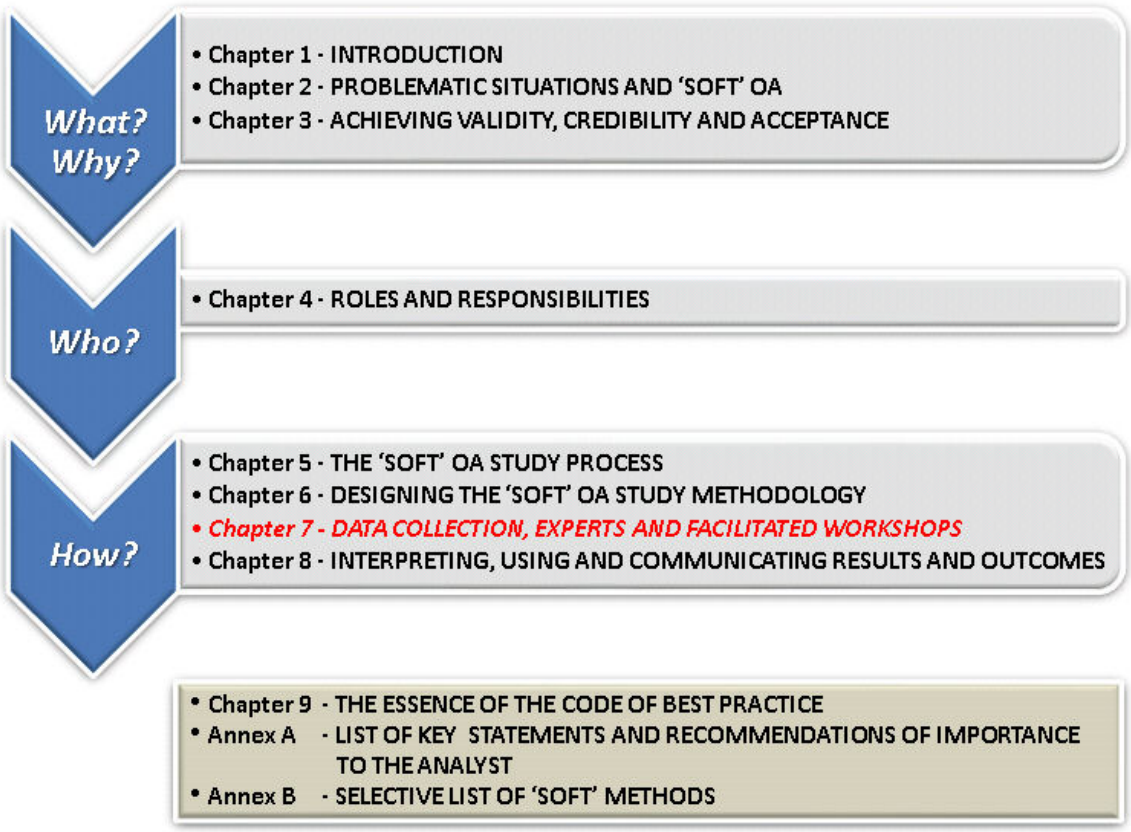
Chapter 7 – DATA COLLECTION, EXPERTS AND FACILITATED WORKSHOPS



- Understand what the three viewpoints for using humans as data sources mean for the study: the cognitive, critical and constructive viewpoints. Understand types of bias that are recognised within each perspective's context.
- Consider carefully what stakeholders (including subject matter experts) to include in the study, and how they will be invited to participate.
- Design facilitated workshops in order to engage with stakeholders.
- Select the key conditions in the Schuman model that are considered to be critical to conducting workshops in the current study.
- Ensure that the 'theory of action' underpinning any considered course of action is understood and documented.
- Design (additional) data gathering to be conducted outside a workshop setting, including what sampling strategy is used.
- Consider using the Human Environment Analysis Reasoning Tool.
- Document all data collection measures taken in a study, including the methods, the sources and the collectors.

7.1 INTRODUCTION

This chapter discusses approaches for collecting and analysing judgement-based data. This chapter assumes that data collection is guided by four general premises [1]:

- Premise 1: Problems are socially constructed entities.
- Premise 2: Subjectivity is unavoidable.
- Premise 3: Clients want 'satisficing' solutions.
- Premise 4: Participation increases commitment for implementation.

These premises will inform how data is viewed and the choice of data collection methods. This is discussed in the first part of the chapter. The remainder of the chapter then discusses using workshops for data collection, other data collection approaches, and the use of Subject-Matter Experts (SMEs).

7.2 THE PROBLEMATIC NATURE OF DATA IN 'SOFT' OA

Collection of input material to help with formulating and characterising problems is a key aspect in 'soft' OA. Such inputs are usually referred to as 'data' though it is recognised that they are part of a hierarchy or pyramid comprising data, information, understanding, knowledge and wisdom [2]. We will not try to differentiate the lower-positioned concepts in this model but will note that there is deeper understanding of system behaviour as we move towards wisdom. Thus we will use data in its broadest sense – material (i.e. pieces of information) that we do not initially know but is potentially required in the study. Importantly, data should not be considered as merely quantitative properties of well-defined constituent items. In addition, we might need to know about procedures, interactions of system components, constraints and bounds, ownership of elements, relative importance and weightings, etc.; these are all data relevant to the problematic situation.

Different views on using humans as sources of data exist, originating from different views on how valid knowledge is created. As we attempt to mix methods from 'hard' and 'soft' approaches, none of them can be ignored in an investigation using human sources. In this chapter, these views will be called the *cognitive*, *critical* and *constructive* viewpoints.

7.2.1 The Cognitive Viewpoint

In this viewpoint, humans are seen as fallible observers of reality. Due to limitations in the cognitive system errors or biases appear – different errors in information processing may appear in different stages of the cognitive system [3], such as the following:

- The ease with which information can be recalled from memory affects how frequently a given type of event is deemed to be. Well-publicised events, such as tornadoes, may be assessed to be more frequent than they actually are.
- The mind does not register what it cannot perceive. We cannot know the actual performance of an option that was considered but subsequently rejected. In a game of chance, there is thus an inclination to believe that the actual outcome was more likely than it would otherwise have been deemed before the event.
- How information is presented affects how it is remembered. The first and last element in a list is more likely to be remembered. Easily available information may be prioritised over information that has to be sought after.
- Concrete information is more salient than abstract information. A vivid description is more easily recalled than statistically summarising data. One personal experience of a failure may be given more weight than statistics that show the system in question is actually quite reliable.

- What a person expects to see dramatically affects how reality is perceived. Playing cards with red spades, for instance, is extraordinarily difficult.
- There is also a confirmation bias, i.e. people tend to seek information that is consistent with their hypothesis rather than information that could cause them to reject a hypothesis.
- A special case occurs when experts are expected to quantify their input, such as when giving probabilities. If a person is an expert in a specific area, his judgement may be vulnerable to particular biases when assigning probabilities, but general risk management experts may be less affected ([4], [5]).
- A well-known bias associated with workshops is group-think. Symptoms of group-think include:
  - The illusion of invulnerability creating excessive risk-taking;
  - Collective efforts to discount warnings that might lead members to reconsider their assumptions;
  - An unquestioned belief in the inherent morality of the group;
  - Stereotyped views of rivals and enemies; and
  - Direct pressure on any members that express strong arguments against any of group stereotypes and self-censorship of doubts or counterarguments that a member of the group might have in order to create an illusion of unanimity within the group [4].
- Other types of bias that affect groups include:
  - Imposing imaginary constraints on the range of options;
  - Sensitivity to reference points (e.g. the way we mentally bracket groups of decisions together often influences how much risk we are prepared to take when making each decision; as an example: taking a broad view on study portfolios can act as an antidote to excessive risk aversion when dealing with individual studies); and
  - Non-rational escalation of commitment (an unwillingness of individuals to reverse decisions if they feel high personal responsibility for poor outcomes occurring early) [6].

Methods for reducing the effects of cognitive bias include conducting statistical surveys (essentially in order to average out the bias), triangulating several sources and including technical or ‘hard’ investigations in order to confirm statements about measurable quantities. When addressing group-think, the critical aspect is effective facilitation (ref. Chapter 4 and Section 7.3).

7.2.2 The Critical Viewpoint

Critical analysis of sources (be they humans directly in person or indirectly through written sources) view humans as actors with a possible stake in the situation. This view essentially includes the previously described cognitive viewpoint, but also adds that, as a stakeholder, the person may have an interest in concealing facts or taking a certain perspective on events to try to affect outcomes in his favour. Important criteria to look for in the critical analysis of any source are[1]:

- Authenticity (i.e. is the source what it claims to be?);
- Concurrence (i.e. is the source reasonably concurrent with the reported events, how close was the person to the events they are describing?);
- Independence (i.e. are two seemingly confirming sources actually mutually independent?); and
- Bias (i.e. does the writer have any reason to skew the message?) [7].

[1] Note the relationship with issues discussed in Chapter 3.

Bias in this perspective is no longer merely the unconscious bias that comes from the cognitive shortcomings of humans as outlined in Section 7.2.1, but also the bias that comes from an actor with a stake, and his possible reasons to alter or conceal available information. Within the critical tradition, it is important to try and identify what the bias might be, and how the bias may affect the data.

Normally, several sources are used to conduct an investigation. In order to confirm any statements, it is important to know whether the sources are actually independent. A common occurrence is so-called 'narrative contagion' between sources, which, for instance, occurs when witnesses have had the opportunity to confer. This process creates a bias that means that the sources can no longer be used for mutual confirmation of statements.

Methods for conducting critical analysis of sources are primarily to assess each source according to the criteria for critical analysis (authenticity, concurrence, independence and bias) and again triangulating several independent sources in order to try to minimise the effects of the limits of each source.

7.2.3 The Constructive Viewpoint

The two previous viewpoints are essentially realist; they take as their starting point the axiom that there is a reality 'out there' that can be discovered, at least imperfectly (as with *critical realism;* ref. Section 3.3). On the other hand, the constructive viewpoint takes as its point of departure that reality is essentially socially constructed. 'Truth' in this context is the best informed and most sophisticated construction on which there is consensus, though this definition allows several constructions that meets this criterion [8]. This is the tradition underpinning qualitative investigations in the social sciences.

Our starting point for 'soft' OA is that problems are socially constructed; thus this viewpoint is especially salient for problem formulation. In the constructive view, there is no such thing as an independent 'fact', facts only acquire meaning according to the context in which they become relevant. Thus 'bias' has no absolute meaning in the constructive viewpoint. Each stakeholder's view is essentially equally legitimate. This could be construed as an 'anything goes' viewpoint, but the process of consensus acts as guarantor of 'truth' (or some truth at least), and thus protects to some extent against 'anything goes'. In the context of 'soft' OA, the conclusion is that those stakeholders that meet to negotiate a problem formulation essentially create their own new 'truth' in that process, to the extent that they are able to reach consensus.

The main challenge when conducting an investigation from a constructive viewpoint is ensuring that all key stakeholders are given a 'fair' chance to air their view and take part in the construction of the problem, and that there is an equitable, facilitated process that allows reaching consensus.

7.2.4 Data Considerations in a Multi-Methodology Study

Some proponents insist that the constructive and realistic paradigms cannot be used together, but experience shows that multi-methodology investigations work well in practice. This is also supported by extensive literature from the social sciences field, proposing the pragmatic position that considers the combination of quantitative and qualitative methods perfectly reasonable, and even innovative (for instance [9], [10] and [11]).

While the viewpoints as discussed in Sections 7.2.1 – 7.2.3 may differ, the approaches for ensuring data quality have strong similarities. Triangulating several sources is therefore desirable, as is conducting a fair facilitation process. Triangulation is further discussed in Section 8.2.1.

Data may be gained from the field, through interpretation of procedures (e.g. manuals), generated by models or derived by artificial environments such as war-games or the use of workshops involving SMEs or by approaching experts individually. Data has been described as 'hard' or 'soft' depending on whether it is

respectively derived from observer independent or opinion/observer dependent sources [12]. A recent publication [13] has proposed that field data may be collected through the subjective opinions of stakeholders, through objective measurements or even from informed SMEs. This mix of subjective and objective data is a key aspect of 'soft' OA and should be regarded as a strength (because of its richness) rather than a weakness, even though there may be a perceived bias [14] towards quantitative data measured in a 'statistical manner'. Nevertheless, the sources of data gained by different means should be well documented, particularly when one relies on subjective opinion and informed SME speculation.

7.3 WORKSHOPS, MODELLING AND FACILITATION

The conduct of workshops and facilitated model building is the most common approach taken by many 'soft' OA methods [15]. Understanding the main strengths and weaknesses of workshop methods is thus an important issue when conducting a 'soft' OA study. Workshops are mainly used 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.

In a series of workshops addressing new operational concepts for maritime mine counter measures, participants sometimes had difficulty with keeping to agreed definitions and assumptions (new ideas kept popping up). Also the change of, in the first workshop, evaluating against each of several specific scenarios to, in the follow-on workshop, evaluating against a general mine-hunting setting appeared confusing for some and posed challenges to the facilitator. If a study requires several workshops with some participants always attending and others not, the end-to-end integrity of the analysis must be ensured.

Schuman and Rohrbaugh [16] have introduced a model for working with groups (Table 7-1[2]). In an ideal group, all the twelve conditions are fulfilled. The model can also be used for diagnosis if difficulties appear in conducting workshops. In a situation of limited resources, the facilitator may have to focus on fulfilling a selected sub-set of the Schuman conditions. The model should be used as a checklist by the analyst and facilitator to identify the key conditions that will ensure that the major obstacles to a successful outcome of the workshops are removed.

Table 7-1: Conditions for Working with Groups (Adapted from [16]).

Factors → / Perspectives ↓	Group Context	Group Structure	Group Process
Relational	Incentives provided to motivate collective work.	Participants are sincere, open to each others' views and promote trust.	Conflict is managed.
Political	Resources adequate to complete task.	Legitimate leadership present; participants have authority to make decisions (up to a point).	Stakeholder interests well represented.
Empirical	Meeting environment designed to foster productivity.	Group composition provides needed skills and abilities.	Modes of communication enhance interactions.
Rational	All relevant data/artefacts/ expertise is available.	Goals, objectives, tasks clearly defined.	Problem exploring and (possibly) solving methods used.

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

[2] Their circular model is shown as a table in the CoBP.

that may affect the group[3]. One option for addressing the possible bias that may occur due to power relations between the group members is to deploy a method that allows anonymous data entry, such as computer supported *Journey Making* [18]. Two important pitfalls are the emergence of 'group-think', and the tendency for premature concurrence. The facilitator needs to initially encourage divergent thinking in order to avoid group-think, and then help turn the group towards convergent thinking in order to reach consensus. The job of the facilitator is to encourage and support everyone within the expert group to do their best thinking. In addition, the facilitator needs to have enough knowledge about the subject matter being discussed and the acronyms being used during the workshop so that he can keep track of the flow of the discussions, ask the right questions and effectively guide group processes and procedures. It definitely helps, but it is not absolutely necessary, for the facilitator to have significant content related knowledge. For a further discussion of the facilitator's role, see Chapter 4.

Even in a single language setting, common words and phrases may have different meanings in different organisations or services. Hence, in order to avoid mis-communication, it may be useful to create a lexicon for participants that provides standard definitions of key terms used within the 'soft' OA study. Further, facilitators may need to provide assistance to participants in the NATO setting who do not have a good command of the chosen language in which the study is being conducted, e.g. remaining neutral but also helping such individuals in expressing and defending their viewpoints.

In most 'soft' OA methods, a model of some kind is a central artefact that the group constructs together. A model in this sense is a representation of reality built for some definite purpose [19]:

> *"The model should serve as an aid to thinking and group learning but will not produce the right answer. The model should be 'requisite', i.e. sufficient in form and content to resolve the issues at hand. It represents the collective view of the group at any point during its generation and modification, and serves as a means to examine the impact of differences in perspective or vagueness in the data. Because the model is projected for all participants to see it as it is created, it is less likely to be perceived by participants as a 'black box', which helps to gain confidence in model results."* ([20], see also Section 5.4).

These models are usually qualitative in nature. They describe the various concepts that are used in the problem formulation, and how the concepts can be combined. The different 'soft' methods have different approaches and styles of modelling.

If (parts of) the problem (are) is amenable to quantification, a qualitative approach can be supplemented with quantitative models. Suitable quantitative modelling environments that can be built in a workshop setting include System Dynamics and Bayesian networks. The analyst needs to be aware of which types of problems are suitable for quantitative treatment in a workshop setting (see also [21]).

The facilitated model can also serve as a test bed for suggested courses of action. If the model is used in this fashion, it serves as an aid for discovering the possible consequences of action. The group is starting to formulate a 'theory of action' for possible future interventions [22]. The facilitator can assist by making this theory more explicit. On occasion the theory can be compared with established knowledge on 'what works', but for many messy problems no such established theory exists. The group's theory of action is essentially an assumption or a hypothesis on what **may** work.

As we have seen in Section 6.3, gaming may be a suitable approach when the problematic situation we are facing is dominated by intentional and qualitative uncertainty, as is often the case in a military context. Like workshops and facilitated modelling, gaming is (in this context) intended for collective learning

[3] In the context of military decision making, the main client is normally either a senior officer or a senior Defence official. In addition, military procedures tend to be formal and traditional. This will affect how a problem can be approached and what methods may be socially (i.e. in a Defence environment) acceptable [17].

about the challenges facing stakeholders. Gaming should not be seen as a replacement for problem formulation, but as a continuation of the exploration of options for addressing the challenges ahead. Gaming approaches certainly include war-gaming to explore tactical and operational issues, but may also include other forms of games. Gaming may include an element of role-playing, when members of the gaming group assume different roles in order to explore the options available for external and internal stakeholders, and normally require one (or several) scenarios, a fictitious setting derived from the general problem statement. Gaming can give a deeper understanding of the nature of the problem, and the options available to external stakeholders [23].

In addition to some well-established methods for problem structuring in a workshop setting which are all usually carried out in a facilitated modelling mode ([1], [15]), another methodology that can be useful within a workshop setting is Multi-Criteria Decision Analysis (MCDA). This family of methods is focused on choice in a situation where a single criterion for choice between options does not exist, and on a structured approach to prioritising between multiple criteria [24]. The weighting and scoring activities that are required pose challenges to both the analyst and the facilitator when dealing with the different preferences that usually exist in groups.

Once the 'right' terms are identified, objective errors (measuring the thing 'right') appear in addition to residual subjectivity issues. Any term ending in 'ility' (such as mobility) or a similar suffix (such as 'ness' or 'ment') is likely to be prone to this problem. Such issues are an indication of the appropriateness of a 'soft' OA approach. Thus, for example, military effectiveness may be reasonably proposed to comprise a mix of subjectively weighted terms like lethality, mobility, survivability and sustainment. Each of these derived terms is challenging to define and is likely to be composed of another subjective weighting of selected surrogate terms. There are established means to treat such weightings ranging from consensus to sophisticated MCDA approaches [25]. Again an audit trail and agreement are required[4].

A study involved a 3-day workshop covering the design and preliminary evaluation activities regarding alternative options for new operational concepts for maritime mine counter measures. It used expert opinion in addition to previously assembled assessment information in a multi-methodology analysis. After this, a more technology-oriented description of the concepts was evaluated in a follow-on workshop: experts assessed the technology and its impacts on the operational concepts using multi-criteria analysis.

Presence of technical (in addition to operational) expertise as well as all relevant organisational parts of the Navy being represented proved to be crucial in both workshops.

Proper planning and preparation for the group session is critical in order to help develop participant confidence, cooperation and ownership of the session's products. The following should be addressed as part of the planning process: session objectives, actual products of the session, session stages[5] and agenda, participants, presentations, reading package, consultation and expectation management ('probable issues'), record keeping arrangements, and organisational practicalities. The reader is referred to [28] for further information on facilitating workshops.

The quality challenges that appear in problem formulation in a workshop setting are more or less connected to the fairness of the process, for example:

- Were all key stakeholders considered?
- Was the process accepted by the involved stakeholders?
- Does the problem formulation accurately reflect the concerns of the stakeholders?

[4] Although scores and weights of 'dissenters' may be investigated in a sensitivity analysis, rather than forcing them to agree to consensus.

[5] The use of short scripts ('thinklets' [26], or a ScriptsMap framework [27]) that describe and visualise distinct activities during a session may be helpful to get the purpose of these activities across to the participants and create a desired collaboration mode.

These challenges are met by adhering to process and facilitation standards as indicated earlier.

Other quality challenges are added when options for action are considered, for example:

- Will the options work as intended?
- Will the options meet their objectives?
- Will the options be executable within reasonable constraints in terms of time and resource allocation?
- Will the options be acceptable by key stakeholders?

These challenges can only partially be met within the framework of the workshop setting. There, these issues should be addressed by ensuring that the right experts are consulted and that the assumptions underpinning the options are made explicit, including the 'theory of action'[6] behind each option. If the situation is characterised by dynamic uncertainty, designing options that retain freedom of action and support knowledge generation should be considered.

7.4 OTHER DATA SOURCES AND SAMPLING STRATEGIES

It may not be possible or desirable to conduct all required data collection for a certain study in a workshop setting. Other data collection approaches may be necessary[7]. Studies of documents, conducting interviews with stakeholders and eliciting opinions from experts are other options for data collection. This could include experts or stakeholders who, for some reason, could not be included in the problem formulation process, but could be consulted in order to get a view from outside the core group conducting the problem framing.

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 the behaviours being observed.

When working with judgement-based data collection, it is important to have a purposeful sampling approach, i.e. to know why certain sources, stakeholders or experts are chosen for inclusion in the study. The sampling approach also need to take into account what approach was used for including stakeholders in the problem formulation process in the first place. Options for qualitative sampling are described in Patton [9].

Stakeholders can be interviewed in order to get an understanding of their view on an issue, or to gather deeper knowledge. Options for interview styles include the interview guide approach, where the topics of the interview is identified, but the actual formulation of the questions takes place during the interview, and the standardised open-ended interview, where the exact questions are formulated before the interview. Interviews are normally conducted one to one, but focus group interviews are also an option. The quality of the results of an interview is largely dependent on the skills of the interviewer [9].

[6] The 'theory of action' [22] (or 'theory of change') answers the question "Why do we think this course of action will reach our objectives?".

[7] Several kinds of more in-depth quantitative investigations may be part of a study, but data quality issues for quantitative investigations are not considered in this CoBP.

The NATO SAS-074 Activity has recently devised a Human Environment Analysis Reasoning Tool (HEART). The tool is designed to enhance access to data and methods relevant to human performance. 'Soft' methods are often the only techniques through which human aspects can be addressed. It is recommended that 'soft' OA analysts should access the tool where appropriate[8].

7.5 USING SUBJECT-MATTER EXPERTS

The opinions of SMEs can be vital to a 'soft' OA study. SMEs may be included in workshop sessions or interviewed. Another option, that does not require a workshop setting, may be to conduct a Delphi study. The SME is one source of input to a 'soft' OA study. While the SME does have detailed knowledge it should be recognised that it is not likely to be complete, could be biased (whether intentional or not) and is only one source. Of course, unless the analyst has intimate knowledge of the system, one of more subject-matter experts should be involved in a 'soft' OA study at some point. Franco and Meadows [29] propose four stages where SMEs may usefully contribute, with this CoBP's corresponding phases added between brackets:

- Gathering information about the problematic situation (Appreciation phase);
- Structuring issues (Analysis phase);
- Designing options (Assessment phase); and
- Evaluating options (Assessment phase).

In addition, this CoBP proposes an Action phase (Chapter 5), where it is most likely that SMEs will contribute too.

As a study participant, the responsibility of a SME is to provide his informed opinion, based on his knowledge, experience, and (technical, military, social, etc.) expertise. SMEs are recognised as experts by their peers; they may be military or civilian. For example, the SME may be asked to provide assumptions regarding future doctrine, performance data, force mixes, organisational structures, or force employment scenarios. In the development of a war-game, the SME could contribute by proposing system descriptions or by developing realistic scenarios, and during its execution, the SME could consequently play the role of sub-unit commander.

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. Morphological analysis was identified as a tool to obtain a more detailed description of expeditionary operations that could be used.

One issue that the study had to overcome was the number of experts that needed to participate due to the broad subject area. A simple electronic data collection tool was developed to collect views on the components of Expeditionary Operations using Morphological Analysis as a framework. This tool was able to be sent out via email for relevant subject-matter experts to complete individually. It was also used as a data capture tool in a series of workshops, allowing flexibility in data collection. The tool had to be carefully designed to allow remote collection of qualitative data.

In order to meet his responsibility, the SME may need to prepare for his sessions by reading study background material that has been supplied to him. SMEs should be selected in a way that helps ensure that experts from all major points of view are represented, hence helping to minimise bias. SMEs may be selected by relying on the primary client's knowledge to identify SMEs and/or by asking known SMEs to name other SMEs. However, the latter may result in a lack of diversity in viewpoints. The number of SMEs chosen to participate depends on the nature of the topic being addressed, the desired type of interaction between the

[8] Draft NATO/RTO Technical Report (IST-999) to be published in 2011. See also [a] in Section 7.7.

SMEs (e.g. face-to-face group session, Delphi) and SME availability and willingness to participate. If too few SMEs are chosen then the broadness of the discussions may be too limited, whereas having too many SMEs may mean that not everyone has an adequate opportunity to contribute.

In inviting SMEs to participate in a study, information needs to be provided on the study aim, the identity of the sponsor, what tasks the SMEs will be expected to perform, and how much time it is expected that the SMEs will need to devote to the study and over what period of time. Some of the real experts may be too busy to participate at the required level of effort. They may change their minds if they are motivated by the opportunity to make a significant contribution to the issues being addressed by the study and by the recognition such contributions may result in. Rewarding SMEs for their services may slant the results [30].

Expert judgement is affected by the process of gathering it. It can be conditioned by how questions are phrased. Experts need to understand what they have to do in the working group session and why (e.g. how their outputs are to be used) and how they are expected to do it. There needs to be a clear and common interpretation of terminology being used, the scales on which judgements (e.g. ordinal measurements) are expressed and how uncertainty is to be dealt with (e.g. provision of estimates as a range of values rather than a point value). Facilitators may need to deal with situations in which there is wide disagreement between experts' judgements or in which there is a seeming consensus in the judgements except for one significant outlier. Study results will be criticised if there is the perception that there was a skewed choice of experts or if irregularities are perceived in the elicitation and analysis process. Readers interested in more detail on the elicitation of (quantitative) judgements are referred to one of the books on knowledge elicitation (e.g. [30]).

As for any 'soft' OA study, circumstances will dictate where and at what stage of the study an SME could be used. In this respect, the situation for 'soft' OA will most likely be different from that for a 'harder' OA where there is more certainty of the issues, data and nature of the study on the outset. For this reason early involvement of SME is often recommended in optimisation-biased OR textbooks. The pros, cons and requirements of SMEs are summarised in Table 7-2 in terms of the '4 A-phases' model described in Chapter 5.

Table 7-2: Pros and Cons of Including SMEs in Different Phases of the Study.

Stage	Pros of Involving a SME	Cons of Involving a SME	SME Requirement
Appreciation	Detailed inside knowledge. Could be tasked to obtain specific information.	Incomplete knowledge of the system. Need to balance analyst team contribution against SME.	In depth knowledge of how the system should operate and its actual behaviour. Ability to work with analysts.
Analysis	Gives peer review. Provides sources of data to test the model. Provide personal experience on current deficiencies. May provide useful speculation on new ideas.	Might bias the rest of the study through a personal or institutional mind set. Formulation of a model that is too literal with little opportunity to explore innovative changes. Embarrassment to the study team if the model is poor and this is the first time the SME sees it. May be reluctant to provide useful speculation on new ideas.	Acceptance of another's perception of his system. Ability to work with analysts. Ability to generalise on the nature of data and its applicability. Ability to speculate on 'out of the box' interventions. Ability to work with analysts.
Assessment	May identify the study team's unknown obstacles to change.	May apply their own filters if the changes do not fit their value systems.	Ability to provide an honest sanity check. Ability to work with analysts.
Action	Provides credibility to the study. Identifies pragmatic courses of action.	Would probably have to be involved in most of the process – time constraint.	Needs to speak with authority and be recognised as such by the executive decision makers.

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7.7 RECOMMENDED ADDITIONAL READING

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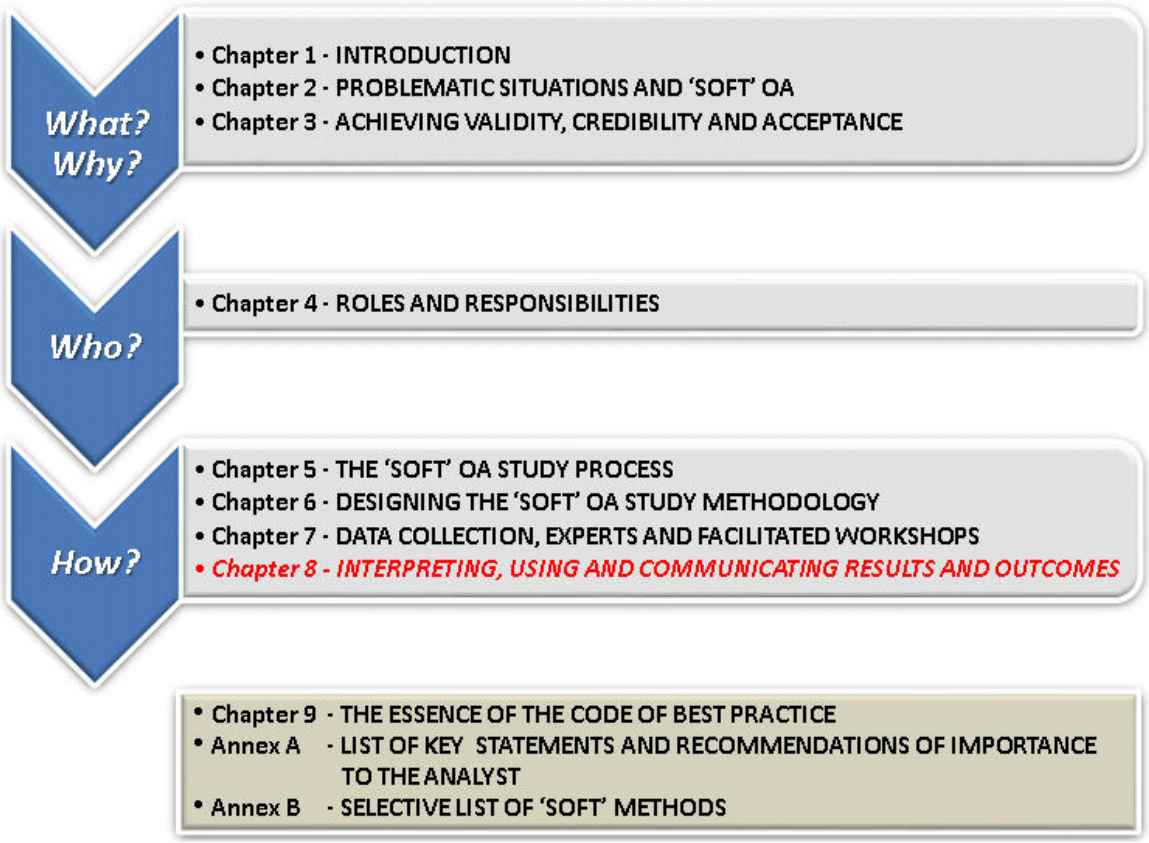
Chapter 8 – INTERPRETING, USING AND COMMUNICATING RESULTS AND OUTCOMES



- Document planned method(s) to provide a reference for later scrutiny of results.
- Conduct triangulation of judgement, using documentation and empirical data where possible to increase confidence in and evidence for judgement.
- Determine, in co-operation with the client, where bias should be controlled and where it should be measured to improve understanding.
- Use feedback as a tool to understand sensitivity and vested interests.
- Give careful consideration to the perceived independence of the analyst.
- Develop a clear lexicon by which outputs of the study can be described to the client community.
- Where possible include the client or his stake in the study process in order to generate ownership of the outcomes.
- Consider how learning from the study will take place iteratively, and provide outputs that support this.
- Provide capture and reporting as necessary to provide traceability and transparency in the methods used.

8.1 INTRODUCTION

This chapter will address issues concerning the results and outcomes of a study employing 'soft' methods: interpretation, usage and communication. Their credibility and acceptance depend to a large extent on the study's elements that have been discussed in previous chapters (e.g. the study plan) but also depend on how results are dealt with and outcomes are communicated. Triangulation, sensitivity analysis and coping with bias all contribute to the validity of the results and will be discussed in this chapter (partly again but from a fresh perspective). The final sections will address how to communicate and report on the study, not only its results and outcomes but also how it was conducted as this contributes to its traceability and transparency, and thereby its auditability. Refer to Section 1.6 or the Glossary for definitions of the concepts of result and outcome of a study.

8.2 INTERPRETING THE RESULTS OF A 'SOFT' OA STUDY

Interpretation can be defined as *'to explain or identify the meaning of* [1]*'* (the results of an OA study). The interpretation of the results of a piece of analysis will primarily be conducted based on the original objectives of the study. However when considering a study based predominantly on human judgement, a number of considerations raise themselves when interpreting results.

A method used for a 'soft' OA study may try to generate consensus, find common understanding or identify different distinct viewpoints on a topic of interest. Despite this there is the scope for different cognitive interpretations of the results from the study, based on the different personalities of stakeholders and their organisational and political stakes in the problem being investigated. It is therefore beholden on the analyst to utilise other evidence that may test competing judgements and provide where possible the most robust interpretation or interpretations. This can be done through the use of a technique known as 'triangulation'.

8.2.1 Triangulation

When planning an operational analysis study more than one method can be employed in dealing with a problem. When using different methods some approach is required to synthesise the results. This process is known as triangulation, and can also be used to combine qualitative and quantitative results.

Patton [1] identifies four types of triangulation:

- *Data Triangulation* – The use of a variety of data sources in a study;
- *Investigator Triangulation* – The use of several different researchers or evaluators;
- *Theory Triangulation* – The use of multiple perspectives to interpret a single set of data; and
- *Methodological Triangulation* – The use of multiple methods to study a single problem or program.

Data triangulation will be familiar as a tool to operational analysts (and, in fact, to all scientists and engineers), the nuance being in this case that the data in question will primarily come in the form of human judgement. This then identifies the need to consider the breadth of judgement being used to support a 'soft' OA study.

In the use of 'soft' OA, where judgements are being collected as data, *investigator triangulation* is an important and useful tool. The assessment of the context within which particular observations are made may change from observer to observer, based on their background, experience and knowledge of the subject under study. The use of a number of observers or evaluators to assess a particular issue is important for avoiding bias. A further possibility is to conduct investigator triangulation as part of the writing of the final report, where the various observers will inform the deductions and conclusions presented to the client.

[1] Merriam-Webster Dictionary.

Using data and investigator triangulation is a process of applying logic and asking questions such as "Could both these statements be true, or are they mutually exclusive?" While triangulation does focus on asking questions about the validity of data, contradictions do not mean that a data set is invalid. Instead, contradictions provide greater understanding and should usually be the subject of further investigation (*theory triangulation*).

Methodological triangulation can be considered when designing a data collection plan, i.e. use of multiple methods to collect a particular piece of data, or when designing a study as a whole. The benefits of a multi-method approach are discussed in Chapter 6. *Theory triangulation* may actually be obtained through method triangulation if more than one 'soft' method, based on different underpinning theories, is used. In the case of PSMs, theory triangulation may be an integral part of the process, as the desired outcome may be an understanding of the various perspectives of a problem.

When an analyst is looking for further practical evidence that may substantiate or discredit competing judgements, he has two further sources against which he can triangulate; the real world and documented records of it. If an opinion about a subject can be underpinned by discernible observations in the real world then it may carry more weight. This could be gauged through an experiment on the issue in question. If the judgement cannot be underpinned by observations in the real world then supportive documentation may provide greater confidence in the judgement. This could be in the form of historical analysis, weight of professional or academic opinion or documentation of relevant policy, process and standards. In the military environment, doctrine or standards often provides a useful initial comparator.

8.3 SENSITIVITY AND BIAS

This section will discuss two other aspects of using judgement (i.e. sensitivity and bias) that could challenge the validity and thereby credibility and acceptance of the results and outcome of a 'soft' OA study.

One of the underpinning aspects of conducting OA within the military environment is that the analysis should be as o*bjective* as possible in support of the decisions being made based upon it. This is not the same thing as the data collected being objective rather than subjective in nature. Instead it means the objective analysis of subjective data; that the results of the study are 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, and that these results are presented as objectively as possible alongside an understanding of the confidence in the results, their sensitivity to particular factors and the key assumptions underpinning them.

'Soft' OA based on human judgement should be treated no differently; assumptions made should be tested and thus should be subjected to debate and *sensitivity analysis*. The sensitivity of judgement given should be captured as part of the method used. There are a number of practical ways and methods for collecting data on the sensitivity of human judgement. Often these are based around asking those providing their judgement to also assess how confident they are in that judgement or trying to capture in some way the consensus or diversity of opinion about a particular factor.

As such one of the most useful and important practical tools when capturing and interpreting judgement is getting those participating to provide *feedback* on their judgements. Some 'soft' OA methods will build this in as part of the process, either as the individual providing feedback on their own judgements or on the judgements of the group as a whole: a good example is the Delphi technique. Feedback by participants, to provide sensitivity on judgements given should be built into any study relying on them.

If a 'soft' OA method includes quantification of some aspects of judgement, then it may also be possible to conduct sensitivity analysis by changing weightings or factors within the data. A good example of where this may be appropriate is Multi-Criteria Decision Analysis.

Another traditional underpinning value of military OA is that analysis should be *independent of vested interests* (i.e. 'impartial'). However in some cases when using 'soft' OA, the family of Problem Structuring Methods (PSMs) in particular, this may not be wanted or the case. The purpose of the analysis study in itself may be to capture and better understand the vested interests at play. This is often the case when trying to structure a messy problem and where human perception defines both the problem and the potential solutions available.

In light of this, when designing a 'soft' OA study, the analyst must carefully reflect on and deal with *bias*. A decision will need to be made, based on the understanding of the desired outputs of the study with the client, where vested interests and bias should be mitigated and where it should be deliberately captured and understood.

The analyst should understand that he also (alongside those also involved in collecting data throughout the analysis study such as the facilitator; ref. Chapters 4 and 7) will introduce bias to the analysis. When collecting judgement-based data through the use of observers, for example, it is important to triangulate to avoid the views of one observer providing a potentially biased view.

Finally, in some 'soft' OA studies, and particularly in PSMs, the perceived stake of the analyst, be it by organisational identity or otherwise, may lead to the objectivity of the analyst being questioned by some within the wider client/stakeholder community. In an ideal world, data collection activities such as workshops would be facilitated and analysed by people truly independent of any party within the client system, however in reality this can be difficult to achieve.

In these cases participation of the analyst within the method can and should be carefully designed. Some alternates to having impartial analysts could be to form an analysis team with 'trusted representation' by all clients/stakeholders, or to allow a number of reports to be written by different stakeholders based on one set of data and analyses. In every case the relationship of the analyst with the clients and other stakeholders will be a large factor in both understanding and dealing with perceptions of the analyst's impartiality.

8.4 USING AND COMMUNICATING RESULTS AND OUTCOMES

Methods based on judgement are quintessentially concerned with communication amongst the stakeholders. It is wise to ensure that the plan for application of 'soft' methods is well understood by participants and clients. The same goes for the outputs of the study and their utility. Good use should be made of opportunities for debate and sensitivity analysis, preferably with the involvement of all stakeholders. Whatever happens, the experience of stakeholders will be enhanced if they receive feedback on their involvement and they will be more likely to contribute further to both the current analysis and further studies. When reporting the results from analysis studies there are two primary aims:

- Communicating the results to the client system; and
- Providing a transparent record of the analysis for audit purposes.

The methods used for communicating both the results and providing a record of the study will differ from case to case, however the considerations for each stemming from judgement-based or 'soft' OA are highlighted below. If the primary audience for output is policy makers, the relevance, clarity, utility and applicability of the findings will be of the utmost importance.

8.4.1 Communicating Results and Outcomes to the Client(s)

One of the differences between judgement-based OA and 'hard' OA is that the results are primarily designed to improve understanding and support decision making rather than identify a unique or optimal

solution. This means that the clients and other stakeholders (or their proxies) will need to be willing to participate in any judgement elicitation process and must understand that they, not the analyst, will need to own the model and the results. *Inclusion*, or at least representation, of the client base is a prerequisite for success of a 'soft' OA study. It also means that the outcomes of the study will be influenced by the client and will not be generated purely by the analyst. Politics and personalities may prove to be significant factors in the refinement and communication of outcomes.

This *perception of the validity* of the analysis amongst the stakeholders (including the client community and other participants) will be important for its successful use. Its *acceptability* for use in supporting a decision will determine whether it is seen as a successful piece of analysis. If there is 'expectation failure' with client doubt, whether reasonable or unreasonable, in the results analysis that is of high quality from a scientific perspective may go unexploited.

A history-based analysis of triggers, causes and events allowed forecasting of possible consequences of Australia's deployment to East Timor, in particular the effect on the population. While the intent of the study was to identify possible situations thus allowing 'what-if' studies and to formulate campaign metrics, there was a notion that the results could be used to *predict actual* (rather than *forecast possible*) events in a statistical manner.

Resolution of this misinterpretation was however readily achieved after explanation of the role of a 'soft' OA study. This is an example of how too much may be made of 'soft' OA studies, particularly when it comes to the prediction of likely events.

There are a number of outcomes from a 'soft' OA study of which the analyst needs to remain cognisant ([2], [3]). Each will have different import for the different stakeholders:

- The *model* built of the situation, which contains the structuring of the problematic situation and/or the solutions suggested. The model will be used for performing analyses and drawing conclusions from its responses in the study itself, but will also have potential to assist in the analysis of other similar situations and to inform later decisions about the system under study.
- The *communication* between participants providing judgement in the study. 'Soft' OA methods have the ability to allow communicative exchanges between stakeholders that are more comprehensible, legitimate and accurate. With a structured method the ability to process information is improved allowing participants to focus more on the content and their arguments.
- Providing *increased and shared understanding* of the problematic situation. This is often the real underlying benefit of a 'soft' OA study. The participants and stakeholders should achieve together a better understanding of the problem, potential courses of action and others' beliefs and positions about the situation.
- Strong *ownership* of the problem formulation and the actions being taken to address it. Improved shared understanding will hopefully lead to an improved common purpose in moving ahead, and promote ownership of the problem and actions being taken.

Although the model and the results of the study will likely be presented and clearly visible to the client the other outcomes identified in the bullet list above, unless articulated by the analyst, will likely remain invisible (ref. Figure 8-1). The benefits of communicating and shared understanding for the stakeholders and participants should be identified and clearly articulated by the analyst alongside the direct results and conclusions from the analysis. Likewise, the analyst should ensure the study method and process enhance the ownership of the problem and solution by particular stakeholders as well as articulate it directly to the client system when appropriate.

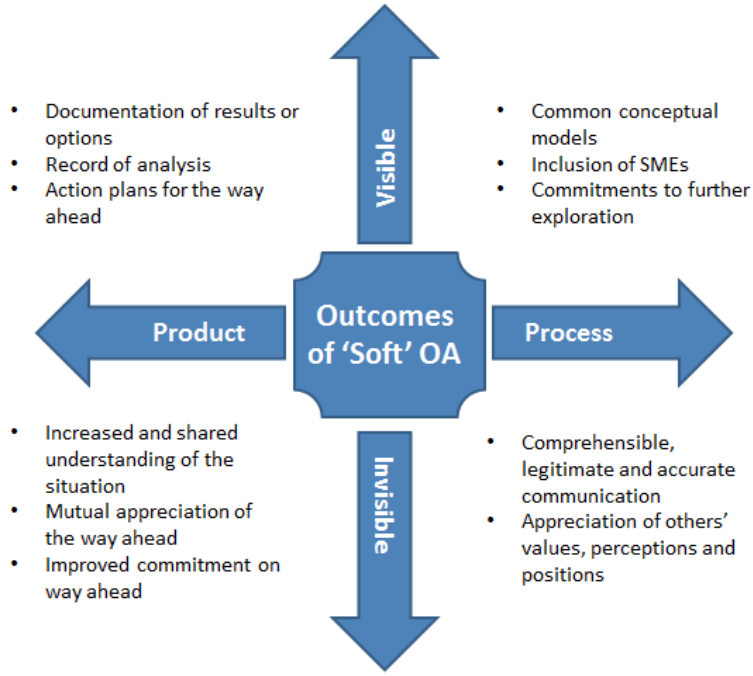


Figure 8-1: The Visibility of Outcomes of a 'Soft' OA Study (Adapted from [4]).

In the defence sector, where 'hard' methods have been used for many years, it may be difficult for the client(s) of OA to understand the differences in product, output and expectation with judgement-based OA. In fact 'hard' and 'soft' OA may be understood better by particular clients depending on their background: an education in the physical sciences as opposed to, say, policy analysis or business studies may bias perspectives of utility or validity. To compound a lack of understanding of the outputs of judgement-based OA the client may also lack confidence in the same analyst to deliver those outputs as results from a more typical 'hard' OA study.

The consequence of all of this is that the analyst will need to be careful that the type of outcome sought by the client and that expected to be provided by the analyst are not different. The analyst will need to explain clearly to clients and other stakeholders what will constitute the output of a judgement-based OA study. As discussed in Chapters 4 and 5, the analyst will need to include the client in the definition of the problem space and then subsequent (if necessary) iterations of the problem statement and options so that this difference in expectation is avoided.

One of the difficulties with elicitation of judgement and the analysis based on that elicitation is that if a stakeholder has not participated in the process, he does not have the experience or 'buy in' for the results. Often results based on judgement will not be transferable to those who have not been part of the process, who will perceive that their views have not been taken into account and distrust the results. This underscores the importance of identifying key stakeholders and as much as possible including them in the judgement process, from problem formulation through discussions of solution options[2].

8.4.2 Reporting and Delivery

Based on the different outputs identified above, a 'soft' OA study will provide usable results throughout the study as well as at the end. As outlined in Chapter 5, 'soft' OA generally follows a dynamic and iterative process that looks to improve understanding as the problem space is investigated further. This means that

[2] Sections 4.3.3 and 6.4 discuss the possible ways in which to involve stakeholders.

delivery of results, through communication and reporting will need to be a continuous process throughout the study.

The iterative nature of the process, however, has the ability to cause tension with clients. Most OA studies in the defence sector will be part of a wider program of work that will be time and resource limited and likely managed using a standard project management framework[3]. To make 'soft' OA results credible they will need to produce outputs to meet deliverable timelines. The analyst will need to describe progress clearly to his clients, helping to map the outputs of the 'soft' OA study to the wider progress of the client's work.

Traditionally, an analyst is often responsible for producing the final report (if agreed to as being a deliverable) and briefing interested parties on study recommendations and end products. Although formal closure and reporting of the study is needed, given the nature of 'soft' OA, it is likely that politically feasible agreements are made before analysis is complete and before the final report is finished. It is also likely that the analyst will need to provide continued support to the client in refining and delivering the identified outcomes from the study.

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 and concept mapping to identify operator strategies and reasoning as they worked with systems to complete tasks.

A turnover in the leadership of the project, for both the client and the lead nation, occurred between the completion of the experiment and the publication of the analysis. This happens frequently in a military environment. This resulted in a loss of momentum with the results of the experiment. The cognitive task analysis and concept maps should have probably been the most enduring parts of this work (rather than tool specific recommendations), but were never published and once staff had rotated they were less accessible to their replacements.

A senior decision maker will usually want to 'deconstruct' the analysis, in the sense that they will want to understand what particular features of the alternative options and scenarios presented are giving rise to the results. They may then wish to 'repackage' these insights to reach different conclusions about the preferred way ahead or to generate different outcomes. These may differ from those that the analyst or a lower-level customer might have identified, not least, of course, because the more senior the decision maker the more strategic the viewpoint tends to be and the more options become available.

It is quite right that decisions should be taken at an appropriate level; it is not for the analyst to usurp a policymaker's own role in using judgement in their decision; but neither should he simply report the results of his analysis in a mechanistic way and wash his hands of any interpretation. The analyst's task when delivering a study should therefore be to provide conclusions in a way which allows decision makers to carry through the thought processes in a structured, auditable way and which inter alia facilitates:

- *Identification* of the issues that have been resolved by the analysis and how they interact with those that have not;
- *Isolation* of the key judgements that have been made and the factors on which they depend;
- *Resolution* of 'what-if' questions in real time; and
- *Negotiation* of a rational path through a complex problem to a final decision.

Theoretically from a systems perspective, even after action is taken, the flux of events, ideas, learning and the need to cope continues indefinitely. It is for this reason that the intangibles produced during the study continue to provide value even after the study is formally ended. When considering the output and reporting of 'soft' OA an analyst should consider how they can support this further organisational learning, through the presentation of models and data and pursuing strong ownership of the way ahead.

[3] For example: Projects In Controlled Environments or PRINCE2 as used by the UK government http://www.prince-officialsite.com/.

The typical models and subjective data that come from a 'soft' OA study may also be considered more difficult to present and understand than some of the outputs of 'hard' OA studies. Diagrammatic outputs, such as rich pictures, cognitive maps and causal maps may not have been seen before by a client, and without participation in building them, may be difficult to grasp and understand. Furthermore over time, the utility and understanding in these products may decrease as those who worked on them are increasingly unavailable to describe them first hand. These are considerations when reporting results that are expected to have use for a prolonged period. The analyst will also need to consider ways of dealing with qualitative data, such as grouping by theme and colour coding outcomes.

8.4.3 Traceability and Transparency

Judgement-based analysis, just as with any form of OA should be *trustworthy*. The analyst should aim to be as independent and objective as possible whilst results should be reported with no undeclared assumptions or unstated simplifications to the model developed. As a member of a scientific community, analysts have an obligation to monitor and report their own analytical processes so that they may be subjected to scrutiny.

In contrast to scrutiny of 'hard' OA, the reason for transparency in judgement-based OA may not only be so that results are repeatable – although, in theory, this is a desirable goal. Indeed, working with the inherent variability of opinions and judgements of humans, there will be limited ability to repeat a method with a different group of experts and produce the same result[4]. However, the analysis methodology should still be documented alongside the results so that an external scrutineer can understand the methodological framework, and what it aimed to achieve. This will help to demonstrate the legitimacy of the processes undertaken during the analysis as well as the legitimacy of the results. Methods used should be shown to be based on solid theoretical and philosophical grounds. Furthermore, a list of the participants and SMEs who have provided judgement to support the study should be captured and reported. This will help those who wish to scrutinise the study to understand where data in the form of judgement has come from. Although it may be inappropriate to report the names of individual participants, information about their expertise or organisational stake should be recorded and presented.

A sound elicitation of judgement should therefore be preceded by thorough preparation, including the building of a sound analysis plan. This should include considerations for dealing with bias, being able to conduct sensitivity analysis and building confidence in the credibility and acceptability of the results. Practical ways of doing so are explored further below.

The methods selected and the level of validation needed will depend on the level of risk and importance of the decision being supported. There is always the need for this to be agreed and understood between the analyst and the client. When conducting judgement-based analysis, particularly when using PSMs it should be recognised that this may not be clear at the beginning of the analysis process, in fact it is something that will have to be iteratively developed along with the exploration of the problematic situation.

The documentation of an analysis plan also plays another key role. When looking at the validity of the results, particularly of PSMs, it provides a reference for scrutiny purposes. The plan outlines in advance the methodological framework, in terms of which something will be defined that counts as 'knowledge to be gained from the analysis'. Through this an external person can recover the mental processes used throughout the analysis which led to the conclusions reached, helping to prevent different interpretations of the results by a scrutiniser and the analyst.

A good plan will address most of the issues identified in the preceding chapters of the CoBP. The plan should also recognise the potential for introducing biases into the analysis process, and identify how to

[4] This may rather be regarded as a strength of 'soft' OA: repetition with different groups leading to different results may open up and even extend, for example, the option space.

understand them if not how to control them (they may be a fundamental part of the outcome wanted in a 'soft' OA study).

Practically, the traceability of the analysis will normally be provided by a full and detailed study report. Other tools that can help: an analyst can keep a logbook of their progress with judgement-based analysis just as they might when running a simulation. This can be used to note observed bias, political viewpoints as well as the iterative development of both problem and solution space. As with other OA studies, results and method(s) can be exposed to peer group professionals through conferences, journals and papers.

8.5 REFERENCES

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8.6 RECOMMENDED ADDITIONAL READING

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Chapter 9 – THE ESSENCE OF THE CODE OF BEST PRACTICE

This chapter concludes the analyst-oriented volume of the Guide and summarises its essential points.

Three key aspects characterise a judgement-based ('soft') OA study:

- It enables progress to be made for some otherwise intractable and complex decisions.
- It involves a creative journey of discovery and learning that can be used to the advantage of decision makers.
- 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 used to inform decisions where the subject matter is incompletely known or understood, where many and possibly conflicting viewpoints are involved and there is initially, at least, no obvious single solution. Many real-world and military issues can be described in this way. The term 'soft' is used in the academic community to denote such OA studies as often much of the input and output comprises subjective information. These issues may be compared to cases where most of the issues of a problematic situation are known and there is a logical process to derive more quantitative 'hard' insights. In reality there is no rigid distinction and most analyses comprise both 'hard' and 'soft' elements.

An easy way to distinguish between the two is to note that 'hard' OA is more likely to give checkable *facts* whereas 'soft' OA is predominantly based on judgement (i.e. informed opinions) and more likely to lead to a body of evidence allowing exploration and comparison of *possibilities*. Many real-world issues lie in the latter category: particularly, high-level questions relating to strategy, capability development and major acquisitions.

It should also be noted that a judgement-based approach may still include some 'hard' or quantitative elements (ref. bottom boxes of Figure 3-1); this is known as 'complementarity'. It is often the case that the analyst needs to dig deep into a problem, for instance, to test the feasibility of adopting a particular option.

Chapter 2 of this Code contains a table (Table 2-2) that characterises 'soft' and 'hard' OA and suggests which is more suitable for different types of problematic situations. Chapter 6 contains a list of questions (checkboxes; Section 6.2) that helps determine the nature of a problematic situation. The decision on whether to take a typical judgement-based approach should properly be left to the analyst after due discussion with the client.

This volume of the Guide is focused for the benefit of an analyst on the concept and structure of a 'soft' OA study and its methods and on how to achieve rigorous and auditable quality control of both process and content. However, good practice requires that both the analyst and client are aware of their roles and responsibilities regarding the study and that judgement-based OA is in many ways a collaborative journey involving subject-matter experts, clients and analysts.

The analyst is the expert in the design, development and implementation of the study plan. He should be guided by established practice, previous work and experience and his general skills. Part of his expertise lies in knowing what steps to take 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?)*

The good 'soft' OA analyst will have many attributes and skills to bring to problematic situations. He will also be responsible for assembling an analytical team comprising the appropriate skill sets and access to

computers and other resources. Chapter 4 discusses the skills needed by a good 'soft' OA analyst, including a summary of his responsibilities (Section 4.5).

As has been discussed in the CoBP, the validity of a judgement-based OA study is hard to assess. Similarly, it is difficult to define in advance a formal pattern of analytical work. Thus a flexible approach, allowing for review and iteration, is preferred to a rigid mechanism where every step has to be completed before the next can be started. Chapter 5 discusses this iterative and divergent/convergent nature of a 'soft' OA study.

The CoBP has discussed key activities to be conducted by the analyst and has suggested ways of conducting them so as to maximise the study's validity. It is, of course, recognised that individual Nations will chose to implement the recommendations of the Code in different ways. For instance, some parts may be strengthened, others ignored. It is, however, to be noted that documentary record of the design process would provide good primary evidence of validity for any judgement-based study that was likely to generate contentious debate, such as for major acquisitions. This should not indicate simply that every step was completed, but rather that each one was reflected upon with reasons given where it was not followed.

It needs to be remembered that a study outcome is only one input into a decision-making process. For more quantitative OA, these decisions may be easy to make as there is clear numerical evidence presented for a well-understood issue. For judgement-based OA neither the initial issue is well understood, nor are the results of the study usually clear cut. These circumstances can be seen in both a positive and negative light, leading to the identification of the benefits of, and threats to, a 'soft' OA study. The benefits are set out in Table 9-1.

Table 9-1: Benefits of a 'Soft' OA Study.

- The ability to analyse, make progress on, and perhaps resolve, problematic situations that would otherwise remain intractable.
- An improved and more widely shared understanding of issues and solutions.
- An improved sense of common purpose and greater commitment to ways forward.
- The discovery of alternative options for dealing with an issue.
- The iterative development of acceptable ways forward.
- The systematic gathering and analysis of relevant information and knowledge.
- A better appreciation of different objectives, perspectives and values, and the ability to reconcile them.
- The delivery of usable products throughout the study.

All of these items contribute to the development of a shared common picture of the issues, even if there is disagreement on detail. They add value to the client and allow an informed climate of debate. If these items are conducted in the best possible way, that value is likely to be maximised.

The threats to a 'soft' OA study, whether intentional or unconsciously directed by individuals' decision making preferences or backgrounds, are set out in Table 9-2.

Table 9-2: Threats to a 'Soft' OA Study.

• Disagreement with a specific part of the study leading to a dismissal of the rest of the material.
• Treating 'soft' OA study results with too much certainty (e.g. as a prediction).
• Too rapid a progression from an ill-formed concern to a rigid plan for change (e.g. an acquisition).
• Biased preference of some forms of evidence (e.g. quantitative sources).
• Selective interpretation to support a specific argument.

It is the key task of both the analyst and, if present, the facilitator to recognise and minimise the effect of the threats. If done properly, this will also add to the study's validity and thereby credibility and acceptance.

In summary, the analyst should work with the client to ensure that an appropriate degree of validation has been achieved by a judgement-based OA study, particularly when SMEs or other stakeholders may bring information into the study at any time (Chapters 6 and 7). This cooperation is of crucial importance through the entire cycle of the study in order to generate ownership. The CoBP addresses how the approach to a study, and the cooperation with the stakeholders, contribute to validity. Chapter 3 in particular discusses the general philosophy of achieving validity (Figure 3-1). Chapter 4 addresses the responsibilities that stakeholders (including clients) may discharge in this matter.

Finally, Annex A collects together the key statement boxes which open each chapter. Reflecting upon the key statements and exploiting the checklists is one possible use of this CoBP in seeking to achieve valid and thereby credible and accepted study outcomes.

Annex A – LIST OF KEY STATEMENTS AND RECOMMENDATIONS OF IMPORTANCE TO THE ANALYST

➢ **Key statement (to be kept in mind)**

☐ **Recommendation (to be checked and ticked)**

A.1 CHAPTER 2 – PROBLEMATIC SITUATIONS AND 'SOFT' OA

➢ Three types of a problematic situation can be distinguished: puzzle, problem (proper), mess. Each type is approached somewhat differently. 'Soft' OA tends to be more suitable for problems (proper) and messes.

➢ 'Hard' and 'soft' OA both support decisions regarding problematic situations. There are however numerous differences between them from a large number of perspectives, although in practice each perspective represents a spectrum.

➢ Uncertainty is one of the key phenomena that need to be addressed in a problematic situation as it characterises a problematic situation to a large extent.

➢ 'Soft' OA aims to structure problematic situations (with a focus on problems proper and messes), identify stakeholders and their interests and perceptions, include them in the study, use modelling primarily as a means to clarify issues and enhance communication but also to identify possible options for a most preferred way ahead in resolving the problematic situation.

➢ Messy problems cannot be fully resolved but should rather be managed.

➢ 'Soft' and 'hard' OA are in many respects complementary to one another; they are not competing OA approaches.

A.2 CHAPTER 3 – ACHIEVING VALIDITY, CREDIBILITY AND ACCEPTANCE

➢ The CoBP identifies how validity, credibility and acceptance can be achieved in a 'soft' OA study.

➢ The primary dimensions of validity are objectivity and rigour; credibility and acceptance are not distinct qualities but are rather derived from validity.

➢ The analyst's aim should be to make a clear distinction between the reality which is shared amongst the stakeholders, and the sectional perspectives which each may propagate for his own reasons.

➢ Gathering subjective judgements from experts exposes the analyst and his study to bias which can be motivational or cognitive in nature.

➢ The biggest threat to validity is ignorance at the design stage of what is likely to be important. This threat can itself be mitigated by creating an iterative design similar to that used in experimentation.

➢ An analyst needs to conduct activities in an ethical manner that deserves the confidence of all parties involved.

- Credibility and acceptance will be reinforced by independent scrutiny.

A.3 CHAPTER 4 – ROLES AND RESPONSIBILITIES

- Many roles and responsibilities are undertaken during the conduct of a 'soft' OA study. Moreover, one individual may adopt different roles involving different responsibilities. Each individual involved in the study contributes to its quality and success.
- The analyst, through his design and conduct of the study and through his reporting and interpretation of the study's outcomes, plays a key role in contributing to the study's validity, credibility and acceptance.
- The facilitator too, through his management of study process (the way participants interact), plays a key role in contributing to the study's validity, credibility and acceptance.
- The (primary) client has a responsibility towards the analyst in supporting the execution of the study and should act as a partner to the analyst.
- Good stakeholder management is the responsibility of the analyst and is critical to study success.

A.4 CHAPTER 5 – THE 'SOFT' OA STUDY PROCESS

☐ Consider designing the study as a process with the following phases:

- *Appreciation* – 'What is happening'?
- *Analysis* – 'Why and how is it happening'?
- *Assessment* – 'How can it happen in a better way'?
- *Action* – 'What needs to be done'?

☐ Ensure that the study team and the (group of) client(s) reach an agreement about the following concepts at the end of each of the 4A-phases:

- *Study plan* (← Appreciation phase)
- *Problem understanding* (← Analysis phase)
- *Set of options* (← Assessment phase)
- *Action plan* (← Action phase)

☐ Be aware that the people involved in the process belong to one of the following groups, though they should cooperate with each other:

- *Study Team*: group of people who 'do the work' (e.g. the facilitator, the analysts, the SMEs, and sub-sets of other stakeholder types including clients); and
- *Client(s)*: group of decision makers (possibly including sponsors and customers).

☐ Be aware of the iterative (cyclic) and dynamic nature of the process and its phases.

☐ Recognise the divergent or convergent nature of subsequent phases and accommodate for it.

☐ Ensure that the plan for application of 'soft' methods is understood by participants and clients as part of their programme of progressive development. The same goes for the outputs and their utility.

- ☐ Provide a framework which allows decision makers to carry through their decision-making processes in a structured, auditable way.
- ☐ Create a roadmap depicting achievements and interrelations, perhaps in a facilitated workshop.

A.5 CHAPTER 6 – DESIGNING THE 'SOFT' OA STUDY METHODOLOGY

- ☐ Communicate with client(s) including key stakeholders and seek agreement on any assumption, action and delivery.
- ☐ Determine the most likely nature of the problematic situation by trying to shed light on key aspects.
- ☐ Decide on the appropriateness of a trajectory from perceived mess to either a problem proper or a manageable mess.
- ☐ Identify which type(s) of uncertainty exist(s) and contemplate on both the adequate attitude to uncertainty and ways of coping with it.
- ☐ Identify stakeholders and their interests and attitudes towards the study by conducting a stakeholder analysis.
- ☐ Decide on the appropriateness of a single or a multi-methodology study approach.
- ☐ Examine all methods on their merits to the problematic situation at hand and decide on the appropriateness of specific candidate methods. Recognise own limitations in knowledge/expertise and seek assistance.
- ☐ Decide on data and other resources needed including the use of software.
- ☐ Be aware of the danger of dissipation of results from 'hard' OA methods when interleaving 'hard' and 'soft' OA methods in a multi-methodology approach.
- ☐ Maximise objectivity and rigour, gauging the validity of the overall approach in terms appropriate to the problem domain being addressed.
- ☐ Document the argumentation and rationale for modelling decisions and keep a record.
- ☐ Document the argumentation and rationale for changes in the study's assumptions and aim (including aims of specific study phases), the definition (or, alternatively, the common understanding) of the problematic situation in order to ensure end-to-end integrity.

A.6 CHAPTER 7 – DATA COLLECTION, EXPERTS AND FACILITATED WORKSHOPS

- ☐ Understand what the three viewpoints for using humans as data sources mean for the study: the cognitive, critical and constructive viewpoints. Understand types of bias that are recognised within each perspective's context.
- ☐ Consider carefully what stakeholders (including subject-matter experts) to include in the study, and how they will be invited to participate.
- ☐ Design facilitated workshops in order to engage with stakeholders.

- ☐ Select the key conditions in the Schuman model that are considered to be critical to conducting workshops in the current study.
- ☐ Ensure that the 'theory of action' underpinning any considered course of action is understood and documented.
- ☐ Design (additional) data gathering to be conducted outside a workshop setting, including what sampling strategy is used.
- ☐ Consider using the Human Environment Analysis Reasoning Tool.
- ☐ Document all data collection measures taken in a study, including the methods, the sources and the collectors.

A.7 CHAPTER 8 – INTERPRETING, USING AND COMMUNICATING RESULTS AND OUTCOMES

- ☐ Document planned method(s) to provide a reference for later scrutiny of results.
- ☐ Conduct triangulation of judgement, using documentation and empirical data where possible to increase confidence in and evidence for judgement.
- ☐ Determine, in co-operation with the client, where bias should be controlled and where it should be measured to improve understanding.
- ☐ Use feedback as a tool to understand sensitivity and vested interests.
- ☐ Give careful consideration to the perceived independence of the analyst.
- ☐ Develop a clear lexicon by which outputs of the study can be described to the client community.
- ☐ Where possible include the client or his stake in the study process in order to generate ownership of the outcomes.
- ☐ Consider how learning from the study will take place iteratively, and provide outputs that support this.
- ☐ Provide capture and reporting as necessary to provide traceability and transparency in the methods used.

Annex B – SELECTIVE LIST OF 'SOFT' OA METHODS

This annex is taken from a UK Dstl Study [1] (with slight adaptation), which is UK © Crown copyright 2010. It is re-published here with the permission of the UK Defence Science and Technology Laboratory on behalf of the Controller of Her Majesty's Stationery Office.

As an example of 'soft' methods in use in a defence environment, the table below lists the 'soft' methods most commonly used within Dstl, the UK Defence Science and Technology Laboratory [1]. The table also indicates the types of analytic activities to which they are most suited. More details are given in the following sections, taken from [1] (but textually slightly adapted). Another useful source of recommendations and techniques for defence analysis, including 'soft' analysis, is [2].

Table B-1: Some 'Soft' OA Methods and Their Uses.

No.	Method	Analytic Activities
1	Benefits modelling (matrix method)	Option selection
2	Benefits modelling (map-based)	Problem structuring / Option generation / Option selection
3	Cognitive mapping	Problem structuring
4	Causal mapping	Problem structuring
5	Influence diagrams	Problem structuring
6	Decision Trees	Problem structuring / Option generation / Option selection
7	SODA (Strategic Options Development and Analysis)	Problem structuring / Option generation
8	Strategic Choice Analysis	Problem structuring / Option generation
9	SSM (Soft Systems Methodology)	Problem structuring
10	SAST (Strategic Assumptions Surfacing and Testing)	Problem structuring
11	SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis	Problem structuring
12	PESTLEM analysis (Political, Economic, Social, Technological, Legal, Environmental, Military)	Problem structuring
13	Scenario building/planning	Problem structuring / Option generation
14	Interactive Planning	Problem structuring / Gap analysis / Concept formulation
15	Robustness analysis	Option generation and selection
16	Hypergames	Problem definition / Scenario generation
17	Delphi	Prioritisation of issues / Option selection
18	AHP (Analytic Hierarchy Process)	Prioritisation of issues / Option selection
19	Drama theory / Confrontation analysis	Scenario generation
20	Viable systems model	Problem structuring / Option generation
21	Total systems intervention	Problem structuring / Planning the analysis

There are several other 'soft' methods that have not been mentioned in [1] and Table B-1 but may be useful as well, including: Morphological analysis (for problem structuring, option generation, scenario building), (qualitative) System Dynamics, (for problem structuring, time-dependent multiple perspective analysis, option generation and selection), brainstorming using group support systems (for problem structuring, option generation), several other (qualitative) multiple criteria methods (for option selection).

B.1 BENEFITS MODELLING (MATRIX METHOD)

Benefits modelling is a flexible technique by which the improvements in an enabling technology (such as CIS) can be systematically and quantifiably related to improvements in the overall effectiveness of the organisation which the technology supports. The key philosophy behind the approach is to decompose the problem into a number of distinct steps, each of which represents a concept that can be directly related to the real world. Decomposition of the problem in this way to form a 'benefits chain' has many advantages as it allows individual aspects of the problem to be considered separately. However, the benefits chain forms a static model which does not allow any form of feedback to earlier stages.

Benefits modelling is a multi-criteria analysis technique, in that multiple measures can be used at each stage of the benefits chain, including the final measures of effectiveness. Traditionally the data needed to populate a benefits model have been obtained from technical and military judgement. The use of a benefits chain facilitates the use of judgmental techniques in situations where a wide range of types of experience is required. However, the benefits model technique is not restricted to using judgmental data. Data could be derived from the results of lower-level objective models. Note that judgements are used directly in the model to quantify improvements; this is in contrast to techniques such as the Analytical Hierarchy Process (AHP) where judgements are used to derive weights through some form of pair-wise comparison.

The benefits chain is constructed from a series of dependency matrices each of which represents the relationship between one set of concepts (often referred to as an axis) and those relevant to the next step in the chain. The matrix transitions typically relate CIS system performance, through intermediate measures (such as measures of C2I function performance), to high-level measures of effectiveness which quantify how well warfare (and OOTW) functions can be performed. A generic structure might have five axes as follows:

- **Investments** – Meaningful units of investment in some aspect of the system-of-systems, including equipment and training.
- **System Functions and Attributes** – Primarily related to the performance of technical elements of the system, but could include human skills if the investment is in training.
- **Organisation Activities and Attributes** – Related to the combined socio-technical system, and covering activities such as information processing and attributes such as flexibility.
- **Military Capabilities and Attributes** – The outputs of the organisation; the activities or attributes that are necessary for achieving a valuable outcome.
- **Value System** – Those concepts that define a successful campaign.

B.2 BENEFITS MODELLING (MAP-BASED)

Benefits analysis is a technique which arose in the 1990s, combining elements of Multi-Criterion Decision Analysis (MCDA) and causal mapping. It aims to model the consequences of investment decisions in terms of their impact on operational effectiveness.

The construction of the causal map often (but not invariably) starts with the identification of the desired end benefit of the programme. The map is laid out so that the means precede the end – so, for each effect,

all possible causes of that effect must be identified. This process is iterated until no further decomposition of causality can be achieved; the final causes are the inputs to the model, against which (in this case) investment options are to be scored. This mapping process can be very helpful in establishing in broad terms whether all aspects impacting on capability have been covered by a requirements document.

Once the causal map has been developed, and a stable state reached, it can be used as the basis for MCDA analysis. In generic terms, the most fundamental level in the causal map will need to be measured numerically and scored, and then the mathematical relationships between each layer of the map formalised and weighted. This will permit the maps to be used in quantitative analysis.

B.3 COGNITIVE MAPPING

This technique maps the vision of a system, issue or event from the point of view of an individual ('group map' or 'concept map' is the term usually used when reflecting the views of a group of people). It captures the interpretation of how concepts relating to the area of interest interact. The cognitive map can be used to analyse the knowledge and opinions of the stakeholder(s).

Generally, cognitive maps used in 'soft' OA are constrained to be causal maps, representing cause and effect between the various concepts in the problem space. The process of developing the map will generally start with a less formal structure and the map will be refined over the course of the workshop.

The language used in a cognitive map is chosen carefully. For example, in the SODA approach concepts are phrased as imperatives (commands to carry out an action). In general, the manner of phrasing a concept should be consistent throughout the finished map. However, during the mapping process, facilitators should be observant of the language used by stakeholders to express the concepts, which can be significant.

Cognitive mapping is a way of improving understanding of a problem area, and can be particularly useful in teasing out the different viewpoints of various stakeholders. It is particularly useful at the scoping phase of a study.

B.4 CAUSAL MAPPING

This is a variant of cognitive mapping, which imposes the discipline that the elements on the map must form a causal sequence. Causal maps can be used as the basis for a benefits model by representing the impacts of study interventions on operational effectiveness.

Causal maps can be constructed top-down or bottom-up. There are advantages to each method, depending on how well the problem is understood. The top-down approach requires the goal to be clearly defined, and imposes a strict discipline; at each stage the question "HOW does this concept cause the next?" must be asked.

Where the map is representing a well-understood system, the inputs (variables or interventions) can be used as the starting point and the consequences inferred. Whichever method is used to construct the map, it is important to cross-check using the alternative route – for each concept asking "HOW might this be achieved?" and "WHAT are the consequences of this?"

B.5 INFLUENCE DIAGRAMS

Influence diagrams are simple representations of problems, including decisions, uncertainties and aims and how they influence each other. They are particularly useful in the early phases of structuring big and complex problems, as they enable the relationships between the main elements of the problem to be identified. They are often used together with decision trees.

B.6 DECISION TREES

Decision trees are used to provide a diagrammatic representation of a problem, setting out possible courses of action and their consequences. They show the details of a problem and can provide a means of quantifying and evaluating options.

B.7 STRATEGIC OPTIONS DEVELOPMENT AND ANALYSIS (SODA) (RENAMED TO: JOURNEY MAKING)

SODA is most suited to complex, ill-defined problems with multiple stakeholders with differing views of the problem space. It captures the various views and provides the opportunity for the stakeholders to reach a shared understanding of the problem.

SODA uses individual and group Cognitive Maps (see above) to explore a problem space. This leads to the identification and negotiation of possible solution options in facilitated workshops using the Oval Mapping technique. The technique aims to create a causal map with a "teardrop" shape, with one or a small number of goals, supported by a greater number of issues or strategies which are in turn supported by more, detailed options.

A successful outcome from SODA would be the achievement of consensus among the stakeholders on a set of possible viable courses of action. It would not seek to define the optimal solution, but could be used as a precursor for MCDA.

B.8 STRATEGIC CHOICE ANALYSIS (SCA)

This method is related to interactive planning. It sets out to establish and manage the areas of uncertainty in a problem, through collaboration between stakeholders. It considers all the decisions involved in a particular situation in parallel, rather than taking them according to perceived priority or timescale, which permits the impacts of immediate actions of future decisions to be explored.

Three key areas of analysis are used to structure the problem:

- The decision area, where alternative courses of action are being considered.
- The comparison area, where the alternatives are assessed and ranked.
- The uncertainty areas, where the following issues are investigated:
  - Working environment;
  - Guiding values (policies); and
  - Related agendas (other perspectives).

Four complementary areas of decision making are considered in SCA:

- Shaping, where the problem structure and linkages are considered;
- Designing, where potential courses of action are explored;
- Comparing, where the criteria for assessing courses of action are decided; and
- Choosing.

The key to this approach is in the consideration of the whole problem space, which ensures that options generated for different parts of the problem will be compatible. The effectiveness of SCA is heavily dependent on the skill of the facilitator.

B.9 SOFT SYSTEMS METHODOLOGY (SSM)

Soft Systems Methodology helps to structure complex problems where there may be divergent views about the nature and definition of the problem. It is particularly useful for requirements capture. It uses 'real-world' descriptions and systems engineering terms to ensure both that the problem is fully described and that it can be rigorously modelled.

The main elements of SSM are as follows:

- Through facilitated workshops and interviews with the problem stakeholders, a "rich picture" is created, using "real-world" terms which encourages the issues to be explored creatively and ensures that all relevant factors are considered.
- Using the rich picture, the analyst derives the root definition of the problem using the mnemonic "CATWOE" (see below) to ensure that all relevant aspects of the problem are included:

  C – Customer;

  A – Actor;

  T – Transformation;

  W – World view (Weltanschauung);

  O – Owner; and

  E – Environmental constraints.
- The root definitions are used to create conceptual models of the activities implied by the root definition.
- These models are then compared with the real world.
- Potential interventions and their likely impacts can then be defined.

B.10 STRATEGIC ASSUMPTIONS SURFACING AND TESTING (SAST)

Strategic Assumptions Surfacing and Testing is a method used to bring consensus to a group of stakeholders where differing views are preventing them from making progress in dealing with a problem. As the name suggests, it draws out the underlying assumptions held by the stakeholders and clarifies the common and opposing issues.

It is a five-stage process; the stages are described below.

- **Group Formation** – The stakeholders are formed into mixed groups (chosen to provide a range of roles and experiences but also to minimise conflict) and each group is given a "viewpoint" from which to address the issue.
- **Assumption Surfacing** – Each group brainstorms the issue from their specific viewpoint and identifies the relevant assumptions.
- **Intra-group Dialectic Debate** – At this stage each assumption is tested for importance by examining its opposite, and for certainty according to the group's best estimate. Assumptions that are deemed to be neither certain nor important are dropped at this stage; those which are both certain and important are retained and the others ranked within the group (importance is generally rated more highly than certainty).
- **Inter-group Dialectic Debate** – Each group presents its findings before a whole group discussion is held. The output of this stage is a set of agreed assumptions (which will be taken as underpinning principles on which to proceed) and a list of those requiring further debate.

- **Final Synthesis** – The whole group works on the outstanding controversial issues to achieve consensus. The final output is a prioritised list of the most important issues, an assessment of the status of potential solutions to the issues and a proposal for the next steps.

This method is particularly useful in developing plans from a high-level strategy.

B.11 SWOT (STRENGTHS, WEAKNESSES, OPPORTUNITIES, THREATS) ANALYSIS

This method provides a structure for brainstorming a problem in its early stages. It is particularly helpful in generating solution options. The TOWS technique extends this by pairing the individual elements.

B.12 PESTLEM ANALYSIS (POLITICAL, ECONOMIC, SOCIAL, TECHNOLOGICAL, LEGAL, ENVIRONMENTAL, MILITARY)

Again, this method provides a structure for brainstorming workshops, in this case examining the system constraints and operating environment.

B.13 SCENARIO BUILDING/PLANNING

This method is intended to achieve a better understanding of the future environment. It is a group process which draws out an understanding of the key issues affecting the future. The aim is to produce a number of diverging stories by extrapolating the main driving forces. This should:

- Increase the knowledge and understanding of the problem environment; and
- Widen the perception of possible future events.

The method involves a 5-step process:

- Identify the key issue;
- Identify the primary driving forces affecting the issue at present (using the PEST categories);
- Identify the predetermined, fixed elements of these driving forces;
- Identify the critical uncertainties and cluster them so that two orthogonal axes of uncertainty are defined, and create a matrix defining four quadrants of uncertainty. Each of these quadrants can then define a possible future scenario; and
- Use the main drivers to flesh out the scenarios defined by the four quadrants.

This method provides a set of four contrasting potential future scenarios against which future plans can be tested.

B.14 INTERACTIVE PLANNING

This technique is associated with process change programmes, where an organisation needs to evolve. It is a three-step method:

- **Mess Formulation** – Where multiple interdependent problems exist, the first stage is to focus on the current business situation and analyse the function, structure and critical processes of the organisation. This analysis will help to identify the current obstacles to meeting the organisation's goals, from which a reference scenario can be generated describing the worst-case consequences of retaining the status quo.

- **Design Process** – This step requires blue-skies thinking to create an unconstrained vision of the future organisation, which can then be iteratively refined so that the vision, mission, structure and process can be defined. The reference scenario is used to check the design to ensure that the obstacles and problems identified in the first stage can be handled.
- **Means Planning** – Where the strategy and tactics to achieve the new organisation are developed.

The strength of Interactive Planning is the clearly structured process which starts with the identification of the current barriers to success before attempting to design the new organisation.

B.15 ROBUSTNESS ANALYSIS

Robustness analysis looks at decision-making in conditions of considerable uncertainty. It requires the analyst to acknowledge that it is not possible to predict the future, or event to estimate the possibilities of future events, but instead one should use decision trees to look at all possible futures and consider their desirability.

This technique uses only the most reliable information about the decision tree – the number of branches at any point – and does not look at the probabilities of any of the events; effectively, it considers all futures as equally likely. The robustness of a decision option is defined as the number of acceptable futures at the planning horizon with which the option is compatible (as a percentage of the total number of acceptable futures at the planning horizon).

B.16 HYPERGAMES

Hypergames build on classical game theory to give a method of more practical use by recognising that the players (two or more) have different perceptions of the game being played. This representation of different perceptions is important in judging the value of different strategies to different players, and hence this approach can be used to define (and subsequently refine) a solution space for a complex problem. Because of the increased complexity of hypergames compared with classical gaming methods, families of decision trees rather than matrices are used.

B.17 DELPHI

Delphi is a term applied to the collection of expert judgements from a group of people. In particular, the information is not attributable to any individual; it is collected anonymously and discussed without reference to individual opinions. Usually the data gathering will involve the use of questionnaires and secret voting, followed by generalised feedback and discussion sessions before iterating the process. The aim is to generate consensus without direct influence or coercion by any individual.

Numerous methods of implementing this method have been developed, and in particular, where the aim is to rank or score decision options a number of different scoring systems exist.

B.18 ANALYTICAL HIERARCHY PROCESS (AHP OR SAATY METHOD)

AHP is a multi-criteria decision making method widely used in support to defence acquisition. It is designed to assist in ranking solutions to complex problems. The process can be broken into four stages:

- Problem structuring as a hierarchy of criteria and options;
- Criteria weighting;

- Option scoring; and
- Sensitivity analysis.

The first stage identifies the evaluation criteria; the attributes by which the solution options will be judged. In more complex problems, these criteria can be subdivided and a hierarchical structure of criteria will ensue.

The next stage is to weight these criteria in importance and thus prioritise issues. These weightings are subjective; a number of techniques exist for deriving these weights. One of the more commonly used methods is pair-wise comparison, carried out at each node of the hierarchy. More detail on this can be found in the references of [1].

The third stage is to score each solution option against each criterion. Some criteria can be scored objectively, with measurable data; some criteria are subjective. It is possible to quantify subjective judgements using the same numerical scale as for objectively derived scores. Again, this is explained in detail in the references of [1].

Finally, sensitivity analysis should be carried out. This is important in hierarchical models. The impact on the results of small variations in the input data (scores and weights) must be investigated to assess the robustness of the model.

B.19 DRAMA THEORY (ALSO KNOWN AS CONFRONTATION ANALYSIS)

Confrontation analysis also has its basis in game theory. This technique is less formal than hypergaming; it focuses on the tactical, political and psychological relationships between the players, and looks at the players' beliefs about the other players' intentions.

The first stage in the process is to define the present situation, the predicted future situation that would arise if current plans were implemented, each player's preferred outcome and potential areas for conflict and compromise. The next stage involves the analysis of threats and promises; how one player's impression of another player's intentions affect his plans. The culmination of this process is a strategic map which sets out all players' possible courses of action to reach their preferred endpoint. This can then be used to identify courses which lead to a desired outcome.

B.20 VIABLE SYSTEMS MODEL

This model is applicable to organisational change programmes. It proposes five necessary functions which must exist for an organisation to be viable:

- Primary activities;
- Coordination between the primary activities;
- Control;
- Intelligence; and
- Policy.

The application of this model involves the critical examination of each of these functions by the key stakeholders. Workshops are held and the current status and future goals are established. When the gaps have been identified, plans to realise the goals can be generated.

B.21 TOTAL SYSTEMS INTERVENTION

This is a method for characterising problems and mapping them to appropriate analysis methodologies. It is a three-phased approach, starting with data gathering from a wide range of stakeholders, then classifying the problem type and finally implementing the appropriate methodology for its solution.

B.22 REFERENCES

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Judgment plays an important role in all Operational Analysis (OA). NATO practitioners have determined that approaches in OA that are based on human judgement are increasingly critical to defence decision making. The purpose of the NATO Guide for Judgement-Based OA in Defence Decision Making is to create an understanding of what judgement-based OA is; to clarify what this type of analysis can do to help address problematic situations, and what people can expect from it in that respect; and, to provide guidance on how a judgement-based OA study should be carried out to maximise the validity, credibility and acceptance of such a study and its outcomes.

The Guide is published as three volumes: 1) An analyst-oriented document (the Code of Best Practice for 'Soft' OA, setting 'rules of the road' for analysts); 2) A client-oriented document; and 3) A brief summarising brochure for high-level, 'executive' decision makers explaining key aspects.

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