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Morphological Gap-Analysis

Using GMA to find the Δ

Tom Ritchey[♠]
Swedish Morphological Society
Ritchey Consulting LLC

Abstract: Gap-analysis is the process of structuring and comparing two different situations or states in order to determine the difference or "gap" that exists between them. Once the "gap" is understood – and possibly also the "distance" between the states measured or otherwise assessed – it may then be possible to identify the steps or processes required to *bridge* the gap. General Morphological Analysis (GMA) is a non-quantified modelling method that employs a process and a spatial format that makes gap-analyses intrinsic. This article will summarise GMA and give examples of how it can be used as a computer based gap-analysis support method. The examples concern 1) an organisational change model, 2) a model for assessing preparedness requirements for rescue services and 3) a knowledge management tool for identifying the gaps between *knowledge bases* and *knowledge requirements*.

Keywords: Gap-analysis, general morphological analysis; non-quantified modelling; organisational change; social-cultural modelling, knowledge management

1. Introduction

Gap-analysis is a method used to assess the difference (or "distance") between two states of an organization, an activity or a knowledge base. Most commonly, it is used to compare a *current state* of something with a *desired* or *potential future state*. The difference is the "gap" or the "delta": the disparity of between what is and what is sought, or ought to be. Gap-analysis can be applied to *performance*, *knowledge*, *skills*, *market strength* or any other measurable and comparable aspect of organisational life. It is used in order to better understand the requirements for change or development within the context of some organisational goal. This is why it is also sometimes referred to as "requirements analysis" or "needs analysis".

Although a gap-analysis *in itself* does not identify or prescribe any particular implementation for change or improvement, it can be a valuable guide for such in strategic planning, competitive actions, organisational change, and any other actions needed to renew, redirect or otherwise develop an organisation or enterprise.

As we shall see, the *general process* involved in carrying out a gap-analysis in effect represents a *basic modeling procedure* (Ritchey, 2012). One is essentially producing a model of the context one wishes to work with, and then displays and compares different states or configurations in the model. The particular nature of the model produced – including how it can be treated methodologically – depends on the type of *scaling properties* used in defining the parameters of the model. Although there are many examples of gap-analysis that are fully quantified (utilising magnitude scaling and allowing for certain mathematical operations), in virtually in all cases where one is working with social, ideological and policy driven contexts, many or all of the factors involved are not (meaningfully) quantifiable. To make sure that there is no misunderstanding, this paper is about *non quantified* gap-analysis[*].

[♠] Contact: ritchey@swemorph.com

[*] I do not disregard the use of psychophysical scaling techniques in order to produce magnitude measures for certain types of policy studies. However, this is a tricky business and, with the enormous pressures often put on analysts to produce seemingly meaningful quantitative results, it is obviously easy to misuse such techniques. In any event, this would be a much later phase in the types of studies we present here, where we must first *identify the nature of the qualities to be scaled.*

General Morphological Analysis (GMA) is a general method for non-quantified modelling. It produces a graphical field which, *inter alia*, allows one to compare different states or configurations of a given context. One might therefore expect to find some affinity between general morphological modelling and the type of modelling associated with gap-analysis. And indeed one does. In fact, non quantified gap-analysis is *intrinsic to morphological modelling and represents a specific application of GMA.*

Note on scaling: When developing morphological models (whether this be an end in itself, or an initial phase intended to identify and bound a domain that we wish later to quantify), we need only initially concern ourselves with non quantified scaling properties: Firstly, whether the parameters are *ordinal* or *non-ordinal*; and secondly, for those that are non-ordinal, whether they consists of *mutually exclusive conditions* (sometimes called "true variables" or "OR-lists"), or consist of *concurrent* (possibly co-existing) *conditions* ("AND-lists"). Examples of all of these possibilities will be given in the case studies presented here*.

At this point, it is instructive (if admittedly somewhat pedantic) to compare the iterative steps taken in developing a gap-analysis with those taken in developing a morphological model.

The basic iterative steps in a gap-analysis (GA):	**The basic iterative steps in a GMA:**
1. Formulate a focus question concerning what the GA is to treat	1. Formulate a focus question concerning what the GMA is to treat
2. Identify and specify the "factors" (i.e. variables or parameters) to be treated on the basis of this focus question	2. Identify and specify the "factors" (i.e. variables or parameters) to be treated on the basis of this focus question
3. Specify the metrics (if quantified) or attributes (if non-quantified) of these factors	3. Specify of metrics (if quantified) or attributes (if non-quantified) of these factors
	4. Define the relationships *between* the factors by performing a pair-wise cross-consistency assessment (CCA) – thus creating a linked parameter space or morphological inference model
4. Identify/specify the present or initial state of the analysis space as the starting point	5. Identify/specify the present or initial state of the model as the starting point
5. Specify the desired or "target" state of the analysis space	6. Specify the desired or" target" state of the model (if this "state" does not exist – e.g. contains internal contradictions – the model will let you know)
6. Determine the "distance" between the initial and target states, as the combined distances between each of the gap-analysis factors	7. The "distance" between the initial and target states are displayed in the model, as a profile of gaps between each of the factors in the morphological model.

The resemblance between these two processes is, of course, obvious. However, the application of GMA for traditional gap-analysis gives the latter some useful added functionalities:

1. Notice point 4 in the GMA scheme, which is usually absent in traditional gap-analysis. The internal Cross-Consistency Assessment (see the summary of GMA below), besides being a valuable knowledge generator and "garbage detector" in the process of *developing* a gap-analysis, is also a control process which provides the assurance that one is not specifying *internally inconsistent* "states" – especially inconsistent (unrealistic or impossible) *target states*.

* These and other issues of parameter scaling will be treated in detail in a forthcoming article to be published in *Acta Morphologica Generalis*: "Parameter formulation in General Morphological Analysis".

2. The GMA modelling of the gap-analysis space always allows us to work interactively. GMA models are inference models in which different inputs can be specified, drivers defined and outputs obtained. Indeed, in morphological models, any possible "state of the system" can be compared to any other possible state.

This article continues with the following sections:

In **Section 2**, a short background to General Morphological Analysis is presented, for those readers who are new to this area. NOTE: *For those who already have a good working knowledge of general morphological modelling, you can skip this section and go on to Section 3.*

Section 3 will present three examples of gap-analysis utilising GMA. The examples concern 1) an organisational change model, 2) a model for assessing preparedness requirements for rescue services concerning accidents involving hazardous materials, and 3) a knowledge management tool for identifying the gaps between *knowledge bases* and *knowledge requirements*.

2. Background to General Morphology*

The term *morphology* derives from antique Greek (*morphê*) which means *shape* or *form*. Morphology is "the study of form or pattern", i.e. the shape and arrangement of parts of an object, and how these *conform* to create a *whole* or Gestalt. The "objects" in question can be physical (e.g. an organism or an ecology), social/organizational (e.g. a corporation or a defense structure), or mental (e.g. linguistic forms or any system of ideas).

The first to use the term *morphology* as an explicitly defined scientific method would seem to be J.W. von Goethe (1749-1832), especially in his "comparative morphology" in botany. Today, morphology is associated with a number of scientific disciplines where *formal structure* is a central issue, for instance, in linguistics, geology and zoology.

In the late 1940's, Fritz Zwicky, professor of astrophysics at the California Institute of Technology (Caltech) proposed a *generalized form of morphology*, which today goes under the name of General Morphological Analysis (GMA)

> "Attention has been called to the fact that the term *morphology* has long been used in many fields of science to designate research on structural interrelations – for instance in anatomy, geology, botany and biology. ... I have proposed to generalize and systematize the concept of morphological research and include not only the study of the shapes of geometrical, geological, biological, and generally material structures, but also to study the more abstract structural interrelations among phenomena, concepts, and ideas, whatever their character might be." (Zwicky, 1969, p. 34)

Zwicky developed GMA as a method for structuring and investigating the total set of relationships contained in multi-dimensional, non-quantifiable, problem complexes (Zwicky 1966, 1969). He applied the method to such diverse fields as the classification of astrophysical objects, the development of jet and rocket propulsion systems, and the legal aspects of space travel and colonization. He founded the Society for Morphological Research and championed the "morphological approach" from the 1940's until his death in 1974.

Morphological analysis was subsequently applied by a number of researchers in the USA and Europe in the fields operational analysis, policy analysis and futures studies (e.g. Taylor, 1967; Ayres, 1969; Rhyne, 1971; Müller-Merbach, 1976; Godet, 1994; Coyle & McGlone, 1995; Ritchey, 1997). In 1995, while working at the Swedish Defence Research Agency (FOI) in Stockholm, I started developing advanced computer support for GMA. This has made it possible to create interactive, non-quantified

* For a more detailed presentation, see the JORS article:" Problem Structuring using Computer-Aided Morphological Analysis", available at: http://www.swemorph.com/pdf/psm-gma.pdf.

inference models, which significantly extends GMA's functionality and areas of application (Ritchey, 1998-2012). Since then, some 100 projects have been carried out using GMA, for structuring complex policy and planning issues, developing scenario and strategy laboratories, and analyzing organizational and stakeholder structures.*

Essentially, GMA is a method for identifying and investigating the total set of possible relationships or “configurations” contained in a given problem complex. This is accomplished by going through a number of iterative phases which represent cycles of analysis and synthesis – the basic method for developing (scientific) models (Ritchey, 1991).

The method begins by identifying and defining the most important dimensions (or *parameters*) of the problem complex to be investigated, and assigning each dimension a range of relevant *values* or *conditions*. This is done mainly in natural language, although abstract labels and scales can be utilized to specify the set of elements defining the discrete *value range* of a parameter.

A morphological field is constructed by setting the parameters against each other in order to create an n-dimensional configuration space (Figure 1). A particular *configuration* (the darkened cells in the matrix) within this space contains one ”value” from *each* of the parameters, and thus marks out a particular state of, or possible formal solution to, the problem complex.

Parameter A	Parameter B	Parameter C	Parameter D	Parameter E	Parameter F
Condition A1	Condition B1	Condition C1	Condition D1	Condition E1	Condition F1
Condition A2	Condition B2	Condition C2	Condition D2	Condition E2	Condition F2
Condition A3	Condition B3	Condition C3		Condition E3	Condition F3
Condition A4	Condition B4	Condition C4		Condition E4	Condition F4
Condition A5		Condition C5		Condition E5	
				Condition E6	

Figure 1: A 6-parameter morphological field. The darkened cells define one of 4800 possible (formal) configurations.

The point is, to examine all of the configurations in the field, in order to establish which of them are possible, viable, practical, interesting, etc., and which are not. In doing this, we mark out in the field a relevant *solution space*. The solution space of a Zwickian morphological field consists of the subset of all the configurations which satisfy some criteria. The primary criterion is that of internal consistency.

Obviously, in fields containing more than a handful of variables, it would be time-consuming – if not practically impossible – to examine all of the configurations involved. For instance, a 6-parameter field with 6 conditions under each parameter contains more than 46,000 possible configurations. Even this is a relatively small field compared to the ones we have been applying.

* For a list of projects, see http://www.swemorph.com, u/Project List

Thus the next step in the analysis-synthesis process is to examine the *internal relationships* between the field parameters and "reduce" the field by weeding out configurations which contain mutually contradictory conditions. In this way, we create a preliminary outcome or solution space within the morphological field without having first to consider all of the configurations as such.

This is achieved by a process of *cross-consistency assessment*. All of the parameter values in the morphological field are compared with one another, pair-wise, in the manner of a cross-impact matrix (Figure 2). As each pair of conditions is examined, a judgment is made as to whether – or to what extent – the pair can coexist, i.e. represent a consistent relationship. Note that there is no reference here to direction or causality, but only to mutual consistency. Using this technique, a typical morphological field can be reduced by up to 90 or even 99%, depending on the problem structure.

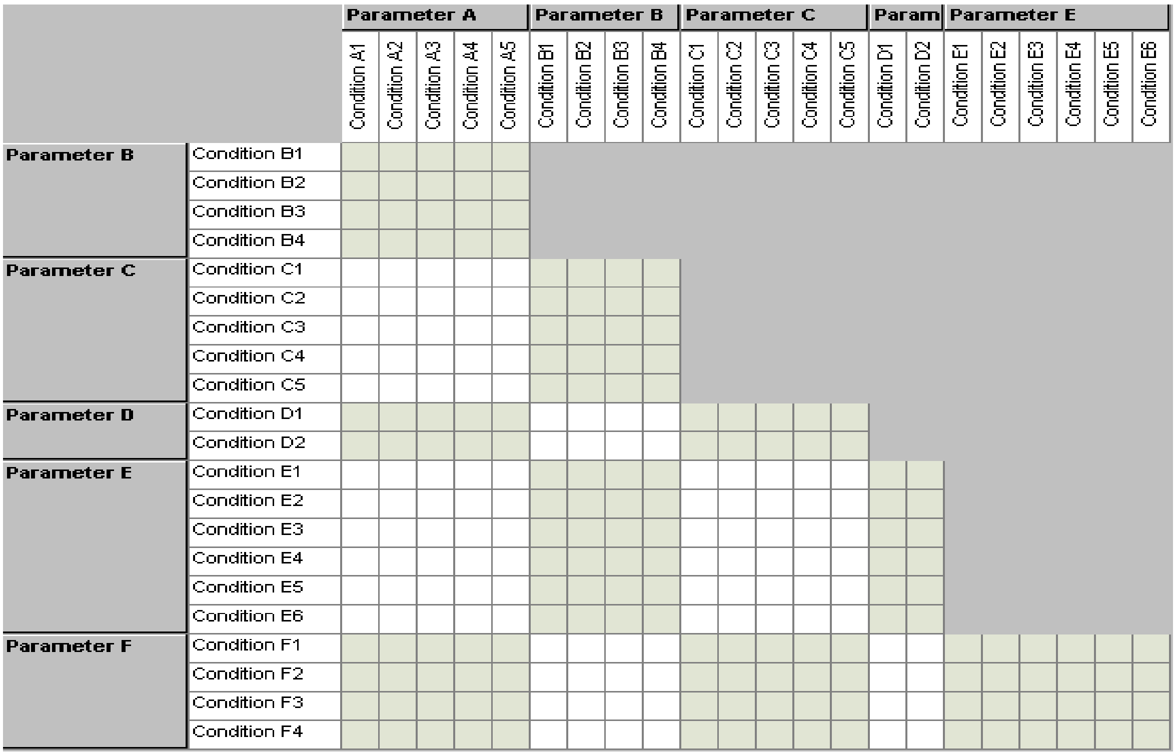

Figure 2: The cross-consistency matrix for morphological field in Figure 1.

There are three principal types of inconsistencies involved here: purely *logical* contradictions (i.e. those based on the nature of the concepts involved); *empirical* constraints (i.e. relationships judged be highly improbable or implausible on practical, empirical grounds), and *normative* constraints (although these must be used with great care, and clearly designated as such).

This technique of using pair-wise consistency assessments between conditions, in order to weed out internally inconsistent configurations, is made possible by a principle of dimensionally inherent in morphological fields, or any discrete configuration space. While the number of configurations in such a space grows exponentially with each new parameter, the number of *pair-wise relationships between parameter conditions* grows only in proportion to the triangular number series – a quadratic polynomial. Naturally, there are also practical limits reached with quadratic growth. The point, however, is that a morphological field involving as many as 100,000 formal configurations can require no more than few hundred pair-wise evaluations in order to create a solution space.

When this solution (or outcome) space is synthesized, the resultant morphological field becomes an *inference model*, in which any parameter (or multiple parameters) can be selected as "input", and any others as "output". Thus, with dedicated computer support, the field can be turned into a laboratory with which one can designate initial conditions and examine alternative solutions.

GMA seeks to be integrative and to help discover new relationships or configurations. Importantly, it encourages the identification and investigation of boundary conditions, i.e. the limits and extremes of different parameters within the problem space. The method also has definite advantages for scientific communication and – notably – for group work. As a process, the method demands that parameters, conditions and the issues underlying these be clearly defined. Poorly defined concepts become immediately evident when they are cross-referenced and assessed for internal consistency. Like most methods dealing with complex social and organizational systems, GMA requires strong, experienced facilitation, an engaged group of subject specialists and a good deal of patience.

3. Three examples of gap-analysis with GMA

3.1 Organisational Structure*

This example is drawn from a project done in the late 1990's for the Swedish National Defence Research Agency (FOI) concerning future *Organisational structure*. (In fact three models were developed for the project: *Organisational structure*, *Markets and clients* and *Security and legal issues*. The model presented here is a truncated version of the original model. It is employed here only as a pedagogical example.)

With the end of the Cold War, Swedish defence research (as with defence research in many other countries) began to develop into broader areas of interest than simply territorial or invasion defence. Also, with changing threat perceptions, there were clear budgetary issues afoot (i.e. budgets were going to be cut!). How could a predominately national defence oriented organisation like FOI reform or re-invent itself to cope with new post-Cold War developments. More specifically, what steps did it need to take in order to develop an organisation compatible with new tasks, working methods and clients?

The first problem is to identify and properly define the dimensions of the problem – that is to say, the relevant *issues* or parameters involved. For the *Organisational structure* study, these included organisational and leadership types, client sectors, products and employee profiles – all at a relevant level of abstraction. One of the advantages of GMA is that there are no formal constraints to mixing and comparing such different types of issues. On the contrary, if we are really to get to the bottom of an organisational or policy problem, we must treat all relevant issues *together*.

Secondly, for each issue (parameter), a spectrum of "values" must be defined. These values represent the possible, relevant states or conditions that each issue can assume, for the particular study at hand. The morphological field for the organisational structure model is shown in Figure 3, below. It contains 186,624 possible configurations – which is simply the product of the number of "values" under each parameter. It also displays a traditional FOI organisation's profile. Note that all of the parameters in this model are non-ordinal. Two of the parameters (*Organisational type* and *Leadership culture*) are *treated* as mutually exclusive, while the rest are non-exclusive.

The next (iterative) step in the modelling process is to reduce the total set of (formally) possible configurations in the morphological field to a smaller set of internally consistent configurations representing a "solution space" – i.e. what we call a "Cross-Consistency Assessment" (CCA, see Figure 4). The CCA allows us to compile an inference model, with which we can define drivers, designate inputs and obtain outputs. It also guarantees that we do not inadvertently choose *target states* in the gap-analysis which do not "exist", i.e. which we have – in the CCA – deemed impossible or improbable due to internally inconsistent conditions.

* Some of this text has been taken from Ritchey (2011), Chapter 2.

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Organisational type	Dominant leadership culture	Main client(s)	Dominate products/ services	Co-operation strategies	Main empolyee incentive	Employee profile
Official state agency	Bureaucratic hierarchy	Ministry dominated	Process + method support	Outside help when needed	Money	Life-long service
Government owned enterprise	Strong scientific leadership	Military and material dominated	Soft studies	Joint ventures	Managerial career	Career researcher
Academy (á la university)	Marketing division leadership	Defence Industry	Hard studies	Consultant purchasing	Pleasure in one's work	Development engineer
Trade institute	Umbrella management	Civilian agencies	Basic research	Mediator only	Educational motivation	"Consultant"
Consultant firm	Gate-keeping	Private markets (national)	Testing, construction		Titles, specialist career	Entrepreneur
"Learning organisation"	Skunk-works (ad hocrati)	International markets	Second opinion		Organisation gives status	Elite troops

Figure 3: One of the organisational development models produced for the Swedish Defence Research Agency, showing a configuration describing the organisation's main traditional profile.

		Organisation						Leadership						Dominant						Dominate						Co-operatio				Principle					
		Official state agency	Governmentowned	Academy	Trade institute	Consultant firm	earning organisation"	ureaucratic hierarchy	Strong scientific	Marketing division	mbrella management	"Gatekeeper"	Skunk-works	Ministry dominated	Military and material	Defence Industry	Civilian agencies	Private markets	Internationalmarkets	Process + method	Soft studies	Hard studies	Basic research	Testing, construction	Second opinion	Outside help	Joint ventures	onsultant purchasing	Mediator only	Life-long	Career researcher	evelopment engineer	"Consultant"	Entrepreneur	Elite troops
Leadership culture	Bureaucratic	F	-	X	F	X	X																												
	Strong	X	X	F	X	X	-																												
	Marketing	K	F	X	F	F	-																												
	Umbrella	X	-	-	X	F	F																												
	"Gatekeeper"	F	K	-	K	X	X																												
	Skunk-works	X	X	-	X	-	F																												
Dominant buyer structure	Ministry	F	K	-	F	K	K	F	X	K	-	-	-																						
	Military and	F	-	-	F	-	K	F	X	K	K	-	-																						
	Defence	K	-	-	-	-	-	K	-	F	-	-	-																						
	Civilian	-	-	K	K	-	-	-	K	-	F	-	-																						
	Private markets	X	-	X	X	-	F	X	-	F	F	-	-																						
	International	X	-	-	X	-	F	X	-	F	F	-	-																						
Dominate product/ service	Process + method	F	-	K	F	F	F	-	-	-	-	-	K	-	F	X	-	-	-																
	Soft studies	F	-	F	F	K	F	-	-	-	-	-	-	F	-	K	F	-	-																
	Hard studies	-	-	F	F	F	F	-	-	-	-	-	-	-	-	F	-	-	-																
	Basic research	K	X	F	K	X	F	K	F	K	-	F	-	X	X	X	X	X	-																
	Testing, construction	-	-	-	K	-	F	-	K	-	-	-	-	X	-	-	-	-	-																
	Second opinion	F	K	K	F	-	F	-	-	K	-	-	K	F	X	X	-	X	-																
Co-operation strategies	Outside help	-	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-										
	Joint	-	-	-	-	K	F	K	-	-	K	-	X	K	K	-	-	-	-	K	-	-	-	-	-										
	Consultant	-	-	X	X	K	X	-	K	-	K	-	-	K	K	-	-	-	-	X	-	-	-	K	X										
	Mediator only	-	X	X	X	-	-	K	X	-	X	K	X	X	K	-	-	-	-	X	-	-	X	X	X										
Principle Employee profile	Life-long	F	-	F	F	X	X	F	-	X	X	F	X	-	-	K	K	K	X	-	-	-	-	-	-	-	-	-	-						
	Career researcher	-	K	F	-	K	-	-	F	X	-	F	F	-	-	-	-	-	-	-	-	-	F	-	-	-	-	-	X						
	Development engineer	K	-	-	K	-	-	-	-	F	-	-	F	K	-	-	-	-	-	K	X	-	X	-	X	-	-	-	X						
	"Consultant"	F	-	K	X	F	K	-	K	F	F	K	X	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-						
	Entrepreneur	-	-	F	K	-	F	X	X	F	F	X	F	-	-	F	F	F	F	-	-	-	-	-	-	-	-	-	-						
	Elite troops	K	K	F	K	-	F	X	F	-	-	-	F	-	-	-	-	F	F	-	-	-	-	-	-	-	-	-	-						
Main employee incentive	Money	K	F	X	K	F	-	K	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	K	K	F	F	-	F
	Managerial career	F	-	F	-	K	K	F	K	-	-	-	K	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	K	K	-	-
	Pleasure	-	-	F	-	-	F	-	-	-	F	-	F	-	-	-	-	-	-	-	-	-	F		-	-	-	-	-	-	F	F	-	F	F
	Educational motivation	-	-	-	F	F	-	K	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-
	Titles, specialist	X	K	F	K	-	-	K	-	-	K	-	K	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	K	X	F	-	F	-	-
	Organisation status	F	-	F	X	K	F	-	-	-	F	-	F	-	-	-	-	-	-	-	-	-	F	-	-	-	-	-	-	-	F	-	-	F	F

Figure 4: Cross-Consistency Matrix for the organisational development model in Figure 3.

Figure 5 shows clustered gap information obtained using a two driver input *Official state agency/-Bureaucratic hierarchy* vs. *Consultant firm/Marketing division leadership*. The light blue cells correspond only to "Official state agency", the medium blue only to "Consultant firm", with the dark blue cells corresponding to both.

Organisational type	Dominant leadership culture	Main client(s)	Dominate products/ services	Co-operation strategies	Main empolyee incentive	Employee profile
Official state agency	Bureaucratic hierarchy	Ministry dominated	Process + method support	Outside help when needed	Money	Life-long service
Government owned enterprise	Strong scientific leadership	Military and material dominated	Soft studies	Joint ventures	Managerial career	Career researcher
Academy (á la university)	Marketing division leadership	Defence Industry	Hard studies	Consultant purchasing	Pleasure in one's work	Development engineer
Trade institute	Umbrella management	Civilian agencies	Basic research	Mediator only	Educational motivation	"Consultant"
Consultant firm	Gate-keeping	Private markets (national)	Testing, construction		Titles, specialist career	Entrepreneur
"Learning organisation"	Skunk-works (ad hocrati)	International markets	Second opinion		Organisation gives status	Elite troops

Figure 5. Organisational structure model showing "gap" information obtained with a two-driver input with *Organisation type* and *Leadership culture*.

3.2 Evaluating Preparedness for Accidents Involving Hazardous Materials

Fortunately, accidents involving hazardous materials, e.g. dangerous chemical substances, are relatively rare in Scandinavia. However, the fact that such accidents are rare makes it difficult for rescue services to gain sufficient experience and routine, as is the case with fire fighting or traffic accidents. One way to increase preparedness is through theoretical evaluations and with the help of scenarios, in order to identify potential deficiencies and to see where improvements can best be made.

In the early 2000's, the Swedish National Rescue Services Agency commissioned a study to develop a computer-based instrument for the bi-annual evaluation Swedish Rescue Services' preparedness for accidents involving hazardous materials. (See Ritchey et al, 2002).

The so-called *ChemPrep* evaluation model which was developed is made up of two inter-linked morphological fields: The *Preparedness Resource* field (the five columns on the left side – Figure 6) describes levels of preparedness for five different preparedness parameters. The *Rescue Response* field (the three rightmost columns) describes possible responses that a rescue service can make (depending on its resources) within a set of critical time periods defined by a *specific accident scenario*.

The exact formulation of the parameters, their order of priority and the "levels of response" expressed within them, were defined by way of specific accident scenarios. Response Fields for eight different cases were developed, which covered different chemical substance groups (e.g. toxic condensed gas; inflammable liquids and gases; explosive substances; raw petroleum spills, etc.). The scenarios were based on actual accidents that had taken place in Europe.

To utilise the instrument, a scenario is chosen and the evaluation module containing that scenario is opened. There are two ways to apply the evaluation matrix. The first way ("synthetic") is to see what level of response is attainable for the *preparedness resources available to the rescue service* in question. Here we use the *Resource field* as "input", and *Response field* as "output" (Figure 6).

The second way ("analytic") is to see what resources would be required in order to realise a desired level of response. Here we use the *Response field* as input, and the *Resource field* as output (Figure 7). This mode of use is more suited for the task of municipal planning in dialogue with political decision-makers. (For a detailed discussion of the synthetic and *analytic* approaches, see Ritchey, 1991.)

To identify gaps, we use a combination of these two methods: A rescue service enters its preparedness profile into the *Resource field*, resulting in a specific response profile in the *Response field*. This initial result is then “frozen”, and new, enhanced values are chosen in the *Response field* (in this case, the three light blue cells under “Response to chemical release” in Figure 8) in order to see how preparedness resource requirements need to be enhanced in order to achieve the designated response. Note that in this example, both planning, training and equipment must be augmented in order to achieve the designated “Response to chemical release”. This does not, however, improve Information and Human Rescue responses, as this is dependent on further increases in planning and cooperative training.

LEVEL of PLANNING	LEVEL of TRAINING and EDUCATION	PERSONNEL AVAILABLE	EQUIPMENT AVAILABLE	COMMAND LEVEL	RESPONSE: to chemical release	RESPONSE: Information to public	RESPONSE: Affected people
Full preparedness plan	Broad co-op. training	11 or more	Special equipment for specific case	Level 4	Reduce by least 80% within 15 min	Warn involved within 5 min	Help many within 30 min
Response plan for specific case	Training for specific case	8-10	Base equipment for specific case	Level 3	Reduce by least 80% within 30 min	Warn involved within 30 min	Help some individuals within 15 min
Standard routine for specific case	Base education + regular training	5-7	Less than base equipment for specific case	Level 2	Reduce by less than 50% within 15 min	No warning within 30 min	Help some individuals within 30 min
Standard routine for general case	Base education only	4 or less		Level 1	Reduce by less than 50% within 30 min		No help within 30 min
Only alert plan					No measures within 30 min		

Figure 6. The *ChemPrep* model showing the preparedness profile for a typical small town in Sweden (red), along with the subject-specialist-evaluated response profile (blue) for a specific accident scenario (release of a condensed toxic gas).

LEVEL of PLANNING	LEVEL of TRAINING and EDUCATION	PERSONNEL AVAILABLE	EQUIPMENT AVAILABLE	COMMAND LEVEL	RESPONSE: to chemical release	RESPONSE: Information to public	RESPONSE: Affected people
Full preparedness plan	Broad co-op. training	11 or more	Special equipment for specific case	Level 4	Reduce by least 80% within 15 min	Warn involved within 5 min	Help many within 30 min
Response plan for specific case	Training for specific case	8-10	Base equipment for specific case	Level 3	Reduce by least 80% within 30 min	Warn involved within 30 min	Help some individuals within 15 min
Standard routine for specific case	Base education + regular training	5-7	Less than base equipment for specific case	Level 2	Reduce by less than 50% within 15 min	No warning within 30 min	Help some individuals within 30 min
Standard routine for general case	Base education only	4 or less		Level 1	Reduce by less than 50% within 30 min		No help within 30 min
Only alert plan					No measures within 30 min		

Figure 7. The *ChemPrep* model showing a desired response (red) and the resultant preparedness resourse requirements (blue) for the same accident scenario.

LEVEL of PLANNING	LEVEL of TRAINING and EDUCATION	PERSONNEL AVAILABLE	EQUIPMENT AVAILABLE	COMMAND LEVEL	RESPONSE: to chemical release	RESPONSE: Information to public	RESPONSE: Affected people
Full preparedness plan	Broad co-op. training	11 or more	Special equipment for specific case	Level 4	Reduce by least 80% within 15 min	Warn involved within 5 min	Help many within 30 min
Response plan for specific case	Training for specific case	8-10	Base equipment for specific case	Level 3	Reduce by least 80% within 30 min	Warn involved within 30 min	Help some individuals within 15 min
Standard routine for specific case	Base education + regular training	5-7	Less than base equipment for specific case	Level 2	Reduce by less than 50% within 15 min	No warning within 30 min	Help some individuals within 30 min
Standard routine for general case	Base education only	4 or less		Level 1	Reduce by less than 50% within 30 min		No help within 30 min
Only alert plan					No measures within 30 min		

In *Figure 8.* New parameters values are chosen in the Response field (the three light blue cells under "Response to chemical release") in order to see how preparedness resource requirements need to be enhanced in order to achieve the enhanced response

3.3. Knowledge management for identifying what we know vs. what we need to know

The SOCUMOD project (Social and Cultural Modelling), commissioned by the European Defence Agency (EDA) in 2007, was concerned with the development of social-cultural awareness for Peace Keeping personnel in the operational environmental. It brought together a group of subject specialists, representing different relevant areas of competence, to develop an initial structure, a common problem space and a prototype modelling framework for a number of social and cultural contexts which needed to be examined and better understood. The morphological modelling phase of the project concerned developing a comparative knowledge management tool for understanding the gaps between *knowledge bases* and *knowledge requirements* for different peace keeping missions, *where it is important for PK personnel to understand, and take consideration of, local social and cultural norms and attitudes*.

Thus the initial *focus question* formulated for the modelling sessions was:

What are the most important factors concerning socio-cultural awareness of the operational environment, which could lead to misjudgements concerning the nature of interpersonal relationships and social structures when interacting with local populations, authorities and relief organizations?

The modeling frameworks and gap-analyses had a number of purposes, including 1) an analysis and decision tool for mission development in general; 2) a training tool for awareness of OP Environments; 3) an analysis and decision tool for operational planning during missions; 4) an analysis and decision tool for "after-analysis" and lessons learned; and 5) as a partial basis for a future social-cultural awareness training simulator

The Gap-analysis model of social cultural awareness consisted of three components:

- *Operational environment* (OpEnv) field (6 parameters).
- *Knowledge models*: a number of social-cultural knowledge data bases and/or theories.
- *Knowledge requirement cases*: a number of tasks or missions which require a certain knowledge base and awareness in order to better understand the social-cultural OpEnv.

The parameters for the OpEnv field are shown in Figure 9.

OP-Environment: institutional structures/factors to be aware about. (PRESERVERS)	OP-Environment: cultural values to be aware of (THEY) (SHAPERS)	OP-Environment: factors concerning local population's motivations & needs: (DRIVERS)	Interactions between IN and OUT groups	Actors/ players to take account of	Indicators/ measures of success (according to mission goals)
Ideology/ religious beliefs	Relation to gender	How are basic needs provided for	Perceptions of "our" force by local populations	Coalition forces	Less criminal offences
National identity and values	Verbal- nonverbal communication	What gives Power	Perception of local populations by "our" forces	Our forces/ national	Amount of territory secured
Political structure/ leadership	Individual/collective scale	What gives Prestige/ status	Perception by national and international opinion	Local populations	Decreased civilian population mortality
Demographic patterns	Power distance	How is economic security acquired	Number of interactions between commander and local authorities	Minority groups among local populations	Increased economic activity/ decrease in poverty
Economic structure	Honour	How can Physical security be gained	Relationship (valence) between commander and local authorities (Key leader engagement)	Local authorities	Increased school attendance
Social network	Tightness-looseness	How do people strive for belonging/ affiliation	Interactions between our forces and local populations	NGOs/IOs	Less attacks on own troops
Information network and info flow via media	Taboos	How is trust acquired	Interactions between our forces and local forces (police and army)	Local security forces (police, army)	Change in number and nature of manifestations
Security structure	Hospitality rules	What are people's expectations for the future	Interaction between "us" and potentially emergent movements	Media opinion	Change in migration patterns
Educational structures	Attitudes to violence	How is self- expression attained	Interaction between "is" and NGO/ IO	Regional countries	Decrease/increase in internal conflicts
	Attitudes to own security forces	What level of education provided and to whom?		Militias and insurgents	Changes in personnel turnover in local forces
	Uncertainty avoidance: society's flexibility			Local non-authority actors	Change in NGO / IO activity
	Attitude towards education			Other stakeholders	Change in nature of rhetoric in media and communication patterns
	Attribution styles				Time spent outside compound

Figure 9: Operational Environment field (6 parameters)

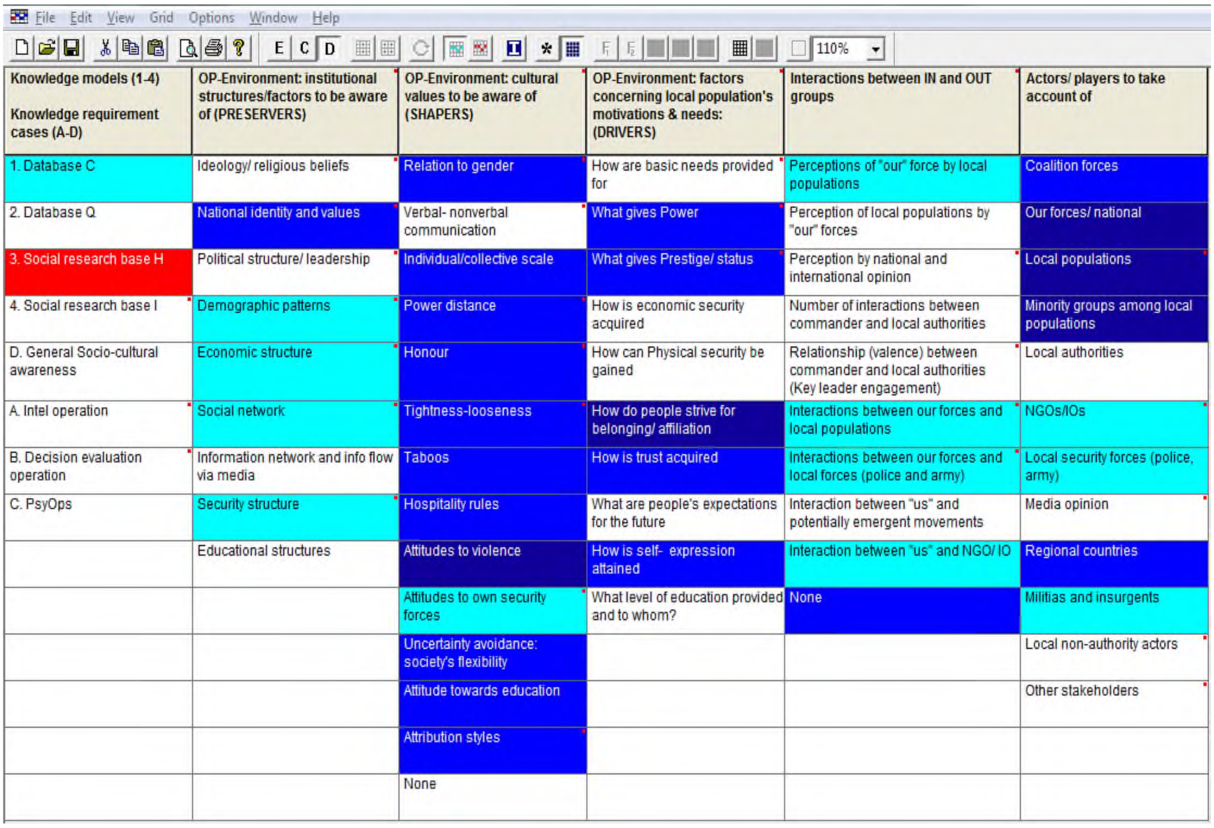
Four "knowledge models" (data bases and research programs) were taken as examples, and four "knowledge requirement cases" were formulated to test the knowledge basis (shown in Figures 10 to 12). Both the *knowledge models* and the *knowledge requirement cases* were then assessed against the 6 parameters of the OpEnv model. Since each *knowledge requirement case* can be compared with each *knowledge model*, this results in (4x4) 16 possible gap-assessments.

We can also compare *knowledge models* with each other to see how well they correlate and how much they cover. Likewise, we can compare different *knowledge requirement cases* in order to ascertain what areas of the Operation Environment these relate to and where they overlap. Examples of each of these are given below.

1. Figure 10: Comparison of two *knowledge models* with significant divergences
2. Figure 11: Comparison of two *knowledge requirement cases* with significant divergences
3. Figure 12: Comparison of *knowledge model* with *knowledge requirement case*.

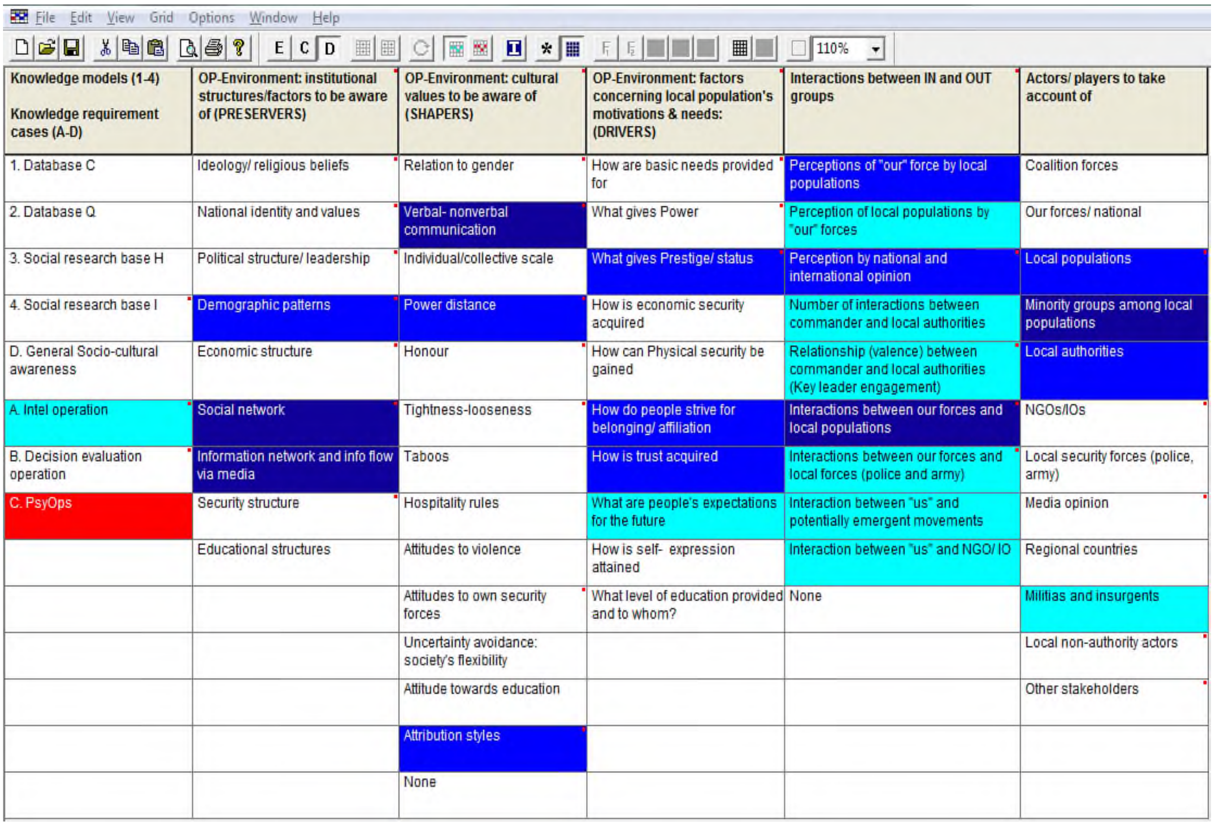
In the comparisons the following colour coding is used:

- The light blue cells in the OpEnv parameters correlate <u>only</u> with the light blue cell in the knowledge model/problem area parameter,
- The middle blue cells in the OpEnv parameters correlate <u>only</u> with the red cell in the knowledge model/problem area parameter,
- The dark blue cells in the OpEnv parameters correlate with <u>both</u> the light blue cell and the red cell in the knowledge model/problem area parameter (i.e. these are the common features of both).



Knowledge models (1-4) Knowledge requirement cases (A-D)	OP-Environment: institutional structures/factors to be aware of (PRESERVERS)	OP-Environment: cultural values to be aware of (SHAPERS)	OP-Environment: factors concerning local population's motivations & needs: (DRIVERS)	Interactions between IN and OUT groups	Actors/ players to take account of
1. Database C	Ideology/ religious beliefs	Relation to gender	How are basic needs provided for	Perceptions of "our" force by local populations	Coalition forces
2. Database Q	National identity and values	Verbal- nonverbal communication	What gives Power	Perception of local populations by "our" forces	Our forces/ national
3. Social research base H	Political structure/ leadership	Individual/collective scale	What gives Prestige/ status	Perception by national and international opinion	Local populations
4. Social research base I	Demographic patterns	Power distance	How is economic security acquired	Number of interactions between commander and local authorities	Minority groups among local populations
D. General Socio-cultural awareness	Economic structure	Honour	How can Physical security be gained	Relationship (valence) between commander and local authorities (Key leader engagement)	Local authorities
A. Intel operation	Social network	Tightness-looseness	How do people strive for belonging/ affiliation	Interactions between our forces and local populations	NGOs/IOs
B. Decision evaluation operation	Information network and info flow via media	Taboos	How is trust acquired	Interactions between our forces and local forces (police and army)	Local security forces (police, army)
C. PsyOps	Security structure	Hospitality rules	What are people's expectations for the future	Interaction between "us" and potentially emergent movements	Media opinion
	Educational structures	Attitudes to violence	How is self- expression attained	Interaction between "us" and NGO/ IO	Regional countries
		Attitudes to own security forces	What level of education provided and to whom?	None	Militias and insurgents
		Uncertainty avoidance: society's flexibility			Local non-authority actors
		Attitude towards education			Other stakeholders
		Attribution styles			
		None			

Figure 10: Comparison of two *knowledge models* with large divergences.



Knowledge models (1-4) Knowledge requirement cases (A-D)	OP-Environment: institutional structures/factors to be aware of (PRESERVERS)	OP-Environment: cultural values to be aware of (SHAPERS)	OP-Environment: factors concerning local population's motivations & needs: (DRIVERS)	Interactions between IN and OUT groups	Actors/ players to take account of
1. Database C	Ideology/ religious beliefs	Relation to gender	How are basic needs provided for	Perceptions of "our" force by local populations	Coalition forces
2. Database Q	National identity and values	Verbal- nonverbal communication	What gives Power	Perception of local populations by "our" forces	Our forces/ national
3. Social research base H	Political structure/ leadership	Individual/collective scale	What gives Prestige/ status	Perception by national and international opinion	Local populations
4. Social research base I	Demographic patterns	Power distance	How is economic security acquired	Number of interactions between commander and local authorities	Minority groups among local populations
D. General Socio-cultural awareness	Economic structure	Honour	How can Physical security be gained	Relationship (valence) between commander and local authorities (Key leader engagement)	Local authorities
A. Intel operation	Social network	Tightness-looseness	How do people strive for belonging/ affiliation	Interactions between our forces and local populations	NGOs/IOs
B. Decision evaluation operation	Information network and info flow via media	Taboos	How is trust acquired	Interactions between our forces and local forces (police and army)	Local security forces (police, army)
C. PsyOps	Security structure	Hospitality rules	What are people's expectations for the future	Interaction between "us" and potentially emergent movements	Media opinion
	Educational structures	Attitudes to violence	How is self- expression attained	Interaction between "us" and NGO/ IO	Regional countries
		Attitudes to own security forces	What level of education provided and to whom?	None	Militias and insurgents
		Uncertainty avoidance: society's flexibility			Local non-authority actors
		Attitude towards education			Other stakeholders
		Attribution styles			
		None			

Figure 11: Comparison of two *problem areas* with large divergences.

Knowledge models (1-4) Knowledge requirement cases (A-D)	OP-Environment: institutional structures/factors to be aware of (PRESERVERS)	OP-Environment: cultural values to be aware of (SHAPERS)	OP-Environment: factors concerning local population's motivations & needs: (DRIVERS)	Interactions between IN and OUT groups	Actors/ players to take account of
1. Database C	Ideology/ religious beliefs	Relation to gender	How are basic needs provided for	Perceptions of "our" force by local populations	Coalition forces
2. Database Q	National identity and values	Verbal- nonverbal communication	What gives Power	Perception of local populations by "our" forces	Our forces/ national
3. Social research base H	Political structure/ leadership	Individual/collective scale	What gives Prestige/ status	Perception by national and international opinion	Local populations
4. Social research base I	Demographic patterns	Power distance	How is economic security acquired	Number of interactions between commander and local authorities	Minority groups among local populations
D. General Socio-cultural awareness	Economic structure	Honour	How can Physical security be gained	Relationship (valence) between commander and local authorities (Key leader engagement)	Local authorities
A. Intel operation	Social network	Tightness-looseness	How do people strive for belonging/ affiliation	Interactions between our forces and local populations	NGOs/IOs
B. Decision evaluation operation	Information network and info flow via media	Taboos	How is trust acquired	Interactions between our forces and local forces (police and army)	Local security forces (police, army)
C. PsyOps	Security structure	Hospitality rules	What are people's expectations for the future	Interaction between "us" and potentially emergent movements	Media opinion
	Educational structures	Attitudes to violence	How is self- expression attained	Interaction between "us" and NGO/ IO	Regional countries
		Attitudes to own security forces	What level of education provided and to whom?	None	Militias and insurgents
		Uncertainty avoidance: society's flexibility			Local non-authority actors
		Attitude towards education			Other stakeholders
		Attribution styles			
		None			

Figure 12: Comparison of knowledge model *Database C* with problem area *Intel operation*.

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The author: Tom Ritchey is a former Research Director for the *Institution for Technology Foresight and Assessment* at the Swedish National Defence Research Agency in Stockholm. He is a methodologist and facilitator who works primarily with non-quantified decision support modelling -- especially with General Morphological Analysis (GMA), Bayesian Networks (BN) and Multi-Criteria Decision support. Since 1995 he has directed more than 100 projects involving computer aided GMA for Swedish government agencies, national and international NGO:s and private companies. He is the founder of the Swedish Morphological Society and Director of Ritchey Consulting LLC, Stockholm.