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Scenario modelling with morphological analysis

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ABSTRACT

Scenarios can serve as points of reference in the future for decisions that we have to make today. Morphological analysis provides a structured method for ensuring consistency and relevance in scenario development. This paper outlines a method for characterizing the entire solution space of future outcomes in a given subject field, and suggests a process for classification of an all-encompassing and mutually exclusive set of scenario classes. The method is illustrated with an example case, taken from Norwegian defense planning, of establishing a scenario set that encompasses all external security challenges to Norway as a security actor. Four parameters are defined – Actor, Goal, Method and Means. Each parameter is defined in terms of an exhaustive set of possible states or values. A Cross Consistency Assessment is conducted to exclude solutions deemed to be impossible on either purely logical grounds (internal consistency) or based on real world assessments (external consistency). Six scenario classes are defined: Strategic Attack, Limited Attack, Coercive Diplomacy, Terrorist Attack, Criminality and Military Peace-time Operations.

1. Introduction

Scenario planners have long dealt with the problem of capturing a complex and uncertain world within the confines of a limited number of scenarios. The problem is fundamental to future oriented studies and planning, and a number of techniques and methods have been proposed to deal with it (Bryant and Lempert, 2010; Postma and Liebl, 2005; Groves and Lempert, 2007; Nguyen and Dunn, 2009; Kwakkel et al., 2013). Although no single approach will ever be able to transcend the gap between scenario models and the real world, this paper suggests that General Morphological Analysis applied to scenario modelling may solve some of the most pressing problems related to established scenario methodology.

This paper looks at the scenario modelling problem from the standpoint of long term defense structure planning. In the defense planning process, scenarios serve vital functions as vehicles for war gaming, simulation, and analysis to support the design of a future force. As an illustrative case and as an example of the morphological process in practice, the paper goes into some detail in explaining the development of a scenario set for Norwegian defense planning.

A scenario can usefully be defined as a description of a possible future state or condition within a subject field. Scenarios are not predictions of future events, and although they sometimes provide probabilities, their main function is to present decision makers with a set of alternative futures against which different courses of action might be measured. The basic criterion for inclusion of a scenario in a scenario set, thus, is not the probability that it will eventually happen, but the fact that it *might* happen given certain assumptions about the surrounding world. Schwartz (1996 p. 4) consequently defines scenarios as "tool [s] for ordering one's perceptions about alternative future environments in which one's decisions might be played out".

In order to provide a useful tool for thinking about the future, scenarios have to relate to established knowledge about the outside world, and to a certain conception of what might actually happen in the future. In that vein, van der Heijden (2005 p. 225) posits that scenarios must conform to the principles of *plausibility* – scenarios must build on a logically derived cause-and-effect relationship between and within real world phenomena; *consistency* – scenarios must build on assumptions that are not mutually exclusive; and *relevance* – a scenario must contain sufficient high quality information to make it useful for its purpose. As an additional admonition, he states that the number of scenarios should be restricted to two, three or – at the most – four, since that is the maximum number decision makers are able to relate to in a systematic way.

A number of schools and traditions have dealt with, and proposed their own solutions to the complexities of scenario writing. Bradfield et al. (2005) identifies three dominant schools in scenario building: The French *La Prospective* school; the *Probabilistic Modified Trends* school associated with RAND; and the *Intuitive Logics* school. The *Intuitive Logics* approach, associated with the oil company Royal Dutch Shell and the Global Business Network, is perhaps the best known among them (Bryant and Lempert, 2010). Being extensively applied for a wide

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variety of purposes, it has become something of a convention for scenario and planning purposes.

Wack (1985) describes how the Intuitive Logics method was developed by analysts at the Shell oil company during the 1970s in a situation with deep uncertainty about the future development in the international energy market. The key element to the intuitive approach is a firm grip on what constitutes the forces driving the system, and awareness that there are some outcomes that are *predetermined* – events that have occurred, but whose consequences have yet to materialize, and some that are fundamentally *uncertain*. Uncertainty in this context stems from different sources, some purely random, as when an accident causes a halt in the oil production, but also some that are related to choices made by social entities – the actors making up the system. Under this particular type of uncertainty, outcomes are determined by multiple, interacting self-interested actors (Blanken, 2012). Hence, scenarios have to incorporate not only probabilistic uncertainties, but also uncertainties of a *strategic* nature.

By measuring the uncertain factors to the range of possibilities provided by the predetermined factors, some outcomes can be excluded from the scenario selection, while confidence in others is strengthened. As an example, Wack shows that by 1972 analysis of the oil market had established that demand for oil was outstripping supply by a large margin, and that ten years of low economic growth would be required to fit demand to supply. Hence, rising oil prices were seen as predetermined and a balanced oil market with stable, low prices over the long term could effectively be excluded from the company's scenario portfolio (Wack 1985 p. 82).

This approach is well suited to reduce a potentially vast scenario set down to manageable proportions. Moreover, one of the attractions of conventional scenario methodologies is their focus on causality. However, application of a particular causal chain to scenario development might be extremely difficult given the non-linear properties that characterize systems governed by human behavior. Misplaced causality, therefore, is a major source of bias in scenario building, and restricts the prospect of fitting discontinuities that cannot readily be framed in cause-and-effect terms, to the scenario set.

Consequently, according to Kwakkel et al. (2013 p. 1), conventional scenario approaches struggle when dealing with rare events and cases where there are a multiplicity of possible futures. In defense planning, in particular, uncertainties related to political shifts and revolutions, misperceptions and accidents characteristically overwhelm the predetermined elements. To put the matter bluntly, it is impossible to explain war as an incremental and entirely logical process based on observable trends. Or, in a more academic phrasing, conventional scenario building tends to break down when confronted with possible futures that combine extremely low probabilities with potentially disastrous consequences.

This point is borne out by new research that indicates that interstate conflict follows a power law logic where the size and the likelihood of events, including wars, are affected by mechanisms linking micro-level actions to macro-level outcomes in a strongly nonlinear fashion (Cederman et al., 2011 p. 621). Conflicts thus may turn into wars, and small wars into large wars through the operation of highly unstable escalation processes governed by positive feedback loops between the interacting agents.

These dynamics are not easily integrated into scenario methodologies that rest on forward looking causal reasoning. Referring to crisis management, Wright and Goodwin (2009 p. 16) claim that the requirement to incorporate rare and extreme outlier scenarios to the scenario set stands in stark contrast to the Intuitive Logics method since "… the range of focal scenarios is likely to be constrained by components of the construction methodology".

Framing the challenges posed by an exceedingly complex political and military environment therefore requires a radically different approach. Wright and Goodwin (2009) propose to apply a "backward logic" to the Intuitive Logics method in order to create a range of more extreme scenarios (see also Wright et al., 2013). The backward logic works by imagining that rare, high impact events have in fact occurred, and then work backwards by disclosing which conditions would have to be in place for that particular event to materialize.

Intuitive Logics with its recent enhancements go a long way in remedying the shortcomings of forward causal thinking, still the focus on causal chains tends to unnecessarily restrict and complicate the scenario process. This paper, therefore, proposes a shift of focus towards modelling non-reducible, complex problem spaces through the application of General Morphological Analysis.

The remainder of this paper will briefly describe the use of scenarios in long term defense planning. It goes on to flesh out some of the fundamental aspects of General Morphological Analysis. It furthermore suggests a process for classification of future outcomes in the context of long term defense planning. Lastly, it provides an example case where the method is applied to develop scenario classes for defense planning purposes in Norway.

2. The use of scenarios in defense planning

Scenarios are basic to planning of military capabilities. A NATO study (Campbell, 2010) observed that all of the nine nations contributing to the study used scenarios in some way or other for defining future force requirements.

Long term defense planning can be defined as "*the process of defining long-term defense objectives and a strategy for their fulfilment*" (Stojkovic and Dahl, 2007 p. 9). Thus defined, the planning process must consider politically determined objectives as well as technically defined force requirements. The process aims to outline a future force that can support the achievement of strategic objectives. Furthermore, defense planning usually takes place in a resource restricted environment. Hence, the final purpose of the planning process is to create a force plan that conforms to budgetary restrictions at the same time as political and military requirements are fulfilled. Consequently, what the planner is looking for is the most *cost-effective* solution to the force structure problem.

Considering the complexities involved, it seems obvious that the planning problem does not easily lend itself to simple calculation. In reality, the only reasonably reliable method is to execute a systematic search among predefined force structure alternatives which are then tested against a relevant scenario set.

The process may be – and usually is – implemented in two stages (Birkemo, 2013). In the first stage, the force structure alternatives are analyzed with respect to their inherent capabilities and costs. In the second stage, military scenarios are applied as testbeds to derive capability requirements. Scenario analysis may involve war gaming, the use of simulation models and/or considerations of national doctrine. In the final analysis force structure capabilities are compared to capability requirements in order to expose gaps and to direct the development of future force plans.

Capability based planning is sometimes set in contrast to threat based planning. This, however, is misleading, because, as Davis (2002) points out, capability based planning is also very much concerned with threats Davis (2002 p. 8). What it is not, however, is concerned with one specific threat and one specific scenario.[1] Instead, a diverse scenario portfolio is required for an adequate representation of the security environment.

Scenario based analysis for long term defense planning is considered best practice among NATO nations (NATO, 2003). The *NATO Handbook on Long Term Defence Planning* (2003) also stresses that an adequate diversity of scenarios must be applied in order for the scenario set to be

[1] In the NATO context, the shift from Threat Based Planning to Capability Based Planning came as a result of the collapse of the Soviet Union and the need to prepare for a wider spectrum of challenges.

sufficiently descriptive of future threats and challenges. Developing a specific scenario for every conceivable situation, however, is unpractical even if it were not also impossible. On the other hand, scenarios are representative of classes of situations, and several studies have approached this problem by implementing a two tiered approach to scenario classification (Campbell, 2010 p. 9-8). The first tier consists of scenarios defined as generic categories, whereas the second tier scenarios are case studies which can be allocated to either of the generic scenario categories. This process assumes that the total solution space – i.e. all types of situations that can accrue – can be synthesized in one overarching set of generic scenarios.

Generic scenarios and specific case scenarios have different functions. According to Birkemo (2013 p. 11) generic scenarios are employed to derive *mission types* that represent the entire spectrum of future challenges, while specific case scenarios are used for defining capability requirements. This point can be illustrated by an example taken from Norwegian defense planning. The generic scenario *Strategic Attack* represents a certain "class" of military challenges (i.e. a *scenario class*). Scenario classes provide a basis for defining the overall tasks and missions that a defense force is supposed to accomplish. In this particular case those tasks and missions are related to inter alia defensive military operations, protecting vital infrastructure and supporting the reception of allied reinforcements. Within the confines of this generic class of challenges, any number of different specific case scenarios may be defined having the same basic characteristics, but being more or less dissimilar in terms of overall scope, axes of advance, operational time lines etc. The case scenarios, thus, provide quantitative measures as to the specific capabilities that are required to accomplish a mission set.

This distinction relates to two different problem sets in defense planning. On the one hand, generic scenarios provide answers to the question of *what* the defense structure is supposed to accomplish, whereas case scenarios, on the other hand, establish *how* – in terms of available resources – this can be done. Capabilities, in addition, are versatile, so even a many-sided mission set may be served by a limited number of capabilities. Thus, the aim of the analysis is to seek out an optimal mix of capabilities, i.e. the least costly force structure that solves all missions.

This approach to scenario modelling distinguishes itself radically from conventional scenario methodology in its focus on the entirety of possible future outcomes instead of narrowly aiming for a reduced scenario field. Instead of down-selecting an infinite number of potential scenarios to the standard four scenarios of the Intuitive Logics method, the two tiered approach basically builds a typology consisting of qualitatively different scenario classes that frame the entire space of potential outcomes.

By implication, this also means that generic scenarios cannot be derived by considering the forces driving the system. Rather, generic scenarios are construed as static points in a parametrically defined solution space, and not as a process involving cause and effect relationships among variables. The next chapter will dig deeper into General Morphological Analysis as a methodological approach for the development of generic scenarios.

3. General Morphological Analysis

Morphological analysis – strictly speaking the study of forms – is well established as a method for modelling structural relationships between objects and phenomena in a number of scientific fields like botany, linguistics, geology and mathematics. A generalized version of the method was originally proposed by Swiss-American physicist and astronomer Fritz Zwicky (1898–1974) who used it for purposes ranging from astronomy to technological forecasting and social/political problem solving.

In its generalized formulation, morphological analysis can be defined as a general method for non-quantified modelling (Álvarez and Ritchey, 2015 p. 2). The method aims at identifying and structuring all possible aspects and solutions for non-reducible, complex problem spaces which in most cases involve human behavior and political choice. These problems are typically permeated with normative and judgmental processes, making them even less accessible to quantification or causal modelling. Finding solutions to such problems therefore require an uncompromising openness of mind to new, unexpected possibilities. Zwicky himself does indeed characterize the method as "totality research" (Zwicky, 1969 p 30).

The morphological process can be described as a dialectical progression through repeated sequences of analysis and synthesis. Regarding the most frequently applied post-Zwicky version of morphology – the method of the Morphological Box[2] – it moves ahead in five distinct steps (Zwicky and Wilson, 1967 p. 285; Zwicky, 1969 p. 115–120).

The first step requires an exact as possible formulation of the problem, admitting that a precise delineation of the matter at hand may be unlikely. In the next step the problem must be broken down into a parameter set that frames the problem. Each parameter must be precisely defined and an exhaustive and mutually excluding set of possible states, or *values*, pertaining to each parameter, has to be decided. The third step involves the construction of the morphological box – or multidimensional matrix – that contains all solutions related to the problem. A "solution" in this respect denotes a *shape* or *configuration* where one value is designated for each parameter. In the example below (see Table 3.1), the shaded cells represent one particular solution.

The morphological box contains within itself the entire *morphological field* (or the *problem space)* of the given problem. The problem space comprises all solutions that can be constructed on the basis of the parameter set. However, the problem space usually consists of a large amount of "noise" in the form of inconsistent – or impossible – solutions. The fourth step therefore entails a thorough analysis of the entire morphological field in order to reduce the amount of such noise, and to delineate a *solution space*. The solution space, then, is a refined subset of the problem space that only contains solutions that are considered consistent.

Consistency in this context is assessed on the basis of two criteria: Firstly, *logical consistency*, i.e. the internal relationships of the concepts involved cannot be mutually contradictory; secondly, *empirical consistency*, i.e. a solution cannot rest on empirically impossible or highly improbable assumptions.

In the fifth step the remaining solution space is surveyed and the best solutions are selected for practical application.

Even a relatively small morphological field may contain a prohibitively large number of theoretical solutions. This is evidenced by that fact that a matrix consisting of six parameters each with four values, as in the example above, contains $4 \times 4 \times 4 \times 4 \times 4 \times 4 = 4096$ different solutions. An examination of each and every one of the configurations in the matrix, therefore, would be an insurmountably complex task even for a moderately large morphological field. Luckily, there is a way around this problem. In most morphological fields, there are numerous value pairs that can be assessed as inconsistent, either on purely logical grounds, or empirically. Since the solution space cannot contain inconsistent value pairs, usually, the vast majority of the configurations in the morphological field can be eliminated from further analysis. The weeding out of inconsistent value pairs and, hence, inconsistent configurations, is done using a procedure called Cross Consistency Assessment. It is not unusual that this process reduces

[2] Zwicky worked with a number of different techniques related to morphological analysis. In addition to the method of the Morphological Box, these are, among others, Systematic Field Coverage, Negation and Construction, the Method of the Extremes, Reasoning and Action by Analogy, Generalization and Approximation, Flexibility of Scientific Truth, the Principle of Perfection and Imperfection (Zwicky and Wilson, 1967 p. 284).

Table 3.1
The Morphological Box can be presented as a matrix with the parameters in the top row and the values in columns under each parameter.

PARAMETER A	PARAMETER B	PARAMETER C	PARAMETER D	PARAMETER E	PARAMETER F
A1	B1	C1	D1	E1	F1
A2	B2	C2	D2	E2	F2
A3	B3	C3	D3	E3	F3
A4	B4	C4	D4	E4	F4

the morphological field by more than 90%. Even if this is not so, and it sometimes happens that a large solution space remains after the consistency analysis, increased structure and oversight of the morphological field will be gained.

In practice, the Cross Consistency Assessment is carried out by systematically working through the entire matrix assessing the consistency of each and every value pair. Since the number of pairs in a matrix increases at a much lower rate than the number of configurations when new parameters are added, a relatively small number of pairwise consistency assessments will suffice to analyze even a large morphological field (for a formal explanation see Ritchey, 2015). For instance, the 6×4 matrix in the above example, producing 4096 unique configurations, contains only 240 value pairs. This process, although simple in principle, can be exceedingly time-consuming if done manually, so a computerized support tool that presents results in an orderly fashion usually is required (Ritchey, 2006).

The outcome of the morphological process is an abstract description of the entire solution space, i.e. all possible solutions – or forms – related to a given problem. The solution space thus amounts to a classification, or a typology, of any given problem or phenomenon. A typology is generally multidimensional and conceptual (Bailey, 1994 p. 4). Thus, each solution – or configuration in the morphological field – is an internally consistent representation of real world phenomena that are similar and that can be grouped together.

In contrast to some classification techniques in the social sciences (see Elman, 2005 on the use of *explanatory typologies*), the morphological process does *not* make any theoretical claims or purport to explain a given phenomenon in terms of cause-and-effect relationships. The only information one can extract from the morphological process is whether a given solution is consistent or not, i.e. whether it relates to something that may exist in the real world. Hence, morphological analysis is as much a problem structuring tool as it is a means for analysis and modelling.

4. Modelling scenario classes for long term defense planning in Norway

In this section we will present General Morphological Analysis applied to the problem of creating an all-encompassing typology of scenario classes. The analysis was originally carried out as an assignment for the Norwegian Chief of Defense in order to provide a relevant scenario set for the Defense Study 2007 (see Johansen, 2006). For this work, a small group of subject matter experts was assembled to contribute ideas as well as to assure quality of results. Furthermore, major stakeholders within the Defense organization were consulted at vital turning points during the process.

Of course there are no fixed answers to exactly how this problem can be framed, what the essential parameters are, or how the internal consistency in the morphological field can be established. What follows is a concise summary of problems the group had to tackle in the course of the analysis.

4.1. Stating the problem

We begin by stating the problem: What are Norway's future security challenges and how can they be described? Before we move on, two things need to be clarified. Firstly, how can the referent object of the study be defined, and secondly what do we mean by a security challenge? To answer the first question, Norway is defined as a specific *territory* (i.e. the Kingdom of Norway), a *population,* and *state* institutions that enable the exercise of sovereign authority over the territory and the population. As for the last question, national security refers to the relationship between the state and its environment. Security challenges, thus, for the most part, are those that are external to the state itself. What the analysis, thus, seeks to clarify and describe are challenges to the security to the state of Norway as defined above, that primarily emanate from entities within the international system.

4.2. Defining parameters and values

Having stated the overarching problem, there are obviously an infinite number of ways to break it down into a parameter set. Maria Stenström states that good parameters should be *meaningful*, equally *important*, *abstract*, *straightforward*, *independent* of each other, and have many internal *connections* (Stenström 2013 p. 21–22).

The work group approached the problem by asking four simple questions: (i) which type of *actor* can be a source for security challenges to Norway? (ii) what type of *goals* in the security domain can be seen as relevant to a given actor type? (iii) which *methods* are relevant to actors in order to reach a specific goal? (iv) what are the *means* required to implement a specific method?

Thus, we have the parameter set of *actor*, *goal*, *method* and *means*. These parameters were assessed to be meaningful to the subject matter expert group, and to have an equal importance relative to the problem being analyzed. They also are abstract, straightforward, independent, and they have potentially many internal connections.

4.2.1. Actor parameter

The term “actor” denotes any generic type of actor operating in the international system that can represent a security challenge to a state. Note that we are not looking for specific actors, but rather representative types of actors.

Although there is no established procedure to define a fixed value set, two criteria must be satisfied: (i) the range of values must cover all possible states of a parameter, and (ii) there must be as little as possible (ideally no) overlap between values, whether they constitute a scale or just separate points with no particular internal ordering (Stenström 2013 p. 23). For the practical process of defining values, the same ideals apply as for the parameters. In addition, a useful approach in searching for a value range is to begin by deciding the end points, i.e. the largest and most comprehensive vs. the smallest and most constricted value. When the end points are defined, further analysis will determine what can be a suitable value range for the in-between.

The most comprehensive value on the Actor parameter obviously is a *state*. Hedley Bull asserts that states are “independent political communities, each of which possesses a government and asserts sovereignty in relation to a particular portion of the earth's surface and a particular segment of the human population" (Bull, 1977 p. 8). States are sovereign entities that do not accept any political authority above themselves. A state, thus, is the highest level of organization in the international system and, consequently, forms one end point on the actor parameter.

In the other end of the continuum a single individual clearly is the most constricted value. Individuals obviously are extremely limited in their abilities to operate as actors in the international system, let alone pose threats to a society and a state. However, technological development in all its aspects, including the interconnectedness of everything that govern people's daily lives, increasingly empowers single individuals as well as groups to threaten people and states. Consequently, we define individuals – including groups of individuals – as the low end point on the Actor parameter.

Between those two extremes, the number of potential intermediate values obviously is unlimited. Here, we will settle for two – *network* and *business enterprise*. Network organization is a product of technological developments that enable coordinated activities without regard to physical space, formal organization or large and complex infrastructures. The network consequently is the preferred form of organization for non-state actors that threaten Western societies.

A business enterprise is an organized entity that mainly engages in the pursuit of profit. While usually being of no particular security concern, business enterprises nevertheless might acquire relevance as security political actors by e.g. employing economically backed pressure against a government, or its agents might violate borders or engage in other activities that impinge upon a state's sovereignty.

4.2.2. Goal parameter

Next is the Goal parameter. Of course, the concept of "a goal" is perhaps even more nebulous than the concept of "actor". However, a workable approach to define a value range might be to focus on things that an actor might seek to achieve that may threaten or weaken the security of the targeted state. Again, we start by defining the most comprehensive value in the range. We determine this to be the overthrow of the existing political regime. Thus *regime change*, which obviously also implies the complete elimination of political sovereignty, is defined as the most extreme value on the Goal parameter.

As a counterpart to regime change, at the other end of the spectrum we define *economic gain* to be the most trivial goal that still might serve as motivation to actions that can have security implications for a state.

Having thus defined the end points of the value range, we move on to consider which values can be defined in the interval between the extremes. First, we focus on enforcement of *political concessions.* While both goals – regime change and the attainment of political concessions – play on the overarching ambition to impose one's will on (the government of) another state, it is presumed that the latter is the less demanding strategy both in terms of resources and risk.

Second, while being of a less aggressive nature, a foreign actor may maintain a high readiness of military forces involving exercise deployments and training missions. In addition, that actor may target a specific state in order to gather information for intelligence purposes, or maintain a general military posture that is more or less openly directed against another state. Thus, we define *military exercise/intelligence gathering* as the next lower level on the Goal parameter.

4.2.3. Method parameter

The Method parameter signifies alternative ways an actor can proceed to achieve a goal. In this sense this parameter is analogous to the concept of *strategy*. Again, moving ahead by delineating the extremes in the value set, the most comprehensive method that can be conceived of in this context is *establishing military control over the entire territory of another state*. Territorial control in this context is defined as the ability to deploy own forces at will in a given territory, while at the same time denying other actors' forces access to the same territory.

As an alternative and more limited method of military control, we define the establishment of *military control on limited parts of another state's territory*. "Limited", in this context, is used in a purely spacious or geographical manner. The degree of "limitness", however, may range from single points – e.g. a building or a small town – up to larger parts of a country's land territory.

As an even less comprehensive method for the application of military force, an enemy actor might conduct operations to deny an opponent access to certain areas or domains while not attempting to establish control in those areas in a military sense. This is a military method that lately has been termed *Anti-Access/Area Denial* (Thomas and Dougherty, 2013 p. 64–71). *Anti-Access/Area Denial*, thus, is defined as a separate value on the method parameter.

Control and denial of access involve the active use of armed force. An actor, however, may choose to employ military force purely for signaling purposes e.g. by engaging in threatening military maneuvers, conducting aggressive force deployments, putting forces on alert status etc. On the other hand, military deployment may be entirely covert or concealed, or indeed primarily intended to deceive or to create confusion. These activities do not entail the targeted use of weapons. We will designate this method *symbolic use of force*.

States also routinely deploy military forces for exercises, intelligence gathering etc. We will call this particular method for the employment if military force *peace time operations.* Although not hostile or threatening, this type of operation may anyway be of a concern, depending on factors such as geographical proximity, military posture, degree of political (dis)trust, etc.

In order to complete the value range on this parameter we also include relevant methods that do not necessarily imply the use of military force. We define the following three methods: firstly, *attack against infra-structure and/or civilian population*, secondly, the *use of economic force,* and lastly *criminality* (any activity that constitutes a violation of the legal code).

4.2.4. Means parameter

The Means parameter define both the type and the scope of resources available to an actor. Again we start with the most comprehensive parameter value, which we define to be *large scale use of military force*. This value implies the build-up, preparation and employment of sea, air and land forces in joint operations that are led on the strategic level of command.

On the next level we define *limited use of military force*. Of course, any use of force which cannot be considered large scale is in some sense limited. However, to be more specific we define limited use of military force to comprise the deployment of ready forces only (e.g. with little or no call up of reserves, transfer of forces etc.) that are led on the operational level of command.

On the non-military side we define the concepts *large scale use of non-military force*, and *limited scale use of non-military force* respectively. Non-military, in this respect, signify that the use of force is carried out by entities that are not part of any recognized military force. The difference in scale may not be entirely clear. For the purposes of analysis we draw a distinction between uses that require the concerted efforts of larger networks over time, and uses that that may be put into effect by individuals or smaller groups with limited input in terms of planning, materiel and personnel resources.

It also seems relevant to include means that primarily belong to the economic domain as a separate value. Thus, we include *economic sanctions* to the value set. Lastly, there are obviously any number of other means that may be used by an actor to achieve a particular goal or to support a particular strategy. However, we do not need to specify this any further, so the last value in the value range is simply *other means*.

Table 4.1
Multidimensional matrix.

ACTOR	GOAL	METHOD	MEANS
State	Regime Change	Military Control over Entire Territory	Large Scale Use of Military Force
Network	Political Concessions	Military Control over Parts of Territory	Limited Scale Use of Military Force
Business Enterprise	Military Exercise, Intelligence Gathering	Anti-Access/Area Denial	Large Scale Use of Non-Military Force
Individual(s)	Economic Gain	Symbolic Use of Force	Limited Scale Use of Non-Military Force
		Peace Time Operations	Economic Sanctions
		Attack Against Infra-structure/Population	Other Means
		Use of Economic Force	
		Criminality	

Table 4.2
Consistency matrix. Cells with an "x" indicate an inconsistent value pair. Open cells indicate that the relevant values are assessed to be consistent.

	State	Network	Business Enterprise	Individual(s)	Regime Change	Political Concessions	Mil. Exercise/Intel. Gathering	Economic Gain	Mil. Control Entire Territory	Mil. Control Parts of Territory	Denial of Access	Symbolic Use of Force	Peace Time Operations	Att. Infrastr./Population	Economic Force	Criminality	Large Scale Use of Force	Limited Use of Force	Large Scale Non-Mil. Force	Limited Non-Mil. Force	Economic Sanctions	Other Means
State																						
Network																						
Business Enterprise																						
Individual(s)																						
Regime Change		x	x	x																		
Political Concessions			x																			
Mil. Exercise/Intel. Gathering			x	x																		
Economic Gain	x	x																				
Mil. Control Entire Territory	x	x	x	x		x	x	x														
Mil. Control Parts of Territory		x	x	x	x		x	x														
Denial of Access		x	x	x	x		x	x														
Symbolic Use of Force		x	x	x	x		x	x														
Peace Time Operations		x	x	x	x	x		x														
Att. Infrastr./Population			x		x		x	x														
Economic Force		x		x	x		x	x														
Criminality	x	x			x	x	x															
Large Scale Use of Force		x	x	x			x	x			x	x	x	x	x	x						
Limited Use of Force		x	x	x	x			x	x						x	x						
Large Scale Non-Mil. Force	x		x	x	x		x	x	x	x	x	x	x		x	x						
Limited Non-Mil. Force	x		x		x		x	x	x	x	x	x	x		x	x						
Economic Sanctions		x		x	x		x	x	x	x	x	x	x	x		x						
Other Means					x	x	x		x	x	x	x	x	x	x							

4.3. Constructing the multidimensional matrix

Now that all parameters and parameter values are defined, the multidimensional matrix, or morphological box, can be constructed. In Table 4.1 the parameters are presented in the top row, while the values are placed in the columns under each parameter.

4.4. Cross consistency assessment

The matrix represents the entire morphological field of the problem, which is $4 \times 4 \times 8 \times 6 = 768$ unique configurations. The Cross Consistency Assessment involves a thorough examination of each pair in the matrix. Here, the number of pairs is $4 \times 18 + 4 \times 14 + 8 \times 6 = 176$.

The result of the Cross Consistency Assessment is presented in Table 4.2.

It is not practical to present an in-depth examination of each and every pairwise assessment in the matrix. However, a few comments can be made. Firstly, and perhaps surprisingly, the value pair *State – Military Control over Entire Territory* is assessed to be inconsistent. While this generally can be held to be a "true" value pair, in the context of this analysis (security challenges to Norway), we will have to find, firstly, at least one real world actor that may have a motive and, secondly, assess whether the relevant actor(s) has the capabilities to put such a strategy into effect. The analysis (see Johansen, 2006 p. 22–30) identified only one possible candidate – Russia.

This primarily methodological analysis is not the place for an in depth inquiry into Russia's military capabilities, posture or doctrine. Suffice it to note that given the extent of the required build-up of forces, the time needed for that to take place and the ability of Norway and the NATO alliance to put a defensive force in place, a strategy that seeks to establish military control over Norway's entire territory is deemed inconsistent with Russia's military capacity today and in a foreseeable future. All scenarios associated with this value pair, consequently, are also considered inconsistent. Note also that all scenarios containing the value *Regime Change* on the Goal parameter fall outside the solution space since it too presupposes the establishment of full territorial military control.

On the other hand, the less demanding method of establishing partial military control can plausibly be put into effect without a sizeable force build-up, primarily by enabling the effect of surprise. Scenarios associated with this value, thus, may be considered consis-

Table 4.3
Solution space.

State	Political Concessions	Mil. Control Parts of Territory	Large Scale Use of Force
State	Political Concessions	Mil. Control Parts of Territory	Limited Use of Force
State	Political Concessions	Anti-Access/Area Denial	Limited Use of Force
State	Political Concessions	Symbolic Use of Force	Limited Use of Force
State	Political Concessions	Att. Infrastr./Population	Limited Use of Force
State	Political Concessions	Economic Force	Economic Sanctions
State	Mil. Exercise/Intel. Gathering	Peace Time Operations	Limited Use of Force
Network	Political Concessions	Att. Infrastr./Population	Large Scale Non-Mil. Force
Network	Political Concessions	Att. Infrastr./Population	Limited Non-Mil. Force
Business Enterprise	Economic Gain	Criminality	Other Means
Individual(s)	Political Concessions	Att. Infrastr./Population	Limited Non-Mil. Force
Individual(s)	Economic Gain	Criminality	Other Means

Table 4.4
Scenario Class I: Strategic Attack (shaded cells).

ACTOR	GOAL	METHOD	MEANS
State	Regime Change	Military Control over Entire Territory	Large Scale Use of Military Force
Network	Political Concessions	Military Control over Parts of Territory	Limited Scale Use of Military Force
Business Enterprise	Military Exercise, Intelligence Gathering	Anti–Access/Area Denial	Large Scale Use of Non–Military Force
Individual(s)	Economic Gain	Symbolic Use of Force	Limited Scale Use of Non–Military Force
		Peace Time Operations	Economic Sanctions
		Attack Against Infra–structure/Population	Other Means
		Use of Economic Force	
		Criminality	

tent.

The outcome of the cross consistency assessment is a *solution space* consisting of 12 "surviving" configurations, or "scenarios". This represents a reduction of more than 98% compared to the total morphological field. The solution space is presented in Table 4.3.[3]

The solution space contains all possible security challenges to the object of the analysis, which in this case is a particular state actor – Norway. The analysis does not, however, end here. The solution space matrix gives little meaning unless the result can be synthesized into meaningful categories. We defined the goal of this analysis to be the construction of a set of all-encompassing scenario classes. The matrix will aid the formulation of scenario classes by providing a framework for this process. In the next chapter we will define a set of scenario classes based on the solution space.

4.5. Defining scenario classes

In defining scenario classes, what we are looking for is an exhaustive typology of security challenges. The process takes as its point of departure the solution space matrix. However, among the twelve unique solutions present in the matrix there may be certain solutions that overlap, or there may be sets of solutions where the division between them serves no practical purpose. This process starts with a thorough examination of the solution space matrix aimed at collapsing solutions that resemble each other into one scenario class (see Elman (2005) on *pragmatic compression* p. 300).

4.5.1. Scenario Class I: Strategic Attack

We start by seeking out the configuration in the solution space matrix that represents the most comprehensive military challenge. Logically, this would be any configuration containing the parameter value *Large Scale Use of Military Force* on the Means parameter. There is only one configuration in Table 3.1 which contains that value. Together with the values *State – Political Concessions – Military Control over Parts of Territory*, this configuration amounts to the most extensive military scenario in the solution space. It indicates the possibility of a state employing sizeable military force in large scale joint operations, establishing some degree of (temporary) military control to enforce political concession on another state actor. This scenario class is designated *Strategic Attack* (Table 4.4).

4.5.2. Scenario Class II: Limited Attack

Moving down to *Limited Scale Use of Military Force* on the Means parameter, this parameter value combines with *State*, *Political Concessions* and *Military Control over Parts of Territory*. In this case, however, the configuration also combines with *Anti-Access/Area Denial* and *Attack against Infra-structure and/or population* on the Method parameter. Taken together these solutions represent clearly a more limited employment of military forces than that portrayed by the scenario class Strategic Attack. We will call this scenario class *Limited Attack* (Table 4.5).

4.5.3. Scenario Class III: Coercive Diplomacy

Still focusing on configurations containing the parameter values *State*, *Political Concessions* and *Limited Scale Use of Military Force,* we identify two additional configurations that combine with, in the first case, *Symbolic Use of Force* and, in the other, *Use of Economic Force* on the Method parameter. Both of these configurations signify actions on the part of a state actor to coerce a targeted actor to alter behavior on some issue. Coercive strategies rely on the threat of force, but do not necessarily involve the use of force. They may, however, involve deployment of military forces or the application of *economic sanctions*, either in combination or as separate strategies. This particular sort of strategy is designated *Coercive Diplomacy*.

Coercive diplomacy is here thought of as an offensive strategy as

[3] Changing assessments on any value-pair would change this outcome, and a sensitivity analysis in order to test alternative assessments and their outcomes is recommended. An altogether alternative method is the Battelle approach (see Nguyen and Dunn, 2009) which applies a five point consistency scale in order to obtain a more flexible result.

Table 4.5
Scenario Class II: Limited Attack (shaded cells).

ACTOR	GOAL	METHOD	MEANS
State	Regime Change	Military Control over Entire Territory	Large Scale Use of Military Force
Network	Political Concessions	Military Control over Parts of Territory	Limited Scale Use of Military Force
Business Enterprise	Military Exercise, Intelligence Gathering	Anti–Access/Area Denial	Large Scale Use of Non–Military Force
Individual(s)	Economic Gain	Symbolic Use of Force	Limited Scale Use of Non–Military Force
		Peace Time Operations	Economic Sanctions
		Attack Against Infra–structure/Population	Other Means
		Use of Economic Force	
		Criminality	

Table 4.6
Scenario Class III: Coercive Diplomacy (shaded cells).

ACTOR	GOAL	METHOD	MEANS
State	Regime Change	Military Control over Entire Territory	Large Scale Use of Military Force
Network	Political Concessions	Military Control over Parts of Territory	Limited Scale Use of Military Force
Business Enterprise	Military Exercise, Intelligence Gathering	Anti–Access/Area Denial	Large Scale Use of Non–Military Force
Individual(s)	Economic Gain	Symbolic Use of Force	Limited Scale Use of Non–Military Force
		Peace Time Operations	Economic Sanctions
		Attack Against Infra–structure/Population	Other Means
		Use of Economic Force	
		Criminality	

Table 4.7
Scenario Class IV: Terrorist Attack (shaded cells).

ACTOR	GOAL	METHOD	MEANS
State	Regime Change	Military Control over Entire Territory	Large Scale Use of Military Force
Network	Political Concessions	Military Control over Parts of Territory	Limited Scale Use of Military Force
Business Enterprise	Military Exercise, Intelligence Gathering	Anti–Access/Area Denial	Large Scale Use of Non–Military Force
Individual(s)	Economic Gain	Symbolic Use of Force	Limited Scale Use of Non–Military Force
		Peace Time Operations	Economic Sanctions
		Attack Against Infra–structure/Population	Other Means
		Use of Economic Force	
		Criminality	

Table 4.8
Scenario Class V: Criminality (shaded cells).

ACTOR	GOAL	METHOD	MEANS
State	Regime Change	Military Control over Entire Territory	Large Scale Use of Military Force
Network	Political Concessions	Military Control over Parts of Territory	Limited Scale Use of Military Force
Business Enterprise	Military Exercise, Intelligence Gathering	Anti–Access/Area Denial	Large Scale Use of Non–Military Force
Individual(s)	Economic Gain	Symbolic Use of Force	Limited Scale Use of Non–Military Force
		Peace Time Operations	Economic Sanctions
		Attack Against Infra–structure/Population	Other Means
		Use of Economic Force	
		Criminality	

Table 4.9
Scenario Class VI: Military Peace Time Operations (shaded cells).

ACTOR	GOAL	METHOD	MEANS
State	Regime Change	Military Control over Entire Territory	Large Scale Use of Military Force
Network	Political Concessions	Military Control over Parts of Territory	Limited Scale Use of Military Force
Business Enterprise	Military Exercise, Intelligence Gathering	Anti–Access/Area Denial	Large Scale Use of Non–Military Force
Individual(s)	Economic Gain	Symbolic Use of Force	Limited Scale Use of Non–Military Force
		Peace Time Operations	Economic Sanctions
		Attack Against Infra–structure/Population	Other Means
		Use of Economic Force	
		Criminality	

when an actor actively seeks to change the status quo. Of course, the term coercive diplomacy in the academic literature as well as in the political discourse involves a much wider range of actions, not least verbal communication, than those defined in the morphological analysis (for an in depth analysis, see Schelling, 1966). However, a narrow focus on the physical aspects of coercion is validated by the primarily military and security purpose of this analysis (Table 4.6).

4.5.4. Scenario Class IV: Terrorist Attack

The analysis of the solution space matrix reveals that both *Network* and *Individuals* on the Actor parameter combine with Political Concessions on the Goal parameter and use of non-military means (both *Large Scale-* and *Limited Scale Use of Non-Military Means)* on the Means parameter. On the Method parameter, the only option combining with this value set is *Attack Against Infra-Structure/Population*. These value sets make up three separate configurations in the solution space matrix that confirm to *Terrorist Attack* scenarios.

It should be noted, though, that terrorist attacks in most countries, and certainly in Norway, are not in the first instance considered relevant to the external security functions of the state. Hence, it is not a firsthand matter for defense planning. Two factors, however, may indicate otherwise. For one, a terrorist attack may be so large that military action is required to fight or prevent it. Secondly, terrorist attacks may be prepared with active or passive support of another state or in countries with dysfunctional state and legal institutions, requiring intervention by military forces (Table 4.7).

4.5.5. Scenario Class V: Criminality

The scenario class *Criminality* represents scenarios where a private actor (*Business Enterprise* and/or *Individual(s)* on the Actor parameter) further their economic goals by illegal means. For the most part these are scenarios that have only marginal security political relevance but are matters for a state's judicial authorities. However, in some cases, economically motivated criminality may have a security political relevance. This might be the case when unlawful actions take place in remote locations, and it is only military forces that have the capacity to intervene; when a private actor operates as proxy for another state, or when enforcement of jurisdiction is delegated to the military by state authorities. This is the case for the enforcement of the United Nations Convention on the Law of the Sea pertaining to Norway's economic zone (Table 4.8).[4]

4.5.6. Scenario Class VI: Military Peace Time Operations

Military Peace Time Operations comprises any military operation on the part of a foreign state including exercises, intelligence collection or even covert operations that is unrelated to any other scenario class. Such operations are endemic features of inter-state military relationships, hence states normally allocate significant resources to monitor and, if it is required, intercept another state's military units. This particular class of challenge lies at the base of any state's security functions, thus, representing a "base line" scenario to its military establishment (Table 4.9).

5. Conclusion

We started out stating that conventional scenario methodology may be less effective in incorporating future shocks and discontinuities in the scenario set. Two factors in particular inhibit the possibilities to span the scenario canvas wide enough. First, the focus on and reliance on modelling the effect of driving forces and, secondly, the need to keep the scenario portfolio as limited as possible. These two considerations force scenarios to concentrate around observable trends and "most likely" developments. Especially in the case of defense planning a strong trend focus can have negative effects. The defense planner, more than most, has to take into consideration effects and developments that lie far beyond the normal operation of a state's security environment. Wars, after all, are rare and extreme events, but still they are what defense planning in the last instance is all about. So, a viable scenario methodology must, as a minimum, enable the analyst to identify developments that lie beyond the most likely trajectories, thus widening the scope of the scenario space.

Complex problems by their very nature consist of an infinite number of parameters and may produce an equally infinite number of solutions. Consequently, there are no answers or solutions that are completely "right" or completely "wrong". Applying morphological methodology to the process does not alter that fact. However, solving the problem or finding the right answer may not be the essential issue, but rather to finding something that "makes sense" – that works in a pragmatic sense – and the morphological approach may provide just that.

As the example case discussed in this article shows, the morphological approach is well suited to explore both the possibilities and the limits to future developments. It also comes with a number of other advantages.

Firstly, the morphological approach offers the analyst a structured process to the development of scenarios that leaves a clear audit trail, which is open to investigation by outsiders. Effectively, the final result can be retraced back to exactly which considerations produced a given scenario set.

Secondly, instead of focusing on a limited number of point scenarios in an unlimited space, the morphological process enables a generic classification of the entire solution space. This classification ensures, (i) that every generic security challenge is represented in the final scenario set, and (ii) that inconsistent scenarios are eliminated from the scenario selection.

Thirdly, by systematically exploring all possibilities to a problem,

[4] http://www.fisheries.no/resource_management/Area_management/economic_zone/#.V9h0GPmLSM8.

the morphological approach enables the definition and selection of outlying solutions just as much as those most likely and mainstream.

However, there are also challenges. One is obviously that a full blown morphological process may be demanding in terms of time and resources, and with – at least in the beginning – uncertain prospects of a useful result. Another is that the morphological process for a very large part rests on a lot of judgmental evaluations. This goes from the first formulation of a research question, through the definition of parameters and values, to the consistency assessment and selection of final solutions. This, however, is exactly where a sound and structured process has its place. In addition, by establishing firm criteria for the analysis of the morphological field, and making that process transparent, it is possible to communicate results to those who may apply results in practice as well as to the wider scientific community.

This leads to the final overarching challenge – can we be certain that the solution space actually is exhausted and that there are not unidentified scenarios that lie beyond the defined limits of the morphological space? The answer is, of course, that we cannot. This, however, is no different from any scientific process, the hallmark of which is that discoveries must be open to challenge when new evidence is brought to the table.

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