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Abstract

The Northern Sea Route is an area that is prone to wicked problems. Wicked problems are problems that are not predefined, nor do they have a single solution. They are problems that exist due to the opinions and wants of the stakeholders in the problem complex. The first part of *Future Risk Scenarios of the Northern Sea Route* revolves around operationalizing wicked problems into something analysable. As the problems are subjective, they are non-quantifiable, non-linear, non-delineated problems. One can therefore not use ontic quantities to reduce their epistemic uncertainty. In contrast one can use discrete models that reduce epistemic uncertainty in other ways models such as the general morphological analysis approach. Following this methodology, the thesis constructs a conceptual space containing the main dimensions that influence the Northern Sea Route, and the corresponding conditions it can take on. Through the process of cross-assessment of the criterion of whether different dimensions' conditions can coexist. The criterion of pairwise coexistence is constrained by logical, empirical, and normative assessments. Which leaves an interactive inference model in which one can investigate scenarios and scenario clusters that can realistically occur. By using this interactive inference model, the thesis identifies *East/West Relations*, *Global Environmental Politics*, and *Technical and Navigational Requirements* as the most pivotal dimensions for the formation of sates of affairs. The interplay between the connections in these parameters clearly forms distinct opposing scenario clusters for possible futures. The following discussion therefore delves into how the empirics of these dimensions and contends why they exclude or include specific scenario clusters. Concluding that *East/West Relations* determine the stability of the Northern Sea Route for stakeholders, whilst *Technical and Navigational Requirements* and *Global Environmental Politics* include and exclude stakeholders on a basis of sociotechnical and local environmental safety concerns. Effectively identifying relations, technology, and environmental politics as the strategic areas to target to shape *the future of the Northern Sea Route.*

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Chapter 1

Introduction

Before one delve into the explorers of old, and the agendas of new, a course must be charted. This course, the thesis, is a voyage through the uncertainty and risks that surrounds *the future of the Northern Sea Route.* The Northern Sea route is a system that is shaped and formed by the many that want to stake their claims along it. In other words it is a social system that is prone to what is known as *Wicked Problems.*

To tame *Wicked Problems* is not an easy task, and neither is the prospect of forecasting the future. The future, and *Time* itself is such a complex *Dimension* of existence, that everything that is inherently contingent on transitions in *time* become complex themselves. *Risk* and *Uncertainty* are two such *Conditions* of existence that are intertwined in the transition of going from one *State of Affairs* in time to another. The first stop on this voyage is therefore a theoretical chapter. The theoretical chapter is constructed with the concept of forecasting the future in mind, and as the only knowledge one can have of the future is that of expectation, that of *Inference*, this chapter is built around it. It starts by firstly, placing the reader into the context of inference, namely Societal Safety and Risk Management, and thereafter moves along the complexities of the forecasting through discussions of *risk*, *uncertainty*, *time*, and *wicked problems.*

With a bag packed with new terms, and the knowledge of the problems that lay ahead the voyage sets course for its second stop. This stop is at the port of strategy, where decisions are made about how to infer the future, and why. This stop is the methodology chapter. The first stop in this chapter is a discussion about what form of *Epistemic Tool* is suited to infer the future with reduced *Epistemic Uncertainty* when one cannot do it with quantitative methods, nor reduce *Intrinsic Ontical Uncertainty.* By breaking down the future to *states of affairs* the chapter identifies *Scenarios* as the best means of reflecting the future.

Continuing further into the methodology chapter one is faced with the problem of choosing an *epistemic tool* as a method of *inference* of *scenarios*. Through much deliberations it is found that *Morphological Analysis* is the best suited method for this form of *inference*, as it is a tool that largely deals with future *inferences* of *wicked problems*. The proceeding part of the chapter deals with the theoretical and practical aspects of *Morphological Analysis*, and culminates in a discussion about *inference* as knowledge in regards to contending the legitimacy of results.

With an even bigger bag of new terms, and more knowledge of the problems that lay ahead the voyage embarks upon the *morphological analysis* process. The *morphological analysis* method is a *epistemtic tool* that reduces *epistemic uncertainty* through the processes of *Concept Structuring*, *Cross-Consistency Assessment*, to create a *computer integrated inference model*, that is capable of *Iterative Model Overhauls*.

The first step in this process is therefore to describe the *Problem Complex*, *the future of the Northern Sea Route* within a *Conceptual Space*. Through *inductive* literary *Analysis*, one general, and one systematic the thesis identified the pivotal *dimensions* and *conditions* within the *conceptual space*.

The second step in this process thereafter go through the *Synthetic* process of *cross-consistency assessing* the different connections between these *dimensions* and *conditions*. This process reduces the *epistemic uncertainty* of the *inference*, by applying logical, empiric, and normative constraints to the *dimensions* and *conditions*.

The third step in this process is check the *configurations* that are *scenarios* that represent *states of affairs* to see if they conform to the *conceptual space*. In this voyage this step caused a total of 6 iterative model overhauls, but the documentation in the thesis only details the last one.

The fourth an final step in this process and the second to last stop in this voyage is the *inference of scenarios*. Which on this voyage was done with both a *contextual* and *non-contextual* backdrop to convey *inferences* that has value to humans such as *risk pictures* and to infer some general *traits* of this *problem complex*.

The last step is the bon voyage, the conclusion. The conclusion derives distillates all the most important facets of the entire journey, and culminates with some parting words on potential future research on *the future of the Northern Sea Route*.

With the course charted, let set sail!

Chapter 2

Background: The Region Under The Bear

The Arctic or *arktos* the "region under the bear" as coined by the Greeks as means of locating it, based on the constellation *Ursa Major* is the Northern most part of our globe (Liddell & Scott, 1897). The Arctic has been called the last frontier of humanity(Bloomfield, 1981). And for a long time, it has been portrayed as a desolate, cold, remote, and uninhabitable space where the great bear *Ursus Maritimus*, the Polar Bear roams indeed. Despite this claim, the Arctic has been inhabited, exploited, and explored by many over the timespan of human history.

Its earliest inhabitants and exploiters were the Inuit, after them came the Vikings, and with the Vikings came networks of trade cantered around the North Sea, Bering Sea, White Sea and so forth therefore one can imagine that they were not the only traders and inhabitants along these Arctic Shores (Perdikaris & McGovern, 2009; Le Mière & Mazo, 2013).

Later, during the age of discovery British and Dutch sailors in search of a North Western Passage to establish a trade-route to China and the Indies via Canada ventured into the seas of the high north (Vaughan, 1994; Fleming, 2011). During a likewise exploration the Dutch merchant Willem Barentsz happened upon Spitsbergen while searching for a North Eastern Passage (Vaughan, 1994; Fleming, 2011). This led whaling around the Svalbard archipelago, which later expanded into Greenland (Einarsson & Young, 2004).

The prospects of resource exploitation in the Arctic was therefore evident to a lot of other nations, which lead to the area not only being explored by also the stage of geopolitical contestation between nations (Vaughan, 1994). Within the Arctic nations themselves, rigorous exploration also took place and the Russians managed to make the first journey through the North East Sea Route by the mid-seventeenth century (Vaughan, 1994). It was not a continuous voyage, but the voyage went from the White Sea to the Bering Strait (Vaughan, 1994).

It was evident that the Arctic did not only hold vast amount of resources, but that it could indeed be an area where trade could prosper as well (Fleming, 2011). However, at the current point in time the continuous voyages could not be made due to the thickness of the ice, the technological insufficiency of the time, and the ever present natural hazards (Marchenko, 2012).Despite this obstacle, explorers, fishers, sailors, merchants, and traders continued their operations in the Arctic (Hoffecker, 2005; Einarsson & Young, 2004).

The British Admiralty even accelerated and expanded their search in the Arctic during the time post the Napoleonic wars (Fleming, 2001). Under the supervision of John Barrow numerous geographical and hydrological investigations were made (Fleming, 2001). Due to this continuous spark of interest transits through the North West and North East Passages took place between 1878 and 1906 (Fleming, 2001).

Not long after, in 1909 the North Pole was reached by Roald Amundsen. Many years of exploration, exploitation, and persistency in venture culminated in this apex of Arctic exploration (Fleming, 2011).

Meanwhile, the industrial revolution had arrived even in the Arctic and infrastructure sprung out in areas such as Svalbard, Murmansk, and Narvik (Vaughan, 1994). However, the wheels of progression also went around in the areas outside of the Arctic. Unfortunately, these were the wheels of the military industrial complex.

As such, the Arctic like many other regions became geopolitically important for the involved nations (Bourmistrov et al., 2015). During the First, Second, and Cold Wars military presence and contestation remained present in the Arctic to confirm, or dispute claims of supremacy (Bourmistrov et al., 2015). However, during this time the Northern Sea Route was continuously utilized by Russia for regional and international supply and transport (Marchenko, 2012).

After the Cold War however, the North Pole and the Arctic has been divided between the Arctic Nations, and the Arctic Council was established as a forum for discussion and policy enactment in coordination between the Arctic Nations (Petersen, 2009; Bloom, 1999). But as all affairs of men, both the explorers of old and the agendas of the new, there is an ebb and flow of opinions or wants of the many that claim their stake.

What is written of the past cannot be altered, but as one moves into the future there are many that want to write it, and of the top of the world in the Arctic there are many pens at hand. With effects of global climate change pressing down on the Arctic unlike anywhere else its impacts are felt by the flora, fauna, and weather in a myriad of ways (AMAP, 2012). Nevertheless, the change that has caused men to raise their pens once again is the changes to year-round and seasonal sea ice and fast ice (Le Mière & Mazo, 2013).

The melting of the ice sheets of the Arctic has seeded the prospect of using the Northern Sea Route as one of the main transport routes in the world global trade infrastructure. The Northern Sea Route stands out as a valid alternative to the Suez and Panama Canal's, in addition it bears the prospect of being less geopolitical tense than the Malacca Strait (Rahman et al., 2014). This opens the possibility of more, and more frequent continuous voyages from the Barents Sea to the Bering Strait.

The melting ice sheet has also attracted a lot attention from other kinds of stakeholders, such as the petroleum and liquefied natural gas industry, and tourism companies. What is in eyes of all the beholders is the same prospects of the explorers of old, exploration and resource exploitation. But as all conquest comes at a cost, the utilization of the Northern Sea Route will not be free (Bourmistrov et al., 2015; Østhagen, 2016).

The cost this time is not the blood sweat and tears that the explorers of old paid for guts and glory, but the planet itself. The Arctic's many ecosystems of communities and populations are under the constant threat of global and local emissions. In which these new industries pose as a local environmental hazards.

These prospects and challenges take place within the grand narrative of global geopolitics. In which actors within and outside of the Arctic stake their claims in forming the future of the Arctic. As a result, the Arctic is what one can coin a *Wicked Problem*, a problem not wicked in the sense that it is entirely evil or malicious, but in the way that no matter what decision is made, someone will want your head (Ritchey, 2011; Rittel & Webber, 1973). It is the way of social systems.

Much like the first settlers, the explorers of the past, and the conquerors of the North Pole, this thesis sets out to chart the areas that would previously be denoted where dragons dwell, or perhaps polar bears roam. Therefore, this thesis face a challenge much like the one of the first settlers, and explorers of the past that conquered the

Arctic. It seeks to chart the areas that would previously be denoted to be the areas where dragons dwell, or perhaps where polar bears roam.

The dragons in old sea charts were, however, not actual dragons, they were portrayals of the *hazards*, and *risks* that with *uncertainty* awaited seafarers in these uncharted seas. Hence, this thesis does not seek to uncover draconic agendas or empires in the north, but rather to extinguish the notion of these and bring some clarity to the prospect of *the future of the Northern Sea Route*.

Chapter 3

Research Problem

In order to investigate *the future of the Northern Sea Route* this thesis needs to construct a set of research questions which facilitate this. The first steps of the thesis will be to investigate how one can create an *epistemic tool* that lets one *infer* the future with reduced *epistemic uncertainty* in a context related to Societal Safety and Risk Management. As a result, the first research question can be distilled to:

R1: How can one create *risk pictures* of *the future of the Northern Sea Route*?

Consequently, with a tool for *inference* in hand, one can derive possible *futures of the Northern Sea Route*. The next steps of this thesis becomes about what one can *infer* from this *epistemic tool.* The final research question therefore writes itself as:

R2: What *scenarios* can one *infer* from this epistemic tool?

Chapter 4

Theory of Inferences of the Future

The problem complex of this thesis is *the future of the Northern Sea Route*, as such this seminal chapter is on the theory behind inferences. More specifically it is on the theory of inferences in the form of risk in the context of Societal Safety and Risk Management. The first two sections on this chapter are therefore devoted to the theory on the philosophy of science behind analysis and synthesis to create inferences within *systems theory*. The following sections is on the topics *risk*, *uncertainty*, and *time*. The final section of this chapter is on the *epistemitc and ontic uncertainty* of *wicked problems*.

4.1 Societal Safety and Risk Management: Inferences Contextualized in Systems

Societal safety and Risk Management is the common term used by Norwegian safety and security professional both within scientific research and within public and private sector (Engen et al., 2016). Hence, the term encompasses everything from disaster prevention and mitigation to prevention and mitigation of maliciously intended events (Engen et al., 2016). This thesis will not get into the nitty-gritty of how the different types of researchers decide to typologies themselves or others, but rather contend that its inherently a cluster of professionals that operate within a fuzzy multi-field that deals with different conceptions of event identification, prevention, and mitigation related to loosely or clearly defined systems, which their methods make inferences about(Aven et al., 2004).

4.1.1 Deriving Inferences from Systems

The reason that the words *events* and *systems* is used here is because they are inclusive categories. This lets one go around the vast semantic bog of differing terminologies and typologies for essentially identical or almost identical concepts or phenomena. This is not to say that there is no merit in these terms or types, it is more a nudge towards the need for general theory in this fuzzy multi-field. Hence, on the topic of a general theory one needs to consider what is at the core of societal safety and risk management as unifying term for this multi-field in science. Therefore, take it as given henceforth that when referring to societal safety and risk management, it is explicitly expressed that one is known with it being a fuzzy multi-field, and that practices may vary, but that for the sake of explanation it is generalized(Engen et al., 2016; Aven et al., 2004).

As fields in science, the societal safety and risk management clusters are largely concerned with types of system investigation (Aven, 2012; Aven et al., 2004; Engen et al., 2016). In broad terms *a system is a circumscribed object which consists of several components, which work together to cause an effect*(Ritchey, 1991, p.6-7). As such, one sees that the term system is so general that it can broadly encompass everything. This makes this term relatively flexible, but it should be emphasized that when one uses a system as a unit of investigation that *one is delineating it to be a specific system, at a specific time, and/or at a specific location. These delineations can and will vary, sometimes it may not be fruitful nor possible to make all these distinctions*(Ritchey, 1991, p.6-7; Ritchey, 2011).

Regardless, one sees that one can view the system from two foundational perspectives. One perspective where we see *the system as a primary unit* or a *black box.* Here one observes the system by inserting inputs and observing the outputs. The other perspective is to view the system as *a series of components that cause the effect of the system.* When observing the system from this perspective one examines the construction of the system, its internal structure, and sub-system/component processes and interactions(Ritchey, 1991; Gallagher, 1984).

4.1.2 Ontology and Epistemology

In meta-physics one distinguishes between two branches of philosophy. Ontology, which is the branch that deals with what exists in nature, the nature of what exists, or our universe/world itself (natural laws)(Rosa, 1998). Epistemology is the branch which refers to how one obtains knowledge, the process of how one obtains this, and whether we can justify this knowledge as sound(Rosa, 1998). Hence, system investigation is an *epistemic heuristic* or *tool* that lets one investigate what is ontically out there(Ritchey, 1991). Another word for an epistemic tool more familiar to the casual reader would be method. That is to say system theory revolves around methods that categorize knowledge in the same way.

4.1.3 Analysis and Synthesis: The Processes of Deriving Inferences from Anything

In the process of science, one divides the pursuit of deriving inferences about anything through epistemology into *analysi* and *synthesis* (Ritchey, 1991; Gallagher, 1984). Synthesis is akin to the black box view of systems theory. While analysis is akin to the component perspective. Albeit, almost all forms of science are categorized by a constant back and forth between these processes, there are however conditions in which either is more suited than the other. Which was perhaps made most eloquently evident by Bernhard Riemann in his work *Mechanik des Ohres*, in which he criticizes Herman von Helmholtz' *Die Lehre von den Tonempfindungen als physiologische Grundlage für die Teorie der Musik* based upon its epistemic approach rather than findings (Gallagher, 1984; von Helmholtz, 1863).

In the synthetic approach, one can make inferences about the effect of a system based upon having intimate knowledge about the system and the laws of nature, or rather having knowledge about its causes. (Gallagher, 1984)

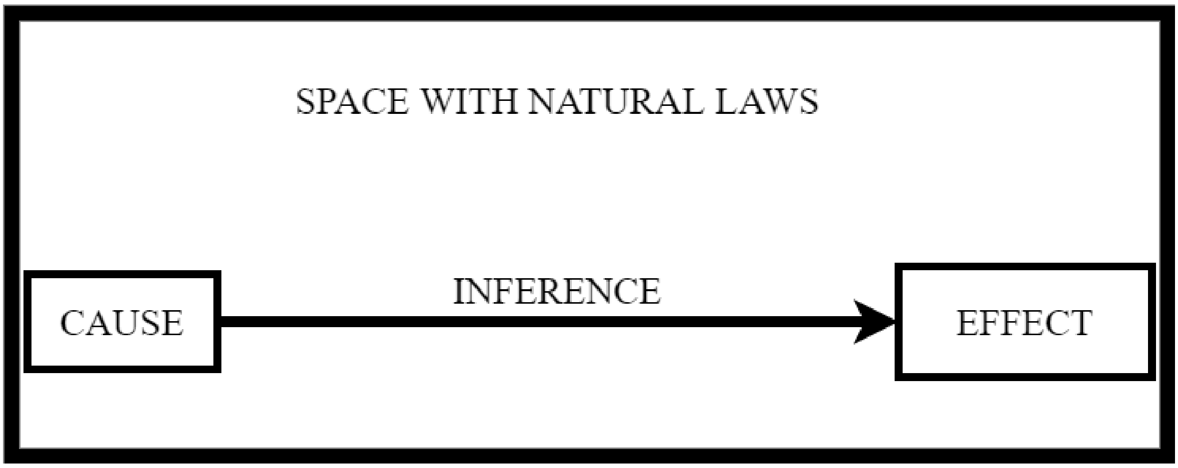

Figure 4.1: The synthetic route of inference.

When engaging in synthetic methods one infers the effects on the basis of causes. In broad strokes that means that one makes inferences about the given effect based upon our knowledge of the causes. Hence, synthetic methods requires one to have knowledge about the internal processes of the system, but not necessarily the output as one can deduce it by knowing the governing rules and interactive processes of the system (Ritchey, 1991).

In the analytic approach, one knows the effect of a system, but one seek to explain the effect in its unknown causes, or the laws of nature that influence the causes. (Gallagher, 1984)

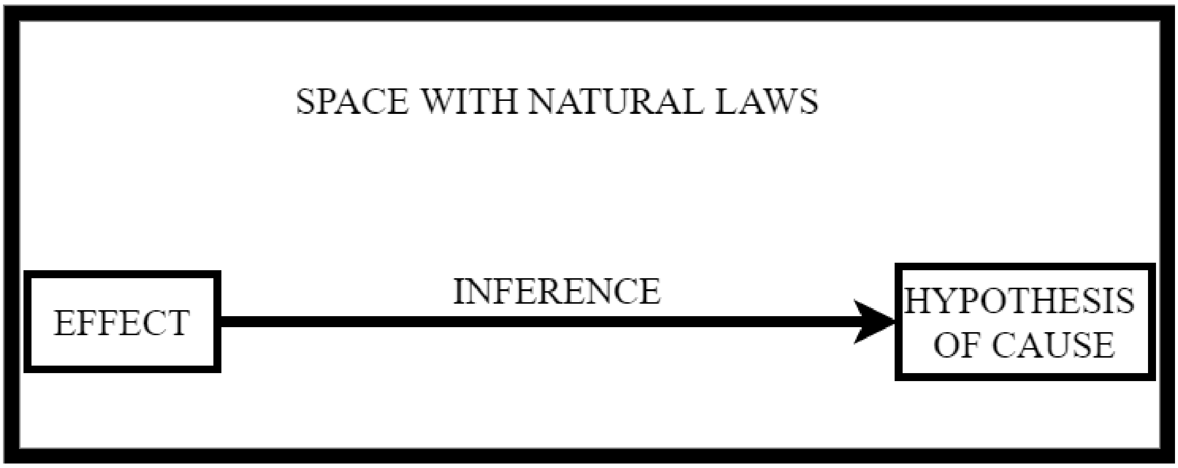

Figure 4.2: The analytic route of inference.

In contrast, when engaging in analytic models one draws conclusions about causes on the basis of effects. Hence, this means that one infers the cause of internal processes in the system based upon its effects. Effectively, meaning that one needs to have knowledge about the systems overall behaviour as in the output or effect, but not necessarily knowledge about the internal workings and governing principles that surround a system (Ritchey, 1991).

As this can be quite complex to understand for the untrained reader, an example from the technical disciplines of societal safety and risk management is in order:

Example: The Abrasive Water-Jet Nozzle

In the process of determining the safety of a nozzle for an abrasive water jet cutter one creates it with knowledge of the materials, laws of hydrodynamics, and thermodynamics in mind. Thereafter, one tests if it performs what it should without failure. This process of construction and testing the hypothesis is analysis. When one has knowledge of this nozzle, and its capabilities of cutting at up to 4000 bar of max pressure, one knows that *if it is then used with 2000 bars of pressure that it will likely not fail. This process of inferring that there will likely be no failure is synthesis.*

The example above describes a situation in which both processes work together to infer effects and causes based upon the knowledge available and experimentation with hypothesises in mind. In contrast, sometimes situations arise in which one infers without knowledge of cause, nor effect. In these situations, the practitioner commits to the fallacies of teleology and analogy (Ritchey, 1991; Gallagher, 1984).

An example of this that will make more sense later is:*to ascribe risk to an event as an intrinsic ontic quality of this event. While risk is not intrinsic at all it is a extrinsic quality of an epistemology* (Njå et al., 2017).

4.1.4 Conceptual Space and Problem Complexes

Another distinct trait within epistemology is the construction of *conceptual spaces*. Conceptual spaces are constructed realities that are supposed to represent objective reality. By creating conceptual space, one circumscribes the system to attain to this spaces rules, constellations of content, and temporal limits. It is a way of structuring the system, or the problem complex in the case of this thesis, into something analysable(Ritchey, 1991). Conceptual spaces go under many names: conceptual models, universes, universal sets, they are all the same and their use is interchangeable in this thesis.

The core idea is that a system's effect becomes inferable by isolating it to these spaces. When the laws of nature, and laws of the system are known, one can use synthesis to infer effects via causes. However, such a space relies on multiple analysis processes to come to be. These analysis effects are of *composition, function, and taks.* While analysis of composition is merely to list the contents of the conceptual space, analysis of function is derive the effects that components need to produce, and task is to find out the overall problem the system is trying to solve (Ritchey, 1991; Gallagher, 1984).

Out of all of these a task analysis is the only one that will eventually create solutions to the problems of the system. By dissecting the system through a task analysis, one goes through every single component and the system as a whole to derive the desired effects. When desired effects are known one can start to formulate solutions. This is the construction of the solution space through synthesis(Ritchey, 1991; Gallagher, 1984).

Solutions space contain all the solutions to a problem, which is any case is a lot of solutions. An analysis of tasks by the means of an epistemic tool, will at best find a *sufficient solution*, and in most cases find a *necessary solution.* In which sufficient solutions is the most optimal solution to a problem, while a necessary one is a solution to a problem that works but may not be the most optimal. One will deliberate on this later in the method chapter.

Consequently, the limitations in analyses and syntheses is that they will always be bound to their epistemic tool. One can never diminish the uncertainty, relativity, of the human element, nor have perfect information. In any case, as will be discussed later perfect information will not solve every single problem, because if it did, one would be within the deterministic space of the Laplace Demon (Ritchey, 1991; Gallagher, 1984; Njå et al., 2017).

4.2 Metaphysics of Risk, Time, and Uncertainty

4.2.1 Risk

Risk: Dichotomies in Paradigms

Risk is a word that everyone seems to have some kind of relation to, to some it means hazards and dangers, to others it means to stake something for gain, glory, or guts, whilst for contemporaries of societal safety it something one cannot entirely agree upon. Contemporaries like Aven, Braut, Njå, and Solberg have all followed the etymological route to deduce its origin or meaning, but as the latter three found there was no resound agreement about this (Njå et al., 2017; Aven et al., 2011; Aven, 2012).

Then how can one answer the most conflagrating question in societal safety and risk management: What is risk? One must first understand where this match is lit, or conflict arises. One can trace this back to societal safety being a fuzzy multi-field of scientist from different disciplines. Within the scientific sphere revolving around risk, one have numerous different definitions, understandings and, uses for risk . It is viewed as a measurement, a methodology, a concept, and a phenomenon (Rosa, 1998; Solberg & Njå, 2012). However, much like the concept of democracy, freedom, and, peace the variations in interpretation of the definition and use of risk as a concept can become a semantic bog.

Yet, distinguish two dominant paradigms of meta-philosophical understanding of risk that internally vary (Rosa, 1998). The first understanding that is clearly distinguished is what Rosa called the *positivistic paradigm*, the technical risk analysis, or rational actor approaches. The second understanding is the *constructivist paradigm*, rooted either in cultural theory or similar social construction theories. Where these theories differ in broad strokes is in the understanding of the part of metaphysics that is concerned with the ontology and epistemology of this world.

In the positivistic paradigm, the world is seen through the eyes of the ontology of realism. That is the belief in that the world exists independently of us humans and can thus be objectively examined independent of humans as subjects. This view sees risk as something that exist and something that is known; hence it is both ontological and epistemological in the sense of philosophy of science. Knowledge of risk can therefore be derived from the process of logical empiricism through the rigorous process of science that can pass the three-part test(Rosa, 1998). In the case of risk, this process would be a risk analysis. Which are processes which has consistent internal logic, empirical support, and predictability of outcomes under like conditions. However, this approach rests on the relationship between the realist ontology and its corresponding understanding of epistemology. As one can obtain objective knowledge about the world, void of subject one reduces the epistemology of the world to that which is only obtained by scientific methodologies. Risk as phenomena or casual mechanism is therefore in this view something that exists due to its explanation in scientific reality, and due to its scientific nature its neutral towards bias, ethics, and societal impacts. The power of the distillation of the unknown and abstract into logical, mathematical, and semantically explainable terms through the scientific method thus becomes a double-edge sword. The power of explanation and presentation comes at the cost of voiding the subject interaction with the object. As Rosa points out, and which should be evident within itself; risk analysis processes are conducted based upon value-statements from individuals and organization. Hence, by conforming to this reductionism of the world into objective-realism this paradigm fails to explain its own origin (Rosa, 1998).

The opposite paradigm of the positivist paradigm is diametrically opposed as it takes the subjects interaction with the object but voids the object . The constructionist or social theory paradigm springs from the metaphysics of relativism . Relativism is a form phenomenological philosophy, where phenomenon is separated from our ontology of the world . Hence, the lack of separation or distinction between ontology and epistemology is also a reductionist step taken in this paradigm. In this paradigm however, the distinction is not in the direction where our epistemology is evident due to our examination of a real and objective world, but in the direction that risk is a social construct. In this view, risk is therefore a phenomenon that exist because humanity wants it to exist, its scope, mechanism, and probability is therefore humanity defined. This paradigm therefore vows a lot of attention to risk identification and risk evaluation as them being human constructs. Hence, the reality of this paradigm is centred around risk as construct of social design, culture, or/and language. Though, it fails to eloquently address whether risk really exists, and whether the world is probabilistic or deterministic in design(Rosa, 1998).

Risk: Epistemic Conditions and Required Distinctions

Departing from the previous discussion of paradigms of risk as largely prescribed from Rosa, one may be non-the-wiser about what risk is. This breakdown of paradigms elucidates the dichotomy in a discussion about whether risk is an object or subject of our world (Rosa, 1998). Two other contemporaries that muddle through the ontological and metaphysical existence of risk is Solberg and Njå (2012). In their lengthy discussion whether risk can ontologically exist, they extrapolate that risk as an ontic concept relies on the epistemological conditions:

(I) Risk relates to an *event* (II) This event takes place in *the future* (III) This event has a *consequence* of either *positive* or *negative* nature (IV) involving *something humans value* (V) shrouded in *uncertainty*. In addition, for risk to exist there needs to be a reality-possibility distinct (Solberg & Njå, 2012).

The reality-possibility distinction simply put is the belief in that risk is tied to the possibility or perceived possibility of altering the future (Zinn, 2008). Solberg and Njå contests that the temporal condition of this statement might not hold true. In short, time relies on a tense, a flow of one *state of affairs* or status of the world to another. The epistemic conditions of the presence of an event and a consequence need this tensed transition to happen. This in turn may allude to that one needs some sort of full-future world of casual-deterministic nature as well. In turn, this creates the condition that when risk is the mechanism from one state of affairs to another, then the future or the new state is the only state that can occur. As all other probabilistic outcomes of the specified outcome space of risk will not occur (Solberg & Njå, 2012; Ritchey, 1997). The conditions do however cause risk to be paradoxical as the mere concept of determinism excludes risk, as risk needs the possibility-reality distinction. Without the ability to alter the future, risk just becomes a sign for an already predetermined future, hence as Solberg and Njå quite eloquently puts it: *(...) risk would be nothing more than something upholding the "illusion" of free will*(Solberg & Njå, 2012).

4.2.2 Is Risk Uncertainty?

Before one expands upon uncertainty as an ontic quality of the future, it seems prudent to first extinguish the misconception that risk and uncertainty is the same. The truth to the matter of uncertainty is that there is a misconception around the word (Ritchey, 1997). The misconception is that risk and uncertainty is often one and the same thing, however it is not. The most eloquent distinction of this comes through Ritchey's paraphrasing of different facets within Knight's *Risk, Uncertainty, and Profit* 1921:

"*(. . .) Uncertainty must be taken in a sense radically distinct from the familiar notion of Risk, from which it has never been properly separated(. . . .) The essential fact is that "risk" means in some cases a quantity susceptible of measurement, while at other times it is something distinctly not of this character; and there are far-reaching and crucial differences in the bearings of the phenomena depending on which of the two is really present and operating. (. . .) It will appear that a measurable uncertainty, or "risk" proper, as we shall use the term, is so far different from an un-measurable one that it is not in effect an uncertainty at all*" (Ritchey, 1991 24; Knight, 1921).

Knight clearly distinguishes here that what we call risk is something measurable. If one takes into consideration the distillation of risk into its five epistemic conditions this must be said to be true. When one does a risk analysis one tries to root a problem complex into reality by using a model that lets one gather knowledge of the world, this is an epistemological tool. Risk Analysis is the employment of epistemological tools that includes those five conditions. In which uncertainty is often taken as something that experts determine.

In mathematical terms of statistics, one would say that risk is analysis into known outcome spaces, since we follow a methodology that looks for specific facets, one knows what one is looking for. However, uncertainty is what we do not know what we cannot know, it is an unknown.

4.2.3 Uncertainty

4.2.4 An Ontic Quality of the Present, Future, and the Past?

The dissection of the relationships between, time, knowledge, and uncertainty has already been eloquently discussed by Njå, Braut, and Solberg as such this section follows their reasoning in investigating uncertainty. Hence, the section will move from time to knowledge. As such one shall first touch upon the concept of states as it broadly used in the thesis and in this material. Briefly within the section on risks and its epistemic conditions and required distinctions one touched upon the concept of state of affairs. A state of affairs is the current situation of things, it can be the present state, the past state, the future state, or it can be the non-expressed variations of each of these. Hence, in this thesis whenever a state is mentioned, it should be taken as a state of affairs (Solberg & Njå, 2012).

As one can see, state of affairs appear in time, but what is time? Time as a concept that is used in everyday life is what one might call Newtonian time with a past, present, and future. However, the concept of measuring time has nothing to do with time itself it is human construct to create relatable points. In Newtonian time the past is all time that became before now, the present is the transition in time from past to future, and future is the abstraction of all time beyond now (Njå et.al, 2017, p.12).

On the topic of time there are various theories that contend different points, but the most controversial one as pointed out by Njå et.al is whether the future is real. *Eternalists* argue that all events in time exist, *possibilists* see the present and future as real, and *presentist* argue the present is real. However, McTaggart in his essay *The Unreality of Time*, sees an inconsistency in Newtonian time. Events or changes in state of affairs in McTaggart's view move through past, present, and future, and as such time in the Newtonian sense is unreal as the states of affairs of the different tenses would be incompatible (Njå et.al, 2017, p.12-13; McTaggart, 1908).

To discuss this McTaggart introduced two time series A-series and B-series. A-series is time with the time categories past, present, and future where events are seen as in relation to another in the sense that they happen before, simultaneously, and after another. However, this theory is not in line with the theory of relativity (Njå et. al, 2017, McTaggart, 1908)

B-Series on the other hand is a tense less time series, where all events relate to another all the way from the Big-Bang to the future. As such all events that have happened, all that are happening, and those that are yet to happen are equally as ontically real as time is relative (Njå et. al, 2017, p.13-14; McTaggart, 1908). In relation to the concept of uncertainty Njå, Braut, and Solberg raises the question of whether uncertainty is contingent on how time is interpreted which they answer its partly yes. In dissection they make it clear that: (1) It is not clear whether uncertainty pertains only to the future, (2) if one adheres to a B-series timeline then an unreal future would be of no relevance, since in time-space relativity is does not exist, (3) if the future is unreal it does not exclude any logical possible future states (2017, p.13; McTaggart, 1908).

This leaves one in the discussion of knowledge. A common misconception within the world of science and especially societal science is that if one has enough information about the world then one can control it, however this implies the sort of deterministic system present in the Laplace Demon, which would make any attempt at controlling it futile (Njå et al., 2017). In addition, uncertainty is something ontic not epistemic, its not like risk which is a set of epistemic conditions under one concept, it is a characteristic of the future (Ritchey, 2011; Njå et.al, 2017, p.14).

A further dichotomy to make is the difference between knowledge one derives from hypothesis and the knowledge that is. The knowledge that is, is certain, it is experience, it is proven and of objective reality as something ontically real until proven otherwise. The knowledge one derives from a hypothesis is the result of the iterative process of analysis and synthesis, it is an interpretation of the knowledge that is through an epistemology targeting certain knowledge in a constructed reality of a conceptual space. This reality adheres to the rules chosen for it and is only made up of the content chosen by the epistemology. Hence, it is not complete knowledge, it is not the knowledge that is, it is a prediction of the knowledge that is in another state of affairs, it is an *inference*(Njå et al., 2017).

This brings one back to the concepts of sufficient, and necessary solutions in which one must contend that in foresight that one can never really provide a necessary solution as the actual effect of the system is not given. What is given is the laws of nature, and consequently also uncertainty as uncertainty cannot be deduced by the attainment of more knowledge. Because uncertainty runs parallel to knowledge, it is the expression of all the states that can and cannot happen. This means that uncertainty is an ontic quality of the future as phenomenon (Njå et al., 2017).

4.2.5 Future Knowledge

Taking these perspectives into account one must ask like these contemporaries what knowledge one can have of the future. In which one must argue that one has no knowledge of the future since this is uncertainty. Ontological uncertainty cannot be reduced through epistemology, what is reduced is epistemological uncertainty. Epistemological uncertainty is however a facet of the present and the past and not the future and is completely removed from the future in the ontological sense (Njå et al., 2017).

As a result, when a risk analysis says that they are estimating the uncertainty of an outcome they are not actually estimating ontological uncertainty but rather the uncertainty in their epistemology. This must then be contended to seem quite arbitrary to the future as this uncertainty then is related to only past and present and is entirely separate from the future. What one must then see it as is a reduction of uncertainty with relation to a different constellation of the present or the past (Njå et al., 2017).

Consequently, if one then were to predict whether something could happen in the future based on such estimations then one would infer effects based on teleology of epistemology. That is to say, that any prediction of the future is relative and subjective (Njå et al., 2017).

4.2.6 Wicked Problems: The Problem with Subjective Reality

At this point, it is evident that scientific inference is already a highly complex process. To make matters even more complicated scientific inquiry also deals with subjective realities. Subjective realities are the result of human social systems. In these systems what comes to be as an ontic quality of the future is the result of a stakeholders wants and beliefs. These wants and beliefs are entirely relative to the stakeholder's current cognitive heuristic(Rittel & Webber, 1973; Ritchey, 2011).

This causes *Wicked Problems*. *Wicked problems* are problems that are not predefined, nor are there solutions known. These are therefore not *puzzles* which are well defined problems with a single solution, nor *problems* which are well-defined problems with various solutions (Stenström, 2013; Pidd, 1997; Rittel & Webber, 1973).

In scientific terms they are non-quantifiable, non-delineated, non-linear, unknown, and uncertain. Simply speaking, one cannot know of these problems until they occur (Ritchey, 2011). In the following section it will be touched upon how one can try to infere these.

Chapter 5

Method

People who write about methodology often forget that it is a matter of strategy, not of morals. There are neither good or bad methods but only methods that are more or less effective under particular circumstances in reaching objectives on the way to a distant goal (Homans, 1949, p.330).

In the spirit of this quote by Homans, this chapter is devoted to the detailing of this thesis' strategy towards methods. As a consequence, this chapter follows the process of going from a set of wicked problems to the creation of morphological analysis inference model. The first step in this process is to detail why *scenarios*, and subsequently a *computer integrated inference model* was chosen to create risk pictures of *the future of the Northern Sea Route.* The second step is to familiarize the reader with *morphological analysis* as a method, and the inner workings of this method. Thereafter, a summary will be given of the practical steps of *morpohological analysis*, before the chapter culminates in a discussion on the *limitations*

5.1 The Ontic Dilemma

In the theory chapter one finds a discussion that deals with the concept of risk as an ontological phenomenon (Solberg & Njå, 2012). To summarize this discussion: it culminates in the conclusion that one can perhaps model some forms of risk from an ontological perspective if one views risk as an inherent phenomenon in objective reality (Rosa, 1998). Risk within this thesis can in contrast not be described as entirely of objective reality. As the Northern Sea Route as a system is governed by humans, it as a system will contain subjective decision-making. Consequently, the system is not only prone to wicked problems, it is inherently run by wicked problems (Ritchey, 2011).

More specifically, this means that quantitative risk analysis methods cannot be used as epistemic tools in this instance (Ritchey, 2012). The system is a social system, and is therefore run by the social, political, and cognitive decisions of stakeholders . In other words, this means that the problem complex of predicating *the future of the Northern Sea Route*, is within an outcome space of genuine uncertainty(Solberg & Njå, 2012; Knight, 1921). Quantitative methods rely on objective qualities, which one can quantify, opinions and wants cannot be quantified in a meaningful way, nor can their effects be expressed in the same way. Moreover, one must as a result assume that the system is non-linear as in everything will affect everything(Ritchey, 2011).

In other words, one cannot utilize traditional quantitative risk analysis methods as one cannot make inference about the effect of the system, based on causes one cannot analyse. Consequently, one needs to take steps to make the system analysable in other ways(Gallagher, 1984). The solution therefore becomes to utilize an epistemic tool that can enables us to analyse the problem complex, so that inferences can be made from it (Ritchey, 1991; Gallagher, 1984; Ritchey, 2012).

5.2 The Requirements of an Epistemic Tool

In order to make the problem complex of this thesis analysable, one needs to employ a method as an epistemic tool that lets one infer possible future states of affairs (Strand, 1999; Solberg & Njå, 2012). However, as already argued the traditional quantitative methods of risk analysis will not suffice to reduce the uncertainty of the epistemic tool.

As a consequence, one needs to utilize a method that allows for the reduction of epistemic uncertainty by way of other methods. By referring to the initial five epistemic conditions of risk, one can deduce what empirics one needs to detail to create a risk picture. In addition, with regards to the wicked problem aspect of the problem complex a solution is evident. By utilizing a method that derives inferences of static states of affairs one circumvents the uncertainty of the subjective preferences and wants of stakeholders(Solberg & Njå, 2012; Njå et al., 2017; Ritchey, 2011)

5.3 Scenarios as Inference of the Future

Inferences are the predictions of possible future states of affairs derived from an epistemic tool. In businesses, governmental agencies, policymaking, and in the military scenarios are often produced in order to experiment or make inferences about possible future states of affairs (Varum & Melo, 2010). Scenarios are often utilized within the multi-field of societal safety and risk management as well, and they have been functionally employed as risk pictures before(Carbonell et al., 2017; Solberg & Njå, 2012; Rosa, 1998).

Accordingly, scenarios seem like an appropriate risk indicator to make inferences from. The contention to this is that there is no general theory for scenario building and as a result it is used in different ways, with different methods, to serve different ends (Varum & Melo, 2010).

To find a necessary approach that will address all the requirements that the thesis has to an epistemic tool, one must consult scenario theory. In Börjeson et.al a concise typology is given with regards to scenarios (2006). In summation the commonality one finds in all scenarios is that they are intended to predict the future, but the intent behind the use of them differ. According to Börjeson et.al there are two general distinctions to make about one a system before constructing scenarios:

1. The system as a delineating property.
2. The external/internal distinction.

(2006, p.725-726)

Simply put, before one can begin constructing scenarios one needs to (1) define the system one is investigating, and (2) define whether one is looking at effects/causes that are external or internal to the system. With these conditions in mind, one thereafter need to establish what the purpose of the scenarios are. According to Börjeson this is often given by way of which way one thinks about the scenarios, in which they say that there are three starting points:

1. *What will happen in the future?*
2. *What can happen in the future?*
3. *How can a specific future be reached?*

(Börjeson et. al., 2006, p.725-730)

The differences in these ways of thinking are striking. While (2) clearly is scenario creation with inference in mind, (1) and (3) reflect another form of thought. The difference here is that (1) and (3) clearly supposes that one can use scenarios reduce uncertainty of the future. This is in stark contrast to what has been contended earlier in the theory. One cannot however say that is entirely unfounded.

The difference in thinking is that (1) and (3) supposes that one has agency of the system. This is the perspective found within a lot of operative societal safety and risk management professions, and the general thought here is that with enough information about the future one can control it in its entirety, the Laplace Demon(Börjeson et al., 2006; Njå et al., 2017). The fault of this way of thinking is that it is entirely deterministic, and neglects to address uncertainty(Solberg & Njå, 2012; Njå et al., 2017). In other words, if one can control the future with perfect information, it means that any information one gets is already determined to be given to you, and any information you neglect is determined to. Nevertheless there is an unprecedented conception that one through agency makes ones inferences about the future self-fulfilling(Njå et al., 2017).

As a consequence, one must argue that (1) and (3) are not ways of thinking fit for inference as they are inadvertently deterministic. Börjeson et.al goes onto create typologies of scenarios into further. The rudimentary principle of this further typology is that scenarios are created within different conceptual spaces of defined rules and information, and that there is different agency behind(Börjeson et al., 2006). As a result, some scenarios entirely synthetic, some are entirely analytic, and the use of the scenarios are contingent on both. Nevertheless, as the requirements of the thesis' epistemic tool is already known there is no need to anchor the scenario building to any typology, as typologies are general types(Ritchey, 1991).

Börjeson et.al also delves into the epistemic tools for scenario creation, which they coin as techniques. This further typology goes into the sub-types: *generation*, *integration*, and *consistency checking* (Börjeson et al., 2006).

Generating techniques are largely inductive data collection methods that are concerned with the collection and generation of knowledge. The methods listed are largely interview based methods such as the Delphi-method and workshops, or surveys. It must be contended that this typology neglects literary/document analysis (Börjeson et al., 2006).

Integrating techniques are concerned with the integration of this data into computer systems, that utilize quantitative, and logic based mathematical environments, to hypothesis test it under controllable conditions. This reduces epistemic uncertainty of outcome by way of experimentation(Börjeson et al., 2006).

Consistency checking techniques are concerned with the checking of the integrity of the concepts involved in integration model, and effectively weeding out any internally contradictory or incompatible relationship between variables to find the internally consistent ones. This reduces epistemic uncertainty of outcome by way of logical elimination(Börjeson et al., 2006).

This typology of sub-types makes it clear that there is no general theory of scenario building, there are variations that employ partial or all techniques suggested here. Before concluding their paper Börjeson et.al makes a casual reference into the prowess of General Morphological Analysis, as a technique that employs all these techniques (Börjeson et al., 2006).

Consequently, further induction into general morphological analysis showed that it is well suited as an epistemic tool for the inquiry into wicked problems. In fact, it is used almost entirely to deal with wicked problems (Ritchey, 2011).

5.4 The Chosen Epistemic Tool: Morphological Analysis

The induction into *morphological analysis* as an epistemic tool yielded that it meets with all the thesis' requirements. Consequently, the following sections are devoted to detailing what morphological analysis is, how it works, how it meets the requirements, and how it is used in the thesis.

5.4.1 Morphological Analysis: What is it?

Morphological analysis is a method that can be used to generate, integrate, and consistency check new phenomena, concepts, and the like. It does so through the examination of the shape of a whole by studying the objects, which conform to the whole (Ritchey, 2011).

From von Goethe to Dilthey and Weber

The first mention of morphology stems from von Goethe which used morphology in attempt to distance the life-sciences from Newtonian mechanics by focusing on how morphotypes or rather the form and quality of organic bodies, influenced formation and transformation (Ritchey, 2011).

In life sciences today, it is the Darwinian evolution paradigm that dominates, not von Goethe's morphology, but it was adopted by others. Classical German Sociologists such as Wilhelm Dilthey and Max Weber adopted the concepts of morphology and named it typologies(Ritchey, 2011).

The difference in typologies and morphologies can first and foremostly be derived from their classical Greek names that quite clearly distinguishes this. Morphology comes from the ancient Greek word of *Morphê*, which means shape or form. This is in contrast to another classical Greek word *Typos* which means hollow mould or matrix(Ritchey, 2011).

In morphology, one is concerned with describing how something conforms to the whole. In other words, how something relates to the natural shape of the whole. In typology one is in contrast concerned with arranging concepts, traits, and characteristic under a type. In other words, one creates constructed wholes(Ritchey, 2011). Another term for these two processes, is *concept structuring*.

In broad scientific terms concept structuring is a way of reducing epistemic uncertainty. Yet, these two methodologies do it in diametrically opposing ways. In typology epistemic uncertainty is reduced by arranging concept, traits, and characteristics that are similar under constructed types. In other words, one defines the task or function of what one is investigating. In morphology epistemic uncertainty is reduced by assessing which dimensions(parameters) conform to the whole, and subsequently which of these dimensions' conditions(values) constrain each other (Ritchey, 2011, 1991).

The Father of Modern Day Morphology: Fritz Zwicky

The divide between typology and morphology can be traced to a single person: Fritz Zwicky. His name may not be familiar to laymen today, but in his prime Fritz Zwicky revolutionized multiple fields involving science, technology, engineering, and math (STEM). He was first and foremost a very renown Astrophysicist, but he is known as the "father" of the modern-day Jet-Engine and was one of the first people to map dark matter(Ritchey, 2011).

In his work as a maverick in science he employed what he termed as *morphological research*, by using his *morphological fields* and *Zwicky boxes*. The morphological field can appear very much like a typology. In contrast it is not a typology, but the first step in creating a morphological field is akin to typologies(Zwicky, 1967).

The first step in creating a typology is to create a two-dimensional matrix in which the left side of the matrix represents a parameter and its values, and the topside another parameter and its values. The remaining fields give us the ideal types or the configurations of parameters. This methodology is limited to two-dimensional space(Ritchey, 2011).

Fritz Zwicky used morphological fields which are similar matrixes that represented n-dimensional space. This n-dimensional space is often characterized as the Zwicky box. The Zwicky box is an n-dimensional box that contain the internally consistent configurations of the combination of the conditions(values) of the dimensions(parameters) in the matrix(Ritchey, 2011). In other words, it shows the possible configurations(combinations) of the dimensions' (parameters) conditions.

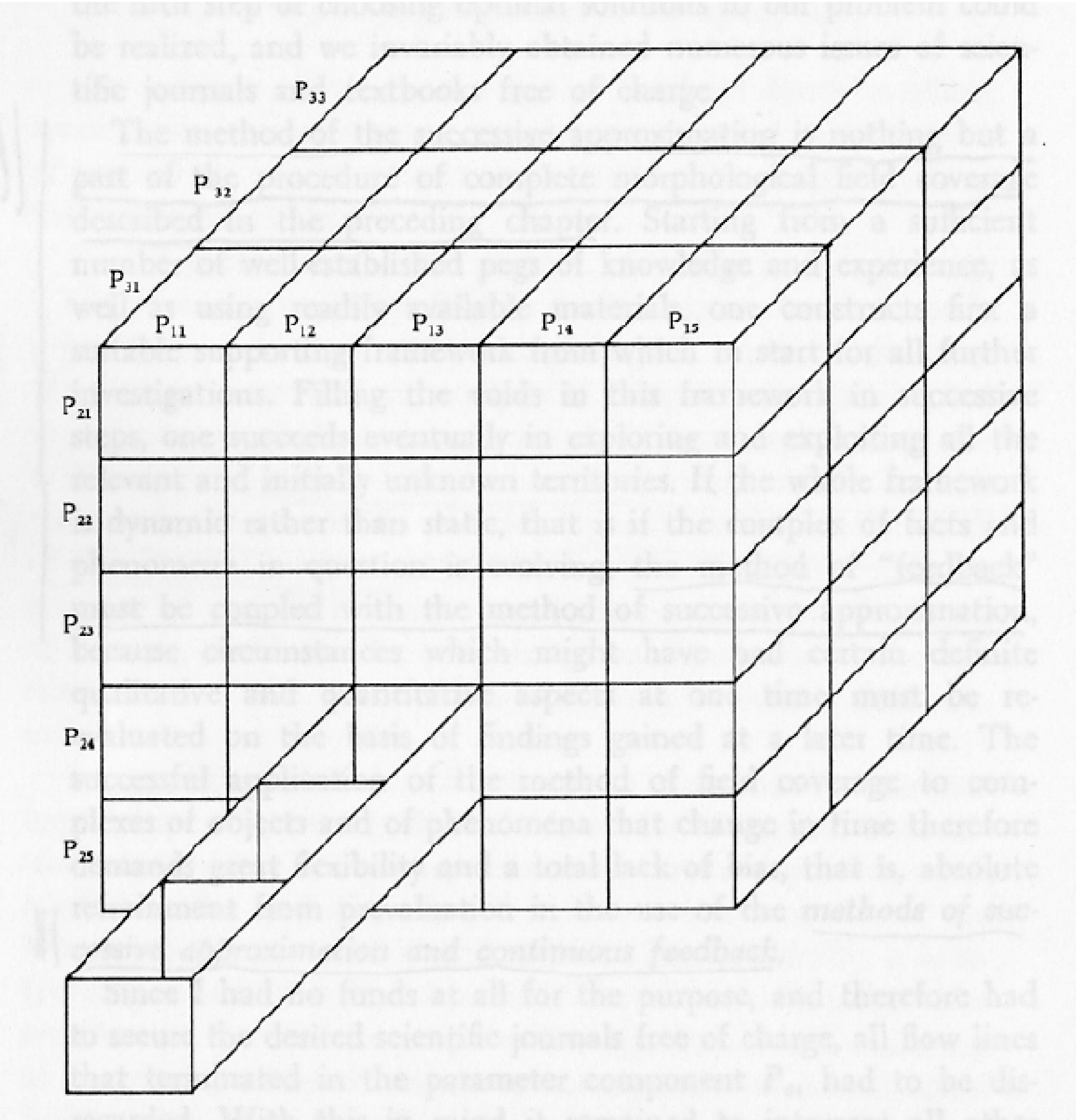

Figure 5.1: The N-dimensional Zwicky Box from (Zwicky, 1967) by way of (Ritchey, 2015).

5.4.2 The Theory of Constructing a Conceptual Space within Morphology

The term concept structuring comes from the initial process in typologies and morphologies, the creation of the conceptual space. Typologies create constructed types, and morphologies create morphotypes of phenomenon.

Constructed types and ideal types are what one might want to call a problem complex. It is what one is trying to define or investigate. In the case of this thesis it is *the future of the Northern Sea Route.*

Within systems theory, one can understand the problem complex as the system. This system exists within a conceptual space. In this conceptual space the problem complex is defined by the spaces' laws. In contrast the conceptual space is defined by its content (system(s)). By describing its content, one is constructing the conceptual space by defining which dimensions(parameters) and conditions(values) that will serve as a scaffolding for inference(Ritchey, 1991; Gallagher, 1984).

The abstractions above are describing how the content of the conceptual space aligns, and how it is hierarchically arranged. Primarily, the mathematical terms such as parameters and values could suffice to explain these hierarchies, but to create greater understanding and to solidify some morphological terminology, a table matrix and a logic set model is provided below.

Notation	Term	Explanation	Set Theory Notation
$^{n}/_{a}$	Conceptual Space	The constructed reality that is made up of the problem complex and its dimensions, and conditions.	U
$^{n}/_{a}$	Problem Complex	What one is investigating, the concept: The Future of The Northern Sea Route	X_1
P_n	Dimension	A parameter of the problem complex that when defined, defines the content of the conceptual space	$X_1 \subset X_n$
V_n	Condition	The different states or values a parameter can take in a parameter range.	$X_1 \subset X_n \subset X_n$
P_nV_n	Condition*	A specific condition of a dimension	$X_1 \subset X_n$
$^{n}/_{a}$	Configuration	A combination containing at least one parameter value/condition from each parameter/dimension.	$X_n \cap X_n$
$^{n}/_{a}$	Possible Scenario	A combination containing at least one parameter value/condition from each parameter/dimension.	$X_n \cap X_n$
$^{n}/_{a}$	Impossible Scenario	A combination containing less than one parameter value/condition from each parameter/dimension.	$(X_n \cap X_n)$ - X_n
$^{n}/_{a}$	Morphological Field	The graphical representation of a n-dimensional morphospace in a 2-dimensional matrix.	$^{n}/_{a}$
$^{n}/_{a}$	Parameter Block	A specific part of the cross consistency matrix that dyadically assesses two parameters and their values.	$^{n}/_{a}$

Table 5.1: Summary of Morphological terms with combinatoric and set theory notation
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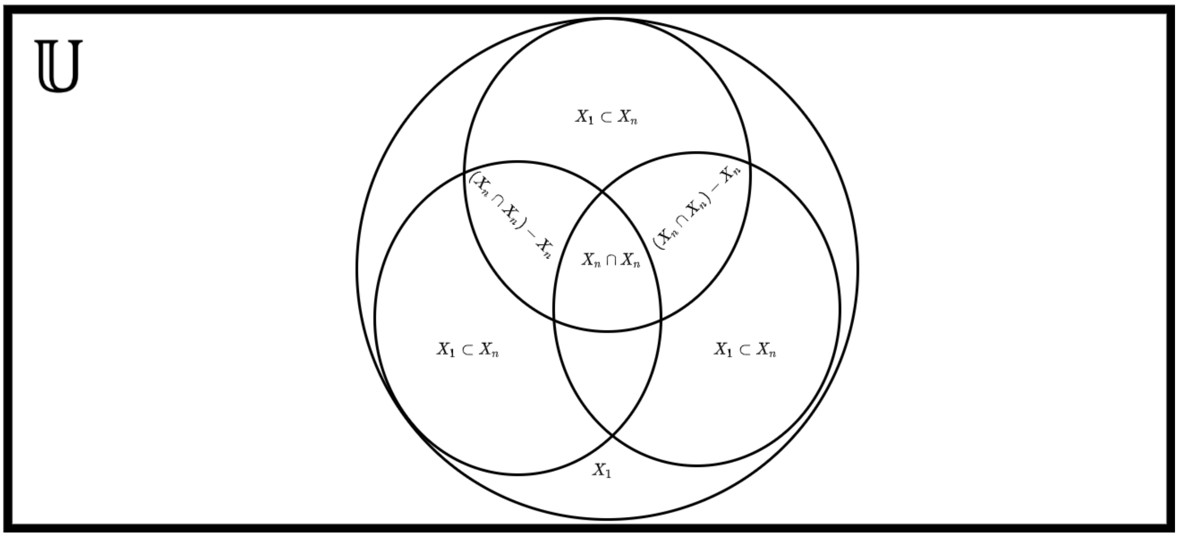

Figure 5.2: A mathematical logic illustration of the hierarchy in a conceptual space

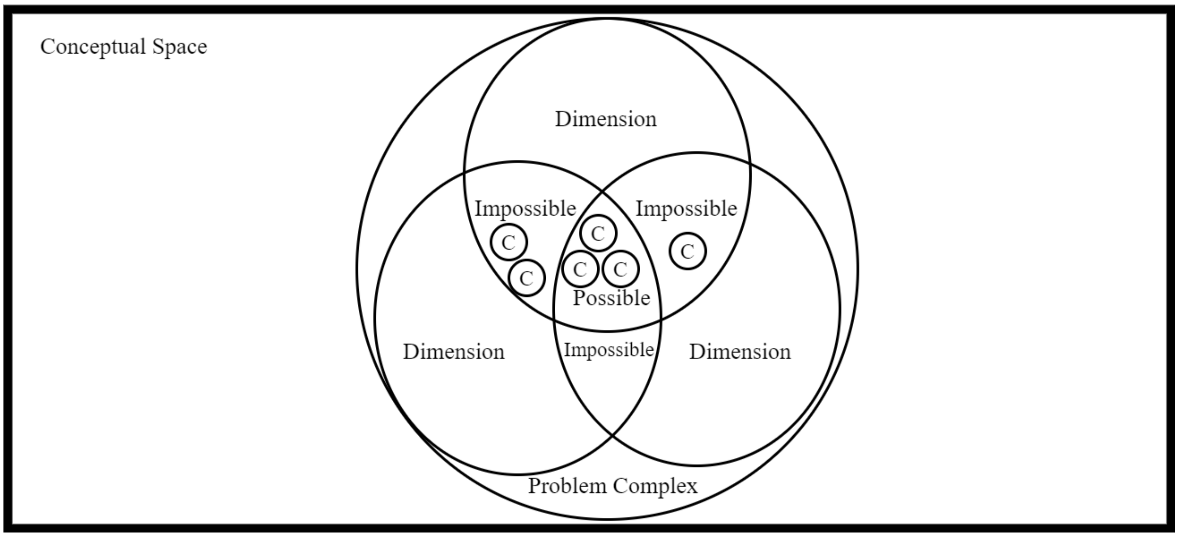

Figure 5.3: A mathematical logic illustration of the hierarchy in a conceptual space using Morphological Analysis terminology.
* C = Condition

Before parting onto the practical side of creating conceptual spaces it seems fitting to seed a quote by Bernhard Riemann on the matter of spaces:

On the hypotheses which lay at the basis of geometry": i.e. that even the seemingly self-evident, three-dimensional physical space we live in is not given a priori, but is determined by its content, i.e."in the forces which bind together its elements." (Riemann, 1953, by way of Ritchey, 2011).

The parting thought to ponder here is that Riemann mentions "binding forces", stow away this for now, but remember it for later.

5.4.3 The Practice of Constructing a Conceptual Space

The hierarchical arrangement of the content of conceptual spaces and some of the esoteric terms of morphology should now be familiar to the reader, but the practicalities are still unknown.

In practical terms the first step of constructing a conceptual space is induction or analysis into the problem complex. The conceptual space of this thesis was constructed by conducting two literary analyses into the problem complex: *the future of the Northern Shipping Route*. The first literary analysis targeted the problem complex as a whole using the terms in the table below. This resulted in the identification of the most pivotal dimensions of the problem complex. The secondary literary analysis targeted these dimensions with the scaling/parameterization of the conditions of the complex in mind. -

Search Words
Northern Sea Route
Northern Shipping Route
Arctic Shipping
Arctic Petroleum
Northern Sea Route Administration
Arctic Geopolitics
Norwegian Arctic
Russian Arctic
American Arctic
Arctic Maritime Regulation
Arctic Environment
Arctic Future

Table 5.2: Table containing preliminary key words.

The second practical step of constructing a conceptual space is to fill it into the morphological field. As mentioned before, the morphological field is a two-dimensional table matrix that serves as visual representation of the dimensions and conditions that attain to the n-dimensional concept space(Ritchey, 1991).

In this thesis the identified dimensions and conditions from these preliminary analysis were integrated into a morphological field, using the software CarmaCCA Viewer. CarmaCCA viewer, is a morphological analysis integration software which was developed by the Swedish Defence Research Agency under Tom Ritchey and contemporaries. Today the software is offered pro bono through the Swedish Morphological Societies research support program (Ritchey, 2020). For a full detailed description of the cooperative efforts of the Swedish Morphological Society, and the technical features of CarmaCCA Viewer refer to Appendix A.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 5.4: An "Activated" Morphological Field in CarmaCCA Viewer.

For the untrained reader, this image offers up more questions than answers. This is because the reader is most likely not familiar with the process of reading morphological fields. A morphological field cannot be read as table matrix. The columns represent dimensions, and the rows represent conditions(Ritchey, 2011).

If one is to read it one reads it from left to right, where a combination of least one condition from each dimension makes a configuration. In more familiar theoretical terms, these configurations, either as visualized in the box or represented in the matrix, are fixed states of affairs or scenarios. They are the combination of the epistemic conditions one uses to define the problem complex and their relations suspended in time(Ritchey, 2011).

To be more specific they are was one can infer from the morphological analysis model. A table is provided below to explain the colour coding of the field.

Colour	Explanation
(white)	Not Possible/Not Activated
(blue)	Possible
(red)	Independent Variable

Table 5.3: Colour Coding used in Morphological Fields in MACarma and CarmaCCA Viewer.

5.4.4 Combinatorics and Notation

The concept of combinatorics has been mentioned several times now, and morphology does deal within the mathematical practices of combinatorics and optimization. Yet, the reader will not have to be seasoned in mathematics to understand the inferences made within this thesis. The reader will however have to understand some rudimentary notation and mathematical properties to grasp the model. Therefore, this section details the most rudimentary mathematics used in this thesis: the notation in documentation.

Firstly, we let N denote the number of the dimension in the morphological field. Thereafter, we let P denote specific dimension as such

$P_1, P_2, P_3 \ldots P_N$

Thereafter, we let V_x =number of conditions found within the dimension P_x, we can thus quantifiable define the morphological field as:

$\{\mathrm{P_x v_i}\}_{\mathrm{x,i}}$

One can thereafter, let the total number of simple configurations (the number of configurations pertaining to a Boolean OR-list) in a morphological field be $\mathrm{T_{SC}}$, thus:

$\mathrm{T_{SC}} = V_1 * V_2 * V_3 \ldots . V_N$

or show that $\mathrm{T_{SC}}$ increases in a geometrical factorial manner by:

$\mathrm{T_{SC}} = \prod_{i=1}^{n} v_i$

(Ritchey, 2011, p.48-49)

As a result, of one uses these formulas one can infer that the thesis' field amounts to 115,200 configurations, quite a number to assess by hand. A normal morphological model does usually do not exceed 7-8 dimensions and 7-8 configurations. Nevertheless, this is still a considerable amount to map out for hand, hence why integration software is used in this thesis (Ritchey, 2011).

P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**
P1V1	P2V1	P3V1	P4V1	P5V1	P6V1	P7V1	P8V1
P1V2	P2V2	P3V2	P4V2	P5V2	P6V2	P7V2	P8V2
P1V3	P2V3	P3V3	P4V3	P5V3	P6V3	P7V3	P8V3
P1V4	P2V4		P4V4	P5V4	P6V4	P7V4	
P1V5			P4V5			P7V5	
						P7V6	
						P7V7	
						P7V8	

Table 5.4: The morphological field of this thesis notated with combinatoric notation.
P = Dimension,
*V = Condition

5.4.5 Reducing Epistemic Uncertainty: Constraints

A requirement for this thesis' epistemic tool, was that it should at least be able to reduce epistemic uncertainty, as one cannot reduce ontical uncertainty. In other words, one needs to assure that what one infers is possible.

In the constructed types of typologies, one says that the content of a conceptual space exists in the conceptual space and therefore is a part of the problem complex. This is by no means a subjective inference in the way that it is the result of inductive analysis. The contrast is that if one entertains *necessary and sufficient solutions*, one cannot make out if the inferences is either type of solution. In other words, one does not know if the types necessarily require all the concepts, traits, and characteristic ascribed to it. Take for example the problem complex: What is a democracy? Well a democracy can be arranged in many ways, but there must exist a minimum condition like that supposed by Dahl(Ritchey, 1991; Gallagher, 1984; Dahl, 1989).

In morphology one goes through iterative processes to determine how the problem complex will take shape, and the way that it does this is through cross-consistency assessment. Cross-consistency assessment is process of constraining the dimensions in the problem complex. This process ensures that the configurations of the conceptual space are internally consistent. This differs from typology in the way that one systematically assesses the *possibility* of the configurations through combinatoric optimization(Ritchey, 2011). The process of morphological analysis is without a doubt the use of the morphological field, and the visualization of the Zwicky box, but in the mathematical logic of the integration software CarmaCCA Viewer, morphological configurations can be understood as undirected graphs(Ritchey, 2011).

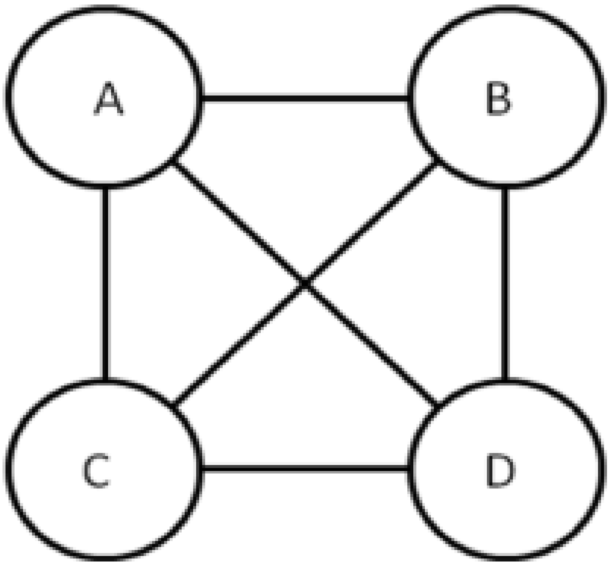

Figure 5.5: An undirected graph showing constraints derived from (Ritchey, 2012)

As one can see there are many nodes representing conditions in the undirected graph. The process of combinatoric optimization is to find out which of these finite conditions represent an optimal configuration. From this one can derive the term connectedness, as the different conditions in the graph are connected and will impact each other somehow(Ritchey, 1991).

The many layers of abstraction surrounding this modelling process may be confusing to the reader non seasoned in mathematics and informatics. However, as the morphological space uses logical, empiric, and normative constraints instead of metric constraints, this process may be more intuitive than first envisioned.

5.4.6 Applying "Binding Forces"

Consequently, the practical application of constraints revolves around two kinds of questions: 1. Are these two dimensions connected? 2. If "Yes" do the conditions of the dimensions constrain each other through logical, empiric, or normative constraints? The connection one speaks of here should be understood as influence, is there a direct way that dimension $P1$ will impact dimension $P2$.

In contrast the constraints are about how the dimensions are impacted by logic, empirics, or norms. These impacts will vary greatly from dimension to dimension, and condition to condition. The impacts are important aspects of documentation, and the understanding of how the content of the space form configurations, but the practical consideration here is whether the conditions can "coexist"(Ritchey, 2011).

The practical consideration of whether dimensions are connected, and whether their conditions can coexist are done in what one calls a cross-consistency matrix. Within the cross-consistency matrix one finds parameter blocks, these are the pair-wise assessment blocks of two dimensions and their conditions(Ritchey, 1991).

	P1V1	**P1V2**	**P1V3**
P2V1			
P2V2			
P2V3			

	P1V1	**P1V2**	**P1V3**
P2V1	**X**	**-**	**-**
P2V2	**-**	**-**	**X**
P2V3	**K**	**-**	**-**

Table 5.5: Two parameter blocks with combinatoric notation.

The tables shown above are parameter blocks, these will be found within the documentation along with the combinatoric notation keys so that the reader may understand how constraints were applied. Additionally, the reader may see that one of the tables is empty, while the other one contains notation. This notation is from CarmaCCA Viewer which was used to apply these constraints(Ritchey, 2011)

As CarmaCCA Viewer is an integration software it removes the requirements of mathematical prowess and the human computational ability that manual morphological analysis requires. The process of cross-consistency assessment can therefore be done expediently by inserting the notation below into the software and by keeping documentation of the assessment(Ritchey, 2011, 2015).

	Type of Constraint		
Degree of Constraint	**Logical**	**Empirical**	**Normative**
-	Possible	Quite alright; good fit; or optimal	No problem, even desirable.
K	Possible	Not-impossible; not-optimal, unlikely or farfetched	Debatable; problematic
X	Impossible	Impossible or not viable; e.g goes against laws of nature, etc.	Unacceptable or functional on ethical grounds

Table 5.6: Degrees and Types of Constraint table adapted from (Ritchey, 2015), containing the notation used in MACarma and CarmaCCA Viewer.

5.4.7 Reducing Epistemic Uncertainty: Iterations

The constraints reduce the epistemic uncertainty of the problem complex by ensuring that the solution space to the problem complex is internally consistent with the conceptual space. The solution space can be understood at the space of the Zwicky box, it is a space that only contains the internally consistent configurations of the conceptual space. In other words, the possible solutions(Ritchey, 2011).

The limitations of human manual computation would usually mean that the process of arriving at a solution space would be a long and laborious endeavour. In contrast, by using CarmaCCA Viewer this process takes days instead of weeks (Stenström, 2013).

CarmaCCA Viewer, also allows for the viewing of two solution spaces. The primary, and the secondary. The primary solution space contains all possible solutions. While the secondary solution space contains all the possible solutions, that are not necessarily optimal. In other words, the solutions that can occur, but it is not the most optimal/best fit pairings of conditions in a configuration. Consequently, the morphological inference model can also be used to reduce epistemic uncertainty through iteration, and through consulting both spaces(Ritchey, 2005, 2011).

Iteration is the process of repeating a procedure over and over again to closer approximate a sufficient solution to a problem. In CarmaCCA Viewer one can apply diagnostics to the solution space by designating a condition as a independent variable. By designating a condition as an independent variable, one is left with all the possible solutions that contain this condition(Ritchey, 2005, 2011).

Through this process of “running” the model with different independent variables one can assess whether the solutions one arrives at are in line with logic, empirics, norms, and expectations. If the solutions provided are deemed to need adjustment one can adjust the morphological field and the cross-consistency matrix to iterate the model. This process can be repeated as many times as needed to arrive at a consistent solution space(Ritchey, 2005, 2011).

In this thesis, the inference model created in CarmaCCA Viewer was iterated a total of 6 times. Most of these iterations were cosmetic, while some of them changed entire dimensions, specter of conditions, which resulted in a total of 4 cross-consistency matrix adjustments. In which two of them were entire matrix adjustments of all parameter blocks.

Primarily, one must view this iterative process as another way of reducing epistemic uncertainty as the solution space and cross-consistency assessment is a learning process into the problem complex. In broad terms it can make it clear whether the dimensions are *mutually constrained* or *orthogonal* to each other or *completely orthogonal* to the problem complex (Ritchey, 2012).

Finally, the concepts of orthogonality and mutual constraints are mathematical terms. Orthogonality in the context of cross-consistency assessment means that two dimensions or conditions are independent of each other, which means they do not constrain each other. Mutually constrained means they are connected and constrain each other somehow.For a full breakdown of the formal mathematical properties of the CCA consult Appendix B, this is intended for the reader seasoned in mathematics, and informatics (the appendix is a compilation of Ritchey's multiple papers and book on teh subject (2011, 2012, 2015), which is highly recommended reading on the method).

5.4.8 From Analysis to Synthesis: Deriving Inference from Morphological Models

Modern day morphological analysis conducted with computer integration software allows anyone to make inferences about any problem complex through the simple steps provided above. No matter how easy this seems, one must emphasize there lays vast amount of analysis and synthesis work behind using such a model. This section is a summary of these processes

The first steps in the creation of this model was the analysis processes. In other words, the two literary analysis that targeted the problem complex *the future of the Northern Shipping Route*. Before integrating the findings of these two analyses into the morphological field in the CarmaCCA Viewer, the dimensions and conditions were analysed. The summary of the "findings" of these analyses can be found in the next chapter. The dimensions chapter breaks down the dimensions, and the reasoning behind choosing their conditions(Ritchey, 2005, 2011).

The secondary process in the creation of this model is the creation of configurations. Configurations are created through the process of cross-consistency assessment in the cross-consistency matrix. During this assessment in CarmaCCA Viewer, documentation was kept about all the pair-wise assessments of dimensions and conditions. This documentation can be found after the dimensions chapter. A word on this chapter is that its is as much a "findings" chapters as a "discussion" chapter. It details the cognitive process behind applying constraints through synthesis. Reading of this chapter requires strong command of morphological terms(Ritchey, 2005, 2011, 2015).

The third process in the creation of the integration model is parameter checking and iteration. When the model is created a one needs to analyse the model itself and see if it reflects the relationships documented in dimensions and cross-consistency assessment documentation. This is done through using the model for inference by selecting a condition as an independent variable. If the model performs as intended and creates empirical and logical possible configurations it needs no iteration. The model of this thesis needed 6 iterations(Ritchey, 2011, 2005).

The fourth and final process is the inference itself. To use the inference model, one selects a desired or undesired condition and view what state of affairs can contain this condition. As this model is a morphological model intended for scenarios, it has many different scenarios for each condition. As a result, one can either use multiple independent variables to isolate single scenarios or look at clusters of scenarios.

5.5 Limitations

5.5.1 Risk, Agency, Intent

Before departing onto the analysis, synthesis, and final inference chapter some aspects need to be addressed about the inferences themselves.

In the preliminary theory chapter, it was established that ontic risk does not exist outside of its epistemic conditions(Solberg & Njå, 2012). Moreover, it was also established that one cannot reduce the ontical uncertainty of the future by quantitative risk analysis. In contrast, what one could reduce was the epistemic uncertainty in methods(Njå et al., 2017). Wicked problems can however not be investigated with quantitative methods due to their subjective nature(Ritchey, 2011; Rittel & Webber, 1973). This led to the conclusion that one needed to force wicked problems into state of affairs that reflected sets of preferences to analyse them.

Through the method chapter, it was further established that a way of forcing these preferences would be to use scenarios. Scenarios would also be states of affairs suspended in time. Through the discussion of scenario theory, one found that some forms of scenario building are incompatible with the thesis view on uncertainty, as they employ methods that rely on a deterministic world view(Börjeson et al., 2006; Schoemaker, 1993; Varum & Melo, 2010). In other words, they claim to be able to reduce ontical uncertainty.

As a result, one was able to distinguish that the characteristic of agency plays a key role in understanding scenarios(Börjeson et al., 2006). Agency can also be understood as intent, or an action that relates to a value system. This can therefore be seen as risks epistemic condition that says that risk relates to something humans value(Solberg & Njå, 2012). As following scenarios through agency to try to shape a future lay on a different plane than the future itself, the thesis will no deliberate any further on this.

In contrast, the thesis will use this insight into agency's role in scenarios to contend that for any inference to have any value, it must be assigned to a human value system(Solberg & Njå, 2012). As this thesis set out to find a broad spectrum of risk pictures of *the future of the Northern Sea Route* it had no preconceived value system. Therefore, to investigate the problem complex the thesis will construct stakeholder contexts. These contexts will guide the inference to look for scenarios and scenario clusters that have value to certain stakeholders.

5.5.2 Relativity, Time, Subjectivity, Belief

The preliminary theory chapter also contended that as everything is uncertain in the future one cannot know anything about the future . The only knowledge one can have about the future is expectations or in other words inferences. This means that all knowledge of the future is subjective, and relative(Njå et al., 2017).

The future itself must also be said to be relative. In the sense that the only way that one can conceptualize time without determinism is to adhere to tenseless time that is within relative space time. As a consequence, when the thesis inference future states, it is not given which time it will be, nor if the future will come to be. What the inference says, is that based on how these dimensions are connected, the futures we infer are possible(Njå et al., 2017; McTaggart, 1908).

Possibility does not mean it will happen; it means it can happen. The distance between will and can is agency. In other words, to make future come true one needs to constantly assure that all the conditions in the configuration align. Yet, this still will not assure absolute certainty of outcome.

Where this leaves us is in the middle of uncertainty. In traditional quantitative risk science degrees of belief is used to assign uncertainty to outcomes(Aven et al., 2011; Aven, 2012). This is however in contrary to everything discussed so far. Therefore, if one is to assign any belief it must be the belief in the epistemic tool, and in this tool, there is a lot of certainty(Njå et al., 2017).

The certainty is nevertheless not about the future, it is about how these dimensions of the problem complex act together, given the thesis' subjective synthetic assessments, based on empirics arrived at through an inductive analysis.

What the inferences therefore can tell us is not the future, but the relative possible configurations of the problem complex. In other words, it can tell us about how the Northern Sea Routes dimensions act together. Which one can coin as the *mechanics of the whole* (Ritchey, 2011).

Therefore, one must contend that due to the inference models ability to reduce epistemic uncertainty one can be certain that one of these configurations will occur, and one can also investigate which parts of the whole which will prove most pivotal in shaping a potential future under the condition of a relatively and uncertainty.

Yet, there remains uncertainty in the form of the human element. As I, as both the morphologist and the subject matter specialists is constrained to my own knowledge of both. In the general form of morphology practiced by the likes of Tom Ritchey and Maria Stenström, this uncertainty is dealt with by referring to multiple subject matter experts, and by having the morphologists as a facilitator rather than a participant in the analysis. This both enables more perspectives to be included in analysis, and removes the subjectivity that a subject matter expert may have as a facilitator in analyses they have claims in (Stenström, 2013; Ritchey, 2011).

Knowing that I act as both the morphologist and as the subject matter experts, I know there are likely knowledge gaps. Morphology also requires vast knowledge about multiple areas of a problem complex, and as such anyone that takes on both sides of the process is bound to be spread thin and be a jack of all trades, and perhaps a master of some (Stenström, 2013; Ritchey, 2011).

5.5.3 Expectations at last

If one is looking for some form of Eureka-moments with regards to metaphysics this not the place, but what one must leave on is that inferences are expectations at last. They can or cannot come true, it is relative. If anything, the difference in using an inference model, and subjectively infer is the difference between using your finger as a weathervane, and a multi-million-dollar meteorological laboratory.

Concluding that the thesis will infer with some contexts in mind, and thereafter deduce the most pivotal mechanics of the whole. It admits that subjectivity, relativity, and uncertainty plays a role in whether this will come to be or not. As Njå, Solberg, and Braut contended; whether our reality is entirely deterministic or entirely filled with chaos and randomness does not matter as either of these realities make investigations into reality trivial (2017). One must therefore assume that reality is somewhere in between, and that inferences are educated guesses at best, and entirely futile at worst. Solidifying that if one is to pursue science, and not see it as a trivial endeavour, then one must believe in ones inferences, and consquently also the reality-possibility distinction (Solberg & Njå, 2012).

Chapter 6

Morphological Analysis

6.1 Constructing a Conceptual Space: Dimensions and Conditions

This ensuing section is the first step of the morphological analysis. It is the documentation chapter of the findings from the primary and secondary literary analysis that constitutes the process of constructing a conceptual space. The subsections are structured around deliberations about the different dimensions, and discussions about their conditions and their role and direction. At the end of every subsection a summary table is provided for convenience. In practical terms this is the grunt work behind the construction of a morphological field before it is integrated into CarmaCCA Viewer.

Dimension I: Involved Stakeholders

The Northern Sea Route would in of itself exist within objective reality as a geographical location, however as socially governed system that serves as a transportation route it would not. It is therefore quite evident that the Northern Sea Route as a system in the past, present, or future is contingent on the presence of humans.

Albeit, one could argue that the Northern Sea Route as a system can be contingent on humans from the scale of singular individuals to international forums such as the United Nations or the Arctic Council, this thesis has chosen to stratify this dimension into blocks of countries that have stakes within global maritime trade(Le Mière & Mazo, 2013).

As noted in the initial introductory chapters to this thesis, the Arctic has been an area of exploitation and habitation for an undetermined amount of time, by a myriad of different actors (Perdikaris & McGovern, 2009). However, at its current state the Arctic water-ways of the circum-polar area is largely governed by the countries surrounding it (Hansen-Magnusson, 2019).

One is then left with a set of *Local Actors* that will always have a stake in the Arctic. These local actors are Russia, USA, Norway, Canada, and Greenland (Petersen, 2009).

With regards to the Northern Sea Route, the most prominently important actor of these is Russia This is in of itself due to the fact that the Northern Sea Route in its current constellation exists almost exclusively within Russia waters, and is kept viable under its varying conditions by her coastal, military, and civil infrastructures (Blakkisrud, 2019).

In addition to Russia, we find two other nations that are directly connected to the Northern Sea Route . These are two nations which have open-water (free of ice) along, or adjacent to the Northern Sea Route. They do not have power directly over the NSR, but they can extend their sphere of influence to contest its position in global trade, as shall be briefly elaborated upon in the next dimension (Østhagen, 2016; Blakkisrud, 2019).

The remaining two actors are Greenland and Canada, the point of contestation here which makes these actors different than Norway and USA is that they do not currently have ice-free open water borders adjacent or directly connected to the shipping route. By comparison however, these two nations along with USA share an alternate route to the Northern Sea Route, the North West Passage (Le Mière & Mazo, 2013). One therefore sees that there are many facets to this local condition.

The next condition is the *Eastern Actors*, this condition consist of all the so-called eastern countries (Young, 2010). This condition contains predominantly a large array of countries that will benefit from exploitation of the use of the Northern Sea Route with regards to global trade (Young et al., 2013). As noted by numerous contemporaries there are whispers among global trade actors about opening using the route for means of trade instead of the current water-ways to save money, and valuable time (Le Mière & Mazo, 2013).

Another stake holder is the *Western Actors*, as with the latter condition this condition contains predominantly a large array of countries that will benefit from the route with regards to trade (Le Mière & Mazo, 2013). There has also been rumours in the western sphere about using the route for the exact same monetary and time saving reasons(Le Mière & Mazo, 2013).

An area of the world that could benefit from the Northern Sea Route is the *African Coastal States*, here a explanation of a separation should be given. Whilst countries such as Egypt on the Eastern Coast of Africa sees a lot of traffic. Countries on the Western side see less traffic. However, it seems more feasible out of convenience of cargo transport that the North Eastern African actors would utilize the route. This condition does however includes every single one of the coastal state, though it may not be fruitful nor possible for all actors to go through the NSR (Le Mière & Mazo, 2013).

The final actor distinguishes itself in the way that it is the glowing powerhouse of production industry in the world. The decimation from the Eastern actors is however due to the political separation. When *China* bargains, China bargains for themselves. As such, it does not make sense to include them with Japan, South-Korea, Singapore and the like as they compete and partake on different grounds (Lanteigne, 2014; Mariia, 2019; Rahman et al., 2014).

As such one can see that this dimension as a parameter contains the following conditions as values:

INVOLVED STAKEHOLDERS	
P1V1	Local Actors
P1V2	Eastern Actors
P1V3	Western Actors
P1V4	African Coastal States
P1V5	China

Table 6.1: Conditions of the Dimension: Involved Stakeholders with combinatoric notation.

Dimension II:
East/West Relations

As made evident in the discussion of the previous condition, Arctic affairs have consisted predominantly of exploitation and contestation (Le Mière & Mazo, 2013). However, East/West Relations deals with the concept of contestation, but not predominantly within the circum-polar area. It attains to the more global separation of the world into two spheres of "the East" and "the West".

The East and The West, however it should be made quite evident here that this dimension is ambiguous. It is quite ambiguous on purpose; this is due to goal of the thesis. The thesis is predominantly concerned with scenarios for the future states of the Northern Sea Route. It is not concerned with which challenges arise between which countries, but more about whether the country block stratifications cooperate or not.

The Arctic Seas have never seen an grand scale escalated military conflict before with the exception of skirmishes around Spitsbergen and the Second World War (Bourmistrov et al., 2015). It has however not been an area that has been static in international relations. The Arctic Seas are under constant discussion by local and external actors due to the vast amount of untapped resources residing there. Current examples would be the US offering to buy Greenland from the Danish sovereignty and the Norwegians refusal to sell large land areas of Spitsbergen to Chinese investors, whilst an older one would be the Norway Russia conflict over the Spitsbergen Archipelago and the Barents Sea border (Breum, 2019; Pettersen, 2014). However, these have all been conflicts that have been resolved with diplomatic means. This is because all of these conflicts have been due to resources, it is matters of the economy, they are not declarations of war. They are what some may coin soft politics, and soft politics between cooperating neighbours is not gunboat diplomacy (Bourmistrov et al., 2015; Østhagen, 2016).

This cooperation and ability to solve challenges together are solidified in examples such as the numerous treaties between Norway and Russia in the Barents Sea, and the coast guard cooperation between the USA and Russia in the Bering Sea (Bourmistrov et al., 2015).

Even though relations are good at the current time, one must consider that they could change. However, judging by the already pre-existing pattern of cooperation it is not likely that an event in the Arctic is going to cause a change in relations, nor does it seem likely that any military escalation or intervention will take place in the Arctic (Østhagen, 2016). It is more likely that hard political challenges outside of the Arctic may escalated into an event that has a political impact on the accessibility of the Arctic (Østhagen, 2016; Bourmistrov et al., 2015). This is not to say that it cannot occur, all stakeholders in the Arctic both local and external all have their national, international, and global agendas but how they will play out is genuinely uncertain.

With this genuine uncertainty in mind it does not make sense to measure the flux of international relations by describing them as results of events. This approach also ensures a sinew of impartiality, as it does not point fingers as to who did what, and who is to blame. Such parameterization of dimensions would be counterproductive. Instead the parameterizations attain to relations instead between the two main stratifications referred to in global politics “The East” and “The West”.

This may seem quite ambiguous, but the intention of this stratification is to be all-encompassing rather than precise. Its not about who did what, where, and when, it is more of a “temperature check” on the environment of international relations. It should however be addressed that this stratification is perhaps old-fashioned. With the balance of power revolving more around singular nations now than before, it seems evident that that this stratification may fail to capture the gravitas of nations such as Russia, the USA, and China.

The first condition is *Cooperation and Agreement* and it signifies that there is cooperation between the country blocks, and that there is agreement around the global and local agendas brought forward by the different blocks or countries. Albeit, it is quite evident that one cannot empirically have agreement upon all topics, but this agreement is not about specifics .There can for example be agreement on the topic of mitigating the effects of climate change, and preventing possible escalation of these effects, but still be disagreement upon how to do this(Aarebrot & Evjen, 2014; Møller & Skaaning, 2013). Similarly, there can be a general understanding that one needs to fight poverty and famine in less disenfranchised countries, but carrying it out in completely different ways. Hence, this is not a utopian ideal state, but rather a less tumultuous state. The enemy is no longer a person, state, or country block, it is something else. An example would be the global covid-19 pandemic, where country leaders has expressed that they are at war with the virus, and there is resound agreement around fighting it on a global scale(**?**).

The second condition which revolves around the concept of *Neutral Involvement* need not be too different from the first condition, but their inherent differences need to be expressed. As the previous condition was supposed to express a less tumultuous state, the neutral state can inhibit both turmoil and stability. Hence, this turmoil may be rooted in disagreements on global or local agendas. Their significance is not impacting either block in such a way that its internal stability is questioned to the level that it endangers the sovereignty of the nation or nation block (Aarebrot & Evjen, 2014; Møller & Skaaning, 2013). Hence, trade wars, proxy wars, the spreading of disinformation, the escalation of decentralized conflicts, and the like can occur (Østhagen, 2016). As long as these events do not question the sovereignty of the pivotal actors within these blocks forcing their hand to act (Aarebrot & Evjen, 2014). Challenges within this state can largely be resolved by means of meetings and statements.

The third condition is *Challenging Tensions* it is the state of affairs in which disagreement starts to force a country of country blocks hand. Largely, this must be ascribed to situations that question or undermines the sovereignty of the a country or country blocks (Aarebrot & Evjen, 2014; Møller & Skaaning, 2013).Hence, this state signifies a real transition into turmoil. The actions done to transition in to this state is of such grandeur that meetings, and statements do not justify as reparations for the damage it has done and considerable diplomatic resources need to be assigned to restore the reputation between the involved parts (Aarebrot & Evjen, 2014). However, the option of diplomacy is still there. As such this state of challenging tension is both challenging in the way that an actual country of country blocks sovereignty is questioned, but also in the way of it being a challenge that can be overcome.

The fourth condition is when diplomacy is out the window, *Challenging Involvement*. The state of relations is not amendable due to the nature of the disagreement. The country or country blocks sovereignty has been questioned or undermined in such a way that explicit challenging involvement occurs within either country or country blocks dominion (Aarebrot & Evjen, 2014). Where challenges have previously been of the nature in which one can look the other way or talk it over, direct involvement will occur.

A word on this dimension is that it is an “or” dimension in this morphological model. It is much more definitively an “and” dimension in the broad landscape of politics. Countries and country blocks can cooperate and have agreements on some fronts, whilst others cause challenges. Hence, one must understand that this dimension is seen in the relation of the conceptual space. It is a constructed reality state that is meant to show how this dimension will impact the Northern Sea Route, therefore this generalization is made.

As such one can see that this dimension as a parameter contains the following conditions as values:

GLOBAL POLITICAL ENVIRONMENTAL STANCE	
P2V1	Cooperation and Agreement
P2V2	Neutral Involvement
P2V3	Challenging Tension
P2V4	Challenging Involvement

Table 6.2: Conditions of the Dimension: East/West Relations with combinatoric otation.

Dimension III:
Global Demand for Arctic Trade Traffic

The dimension attaining to the Global Demand for Arctic Maritime Trade traffic was borne from the increased interest in goods transportation along the Northern Sea Route. Interests have piqued among global actors with regards to how the effects of climate changing makes the Northern Sea Route, and particularly the Shipping route more viable (Le Mière & Mazo, 2013).

The shipping route could possibly reduce the travel time for products from European port such as London to Asian port such Yokohama by up to 12 days (Østhagen et al., 2018). A result of this would be reduced fuel cost, and overall costs of running a vessel (Melia et al., 2017; Moe & Stokke, 2019). However, this is contingent on how efficient the vessels can be maneuver along the Northern Sea Route (Pierre & Olivier, 2015). In

In addition one sees an increase in traffic in the area due to petroleum and LNG developments such as the search for resources in the Barents Sea, the development of the Shtrokman Field, the Yamal LNG plant, and more (Bourmistrov et al., 2015). Not only will these developments need cargo transport but they will also need supply vessels, bunkering and so forth(DNV GL, 2017).

At the current time, the traversing by vessels across ice-covered seas is not a predictable endeavour (K. E. Solberg et al., 2016, 2017; Gudmestad & Solberg, 2018). At the one side of things the vessels are contingent on the sociotechnical systems of the Northern Sea Route Administration and their coordination with other federal agency to assure correct and safe passage (Northern Sea Route Administration, 2020; Marchenko, 2014). On another, one is at the mercy of the weather and climate along the Northern Sea Route (Marchenko, 2012; K. E. Solberg et al., 2016, 2017; Gudmestad & Solberg, 2018). Hence, one cannot know if the weather will prolong or shorten a voyage (Marchenko, 2012). In addition, the quality of information that one gets about the ice conditions, and weather conditions are quite different in the Arctic than in the rest of the seas (K. E. Solberg et al., 2016, 2017; Gudmestad & Solberg, 2018). Voyages within the Arctic waters thus becomes prone to the myriad of different phenomena that can occur simultaneously in this area. This is myriad of problems is often coined "The Arctic Problem", in which the key characteristic here is not the singular effects and phenomena that appear in the Arctic, but rather the fact that these phenomena occur simultaneously in the Arctic (Hangaslammi & Hatakka, 2018). This compounding effect makes any vessel within the Arctic prone to levels of external stress that is unlike anywhere else in the seas except for the Antarctic Coast (Hangaslammi & Hatakka, 2018). Which is why special codes have been made to prescribe common rules for seafaring in polar waters to mitigate some of these hazards (International Maritime Organization IMO, 2014). However, as the SARex reports has shown there are ways to go about this as well(K. E. Solberg et al., 2016, 2017; Gudmestad & Solberg, 2018). In addition, we see that the Russian government has implemented some serious safety measures in form of shifting more responsibility onto Rosatom(Aker Artic, 2020).

As such we see that the global demand for Arctic maritime trade is initially comprised by two main facets, efficiency and profitability (Misra, 2008). Where profitability is contingent on the effectivity facet. Whilst efficiency is the comprised of a wide array of different sociotechnical and natural factors that influence a vessels voyage time, fuel consumption, safety, and overall budget (Pierre & Olivier, 2015). Thus, the conditions one is left with is:

The first condition *High*, is a state where one has high profitability, and high efficiency. Hence, this condition presupposes that the effects of the natural occurrences such as ice and the conditions of the sea is mitigated or prevented in such a manner that the voyages success is essentially replicable every time. In addition, it supposes that the fuel cost of Arctic voyages has been reduced by a considerable amount either by technological advancements or by the other aspects attaining to the prevention and mitigation processes attaining to “The Arctic Problem” (Misra, 2008).

The second condition *Medium*, is a state where profits can be attained, and the voyage efficiency is at a higher level. Hence, this condition supposes that one can to a large extent mitigate/control the effect of the natural occurrences such as ice and weather, to a degree in which voyage success is largely replicable (Misra, 2008). In contrast, it does however suppose that fuel costs and additional incurred costs specific to Arctic maritime activity is reduced, but not to a marginal level where voyages are highly profitable (Pierre & Olivier, 2015). Hence, this can either be due to stagger of technological progress, or due to the cost of upholding the IMO Polar Code, or the cost of Rosatomflot Icebreakers, and so forth (Northern Sea Route Administration, 2020; Aker Artic, 2020; International Maritime Organization IMO, 2014). Essentially, any Arctic, Polar, and NSR specific cost that influences profitability can sway this.

The third condition *Low*, is a state where profits and efficiency will vary. This is a condition in which the mitigation/control and prevention of the natural effects of sea and ice is not securing a replicable transit (Misra, 2008). Vessels can get stuck in ice due to these effects and weather phenomena at undetermined intervals of time, and thus the costs of the voyage with regards fuel and crew can make the profit margins flux (Marchenko, 2012). The profit margins will even flux further with regards to what implications late transport of merchandise implies (Pierre & Olivier, 2015). In other words, this is a condition in which the outcome would be deemed to be of high risk in economic terms.

As such one can see that this dimension as a parameter contains the following conditions as values:

GLOBAL DEMAND FOR ARCTIC TRADE TRAFFIC	
P3V1	High
P3V2	Medium
P3V3	Low

Table 6.3: Conditions of the Dimension: Global Demand for Arctic Trade Traffic with combinatoric notation.

Dimension IV:
Global Political Environmental Stance

As our climate is changing, mankind is at the precipice of decision once again. Where, previously decisions have been about war on people, groups, or countries mankind is now faced with another challenge that is bigger than itself . This challenge, is the effects and causes of global climate change(Diebold & Rudebusch, 2019) . Albeit, the effects and causes of climate change is empiric in nature, the decisions to do something about it is entirely of normative nature. Hence, this dimension attains to the normative stance that the majority of the global community takes on the matter.

A word must however be spoken about this dimensions parameterization before one proceeds to expand on them. Though normative in nature, it should suffice to say that the denotations should be taken from these conditions, and not the normative connotations that one has about these words. Radical does not mean "bad" as it can be connoted, it simply means a drastic change, and in this instance from the status quo. However, one must suppose that one should expand on the status quo and this directional heading as well. With regards to the status quo, one finds oneself in the position of where the world has had both the Kyoto Protocol and the Paris agreement where they want to reduce the effects of climate change, and mitigate causes (Grubb et al., 1999; Schleussner et al., 2016). Hence, this is the *conservative* stance, it is the now, it is the status quo. Any directional heading either progressive or regressive in this manner simply means to move along or against the status quo. Thus, it should be evident that this thesis makes no moral claims here, but expresses normative stances anchored in status quo actions.

Hence, if one is to root these conditions in some kind of linearity of understanding *Radical Progressive* stances would be to do and employ all that is possible to mitigate and prevent the causes and effects of global climate change and potential harm to the environment. Whilst, *Radical Regressive* would be to mitigate effects, but to do it in pursuit of some other goal.

Take the Northern Sea Route into consideration, the dimension “Achieved Levels of Sustainable Maritime Technology”, is a dimension that attains to the conservative to progressive scale of the political environmental stance. Whilst the “Global Demand for Arctic Trade Traffic” attains to the regressive scale. The first dimension is distinctly about furthering technology for mitigation and prevention of causes and effects of climate change, whilst the other one is about mitigating effects of climate change.

Technological practices to change types of fuel of vessels to prevent the chance of major oil-spills and general emissions is normatively oriented towards progression from the status quo. Whilst technological practices to increase the robustness and reliability of vessel crossing is not necessarily normatively oriented towards regression nor progression but depending on the political environment it may improve conditions for either side of the spectrum.

As such one can see that this dimension as a parameter contains the following conditions as values:

GLOBAL POLITICAL ENVIRONMENTAL STANCE	
P4V1	Radical Progressive
P4V2	Progressive
P4V3	Conservative
P4V4	Regressive
P4V5	Radical Regressive

Table 6.4: Conditions of the Dimension: Global Political Environmental Stance with combinatoric notation.

Dimension V:
Level of Technical and
Navigational Requirements

This dimension attains to the requirements imposed on vessels and crews operating within the waters of the Northern Sea Route. Some of these requirements are more technical specifications, some are sociotechnical, and others adhere specifically to navigation. The purpose of this section is not to cover the vast number of requirements that attain to vessels and crews. Instead it explains how two primary regulatory organs, and their respective laws govern the Northern Sea Route and discuss how regulation and industry interact to close the gap between functional requirements and a professional standard. IMO Polar Code The first regulatory organization that governs the Northern Sea Route is the International Maritime Organization (IMO). IMO governs the Northern Sea Route with laws such as: as the Law of the Seas, Marine Safety Committee (MSC), International Convention for the Safety of Life at Sea (SOLAS), Marine Environment Protection Committee (MEPC), and The International Convention for the Prevention of Pollution from Ships/Maritime Pollution(MARPOL) (Jensen, 2016).

The primary law that applies in the Arctic and Antarctic is however: IMO's International Code for Ships Operating in Polar Waters (IMO Polar Code) (2014).This code is a risk-based functional code that focuses primarily on the technical and sociotechnical requirements intended for the mitigation and prevention of events related to the unique hazards and risks of the Arctic and Antarctic (IMO Polar Code, 2014).

To understand the Polar Codes place in regulation must understand the concepts of laws and regulations as legally binding laws, and non-legally binding laws. The first are the requirements imposed by governments and international organizations. The latter are norms of an industry that become "legal standards" of that industry (Le Coze 2020, p.59-63).

Maritime laws are traditionally specific requirements imposed by governments or organizations. While the Polar Code is a functional based law. Functional based laws are laws that are formulated in such a way that it gives leeway for a "legal standard" to emerge as result of interaction between the legislature, the industry, and experts within the industry. This is often done within growing industries, or when industries are expanding into new sectors or areas. This form of "soft" regulation is explicitly "soft" to accommodate development, but it comes at the cost of differences in interpretation and adoption (Le Coze, 2019)

These differences can easily occur in the maritime industry operating along the Northern Sea Route as this is an emerging market with new actors that are yet to be familiar with it. To emphasize how these differences can occur some articles, paragraphs, and definitions from the IMO Polar Code will be highlighted.

1.2.7*Maximum expected time of rescue means the time adopted for the design of equipment and system that provide survival support. It shall never be less than 5 days.*

(IMO Polar Code, 2014, para 1.2.7).

1.4.3*For ships operating in low air temperature, survival systems and equipment shall be fully operational at the polar service temperature during the maximum expected rescue time.*

(IMO Polar Code, 2014, para 1.4.3).

Paragraph 1.2.7 clearly specifies that self-survival shall be expected to be 5 days. Paragraph 1.4.3 on the other hand says that equipment shall be fully operational at polar service temperature (PST) during the maximum expected rescue time. Service temperature is defined as:

1.4 2 *For ships operating in low air temperature, a polar service temperature (PST) shall be specified and shall be at least 10oC below the lowest MDLT for the intended area and season of operation in polar waters. Systems and equipment required by this Code shall be fully functional at the polar service temperature.* (IMO Polar Code, 2014, para 1.4.2)

These paragraphs can be grounds for confusion in interpretation, as an additional temperature requirement is implemented in article 8.2.3.3.This article details that one needs to provide survival measures during the abandonment of ship, onto water or ice, for the duration of the maximum time of rescue. The difference here is that 8.2.3.3 abandons the concept of PST for a *habitable environment*, which is defined as:

1.2.4 *Habitable environment means a ventilated environment that will protect against hypothermia.* (IMO Polar Code, 2014, def 1.2.4)

These articles, paragraphs, and definitions are not intended to muster confusion in interpretation. They are all intended to mitigate and prevent the effects of hypothermia. They are written in this way to accommodate functional self-regulation to let standards emerge. The problem is however, when one takes the Polar Code's functional requirements as the absolute requirements (Le Coze, 2020).

To understand how this may be problematic, one must consider more paragraphs and articles such as the goals of chapters 8 and 12:

8.1 *The goal of this chapter is to provide for safe escape, evacuation and survival* (IMO Polar Code, 2014 art. 8.1).

12.1 *The goal of this chapter is to ensure that ships operating in polar waters are appropriately manned by adequately qualified, trained and experienced personnel.* (IMO Polar Code, 2014 art. 12.1)

Chapter 8 clearly details the logistical decisions that needs to be undertaken to assure self-survival of crew and vessel. It does, however, not specify any "legal standard", nor law that addresses the specifications of this equipment beyond paragraph 1.4.1:

1.4.1 *Unless expressly provided otherwise, ship systems and equipment addressed in this Code shall satisfy at least the same performance standards referred to in SOLAS.* (IMO Polar Code, 2014, para. 1.4.1).

The distinction to make here is that 1.4.1 specifically says that the performance standards should *at least* satisfy the standards referred to in SOLAS. Hence, SOLAS is the absolute minimum standard (IMO Polar Code, 2014). But as SARex I, II, and III has shown the SOLAS performance standards do not meet paragraphs 1.2.7, 1.4.2, 1.4.3, nor article 8.2.3.3 (Solberg, Gudmestad Kvamme 2016; Solberg, Gudmestad Skjærseth 2017; Solberg Gudmestad 2018).

In addition, one sees that article 12.3.2.1 only specifies that the master chief and navigational officer onboard a vessel need extensive mariner training for Arctic conditions (IMO Polar Code 2012). While during SARex I-III they identified that leadership, training, and additional preparedness actions done by crew increases the likelihood of survival (Solberg, Gudmestad Kvamme 2016; Solberg, Gudmestad Skjærseth 2017; Solberg Gudmestad 2018).

What the findings of these exercises tell us is that professional standards need to be formulated to set a precedent for the industry. The legislation is not necessarily problematic or wrong, but the gap between legislatures and the industry's problems needs to be closed by either part. If this gap is not closed the liberty that comes with functional self-regulatory law can become a problem.

At one end of the table one has the legislature which has the goal of conducting a policy process to create legally binding laws to control and regulate. While on the other end one has the industry that has value creation as its goal. This is not necessarily a conflict of interest, but it can become one. If the gap is not addressed within the law. Certain actors may then adhere only to the minimum standards to cut initial costs of entry (Le Coze 2020; Black, 2011).In the case of the Polar Code this means that actors will get to sail the Arctic Seas without being prepared for it. NSRA, RS, and Rosatomflot The Northern Sea Route is not only governed by IMO. It is also governed by the laws of The Russian Federation. There is a myriad of sets of laws that adhere to shipping traffic in the Arctic, but noteworthy laws are: Rules of Classification and Construction of Sea-Going Ships, and Rules for Navigation in the Water Area of the

Northern Sea Route by respectively the Russian Maritime Register for Shipping(RS) and the Northern Sea Route Administration(NSRA) (Aker Artic, 2020).

Rules for Navigation in the Water Area of the Northern Sea Route, is the primary law that establishes the Northern Sea Route Administration as the legal regulator of shipping, fulfilment of international obligations of Russia, and port supervision of ships and fees by decree of the Ministry of Transport of Russia (Ministry of Transport of Russia 1998; 2013; Shtrek, 2020).

Previously, it was speculated that the NSRA would also be given control over the development of infrastructure, fleet creation, icebreaker assistance, additional services that pertain to this, structure development, and traffic control services. Taking over the role of Rosatomflot, port development company Rosmorport, the State Marine Rescue Service (Gosmorspassluzhba) and the Russian Sea-River Fleet (Rosmorrechflot) (Staalesen, 2017). However, in 2018 this responsibility was delegated to Rosatom (Aker Artic, 2020).

The intention of the split responsibility is that these regulatory and operational organizations will work together to assure that the Northern Sea Route remain safe and regulated. Together, they will enforce the "hard" side of regulation. In response to this delegation and the ratification of the Polar Code, the RS has drafted new proposals to the Rules of Classification and Construction of Sea-Going Ships (Aker Artic, 2020).

In this proposal tables containing numerous ice-classes have been removed. This comes as the new proposal implements functional requirements to accommodate the risk-based ideology of the Polar Code. Permissible ice-class is now to be the prerogative of the Harbour Master, The NSRA, or Ship Operator. In addition, the number of navigational zones along the Northern Sea Route has been proposed to be increased from 7 to 26. This has been done to accommodate the variance that can occur in ice, weather, and topography along the route (Aker Artic, 2020).

If one, then regards the new functional laws it must be said that these are not prone to the same issues that may arise with regards to the Polar Code. As an authority is going to judge whether the vessel is up to a certain standard. Ship designer are now required to justify their design. These purposed changes to the law are therefore stricter than the initial laws even though they are functional requirements.

The intention here is to sway the industry into making design decisions with safety and navigational issues in mind. The ships are to be specifically designed for the area they are going into. An idea put forward by Aker Arctic is that the intention of this is that these design decisions should also be reflect on the IMO Polar Ship Certificate in the future. This would then be a "legal standard" that would emerge from the industry of Polar Shipping (Aker Artic, 2020; Le Coze, 2019).

6.1.1 Summarizing the Dimension

The Level of Technical and Navigational Prescriptions can therefore be understood as a dimension where the policy-process of legislators meet the economic pursuit of industry. This dimension therefore works as an indicator of technical and sociotechnical safety, while also indicating the exclusion of actors that can or will not meet these requirements.

This dimension cannot be parameterized in definitive variables. This is due to the how functional requirements may be adopted differently. To make this dimension scalable it will therefore be expressed in levels. Higher levels of requirements mean more rigid and defined standards. While lower levels mean minimum requirements with room for multiple interpretations. In the high end of the scale one has more defined standard, less control, but more safety, in the low end one has less defined standards, more control, but less safety.

As such one can see that this dimension as a parameter contains the following conditions as values:

LEVEL OF TECHNICAL AND NAVIGATIONAL REQUIREMENTS	
P5V1	High
P5V2	Medium High
P5V3	Medium
P5V4	Low

Table 6.5: Conditions of the Dimension: Level of Technical and Navigational Prescriptions with combinatoric notation.

Dimensions VI: Achieved Level of Sustainable Maritime Technology

A large part of what governs the future of the Northern Sea Route is technology. Technology not only in the ship hull-design department of ship building, but also within the fuel, bunkering, and coastal infrastructures department. Hence, the standards and requirements that are placed on hull design is not enough to reduce the local risks tied to operating in the vulnerable North(DNV GL, 2019, 2017; Tronstad et al., 2017).

The first risk one wants to reduce by means of this technological development is the local risk. The local risk can be understood as the damages that emissions, and potential leaks, and spills can do to the local ecosystems. Albeit, global climate emissions are impacting these ecosystems on a grander scale in the long run, local leaks, spills and emissions must be considered more critical in the light of the abrupt impact on the immediate area, and its subsequent clean-up and resource mobilization requirements.

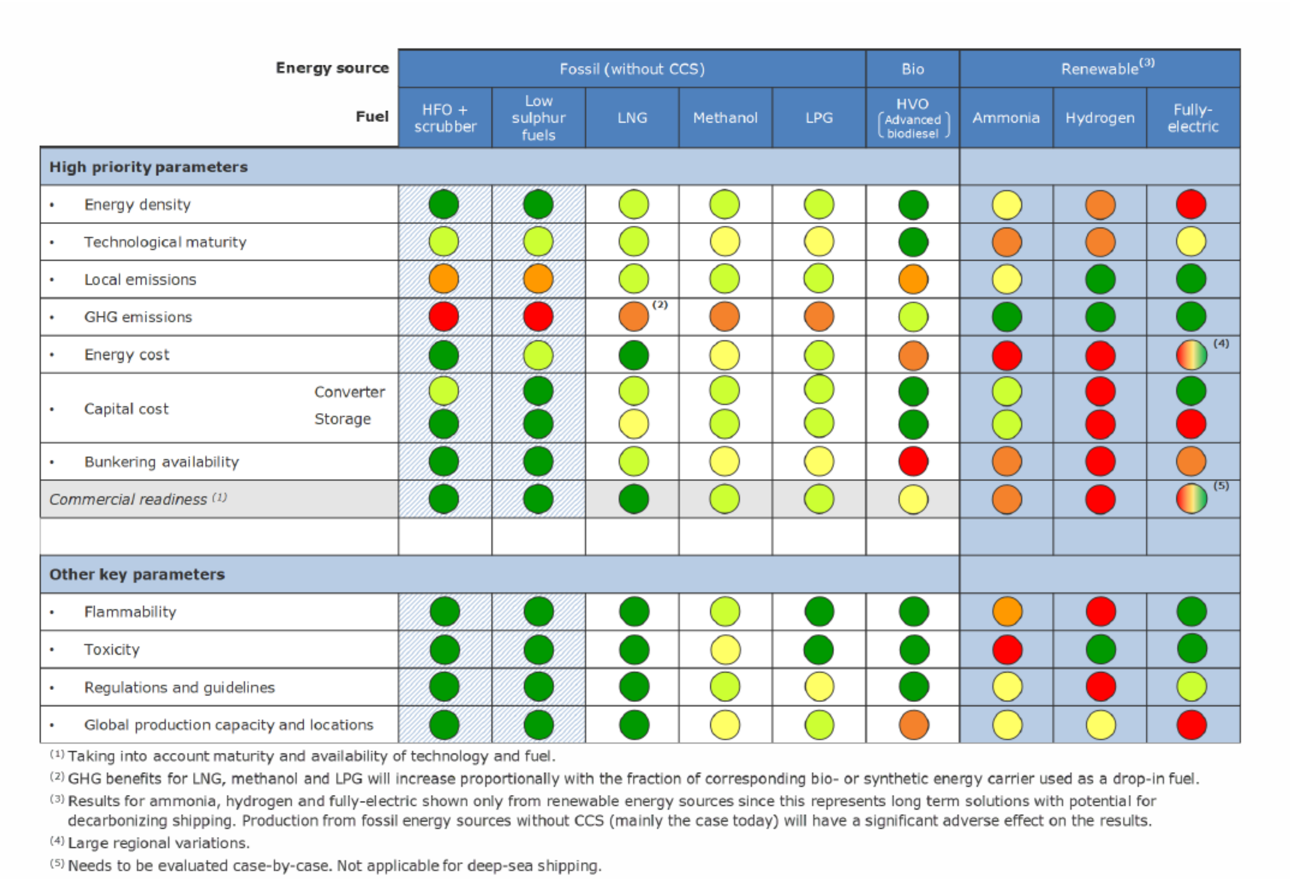

Figure 6.1: DNVGL's results interpretation from their Alternative Maritime Fuels Study (2019, p.8).

As one can see from this figure, there is no fuel alternative that is a jack-of-all trades. In the Arctic context for example the use of heavy fuel oil with a scrubber is not viable due to the potential of local emissions in the case of an oil spill. Whilst hydrogen is clearly a more local friendly alternative, but its fuel density,related safety aspect, energy cost, and other costs associated with a low level of technological maturity makes it less viable at the current moment. On the topic of energy, one must consider ammonia to be better suited, but it also suffers from the economic costs that bring the maturity of this technology up to a higher level. An important point to emphasize here is for example the need for better fuel-cell technology with regards to these energy sources (DNV GL, 2019).

This figure however makes it quite apparent that the solution for the Arctic may not be the solution for the rest of the world in terms of going "carbon clean" in the long run. Due to the vast stretches of underdeveloped infrastructure along the Arctic coasts one clearly sees that significant resource use must go into making the fuel types with low local emissions viable. In addition, significant amounts of more resources must be funnelled into the research and development of the technological systems that might improve storage and bunkering availability within these regions (Tronstad et al., 2017).

Out of the alternatives however, liquefied natural gas seems the most viable due to its vast availability in the Russian Arctic. This brings into question on whether one wants to rely upon renewable or fossil-based fuels. In which liquefied synthetic methane or Bio-LNG seems more viable than fossil LNG in the long run but relies upon further investment into the market. In addition, one must consider how the overall greenhouse gas emissions can be reduced by using bio and synthetic energy carriers with LNG (DNV GL, 2019). However, what one must take into account is whether the adoption of Bio-LNG is a realistic prospect as the amount of Bio-LNG required to entirely fuel the maritime global trade fleet seems a daunting task not only with regards to the sheer volume it would require, but also with regards to the safety requirements need to store this vast amount of LNG. Hence, one must consider that fossil LNG seems a more safe and realistic alternative.

What this leaves us with is an understanding of the how sustainable energy sources may impact the Northern Sea Route. What is evident is that one is looking for a fuel alternative that can offer up high profitability, and low local and overall emissions. In addition, we see that their alternatives that offer up low overall emissions but prove to have higher local environmental risk associated with it. There is also the variable of availability, and the need for infrastructural costs and further research development that is not directly captured by this condition. There are very real costs to this aspect of developing maritime sustainable practices, in which one must consider whether this is something for a government to spearhead rather than industry.

Industry is demand driven, and demand is contingent on costs and profitability. If one for example takes hydrogen vessels into perspective, this is a technology largely progressed by the Norwegian Ministry of Transport. If one is to make leaps within the sector of alternative energy practices to fossil fuels, considerable amounts of resources must surmount, and one cannot rely entirely upon industry to do so (DNV GL, 2019).

If one continues on this example of hydrogen, one must also consider other expenditures with associated with alternate fuels. To produce hydrogen outside of natural gas reforming which leaves global emissions, one requires vast amounts of energy to conduct electrolysis or other similar procedures that requires power. If one is to produce "clean" hydrogen, then one must presuppose that the electricity used for these processes is clean as well. Hence, it is contingent on renewable energy sources such as solar panels, water-turbines, and wind-turbines. In addition, one is contingent on battery technology to store power from such grids when there is a surplus. The transport of hydrogen also needs to be "clean" for the full emissions tally to be considered clean. Then what fuel would be used for transport? A steady amount of questions arise, in which we must consider that the development of technologies are not non-connected from development of technologies elsewhere (DNV GL, 2017, 2019; Tronstad et al., 2017). Costs are going to be incurred from every stage, and to mitigate total emissions these costs are going to be beyond imagination.

Hence, one is left with a parameterization that reflects the emission and profitability of the technologies rather than contending for one single energy source as the futures alternative. As this is something entirely uncertain, but we can ascertain that it is contingent on these two variables.

As such one can see that this dimension as a parameter contains the following conditions as values:

ACHIEVED LEVEL OF SUSTAINABLE MARITIME TECHNOLOGY		
P6V1	High	Low Emissions, High Profitability
P6V2	Medium High	Medium Emissions, High Profitability
P6V3	Medium	Medium Emissions, Medium Profitability
P6V4	Low	High Emissions, High Profitability

Table 6.6: Conditions and explanation of conditions of the Dimension: Achieved Level of Sustainable Maritime Technology with combinatoric notation.

Dimension VII: Wildcard Events

This dimension is perhaps the most complicated one when it comes to its constraints. It is an Boolean "and" category that attains to many different events that can occur in the possible future states of the Northern Sea Route. It is indubitably a unique dimension, as its constraints are not tied to the dimension itself but to its conditions. The inclusion of this dimension is essentially to tie some possible events that can have cardinal effects on the use of the Northern Sea Route. As such this section is quite different than the other dimensions, as it contains subsections that each tie in the empiric nature of the events, instead of a seminal coherent deliberation, as these events can be entirely orthogonal within the same parameter block.

6.1.2 Maritime Accidents or Incidents in the Arctic

Major maritime incidents can occur in the Arctic due to what has been termed the Arctic Problem. The Arctic Problem is essentially the combination of natural phenomena and fauna that are ever present but seasonally changing in the Arctic (Hangaslammi & Hatakka, 2018). Hence, the span of hazards and dangers is wide, but the ones of importance to this section are the maritime hazards, these are clearly defined within the IMO Polar Codes introduction chapter, under subchapter 3 – Hazards (International Maritime Organization IMO, 2014). Whilst they are even further emphasized by contemporaries such as Marchenko, Solberg, Gudmestad, Sollid and a multitude of others(K. E. Solberg et al., 2016, 2017; Gudmestad & Solberg, 2018; Marchenko, 2012). Below you can see a table detailing some of the most pertinent hazards for maritime activities, adopted from my 2019 paper on the matter (Johannessen, 2019):

Thus, we see that there is a myriad of hazards that can impact maritime activities in the Arctic. Which is why organizations such as Rosatom, The Northern Sea Route Administration, The International Maritime Organization, and the like put forward strict guidelines in which operators much adhere to (International Maritime Organization IMO, 2014). However, a common misunderstanding is that these hazards manifest alone. As I put forward in my 2019 paper the polar maritime accidents of Marxim Gorkyi, MS Explorer, and Northguider all shared the common characteristics that multiple hazards were present simultaneously and compounded a bad situation into a calamity (Hovden, 2012; Reel, 2007). Additionally, these matters become worse due to the vastness and infrastructural deficiencies in the Arctic Seas (Hangaslammi

Hazard	Impact
Seasonal Darkness	Impairs vision and navigation
Rapid Changing Weather	Causes uncertainty about risk of navigation
Sea and Glacier Ice	Causes physical hazards to vessel integrity
Lack of local information	Impairs judgements and decision-making
Vastness and great distances	Impairs SAR and self-rescue
Lack of physical and social infrastructure	Causes logistical and SAR impairments
Lack of communication infrastructure	Impairs self-rescue and decisions-making
Polar influence on navigation	Decreases reliability of navigation by GPS
Lack of oceanographic data	Decreases reliability of navigation and predictability of risks
Lack of meteorological data	Decreases predictability of risks
Cold Temperatures	Causes hypothermia

Table 6.7: Hazards and Potential Impacts of Hazards adopted from (Johannessen, 2019, p.8) and compiled by means of (International Maritime Organization IMO, 2014; K. E. Solberg et al., 2016, 2017; Gudmestad & Solberg, 2018; Marchenko, 2012)

& Hatakka, 2018). One relies upon vessels of opportunity and vessels of convenience when such instances occur, which were the “Hail Mary” for all of these incidents, albeit Northguiders vessel of convenience was an airliner that happened to pick up their "mayday" transmission (Rommetveit, 2019).

Major Oil-Spill in the Arctic

With regards to major oil-spills in the Arctic, this is problematic as it involves possibly dealing with such oil-spills within ice conditions, and during the exposure to polar lows, and reliance on ice-breakers or ice-resistant vessels to do so (Sollid et al., 2018). As with every arctic activity and accident, the exact risk picture of such an event cannot sufficiently be pre-assessed. Albeit, it is likely that such an incident would be initiated by either a grounding, by hitting ice or by collision in a convoy (Sollid et al., 2018; Norwegian Maritime Association, 2017).

As the statistics from the Norwegian Maritime Administration, shows out of the 14 maritime incidents around the Arctic Archipelago of Svalbard 12 of these were groundings. By taking the accident transcription of Marchenko into account it does seem quite likely that this will occur along the Northern Sea Route as well (Norwegian Maritime Association, 2017; Marchenko, 2012). This seems further supported by findings from Greenland from 1990 to 2012 in which 499 registered groundings out of a total of 788, were groundings north of 60 degrees (DNV GL, 2015). Further emphasized by Sollid. et.al., and Macrae it seems evident that grounds will happen regardless due to it largely being contingent on the human element, and the human element is especially prone to failure within compounding arctic environments (Sollid et al., 2018; Macrae, 2009).

Hence, one sees that one can reduce the probability of oil spills by making technological advances in the areas of vessel design, and combustion system designs. In addition to implementing prescriptive and descriptive laws that attain to these two facets. But to completely rule it out seems contingent on technological leaps towards other products than oil for combustion, lubrication, and the like.

Major Cruise Ship Accident in the Arctic

Cruises are as prone as any other vessel to grounding as the Research Vessel Akademik Ioffe in the Canadian Arctic in 2018 showed us. In addition, we have to take into consideration the cruise accidents in polar areas involving ice and other compounding hazards such as the Marxim Gorkyi incident in 1989, and the MV Explorer in 2007 (Reel, 2007; Humpert, 2018; Hovden, 2012). The reason why these cruises are especially prone to accidents is because they are intended for exploration, they seek glaciers, and ice up close. This pursuit becomes even more concerning if one takes into consideration the new flux of interests from larger non-exploration cruise ships to fare in arctic waters.

Thus, the risk impact of the hazards that vessels normally expose themselves to become manifold with the involvement of more, and more passengers. Which became quite apparent when the MV Viking Sky nearly grounded near Hustadvika, Norway in 2019. It took an insurmountable effort to rescue passengers with helicopters from the vessel stuck in a storm and close to grounding, in a consorted effort over many hours (Quinn, 2019). If MV Viking Sky, MV Explorer, Marxim Gorkyi, and Akademik Ioffe has taught us anything it is that an incident involving a cruise is tumultuous at best (Reel, 2007; Humpert, 2018; Quinn, 2019). Thus, one must ask oneself if the reward is worth the risk in the Arctic as the compounding effect much repeated here makes search and rescue efforts an unimaginable task (Hangaslammi & Hatakka, 2018). MV Viking Sky was in trouble near an airport and had 6 of Norway's 14 rescue helicopters evacuating it, and the evacuation was still not controlled (Quinn, 2019). One must therefore consider, what happens if such an incident occurs in "the middle of nowhere" in the arctic seas with no vessels of opportunity, nor convenience close by. The IMO Polar Code has a lot of prescriptions that stipulates the need for Personal Protective

Equiopment(PPE), technical ship specifications, and training (International Maritime Organization IMO, 2014). Also, as the three first SARex exercises showed us this is insufficent(International Maritime Organization IMO, 2014; K. E. Solberg et al., 2016, 2017; Gudmestad & Solberg, 2018; Marchenko, 2012).

Thus, one sees that the only real way to reduce the possibility of such a calamity is stricter controls, prohibition, or very stringent technological requirements to design.

6.1.3 Challenges Regarding Competing Trade Routes

The gradual decline in ice in the Arctic has caused a resurgence of interest with regards to using the Northern Sea Route as an alternative to The Suez Canal, The Panama Canal, the Malacca Strait, and the Horn of Africa (Liu & Kronbak, 2010). Predictions and forecasts into the pros and cons of the Northern Sea Route and the shipping route with it, often focuses upon the economical aspects of the route (Le Mière & Mazo, 2013; Pierre & Olivier, 2015; Rahman et al., 2014). However, there are pros and cons to be found with regards to the much broader international relations perspective.

The topology of international relations is in constant fluctuation, and as such it is not always possible to determine the full extent of actions, nor to see actions as black and white. International relations are clearly non-binary, and non-linear.

Hence, one must consider that challenges can arise in one sector, but not scale into all sectors. An instance of such could be a trade war, an embargo, or a cold war. It need not escalate into involvement of military measures, but it will cause challenges in other areas of a nations affairs.

With regards to these different trade routes one must consider that trade wars can escalate, and their influence can be used by some countries to influence other countries to place embargo to block out their opposition.

If one, for example, takes into consideration the current “trade war” as the media has coined it, between the USA and China. If this was to escalate in an untimely manner, influence could be exerted by for example USA upon Malaysia, Singapore, Thailand, Indonesia, and Panama to close off the Malacca Strait and the Panama Canal for Chinese cargo. In such an instance, the Northern Sea Route would prove a faster route. The same could be said for any challenge that arises that causes the route to be a better alternative than others. The Northern Sea Route thus has its place within geopolitical planning for prevention and mitigation of challenges.

6.1.4 Arctic Infrastructural Developments

The development of Arctic infrastructures in the regions of petroleum and shipping is a currently ongoing project that is largely spearheaded by Russia. The Russian Federation has turned its full attention to the direction of the Arctic, and the Duma has passed a number of policies intended to further develop the Arctic. Though, the separation of the coastal infrastructures from the petroleum and LNG infrastructure is a deliberate choice to define the differences between these sectors with regards to the Northern Sea Route.

Extended Development of Arctic Coastal Infrastructures

The development of Arctic Coastal infrastructures is about the development of ports, safe havens, and coastal cities and the infrastructure that support these cities. Hence, these are developments done to cities such as Kandalaksha, Murmansk, Arkhangelsk, Vitino, Naryan-Mar, Belomorsk, Dikson, Dudinka on the Yensei River Gulf, Igarka, Tiksi, Pevek, and Vladivostok. One should notice that Severomorsk is excluded as this is primarily closed military infrastructure (Devonshire-Ellis, 2017).

From West to East these ports are at the standard and level of inhabitants where they can facilitate loading and unloading of cargo or can serve as safe havens during storms. During recent years the federation has devoted a lot of resources to these ports to facilitate this. The implementation of new rail roads and airport infrastructures are also on the agenda for some of these cities to make them more connected to the larger urban areas of Russia, as Vladivostok is to Moscow with the trans-Siberian railway(Russia Briefing, 2020, 2019).

Arkhangelsk and Murmansk are of course already established shipping ports with these capabilities, but developments are not only targeted in the direction of trade. As noted quite a number of times, the Northern Sea Route faces as an infrastructure a myriad of challenges in the form of the Arctic Problem. A facet of this problem is the vastness and distances between inhabited infrastructures. As such these developments are also being made to extend the search and rescue capabilities of the Northern Sea Route beyond its current scope(Bourmistrov et al., 2015).

One must take into consideration that the vast majority of search and rescue resources and capabilites will be found between the Barents Sea and the Kara Sea as the city of Severomorsk houses the Northern Fleet and the largest amount of SAR resources found in the Arctic. Whilst it also borders to Norway which has continuous coast guard cooperation and treaties with Russia in the Barents Sea. Hence, the critical areas are beyond the Barents and White Seas.

Extended development to these infrastructures will therefore improve not only the trade capabilities of these ports, but it will also increase the overall safety of the Northern Sea Route. There is a vast amount of search and rescue resources in the Russia Arctic, but due to her vast size and long coast it takes time to reach accident sites. This is taken into consideration by international organs such as the International Maritime Organization, as made evident in the IMO Polar Code paragraphs 1.2.7 and 1.4.3:

1.2.7 *Maximum expected time of rescue means the time adopted for the design of equipment and system that provide survival support. It shall never be less than 5 days.* (IMO Polar Code, 2014 para 1.2.7).

1.4.3 *For ships operating in low air temperature, survival systems and equipment shall be fully operational at the polar service temperature during the maximum expected rescue time.* (IMO Polar Code, 2014 para 1.4.3).

The developments therefore facilitate the capabilities of self-rescue, or the opportunity of rescue by vessels of opportunity and convenience beyond Rosatom and The Northern Fleet resources. Seen from the perspective of the plans made by the Federation. It seems evident that extensions of these developments are to stay if the Northern Sea Route, and the Northern Sea Route with it is to stay open.

Extended Development of Arctic LNG and Petroleum Infrastructure

The development or Arctic oil and gas facilities is a project in which Norway works in close relation with Russia. As contended by Overland and Krivorotov the countries have a good relationship, characterized by mutual trust, coordination, and the ability to solve challenges together (Bourmistrov et. al. 2015, p.96). Hence, it is no surprise that the two countries can work together as regulators of the Arctic oil and gas sector through their state-owned oil-companies Gazprom, Rosneft, and Equinor(formerly Statoil) (Bourmistrov et. al. 2015, p.96).

Norway and Russia do however regulate the Arctic oil and gas sector together within the Barents Sea. As a province it is divided in two by the Norwegian-Russian maritime border which is 1,680 km long. As a province it is rich in both resources and common history. As such this area has been contested and has been and still is a hotbed for Norwegian-Russian relations, but time and time again these countries have shown to have a working relationship that allows for such challenges to be solved. As made evident through numerous efforts to delineate the Barents Sea amongst each other from the 1960s until 2010, where it was evenly split between the two co(Bourmistrov et al., 2015). That is not to say that the issues are resolved, but rather to indicate that issues that arise may be dealt with in a cooperative and understanding fashion.

Further investigations into the petroleum ventures of the two countries jointly in the Barents Sea can attest to this. The planning of the Shtokman development, the cooperation between Rosneft and Equinor, and Lukoil and Rosneft's entry into the Norwegian continental shelf attest to this (Bourmistrov et al., 2015). This is made further evident by the stipulations with regards to oil exploration in the Murmansk Treaty (Bourmistrov et al., 2015). Both countries are pursuing petroleum ventures together in the Barents Sea and they are there to stay. Norway's commitment to the cause has however been questioned since Norwegian labour party's expressions of not wanting to expand into the Arctic, whilst the recent relocation of the "ice edge" as defined by the current Norwegian administration attest to another perspective (Cosson-Eide et al., 2020).

Arctic Petroleum infrastructure is however not isolated to the Barents Sea; along the entire Northern Coast of Russia one has found oil and gas deposits (Bourmistrov et al., 2015). However, these further development of this are contingent on developments in Arctic infrastructures, and Arctic coastal infrastructures. Those infrastructures are also contingent on the oil and gas developments. In addition, one can speculate in whether the developments in the Barents Sea will make it easier to facilitate further expansions along the Northern Sea Route. Either way, the Arctic Infrastructures mentioned will have some form of spill-over effect on each other. As such, it is quite clear that there is a lot of factors that influence the extension of oil and gas infrastructure in the Arctic, and its complexity is as non-linear and non-quantifiable as this thesis' problem complex.

6.1.5 Ice conditions

Another set of conditions that can occur along the Northern Sea Route is ice conditions. As an effect of climate change, the polar icecaps are melting, and the presence of different types of sea ice is becoming less frequent during the Arctic summer season. As a result, the trade and transport routes of the Northern Sea Route becomes affected. Hence, what we today know as the Northern Sea Route may be subject to change in the future. As shown in both the maps by Marchenko, and Allen there are numerous routes to take along the Northern Sea, and in addition the ice-conditions will vary.

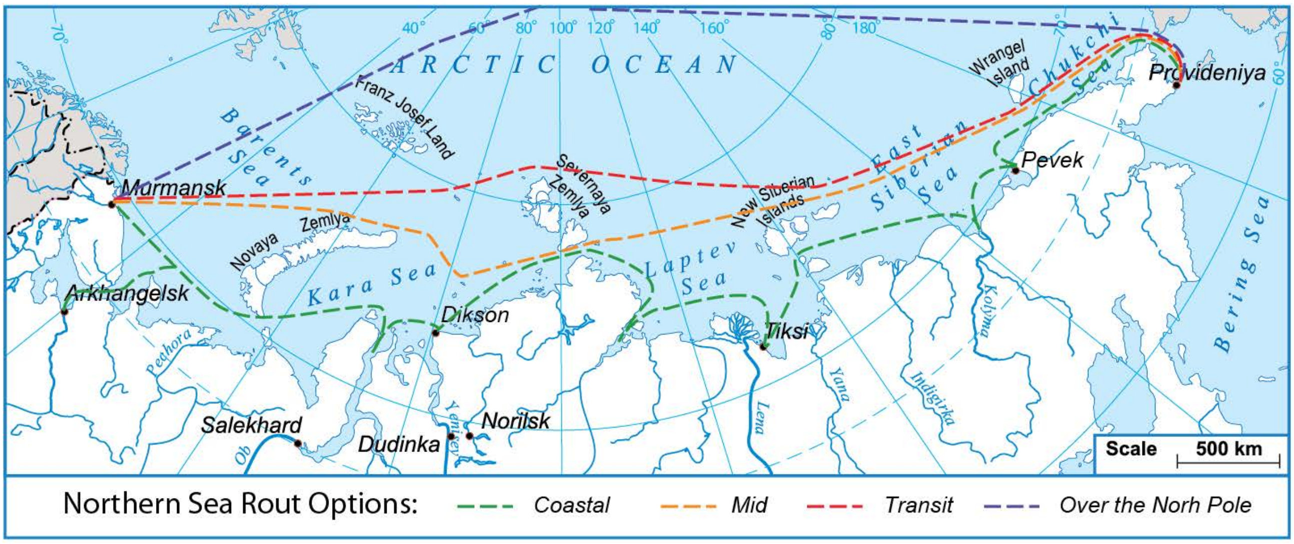

Figure 6.2: Routes along the Northern Sea Route from (Marchenko, 2014)

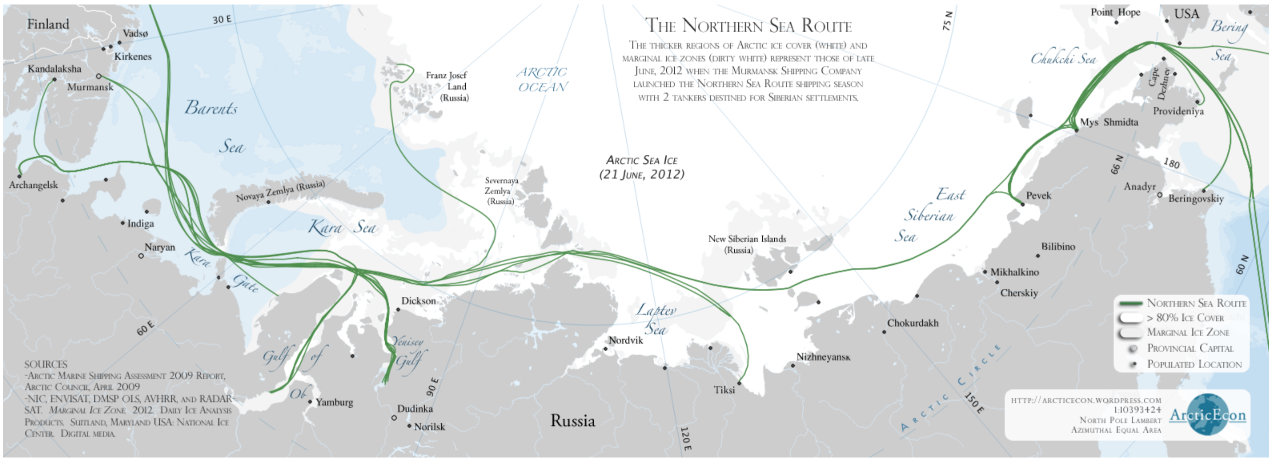

Figure 6.3: Northern Sea Route Traffic Illustration illustration from (Allen, 2012)

Albeit, one does not know exactly how the ice conditions will change or at what rate, research into this subject has given us some projections. In which some of them even predict that there will be no Arctic sea ice by 2050 (Diebold Rudebusch, 2019).

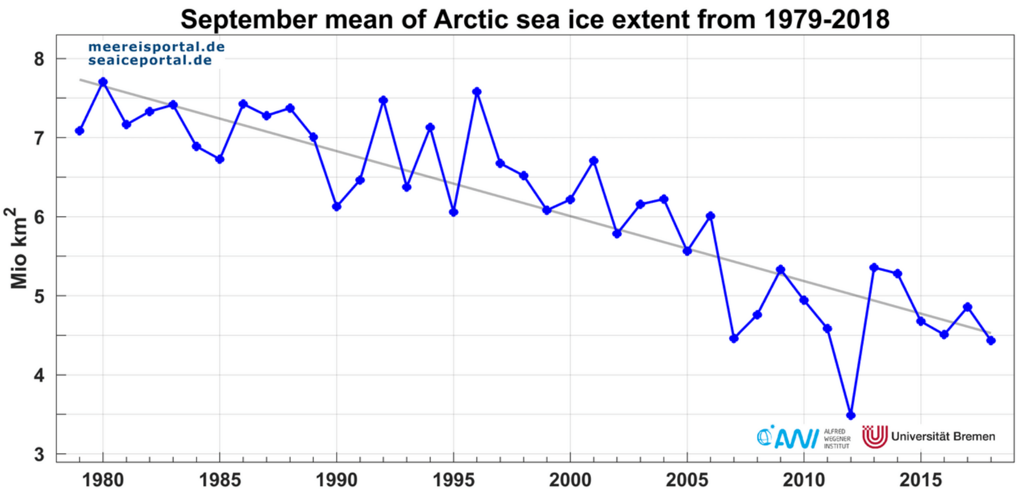

Figure 6.4: Shrinking cover of Arctic Sea Ice (Applicate, 2018)

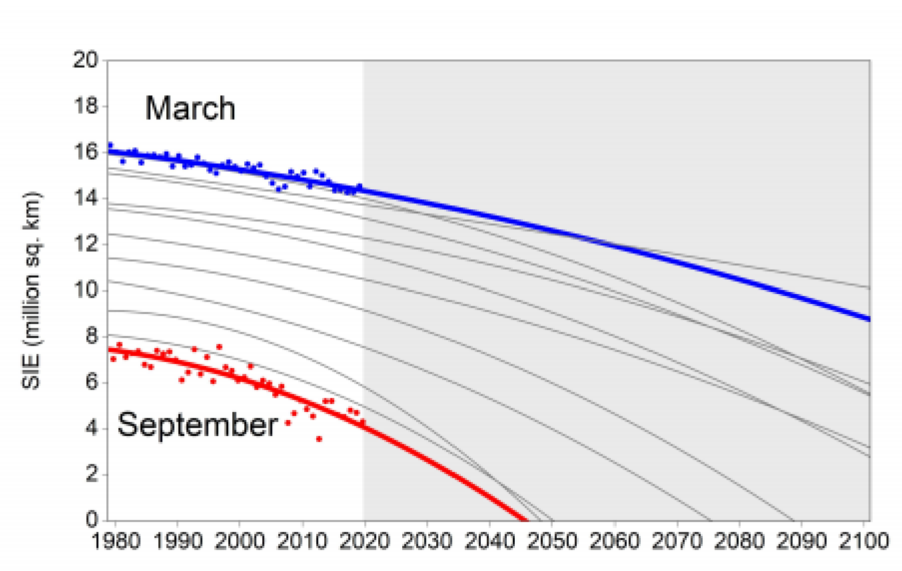

Figure 6.5: Model of Future Sea Ice Extent (Diebold Rudebusch, 2019, p.9)

The predicament at the current stage thus seems to be a variety in ice-conditions combined with the uncertainty regarding this variety. Whereas earlier, the ice-conditions along the Northern Sea Route would be more predictable the current effects of climate change makes them more unpredictable.

It does therefore not come as a surprise that the Rules for Navigation in the Water Area of the Northern Sea Route is currently undergoing an approval process because of newly drafted changes. In which a noteworthy change is made with regards to increasing the amount of navigational zones in the Northern Sea Route from 7 to 26 to reflect the unique ice conditions of different geographical locations (Aker Artic, 2020).

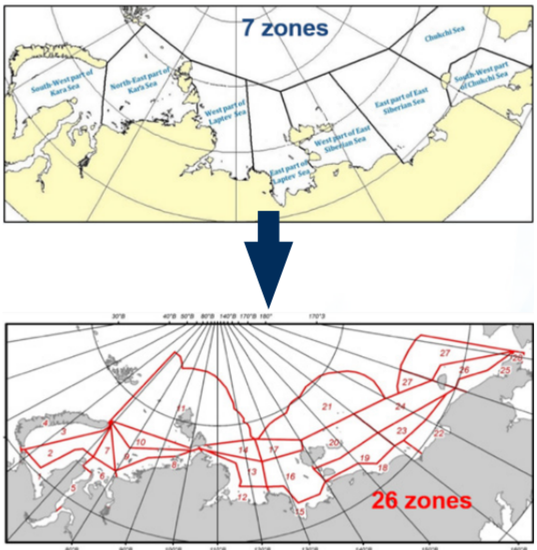

Figure 6.6: Navigation Zones from (Aker Arctic, 2020, p.5)

Thus, it seems evident that one should take into consideration at least some of the ice changes that can occur along the Northern Sea Route that will impact the shipping route. The first condition is the extended ice-free NSR, this condition attains to the steadily extended ice-free seasons of the NSR which seems quite on topic if one takes into consideration the ice conditions during last August (Staalesen, 2019). Another, condition attains to how the ice conditions within the NSR can vary greatly, and as a consequence on might still have ice year-round in some parts of the NSR, whilst in others not. Finally, one must consider the condition in which the circum-polar ice sheet starts to only consist of first year ice, giving some eligibility for the extension of the NSR and also the North Western Passage (Diebold & Rudebusch, 2019)

6.1.6 Summarizing Wildcard Events

As one can see, these wildcard events attain to events that can occur and alter the future of the Northern Sea Route, and the condition one is left with is:

WILDCARD EVENTS	
P7V1	Major Oil-Spill in the Arctic
P7V2	Major Cruise Ship Accident in The Arctic
P7V3	Challenges Regarding Competing Trade Routes
P7V4	Extended Development of Arctic Coastal Infrastructures
P7V5	Extended Development of Arctic LNG and Pet Infrastructure
P7V6	Extended Ice-Free NSR
P7V7	Year-Round Ice in Parts of NSR
P7V8	First-Year Ice in Cross Polar Path

Table 6.8: Conditions of the Dimension: Wildcard Events with combinatoric notation.

Dimension VIII:
The Availability State of The Northern Sea Route

The Availability State of The Northern Sea Route is the dimension that describes if the route is open or closed.

When this dimension takes on the condition of "open", this means that the Northern Sea Route is legally open, and the vessel can sail along the navigational zones without icebreaker escort. Seasonal closing, or the closing of certain navigational zones due to ice conditions or weather can occur during this condition. These still constitute an open route but may go into the next condition.

When this dimension takes on the condition of "open with tariffs", this means that the use of an icebreaker is required. As such, tariffs will be imposed on the vessel or vessel owner per The Ministry of Justice of Russia 2014, Annex to the order of the Federal service of tariffs of March 4, 2014, N-45-t/1. This document entails the different tariffs that will be imposed based on ice class of vessel, navigational zones crossed, and gross tonnage of vessel(Northern Sea Route Administration, 2020).

Another document that is critical to consider during the "open with tariffs" condition is Rules for Navigation in the Water Area of the Northern Sea Route (Northern

Sea Route Administration, 2020). This document requires vessels sailing the Northern Sea Route to use Rosatomflot's icebreakers and ice pilots when a vessel does not satisfy ice-class, navigational, or experience requirements set forth by the Northern Sea Route Administration.

When this dimension takes on the condition of "closed", this means that the Northern Sea Route is legally closed for non-local actors. This can be either due challenging tension, involvement, or due to other events that would cause the route to be closed by local actors with the power to do so.

As such one can see that this dimension as a parameter contains the following conditions as values:

THE AVAILABILITY STATE OF THE NORTHERN SEA ROUTE	
P8V1	Open
P8V2	Open with tariffs
P8V3	Closed

Table 6.9: Conditions of the Dimension: The Availability State of the Northern Sea Route with combinatoric notation.

6.2 Cross-Consistency Assessment: Applying Constraints in Parameter Blocks

The following chapter is the second step of the morphological analysis. It is the documentation chapter of the pair-wise assessments of dimensions and conditions, known as the cross-consistency assessment. The subsections are structured around parameter blocks of tow dimensions in which there is first a brief discussion around choices in constraint application and followed by representative parameter block tables and explanatory tables. In practical terms it details the exact process conducted in CarmaCCA Viewer.

	Type of Constraint		
Degree of Constraint	**Logical**	**Empirical**	**Normative**
-	Possible	Quite alright; good fit; or optimal	No problem, even desirable.
K	Possible	Not-impossible; not-optimal, unlikely or farfetched	Debatable; problematic
X	Impossible	Impossible or not viable; e.g goes against laws of nature, etc.	Unacceptable or functional on ethical grounds

Table 6.10: Degrees and Types of Constraint table adapted from (Ritchey, 2015), containing the notation used in MACarma and CarmaCCA Viewer.

Parameter Block 1: Involved Stakeholders | East/West Relations

Involved Stakeholders and East/West relations are directly connected dimensions that constrain each other. This constraint is an empirical descriptive constraint of how stakeholders and relations interact.

If relations are challenging, one must consider that it is not feasible for stakeholders beyond the locality of the Arctic, to be involved (Østhagen, 2016). As such the determinant becomes whether these challenges arise as tension or involvement.

As tension can take many forms one cannot exclude that stakeholders beyond the locality of the Arctic can participate in the Arctic. However, it is not certain how they will participate either, as such it seems not an impossible combination of coexistence, but certainly one that would require further information to predict.

In addition, one must consider that China through their peaceful trade driven policies will most likely try to get in place lateral trade agreements rather than to get involved in involvements or conflicts. As such their involvement seems a good fight through all relations(Mariia, 2019; Lanteigne, 2014)

Finally, one must consider that relations do not impact local stakeholders involvement in the Northern Sea Route. One can attribute this to their continuous cooperation in the area, exclusion of escalated conflicts there, and involvement due to their constant border attachment regardless of political declination.

INVOLVED STAKEHOLDERS	
P1V1	Local Actors
P1V2	Eastern Actors
P1V3	Western Actors
P1V4	African Coastal States
P1V5	China

EAST/WEST RELATIONS	
P2V1	Cooperation and Agreement
P2V2	Neutral Involvement
P2V3	Challenging Tension
P2V4	Challenging Involvement

Table 6.11: Conditions of the dimensions: *Involved Stakeholders* and *East/West Relations.*

	P1V1	**P1V2**	**P1V3**	**P1V4**	**P1V5**
P2V1	-	-	-	-	-
P2V2	-	-	-	-	-
P2V3	-	-	-	**K**	**K**
P2V4	-	**K**	**K**	**X**	**K**

Table 6.12: Parameter Block 1: Cross-consistency assessment of *Involved Stakeholders* and *East/West Relations.*

Parameter Block 2: Involved Stakeholders | Global Demand for Arctic Trade Traffic

Involved Stakeholders and *Global Demand for Arctic Trade Traffic* are directly connected dimensions that constrain each other. This constraint is an empirical prescriptive constraint that attains to demand being stakeholder involvement.

Going by demand as essentially stakeholder involvement in trade, one sees that it could seem impossible to have more than a few involved parties during low demand. However, one must consider that the Northern Sea Route could serve as an alternative route for certain stakeholders in the different groups pending on different political or economic aspects. As such, we must see it as not impossible, but specify that there needs to be an exceptional circumstance for them to use the route during low demand. Such as the closing of competing trade routes, or circumstances that are like this(Lanteigne, 2014; Rahman et al., 2014).

In addition, one must consider that China will likely be involved during all stages of demand due to the strategic place that the Northern Sea Route holds within numerous sectors. Their goal is to attain lateral trade agreements, or to gain lands in the Arctic as such they will stay involved at any cost(Lanteigne, 2014).

Finally, for local actors their involvement is not contingent on demand. It is given by their geographical placement in the area, and one could consider them to be orthogonal to such an assessment.

INVOLVED STAKEHOLDERS	
P1V1	Local Actors
P1V2	Eastern Actors
P1V3	Western Actors
P1V4	African Coastal States
P1V5	China

GLOBAL DEMAND FOR ARCTIC TRADE TRAFFIC	
P3V1	High
P3V2	Medium
P3V3	Low

Table 6.13: Conditions of the dimensions: *Involved Stakeholders* and *Global Demand for Arctic Trade Traffic.*

	P1V1	**P1V2**	**P1V3**	**P1V4**	**P1V5**
P3V1	**-**	**-**	**-**	**-**	**-**
P3V2	**-**	**-**	**-**	**K**	**-**
P3V3	**-**	**K**	**K**	**X**	**K**

Table 6.14: Parameter Block 2: Cross-consistency assessment of *Involved Stakeholders* and *Global Demand for Arctic Trade Traffic.*

Parameter Block 3:
Involved Stakeholders | Global Political Environmental Stance

Involved Stakeholders and Global Political Environmental Stance are directly connected dimensions that constraint each other. The constraint here is normative, as the global normative stance adapted will set the discourse for Arctic politics.

There is not a lot to comment here except for the fact that these stances presuppose that certain requirements are in place. As stated, before numerous actors ranging from Nike to the president of France Emmanuel Macron has stated that they will not take part in Arctic economic endeavours based on political environmental stances. As such, it seems evident that during radical progressive stances that it should not be entirely possible to be involved. However, one must consider that its is not only the climate that is changing, technology, and people are changing as well to counteract the effects of global warming. Therefore, there is the possibility that technology may reach levels where participation in the Arctic is morally grounded. As such its not impossible to be involved during this normative stance, but its certainly contingent on developments in technology (Krane, 2020; Regan & Reznik, 2019)

On the other end of the spectrum one must consider that regression from the current status quo the so-called conservative option would yield more involvement and more intrusive measures in the Arctic. It would also open up for actors that perhaps do not meet the requirements of the numerous codes, and laws pertaining to the Arctic nor can they afford to meet them such as African Coastal States as stakeholders (International Maritime Organization IMO, 2014; Le Mière & Mazo, 2013)

Parameter Block 4:
Involved Stakeholders | Level of Technical and Navigational Requirements

Involved Stakeholders and *Level of Technical and Navigational Requirements* are directly connected dimensions that constrain each other. The constraints here are empirically prescriptive. Prescriptive requirements in empiricism attains to laws, in this case the stakeholder involvement is legally dictated by the requirements. The requirements constrain stakeholders as it is a barrier to entry into the Northern Sea Route.

INVOLVED STAKEHOLDERS	
P1V1	Local Actors
P1V2	Eastern Actors
P1V3	Western Actors
P1V4	African Coastal States
P1V5	China

GLOBAL ENVIRONMENTAL POLITICAL STANCE	
P4V1	Radical Progressive
P4V2	Progressive
P4V3	Conservative
P4V4	Regressive
P4V5	Radical Regressive

Table 6.15: Conditions of the dimensions: *Involved Stakeholders* and *Global Political Environmental Stance.*

	P1V1	**P1V2**	**P1V3**	**P1V4**	**P1V5**
P4V1	**-**	**K**	**K**	**K**	**K**
P4V2	**-**	**-**	**-**	**K**	**-**
P4V3	**-**	**-**	**-**	**-**	**-**
P4V4	-	-	-	-	-
P4V5	-	-	-	-	-

Table 6.16: Parameter Block 3: Cross-consistency assessment of *Involved Stakeholders* and *Global Political Environmental Stance.*

For some stakeholders such as Eastern Actors, Western Actors, and African Coastal states the barrier to entry is due to the cost associated with revitalizing their fleet and training their crews for seafaring in the Arctic Seas (K. E. Solberg et al., 2016, 2017; Gudmestad & Solberg, 2018). For African Coastal States this cost to entry may outweigh the benefits in costs.

For other such as China and the US requirements that specify that one needs to use Russian icebreakers and adhere to their local governance and laws may seem as consolidating policies and norms that they do not agree with (Lanteigne, 2014).

As such with regards to stakeholder involvement one must entertain that these requirements have clear safety aspects to some but may have ideological aspects to other. Whilst the safety aspects clearly improve seafaring in the Arctic, the ideological aspect undermines it and can cause challenges in the future.

Furthermore, one sees that local actors will not necessarily have problems with involvement due to their geographic locality, but it must be contended that they also have economic and moral costs associated with these requirements.

INVOLVED STAKEHOLDERS	
P1V1	Local Actors
P1V2	Eastern Actors
P1V3	Western Actors
P1V4	African Coastal States
P1V5	China

LEVEL OF TECHNICAL AND NAVIGATIONAL REQUIREMENTS	
P5V1	High
P5V2	Medium High
P5V3	Medium
P5V4	Low

Table 6.17: Conditions of the dimensions: *Involved Stakeholders* and *Level of Technical and Navigational Requirements.*

	P1V1	**P1V2**	**P1V3**	**P1V4**	**P1V5**
P5V1	**-**	**-**	**-**	**K**	**K**
P5V2	**-**	**-**	**-**	**K**	**K**
P5V3	**-**	**-**	**-**	**-**	**-**
P5V4	-	-	-	-	-

Table 6.18: Parameter Block 4: Cross-consistency assessment of *Involved Stakeholders* and *Level of Technical and Navigational Requirements.*

Parameter Block 5:
Involved Stakeholders | Achieved Level of Sustainable Maritime Technology

Involved Stakeholders and *Achieved Level of Sustainable Maritime Technology* are directly connected dimensions that constrain each other. The constraints are empirically descriptive as the achieved level describes an empiric situation for the stakeholders to take part in.

There are two aspects to consider here with stakeholder involvement. The first aspect is how the achieved level of sustainable technology ties into the level of requirements needed for participation due to the emissions requirements in laws and standards. The second is the profitability aspect associated with the different levels of tech. For a thorough explanation on these aspect consult “Dimension VI”, and its “Figure 6.8”.

With the requirements in mind though an external factor to this comparison one must consider that if one has lower levels of sustainable maritime technology, then one cannot participate in Arctic maritime activities. This assessment is therefore rooted in an understanding of the Northern Sea Route as adhering to current standards (International Maritime Organization IMO, 2014; Northern Sea Route Administration, 2020).

By being rooted as such one must consider that one is place within the medium level of achieved maritime technology. Where one clearly has good alternatives and are developing others, but currently the revitalization of fleets of vessels is not occurring due to its cost, and considerations of the technology’s viability beyond its emission reductions. Such as safety concerns, availability for bunkering, fuel depots, fuel creation, fuel cell capacity and the like (DNV GL, 2015, 2017, 2019).

E.i one is not using hydrogen powered vessels due to these issues, whilst Rosatmflot utilizes a LNG icebreaker, and most vessels use fossil fuels with scrubbers(DNV GL, 2019; Aker Artic, 2020).

As such one sees that at the medium level only the actors that must bear considerable amounts of costs to revitalize their fleets may see involvement as not impossible, but not necessarily possible either. In addition, we see that at low levels of tech most actors outside of the locality of the Arctic will be excluded(DNV GL, 2019).

E.i vessels will have to use fuels that do not contain sulphides and meet with other environmental requirements, lower levels of tech would neglect this (DNV GL, 2019).

As such, the involvement is not necessarily contingent merely on actor's prowess but more on how technology meets requirements and standards. It is to say without this knowledge of requirements and standards that there would be an element of orthogonality here.

INVOLVED STAKEHOLDERS	
P1V1	Local Actors
P1V2	Eastern Actors
P1V3	Western Actors
P1V4	African Coastal States
P1V5	China

ACHIEVED LEVEL OF SUSTAINABLE MARITIME TECHNOLOGY	
P6V1	High
P6V2	Medium High
P6V3	Medium
P6V4	Low

Table 6.19: Conditions of the dimensions: *Involved Stakeholders* and *Achieved Level of Sustainable Maritime Technology.*

	P1V1	**P1V2**	**P1V3**	**P1V4**	**P1V5**
P6V1	-	-	-	-	-
P6V2	-	-	-	-	-
P6V3	-	-	-	-	-
P6V4	**-**	**-**	**-**	**K**	**-**
P6V5	**-**	**K**	**K**	**K**	**K**

Table 6.20: Parameter Block 5: Cross-consistency assessment of *Involved Stakeholders* and *Achieved Level of Sustainable Maritime Technology.*

Parameter Block 6:
Involved Stakeholders | Wildcard Events

Involved Stakeholders and the *Wildcard Events* are not directly connected dimensions. They are orthogonal to each other. No single event is exclusive to one stakeholder.

INVOLVED STAKEHOLDERS	
P1V1	Local Actors
P1V2	Eastern Actors
P1V3	Western Actors
P1V4	African Coastal States
P1V5	China

WILDCARD EVENTS	
P7V1	Major Oil-spill in the Arctic
P7V2	Major Cruise Ship Accident in the Arctic
P7V3	Challenges Regarding Competing Trade Routes
P7V4	Extended Development of Arctic Coastal Infrastructure
P7V5	Extended Developlement of Arctic LNG and Petroleum Infrastructure
P7V6	Extended Ice-Free NSR
P7V7	Year Round Ice in Parts of NSR
P7V8	First-Year Ice in Cross Polar Path

Table 6.21: Conditions of the dimensions: *Involved Stakeholders* and *Wildcard Events*.

	P1V1	P1V2	P1V3	P1V4	P1V5
P7V1	-	-	-	-	-
P7V2	-	-	-	-	-
P7V3	-	-	-	-	-
P7V4	-	-	-	-	-
P7V5	-	-	-	-	-
P7V6	-	-	-	-	-
P7V7	-	-	-	-	-
P7V8	-	-	-	-	-

Table 6.22: Parameter Block 6: Cross-consistency assessment of *Involved Stakeholders* and *Wildcard Events*.

Parameter Block 7:
Involved Stakeholders | Availability of the Northern Sea Route

Involved Stakeholders and *Availability of the Northern Sea Route* are directly connected dimensions that constrain each other. This connection is an empirically prescriptive connection as the availability of the Northern Sea Route dictates who can use it.

A closed Norther Sea Route excludes all actors that are not local.

A open Northern Sea Route with tariffs excludes actors that for economic or ideological reasons do not want to pay the tariff (Lanteigne, 2014; International Maritime Organization IMO, 2014; Northern Sea Route Administration, 2020).

A open Northern Sea Route without tariffs do not exclude anyone on economic or ideological grounds.

INVOLVED STAKEHOLDERS	
P1V1	Local Actors
P1V2	Eastern Actors
P1V3	Western Actors
P1V4	African Coastal States
P1V5	China

ACHIEVED LEVEL OF SUSTAINABLE MARITIME TECHNOLOGY	
P8V1	Open
P8V2	Open with Tariffs
P8V3	Closed

Table 6.23: Conditions of the dimensions: *Involved Stakeholders* and *Availability of The Northern Sea Route.*

	P1V1	**P1V2**	**P1V3**	**P1V4**	**P1V5**
P8V1	**-**	**-**	**-**	**-**	**-**
P8V2	**-**	**-**	**-**	**K**	**K**
P8V3	**-**	**X**	**X**	**X**	**X**

Table 6.24: Parameter Block 7: Cross-consistency assessment of *Involved Stakeholders* and *Availability of the Northern Sea Route.*

Parameter Block 8: East/West Relations| Global Demand for Arctic Trade Traffic

East/West Relations and *Global Demand for Arctic Trade Traffic* are not directly connected dimensions. They are orthogonal to each other. Any level of demand can be present during any level of relations. It does not necessarily mean that there would be supply so to speak with open borders, but the demand for this kind of transport would still be present.

EAST/WEST RELATIONS	
P2V1	Cooperation and Agreement
P2V2	Neutral Involvement
P2V3	Challenging Tension
P2V4	Challenging Involvement

GLOBAL DEMAND FOR ARCTIC TRADE TRAFFI	
P3V1	High
P3V2	Medium
P3V3	Low

Table 6.25: Conditions of the dimensions: *East/West Relations* and *Global Demand for Arctic Trade Traffic.*

	P2V1	**P2V2**	**P2V3**	**P2V4**
P3V1	-	-	-	-
P3V2	-	-	-	-
P3V3	-	-	-	-

Table 6.26: Parameter Block 8: Cross-consistency assessment of *East/West Relations* and *Global Demand for Arctic Trade Traffic.*

Parameter Block 9:
East/West Relations| Global Political Environmental Stance

East/West Relations and Global Environmental Stance are directly connected dimensions that constrain each other. This is a logical constraint regarding the feasibility of major political changes during challenging international relations.

From a logical perspective one knows that it takes vast amounts of resources, political power, and the coordination of these to change global politics. As such, it does not seem feasible to have radical progressive environmental stance during challenging relations. Nor does a progressive stance.

In contrast one knows that such challenges can easily end up in regressive stances from the status quo or the conservative stance as its coined here. Feasibility for coexistence is quite clear here.

EAST/WEST RELATIONS	
P2V1	Cooperation and Agreement
P2V2	Neutral Involvement
P2V3	Challenging Tension
P2V4	Challenging Involvement

GLOBAL POLITICAL ENVIRONMENTAL STANCE	
P4V1	Radical Progressive
P4V2	Progressive
P4V3	Conservative
P4V4	Regressive
P4V5	Radical Regressive

Table 6.27: Conditions of the dimensions: *East/West Relations* and *Global Political Environmental Stance*.

	P2V1	**P2V2**	**P2V3**	**P2V4**
P4V1	**-**	**-**	**K**	**X**
P4V2	**-**	**-**	**K**	**K**
P4V3	**-**	**-**	**-**	**-**
P4V4	-	-	-	-
P4V5	-	-	-	-

Table 6.28: Parameter Block 9: Cross-consistency assessment of *East/West Relations* and *Global Political Environmental Stance*.

Parameter Block 10: East/West Relations| Level of Technical and Navigational Requirements

East/West Relations and *Level of Technical and Navigational Requirements* are directly connected dimensions that constrain each other. This constraint is a logical constraint attaining to the logic that for international laws

From a logical perspective, one knows that the functional laws that applies in the Northern Sea Route is contingent on the interaction between legislature and the industry. The industry is made up of numerous different vessels from different countries. While the regulatory organs are primarily the international maritime organization and the Ministry of Transportation of Russia. If there is a challenging environment this may impede on the development of professional standards in the Northern Sea Route(Le Coze, 2019; International Maritime Organization IMO, 2014; Northern Sea Route Administration, 2020).

It is not practical from a logical perspective to have this challenging environment when one is supposed to cooperate to make these standards. As such a high level of requirements cannot emerge during challenging involvement. Its not entirely impossible but not necessarily a good combination.

In addition, it is not likely that one will fail to cooperate to develop standards during good relations. One must deem it impossible for standards to remain as minimum requirements if relations are good and no external factors influence the sector.Nor is it very likely that one does not develop these standards to higher levels during neutral and cooperative relations, but again entirely possible(Le Coze, 2019).

EAST/WEST RELATIONS	
P2V1	Cooperation and Agreement
P2V2	Neutral Involvement
P2V3	Challenging Tension
P2V4	Challenging Involvement

LEVEL OF TECHNICAL AND NAVIGATIONAL REQUIREMENTS	
P5V1	High
P5V2	Medium High
P5V3	Medium
P5V4	Low

Table 6.29: Conditions of the dimensions: *East/West Relations* and *Level of Technical and Navigational Requirements.*

	P2V1	**P2V2**	**P2V3**	**P2V4**
P5V1	-	-	K	X
P5V2	-	-	K	K
P5V3	K	K	-	-
P5V4	X	K	-	-

Table 6.30: Parameter Block 10: Cross-consistency assessment of *East/West Relations* and *Level of Technical and Navigational Requirements*

Parameter Block 11: East/West Relations | Achieved Level of Sustainable Maritime Technology

East/West Relations and *Achieved Level of Sustainable Maritime Technology* are directly connected dimensions. This connection is a logical constraint attaining to how technological investment into new areas requires cooperation and stability.

As established earlier, one knows that vast amounts of resources, political power, and the coordination of these are needed to change global policy. Likewise, the same is needed to make leaps in technology into new practices.

It is therefore not logical that one achieves higher levels of sustainable maritime technology during challenging involvement. It seems possible during tension, as tension can take many forms and may not necessarily impact the economy, but during challenging involvement it is impossible (Aarebrot & Evjen, 2014; Le Coze, 2019; Pierre & Olivier, 2015). This is due to the implications that involvement has, when one gets involved one expends resources, one gets troops on the ground, one shifts focus.

Adhering to the same logic, it seems impossible to not be able to achieve medium or higher levels of sustainable maritime technology during cooperation and agreement. This is because cooperation and agreement imply that there is sound agreement and a general common heading. This is not present in neutral relations which is definitely a stable state in international relations, but it does not have the implications of heavy cooperation that is present in cooperation and agreement (Aarebrot & Evjen, 2014; Le Coze, 2019; Pierre & Olivier, 2015).

EAST/WEST RELATIONS	
P2V1	Cooperation and Agreement
P2V2	Neutral Involvement
P2V3	Challenging Tension
P2V4	Challenging Involvement

ACHIEVED LEVEL OF SUSTAINABLE MARITIME TECHNOLOGY	
P6V1	High
P6V2	Medium High
P6V3	Medium
P6V4	Low

Table 6.31: Conditions of the dimensions: *East/West Relations* and *Achieved Level of Sustainable Maritime Technology.*

	P2V1	**P2V2**	**P2V3**	**P2V4**
P6V1	-	-	K	X
P6V2	-	-	-	K
P6V3	K	-	-	-
P6V4	X	K	-	-

Table 6.32: Parameter Block 11: Cross-consistency assessment of *East/West Relations* and *Achieved Level of Sustainable Maritime Technology.*

Parameter Block 12:
East/West Relations| Wildcard Events

East/West Relations and *Wildcard Events* are directly connected in one condition of *Wildcard Events.* This is connection is in the form of an empirical descriptive constraint in which relations need to be challenging for there to be challenges in competing trade routes. All other conditions of *Wildcard Events* are orthogonal to East/West relations at they do not impede or rely on each other with regards to the criterion of coexistence.

INVOLVED STAKEHOLDERS	
P2V1	Cooperation and Agreement
P2V2	Neutral Involvement
P2V3	Challenging Tension
P2V4	Challenging Involvement

WILDCARD EVENTS	
P7V1	Major Oil-spill in the Arctic
P7V2	Major Cruise Ship Accident in the Arctic
P7V3	Challenges Regarding Competing Trade Routes
P7V4	Extended Development of Arctic Coastal Infrastructure
P7V5	Extended Developlement of Arctic LNG and Petroleum Infrastructure
P7V6	Extended Ice-Free NSR
P7V7	Year Round Ice in Parts of NSR
P7V8	First-Year Ice in Cross Polar Path

Table 6.33: Conditions of the dimensions: *East/West Relations* and *Wildcard Events*.

	P2V1	**P2V2**	**P2V3**	**P2V4**
P7V1	**-**	**-**	**-**	**-**
P7V2	**-**	**-**	**-**	**-**
P7V3	**X**	**X**	**-**	**-**
P7V4	**-**	**-**	-	-
P7V5	-	-	-	-
P7V6	-	-	-	-
P7V7	-	-	-	-
P7V8	-	-	-	-

Table 6.34: Parameter Block 12: Cross-consistency assessment of *East/West Relations* and *Achieved Level of Sustainable Maritime Technology*.

Parameter Block 13: East/West Relations | Availability of the Northern Sea Route

East/West Relations and Availability State of The Northern Sea Route are directly connected dimensions. This connection is logical restraint adhering to how the Northern Sea Route is contingent on good relations for it to be open to stakeholders from beyond Russia.

Challenging tension and involvement presuppose that relations are not the greatest between the actors of the East and the West. Therefore, it is impossible for the sea route to be open during challenging involvement. However, during challenging tension it is possible, but not a great fit.

Cooperation and agreement on the other hand presupposes a common goal, and agreement. It is therefore possible, and even desirable to have an open route during such relations.

Open with tariffs however differ in the sense that it is not necessarily impossible during cooperation and agreement, but if there is a common goal and agreement it does not seem like a good fit of characteristics. Nor does challenging involvement and open with tariffs, as it supposes a situation in which a closing would be better.

A note to take here is however that the possibility of these outcomes that do not seem as a good fit, are taken as possible since one cannot forecast how things might play out. Russia might let some countries use the route during turmoil, or the Arctic 5 may enforce tariffs during good relations(Østhagen, 2016; Blakkisrud, 2019). It is not something we can predict; it is entirely uncertain.

EAST/WEST RELATIONS	
P2V1	Cooperation and Agreement
P2V2	Neutral Involvement
P2V3	Challenging Tension
P2V4	Challenging Involvement

AVAILABILITY OF THE NORTHERN SEA ROUTE	
P8V1	Open
P8V2	Open with Tariffs
P8V3	Closed

Table 6.35: Conditions of the dimensions: *East/West Relations* and *Availability of the Northern Sea Route*.

	P2V1	**P2V2**	**P2V3**	**P2V4**
P8V1	**-**	**-**	**K**	**X**
P8V2	**K**	**-**	**-**	**K**
P8V3	**X**	**K**	**-**	**-**

Table 6.36: Parameter Block 13: Cross-consistency assessment of *East/West Relations* and *Availability of the Northern Sea Route*.

Parameter Block 14: Global Demand for Arctic Trade Traffic| Global Political Environmental Stance

Global Demand for Arctic Trade Traffic and *Global Political Environmental Stance*are directly connected dimensions that constrain each other. This connection constrains these dimensions through empiric description of a situation where demand is contingent on popular choices.

Demand is the sum of the wants and preferences of stakeholders in all forms, if the global political stance regarding economics takes a turn to the radical progressive side global demand for Arctic trade traffic may take a hit. If one takes the current events that relate to environmental politics and trade traffic demand into perspective one sees that due to environmental concerns, France and Nike has backed out of further Arctic ventures (Krane, 2020; Regan & Reznik, 2019).

However, one must consider that if steps are taken to improve the environmental safety and general safety side of Arctic trade traffic, then it might be possible for radical progressive and progressive political stances to coexist with high and medium demand. However, without these steps it is not possible.

In addition, one must see medium demand and low demand to be possible but not necessarily a good fit regressive and radical regressive political stance. One presupposes that on this side of the spectrum one can neglect environmental safety to ensure a reliable crossing of the Northern Sea Route.

GLOBAL DEMAND FOR ARCTIC TRADE	
P3V1	High
P3V2	Medium
P3V3	Low

GLOBAL POLITICAL ENVIRONMENTAL STANCE	
P4V1	Radical Progressive
P4V2	Progressive
P4V3	Conservative
P4V4	Regressive
P4V5	Radical Regressive

Table 6.37: Conditions of the dimensions: *Global Demand for Arctic Trade* and *Global Political Environmental Stance.*

	P3V1	**P3V2**	**P3V3**
P4V1	**-**	**K**	**K**
P4V2	**-**	**K**	**K**
P4V3	**-**	**-**	**-**
P4V4	**K**	**K**	**-**
P4V5	**X**	**K**	**-**

Table 6.38: Parameter Block 14: Cross-consistency assessment of *Global Demand for Arctic Trade Traffic* and *Global Political Environmental Stance.*

Parameter Block 15:
Global Demand for Arctic Trade Traffic | Level of Technical and Navigational Requirements

Global Demand for Arctic Trade Traffic and *Level of Technical and Navigational Requirements* are directly connected dimensions that constrain each other. This connection constrains these dimensions through the empiric prescription, in which demand is governed by the principle of reliability which is ensured by requirements.

Going by the principle that demand is governed by reliability, the one must say its impossible to have low demand with high levels of requirements. In contrast its impossible to have high demand with low levels of requirement (Misra, 2008).

In addition, it seems possible, but not necessarily a good fit to have medium demand with high levels of requirements. These requirements are contingent on traffic and stakeholder participation to be developed, as such one sees that during the development of industry standards a stance such an instance can occur, but that it seems less likely in the long run. This could also be the case when one has medium demand and low levels of requirements(Misra, 2008; Aker Artic, 2020; Sollid et al., 2018).

Low levels of requirements and low demand are also a good fit as it is less likely that stakeholders would risk their merchandise and vessels by crossing unregulated waters. Which could easily be the stages before regulation.

GLOBAL DEMAND FOR ARCTIC TRADE	
P3V1	High
P3V2	Medium
P3V3	Low

LEVEL OF TECHNICAL AND NAVIGATIONAL REQUIREMENTS	
P5V1	High
P5V2	Medium High
P5V3	Medium
P5V4	Low

Table 6.39: Conditions of the dimensions: *Global Demand for Arctic Trade* and *Level of Technical and Navigational Requirements*.

	P3V1	**P3V2**	**P3V3**
P5V1	-	K	K
P5V2	-	-	K
P5V3	K	-	-
P5V4	X	K	-

Table 6.40: Parameter Block 15: Cross-consistency assessment of *Global Demand for Arctic Trade Traffic* and *Level of Technical and Navigational Requirements.*

Parameter Block 16:
Global Demand for Arctic Trade Traffic| Achieved Level of Sustainable Maritime Technology

Global Demand for Arctic Trade Traffic and *Achieved Level of Sustainable Maritime Technology* are directly connected dimensions that constrain each other. This is an empirical descriptive constraint in which demand is governed by reliability, and local environmental safety is a part of this picture.

In knowing that environmental safety is a part of the general safety picture in the Arctic one can deduce that it is impossible to have achieved low levels of sustainable maritime technology and have less than medium demand. In addition the inverse is true as if one does not meet at least a medium level of environmental safety concerns, then one is not meeting with the standards of the Polar Code (International Maritime Organization IMO, 2014).

Going by the same logic one sees it as possible, that low demand can occur during medium high levels of technology, but that one must consider that with medium levels of technology an inclination from the maritime sector would be that there is more reliability. Therefore, on the grounds of this one must consider it as a less possible pairing, but a possible on at least.

In addition, we see that medium high levels of technology and low levels of demand can occur, one must consider that there might be slowness in the system to adapt. Therefore, it is a possible pairing, but not necessarily a good fit with the same logic of assessment in mind.

GLOBAL DEMAND FOR ARCTIC TRADE	
P3V1	High
P3V2	Medium
P3V3	Low

ACHIEVED LEVEL OF SUSTAINABLE MARITIME TECHNOLOGY	
P6V1	High
P6V2	Medium High
P6V3	Medium
P6V4	Low

Table 6.41: Conditions of the dimensions: *Global Demand for Arctic Trade* and *Achieved Level of Sustainable Maritime Technology.*

	P3V1	**P3V2**	**P3V3**
P6V1	**-**	**-**	**K**
P6V2	**-**	**-**	**K**
P6V3	**K**	**-**	**-**
P6V4	**X**	**-**	**-**

Table 6.42: Parameter Block 16: Cross-consistency assessment of *Global Demand for Arctic Trade Traffic* and *Achieved Level of Sustainable Maritime Technology.*

Parameter Block 17:
Global Demand for Arctic Trade Traffic| Wildcard Events

Global Demand for Arctic Trade Traffic and *Wildcard Events*s are directly connected dimensions when it comes to conditions that deal with events that may be affected by or affect demand. Therefore, we see that any ice condition that improves the manoeuvrability of the route make low demand impossible. In addition, one must consider that extended infrastructures are contingent on demand in the long run, and for them to be viable demand must be higher than low. All other conditions are however orthogonal to demand and is therefore not constrained.

GLOBAL DEMAND FOR ARCTIC TRADE	
P3V1	High
P3V2	Medium
P3V3	Low

WILDCARD EVENTS	
P7V1	Major Oil-spill in the Arctic
P7V2	Major Cruise Ship Accident in the Arctic
P7V3	Challenges Regarding Competing Trade Routes
P7V4	Extended Development of Arctic Coastal Infrastructure
P7V5	Extended Development of Arctic LNG and Petroleum Infrastructure
P7V6	Extended Ice-Free NSR
P7V7	Year Round Ice in Parts of NSR
P7V8	First-Year Ice in Cross Polar Path

Table 6.43: Conditions of the dimensions: *East/West Relations* and *Wildcard Events*.

	P3V1	**P3V2**	**P3V3**
P7V1	-	-	-
P7V2	-	-	-
P7V3	-	-	-
P7V4	-	-	X
P7V5	-	-	X
P7V6	-	-	X
P7V7	-	-	X
P7V8	-	-	X

Table 6.44: Parameter Block 17: Cross-consistency assessment of *Global Demand for Arctic Trade Traffic* and *Wildcard Events*.

Parameter Block 18: Global Demand for Arctic Trade Traffic | Availability of the Northern Sea Route

Global Demand for Arctic Trade Traffic and *Availability of the Northern Sea Route* are not directly connected dimensions. They are orthogonal to each other. There can be demand for the use of the Northern Sea Route even if its closed.

GLOBAL DEMAND FOR ARCTIC TRADE	
P3V1	High
P3V2	Medium
P3V3	Low

AVAILABILITY STATE OF THE NORTHERN SEA ROUTE	
P8V1	Open
P8V2	Open with Tariffs
P8V3	Closed

Table 6.45: Conditions of the dimensions: *Global Demand for Arctic Trade Traffic* and *Availability of the Northern Sea Route.*

	P3V1	**P3V2**	**P3V3**
P8V1	-	-	-
P8V2	-	-	-
P8V3	-	-	-

Table 6.46: Parameter Block 18: Cross-consistency assessment of *Global Demand for Arctic Trade Traffic* and *Availability of the Northern Sea Route.*

Parameter Block 19: Global Political Environmental Stance| Level of Technical and Navigational Requirements

Global Political Environmental Stance and *Level of Technical and Navigational Requirements* are not directly connected dimensions. They are orthogonal to each other. These requirements would be formulated independent of environmental concerns.

GLOBAL POLITICAL ENVIRONMENTAL STANCE	
P4V1	Radical Progressive
P4V2	Progressive
P4V3	Conservative
P4V4	Regressive
P4V5	Radical Regressive

LEVEL OF TECHNICAL AND NAVIGATIONAL REQUIREMENTS	
P5V1	High
P5V2	Medium High
P5V3	Medium
P5V4	Low

Table 6.47: Conditions of the dimensions: Global Political Environmental Stance and *Level of Technical and Navigational Requirements*.

	P4V1	**P4V2**	**P4V3**	**P4V4**	**P4V5**
P5V1	**-**	**-**	**-**	-	-
P5V2	**-**	**-**	**-**	-	-
P5V3	**-**	**-**	**-**	-	-
P5V4	-	-	-	-	-

Table 6.48: Parameter Block 19: Cross-consistency assessment of Global Political Environmental Stance and *Level of Technical and Navigational Requirements*.

Parameter Block 20:
Global Political Environmental Stance| Achieved Level of Sustainable Maritime Technology

Global Political Environmental Stance and *Achieved Level of Sustainable Maritime Technology* are directly connected dimensions that constrain each other. This is an empirical descriptive constraint in which global environmental politics dictate the push towards sustainable practices.

Adhering to the environmental politics as a description of the state of affairs, one must consider it impossible to have high and medium high levels of sustainable technology achieved if the state of affairs are regressive or radical regressive. In the same line it is impossible to have medium and low levels of sustainable technology during progressive and radical progressive states of affairs.

Additionally, it must be possible to move in either direction on the technological spectrum during conservative states of affairs. There can be many reasons for this, it could be the transition from one state to another, or it could be some peculiar instance. It does not help the analysis to try to disseminate this genuine uncertainty, but one should certainly entertain the notion that it can happen.

GLOBAL POLITICAL ENVIRONMENTAL STANCE	
P4V1	Radical Progressive
P4V2	Progressive
P4V3	Conservative
P4V4	Regressive
P4V5	Radical Regressive

ACHIEVED LEVEL OF SUSTAINABLE MARITIME TECHNOLOGY	
P6V1	High
P6V2	Medium High
P6V3	Medium
P6V4	Low

Table 6.49: Conditions of the dimensions: *Global Political Environmental Stance* and *Achieved Level of Maritime Technology.*

	P4V1	P4V2	P4V3	P4V4	P4V5
P6V1	-	-	K	X	X
P6V2	-	-	-	X	X
P6V3	X	X	-	-	-
P5V4	X	X	K	-	-

Table 6.50: Parameter Block 20: Cross-consistency assessment of *Global Political Environmental Stance* and *Achieved Level of Maritime Technology.*

Parameter Block 21:
Global Political Environmental Stance| Wildcard Events

Global Political Environmental Stance and *Wildcard Events* are connected dimensions in the conditions in which the global political environmental stance will impact industries. This is therefore an empirical descriptive constraint in which the global political stance makes these events less possible, or impossible.

If the political stance or state of affairs is inclined towards progressive or radical progressive stances one must consider that it seems less possible to have major oil-spills in the Arctic. It is entirely possible that oil can be used as fuel or transported along the Northern Sea Route during these stances, but it seems less likely that there will be spills due to the implications in strict environmental policies that one would enact with these political stances.

In addition it must be impossible to have major cruise-ship accidents during radical progressive stances since one must consider that strict environmental policies most likely will prohibit cruise traffic in the Arctic, if not in the world in general. If not, it must be restrictive, and the policy must be progressive and not radical progressive.

Finally, it must be impossible to have extended infrastructural developments at LNG and petroleum plant sin the Arctic during radical progressive stances, and less possible during progressive stances. Here it must however be contended that this depends on what fuel technology that one employs in the future, as such an admittance of a margin for error is in place. One cannot know this with certainty.

GLOBAL POLITICAL ENVIRONMENTAL STANCE	
P4V1	Radical Progressive
P4V2	Progressive
P4V3	Conservative
P4V4	Regressive
P4V5	Radical Regressive

WILDCARD EVENTS	
P7V1	Major Oil-spill in the Arctic
P7V2	Major Cruise Ship Accident in the Arctic
P7V3	Challenges Regarding Competing Trade Routes
P7V4	Extended Development of Arctic Coastal Infrastructure
P7V5	Extended Development of Arctic LNG and Petroleum Infrastructure
P7V6	Extended Ice-Free NSR
P7V7	Year Round Ice in Parts of NSR
P7V8	First-Year Ice in Cross Polar Path

Table 6.51: Conditions of the dimensions: *Global Political Environmental Stances* and *Wildcard Events*.

	P4V1	**P4V2**	**P4V3**	**P4V4**	**P4V5**
P7V1	K	K	-	-	-
P7V2	X	K	-	-	-
P7V3	-	-	-	-	-
P7V4	-	-	-	-	-
P7V5	X	K	-	-	-
P7V6	-	-	-	-	-
P7V7	-	-	-	-	-
P7V8	-	-	-	-	-

Table 6.52: Parameter Block 21: Cross-consistency assessment of *Global Political Environmental Stance* and *Wildcard Events*.

Parameter Block 22:
Global Political Environmental Stance| Availability of the Northern Sea Route

*Global Political Environmental Stance*and the *Availability of the Northern Sea Route* are not directly connected dimensions. They are orthogonal to each other. This is due to the availability of the Northern Sea Route being determined by Russian internal politics, to sway them would mean to either have the totally collaborate in policy, or to get involved in their internal policies.

GLOBAL POLITICAL ENVIRONMENTAL STANCE	
P4V1	Radical Progressive
P4V2	Progressive
P4V3	Conservative
P4V4	Regressive
P4V5	Radical Regressive

AVAILABILITY OF THE NORTHERN SEA ROUTE	
P8V1	Open
P8V2	Open with Tariffs
P8V3	Closed

Table 6.53: Conditions of the dimensions: *Global Political Environmental Stance* and *Availability of the Northern Sea Route*.

	P4V1	**P4V2**	**P4V3**	**P4V4**	**P4V5**
P8V1	-	-	-	-	-
P8V2	-	-	-	-	-
P8V3	-	-	-	-	-

Table 6.54: Parameter Block 22: Cross-consistency assessment of *Global Political Environmental Stance* and *Availability of the Northern Sea Route*.

Parameter Block 23:
Level of Technical and Navigational Requirements | Achieved Level of Sustainable Maritime Technology

Level of Technical and Navigational Requirements and *Achieved Level of Sustainable Maritime Technology* are directly connected dimensions that constrain each other. This is a logical constraint in which one knows that both dimensions adhere to the development of environmental safety.

Knowing that a high level of prescriptions is a state in which one has developed clearly defined rigid professional standards for safety, one knows that environmental safety will be stipulated in here as well. As such it is impossible to have low levels of requirement and high levels of sustainable technology. It is also less likely to have medium high levels of requirements and low levels of sustainable technology.

The inverse also holds true one cannot have high levels of requirements and low levels of sustainable technology. It is also less likely to have medium levels of requirements and high levels of sustainable technology.

In addition, one must consider that medium levels of sustainable tech and high levels of requirements can occur. It is possible, but its not necessarily a good fit it can be due to system slowness to adapt, or due to slowness in development of technology. One cannot rule out that it can happen, but one cannot accurately predict the state it can happen in.

The same can be said for medium high levels of requirements and low levels of sustainable technology. This is however a situation that most probably is due to system slowness to adapt.

LEVEL OF TECHNICAL AND NAVIGATIONAL REQUIREMENTS	
P5V1	High
P5V2	Medium High
P5V3	Medium
P5V4	Low

ACHIEVED LEVEL OF SUSTAINABLE MARITIME TECHNOLOGY	
P6V1	High
P6V2	Medium High
P6V3	Medium
P6V4	Low

Table 6.55: Conditions of the dimensions: *Level of Technical and Navigational Requirements* and *Achieved Level of Sustainable Maritime Technology.*

	P5V1	**P5V2**	**P5V3**	**P5V4**
P6V1	-	-	**K**	**X**
P6V2	-	-	-	**K**
P6V3	**K**	-	-	-
P6V4	**X**	**K**	-	-

Table 6.56: Parameter Block 23: Cross-consistency assessment of *Level of Technical and Navigational Requirements* and *Achieved Level of Sustainable Maritime Technology*

Parameter Block 24:
Level of Technical and Navigational Requirements | Wildcard Events

Level of Technical and Navigational Requirements and *Wildcard Events* are directly connected dimensions in the conditions where the descriptive empiricism of requirements constrain events from occurring. In other events they are orthogonal to each other.

If the level of requirements is high or medium high there is an evident rigidity that makes it impossible or less possible for maritime incidents such as cruise ship accidents and oil-spill to occur. It is not to say that they cannot occur, but in the instance of high requirements it seems so vividly farfetched with the amount of controls from governments and industry alike that one must rule it as an impossibility, or black swan at worst case.

One must consider that industries that are demand dependent are contingent on the reliability of transport to be expanded. Therefore, it must be impossible to have these extended infrastructural developments with low standards. It can be possible at medium levels, however with extended development comes more traffic, more traffic needs to meet more standards, regulations and so forth. The industry must get involved, and new standards will rise, hence it is a question of system slowness.

One must also consider what many of these requirements address, they address ways to mitigate hazards and risks. If the hazards such as ice is not present anymore there will be no need for extensive standards that address them, but one cannot rule out that they develop before one reaches this level. However, one can rule out that they will not reach this level, it will take time it will contain system slowness and there will be states of low standards and medium standards, but likely they will settle higher.

LEVEL OF TECHNICAL AND NAVIGATIONAL REQUIREMENTS	
P5V1	High
P5V2	Medium High
P5V3	Medium
P4V4	Low

WILDCARD EVENTS	
P7V1	Major Oil-spill in the Arctic
P7V2	Major Cruise Ship Accident in the Arctic
P7V3	Challenges Regarding Competing Trade Routes
P7V4	Extended Development of Arctic Coastal Infrastructure
P7V5	Extended Developlement of Arctic LNG and Petroleum Infrastructure
P7V6	Extended Ice-Free NSR
P7V7	Year Round Ice in Parts of NSR
P7V8	First-Year Ice in Cross Polar Path

Table 6.57: Conditions of the dimensions: *Global Political Environmental Stance*s and *Wildcard Events*.

	P5V1	P5V2	P5V3	P5V4
P7V1	X	K	-	-
P7V2	X	K	-	-
P7V3	-	-	-	-
P7V4	-	-	K	X
P7V1	-	-	K	X
P7V1	K	K	-	-
P7V1	-	-	K	K
P7V1	K	K	-	-

Table 6.58: Parameter Block 24: Cross-consistency assessment of *Level of Technical and Navigational Requirements* and *Wildcard Events*.

Parameter Block 25: Level of Technical and Navigational Requirements | Availability of the Northern Sea Route

Level of Technical and Navigational Requirements and the *Availability of the Northern Sea Route* are not directly connected dimensions that constrain each other. They are orthogonal to each other, the Northern Sea Routes availability is determined by local politics, and the need for an icebreaker is therefore considered to be outside the requirements, as the need for it the prerogative of the Northern Sea Route Administration, The Harbour Master, or the ship designer (Aker Artic, 2020). As in if the ship designer cannot legitimize their ice-class then they will have to use an icebreaker escort.

LEVEL OF TECHNICAL AND NAVIGATIONAL REQUIREMENTS	
P5V1	High
P5V2	Medium High
P5V3	Medium
P4V4	Low

AVAILABILITY STATE OF THE NORTHERN SEA ROUTE	
P8V1	Open
P8V2	Open with Tariffs
P8V3	Closed

Table 6.59: Conditions of the dimensions: *Global Political Environmental Stances* and *Wildcard Events*.

	P5V1	**P5V2**	**P5V3**	**P5V4**
P8V1	**-**	**-**	-	-
P8V2	**-**	**-**	**-**	-
P8V3	-	-	**-**	-

Table 6.60: Parameter Block 25: Cross-consistency assessment of *Level of Technical and Navigational Requirements* and *Availability of the Northern Sea Route*.

Parameter Block 26: Achieved Level of Sustainable Maritime Technology | Wildcard Events

Achieved Level of Sustainable Maritime Technology and *Wildcard Events* are not connected dimensions that constrain each other. They are orthogonal to each other. In the instance in which one would doubt this grounded in events that describe events with fossil fuels, one must entertain the notion that fossil fuels will always be used for chemical purposes, and that LNG might be an alternative to other fossil fuels with other forms of emissions (DNV GL, 2019)

ACHIEVED LEVEL OF SUSTAINABLE MARITIME TECHNOLOGY	
P6V1	High
P6V2	Medium High
P6V3	Medium
P6V4	Low

WILDCARD EVENTS	
P7V1	Major Oil-spill in the Arctic
P7V2	Major Cruise Ship Accident in the Arctic
P7V3	Challenges Regarding Competing Trade Routes
P7V4	Extended Development of Arctic Coastal Infrastructure
P7V5	Extended Development of Arctic LNG and Petroleum Infrastructure
P7V6	Extended Ice-Free NSR
P7V7	Year Round Ice in Parts of NSR
P7V8	First-Year Ice in Cross Polar Path

Table 6.61: Conditions of the dimensions: *Achieved Level of Sustainable Maritime Technology* and *Wildcard Events*.

	P6V1	**P6V2**	**P6V3**	**P6V4**
P7V1	-	-	-	-
P7V2	-	-	-	-
P7V3	-	-	-	-
P7V4	-	-	-	-
P7V5	-	-	-	-
P7V6	-	-	-	-
P7V7	-	-	-	-
P7V8	-	-	-	-

Table 6.62: Parameter Block 26: Cross-consistency assessment of *Achieved Level of Sustainable Maritime Technology* and *Wildcard Events*.

Parameter Block 27:
Achieved Level of Sustainable Maritime Technology | Availability of the Northern Sea Route

Achieved Level of Sustainable Maritime Technology and the *Availability of the Northern Sea Route* are not directly connected dimensions that constrain each other. They are orthogonal to each other, the Northern Sea Routes availability is determined by local politics and is not directly influenced by technological leaps.

ACHIEVED LEVEL OF SUSTAINABLE MARITIME TECHNOLOGY	
P6V1	High
P6V2	Medium High
P6V3	Medium
P6V4	Low

AVAILABILITY STATE OF THE NORTHERN SEA ROUTE	
P8V1	Open
P8V2	Open with Tariffs
P8V3	Closed

Table 6.63: Conditions of the dimensions: *Achieved Level of Sustainable Maritime Technology* and *Availability of the Northern Sea Route*.

	P6V1	**P6V2**	**P6V3**	**P6V4**
P8V1	-	-	-	-
P8V2	-	-	-	-
P8V3	-	-	-	-

Table 6.64: Parameter Block 27: Cross-consistency assessment of *Achieved Level of Sustainable Maritime Technology* and The *Availability of the Northern Sea Route*.

Parameter Block 28: Wildcard Events | Availability of the Northern Sea Route

Availability of the Northern Sea Route and *Wildcard Events* are both orthogonal and connected. Events that require the route to be open to coexist are therefore constrained.

As such we see these as being suboptimal with relation to these events. They are probable, as local traffic still cross the Northern Sea Route, but it seems unlikely that accidents will occur due to local actors having local knowledge and meeting local standards. In addition, it seems unlikely that any widescale developments will occur due to the geopolitical preconditions for local actors to close the route.

WILDCARD EVENTS	
P7V1	Major Oil-spill in the Arctic
P7V2	Major Cruise Ship Accident in the Arctic
P7V3	Challenges Regarding Competing Trade Routes
P7V4	Extended Development of Arctic Coastal Infrastructure
P7V5	Extended Development of Arctic LNG and Petroleum Infrastructure
P7V6	Extended Ice-Free NSR
P7V7	Year Round Ice in Parts of NSR
P7V7	First-Year Ice in Cross Polar Path

AVAILABILITY OF THE NORTHERN SEA ROUTE	
P8V1	Open
P8V2	Open with Tariffs
P8V3	Closed

Table 6.65: Conditions of the dimensions: *Wildcard Events* and *Availability of the Northern Sea Route.*

	P7V1	**P7V2**	**P7V3**	**P7V4**	**P7V5**	**P7V6**	**P7V7**	**P7V78**
P8V1	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
P8V2	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
P8V3	**-**	**-**	**K**	**K**	**K**	**-**	**-**	**-**

Table 6.66: Parameter Block 28: Cross-consistency Assessment of *Wildcard Events* and *Availability of the Northern Sea Route.*

6.3 Summary of Parameter Blocks

In this section is a summary of all the parameter blocks in the form of a screenshot from CarmaCCA Viewer (Ritchey, 2005).

		INVOLVED STAKEHOLDERS					EAST/WEST RELATIONS				GLOBAL DEMAND for ARCTIC TRADE TRAFFIC			GLOBAL POLITICAL ENVIROMENTAL STANCE					LEVEL of TECHNICAL and NAVIGATIONAL REQUIREME				ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY				WILDCARD EVENTS							
		Local Actors	Eastern Actors	Western Actors	African Coastal States	China	Cooperation and Agreement	Neutral Involvement	Challenging Tension	Challenging Involvement	High	Medium	Low	Radical Progressive	Progressive	Conservative	Regressive	Radical Regressive	High	Medium High	Medium	Low	High	Medium High	Medium	Low	Major Oil-Spill in the Arctic	ruise Ship Accident in the Arctic	arding Competing Trade Routes	of Arctic Coastal Infrastructures	ctic LNG and Pet Infrastructure	Extended Ice-Free NSR	Year-Round Ice in Parts of NSR	rst-Year Ice in Cross Polar Path
EAST/WEST RELATIONS	Cooperation and Agreement	-	-	-	-	-																												
	Neutral Involvement	-	-	-	-	-																												
	Challenging Tension	-	-	-	K	K																												
	Challenging Involvement	-	K	K	X	K																												
GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	High	-	-	-	-	-	-	-	-	-																								
	Medium	-	-	-	K	-	-	-	-	-																								
	Low	-	K	K	K	-	-	-	-	-																								
GLOBAL POLITICAL ENVIROMENTAL STANCE	Radical Progressive	-	K	K	K	K	-	-	K	X	K	K	-																					
	Progressive	-	-	-	K	-	-	-	K	K	K	K	-																					
	Conservative	-	-	-	-	-	-	-	-	-	-	-	-																					
	Regressive	-	-	-	-	-	-	-	-	-	-	K	K																					
	Radical Regressive	-	-	-	-	-	-	-	-	-	-	K	K																					
LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	High	-	-	-	K	K	-	-	K	X	-	K	X	-	-	-	-	-																
	Medium High	-	-	-	K	K	-	-	K	K	-	-	K	-	-	-	-	-																
	Medium	-	-	-	-	-	K	K	-	-	K	-	-	-	-	-	-	-																
	Low	-	-	-	-	-	X	K	-	-	X	K	-	-	-	-	-	-																
ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	High	-	-	-	-	-	-	-	K	X	-	-	X	-	-	K	X	X	-	-	K	X												
	Medium High	-	-	-	-	-	-	-	-	K	-	-	K	-	-	-	X	X	-	-	-	K												
	Medium	-	-	-	K	-	K	-	-	-	K	-	-	X	X	-	-	-	K	-	-	-												
	Low	-	K	K	K	K	X	K	-	-	X	-	-	X	X	K	-	-	X	K	-	-												
WILDCARD EVENTS	Major Oil-Spill in the Arctic	-	-	-	-	-	-	-	-	-	-	-	-	K	K	-	-	-	X	K	-	-	-	-	-	-								
	Major Cruise Ship Accident in the Arctic	-	-	-	-	-	-	-	-	-	-	-	-	X	K	-	-	-	X	K	-	-	-	-	-	-								
	Challenges Regarding Competing Trade	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
	Extended Development of Arctic Coastal	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	K	X	-	-	-	-								
	Extended Development of Arctic LNG an	-	-	-	-	-	-	-	-	-	-	-	X	X	K	-	-	-	-	-	K	X	-	-	-	-								
	Extended Ice-Free NSR	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	K	K	-	-	-	-	-	-								
	Year-Round Ice in Parts of NSR	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	K	K	-	-	-	-								
	First-Year Ice in Cross Polar Path	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	K	K	-	-	-	-	-	-								
AVAILABILITY of the NSR	Open	-	-	-	-	-	-	-	K	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Open with tariffs	-	-	-	K	K	K	-	-	K	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Closed	-	X	X	X	X	X	K	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	K	K	K	-	-	-

Figure 6.7: The completed Cross-Consistency Matrix of the thesis' analysis.

Chapter 7

Inferences from the Morphological Analysis: Contextual and Non-Contextual Scenarios and Scenario Clusters

The following chapter is the final step in the morphological analysis. It is the inference chapter. This chapter makes inferences about *the future of the Northern Sea Route* by using the computer integrated inference model that uses the contents of the previous chapters as inputs. The inferences themselves follow a contextual inference, and a non-contextual inference in order to derive two kinds of information. The first kind is inferences that has value to certain stakeholders. The second kind is inferences that have value to any stakeholder.

Colour	Explanation
(white)	Not Possible/Not Activated
(blue)	Possible
(red)	Independent Variable

Table 7.1: Colour Coding used in Morphological Fields in MACarma and CarmaCCA Viewer.

7.1 Contextual Inference

Scenario Clusters Investigation I: China is coming!

7.1.1 Inference Context: The Chinese Dream

The term of a Chinese Dream, is something often used in Chinese international politics in relation to phrases such as rejuvenation which calls for individuals to have a greater role in building the nation (Lanteigne, 2014, p.6-12). China as one of the leading powers in the world has adopted a very different strategy than others in exerting their dominion and staking their claims. This is the policy of peaceful coexistence through, meaning to avoid showing ones capabilities and instead keeping a low profile (Lanteigne, 2014, p.6-12)

As such China's rise to economic power has been a rise of diplomacy and bilateral trade agreements, rather than one of aggression and military actions. In the Arctic they first put their interests into Iceland as a trading partner. They have also continuously invested into research in the Arctic both in Spitsbergen and Iceland, and have acquired their own icebreakers (Lanteigne, 2014, p.6-12). On a later occasion the People's Liberation Army Navy Admiral Yin Zhuo described the North Pole and the Arctic areas as belonging to all people of the world (Lanteigne, 2014, p.6-12).

This is in stark contrast to the attendees of the Arctic Ocean Conference in Illussat, Greenland where the Ilulissat Declaration was brought forward. In short it was a declaration between the five coastal state of the Arctic (Norway, USA, Russia, Greenland, and Canada) to block further international reign over Arctic waters, and to settle differences between nations rather than in international forums such as the Arctic Council (Petersen, 2009).

The Chinese are however coming, regardless of this disagreement in ownership of the Arctic. This is due to the economic benefits of shipping from cities such as Tianjin to cities such as Rotterdam via the Northern Sea Route. But it also due to the strategic value that the route has as an alternative to other trade routes, but the most prominently discussed of these is the Malacca Strait Dillemma (Lanteigne, 2014; Rahman et al., 2014)

Based on this it seems evident that it must be of strategic importance for China as a stakeholder to investigate possible scenarios of how to deal with the Arctic as a future sea way and area of investment.

7.1.2 Inference Model Findings

The initial inference one can draw from the model is that its not possible/optimal for China to operate in the Arctic. By referring to the initial parameter blocks (1-7), one cannot deduce it to be a result of direct constraints but rather to be the result of multiple conditions constraining each other.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.1: Primary solution space with no assigned independent variable.

By consulting the secondary solution space, one finds that China is fixed to two conditions of two dimensions. China needs to have a Northern Sea Route without tariffs for optimality, and it needs a conservative environmental stance. By going through the parameter blocks that attain to these values one finds that this is due to their good fit with most values. They are conditions that are not very mutually constrained or has a high degree of orthogonality from the other conditions.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.2: Secondary solution space with *China* as independent variable.

Hence, to understand this better one needs to look at different scenarios within the clusters. What one finds by manipulating the Global Demand for Arctic Trade is that the other dimensions are mutually constrained to levels of demand. Hence, requirements and achieved levels of technology are not the reason that China does not operate optimally in the Arctic.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.3: Secondary solution space with *China* and *High Demand* as independent variables.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.4: Secondary solution space with *China* and *Medium Demand* as independent variables.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIRONMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.5: Secondary solution space with *China* and *Low Demand* as independent variables.

Therefore, to further investigate into the dimensions East/West Relations is conducted through parameter blocks (1,8-13) and through parameter checks of clusters including and excluding China. What one finds is that China's non-optimally of participation can be traced to the fact that China needs cooperation and agreement or neutrality to operate.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.6: Secondary solution space with *China* as independent variable.

In addition, choosing the global environmental stance yet again and one sees that China can only conform to a conservative stance, where the route is open with no tariffs. This is because problems regarding competing trade routes can only coexist with open with tariffs, paradoxically what seems to be the most important wildcard event for China is not optimal for them.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.7: Secondary solution space with *Open with tariffs* as independent variable.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.8: Secondary solution space with *China* and *Cooperation and Agreement* as independent variable.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.9: Secondary solution space with *Challenges regarding competing trade routes* as independent variable.

This impossibility of having China as a stakeholder during challenges regarding competing trade routes, which is contingent on challenging relations between the East and the West tells us that China needs a means of circumventing this to achieve optimality. This is very much in line with the Chinese strategy of attaining preferential bilateral trade agreements, by playing the game of politics China can operate outside of the hegemonic push and pull of the East and West.

The controls that constraint China are not the requirements of industry or global environmental politics these just push or pull demand in either direction. What constrains China is the laws and requirements of the nations that govern the Arctic. This tells us that there are many scenarios for China's possible future strategy, however, to find an optimal strategy changes need to be made to circumvent global tensions and involvements.

Scenario Clusters Investigation II: Arctic Advancement

7.1.3 Inference Context: The Development of a Legal Framework

After the Murmansk Treaty, developments into the Russian and Norwegian Arctic has skyrocketed with projects such as the development of the Shtokman Field and oil exploration in the Barents Sea. This has been made possible by the increased melting of Arctic Sea Ice because of the effects of global climate change. This has also caused stakeholders beyond the Northern Sea Route to view it as a more viable seaway from shipping transport(Bourmistrov et al., 2015).

The Arctic states are now faced with the challenge of managing these vast and harsh areas through legislation. Albeit, the general consensus among the Arctic sea nations is that one wants the least amount of international involvement into the legislation of the Arctic, the development of the International Maritime Organizations Code for Ships Operating in Poplar Waters(Polar Code) has been largely well received (International Maritime Organization IMO, 2014).

This risk-based functional code facilitates a legal framework of growth which allows for the industry to develop their own standards within the minimum detailed requirements of the code. This paired with Rosatom's transition into the role of fleet and port authority has caused multiple state organs within Russia to facilitate for similar growth within their legal framework(Aker Artic, 2020; Devonshire-Ellis, 2017).

Going into the future the goal of the Arctic states is to increase traffic along their shores, and to potentially develop more infrastructures in the area while maintaining maritime and environmental safety. Therefore, it is evident that one can use the inference model to look at scenarios where the different levels of requirements are reached to interpret how this will impact the rest of the system.

7.1.4 Inference Model Findings

The initial inference one can derive from the primary solution space is that the dimensions Technical and Navigational Requirements can take on any condition. As a result, one can use the entire span of this dimensions to investigate how this dimension includes or excludes potential future scenarios.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.10: Primary solution space with no assigned independent variable.

By selecting low requirements, one finds that this is in fact not a cluster, this fixed condition only has a single possible scenario. The curious aspect about this scenario is that it shows that the only possible East/West Relation is challenging tension. The fact that it cannot be better nor worse testifies to that relations need to be good to develop higher standards. By consulting the secondary solution space one sees that the span goes from neutral involvement to challenging instead, but since it is within the secondary solution space one knows it is not necessarily the best fit.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
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Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.11: Primary solution space with *Low levels of requirements* as independent variable.

Another dimension to look at in this scenario is the Global Demand for Arctic Trade Traffic. The only possible condition here is low demand. By consulting the secondary solution space one sees it can also take on medium, but yet again this is not a good fit and by fixing this variable one sees that the route must be open with tariffs and have a medium level of Achieved Sustainable Maritime Technology.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.12: Secondary solution space with *Low levels of requirements* as independent variable.

By selecting the medium level, one finds that this is a cluster of quite the few scenarios. However, the curious difference here is that Global Demand for Arctic Trade Traffic can reach medium levels, subsequently the route can also be closed during this time. By checking parameter blocks (1-7, 13, 18,22, 25,28) it is evident that this is only the case if only local actors are involved.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.13: Primary solution space with *Medium levels of requirements* as independent variable.

By looking at the secondary solution space one sees that it is possible for this condition to be present with neutral involvement, and cooperation and agreement. This subsequently make infrastructural developments attractive which were impossible in the scenario with low levels of requirements.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.14: Secondary solution space with *Medium levels of requirements* as independent variable.

When selecting medium high level one sees that these developments are possible, but these clusters are confined to neutral involvement and cooperation. As such its evident as to why the developments of infrastructure is possible. The curious thing here is the impossibility of major maritime incidents for high level of traffic to sustain.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.15: Primary solution space with *Medium high levels of requirements* as independent variable.

By consulting the secondary solution space, one sees that both maritime incidents can occur, but that oil-spills only can occur during neutral relations. Further investigations into parameter blocks (1,4,8-13,22-25) shows that this is ascribed to how technology and relations constrain each other. Neutral relations mean lower levels of technology.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.16: Secondary solution space with *Medium high levels of requirements* as independent variable.

By selecting high as the condition of requirements one finds that these scenarios can range with relations from neutral to agreement and the availability can be open with or without tariffs. However, demand is fixed at high, and sustainable technology at medium high.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.17: Primary solution space with *High levels of requirements* as independent variable.

With the context scenario in mind one can see that if one is trying to uncover what kind of effects policy changes will have that one sees that stricter policies increases demand and decreases the amount of wildcard events. Hence the best course to chart for an Arctic Advancement is to increase the level of requirements based on these findings.

Scenario Clusters Investigation III: Climate Calamity

7.1.5 Inference Context: The Vulnerable Arctic

Man has always dreamt of conquest, but the conquest and usurping of the untamed world never came free. The Arctic has gone from being the last untamed frontier of humanity with its vast desolate fields of ice to being an attainable goal for conquest. Man sets out once again to claim what is unknown, the resources and sea-ways of the Arctic(Bloomfield, 1981; Hansen-Magnusson, 2019).

This yet again comes at a cost, but this time it is not the blood, sweat, and tears of the polar explorers of old. It is at the cost of the planet itself. The ecosystem of the Arctic is a fragile environment in which minor errors can cascade into calamity and decimate populations and communities of numerous species(Diebold & Rudebusch, 2019).

On the other hand, this burst of vigour for exploration and resource exploitation is however not shared by all men. From their confines in Beaverton, Oregon, Nike has seeded doubt with regards to the Arctic. In France Emmanuel Macron has gone out with the same persuasion to dissuade stakeholders from partaking(Krane, 2020; Regan & Reznik, 2019).

This attempt at stopping the Arctic expansions has however been futile as both Norway and Russia surmount a stronger foothold in the Arctic through the facilitation of infrastructures to bear industry. The industry is there to stay, but will the environment bear it, or is it necessary to internationally condemn it?

Accordingly, it is evident that one must investigate the worst possible conditions that can occur with regards to the environment. Subsequently one must consider the best conditions, and ideally one must find the conditions that strike a balance between resource exploitation and environmental conservation.

7.1.6 Inference Model Findings

In the setting of this context it seems that are multiple ways to go about finding possible scenario clusters that can be of strategic importance. Because of this it seems that one should start with the political aspect of the future.

Starting with the cluster of the primary solution space one sees that it describes a state which one must see as a non-environmentally friendly. Within this cluster one can both have major maritime incidents, and developments of infrastructure of industries that can be potentially harmful for the environment.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.18: Primary solution space with no assigned independent variable.

The cluster of the secondary solution space does in contrast make more variations in environmental politics possible. By going through stances from radical regressive to progressive one finds that the cut-off for these non-environmentally friendly conditions is the progressive stance. From progressive and above these will not occur.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
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Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.19: Secondary solution space with *Radical Regressive political stance* as independent variable.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.20: Secondary solution space with *Regressive political stance* as independent variable.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.21: Secondary solution space with *Conservative political stance* as independent variable.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.22: Secondary solution space with *Progressive political stance* as independent variable.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.23: Secondary solution space with *Radical Progressive political stance* as independent variable.

On the other hand, global political environmental stance is not the only dimension that constrains this cluster. By having looked at the interplay between requirements, demand, and wildcards in the previous contexts one knows that there the same constraining connection affects this cluster. As a consequence, when trying to find the balance between environmental politics and trade, achieved level of sustainable maritime technology is chosen as an additional independent variable.

Moreover, since the conservative stance is the only one condition compatible with the primary solution space and its clusters, this condition will be an independent variable. By further checking the achieved sustainable maritime technology dimension it is evident that the cut-off for major incidents is high levels, and for industries its low levels.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
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Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.24: Secondary solution space with *Conservative political stance* and *High sustainable technology level* as independent variables.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.25: Secondary solution space with *Conservative political stance* and *Low sustainable technology level* as independent variables.

Yet, to strike a balance one must try to find a cluster that mitigates the most amount of the non-environmentally friendly conditions while having medium to high demand. By looking at both requirements, demand, and relations it is not possible to make out a better outcome. In contrast, by adopting a progressive or radical stance, one sees that one excludes extended petroleum and LNG infrastructure developments.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
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Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.26: Secondary solution space with *Conservative political stance*, High demand, *High levels of requirements* and *High sustainable technology level* as independent variables.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.27: Secondary solution space with *Progressive*, High demand, *High levels of requirements* and *High sustainable technology level* as independent variables.

The question as a consequence becomes quite relative. It is relative in relation to the uncertainty surrounding the type of fuel one is going to use in the future. If this is LNG then one cannot have a stance that excludes LNG. Accordingly, if one supposes that one wants to maximize technology, demand, and requirements to create a reliable future, then one is left with two possible scenarios.

Scenario Clusters Investigation IV: Goodbye World, Hello Neighbour

7.1.7 Inference Context: Geographical and Geopolitical Tension

The Arctic is a geographical area of the world that is under constant scrutiny from the stakeholders that claim ownership of it. Nevertheless, the Arctic has not seen any wide-scale military conflicts since the Second World War, but it remains as an area in which one displays aggression inadvertently through military exercises(Østhagen, 2016; Østhagen et al., 2018).

Experts on the topic of Arctic geopolitics have however contended that it is unlikely that any form of military conflict will escalate in the Arctic. Yet, they entertain that if this were to happen the match that lit the spark would be a due to an involvement outside of the Arctic(Østhagen, 2016).

As a consequence, one must entertain how this conflict can play out in the Arctic, as the Arctic is delineated into Russia, and NATO countries. In other words, it is likely that the conflict would play out as an embargo between these factions, though there remains a possibility that it could escalate further(Le Mière & Mazo, 2013).

Therefore, with respect to the possibility of these outcomes one can use the inference model to infer how this will impact the Northern Sea Route, and by proxy the Arctic trade and industry development sector.

7.1.8 Inference Model Findings

To find out the consequences of potential shift in political relations between the East and West, one needs to designate its conditions as independent variables. By doing a quick parameter check of the different variables one finds that there is a clear divide in possible scenario cluster from neutral relations and up.

When the independent variable is neutral relations one sees that one can have medium and high levels of demand, high and medium high levels of requirements. Furthermore, one sees that maritime incidents are not possible. Finally, one sees that the Northern Sea Route can be open with or without tariffs.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.28: Primary solution space with *Neutral involvement* as independent variable.

By selecting cooperation and agreement one does however not see any major changes in the cluster's possibilities beyond its availability. The Northern Sea Route during cooperation and agreement can only be open without tariffs.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.29: Primary solution space with *Cooperation and Agreement* as independent variable.

Selecting challenging tension does in contrast yield a very different cluster of scenarios. These scenarios contain the possibility of medium to low demand, medium to low requirements. With respect to wildcard events one sees that maritime incidents can occur in this cluster. Yet, if one selects closed as independent variable as well wildcard events become impossible.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.30: Primary solution space with *Challenging Tension* as independent variable.

Yet, selecting challenging involvement is by comparison not very different, as the main distinction between these clusters is whether the route can remain open or not. Which in fact also restricts stakeholders from being involved. As a consequence, one sees that the worst possible scenario that could come of changes in political relations would suppose challenging involvement, and low levels of requirements.

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure 7.31: Primary solution space with *Challenging Involvement* as independent variable.

Primarily, one finds that challenging involvement will not only lead to less desirable outcomes in demand, requirements, and technology, but also the exclusion and closing of the Northern Sea Route. The route will indeed be open for local actors during such a scenario, but with consideration of the other conditions it appears to be a not so fruitful endeavour.

7.2 Non-Contextual Inference

These different contexts have shown how one can use scenarios in different ways, to create risk pictures of the positive and negative outcomes in a problem complex, in a strategic way. Moreover, these inferences have shown how intrinsically complicated wicked problems are, by uncovering how the different dimensions constrain each other.

As a consequence of these contextual inferences, one can make some general non-contextual inferences about *the future of the Northern Sea Route* as a whole. In particular, in each of these contexts one looked at how a primary dimension would constrain or be constrained. Accordingly, some dimensions stood out as being more excluding or including than others. These dimensions primarily acted as gatekeepers for other dimensions rather than being the ones that were gatekept.

For instance *East/West Relations* largely excluded and included stakeholders, and remained the pivotal dimension in determining the condition of the *Availability of the Northern Sea Route.*Furthermore, *Level of Technical and Navigational Requirements* inadvertently determined what level of *Global Demand for Arctic Trade* that would be possible within a cluster. Moreover, there was a particular interplay between *East/West Relations*, *Level of Technical and Navigational Requirements* and the environmental conditions *Global Political Environmental Stance* and *Achieved Level of Sustainable Maritime Technology.*

The interplay between these conditions were apparent in two ways. Firstly, *Global Political Environmental Stance* was so constrained by *East/West Relations* that the only possible condition in the primary solution space was conservative. In contrast if one consulted the secondary solution space on saw that one could arrive at clusters with similar high levels of *Global Demand for Arctic Trade* and exclusions of undesirable *Wildcard Events* as found in the primary solution space. The core difference was the possibility of pushing *Achieved Level of Sustainable Maritime Technology* to high. Secondly, *Achieved Level of Sustainable Maritime Technology* worked very much like *Level of Technical and Navigational Requirements* in regards to *Global Demand for*

Arctic Trade and *Wildcard Events* except it relies upon neutral or good *East/West Relations*.

As a result one can conclude that the interplay between these dimensions will be the most pivotal effect in shaping *the future of the Northern Sea Route*. In which one sees that to reach any desirable future one needs to have good relations, and high levels of regulation. That is to say, that the most desirable futures primarily cluster together with the same conditions, and there are no configurations that have diametrically opposing conditions surrounding regulations or relations that achieve desired levels of *Global Demand for Arctic Trade* and exclude non desired *Wildcard Events*.

In summary, any strategic decision by any stakeholder will not be able to go around this interplay as a pivotal effect in shaping *the future of the Northern Sea Route*.

Chapter 8

Conclusion and Recommendations for Future Research

Conclusion

This thesis started out with a goal to investigate the possible futures of the Northern Sea Route. As a result of this goal numerous questions were formulated to understand how one could create a framework for inference into the future. However, they can all be summarized into how one question: *How can one create risk pictures of the future of the Northern Sea Route*?

The thesis being a thesis of societal safety therefore consulted metaphysics, philosophy of science, and methodologies of synthesis and analysis in societal safety and risk management, as well as theory surrounding risk, uncertainty, and time. What was evident from consulting these different fields and areas was that one needed a way to make inferences about the future as the only way to know anything about the future is through inference.

The problem thus became that the system in which one was to make inferences about was a system prone to *wicked problems*. Its state of being was not governed by the objective laws of nature, it was governed by the preferences and wants of stakeholders. As a result, one needed a methodology in which one could view the state of affairs as a fixed outcome. Scenarios are constructs that adhere to such fixed states of affairs, to reduce *epistemic uncertainty*.

The problem with scenarios however is that there is not general theory about scenarios. Nor was there any methodical framework within classical scenario building that stood out as being useful to create objective scenarios of subjective systems. This is because scenarios are largely either driven by synthesis or analysis. In which synthesis scenarios seek to uncover what will happen in the future. Whilst analysis scenarios seek to uncover what can happen in the future or how can one reach a certain future.

The solution this was to use *morphological analysis* which is a methodology developed for creative scientific discovery in which one looks at the connections between discrete variables rather than their probabilities. This method has largely been used to investigate wicked problems and therefore became quite a natural choice.

The problem thereafter became to assess how this methodology would be able to inhibit what one knows as risk. In short through investigation into the theoretical foundations of risk one could extrapolate that risk is not an ontic phenomenon, but rather a collection of ontic phenomena that are collected by methodologies or epistemic tools that adhere to the five epistemological conditions: (I) Risk relates to an *event* (II) This event takes place in *the future* (III) This event has a *consequence* of either *positive* or *negative* nature (IV) involving *something humans value* (V) shrouded in *uncertainty.*

By back-tracing how the model worked through construction of conceptual spaces to the inferences themselves it became quite evident that what one could infer from the model would be something one could coin risk.

This led to the construction of a conceptual space for the problem complex *the future of the Northern Sea Route.* The conceptual space was constructed through the utilization of two literary analysis into firstly the Northern Sea Route and thereafter its most pivotal dimensions. As a result, one was left with eight dimensions with 4-8 conditions.

Through the utilization of the empiricism that was used to construct the modelling space 28 different parameter blocks were formed in the cross-consistency matrix created in the program CarmaCCA Viewer. Through this software package these parameter blocks were assessed on the criteria of connection and coexistence to constrain the number of formal scenarios to the number of scenarios that would be internally consistent with the conceptual space.

The model also inhibited the functionality of being a model in which one could test out inferences about the problem complex itself and quickly run diagnostics and make iterations in order for the model to be consistent with the empiric material it was based on. As a result, the model was iterated a total of 6 times with minor and major adjustments to dimensions and the cross-consistency matrix.

In the end one was left with a tool that could indeed create risk pictures of the future of the Northern Sea Route. However, as risk theory states, one of the conditions of risk is that it must attain to *something human's value*. When the thesis started it set out to create risk pictures, but for the scenarios to work as risk pictures or as a heuristic for inference. It needs some strategic intent behind it.

The solution therefore became to construct pretexts for inference. With these pretexts one could look at the scenarios of the inference model and *deduce different risk pictures containing the human value in the Northern Sea Route*, rather than inferring just for inference sake.

Through the five different scenarios: The Chinese are Coming! Arctic Advancement, Climate Calamity, and Goodbye World, Hello Neighbour! the thesis was able to showcase different aspects of the model.

Firstly, one was able to determine the most pivotal connections within the conceptual space which serves as the greatest identifier of strategic targeting of policy in the future. Secondly, one was able to derive concrete mechanisms that would play a role in the decisions of these contextual inferences.

In which one must say it is the interplay between *relations*, *requirements*, *sustainable technology*, and *global environmental politics* that serve as the most pivotal dimensions. These dimensions gatekeep the dimensions *stakeholders*, *demand*, *wildcard events*, and *the availability of the Northern Sea Route*. Targeting either of these four dimensions with strategic intent can yield diametrically different possible futures depending on how one approaches them.

Therefore, one can ultimately conclude that one can use scenarios derived from a morphological analysis inference model to create risk pictures of the future of complex sociotechnical systems such as the Northern Sea Route. In addition, one finds that one can deduce multiple risk pictures that can have different strategic values to different stakeholders at different times through the use of morphological inference models.

Recommendation for Future Research

The analysis yielded many possible results, but the most interesting part of the problem complex was perhaps not addressed enough due to the wide scope of the analysis. The interplay between China and the five Arctic coastal nations will become an ever pressing topic in the future. An interesting analysis would be into the possible futures that these nations can have between them.

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Appendix A:
The Practicalities of Computer Integrated Morphological Analysis

This appendix details all the aspects around the computer aided morphological analysis process from correspondence to software breakdown.

Correspondence

Clarifications

Through the Swedish Morphological Societies pro-bono research support program, I was able to use the software package CarmaCCA Viewer. This is the client-side version of the software package MACarma that is used by the Swedish Morphological Society, and the consulting firm Morphologics.

As the Software Usage section will detail there are quite the amount of differences in the client and provider versions of the software. As a result, correspondence is necessary for the computer integration to take place.

Creating a Morphological Field

After the initial acceptance into the pro-bono research support program I was sent an excel spreadsheet. The excel spreadsheet was thereafter filled with the dimensions and conditions of the morphological field and sent back to the Swedish Morphological Society.

In their *edit* they can add these dimensions and conditions. After they had done that, they would send a *scenario* file back to me. This provided me with the morphological field.

Iterations to the field was done a total of 7 times, as such this process was done 7 times.

Activating the Morphological Field

To get the morphological field activated after the cross-consistency analyses (Appendix B). I would send the file back to the Swedish Morphological Society, where they would *activate* the field. Then return the field with additional comments about its properties and advice on inference, and diagnostics.

Iterations to the cross-consistency matrix was done a total of 4 times, as such this process was done 4 times.

Summary of Correspondence

In my correspondence with the Swedish Morphological Society I sent them my morphological field. It was put into CarmaCCA Viewer. I used CarmaCCA Viewer to conduct the cross-consistency assessment. I sent the completed assessment to The Swedish Morphological Society. They sent the activated model back to me. I used it for inferences.

MACarma and CarmaCCA Viewer

CarmaCCA Viewer is the client-side version of the software MACarma which was developed by Tom Ritchey and his colleagues at the Swedish Defence Research Institute. Today it is offered to civilians through the services of Morphologics, and through the pro-bono research support program of the Swedish Morphological Society(Ritchey, 2005).

Functions

CarmaCCA Viewer as a software package is intended for the process of conducting cross-consistency analyses and viewing the morphological field as an inference model.

Within CarmaCCA Viewer one can access a total of two fields: *C- Cross-Consistency Matrix, D – Display Field.* In the provider-side version MACarma and additional *E – Edit* field is accessible.

The *E – Edit* field allows for the editing and creation of the morphological field(Ritchey, 2005).

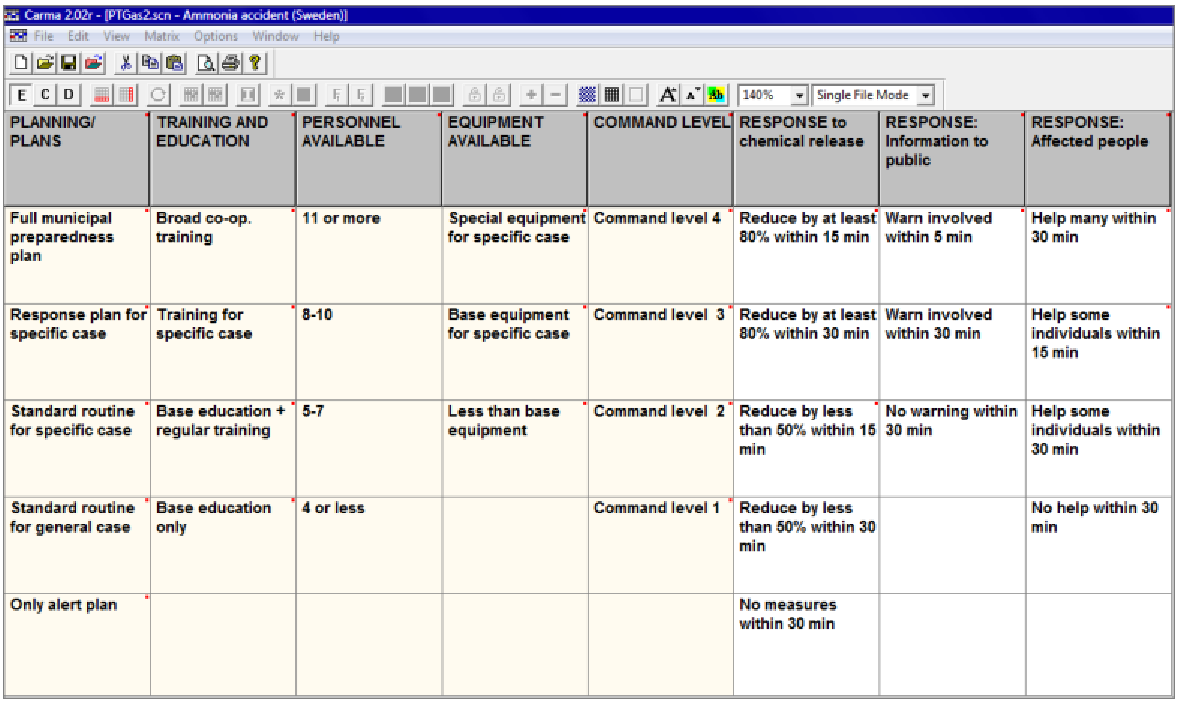

Figure A.1: An Edit field, derived from (Ritchey, 2005)

The *C- Cross-Consistency Matrix* allows for application of constraints by using MACarma notation. It also allow the user to make comments about specific dimensions, conditions, and pairwise assessments. Any square in the matrix can be commented(Ritchey, 2005).

		INVOLVED STAKEHOLDERS					EAST/WEST RELATIONS				GLOBAL DEMAND for ARCTIC TRADE TRAFFIC			GLOBAL POLITICAL ENVIROMENTAL STANCE					LEVEL of TECHNICAL and NAVIGATIONAL REQUIREME				ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY				WILDCARD EVENTS							
		Local Actors	Eastern Actors	Western Actors	African Coastal States	China	Cooperation and Agreement	Neutral Involvement	Challenging Tension	Challenging Involvement	High	Medium	Low	Radical Progressive	Progressive	Conservative	Regressive	Radical Regressive	High	Medium High	Medium	Low	High	Medium High	Medium	Low	Major Oil-Spill in the Arctic	ruise Ship Accident in the Arctic	arding Competing Trade Routes	of Arctic Coastal Infrastructures	ctic LNG and Pet Infrastructure	Extended Ice-Free NSR	Year-Round Ice in Parts of NSR	rst-Year Ice in Cross Polar Path
EAST/WEST RELATIONS	Cooperation and Agreement	-	-	-	-	-																												
	Neutral Involvement	-	-	-	-	-																												
	Challenging Tension	-	-	-	K	K																												
	Challenging Involvement	-	K	K	X	K																												
GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	High	-	-	-	-	-	-	-	-	-																								
	Medium	-	-	-	K	-	-	-	-	-																								
	Low	-	K	K	K	-	-	-	-	-																								
GLOBAL POLITICAL ENVIROMENTAL STANCE	Radical Progressive	-	K	K	K	K	-	-	K	X	K	K	-																					
	Progressive	-	-	-	K	-	-	-	K	K	K	K	-																					
	Conservative	-	-	-	-	-	-	-	-	-	-	-	-																					
	Regressive	-	-	-	-	-	-	-	-	-	-	K	K																					
	Radical Regressive	-	-	-	-	-	-	-	-	-	-	K	K																					
LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	High	-	-	-	K	K	-	-	K	X	-	K	X	-	-	-	-	-																
	Medium High	-	-	-	K	K	-	-	K	K	-	-	K	-	-	-	-	-																
	Medium	-	-	-	-	-	K	K	-	-	K	-	-	-	-	-	-	-																
	Low	-	-	-	-	-	X	K	-	-	X	K	-	-	-	-	-	-																
ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	High	-	-	-	-	-	-	-	K	X	-	-	X	-	-	K	X	X	-	-	K	X												
	Medium High	-	-	-	-	-	-	-	-	K	-	-	K	-	-	-	X	X	-	-	-	K												
	Medium	-	-	-	K	-	K	-	-	-	K	-	-	X	X	-	-	-	K	-	-	-												
	Low	-	K	K	K	K	X	K	-	-	X	-	-	X	X	K	-	-	X	K	-	-												
WILDCARD EVENTS	Major Oil-Spill in the Arctic	-	-	-	-	-	-	-	-	-	-	-	-	K	K	-	-	-	X	K	-	-	-	-	-	-								
	Major Cruise Ship Accident in the Arctic	-	-	-	-	-	-	-	-	-	-	-	-	X	K	-	-	-	X	K	-	-	-	-	-	-								
	Challenges Regarding Competing Trade	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
	Extended Development of Arctic Coastal	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	K	X	-	-	-	-								
	Extended Development of Arctic LNG an	-	-	-	-	-	-	-	-	-	-	-	X	X	K	-	-	-	-	-	K	X	-	-	-	-								
	Extended Ice-Free NSR	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	K	K	-	-	-	-	-	-								
	Year-Round Ice in Parts of NSR	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	K	K	-	-	-	-								
	First-Year Ice in Cross Polar Path	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	K	K	-	-	-	-	-	-								
AVAILABILITY of the NSR	Open	-	-	-	-	-	-	-	K	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Open with tariffs	-	-	-	K	K	K	-	-	K	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Closed	-	X	X	X	X	X	K	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	K	K	K	-	-	-

Figure A.2: The completed Cross-Consistency Matrix of the thesis' analysis. For reference that a red mark means "commented".

The *D – Display* field allows for the viewing of *activated* and *non-activated fields*. Activation merely means that someone has turned on the field in MACarma and run diagnostic of it to see that the model does not choke. Activated fields can be used to infer scenarios, strategies, designs, and a lot more. This is done through selecting conditions as independent variables to *run* the model. There is no limit to how many that can be selected(Ritchey, 2005).

INVOLVED STAKEHOLDERS	EAST/WEST RELATIONS	GLOBAL DEMAND for ARCTIC TRADE TRAFFIC	GLOBAL POLITICAL ENVIROMENTAL STANCE	LEVEL of TECHNICAL and NAVIGATIONAL REQUIREMENTS	ACHIEVED LEVEL of SUSTAINABLE MARITIME TECHNOLOGY	WILDCARD EVENTS	AVAILABILITY of the NSR
Local Actors	Cooperation and Agreement	High	Radical Progressive	High	High	Major Oil-Spill in the Arctic	Open
Eastern Actors	Neutral Involvement	Medium	Progressive	Medium High	Medium High	Major Cruise Ship Accident in the Arctic	Open with tariffs
Western Actors	Challenging Tension	Low	Conservative	Medium	Medium	Challenges Regarding Competing Trade Routes	Closed
African Coastal States	Challenging Involvement		Regressive	Low	Low	Extended Development of Arctic Coastal Infrastructures	
China			Radical Regressive			Extended Development of Arctic LNG and Pet Infrastructure	
						Extended Ice-Free NSR	
						Year-Round Ice in Parts of NSR	
						First-Year Ice in Cross Polar Path	

Figure A.3: An *activated* display field from this analysis.

Colour	Explanation
	Not Possible/Not Activated
	Possible
	Independent Variable

Figure A.4: Colour Coding used in Morphological Fields in MACarma and CarmaCCA Viewer.

Disclaimer

MACarma has a lot more functionality than addressed here, I only listed the pertinent features to this analysis. MACarma is a non-commercial product with a lot of features that are not directly advertised to the public. If one wishes to find out more about its features one could contact the Swedish Morphological Society, Dr. Tom Ritchey, or consult the literature available on the software on the Swedish Morphological Society's website(Ritchey, 2020).

Appendix B: Formal Mathematical Properties of Cross-Consistency Assessment

In the section on the construction of conceptual spaces, it was mentioned that there are "binding forces" that relate the different dimensions within the model to one-another. In the case of inquiry and investigation of objects of the real world, these binding forces need to logically, empirically, or normatively be able to manifest for a configuration to be internally consistent. The cross-consistency assessment is a synthesis process in which one eliminate the internally contradictory, and incompatible relationships between parameters. It does so through asking questions about the logical, empirical, and normative aspects surrounding the manifestation of two conditions at the same time. For example, "can A happen given B". This is allows one to have an internally consistent solution space, effectively reducing the number of configurations one is investigating by manifold (Ritchey, 2015).

In technical matters the CCA is done by way of a cross-consistency matrix , in the matrix one pairs every condition in every dimension with every condition in every other dimension. Within a cross-consistency matrix we find *parameter blocks*, these are all the pairings of two dimensions cross-referenced in a 2-dimensional typology (Ritchey, 2015).

	P1V1	P1V2	P1V3	P1V4	P1V5
P2V1					
P2V2					
P2V3					
P2V4					
P2V5					

Table B.1: A clear parameter block containing two dimensions with 5 variables each in cross-assessment.

To map out how many parameter blocks one will have let N = number of dimensions in the morphological field, then use:

$\frac{1}{2}$N(N − 1) using the thesis as an example $28 = \frac{1}{2}8(8-1)$

Whilst to find out the number of cross-consistency pairs one uses yet again N = number of dimensions in the morphological field, and the number of conditions for dimension P_x is V_x. By means of defining this we can find the dyadic relationship between all conditions or the total number of cells in the CCM by:

$$\text{Ct} = \sum_{i=1}^{n-1} \sum_{j=2}^{n} v_i \cdot v_j$$

Distinctions to be made here is that the model increases in a geometrically factorial manner with each parameter, but does only increase in cross-consistency pairs in proportion to the quadratic polynomial:

$f(x) = 1/2x(x-1)$

Hence, one sees that the formal mathematical properties of the model are:

N = number of parameters
1/2N(N-1) = number of parameter blocks
ΣΣvv = number of pair-related cells in the CCM
Π_V = total number of simple configurations in the model
(Ritchey, 2011, p.49-53).

These properties are contingent on N and V_x, however there are three other quantities that are determined by the empirical aspects of the cross-consistency matrix. In accordance with the innate four formal mathematical properties, these ratios let one typologies within the morphological models.

The first one is the connectivity quotient (κ), this concerns the *connectedness* of the dimensional constructs, or more specifically how different conditions are connected to each other. There are two answers to this question regarding connectedness, either of which can be answered by referring to empirical or logical constraints. Either a pair is *orthogonal*, as in they are independent of each other, as in they do not influence each other. Or they *contain mutual empirical or logical constraints*(Ritchey, 2011, p.51-55)

Orthogonality does however not mean that is no meaningful content associated with the relationship between two conditions, it merely means that there are no mutual constraints between two variables. Hence, if we defer to a CCM, orthogonality is denoted with "- "in MACarma, which can be interpreted as "can coexist". A distinction must however be made with regards to dimensions that are orthogonal to all other dimensions, such a dimension would effectively be an exogenous variable and have no effect upon the model and thus be arbitrary (Ritchey, 2011, p.52-53; Ritchey,2015; Appendix A, Table 1)

Dimensions are mutually constrained when at least one of the pairings within its parameter block is deemed to be impossible, inconsistent, unviable, or beyond comprehension. In MACarma one denotes this by X in the CCM. For example, within the field of this model we can mutually exclude all stakeholders except for local stakeholders when the the NSR is closed, from an empirically prescriptive perspective having other stakeholders during this condition than local ones seems inconsistent and impossible (Ritchey, 2011, p.52-53; Ritchey, 2015).

Hence, one sees that one calls a pair connected if its mutually constrained, whilst one calls it orthogonal if it is not connected. The connection between these parameters is however not a directional connection, its just a denotation about whether two parameters constrain or influences each other. Hence, the connections between two dimensions within an MA model can be seen as an undirected graph(Ritchey, 2011, p.53).

The connectivity quotient (κ) is the ratio of the number of connected parameter blocks to the total number of parameter blocks in the model. However, this presupposes that every dimension must be connected to at least one other dimension, if not one would merely have representational model. Hence, when one know this then the minimum number of connections for the model to hold up becomes $N\breve{}1$, in contrast the maximum number of possible connections between dimensions in the model become $1/2N(N-1)$ as stated earlier. Hence, we have maximum and minimum conditions. $N-1$ is the setting in which every dimension is connected to one dimension and one dimension only, whilst $1/2N(N-1)$ is when every dimension is connected to every dimension and is thus completely connected (Ritchey, 2011, p.53-54)

The distinction to made with these maximum and minimum conditions in mind is that there is a multitude of ways to reach a minimum condition, whilst there is only one way to reach a fully connected model. Thus to find the multitude of ways to reach a minimum condition by using the formula for the number of way to pick k unordered outcomes from n possibilities (Ritchey, 2011, p.54)

However, interesting the way in which we can pick k underordered outcomes from n possibilities might be, the morphologists is not concerned with this. The morphologist makes assessments about the model based on logical and empirical constraints upon the content of the model. Thus, what becomes important is not how one can minimally construct models, but rather how dimensions are connected. However, this inquiry makes sense in relation to the connectivity quotient. As the connectivity quotient (κ) is the ratio of the number of constrained parameter blocks (PB_c) to the total number of parameter blocks $1/2N(N-1)$.

Thus, with the minimum number of constrained parameter blocks being $(N-1)$, the possible range of PB_c is:

$$\kappa = \frac{\text{PBc}}{\frac{1}{2}\text{N}(\text{N}-1)}$$

As such we see that the range of the coefficient (κ), must be between $(1/2)N(N-1)$ and $(N-1)$, where it is given that N must be 2 or greater to satisfy the minimum condition for the model to hold true, namely that one has at least one connection between two dimensions (Ritchey, 2011, p.54-55)

The second ratio lets one typologies within the model is the *consistency quotient* (χ), which is the number of mutually constrained cells C_x in the cross-consistency matrix to the total number of cells in the matrix. The constraint of cells is not determined by the formal properties of the model such as connectivity quotient (κ), it is based empirical input by specialists/data. Hence, to derive C_x one simply counts the number of pairs. Thus one is left with:

$$x = \text{Cx}/\text{Ct}$$

where

$$\text{Ct} = \sum_{i=1}^{n-1}\sum_{j=2}^{n} v_i \cdot v_j$$

(Ritchey, 2011, p.55)

The final ratio is the *solution quotient* (ζ), which is the number of simple configurations making up the solution space ($Config_{sol}$) to the total number of formal simple configurations in the problem space.

$$\zeta = \text{ Config }_{\text{sol}} \text{ [divided by] } \prod_{i=1}^{n} v_i$$

(Ritchey, 2011, p.55)

If one wants to see how these quotients interact, an analysis of this can be found in (Ritchey, 2011, p.56-58).