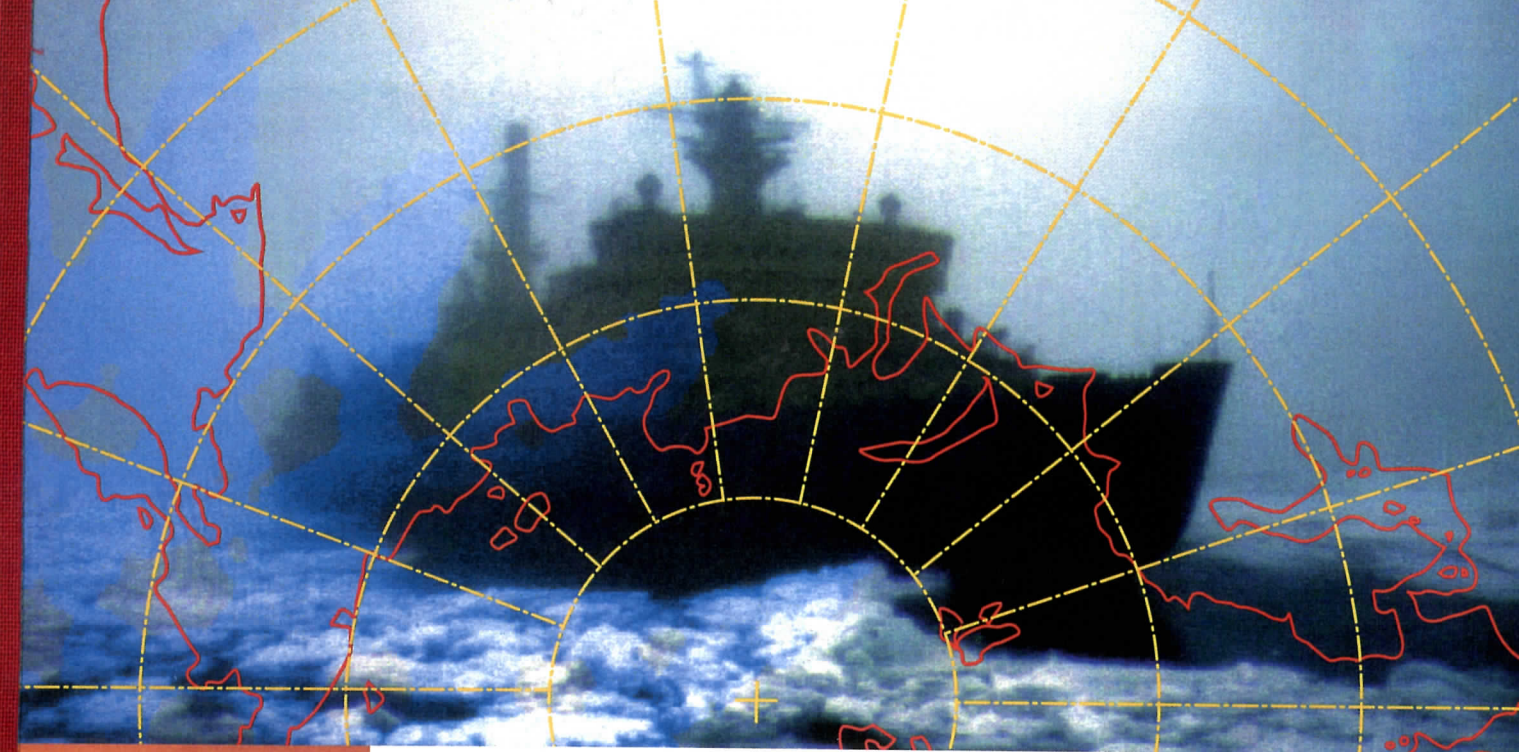

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Northern Sea Route Freight Operations: Survey of Logistic Modelling

Sverre Inge Heimdal and Tor Wergeland

INSROP International Northern Sea Route Programme

Central Marine Research & Design Institute, Russia

The Fridtjof Nansen Institute, Norway

Ship and Ocean Foundation, Japan

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What is an INSROP Working Paper and how to handle it:

FOREWORD - INSROP WORKING PAPER

INSROP is a five-year multidisciplinary and multilateral research programme, the main phase of which commenced in June 1993. The three principal cooperating partners are **Central Marine Research & Design Institute (CNIIMF)**, St. Petersburg, Russia; **Ship and Ocean Foundation (SOF)**, Tokyo, Japan; and **Fridtjof Nansen Institute (FNI)**, Lysaker, Norway. The INSROP Secretariat is shared between CNIIMF and FNI and is located at FNI.

INSROP is split into four main projects: 1) Natural Conditions and Ice Navigation; 2) Environmental Factors; 3) Trade and Commercial Shipping Aspects of the NSR; and 4) Political, Legal and Strategic Factors. The aim of INSROP is to build up a knowledge base adequate to provide a foundation for long-term planning and decision-making by state agencies as well as private companies etc., for purposes of promoting rational decisionmaking concerning the use of the Northern Sea Route for transit and regional development.

INSROP is a direct result of the normalization of the international situation and the Murmansk initiatives of the former Soviet Union in 1987, when the readiness of the USSR to open the NSR for international shipping was officially declared. The Murmansk Initiatives enabled the continuation, expansion and intensification of traditional collaboration between the states in the Arctic, including safety and efficiency of shipping. Russia, being the successor state to the USSR, supports the Murmansk Initiatives. The initiatives stimulated contact and cooperation between CNIIMF and FNI in 1988 and resulted in a pilot study of the NSR in 1991. In 1992 SOF entered INSROP as a third partner on an equal basis with CNIIMF and FNI.

The complete series of publications may be obtained from the Fridtjof Nansen Institute.

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REPORT

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Northern Sea Route Freight Operations

Survey of logistic modelling

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ABSTRACT

This report discusses logistic modelling related to the Northern Sea Route (NSR). Important logistic elements for cargo owners assessing alternative transportation systems are described briefly and are followed by a description of alternative perspectives on logistic modelling depending on who is the decision maker and the time horizon for the analysis.

Alternative regimes of logistic modelling are described in short:

- Preference studies
- Simulation
- Network optimisation
- Socio-economic planning tools

The report suggests that if there should be any activity on logistic modelling, simulating NSR operations will probably be most relevant since other methodological perspectives require data on cargo flows and market potentials compared to other transport alternatives which are regarded as not available.

The work with this report has lacked a well defined user and a well defined decision maker. Both roles are essential in choosing methodological perspective and should be clarified before any new activities are initiated.

KEYWORDS	ENGLISH	NORWEGIAN
GROUP 1	Logistics	Logistikk
GROUP 2	Transportation	Transport
GROUP 3		
SELECTED BY AUTHOR(S)	North Sea Route	Nordlige sjørute
	Model	Modell

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1 INTRODUCTION

The International Northern Sea Route Programme (INSROP) aims to "investigate the possibilities for commercial navigation through the North-East Passage" . The underlying ambition is to develop viable maritime operations which will meet the demand for freight transport between Europe, the northern territories of Russia and the Pacific regions in the northern hemisphere.

This report focuses on tools and models for evaluating freight logistics related to Northern Sea Route (NSR) operations. This first chapter presents the background and purpose for the report followed by an outline of the following chapters at the end of the chapter.

1.1 INSROP and analysis of freight transport demand

The NSR may be regarded as a northern logistic channel or corridor connecting markets in North-America, Asia and Europe, see figure 1. Substantial volumes of cargo flow annually between these markets. Although the NSR has for more than 60 years been used for domestic Soviet and Russian transport and since July 1992 has been re-opened for international shipping, most of the cargo potential of the NSR flows through southern channels or corridors.

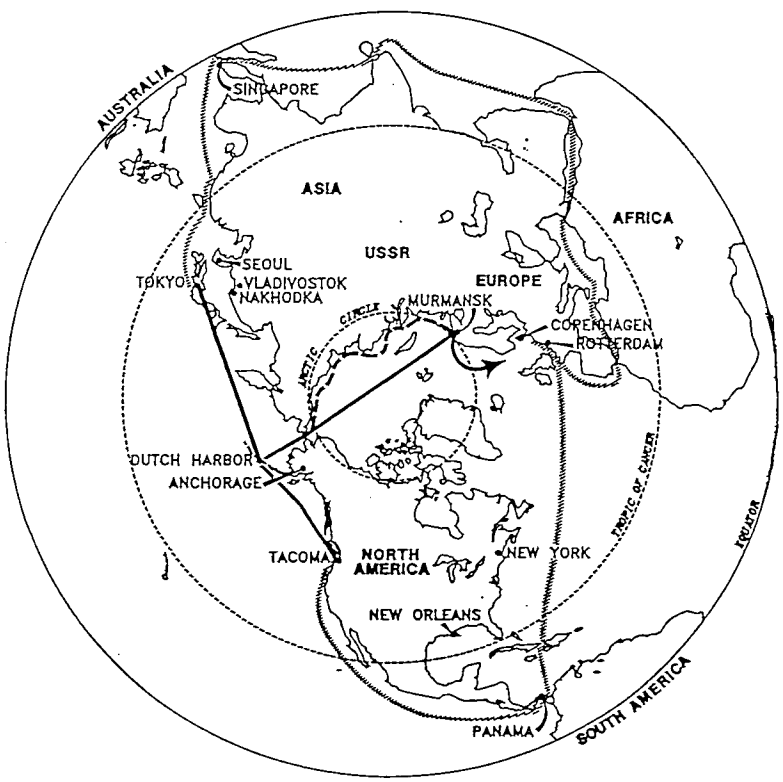

Figure 1: The Northern Sea Route with competing alternatives. From [PFu 92].

Sailings north of Russia may reduce the distance and transport time between large consumer and producer groups with 35 % in the case of the route Hamburg-Yokohama and up to 60% on the route Hamburg-Dutch Harbour in Alaska [TWe 91]. Furthermore, the opening up of Russia using the NSR and giving access to the vast natural resources of Siberia may produce a substantial increase in international trade in raw materials from Russia both eastwards and westwards. The opportunities are significant, however, the existing number of passages through the NSR is still small.

Commercial navigation through the NSR implies commercial maritime operations in an extreme climate with high risk of environmental accidents in a fragile ecological system. Although the NSR is currently serviced by ice-breakers in year-round operation, the harsh climate will most likely, at least in the near future, restrict transit operations to a few months during the summer season.

Efficient NSR operations demand high investments in ships, ports, surveillance equipment and organisational development. To justify these investments there is a need to demonstrate that the NSR is a viable alternative in a competitive, international environment. This report is based on the assumption that the NSR must offer shipping companies and cargo owners value added compared to other alternatives. For the NSR to become more than just a marginal international trading route, the combination of a sufficient cargo potential and the willingness for shippers to pay for NSR services are minimum requirements.

The report describes groups of available scientific tools and methods for analysing the transportation of a given cargo potential or for conducting strategic freight planning. The tools are evaluated as to their ability of comparing the NSR with other alternatives. The tools for strategic freight planning should also serve the purpose of analysing the macro economic dimensions of the NSR, with particular emphasis on infrastructure investments and institutional constraints.

1.2 Outline of the report

This initial chapter, describing the background and purpose of the report, is followed by a chapter which discusses the commodity groups or different types of cargo relevant for the NSR. The important dimensions for the discussion of potential cargo flows are the geographical perspective and the specific demands related to the different commodity groups. The origin - destination pattern and the diversified spectrum of cargo flows are essential information for evaluating the potential of new NSR operations and the specific needs for infrastructure investments.

Chapter three elaborates key concepts in logistics. The special environment in the Arctic

seas will inevitably influence the price and qualities of NSR operations. It is essential to know the characteristic parameters or attributes used to describe the competitive advantage of logistic services and how they influence the choice of transport equipment.

The next chapter presents principles and methodologies for analysing freight transport. The choice of decision support tools will be influenced by time horizons and the scope of analysis. If decisions can be structured in advance in the sense that it is clear what time horizon is relevant and which variables are in focus at different stages of decision making, a hierarchy of different decision processes could more easily be defined.

Chapter five presents computer based tools for modelling cargo flows and evaluating the capacity and capability of the NSR. The main focus is on strategic freight modelling, but other types of models are also discussed.

The last chapter presents some general conclusions and provides some recommendations for further INSROP activities. The main focus should, in our opinion, be on activities leading to results that can provide information allowing potential customers to evaluate how the NSR can be fitted into their total logistical systems.

The report includes comments and suggestions from a review based on a former version of the document. There has been no reason to argue with the comments given by the reviewer. Any error or misjudgment must, however, be addressed to the authors of this document.

2 POTENTIAL NORTHERN SEA ROUTE CARGO FLOWS

If the influence area of the NSR is defined as trades in both directions between Europe and the northern parts of the Far East Region and trades between Europe and the northern parts of the Pacific coast of North America, the current seaborne trade among these regions is limited compared to the total world trade. Estimates from the mid-80s indicate volumes of 21 mill. tons [TWe 91], while total world seaborne trade was estimated at 3.300-3.400 mill. tons [Fea 95].

A more realistic cargo potential including only the most relevant types of cargo gives a total of 6.8 mill. tons eastbound and 2.8 mill. tons westbound, using the same source of statistics [ØAn 95]. In addition the volumes of cargo shipped along the NSR as internal Russian trade, amounted to more than 6 mill. tons of cargo in 1987 [ØAn 95]. The annual volumes of cargo shipped in transit through the NSR in the years 1990-93 ranged according to [ØAn 95] between 0.12 and 0.22 mill. tons . If the NSR should prove viable as a commercial alternative, there seems to be a substantial potential for increasing the volumes shipped in transit while there is a second option that a cheaper and more efficient transport alternative also could create more trade.

This chapter discusses potential cargo which may constitute the basis for viable NSR operations. The first section describes the necessity of knowing the diversity of freight transportation while the next section discusses the interrelationship between NSR operations and different categories of cargo flows.

2.1 Freight transport statistics

The focus of this report is on tools for analysing logistics or freight transport. All existing tools are heavily dependent on data about existing and future cargo flows and the value of the results produced depends critically on the availability and quality of relevant data. The data collection and the process of structuring data is usually the most time-consuming part of any logistical analysis.

The basic argument for developing new, or buying existing, commercial decision support software, lies in the ability of such systems to provide sound decision-making material from large and unstructured data sets. Logistical decision support tools thus have little, if any, value if the relevant data on freight transport cannot be provided.

Several sources exist regarding freight transport statistics, but all the available public sources have some severe drawbacks. Ideally, one would like to have information on all of the following aspects of transportation:

- commodity type
- volume transported
- port (or country) of cargo origin and destination
- mode of transport
- type of carrier
- specifics of carrier (flag, size etc.)
- period (year, quarter, month etc.)

Unfortunately, no single public source of transportation statistics can provide all these sets of information. This is because most trade and transport statistics are collected for other purposes than logistical analyses. It is a fact that sea-borne trade statistics suffer from lack of statistical links between the ship and the cargo. Only a few nations do this on a regular basis and the lack of conformity across nations makes the production of international sea-borne trade statistics difficult.

There exist several standards for making trade and transport statistics. The most aggregated statistics are produced by summing up cargo volumes to 4 or 5 main groups. The column beneath to the left is an example of an aggregated structure found in [TWe 91] while the column to the right represents an alternative structure:

Dry bulk	Dry bulk
Liquid bulk	Liquid bulk
Refrigerated food	General cargo
General dry cargo	Containers
Other dry cargo	

There exist various *national* sources of both trade and transport statistics. Trade statistics for customs purposes are normally collected using nationally defined versions of the Customs Co-operation Commodity Nomenclature[1] (CCCN). This classification system can have up to 7 or even 8 levels with more than 7000-8000 items at the most detailed level. The problem for international comparisons is that the classification is only internationally well defined down to the 4th level. The levels below are nationally adapted to fit national needs. Customs statistics do not normally contain any information about mode of transport and very often volume information of commodity flows is also lacking.

Specific transport statistics do exist in many countries, and in Europe the CTSE classification is normally used for this purpose. This is a classification with only 20 commodity groups, and the reliability of information about cargo origin can sometimes be misleading, due to problems in properly handling the transit trades.

---

1 Previously called the Brussels Nomenclature

The main bodies concerned with international sea-borne cargo statistics are the United Nations Statistical Office, Lloyd's Maritime Information Services (LMIS), Fearnleys, Eurostat and a number of national authorities producing transport statistics. LMIS and Fearnleys both produce statistics based on the tracking of vessels. For some commodities like oil, oil products, iron ore, grain and coal, the coverage is very good as there is a relatively easy link between the vessel and the cargo carried.

The only body that has attempted bridging the gap between trade statistics and ship movements is the United Nations Statistical Office. Their point of departure has been the trade statistics provided on a yearly basis from about 100 nations based on the Standard International Trade Classification (SITC)-rev. II. SITC-rev. II operates with 5 levels of cargo definitions and at the 5-digit level there are about 1600 commodity items. For each of them, the origin and destination of the cargo flow are examined to identify how much of the trade flow is transported by ships. For this purpose individual transport statistics from about 20 nations are used. Each trade flow is then assigned a port of origin and a port of destination and the data is aggregated.

The UN Statistical Office has defined a special 3-level commodity classification that has 128 items at the 3-digit level. Each of these groups has a specific correspondence to the SITC, rev. II. They have also defined a special geographical classification, where the coastlines of the world have been divided into 30 coastal areas. The areas were defined to cope with some of the problems of large countries, like the USA, that have major ports both on the Atlantic Coast and the Pacific Coast or the Gulf of Mexico or countries like France with major ports both on the Atlantic Coast and in the Mediterranean. This data source is the only known public source of a comprehensive, global database of sea-borne cargo movements with a broad commodity as well as geographical coverage. The main problem today is, however, that the United Nations have stopped producing new statistics. The latest complete figures available are from 1985, and preliminary figures exist for 1986. These data can, therefore, only be used for historical analyses.

2.2 Trade and transport flows relevant for the NSR

For the purpose of analysing the cargo potential for the NSR, most available sources generally fail to meet even a minimum of requirements for coverage and relevance. A relatively complete analysis of cargo flows in the influence areas of the NSR, utilising available data, is reported in [An 95]. An older and more aggregated analysis with the same data can be found in [TWe 91]. Both studies indicate that there is a substantial cargo potential for increased transit trades through the NSR, but the former analysis emphasises that an eventual NSR success is not just dependent on the documentation of lower transportation costs, but that other service parameters are equally important.

The existing documentation on the NSR identifies 3 different cargo flows which represent a potential basis for NSR operations. These are:

- Domestic Russian flows
- Russian import and export flows
- Transit flows

As indicated in the beginning of this chapter the potential for transit flows should be significant. All flows representing a basis for NSR operations must, however, be carefully analyzed to see how the NSR will interact with existing and new trade flows. It is also important to identify the commodities with a long term potential which could represent the basis for building new ice classed ships and construct the necessary land-based infrastructure.

The trade and transport statistics reported in the existing documents on the NSR indicate that the NSR today does not suffer from severe capacity restrictions except that transit through the NSR is only available 4 out of 12 months each year. The challenge is therefore to develop the market for transport through the NSR. An important part of this job will be to identify cargo or commodity groups where transport through the NSR will give a competitive advantage.

The search for potential cargo will probably have to be done at a more detailed level than the available transport statistics will support. A helpful structure for initial market assessment could be to elaborate the structure suggested in [TWe 91] to a two-dimensional structure where the second dimension is represented by a future NSR market made out of:

- Existing cargo flows through NSR
- Cargo "captured" from other transport corridors
- New cargo flows due to new business activity.

Potential market niches could be identified from the following table:

	Existing	Captured	New flows
Domestic Russian	?	–	?
Russian Import & Export	?	?	+
Transit	–	+	–

Table 1: Market niches for the Northern Sea Route

The labels in the matrix have the following meaning:

– Potentially low market value
? Unknown market value
+ Potentially high market value

and represent an intuitive classification of market potential based on the description in [TWe 91].

A thorough discussion will be helpful in limiting the search for transport data. The selected market niches will also influence the choice of analytical tools. Transport analyses which include general economic activity and spatial development are usually different from analysing existing flows which usually aim to produce a clear picture out of existing origin/destination matrixes with multi-mode, multi-commodity data.

3 KEY CONCEPTS IN LOGISTICS

Logistics is a multi-faceted subject which includes a variety of activities with relevance for many application areas. The term logistics is closely related to material flows and was originally developed to categorise supply and support activities for military operations. This dimension of logistics has its civilian counterpart in supportive supply and maintenance activities for organisations or production. The other dominant dimension is often labelled "business logistics" which has its focus on material and lately on information flows through production units and between business partners.

When evaluating NSR cargo flows, two different dimensions could be emphasised. The most important is the business logistics dimension, i.e. to what extent the NSR can fit into the logistical perspective of prospective shippers. The second dimension has to do with the planning of the NSR as a transportation system. This implies studying cargo flows at an aggregated level for the purpose of identifying bottleneck-problems related to, e.g. the size and geographical distribution of the icebreaker fleet, available port services, required infrastructure investments, etc.. The latter kinds of analyses with focus on infrastructure are usually associated with the term transport planning and are by nature more macro-oriented.

Modern thinking about logistics focuses on elements that represent significant challenges in making the NSR attractive. Total demand for transportation services is by definition the aggregation of all individual transports, that again are determined by the preferences of individual decision makers. Transport planning must, therefore, take into consideration how the transportation system fits in with individual, and thus often widely varying logistical preferences.

1. Quality	94 %
2. Reliability of delivery	92 %
3. Commitment to continuous improvement	89 %
4. Technical expertise	86 %
5. Flexibility and responsiveness	78 %
6. Customer orientation	76 %
7. Price	71 %
8. Good marketing and publicity	38 %

Table 1: Supplier perceptions of logistic criteria importance [MCh 92].

The traditional models of logistics have been dominated by minimising transportation cost as the primary goal. This has clearly changed in recent years. Cost efficiency is still

important, but there is now increased emphasis on customer service parameters. This may very well change the preference ranking of competing alternatives compared to the cost minimising ranking.

Modern logistic systems must adapt to transport buyer demands which often give priority to quality and reliability above price. Table 1 presents the results of a survey which was designed to identify supplier perceptions of supplier criteria importance for a Japanese-owned car factory in Europe. The suppliers were asked to identify which criteria they regarded as important for doing business with the car factory, and the available answers are ranked according to their frequency among the respondents.

Table 1 clearly indicates that service elements are ranked above price. Price is still important, but the competition between suppliers is so hard, and the price difference often so small, that other or additional criteria may be decisive.

In a competitive business environment cargo owners will prefer transport alternatives which satisfy their most important logistical criteria. The NSR has to offer its users reliable services. This is obvious for transit flows where competitive alternatives exist, but it is also vital for export flows where customers will expect delivery as agreed. This perspective underlines the importance of logistics. Transit traffic as well as Russian exports through the northern territories will have no future if the logistical system fails to match the logistical requirements of the customers.

These aspects of logistics are further discussed in [TWe 95] that refers to a survey of liner shipping customers' preferences. A dominant service requirement referred to here is regularity which most shippers ranked above both transit times and transportation costs.

4 MODELLING PRINCIPLES

A development of the NSR services from the current situation to a competitive transport corridor will require extensive planning and development. Development of logistic services and facilities must be a continuous process and planning tools and planning processes should be designed for this purpose.

This chapter focuses on important modelling principles which should be applied for the NSR logistic planning and development process. European, Russian and Japanese planning traditions all differ, and it will be essential to design a process which benefits from existing planning experiences and is able to meet changes in demand.

4.1 Planning horizons

Logistical planning does not represent a single process, but should be divided into several activities depending on the "lead time" necessary to influence or adapt to external logistical conditions. Efficient logistical systems are characterised by a balanced capacity in all links of the logistical chain without losing the flexibility to meet variations in demand for logistical services.

Necessary capacity is often a result of investments in equipment, transport means and infrastructure. The consequences of making unprofitable investments are so high that investments require planning with long time horizons. Public infrastructure investments usually have planning horizons of at least 20 - 30 years. Shifts in demand are usually not predictable and the need for flexibility is often met by re-organising existing resources. The ability to meet shifts in demand and to see all potential consequences after re-organising requires other types of planning or assessment tools than capacity-oriented investment planning.

It is a general experience that it is impossible to design modelling or planning tools which solve all problems at the same time. Different planning tools and different planning processes must be developed for different planning tasks with different planning horizons.

In terms of the NSR, strategic tools should be developed to find the proper balance between demand and capacity. An important part of the strategic planning process will be to identify cargo groups and transport flows which will constitute the core market segment. The outcome of this process will represent the basis for decisions about vessel types, port locations and other investment-related decisions. Tactical planning, usually, has a shorter time horizon and should aim at identifying options or solutions which give maximum flexibility within the restrictions given by existing infrastructure and requirements due to

economy and social acceptance.

This process implies that tactical decisionmaking will be restricted by implemented strategies. Decisions coming out of the tactical planning process will in the same way restrict available options for operational decisionmaking which is the short term process of meeting actual demand.

It is also important to note that these planning processes will not necessarily be performed by the same bodies. The NSR represents a type of infrastructure which usually belongs to the domain of public responsibility. Many operators along the NSR are or will be private or will act as individual decisionmakers. It is not unlikely that actual operations in the future will be dominated by private companies. The situation could be visualised as follows:

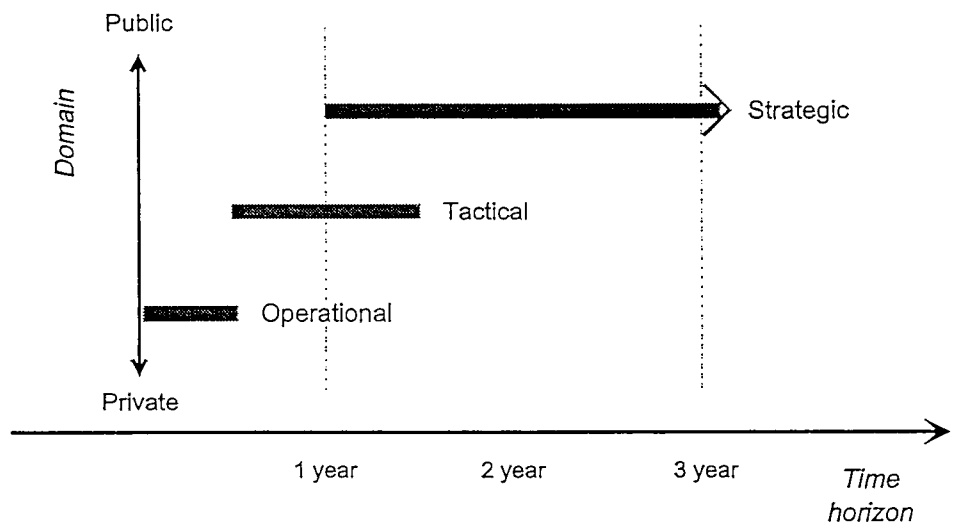

Figure 2: The structure of continuous planning processes

The most significant contribution from public strategic planning will be to reduce uncertainty and define stable external conditions for companies using and operating along the NSR. This is of special importance for the NSR since the operation itself involves a high degree of risk.

4.2 Focus

Planning at any level must include all significant elements which may affect potential users. Before any substantial investments are made, it is necessary to evaluate the competitive position of the NSR compared to other alternatives. This implies that strategic analysis must be based on models which are capable of representing the NSR activities, activities within alternative transport corridors and the interaction between corridors relevant for the NSR.

Strategic assessment of the NSR must have a broad geographical perspective. Tactical and operational planning may have a more limited geographical focus. Planning at the most detailed levels will necessarily be performed more frequently than aggregated planning. The level of detail and the amount of data impose practical restrictions on how models may be used. Another important part of the planning design process will, therefore, be to define how broad the geographical perspective at each level should be.

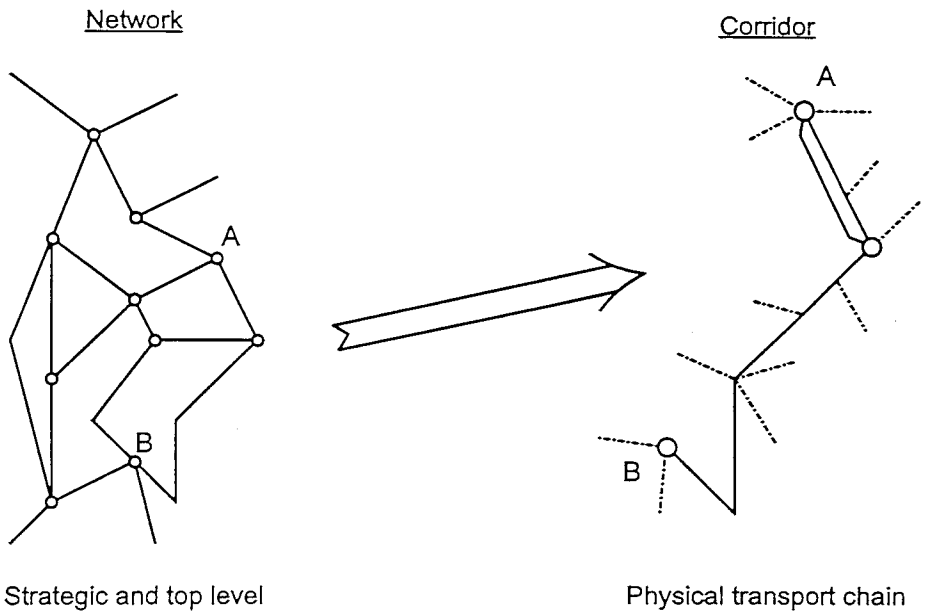

Figure 3: Geographical perspectives on transport planning

The difference can be illustrated by figure 3. The network structure is ideal for representing information about interacting transport systems. An important characteristic is the opportunity to identify second and third order effects of investments or effects following removals of bottlenecks which arise far from the location where changes are introduced.

Network modelling represents a quantitative analytical effort. Modelling can also be done by more qualitative reasoning, but the problem with this type of analysis is that the geographical dimension is often less developed and it is difficult or impossible to identify where changes will occur.

Corridor representation is geographically more limited, but allows the richness of detail often necessary in planning actual operations. The corridor perspective has its focus inwards, at the elements which are necessary to achieve smooth operations and efficient transport chains.

The difference between network and corridor representation is not clear-cut since networks

may be regarded as a set of corridors. For analysis where information about origin and destination is important, the network perspective should be applied. With the corridor representation, interactions with other transport systems are represented by flows in and out of the corridor. Information about origin and destination may not be known or may be irrelevant and the corridor representation should be applied when boundary effects are of minor importance to the analysis.

5 TOOLS FOR ANALYSING FREIGHT LOGISTICS

Before starting the process of trying to choose the appropriate tool for analysing freight transport, the more fundamental question should be asked if there is a need for formal tools at all. Many important strategic questions can be illuminated sufficiently by some simple calculations on the reverse side of an envelope. If it is decided, however, that formal models are necessary, it should be kept in mind that even if a good system or tool is found, the lack of underlying system knowledge or relevant data for analysis can make the output from even the best tools worthless.

This chapter discusses different groups of tools representing different traditions of analysis which may be relevant for analysing NSR operations. Most emphasis will be put on tools for strategic freight analysis, but tools for market assessment and tools for analysing the reliability of NSR operations will also be discussed.

5.1 Preference studies

The existing documentation on the NSR and especially the proceedings from the NSR expert meeting in Tromsø in October 1992 [HSi 93] present promising opportunities for the NSR. Other, more recent studies discuss at length some of the requirements that must be met for the NSR to be successfully established as an alternative sea-route[2] and indirectly they have a more sceptical view as to the immediate success of the NSR.

The first important question must be: Will there be a market for NSR services and how large will that market be ? The existing market is very small, but can it be developed to a lively activity which will benefit both Russian interests and international trade and transportation ?

Within the international transport engineering environments there exists a set of methods and tools for this type of market assessment called preference studies. The preference studies have been applied for over a decade and the development of the methodology must be regarded as a response to the mistakes made in many statistical transport forecasting applications in the 1960s and 1970s: "It is no longer adequate, if it ever was, to project past trends into the future and to assume that existing policies and existing external developments will continue indefinitely." [NPH 91].

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2 [ØAn 95], [BBu 95] and [TWe 95] are all focusing on criteria to be met for the NSR to have market success as an alternative sea-route.

The preference techniques are developed primarily for passenger transport, but can with minor adjustments be applied for freight transport. There are in principle two types of preference studies:

Revealed Preference is an analysis of actual transport flows. The aim of this type of analysis is to find out why people choose the transport solutions that they actually do.

Stated preference analysis is an analysis of how people express their preference between available or hypothetical transport alternatives. The aim of this type of analysis is often to assess transport markets and identify price and quality levels for making new transport alternatives attractive.

The analysis of revealed and stated preference is usually based on interviews or questionnaires. The techniques include methodology for designing and organising data collection and computer-based tools for analysing the results. Many transport engineering consultants have experience with this type of analysis and possess the necessary tools.

5.2 Simulation tools

There seem to be three fundamental concerns that effectively limit the motivation of cargo owners for using the NSR. First, there is a lack of precise information about prices, sailing times and the quality of the ships. Second, there is great uncertainty as to the stability of the administrative system, due to political volatility. Third, and most important, there is a perceived higher risk in using the NSR particularly concerning the regularity aspect.

A potential strategy for demonstrating the reliability of NSR operations and identifying potential bottlenecks, will be to develop simulation programs which calculate and show potential delays and damage to cargo and vessels. The programs should include all relevant climatic conditions, capability of vessels and capacities of all necessary services.

There are at least two areas which should be analyzed. First of all, it will be important to demonstrate the probability of passage without delays and damages for single passages. Second, it is important to show how skewness in the balance between east and west bound traffic will influence on the availability of necessary services and especially ice-breaker assistance.

Simulation is well suited for modelling the NSR operations with the corridor perspective described in the previous chapter. Simulation models for operations in the Arctic climate

have been developed both by Russian and Finnish institutions[3] and INSROP could provide an opportunity of making the knowledge behind these models available to a wider audience. Simulation is well known and the financial resources necessary for acquiring relevant software are within the limits of most institutions. Simulation projects will represent an ideal setting for making the knowledge about the climatic conditions available and operational for the international shipping community. Hopefully, this will contribute to increased international acceptance of the NSR.

5.3 Network optimisation tools

Any representation of freight transport which includes the geographical dimension of cargo may be transformed to a network structure. Networks are intuitively easy to understand and applications in many scientific areas have during the last decades produced a large number of methods and techniques for evaluating and optimising flows in networks.

Network modelling is often associated with operational research (OR) or mathematical programming. Transport belongs to the early applications of OR. There are many publications describing potential applications of constrained optimisation on transport problems. Many applications have failed due to poor problem representation or limited computer resources. The gained insight from unsuccessful modelling experiences combined with more powerful computers have now produced methods and computer programs that are promising and may renew the interest in quantitative transport modelling.

The new generation of tools for freight transport assessment is based on a multi mode - multi commodity representation of cargo flows which provides a general and flexible structure for modelling transport infrastructure with its distribution system. The usual strategy is to model cargo flows between zones. All cargo entering or leaving a zone is either consumed or produced in a zone centroid or transferred from one transport mode to another in transfer nodes[4].

The zoning strategy is important:

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[3] An internal INSROP note gives a survey of many Russian logistical modelling tools. The survey indicates that PC-based computer models exist that focus on the operational side of Arctic navigation. The models are primarily constructed to handle separate aspects of technical operations, like port time in specific ports, possible waiting times in specific areas, etc. At Kværner Masa Yard Technology a simulation model of Arctic navigation exists that will be used in future INSROP projects (project III.07.3).

[4] These tools bear close resemblance to Geographical Information Systems (GIS), where regions are defined in terms of zones and nodes. Within INSROP an ambitious task (project I.1.3) is to develop a GIS for the entire NSR area to study both transport and other economic activities, but also link these with ice- and biological data.

- The zoning structure must be detailed enough to describe local freight flow consequences following changes in infrastructure and transport pattern.

- The zoning structure should be harmonised with administrative areas for collection and presentation of statistics on economic activity, transport and population density.

- The number of zones should be limited to the number of zones needed for ongoing and expected future analysis.

The zoning will usually be constrained by the availability of data. Data collection for network modelling is a very resource and time consuming process and the need for data should in advance be evaluated with great care.

The new network methods are ideal for analysing combined transport and the competitive position between transport means and transport corridors. Depending on available data, evaluation may be done in broad terms or on specific transport legs. The usual strategy is to assign freight flows to the corridors and transport means which give the overall minimal cost solution. Cost minimisation may be based on generalised cost functions which in addition to actual outlays could include costs due to delays and expected damages.

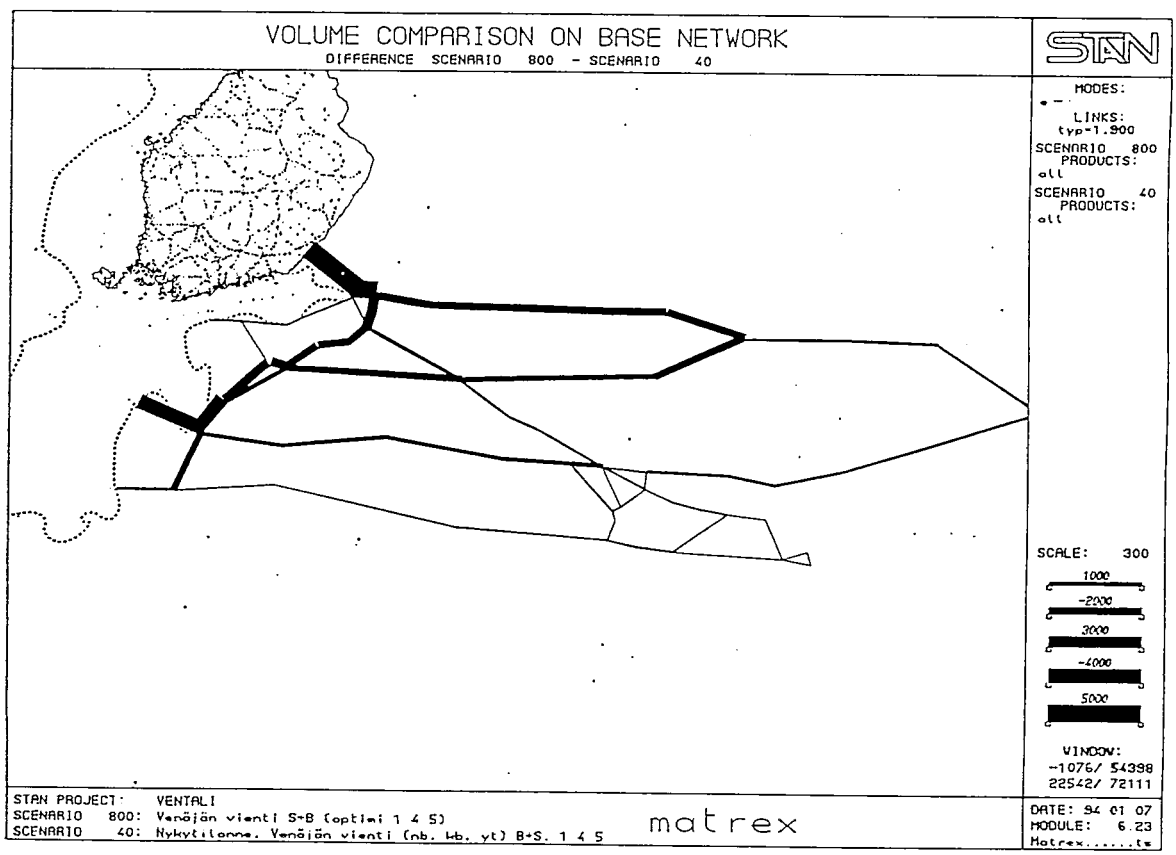

Figure 4: An example of results from strategic freight analysis [Mtx 94]

Figure 4 shows an example from an analysis of Russian cargo flows through the Baltic area. The analysis was performed to demonstrate the competitive position between Baltic, Russian and Finnish ports. Based on the underlying cost structure, most cargo is expected to pass through Finnish and Latvian ports. Detailed studies will, however, show that the results are very sensitive to costs associated with delays and expected losses.

The analysis is performed with a computer program called STAN[5] [CRT 87]. This is one out of few or maybe the only general commercial software package which is developed especially for strategic freight analysis. The STAN software may be used for optimisation when costs and routes are known which implies for the NSR that origin - destination freight volumes, costs and price structures must be known before any kind of analysis can be done.

5.4 Socio-economic planning tools

Transportation has no value of its own, but is a service activity resulting from an imbalance between demand and supply for goods within a region. It is generally accepted that the level of economic activity heavily influences the demand for transport. The supply - demand gap within regions is balanced by storage and transport between regions.

For every region it is realistic to assume a long term balance between production and consumption corrected for net imports and exports as follows:

$$\text{Consumption} = \text{Production} + \text{Imports} - \text{Exports}$$

The balance includes investments, energy and wastes. Models which predict the economic activity level and the following demand for transport will be valuable tools for estimating the demand for different transport means and the load on the available infrastructure.

There exist several examples of transport-related macro-economic modelling:

- GODMOD is an equilibrium model for the Norwegian freight transport market. The equilibrium model includes assumptions about technological efficiency, technological and politically imposed restrictions, taxes and subsidies. The equilibrium solution defines the industrial structure with prices, supply and demand for transport [TØI 93].

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5 The STAN program is unfortunately very expensive. The price varies between CHF 21.000 and CHF 90.000 depending on computer platform and program capabilities. The exchange rate between CHF and USD was at the end of May 1995 1,2 CHF to 1 USD.

- MEPLAN is a commercially available model which is developed for analysing the interaction between land use and transport. The driving force is the general level of economic activities. The MEPLAN model has some capabilities for modelling transport networks. In Sweden the MEPLAN model is used together with the STAN model since this model has a much better structure for modelling freight transport. [VäV 93]

- SMILE is a model developed for analysing freight transport within and through Holland. The SMILE model has two sub-models. The first sub-model describes the macro economic dimensions while the second sub-model focuses on distribution based on available supply and existing infrastructure [TNO 94].

Models of this type are usually not associated with logistics, but belong to the domain of macro economics. There is a substantial international activity in developing integrated model concepts where macro economic models generate data for strategic freight data models.

6 CONCLUSIONS AND RECOMMENDATIONS

The main challenge for successful development of the NSR as a truly international sea-route will be to provide a shipping service that is in conformity with modern logistical requirements. Any modelling activity or model development within the INSROP program should be directed towards providing interested parties with information enabling them to assess the NSR within a total logistical perspective.

Cargo owners will most likely avoid the NSR if other alternatives do exist and they are not convinced about the quality and reliability of the services offered through the NSR. It is not sufficient to point out that the NSR is shorter and cheaper. Solid documentation of the risk elements related to the harsh climate, probabilities for delays, cargo damage and more severe accidents is vital and must be provided in a form that can easily be evaluated by potential NSR customers.

Logistical analysis could be made on a strategic level related to the overall dimensions and capacities of the NSR as a transport route as well on a micro level related to the overall logistical efficiency for individual shippers. Many of the essential elements at the strategic level could potentially be handled within the framework of a Geographical Information System (GIS) that is already under construction within INSROP.

We believe that INSROP should concentrate on providing information related to how the NSR can fit into the modern logistical requirements of cargo owners. Three main activities could be performed:

1) Reliability and regularity are important logistical parameters and simulation models are most likely to illuminate the risk elements in using the NSR (delays, cargo damage, accidents). A detailed survey on existing simulation models would give a basis for defining relevant modelling activities.

2) General logistical information, like freight rates, transit tariff fees, planned sailing times, relevant ship information, administrative rules and regulations should be made available to attract customers to gain actual logistical experiences with non-Russian customers. A related research activity could be to monitor such experiences closely, including the customers level of satisfaction to gain more insight into how the NSR performs.

3) One could invest in a version of the computer system STAN to continue the work of comparing the NSR as a transport corridor with other alternatives, including the Siberian Railway. Again the purpose should be to provide a set of logistical arguments for why the NSR in some cases is a good alternative. This model strategy should not be chosen unless necessary data are available.

It could not be made clear enough that detailed information about the NSR as a logistic corridor will be necessary before any kind of analysis could be done. A cost efficient process of collecting and structuring information will be vital.

Further work with the logistical perspectives of the NSR should have a well defined user of the tools developed and a well defined decisionmaker which is expected to react on the analytical results. Both roles are essential in choosing methodological perspective and should be clarified before any new activities are initiated.

The next step following this project could be to initiate two or three case studies for factories or potential export facilities within the influence area of the NSR. The studies should go into all necessary details which are necessary to identify the most efficient logistic systems for each unit. Similar studies have been done for Norwegian companies within a short sea shipping perspective and have produced important knowledge and interesting results.

The concluding comment will be that further work must incorporate co-operation between Russian and foreign environments at day-to-day work level. Distant co-operation is not sufficient. Necessary funding supplemented with institutional and personal motivation must be available to bridge the cultural and geographical gaps between potential partners.

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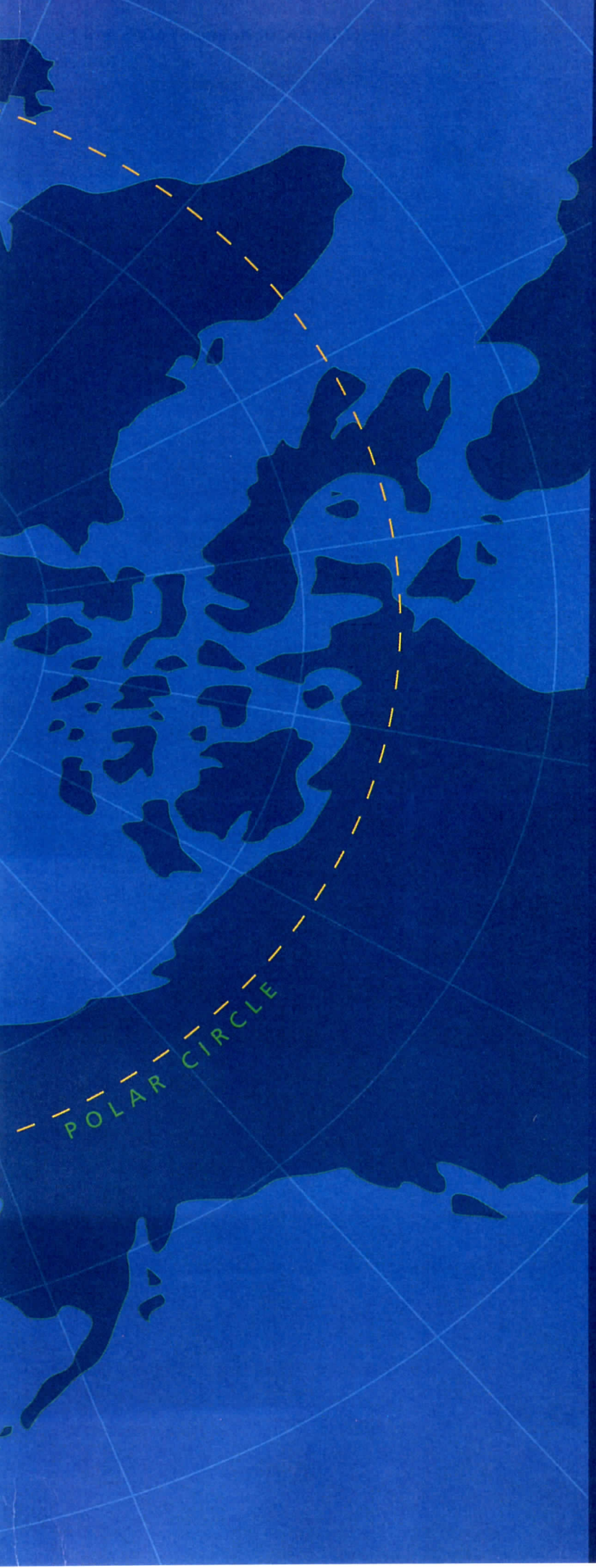

The three main cooperating institutions of INSROP

Ship & Ocean Foundation (SOF), Tokyo, Japan.

SOF was established in 1975 as a non-profit organization to advance modernization and rationalization of Japan's shipbuilding and related industries, and to give assistance to non-profit organizations associated with these industries. SOF is provided with operation funds by the Sasakawa Foundation, the world's largest foundation operated with revenue from motorboat racing. An integral part of SOF, the Tsukuba Institute, carries out experimental research into ocean environment protection and ocean development.

Central Marine Research & Design Institute (CNIIMF), St. Petersburg, Russia.

CNIIMF was founded in 1929. The institute's research focus is applied and technological with four main goals: the improvment of merchant fleet efficiency; shipping safety; technical development of the merchant fleet; and design support for future fleet development. CNIIMF was a Russian state institution up to 1993, when it was converted into a stock-holding company.

The Fridtjof Nansen Institute (FNI), Lysaker, Norway.

FNI was founded in 1958 and is based at Polhøgda, the home of Fridtjof Nansen, famous Norwegian polar explorer, scientist, humanist and statesman. The institute spesializes in applied social science research, with special focus on international resource and environmental management. In addition to INSROP, the research is organized in six integrated programmes. Typical of FNI research is a multi-disciplinary approach, entailing extensive cooperation with other research institutions both at home and abroad. The INSROP Secretariat is located at FNI.