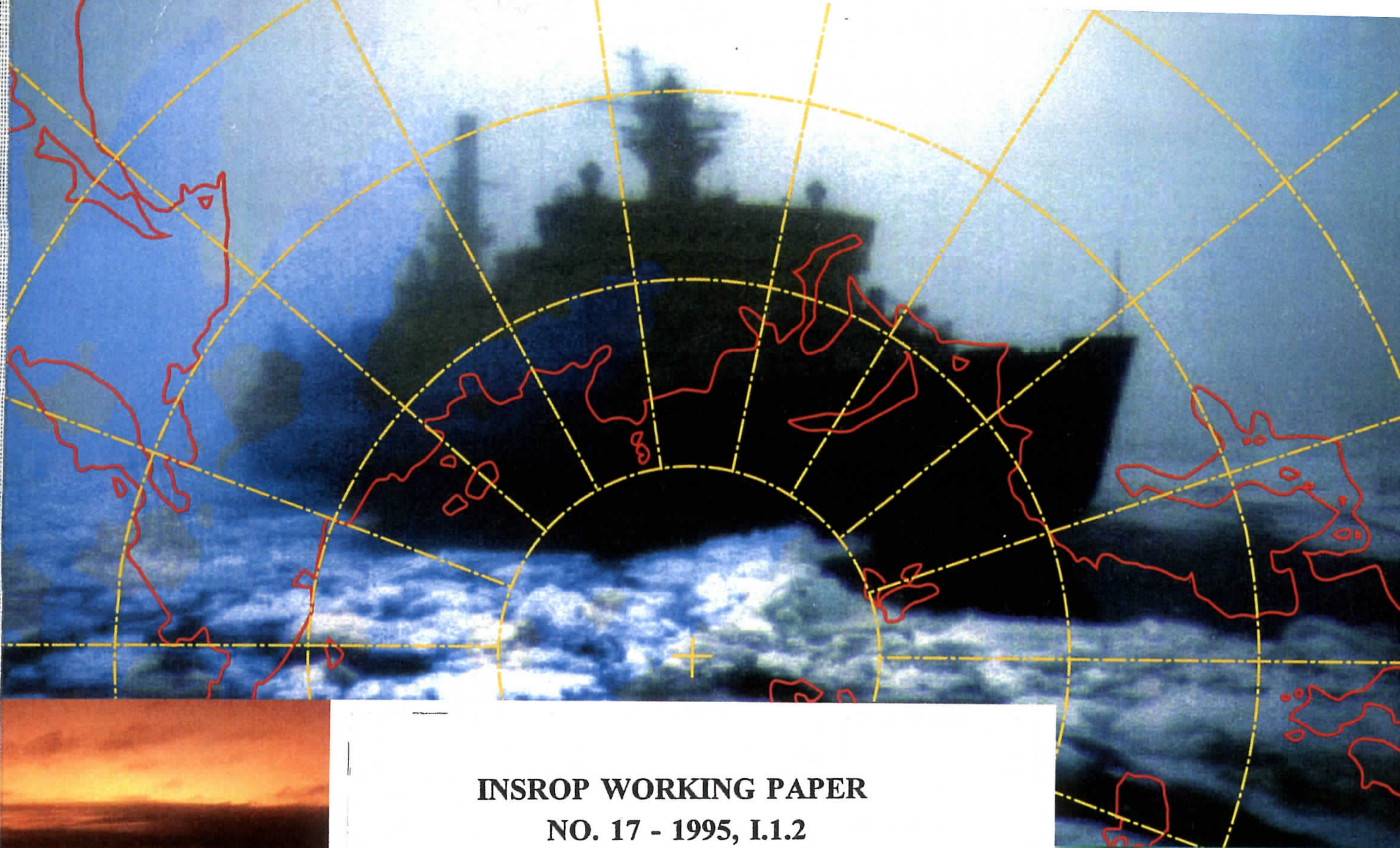

INSROP WORKING PAPER
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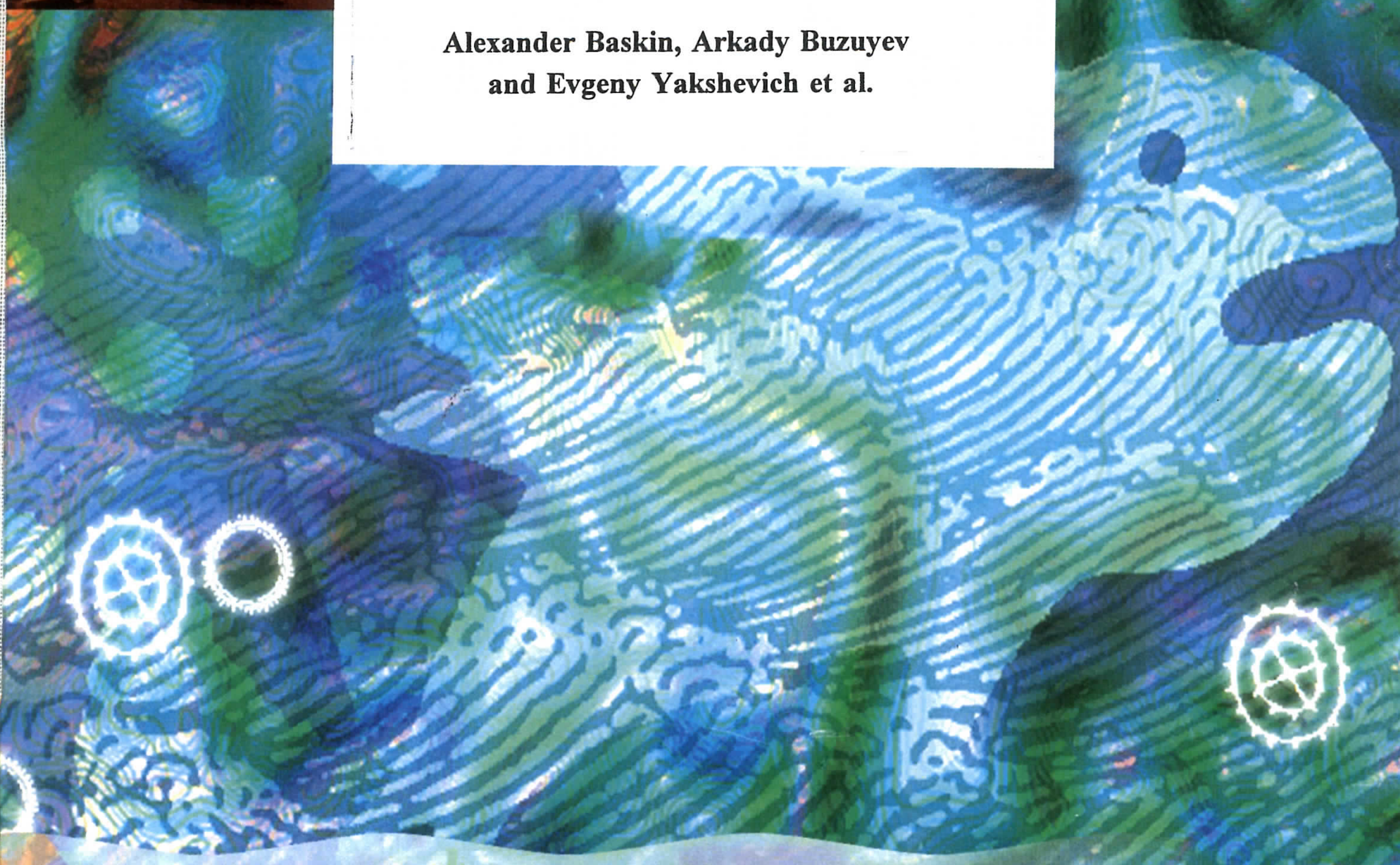
Operational Aspects

Alexander Baskin, Arkady Buzuyev and Evgeny Yakshevich et al.



INSROP International Northern Sea Route Programme

Central Marine Research & Design Institute, Russia

The Fridtjof Nansen Institute, Norway

Ship and Ocean Foundation, Japan

International Northern Sea Route Programme (INSROP)

Central Marine Research & Design Institute, Russia

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Ship & Ocean Foundation, Japan

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Sub-programme I: Natural Conditions and Ice Navigation

Project I.1.2: Operational Aspects

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

This publication forms part of a Working Paper series from the **International Northern Sea Route Programme - INSROP**. This Working Paper has been evaluated by a reviewer and can be circulated for comments both within and outside the INSROP team, as well as be published in parallel by the researching institution. A Working Paper will in some cases be the final documentation of a technical part of a project, and it can also sometimes be published as part of a more comprehensive INSROP Report. For any comments, please contact the authors of this Working Paper.

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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- Norwegian School of Economics and Business Administration
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GENERAL

Report on this Project covers the results of investigations on the wide range of problems relating to operational aspects. The list of tasks was defined when drawing up and agreeing the 1993 research plan.

Basically, this stage of investigations involves the systematization, review, analysis and evaluation of data on operational aspects of the international sailing through the NSR. Emphasis was placed on support of international shipping demands with due regard to peculiarities of sailing in the Russian Arctic.

As a rule, each part of this Project is an integral completed work with its own significance.

The Project is composed of nine Sections, each with a Summary, Key Personnel and Key Words.

We are most grateful to our reviewer, Prof. William M. Sackinger from the University of Alaska, USA, for detailed analysis of the information in the Project reviewed. The comments of the reviewer have been incorporated in the final version of the report. Proposals on further investigations under this Project are in line with our future plans.

I.1.2.1 REGULATIONS

ANALYSIS OF EXISTING NORMATIVE DOCUMENTS (SAILING RULES, MANUALS, INSTRUCTIONS, RECOMMENDATIONS) REGULATING SAILING THE NSR FROM THE STANDPOINT OF ENSURING THE SAFETY OF LIFE AND THE ENVIRONMENT

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SUMMARY

Considered in this Section is the legal framework of Russia, with particular attention to problems related to the NSR. Proposals on legal regulation improvements are made.

KEY WORDS

LEGISLATIVE NORMS, REGULATIONS, CONVENTION, SAFETY OF NAVIGATION.

INTRODUCTION

It is obvious that examination of normative acts regulating NSR sailing should accompany all investigations which are being accomplished or planned within the framework of Project 1.1.2 "Operational Aspects". Efforts should be made to provide instruments necessary for practical implementation of the findings from the Project.

With this in view, the 1993 targets were as follows:
-systematization of national legislative norms regulating activities within the NSR;
-analysis of existing normative documents, including sailing regulations;
-assessment of the existing regulations as to their sufficiency for the needs of international sailing along the NSR;
-preparation of proposals for legal regulation improvements.

The results of the 1993 activities are summarized in the present Section.

TERMINOLOGY

It is not uncommon that Russian experts fail to agree on a matter with their foreign colleagues because the parties involved have differing interpretation of the concepts and ideas. Therefore it might be appropriate to give an insight into how the basic concepts used herein are understood.

Regulation at the international level should be limited to the goal of protecting human life, property and the environment. With this aim in mind all international regulations, be it technical requirements to ships, organizational requirements to shipowners or qualification requirements to seafarers, are worked out, adopted and made effective.

National legislation (State regulation) should provide practical application of provisions of international tools at the national level through a system of laws, decrees, regulations, instructions, orders and recommendations. Depending upon the real situation in a particular country, the national requirements may be more stringent than the relevant international provisions, but never more relaxed.

Safety of navigation is a term not yet defined in international laws. This has set the stage for voluntaristic interpretations, as was the case in the former USSR. There was a demand, of course declarative in chronic shortage of money for damage-preventive maintenance, to provide an "absolute" safety of navigation. When an accident occurred, punishment was inevitable, irrespective of what caused the casualty and whether or not the on-scene crew as able to prevent it. Needless to say, no production processes, merchant shipping among them, can be 100% trouble-free. "Ecologically safe production" is nothing more than a dream. In reality, safety of navigation means the level of transportation reliability which is technically, administratively, economically and politically justified in a particular country at a particular period of time.

EXISTING LEGAL BASE

International Instruments

Basic to the system of the legal of merchant shipping in Russia are the following ratified international conventions:

- International Convention for the Safety of Life at Sea, 1974 with amendments (SOLAS-74);
- International Convention for the Prevention of Pollution from Ships, 1973, modified by Protocol 1978 (MARPOL 73/78);
- Convention on International Regulation for Preventing Collisions at Sea, 1972 with amendments (COLREG);
- International Convention on Load Lines 1966;
- International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978;
- IMO Convention 147 (Merchant Shipping Minimum Standards Convention 1976);
- International Convention on Civil Liability for Oil Pollution Damage, 1969, modified by Protocol 1984;
- International Convention Relating to Intervention on High Sea in Cases of Oil Pollution Casualties, 1969, with Protocol 1973;
- International Convention for Safe Containers, 1972 (CSC);
- International Convention on Tonnage Measurement of Ships (Tonnage), 1969;
- International Convention on Maritime Search and Rescue (SAR), 1979,

and some others.

Next in the hierarchy of the legal regulation of shipping are IMO resolutions. As some 750 such documents have been adopted to date, there is no point in listing them here. Noteworthy is the clear tendency now common in IMO practice to impose upon Administrations the duty of transposing IMO recommendations into imperatives.
Indeed, the legislation of many countries requires the fulfillment of measures recommended by the IMO, and the same is true for Russia. Many IMO regulations have been incorporated into the Rules of the Register of Shipping of the USSR (now the Shipping Register of the Russian Federation), national charters, guides, regulations and recommendations. A recent example is the implementation of the International Safety Management Code (IMO resolution A.741(18)) by the order of the Minister of Transport of the Russian Federation.

It is pertinent to note that in the former USSR the practice of implementation of international laws was somewhat different from that in the West. With rare exceptions, the usual way to implement international regulations has been to split them into many fragments to be forwarded to appropriate authorities for inclusion into relevant national legal acts. The pieces so received at site were usually reworded to fit into style of the national documents they were incorporated into, and distortions were not infrequent.

International conventions and IMO resolutions are distributed by IMO Publication Section, 4 Albert Embankment, London SE1 7SR and by IMO distributors. Publications of IMO documents with parallel texts in English and Russian may be ordered from CNIIMF, 6 Kavalergardskaya str., St. Petersburg, Russia.

NATIONAL DOCUMENTS

In view of the continued applicability of Soviet maritime legislation in Russia, it might be appropriate to say some words about legislative practice employed in the former USSR. Within the frame of the USSR Ministry of the Merchant Marine there were numerous "state shipping authorities, each responsible for production activities in its field and, moreover, competent to draft rules, instructions, guides, orders and the like. One department was charged with the operation of cargo carriers, another with the provision of safety, the third with the prevention of human loss and injuries, etc. Common to all was the top priority - to strive to achieve "higher indices of production". In this struggle, each state shipping authority framed normative documents suitable for its needs and, more important, protecting the interests of its department. As the interests of various departments were different and sometimes contrary, an outcome of their law-making activities was the emergence of innumerable regulations, rules, instructions, etc., not uncommonly contradictory, but all mandatory for the on-scene personnel. It was for shipmaster to decide, depending upon particular circumstances of the case, which of two conflicting but mandatory provisions, is to comply with and which is to ignore.

It is hardly surprising that such an approach to law-making was doomed to failure. Soviet maritime legislation, a product of many years' activities of many people, is enormous in volume, ambiguous in wording, and inconsistent in requirements.

At the moment of disintegration of the USSR, the national maritime legislative base included:

- many tens of legislative acts, decrees and decisions of state bodies of the USSR and Union Republics, in a series of collections;
- orders of the Minister of the Merchant Marine of the USSR, some 1200 in total, grouped in a twelve-volume collection and a special two-volume collection for shipmasters;
- guidance documents put into effect by instructive letters of the USSR Ministry of the Merchant Marine, some 1500 documents;
- Rules of the Register of Shipping of the USSR;
- Orders and instructions promulgated by chief authorities of shipping companies;
- General rules of the trade and fishing ports, with supplements;
- Manuals, regulations and instructions issued by the Head Department of Navigation and Oceanography of the USSR Ministry of Defence, by departments of the USSR Ministry of the Merchant Marine;

and many other classes of documents.

The most of these documents were classified and thus not available to the maritime community - one more evil of the Soviet law-making practice.

For the moment, the Soviet maritime legislation is still valid. Russia had to adopt and continue applicability of the legislation, because there was no alternative to avoid a legal vacuum. The existing legislative norms will remain valid until the moment when and if they are replaced and provided that they are not at variance with Russian legislation.

As far as the NSR sailing regulation is concerned, it is a matter of common knowledge that the USSR had for several decades instituted Arctic shipping regulations for internal use as the Route was closed for foreigners. The first attempt to make the NSR an international shipping line was made in the 1960s. The Instructions for Navigation along the Northern Sea Route were then framed and published. Their purpose was to regulate international transit sailing between the Atlantic and Pacific Oceans without calls of foreign vessels at the Arctic ports. However, this initiative failed because of protests from the Arabs, friends of the Soviet Union at that time, who did not want the NSR to be an alternative to the Suez Canal, closed after the Arab-Israel war.

The idea was revived in the 1990s. In accordance with the USSR Council of Ministers Decision No 565 of 1 June 1990, the Regulations for Navigation on the Seaways of the Northern Sea Route were worked out by the Northern Sea Route Administration, a body to which the regulation of the NSR, including the formulation and implementation of rules of navigation and the like, had been delegated by the Soviet Government since 1971. The Regulations were approved by the Minister of the USSR Merchant Marine on 14 September 1990 and entered into force on 1 July 1991, being announced in the Notice to Mariners No 29 of 13 June 1991. The Regulations state that the NSR is open for vessels of all States on the basis of non-discrimination, provided that vessels satisfy the technical, operational and some specific requirements. These latter prescribe that the Owner or Master of a vessel intending to navigate through the NSR should submit to the Administration (Marine Operations Headquarters) advance notification and request for leading through the NSR, and that the vessel should have aboard a certificate of due financial security with respect to the civil liability of the Owner for damage inflicted by polluting the marine environment and the Northern Coast of the USSR. The Master or his nominee must be experienced in operating the vessel in ice. In case where those persons have no such experience, or when the Master requests so, the Administration (Marine Operations Headquarters) may assign a State Pilot to the vessel to assist in leading it through the NSR. The NSR Regulations say nothing as to who is responsible for foreign vessels being supplied with foodstuffs, fresh water, fuel, tugs, repair, etc.. Instead, it is recommended to have fuel for 40 days, foodstuffs for 60 days and a distilling plant on board.

Open for calls of foreign vessels since 1991 are the Arctic ports of Arkhangelsk, Igarka, Kandalaksha, Murmansk, Naryan-Mar, Onega, Vanino, Magadan and Provideniya.

In accordance with the Council of Ministers of the Russian Federation Decision No 1153-p of 26 June 1993, foreign tankers involved in fuel delivery to the Arctic regions in 1993 navigation were permitted to call at the Arctic ports and harbors of Amderma, Ujedineniya, Dikson, Vil"kitskogo, Zelaniya, Chelyuskin, Anabar, Khatanga, Indigirka, Kolyma, Yana and some others.

As a result of the inter-state agreement between the USA and Russia, several Russian sea ports, including the NSR Anadyr and Dudinka, were opened for calls of US cargo carriers, and restrictions on categories of cargo permitted to carry were relaxed.

For the time being, only transit sailing along the NSR can be accomplished by foreign vessels without restriction, provided that they meet the conditions set to avoid disturbance of the ecological balance. The only port of the NSR presently open for calling of foreign ships is

Igarka. Efforts are now being made by the NSR Administration to open the ports of Dikson, Tiksi, Pevek, Dudinka.

In summer 1993 requirements to documentation relating to vessel characteristics, operational standards, etc. were drafted. Charges for transit cargo carriage were set, and rates of charge for leading foreign vessels through the NSR were established, the latter including icebreaker assistance, pilot services, foodstuffs and fuel supply, dues.

Experience of pioneering international voyages along the NSR has revealed that the weak points are organization and regulation of routine communications between the vessel and the Marine Operations Headquarters or the NSR Administration.

VESSEL CLASSIFICATION

In the Instructions for Navigation along the Northern Sea Route, 1966, natural conditions in the Arctic were described in two articles, one dealing with navigational and hydrographic support and another with hydrometeorological matters. The Guide to Navigation Through the Northern Sea Route now prepared for publishing gives detailed information on all characteristics of the natural environment in sailing areas which are essential for efficiency and safety of sailing. The Russian normative documents regulating Arctic navigation set out special requirements to vessels intending to sail the NSR. Technical requirements to the vessels were developed on the basis of the Rules of the Classification and Construction of Sea Vessels of the USSR Register of Shipping and on the experience gained both in the organization of sea operations in the NSR area and in the operation of Russian icebreakers and ships of different ice classes under various ice conditions.

The Russian normative documents drafted for support of international shipping are worded in the terms of national sea ice nomenclature. This might be difficult for foreigners to understand, so clarification is desirable.

Efforts should continue to make consistent the vessel classification standards applied in Russia and in the West, for both transport vessels and ice-strengthened icebreakers. The approaches taken and the ways to use the knowledge of natural conditions, especially ice cover, should be examined. The operational reliability of a vessel under design depends heavily upon how trustworthy is the information on environments the vessel will operate in. The environment should be described in terms of the values directly affecting the construction and operational parameters of vessels. These values may be divided into two groups: one describing operational environment in "ordinary" seas (wave speed and height, wind speed, water density, etc.) and another in ice covered waters (ice closeness, ice thickness, etc.).

It is a long-standing practice to make the classification of ice-strengthened vessels and the rules for their construction on the basis of either regulation of propulsive performance parameters (ice passability in unbroken ice is the key point) or provision of the needed hull strength to withstand the ice impact (safety of sailing in ice conditions is the object). The first concept is realized in the 1972 Canadian Rules and their interpretations in the German and

British Lloyd's Rules, the Finnish -Sweden Rules for the Northern Baltic, and the Norwegian Veritas Rules. Based on the second concept are the USSR Register Rules and the Rules of the US Shipping Bureau, as well as the latest version of the Canadian Rules to be effective in 1994.

CONCEPT OF STATE REGULATION

Russia is now building up a multistructure market economy, and state management bodies are released from responsibility for economic activities and production figures of organizations and enterprises. Many hundreds of departmental normative documents are no longer needed.

To many unprejudiced specialists in Russia it is beyond question that merchant fleet operation should be regulated on the basis of the legislative system practiced in the civilized world and composed of international conventions, IMO resolutions, State (Administration) documents, shipowner instructions and shipmaster orders.

International instruments must be put into effect directly as they stand, instead of splitting them into pieces to be adapted to and incorporated into innumerable national documents, a procedure both costly and lengthy.

It is time to apply in practice of rulemaking the principle "What is not prohibited is allowed", instead of the Soviet "What is permitted is the all that is allowed". A system of legal regulation based upon detailed listing of what is permitted opens the way for those in authority to make additions, "as an exception", to these permissions (justification can vary) for various categories of seafarers, thus placing the performer in a position of personal dependence on the legislator.

We propose concept for the Russian national system of legal regulation of merchant shipping to be based upon following provisions:

(a) national concept solution of a problem must not contradict the international concept for solving the same problem, should Russia wish to integrate into the world community and to adapt its institutions and legal instruments to the world standards;

(b) the protection of the human life, health, property and the environment should be considered as a top priority in regulation of social relations;

(c) as concerns safety of navigation, the prevention of pollution and other issues of international importance, the basic instruments in the national systems must be the ratified and effective international conventions (as listed above);

(d) all instruments of state regulation should be applied to provide practical implementation of requirements set forth in international documents;

(e) with transition to a multistructure economy, the State should renounce its monopoly of regulation of all issues relating to merchant shipping. It should restrict itself to the matters of nation-wide importance, conveingy an essential share of law space to shipowners;

(f) in accordance with international practice and with current Russian legislation, the legal norms are deemed effective provided that they are available as general publications.

An efficient information system should be developed to bring international and national regulations to the notice of seafarers.

PROPOSALS ON LEGAL REGULATION IMPROVEMENT

It is obvious that in order to provide reliable support for international shipping on the NSR, the existing national normative base should be transformed to include a number of important provisions.

In addition to what was said previously, it is essential that all rules of law regulating NSR sailing should be published in the Notices to Mariners and broadcasted together with routine navigational information. The most important issues should be put in navigational charts and pilot books. There should be made substantial additions and amendments to the Rules of the Shipping Register of the Russian Federation to cover peculiarities of the environment encountered by vessels sailing the NSR. Provisions should be inserted to describe in more detail the NSR situation: division into the western and eastern sectors, seasonal differences in sailing conditions, etc. Futhermore, navigation should be classified according to degree of severity (extreme, heavy, ordinary, easy) and mode of sailing (alone or icebreaker-assisted).

The NSR Administration and the Marine Operations Headquarters, all charging fees for the services provided, should proclaim their obligations as to medical assistance, SAR assistance, repair of ice damages, foodstuffs and fuel supply, mail services, etc.

CONCLUSION

Described in this Section is the present state of national maritime legal framework, including NSR - related matters. Knowledge of the realities is believed to be a pre-requisite for identifying what needs to be done to approach to internationally accepted standards. In fact, the entire body of Russian maritime legislation is undergoing a thorough revision. Unfortunately, this cannot be accomplished overnight.

REFERENCES

1. Правила плавания по Северному морскому пути. 1991 г.

   ((1991): "Regulations for Navigation on the Seaways of the Northern Sea Route")

2. Баскин А.С., Иванов М.К. Нормативно-правовое обеспечение безопасности мореплавания. Предложения о пересмотре и резком сокращении действующей судовой нормативной документации и отчетности. Отчет ЦНИИМФ 51.02.00.03, 1987 г.

   (Baskin A.S., Ivanov M.K. (1987): "Legal Aspects of Safety of Shipping. Proposals on Revision and Drastic Shortening of Ship's Documentation and Reporting", CNIIMF)

3. Баскин А.С. Нормативно-правовое обеспечение безопасности мореплавания. Разработка и пересмотр нормативных документов и пособий по обеспечению безопасности плавания. Отчет ЦНИИМФ 51.1.1-88, 1988 г.

   (Baskin A.S. (1988): "Legal Aspects of Safety of Shipping. Working out and Review of Documentation and Guides on Safety of Shipping", CNIIMF)

4. Баскин А.С., Щеголев В.И. Разработка положения о порядке введения в нормативно-правовую базу торгового мореплавания Российской Федерации документов ИМО. Отчет ЦНИИМФ ХД 51.09.41-92, 1993 г.

   (Baskin A.S., Shegolev V.I. (1993): "Guidelines on the Procedure for the Incorporation of IMO Documents into Maritime Legislation of the Russian Federation", CNIIMF)

5. Баскин А.С. В плену регламентаций. Морской флот, 1986, N12

   (Baskin A.S. (1986): "In Captivity of Directives", Merchant Fleet, N12.)

6. Баскин А.С. Требования к навигационному оборудованию. Итоги науки и техники, ВИНИТИ АН СССР, Водный транспорт, т.12, М., 1985, УДК 629.1.053.1

   (Baskin A.S. (1985): "Requirements to Navigational Equipment. Scientific-Technical Issue", AS USSR, Water Transport)

7. Баскин А.С., Иванов М.К., Нефедов В.И. Органы лоцманского обслуживания и управления движением судов в СССР: проблемы законодательного регулирования их организации, деятельности и ответственности. Л., Транспорт, 1991, Труды ЦНИИМФ

(Baskin A.S., Ivanov M.K., Nefedov V.I. (1991): "Pilot and Vessel Traffic Ccontrol Services in the USSR: Legal Regulation of the Organization, Activities and Responsibility", Transport, CNIIMF Proceedings)

8. Требования к конструкции, оборудованию и снабжению судов, следую их по Северному морскому пути. 1993 г.

((1993): "Requirements for the Design, Equipment and Supply of Vessels Navigating the Northern Sea Route")

9. Номенклатура морских льдов. Условные обозначения для ледовых карт. Л., Гидрометеоиздат. 1974, 86 с.

((1974): "Sea Ice Nomenclature. Symbols for Ice Charts", Gidrometeo, p.86)

10. Правила классификации и постройки морских транспортных судов. М., Транспорт. 1990.

((1990): "Rules for Classification and Construction of Marine Transport Vessels", Transport)

11. Первая редакция Норм ледовой прочности судов. Отчет ЦНИИ им.акад. А.Н.Крылова и ЛКИ. 1994 г.

((1994): "Ice Strengthening Standards for Ships. First Version", Krylov Institute)

12. Разработка новой редакции Правил Регистра России к ледовым усилениям судов и ледоколов. Отчет ЦНИИ им. акад. А.Н.Крылова. Вып.35713, 1993 г.

((1993): "Proposals on New Version of the Russian Register Requirements to Ice Enforcement of Ships and Icebreakers", Krylov Institute)

13. Бузуев А.Я., Рывлин А.Я. Учет неравномерности распределения характеристик ледяного покрова при оценке ледопроходимости судов. Метеорология и гидрология, 1976, N4, с.68-73

(Buzuev A.Ja., Rivlin A.Ja. (1976): "Assessment of Ice Cover Characteristics Variations Distribution in Evaluating Ice Passability", Meteorology and Hydrology, N4, pp.68-73)

I.1.2.2 ROUTE PLANNING
SYSTEMATIZATION OF THE INFORMATION NEEDED FOR THE SUPPORT OF INTERNATIONAL SHIPPING ALONG THE NSR.

KEY PERSONNEL

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SUMMARY

During the year 1993, analysis was suspended on the 60 years research on NSR navigation data, which was not achievable for civil users.

In recent years, navigational-hydrographic and hydrometeorological research has nearly come to halt because of poor state financing. Thus, one of the main aims of the project was to formulate and explain the proposals to the government of Russia on financing and development of systems and aids to support international NSR shipping.

KEYWORDS

HYDROGRAPHIC RESEARCH, AIDS TO NAVIGATION, VESSEL TRAFFIC SERVICE, ICE PILOTAGE.

THE STATEMENT OF TASK

The main aim of work in 1993 was to execute an initial study of information on Arctic seas shipping useful for route planning and the provision of international navigation on the NSR. Thus, work on general classification of required information was planned. We should mention that special Project 12.1 of Subroutine III of INSROP is devoted to improvement of information support on NSR navigation.

During the Soviet period, the structure of information support to NSR navigation was aimed at satisfying state institutions only. The state bodies of the USSR directed to their subordinates administrative decisions and information materials, and each subordinate reported back on reception of orders and their execution.

As far as the Soviet information system was extremely formalized and simple, it was effective for achieving the required results. It was, however, not suitable for international shipping.

The experience of ice navigation and work of all services must form the information base for executing separate transit trips on the NSR. First of all it is necessary to consider current operational aspects. Only then can we offer some conclusions and recommendations.

Many questions connected with the influence of natural conditions on route planning were solved in AARI. Considering the specifics of these questions, AARI materials are introduced in the relevant chapters of the current project.

The INSROP Programme should in the nearest future provide modification of the real information support system to meet the needs of international shipping in relevant and up-to-date information, necessary for route planing.

INFFORMATION NECESSARY FOR NAVIGATION

Maintaining international navigation on the NSR requires both the information usual for operators and vessels, and specific data on the geographical, ecological and political conditions of this unique region.

International navigation needs scientific-methodical information. Its development should advance the perfection of other kinds of information support.

The oceanographic and meteorological conditions of NSR navigation are extraordinary difficult. Therefore, the role of prognosis and operative hydro-meteorological information for Arctic navigation cannot be exagerrated. The specific character of the NSR is determined basically by hydro-meteorological factors, particular parameters of which must be known both for perspective planning, and for operative control of a fleet or a single vessel.

Navigational hydrographic information represents a vital part of information support. Arctic seas are characterized by shallow water and a great number of navigational dangers, so vessels sail in inshore glades under condition of bad visibility when the coast line is masked by ice.

The navigational information in vessel charts and books needs updating, and this in turn requires up-to-date operative navigational information.

Accurate and frequent position fixing is an essential condition of safe Arctic navigation. This problem can be solved by using the satellite navigational system GPS NAVSTAR. The operative and economic advances of GPS NAVSTAR system over radio navigational systems of short, middle and long ranges are obvious. Optimal use of GPS NAVSTAR is possible only in conjunction with video plotters and electronic chart systems, because the advances of GPS NAVSTAR cannot be realized with the traditional paper chart plotting.

Arctic navigation is very specific in route choice and vessel operating methods. This necessitates pilot assistance to masters even if they have ice sailing experience.

The knowledge of real potentialities of NSR infrastructure in the navigating region at each moment is important for operators and vessels. Navigation, especially in Arctic seas, is connected with constant risk. The degree of acceptable risk is often determined by possibility of infrastructure to supply lightering on the port road, to grant divers for surveying the hull, to execute repairs.

The availability and disposition of rescue ships and search aircraft in the region of navigation, and the chances of receiving assistance in case of necessity - that is information necessary to seafarers in the Arctic.

NSR traffic participants should know to whom and when it is possible to address on any questions that may arise.

The contents of legal documents regulating trade navigation in region of navigation, should be made known to seafarers. Otherwise, claims may be wrongly presented.

Knowledge of listed kinds of information, necessary for navigation in the Arctic waters of Russia does not solve the problem but represents only a primary classification.

ANALYSIS OF EXISTING INFORMATION SUPPORT TO NAVIGATION

Scientific and methodical support to navigation in the Arctic is executed by the Arctic and Antarctic Research Institute (AARI, oceanographic and meteorological support - forecasting and operative service, ice qualities of vessels), the Central Marine Research & Design Institute (CNIIMF, safety of navigation, designing of vessels, development of judicial documents, radio navigation and communication), the Hydrographic Department of Ministry of Transport (HD, hydrographic researches, development and operation of aids to navigation, arctic pilotage, development of manuals and directions for navigation), the Joint-stock Company "Lenmorniiproekt" (assessment of norms and designing of Arctic ports and loading installations), the Main Department of Navigation and Oceanography of the Ministry of

Defence (GUNIO, publication of navigation charts, directions and correction materials) as well as by other research, design and operational institutions.

In general, the organizations carrying out scientific and methodical support to Arctic navigation possess sufficient potential for completion of any required work.

Hydrometeorological support to navigation in Arctic seas in terms of data acquisition is executed by the polar stations of hydrometeoservice, polar stations of hydrobases, marine hydrometeostations, river and air ports, weather forecasters of icebreakers, navigators of transport vessels and Russian meteorological satellites. All this information is processed in the polar hydrometeorological centres. The prognosis bodies of Russian hydrometeoservice, relying on advanced infrastructure of national and foreign hydrometeostations, on the bank of data received from meteorological satellites, on advanced theory of forecasting submitted by polar scientists - should supply the operators and vessel with long-term and short-term forecasts for the whole period of Arctic navigation. The marine territorial managements of Gosgidromet executes the transmission of operative hydrometeorological data to all regions of the NSR. Navigators can receive time-scheduled facsimile transmission of ice survey information charts from the nearest oceanological hydrometeorological centre.

Unfortunately, inadequate financial resources have meant that this otherwise effective system of hydrometeorological support sometimes has failures.

Hydrographic support to navigation: the execution of complex researches, necessary for creation of navigation charts, manuals and guidelines for navigation; supplying vessels with navigation editions; installation and operation of aids to navigation; pilotage; information to vessels about changes in navigation conditions, - is the responsibility of Hydrographic Department of DMT, its hydrobases, expeditions and groups.

For 60 years, polar hydrographers have executed depth surveying and charting of all NSR regions on an adequate scale. Certainly this work should continue. But it is possible just now to say that the available cartographical materials permit execution of international navigation in the Arctic without specific difficulties.

Operative navigation information includes the Navigation Notices to Mariners (NAVIM), coastal preventions (warnings) (PRIP) and NAVAREA, transmitted by radio on frequencies announced to seafarers in special editions. Additional operative navigation information is transmitted to the vessels by Marine Operations Headquarters, hydrobases, ice breakers and pilots. As these names indicate, old national and new (on western and eastern ends of NSR) kinds of operative navigation information exist simultaneously. Defects of existing systems are the closing of several radio stations due the absence of financing, and the fact that messages are transmitted only in the Russian language.

The ice breaking support on the NSR scarcely needs the advertising. Russia has the most powerful ice breaking fleet able to provide navigation in the most wide time ranges of arctic navigation.

Pilotage support. The main kind of pilotage is in mouths of the Arctic rivers Yenisey (from Oshmarino to ports of Dudinka and Igarka), Hatanga (distance of pilotage between Cape Kosysty and port of Hatanga - 186 miles), Anabar (between Cape Horgo and settlement Urung-Haja - 65 miles), Kolyma (from the mouth to port Green Cape), realized by pilotage services of hydro bases. At the disposal of pilotage services there are pilot vessels and pilot boats, supported by port ice breakers, and leased helicopters if necessary. Pilots deliver onboard the updated navigation charts. Today's pilotage services meet general requirements, but the weak points are the language of communication and the training of ice pilotage captains.

Radio and wire communication on NSR is considered in detail in separate report in project I.1.2.4 of Sub-programme I.

Port services in all Arctic ports of Russia include in addition to ice breaking and pilotage, tugboat support of berthing operations, lighters and self-propelled barges for unloading of vessels on the road, portal, floating and automobile handling means. Some ports have the branches of Russian banks.

All port infrastructure needs modifying, strengthening and improving to meet the requirements of international shipping.

Passenger conveyance on the NSR in general is executed by aircraft. Almost all ports have airports with passenger service nearby. Almost all polar stations have a landing strip for planes for emergency cases. Passenger conveyance on all big Siberian rivers is executed during the navigational season by passenger and transport vessels.

Postal services are executed by branches of the Ministry of Communications located in all Arctic ports. Airmail service is the most common but delivery times do not meet European norms. Post offices also provide interurban and international telephone communication, but of poor quality.

Goods supply for transport vessels, especially under foreign ensign in the Arctic, is at present extremely restricted because of reduction of freight delivery to polar ports. It concern to all kinds of supply - food, bunker, technical. Precisely therefore, the additions to Regulations for Navigation on the Seaways of the Northen Sea Route require ships to stock fuel for 40 days, foodstuffs for 60 days and to carry installations for water desalination.

Obviously this situation can be essentially improved only with the organization and provision of normal navigation.

Medical assistance is executed in all Arctic ports by polyclinics and hospitals, capable of rendering assistance in case of trauma or illness. Sanitary epidemiological stations function in all Arctic ports.

At present, all medical establishments in Russia have difficulties with medicines, which limits the provision of medical assistance to seafarers.

Repair services. All Arctic ports have possibilities for vessel repair - minor repair, welding, propeller repair, producing some spare parts. The experts of hydro bases can repair navigation devices.

Search and rescue organization. The COSPAS-SARSAT international system of search and rescue duplicated by shore radio centres is in function in Russian Arctic. In practically all ports one of the tugboats is intended for rescue, with the appropriate readiness to exit to sea for rescue operations. Divers are employed in the ports and on the ice breakers. The rescue system includes the Marine Operations Headquarters as organizers, and ice breakers as rescue vessels.

Organizational support. Questions of trade navigation on the NSR are decided by the NSR Administration (NSRA), which is a structural division of the Department of Marine Transport of the Transport Ministry of the Russian Federation. Traffic is regulated by the Marine Operations Headquarters of the western and eastern sectors of NSR (based in the ports of Dikson and Pevek respectively). The NSRA executes the perspective and current planning of marine Arctic operations, coordination of the activity of state departments - hydrometeoservice, civil aircraft, participating in support to Arctic navigation.

The existing organization has justified itself well and can be preserved if adequate financing can be made available. The other important problem is the maintenance of icebreakers and transport vessels as well as infrastructure in operative subordination to the Headquarters.

Legal support. Characteristic of the Soviet legal base was the restriction of access to it: almost all rules of law had limited or restricted circulation rather then open access. At present, efforts are underway to replace outdated rules with normative documents, appropriate to modern international marine law.

TAKING INTO ACCOUNT NATURAL CONDITIONS DURING THE ROUTE PLANNING[1]

General. Recommendations on the navigation route for the vessels are received from the Marine Operations Headquarters. The content of information, the features of its use when issuing recommendations about the navigation route directly during the organization and the operation itself are considered in the corresponding projects of Subprogram I. At the stage of preliminary planning of the route, justification of the possibility and the effectiveness of transit cruises along the NSR, it is important to select the navigation route in advance and to analyze the main environmental characteristics which navigator will encounter. Such data are included in the regulatory documents.

Limitations. During the preparation of the handbooks, sailing directions and manuals for navigation, the constant navigation routes are usually considered. These are determined as a result of iyears of experience and reflect the climatic features of ice distribution in NSR regions. Such an approach, however, cannot take into account interannual and seasonal

[1]AARI

variability in ice cover distribution, or the selective character of the movement of ships in the ice. Polar captains, generalizing their experience of ice operation, ensure that the most effective and safe way is the easiest way in ice conditions, not the shortest one. This feature of ice navigation is taken as a basis in studies of the ice cover as the shipping medium.

The most easy ice navigation route. The safest and most effective ice pathway has been named by AARI "the most easy ice navigation route".

When choosing the "most easy route", one should take into account:
- location of the waypoints (here we are speaking about transit sailing, without entering Arctic ports, and the route is selected from the southern straits of Novaya Zemlia to the Bering Strait);
- draft limits. Over the entire length of the voyage, the possibility for routing ships by nuclear icebreakers of the "Arktika" type (with 11 m draft) is envisaged;
- an optimal combination of the characteristics of the ice cover state, worked out by the experience of ice navigation and the practice of providing hydrometeorological support (minimum concentration and amount of hummocking, absence of strong pressures, etc.)
- minimum of calculated time consumption due to the movement by the shortest distance in easy ice conditions, and the avoidance of heavy ice zones.

The criteria listed above can be specified or supplemented; one envisages the planning of the way for transit navigation of specialized vessels (for example, with a restricted draft) or off-shore structure (for example, drilling platforms).

Seasonal changes in the "most easy route". The position of the "most easy route" for transit navigation undergoes significant interannual and seasonal changes. There are, however, general typical features, as follows. In the colder period of the year (October-May) fast ice is formed along the Arctic coast and in the main navigable straits. Due to atmospheric circulation and under-ice currents flaw polynyas are formed along its edge. The most easy variant of the transit navigation during this period is, as a rule, through the zones of flaw polynyas. First of all, most transit voyages were round the New-Siberian Islands. Only once has the Sannikov Strait been used (1985).

TABLE 2-1 General data on route variants and difficulty rate while performing early and late transit sail through the NSR

Year	Month	Caravan	Waypoints								Region with most hard ice conditions	Delay on hard ice conditions region (hours)
			a	b	c	d	e	f	g	h		
1971	VI	a/i "Lenin" i/b "Vladivostok"	+	-	+	-	+	-	+	-	c.Arkticheskiy i.M.Taimyr	65
1978	V-VI	a/i "Sibir" d/c "Kapitan Misbevsky"	+	-	+	-	+	-	+	-	i.Vil'kitsky - c.Shelagsky	12

Year	Month	Caravan	Waypoints								Region with most hard ice conditions	Delay on hard ice conditions region (hours)
			a	b	c	d	e	f	g	h		
1984	VI	a/i "Arktika" mv "Monchegorsk"	+	-	-	+	+	-	+	+	c.Taimyr - c.Anisiy	4
1985	VI	a/i "Sibir" mv "Kola"	-	+	-	+	+	-	+	-	no data	no data
1985	IX	a/i "Arktika" a/i "Sibir" mv "Tiksi"	-	+	-	+	-	+	+	-	str.De-Longe	10
1986	V-VI	a/i "Rossia" mv "Monchegorsk"	+	-	-	+	+	-	+	-	i.Vil'kitsky c.Shelagsky	130
1987	V-VI	a/i "Arktika" a/i "Rossia" mv "Kola"	-	+	-	+	+	-	+	-	str.Vil'kitsky- i.Vil'kitsky c.Shelagsky	100
1988	V-VI	a/i "Arktika"	-	+	-	+	+	-	+	-	str.Vil'kitsky- i.Vil'kitsky c.Shelagsky	5
1989	V-VI	a/i "Rossia"	-	+	-	+	+	-	+	-	c.Shelagsky- c.Smidta	0
1990	VI	a/i "Sovetsky Soyuz", ½/¬ "Kiev"	-	+	-	+	+	-	+	-	str. Vil'kitsky	0
1991	VI	a/i "Arktika"	-	+	-	+	+	-	-	+	i.Vil'kitsky- i.Wrangel	120
1993	IV-V	a/i "Rossia", mv "Kandalaksha"	-	+	-	+	+	-	-	+	i.Vil'kitsky- i.Wrangel	120
Repetitions of route variant (%)			33	67	17	83	92	8	92	8		

Note: repetitions of hard ice conditions

for western part of NSR - 56%
for eastern part of NSR - 64%

Waypoints:

a - c. Zhelaniya
b - str. Karskie Worota
c - c. Arkticheskiy
d - c. Cheluskin
e - c. Anisiy
f - str. Sannikova
g - c. Shelagsky
h - i. Wrangel

(c.-cape, i.- island, str.- strait, a/i - atomic ice breaker, i/b - ice breaker, d/e - diesel/electric motor vessel; mv -motor vessel)

Regions with the greatest difficulties are, as a rule, confined to the route segment from Vil'kitsky Island (Zhokhov Island) to Long Strait. Only in four earlier transit voyages did the most difficult ice conditions prove to be in the fast ice of the B.Vil'kitsky Strait and at the eastern approaches to it (in the Taimyr Massif).

Commenting on Table 2-1 we should mention that many voyages ended in the port of Pevek, and are not really "transit". According to the preliminary assessment (Subprogramme III) the most difficult is the route from Cape Cheluskin to the port of Tiksi.

Only isolated cases were noted for the considered ice observation series, when the most easy route passed directly from Zhelaniya Cape to the Western Severozemel'sky polynya, from the B.Vil'kitsky Strait - to the area of the New-Siberian polynya, as well as northward of Wrangel Island (the occurrence frequency of such cases is 5-10%).

Within the usual navigation period (July-September) the location of the most easy transit navigation route is governed by the fast ice state before its breakup, and the location of the massifs of drifting ice and generally differs insignificantly from the coastwise navigation routes along the main NSR segments.

Non-icebreaking routes. During planning of the route of particular importance appears to be the choice of the segments, where navigation is possible without the icebreaking support. A considerable NSR extent and the localization of the zones with heavy ice conditions lead inevitably to the need to make a certain part of the transit voyage without the icebreaking support. During winter and spring (December-June) these are the regions of recurring polynyas; in the summer-fall period - the regions of open water, open first-year ice and new ice.

To determine guaranteed dates for possible beginning and end of unescorted navigation for ships of various ice categories, specific criteria have been developed. The number of segments where unaided navigation is possible, and their distribution along the NSR are subject to significant seasonal and interannual variations (FIG.2-1).

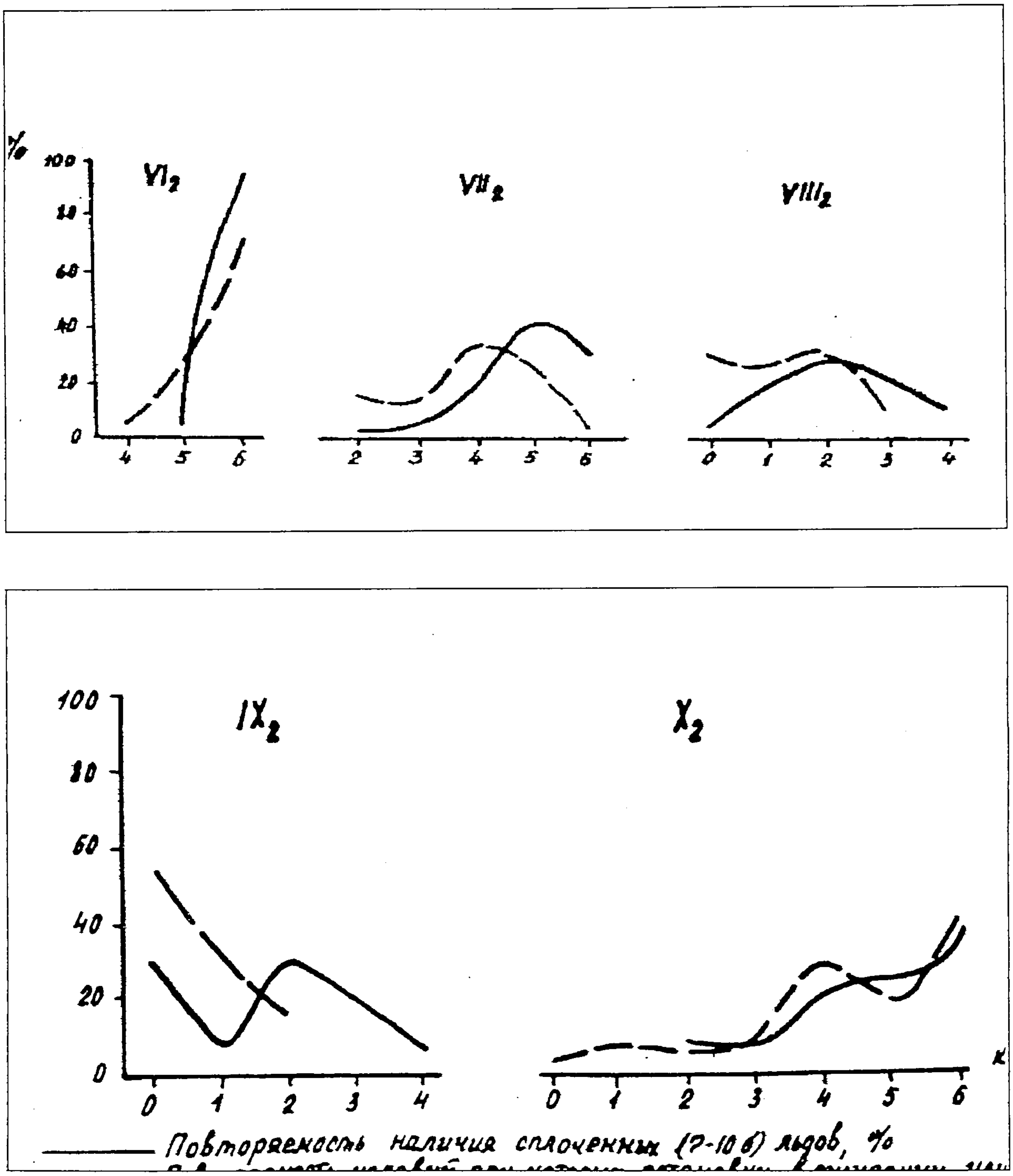

FIGURE 2-1 Distribution of NSR zones with unfavorable sailing conditions in "warm" (June - October) period.

Vertical - probability, %. Horizontal - number of zones.

_______ - recurrence of hard density (70-100 % concentration) ice,
\- - - - - - - recurrence of conditions, within which waiting delays >= 5%.

With the introduction of ULA (ice category) ships the possibilities for through unescorted navigation along the NSR have increased notably. Still, even in September, the most favourable month for navigation, there is no complete assurance of guaranteed unescorted transit navigation of ships of the "Noril'sk" type (ULA category, Table 2-2). The main difficulties for unescorted navigation are usually connected with the segments of transit navigation in the areas of the Severozemel'sky, Taimyr and Aion ice massifs. On the westernmost NSR segment, the mean duration of the period of unescorted navigation constitutes 2.5 months, varying from year to year from 2 to 11 ten-day periods.

TABLE 2-2 Probability (%) of transit non-icebreaker sail through the NSR of ULA ships, 1970-1979.

Vessel type	August last 10 days	September	October first 10 days	October second 10 days
"Amguema" (ULA)	25	52	35	10
"Norilsk" (ULA)	60	75	70	30

Today the information has been stored and systematized, on the basis of which the choice of the transit navigation route can be made. However, not all the problems arising during the organization of the transit shipping, concerning the choice of the most favourable route and navigation period are resolved. First of all, this concerns the automn-winter and the spring periods, where navigation experience on all the NSR segments is limited or indeed lacking. In this connection the priority goals of further studies include the analysis of the available materials (on natural conditions, levels of hydrographical knowledge, etc.), and their possible use for a reliable support to the planning and implementation of international shipping outside the conventional navigation period.

Here, one will have inevitably to investigate the possible use of non-traditional routes, including the high-latitude ones.

To enhance navigation safety on the route chosen it is necessary, in addition to the information on natural conditions, to take into account the type and state of the ship. That is why in the 1960s it was proposed to supply ships navigating in the ice with the ice passports developed for each ship (or several ships of one series) with recommendations on the choice of safe navigation velocities depending on the navigation mode (single, in convoy following icebreaker, etc.) and ice conditions. This ice-passport approach was tested during full-scale observations on the NSR and by the ice tank of the AARI.

In the current edition of the "Rules of the Classification and Construction" of the Marine Register/the USSR Register the following is stated on the use of the ice passports "... it is understood that during the operation the shipowner will be guided by the requirements of the ice passport of the ship, developed by the corresponding institution and the specific conditions for the safe operation of the ship in the ice depending on the category of ice conditions, ice class and icebreaking support".

PROPOSALS FOR IMPROVING ENSURING STRUCTURES

History testifies that the idea of converting the North-East Passage into a normal international transport sea route was always examined by the best minds.

The first Soviet government understood well the military, economic and political importance of developing the NSR. In December 1932 the NSR Headquarters of the Council of People's Commissars of the USSR (GUSMP) was organized, including the NSR Hydrographic Office, two Arctic shipping companies, the polar aircraft administration, two scientific centres, colleges and special schools for training polar personnel.

The significance of scientific and methodical support to navigation in the Arctic is increasing considerably. Therefore the Program INSROP should be designed for a period long enough.

The existing system of information support to navigation along the NSR is oriented to national state structures. Its technical means, methods and language of information should be adapted to the needs of international shipping.

The system of hydrometeorological and navigational hydrographic support to polar navigation should be restored and then complemented by modern hardware and methods.

Pilotage and ice breaker support should be considerably expanded in line with international practice of rules of navigation for ice breakers and the use of ice captains. The tactics of work of ice breakers needs constant refining.

All infrastructure of Arctic ports of Russia requires the qualitative improvement and updating. International shipping on the NSR cannot possibly be widely developed without this.

Specific attention should be paid to getting the Russian legal base conform with international practice to regulate trade navigation in Arctic. This base need to be freed from out-of-date documents, simplified and made available to all operators and seafarers.

REFERENCES

1. Арикайнен А.И. Сквозь льды Арктики: круглогодовая навигация. М., Знание, 1982, 64 с

   (Aprikainen A.I. Through the Arctic ice: all-season navigation)

2. Buzuyev A., Likhomanov V. (1993): "Division into zones of the Northern Sea Route by difficulty and safety of navigation", POAC'93 17-18 August, Hamburg, pp 393-403

3. Оперативная деятельность Госкомгидромета СССР по получению, сбору, обработке и доведению до потребителей гидрометеорологической и гелиогеофизической информации. Л., Гидрометеоиздат, 1990, 104 с

   (GOSKONGIDROMET activity in obtaining, processing and distributing hydrometeorological and heliogeophysical information)

4. Порядок использования информации о состоянии природной среды. Общие положения. М., 1990. 11 с

   (Guidelines on usage of environment conditions information. General statements)

5. Апполонов Е.Н., Нестеров А.Б. Уточненный метод определения расчетных скоростей движения судов во льдах. Сб.ВНТО им. акад. А.Н.Крылова, 1991, вып.51,а, с.4-15

   (Appolonov E.N., Nesterov A.B. Improved methodic of estimation of ship movement in ice)

6. Бузуев А.Я., Рывкин Д.Е. О статистической модели морского ледяного покрова как среды для судоходства. Тр.ААНИИ, 1988, т.401, с.120-130

   (Buzuev A.Ja., Rivkin D.E. Statistic model of ice surface as shipping environment)

7. Гидрографическое предприятие ММФ. Годовые отчеты лоцманских служб за 1985-1993 годы

   (HD MMF. Reports of pilot services 1985-1993)

8. Абчук В.А. Теория риска в морской практике. Л., Судостроение, 1983

   (Abchuk V.A. Risk theory in marine practice)

9. Баскин А.С., Литвинов Я.А., Сорочинский В.А. Испытания приемоиндикаторов спутниковой навигационной системы "Навстар". Сб. трудов ЦНИИМФ. Л., Транспорт, 1990

(Baskin A.S., Litvinov A.Ja., Sorochinsky V.A. "Navstar" satellite navigator receivers trials)

10. Рекомендации по организации штурманской службы на судах Минморфлота. М., Мортехинформреклама, 1991

(Guidelines on MMF vessels watchkeeping)

11. Баскин А.С., Москвин Г.И. Береговые системы управления движением судов. М., Транспорт, 1986, 159 с

(Baskin A.S., Moskvin G.I. Coastal Vessel Traffic Systems)

I.1.2.3 NAVIGATION AND POSITIONING

ANALYSIS OF NAVIGATIONAL AND HYDROGRAPHIC CONDITIONS AND AIDS TO POSITIONING IN ARCTIC SEAS

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SUMMARY

Considered in this Section are the navigational and hydrographic characteristics of the NSR in the context of the safety provision and the differences from traditional navigation with due regard given to natural conditions in Arctic areas.

Navigational hazards peculiar to the NSR are described. Aids to positioning are discussed, with special emphasis on satellite radionavigation systems.

Aids to navigation currently available along the NSR are described.

Interaction with INSROP other projects is outlined.

KEY WORDS

SAFETY OF NAVIGATION, NAVIGATIONAL HAZARDS, AIDS TO POSITIONING, SATELLITE NAVIGATION SYSTEMS, NAVIGATIONAL BUOYAGE

INTRODUCTION

Navigational and hydrographic support of sailing embraces a broad spectrum of safety-related problems. In information presented below, attention is focused on specific features of NSR sailing as far as navigational hazards, positioning facilities and aids to navigation are concerned.

An essential element of the navigational and hydrographic support is the map base available. This point is covered in Section I.1.2.2 of this Project.

An historical review of exploration of the Arctic and development of navigational support facilities in the area is presented in Section I.1.2.5 and Sub-Programme IV.

PECULIARITIES OF SAILING THE NSR

Considered in this Section are the features peculiar to the navigational and hydrographic support in the NSR to provide safety of sailing.

Because of the unique geographical location of the NSR, the methods of and aids to navigation therein differ from traditional techniques employed when sailing the "ordinary" seas. Needless to say the crucial factor for high-latitude sailing is the ice cover. However, the effect of high latitudes themselves is also pronounced, e.g., as far as the operation of gyro devices and navigation systems under ionospheric disturbances is concerned.

Let us consider in more detail several features unique to NSR sailing.

Planning of the general course of a vessel to sail the NSR depends upon the forecasted ice conditions on route. Course planning methods are described in Section I.1.2.2 of this Project. Here, it is worth noting that when sailing the "ordinary" seas the route can be planned with certainty well in advance and practically for entire run. The future course can be plotted to a high accuracy in space and in time, and the navigational aids to be employed for ship position monitoring are known in advance with a high degree of certainty. It is quite another matter to plan the general course for a vessel sailing the Arctic. A run from point "A" to point "B" depends in each particular case upon the ice situation. Shown in Figure 3-1 are the main recommended routes for sailing the NSR (for summer period). It can be seen that, depending upon the situation encountered, widely different routes can be selected for sailing.

Even once the general course has been selected, it remains to be seen whether the vessel will be able to follow the intended track. It may become necessary to alter course at any instant in response to changes in the ice situation.

Sailing the Arctic can be accomplished either in convoy or as a running voyage. In the former case, the problem of navigational support is relatively easier as the responsibility for safety of sailing rests mainly with the convoy leader having a wealth of practical experience and advanced aids to navigation. However, this does not relieve each vessel in convoy of having to control navigational safety. In the running voyage, the vessel herself is responsible for safety of sailing and for what may happen after deviation from the intended track.

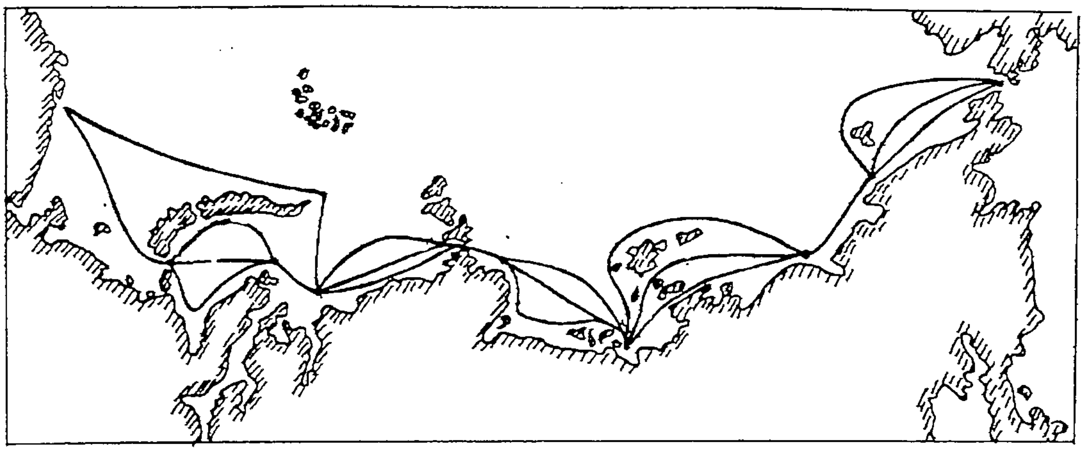

FIGURE 3-1 The Main Recommended Routes for Sailing the NSR (for summer period)

Thus, a main peculiarity of sailing the NSR is that the course is planned and actual sailing accomplished not along the selected narrow lane but within a wide water area which may border on the zones of natural navigational hazards. The likelihood of the latter increases in spring when main navigation routes are covered by heavy ice and only waters along the coastline (water openings, shore leads) are available for sailing. Meanwhile, the majority of navigational hazards are concentrated within the coastal strip.

The presence of multiple navigational hazards and the uncertainty of the actual route to sail make it necessary to equip the NSR seaways with additional buoyage facilities and high-accuracy positioning systems.

CHARACTERISTICS OF NAVIGATIONAL HAZARDS

The geomorphological structure of the Russian Arctic may be briefly outlined as follows.

The Arctic sea bed surface lies on the continental shelf. The surface of the southern continental strip (coast and sea bottom) is smoothed up by glacial processes. Therefore the coastal zone (with the exception of the Chuckchee Sea eastern part) is composed of low-lying shores. Consequently, the sea part of the continental zone is shelfy, whereas the coastal part is lowland. With respect to navigation, this means that there are scarcely any natural landmarks on the coast, and radar capabilities for natural target orientation are severely limited. Estuaries of northern rivers usually extend well beyond the coastline bound. Therefore the natural fairways lie well offshore, posing additional problems for pilot guidance of vessels and for foreign craft pioneering the NSR sailing.

In terms of geochronology, the northern continental formations (archipelagos, islands) of the Russian Arctic are younger structures. Their specific feature is an intricately-shaped configuration.

Strewn over these Arctic areas are several hundreds of banks and rocks, these spot hazards to navigation. Most of them lie close to the coast, with many in the immediate vicinity of the main shipping routes.

Specific to the NSR are two types of navigational hazards arising due to peculiarities of the geographical location of the Russian Arctic.

Not uncommon in shallow waters are so-called "ice banks", fragments of grounded ice hummocks which have frozen fast to the perennially frozen ground. Their upper part has been broken under the effect of heat and winds, and the remainder lies hidden in the water. The ice banks are more frequent in the western part of the East Siberian Sea, in the Laptev Strait and the Sannikov Strait. Because of this, crossing any bottom rises, even safe in terms of true depth, should be avoided when sailing in shallow waters.

Another hazard is due to water surges that can cause appreciable variations (up to 2 - 2.5 m) of sea level. This results in the actual depths being lower than specified on the chart. Up-to-date information on tides and surges occurrence is provided by the navigational warnings system.

Severe ice conditions and dependence of sailing safety thereupon require a high degree of navigator vigilance and a knowledge of the area his vessel is sailing or intends to sail. An extensive navigational database is required including hydrographic information on the entire NSR seaways for transit sailing. This issue calls for further investigation in co-operation with Projects I.3 and I.4.

Of crucial importance in successfully sailing the NSR is the availability of very accurate position fixes of the vessel on route.

The current state of aids to the navigational and hydrographic support of NSR navigation is discussed below.

RADIONAVIGATION AIDS FOR SAILING IN THE ARCTIC

There exists a wide range of devices, instruments and systems, both onboard ships and ashore, employed for support of navigational safety in the Arctic. They are divisible into two groups - autonomous and non-autonomous. The former are the shipborne facilities operating independently of land systems and aids. Among these are gyro, logs and, to a certain extent, radars. Operation of these facilities in high latitudes will be discussed at further stages of this Project.

In this Section, consideration will be given to non-autonomous facilities, i.e. those which operate as a combination of shipborne equipment and land (shore or satellite) systems.

Let us briefly run through available radionavigation systems.

MARS This is a differential range system based upon measurements of phase differences of signals from two land stations. The system consists of three chains, each consisting of a master station and two slaves. Frequencies employed are 64 - 92 kHz. Measurement accuracy is 60 m, providing the positioning accuracy of 2 - 3 cables in the near (200 - 300 km) zone and up to 1 mile in the remote zone. System coverage is about 1000 km, thus embracing the entire marine part of the Russian Arctic. Because of its coverage the system is used on a country-wide scale. *MARS* receivers are installed on icebreakers, hydrographic vessels and other craft engaged in regular sailing on the NSR. The system has been in service over 20 years. As for its use for support of international sailing in the NSR, the system seems to show little, if any, promise. On the one hand, the system has exhausted its technical resources, and its prospects are as yet unknown. On the other hand, satnav systems have come into being which are displacing the *MARS*-type systems.

LORAN-C and CHAIKA *LORAN-C* covers only edges of the NSR - approaches from the west (the Barents Sea) and the east (the Bering Strait).Land stations of the Russian *CHAIKA* system (similar in performance to *LORAN-C*) are so deployed that only a few southern areas of the Arctic seas are within the coverage of the system. Since these areas lie at the edge of *CHAIKA* coverage, the accuracy and reliability of signals received are poor. Because of this and the availability of more efficient alternative systems, neither *LORAN-C* nor *CHAIKA* show promise in the Arctic.

TRANSIT and TSIKADA These are the first generation satellite navigation systems (SNS) based upon low-orbit satellites. The US *TRANSIT* SNS has been used by the transport fleet over some 20 years and has found much favour in marine applications through the world. Fitted with *TRANSIT* receivers are several tens of thousands of ships worldwide. The USSR - made *TSIKADA* is similar in performance to *TRANSIT* and is used nation-wide.

The basic operational feature of low-orbit satellites is a capability of high-accuracy position fixing at the times of a satellite being in view of the vessel. The known disadvantages of SNSs are non-continuous fix rate and dependence upon user velocity measurements. In inter-fix intervals, the current position of the vessel is determined by dead-reckoning. Satellite results are critically dependent upon the accuracy of the ship velocity vector as measured by gyro and log. The DR accuracy is rather poor in Arctic conditions because of non-uniform motion of the vessel in ice, with both heading and velocity alterations occurring every so often. It should be noted that inter-fix intervals in high latitudes are shorter than anywhere else. An average interval between satellite observations is about 1 hour in latitudes 60° - 70° whereas it is some 2 hours at 30° - 40°. This cannot, however, compensate for the position errors arising due to non-uniform motion, which are considerably greater as compared with these under normal sailing conditions. Added to this must be erratic operation of conventional logs in ice conditions.

For these reasons, it has become usual to carry receivers of both *TRANSIT* and *TSIKADA* systems on icebreakers and other vessels regularly sailing in the Arctic. An obvious advantage is a reduction (of about 1.8) in the intervals between satellite observations.

There is no need to consider SNS utilization in more detail, as the long-standing experience is well-generalized and known to specialists. Moreover, the era of low-orbiting SNS is drawing to a close. These systems are expected to remain in service over the next 5 years, until the end of the century. They are now being replaced with second-generation systems, *NAVSTAR* and *GLONASS*.

Data on accuracy and coverage of the various radionavigation systems is given in Table 3-1

TABLE 3-1 Accuracy and Coverage of Radionavigation Systems

Name	Accuracy (P=0.95), cables	Coverage	Remarks
MARS-75	1.0 2.0-3.0 5.0-8.0	Kara Strait approaches to the Yenisei Gulf and Ob Bay, the ports of Dikson and Tiksi, the Vilkitsky, Sannikov and D.Laptev Straits. Other coastal areas within 200-300 km offshore. Sea central areas and beyond the continental shelf limits, within 400-800 km off the continental shore.	
TRANSIT	0.5 (0.2 with double-channel receiver)	Practically global (within the range of latitudes ±87°). The longitudinal accuracy reduces to the north of 87°.	The accuracy is provided by discrete position fixing. The current position determination accuracy depends upon the accuracy of velocity vector.
TSIKADA	1.0	Global	The same as above.
LORAN-C		Lack of positioning capability through the NSR.	
CHAIKA	1.0	South-western part of the Kara Sea	The chain in the Kara Sea eastern part is expected to be put in service in 1995.
NAVSTAR	0.5	Global	
GLONASS	0.5	Global	
Differential GPSs	0.05	Within 400-500 km from the reference stations	Programme of equipping the NSR with the differential GPSs is now

Name	Accuracy (P=0.95), cables	Coverage	Remarks
			under development.

NAVSTAR and GLONASS These are global-position systems (GPS) employing circular-orbit satellites. The major advantage of the GPS is its capability of continuous position fixing with a high degree of accuracy. Of the systems currently available, none is competitive with the GPS. With the advent of GPS, navigators got a universal aid that provides continuous, all-weather positioning capacities throughout all of the ocean areas of the world, and satisfies the most stringent accuracy requirements. Thus, an advanced concept of minimization and versatility of on-bridge equipment has become reality.

In the near future there will be two operational systems similar in performance. They are expected to be placed in full-scale service by 1995. With the two systems being integrated, performance will be improved as far as accuracy and reliability are concerned. Development of unified hardware and software for joint processing of signals from both GPSs involves no technical difficulties.

As for the US *NAVSTAR*, its performance and test results are widely covered in special literature. *NAVSTAR* receivers are manufactured by many companies and installed on many vessels. Less is known about the Russian *GLONASS* GPS. Comparative performance data on both systems are given in Table 3-2.

TABLE 3-2 GLONASS and NAVSTAR Systems Parameter Comparison

Parameter	GLONASS	NAVSTAR
SATELLITES		
Number of satellites	21 + 3 spares	21 + 3 spares
Number of orbital planes	3	6
Orbital plane inclination	64.8°	55°
Orbital altitude (km)	19100	20200
Revolution period (h, min)	11 - 15	11 - 57
SIGNALS		
Signal separation technique	FDMA	CDMA
Carrier frequencies, MHz	1602.5625 - 1615.5	1575.42
Code frequencies, MHz	0.511	1.023
Bit rate, Hz	50	50
Word duration, s	2	6

Parameter	GLONASS	NAVSTAR
ACCURACY (p=0.95)		
Position, m	100	100
Velocity, m/s	0.15	0.10
Time, μs	1.0	0.2
Position reference	SGS-85	WGS-84

Potentially, the two systems can provide even better accuracy than specified in Table 3-2. However, because of military applications of these systems, the super-precision mode is blocked for civil users. Standard accuracy of the systems is estimated at an average of 0.5 cable with a probability 0.95. This is more than sufficient for coastwise navigation, to say nothing of open sea sailing. However, an order of magnitude improvement of accuracy is required for users sailing in restricted waters or engaged in hydrographic, planning, prospecting, etc. activities connected with exploration of the World Ocean.

In order to achieve higher accuracies with GPS, a differential mode has been recently introduced. This allows a position accuracy of up to several meters for movables and less than a meter for fixed objects.

Clearly the support of navigational safety in the Arctic requires employment of the differential GPS in certain areas. Appropriate research programmes and elaborations are currently in progress in Russia. Field trials of differential GPS are scheduled for 1994 in several Russian seas, including the Arctic.

This point will be discussed at greater length in the next stages of INSROP Project.

NAVIGATIONAL AIDS SYSTEMS ON THE NSR

In order to contribute to the safety of navigation in severe Arctic conditions, an efficient network of coastal navigational aids has been developed, including:

- radio beacons;
- land navigational nightmarks;
- sea daymarks;
- navigation radar beacons;
- passive radar reflectors;
- buoyant obstruction beacons.

Currently in operation through the NSR are 47 radio beacons, 17 of them attended and deployed at sites of installation of *MARS* shore stations. All the beacons are home-made and of two types, *AGAT* and *ALMAZ*, with coverage of 100 miles and 150 miles, respectively.

Near completion is the designing of new radio beacons to extend coverage up to 300 miles. Provision is made for interfacing the beacons with the equipment transmitting data for GPS differential correction.

The NSR coast, especially its dangerous areas, is well- equipped with navigational markers. About 30 radar beacons and more then 200 passive radar reflectors are deployed through the region. In most cases these are combined with nightmarks and daymarks. Radar beacons are deployed mainly in the river estuaries and at approaches to them, and operate all year round.

Operating in the NSR are some 250 nightmarks and 200 daymarks. A total of 1000 buoyant obstruction beacons is deployed along the NSR to operate during summer navigation period.

Detailed information on navaids will be provided in the electronic database now being developed (Project I.4.1).

One problem of normally functioning aids to navigation, especially unattended ones, is power supply. Used to this end in the Arctic are isotopic sources, based upon direct conversion of thermal energy generated during strontium-90 radionuclide fission into electricity.

Employed in the Arctic are self-contained thermoelectric generators (RTG) of *Gorn* and *Gong* types with power capacity of 65W and 78W, respectively, and a.service life of 10 years. The RTG design guarantees radiation safety and absence of environmental effects both during operation and in any possible emergency situation. RTGs have been used in the Arctic from 1975 and have proved their efficiency and reliability as a means of power supply to unattended aids to navigation. Some 400 RTGs are currently in operation in the Arctic.

Specification listing for RTGs is given in Table 3-3

TABLE 3-3Specifications

Parameter	**"Gorn"**	**"Gong"B**
Radionuclide heat source	Strontium-90 titanate pellets	Strontium-90 titanate pellets
Total activity, **kCi**	168-185	46-50
Output electrical power (minimum), **W**		
at the beginning of service life	65	18
at the end of service life	40	10
Rated voltage, **V**	28, 14 or 7	14
Efficiency at the beginning of service life (minimum), %	6-7	5.5-6

Mass, kg	1000	550
Overall dimensions, mm height diameter	 1250 820	 945 730
Service life (minimum), years	10	10

TRANSMISSION OF NAVIGATIONAL WARNINGS AND WEATHER REPORTS

The procedures for transmitting navigational and weather information in the Russian Arctic are defined in the "Guides to Communications on the NSR Seaways over the Arctic Navigation Season". The configuration of the communications system is described in detail in Section I.1.2.4 of this Project. Here we will point out some features relating to safety aspects.

Transmissions of ice reconnaissance and review facsimile charts are accomplished by Rosgidromet radio centres at Dikson, Amderma, Tiksi, Shmidt, Chelyuskin and Pevek. These are carried out in the F3C mode at the frequencies and in the terms specified in the "Guides".

Coastal warnings are compiled, recorded and checked by the Marine Operations Headquarters of the Western and Eastern regions of the Arctic.

Weather reports and coastal warnings are transmitted by the Rosgidromet and Marine Transport Department radio centres at Amderma, Tadibe-Yakha, Dikson, Chelyuskin, Tiksi, Khatanga, Pevek, Shmidt, Providence, Igarka, Vladivostok, Murmansk and Arkhangelsk. These transmissions are in the A1 mode at the frequencies and in the terms specified in the "Guides".

Transmissions of *NAVTEX* navigational and weather information are accomplished only by the Marine Department radio centres at Murmansk and Arkhangelsk.

Now in progress is development of a project for extending *NAVTEX* network. The contents of this project will be described at later stages of the INSROP Project.

REFERENCES

1. Баскин А.С., Пересыпкин В.И. и др. Навигационно-гидрографическое обеспечение мореплавания. М.: Транспорт, 1980

   (V.Peresypkin, A.Baskin et al. (1980): "Navigational and Hydrographic Support of Shipping", Moscow, Transport)

2. Сорокин А.И. Гидрографические исследования Мирового океана. Л.: Гидрометеоиздат, 1980

   (A.Sorokin (1980): "Hydrographic surveys of the World Ocean", Leningrad, Gidrometeo)

3. Богданов В.А., Сорочинский В.А., Якшевич Е.В. Спутниковые системы навигации. М.: Транспорт, 1987 г.

   (V. Bogdanov, V. Sorochinsky, E. Yakshevitch (1987): "Satellite navigation systems", Moscow, Transport.)

I.1.2.4. COMMUNICATIONS
REVIEW, ANALYSIS AND ASSESSMENT OF THE CURRENT STATE OF COMMUNICATIONS IN THE RUSSIAN ARCTIC

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SUMMARY

The maritime communication system now in operation on the NSR is designed to meet requirements imposed by specific geographical, natural and climatic conditions in the Arctic.

The organizational basis of the system is the daily communications between ships and ship owners and Arctic radio centres.

Best suited for providing efficient communications through the NSR might be a single system based upon satcom and MF/VHF techniques.

Investigations were based upon advanced theoretical and analytical methods, simulated results and experimental data.

KEY WORDS

SERVICE AREAS, ARCTIC RADIO CENTRES, ORGANIZATION OF RADIOCOMMUNICATIONS, VHF RADIOCOMMUNICATIONS, RUSSIAN SATCOM SYSTEM, USER CHARGES, SES EQUIPPING, LOW ELEVATION ANGLES

INTRODUCTION

Radiocommunication service along the NSR is provided through the departmental network of the Marine Transport Department of Russia. In certain directions, communications are provided by the radio meteo and radio centres of the Federal Service of Russia for Hydrometeorology and Environmental Control.

ORGANIZATION OF RADIOCOMMUNICATIONS IN THE ARCTIC

The basic documents regulating communications procedures over the navigation season in the Russian Arctic are the Guides to Radiocommunications in the Maritime Mobile and Maritime Satellite Services, 1991; the Radio Rules of the USSR Maritime Mobile Service, 1980; the Instructions for Communications on the Seaways of the Northern Sea Route over the Arctic Navigation Season, issued annually; the Regulations for Navigation on the Seaways of the Northern Sea Route.

The Instructions for Communications on the Seaways of the Northern Sea Route over the Arctic Navigation Season are mandatory for all ships sailing the NSR.

When employing the INMARSAT system, the INMARSAT Maritime User's Manual should be followed with.

Communications through the OCEAN satcom system are effected as prescribed in the OCEAN System User's Manual and, when in automatic mode, in compliance with the Instructions for Communicating via Satellite Channels of the OCEAN Domestic Satellite System in the Automatic Mode.

For the purpose of operational traffic control the NSR is divided into a Western and an Eastern Region.

The Western Region extends from 50°E and Zhelaniya Cape to 125°E, including Franz Josef Land and other islands, the Yenisei river area up to Igarka, the Khatanga river area up to the port of Khatanga and the Gulf of Ob up to Kamenny Cape. It is served by the communications centres of Amderma and Dikson and by the radio stations of Igarka, Dudinka, Khatanga, Kosisty and Tadibe-Yakha in the Gulf of Ob.

The Eastern Region extends from 125°E to Bering Strait, including all islands and the Kolyma river area up to the port of Zeleny Cape. It is served by the Tiksi, Pevek and Shmidt Cape communications centres and by the Temp, Tchokurdah, Tchersky and Apapelkhino radio stations.

Communications services to ships in the Arctic are also provided by the radio stations of Zhelaniya Cape, Peter Island, Preobrazheniya Island, Baikalovo, Zeleny Cape, and other radio stations when necessary.

Service areas of the Arctic radio centres are shown in Fig.4-1.

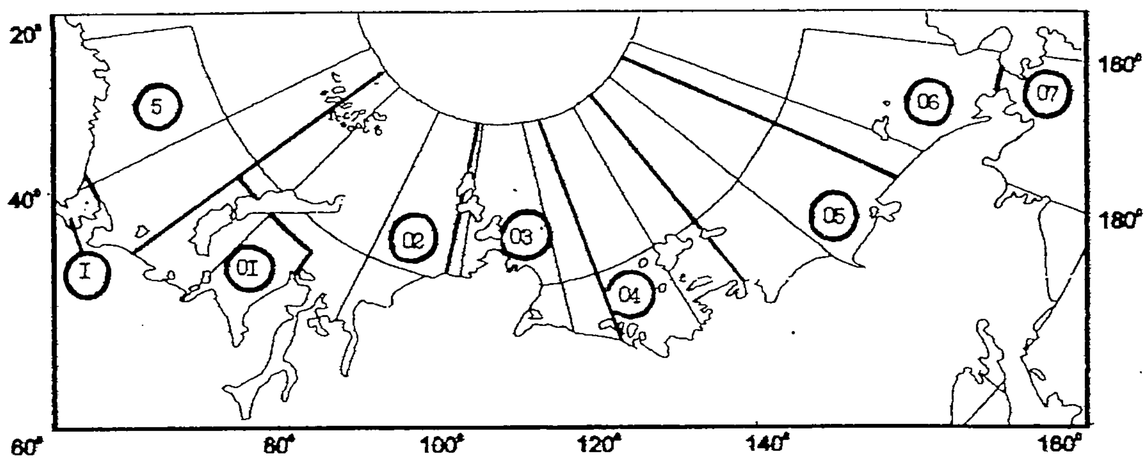


FIGURE 4-1 Service areas of the Arctic radio centres

Boundaries of coverage of these radio centres are as specified below.

01. Amderma: 50° E - 70° E - 74° N, including the Barents Sea eastern part from the Kolguev Island to the Gulf of Ob, the Ob river up to Salekhard, the Kara Sea western part.

02. Dikson: 70° E - 125° E, including the Kara Sea, the Gulf of Yenisei, the Yenisei river up to Igarka, the Arctic Ocean including the Franz Josef Land Archipelago, the Laptev Sea western part, the Gulf of Khatanga, the Khatanga river up to the port of Khatanga.

03. Tiksi: 125° E - 150° E, including the Laptev Sea, the East Siberian Sea western part, the Arctic Ocean.

04. Pevek: 150° E - 175° E, including the East Siberian Sea, the Arctic Ocean.

05. Shmidt Cape: 175° E - 169° W - 65° 50' N, including the Chuckchee Sea, the Arctic Ocean.

06. Providence: 66° N - 52° N, including the Bering Sea.

Employed by Arctic radio centres for service radio traffic is the Automatic Data System of the Rosgidromet which routes service information automatically to all destinations specified in the address.

Traffic management and support on the NSR seaways are provided by two Marine Operations Headquarters: the West Marine Operations Headquarter at the port of Dikson to serve the Western Region and the East Marine Operations Headquater at the port of Pevek to serve the Eastern Region.

Shore-to-ship communications are provided in the VHF, MF, medium HF and HF bands and through satellite channels of the INMARSAT and OCEAN systems.

All ships sailing the NSP should keep watch at 500 kHz on schedule.

Each ship should keep communications at MF with any radio centre which covers her sailing area. Medium frequencies are used for transmission of routine information, such as ice reconnaissance data, weather maps, NAVIM/NAVIP, etc.

Provided by radio centres through the Arctic navigation areas are reliable MF communications with ships sailing within their coverage.

When proceeding to the Eastern Arctic and having 52° N passed, ships should establish communications with the radio centre of Providence. Ships sailing from the west to the Western Arctic should, when in the service area of the Murmansk radio centre, get into communication with the centre at least twice a day.

Ships sailing the NSR seaways should report to their home shipping companies twice a day, either directly or, if direct communications are impossible, through another ship or radio stations.

When in convoy, transport ships may operate MF and HF bands for communications with coast radio centres and radio stations only when permitted to do so by the leading icebreaker.

Long-range HF communications with ships in the Arctic are poorly reliable because of severe ionospheric disturbances. Magnetic storms are more frequent in the auroral zone of peak magnetic activity which crosses the Laptev Sea at approximately the latitude of the New Siberian Islands. The magnetic storms normally last for several hours, but have been known to persist for 24 hours and longer. Magnetic storms recur, the normal recurrence interval being 25 - 30 days.

VHF radio traffic in the NSR may be divided into:
- interconvoy communications;
- communications with coast radio stations, deployed at the Arctic points and polar stations;
- interport communications.

When VHF equipment is available both on ships and on shore objects, the VHF band is preferred for radiotelephone communications.

Used as radio call signs are:
- by ships - ship name or international call sign;
- by aircraft - aircraft side number;
- by coast stations - call sign specified by the State Inspectorate of the Ministry of Communications of Russia.

Employed for interconvoy communications on the NSR routes and in the Arctic are the following channels and frequencies:

- 156.80 MHz (Channel 16) - watch and calling in the international VHF band;
- 156.30 MHz (Channel 6) - operating frequency for ship -ship communications in the international VHF band;
- 122.50 MHz (Channel 1) - calling and operating frequency for communications between ice reconnaissance aircraft and coast radio stations;
- 137.50 MHz (Channel 2) - calling and operating frequency for ship - ship communications in outside waters.

Use of the 137.50 MHz frequency is prohibited within 50 miles off Amderma, Dikson, Tiksi, Pevek and Shmidt Cape.

When lying out in sea ports, ships should keep their VHF stations tuned to Channel 16 (156.80 MHz) during first five minutes of each half hour. Coast stations are called on Channel 16, and the operating frequencies are used for communications.

For interconvoy communications, at least two dual channels must be employed, operating in the receive-transmit mode.

Fitted with VHF radio stations are 37 points and polar stations along the NSR. Certain of polar stations are not equipped with the VHF sets capable of operation in the frequency band of the maritime mobile service.

Responsible for operational management of on-scene NSR communications over the Arctic navigation season are the heads of the Dikson, Tiksi and Pevek territorial communication centres.

When entering or leaving the service area of a radio centre, a ship (or, when in convoy, the leading icebreaker) should notify the senior radio officer of the radio centre involved.

As soon as embarkation is under way at the port of departure, but not later than 10 days prior to entering the NSR waters, the Master of a ship that has been admitted for leading through the NSR should notify the scheduled time of arrival to the NSR Administration in Moscow and to the following NSR local authorities:

- the Administration Representative at Murmansk and the West Marine Operations Headquarters at the port of Dikson (via the INMARSAT, N 1402723 or N 1402724 Dikson MN), if the ship intends to sail eastwards towards the meridians 33°E and 50°E.

- the Administration Representative at Vladivostok and the East Marine Operations Headquarters at the port of Pevek (via the INMARSAT N 1402442 or N 1402443 Pevek MN), if the ship intends to sail eastwards towards the parallel 60° N at Bering Strait.

TELEGRAPH COMMUNICATIONS WITH ARCTIC RADIO CENTRES

Telegraph communications links between Arctic radio centres are shown in Fig. 4.2.

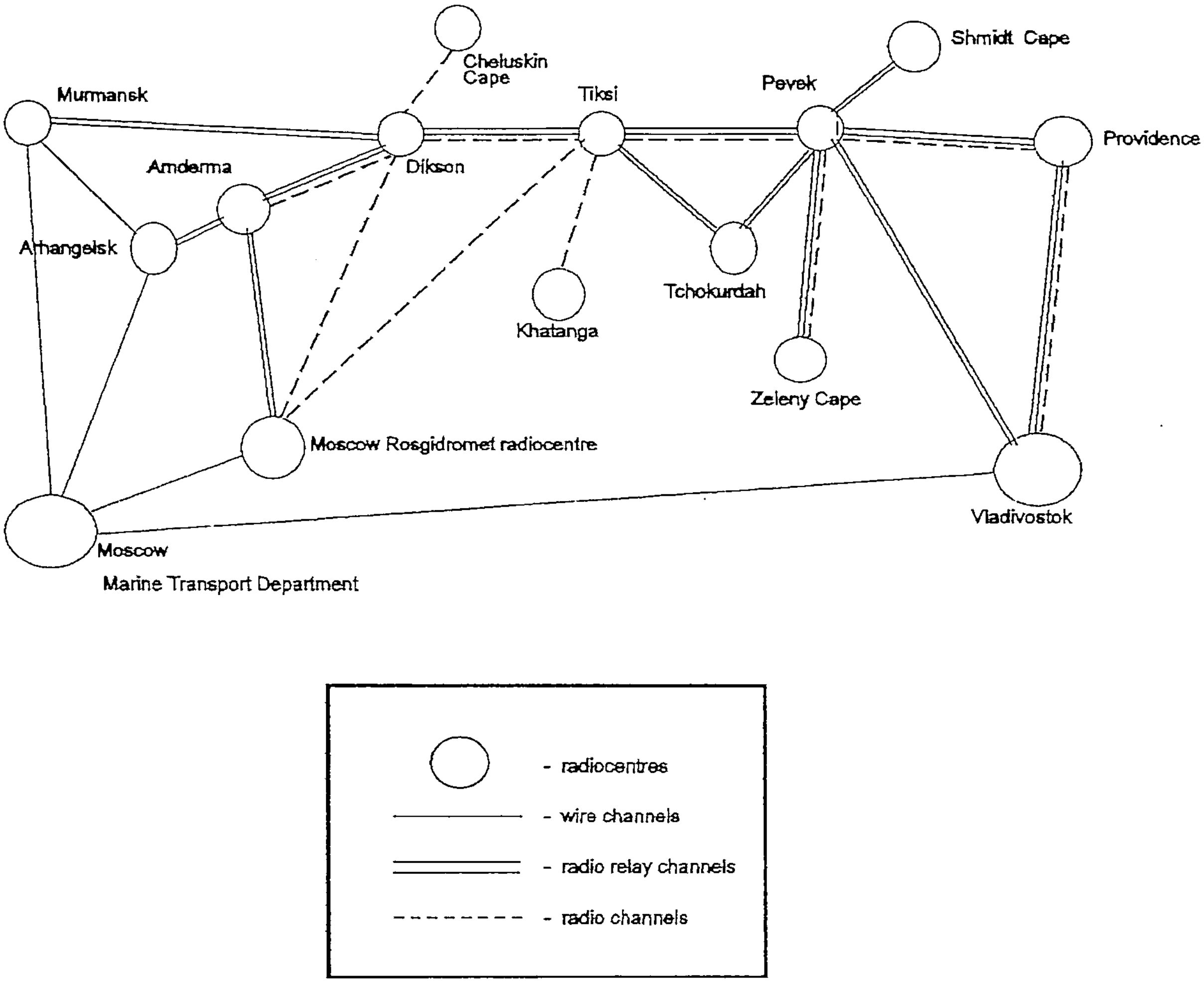


FIGURE 4-2 Coast telegraph links between Arctic radio centres

Telex information from the Marine Transport Department to the Arctic communications centres and vice versa may be forwarded in three directions: through Murmansk, the Moscow Rosgidromet radio centre and Vladivostok. All three centres are the subscribers of the automatic telegraph communications system of the Marine Transport Department through which an access to international telex networks is provided.

When information passes through the Rosgidromet radio centre, it may be further routed in three ways:

- via direct radio channel, directly to Tiksi;
- via radio relay channel (microwave line-of-sight link), through Amderma, Dikson to Tiksi;
- via radio channel to Dikson and then via radio relay channel to Tiksi.

Employed for communications between the Arctic radio centres and radio stations are the radio relay and HF radio channels.

Communications between Tiksi and Pevek are effected via the radio relay and radio channels. The radio relay channel between Pevek and Zeleny Cape is established to operate during the NSR navigation season.

How to route a message is determined by the radio centre involved, depending upon the destination, the communications channels performance, the propagation conditions (for radio channels), the actual channel loading at the time and the message priority.

With the communications channels currently available, the time required for information transfer from the Arctic radio stations/ports to the Far East Shipping Company is 40 - 120 minutes.

Traffic between the Arctic points in certain directions can be provided only via HF radio channels, their performance being seriously affected by adverse conditions (magnetic storms, etc.) that occur in the Arctic.

SATELLITE COMMUNICATIONS IN THE ARCTIC

Communications via satellite channels for support of NSR sailing are currently possible through two satcom systems: the international INMARSAT and the Russian OCEAN.

INMARSAT geostationary satellites serve four ocean regions: the Atlantic West (AOR-W) 54,8°W, the Atlantic East (AOR-E) 15,5°W, the Indian (IOR) 64,5°E and the Pacific (POR) 178,0°E. NSR is partially covered by the AOR-E, IOR and POR satellites. Shown in Fig.4.3 are the boundaries of INMARSAT coverage in the Russian Arctic at elevation angles of 0 and 5 degrees.

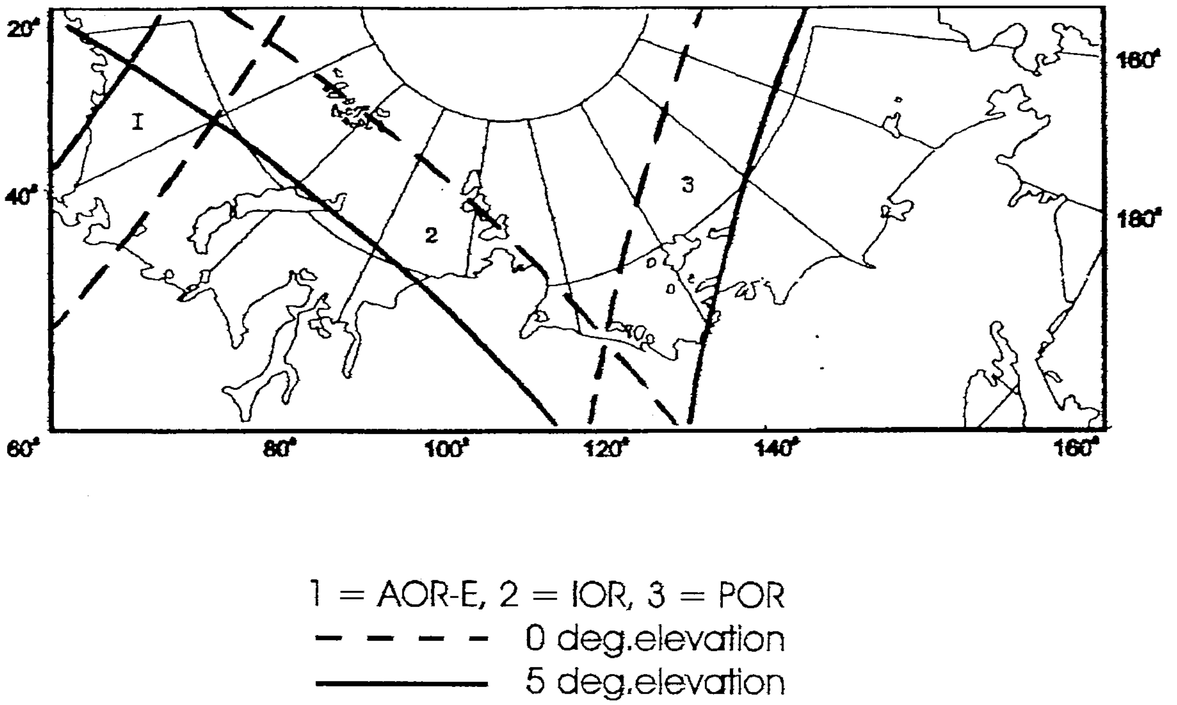


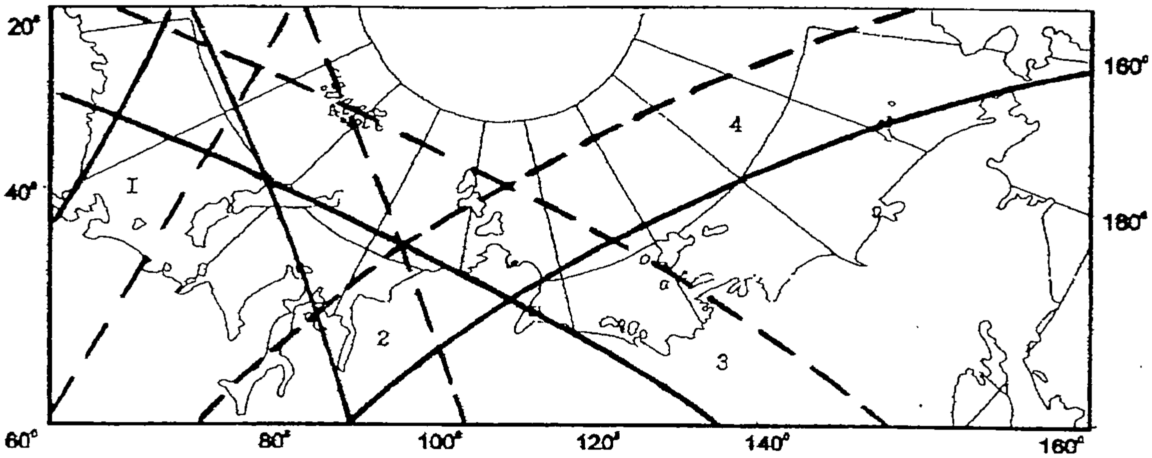
FIGURE 4-3 **INMARSAT coverage in the Russian Arctic**

System capacity allows the communications channel to be assigned automatically within 40 - 50 s after an attempt at initiating a call, with a probability of channel allocation being not less than 0,95.

The Arctic coverage capability of the INMARSAT IOR and POR satellites is reduced because of the gaps extending from 95°E to 135°E. Satcom services in this area are provided by the OCEAN system.

The Russian satcom system OCEAN was put into service in 1987. The system architecture is basically the same as that of the INMARSAT system. However, the OCEAN functional capabilities are limited as compared with INMARSAT, because the system is not intended for operating a large number of Coast Earth Stations (CES).

The OCEAN calling and interrogation frequencies differ from those employed in INMARSAT. That is why only few INMARSAT Ship Earth Station (SES) models are suitable for operation in the OCEAN system. At present these are the Russian Volna-C, Iceberg, the Norwegian Saturn-3C and the Japanese JUE-45. The OCEAN space segment consists of four Horizon geostationary satellites which serve the Atlantic, Pacific and Indian Ocean regions. Arctic coverage of the Horizon satellites at 0 and 5 degrees elevation is shown in Fig. 4.4.



1 = 11°W, 2 = 44°E, 3 = 80°E, 4 = 180°E
– – – – – 0 deg.elevation
———— 5 deg.elevation

FIGURE 4-4 **OCEAN coverage in the Russian Arctic**

The OCEAN ground segment consists of four satcom stations of Azimuth type, three of them located at Gus Khrustalny and one at Nakhodka. The CES at Gus Khrustalny serves three satellite coverage areas, 11°W, 44°E and 80°E. The CES at Nakhodka serves the POR 180° E area.

CESs are fitted with special equipment "Orion", designed for network control and for switching of voice and telex channels connected thereto. Each CES is capable of providing simultaneous communications over 2-3 voice channels and 22 telex channels.

The CES at Gus Khrustalny provides automatic switching of telex channels through the Communication and Satellite System Centre (CSSC) of the Department of Marine Transport, as well as manual operation in voice channels through the switchboard. Telephone and telex communications are provided in the ship-to-shore, shore-to-ship and ship-to-ship directions.

The following services are offered to the SES and land subscribers:
- automatic transmission of telex messages;
- telephone communication via an operator of the appropriate communication centre to which the Orion station is connected;
- processing of SES-originated urgency calls on a priority basis;
- selective calling of groups of ships;

- automatic E-mail with extension to the international telex network.

Introduction of automatic direct dialing service in the OCEAN system is feasible if the OCEAN CESs are fitted with additional equipment, a telephone automatic direct dialing switch. At present the CSSC discusses this matter with the organization-designer of the OCEAN CES equipment.

Communications between shipping company and ship owner can be arranged either:
- by double hop, over the path: shipping company satcom terminal-satellite-CES-satellite-ship satcom SES, or
- with leased terrestrial channels used, over the path: shipping company satcom terminal-terrestrialchannel-CSSC-CES-satellite-SES.

The OCEAN system performance is as follows:

1. Telex mode

When operating in the international telex network:
- call setup - 45-50 s;
- fidelity - not worse than $6 * 10^{-6}$;
- reliability: satcom terminal - 0.85-0.95 depending upon the model used;
  space segment - not worse than 0.998;
  CES - not worse than 0.98;
  international telex network - 0.85-0.87 for Russian legs, 0.9-0.95 - for international legs.

2. Telephone mode

When operating through the CSSC:
- call setup - 1-10 min;
- fidelity - not worse than in INMARSAT;
- reliability - 0.8

Data transmission via the INMARSAT and OCEAN satellite channels and the results of satcom channels performance tests will be considered in a later stage of this Project.

USER CHARGES IN THE INMARSAT AND OCEAN SYSTEMS

The user charges in satcom systems are made up of the space segment charges, the charges for CES services and the landline charges.

The charges for space segment utilization in the INMARSAT -A/B,M and OCEAN system are set on a per minute basis. Unlike this, the charges in INMARSAT-C are set on the basis of per kilobit of data transmitted.

The charges for CES services are normally 0.4-0.6 of the appropriate space segment charges.

The landline charges depend upon the charge bands. The approximate end- user charges are given in Table 4.1.

TABLE 4-1 Approximate Charges, USD

	INMARSAT A	INMARSAT B	INMARSAT C	INMARSAT M	OCEAN
User Charges	per minute	per minute	per kilobit	per minute	per minute
Tele-phone	6 - 8	5 - 6	N/A	3 - 6	4
Telex	4	3 - 4	1 - 1.5	N/A	2
Facsi-mile	as tele-phone	as tele-phone	N/A	as tele-phone	as tele-phone
Data	as tele-phone	as tele-phone	as te-lex	as tele-phone	as tele-phone

EQUIPPING WITH SES

There are about 17500 maritime INMARSAT-A SESs, more than 10000 INMARSAT-C SESs and more than 100 INMARSAT-M SESa now in operation through the world.

Deployed currently in Russia are about 600 INMARSAT-A SESs. A total of 18 icebreakers involved in Arctic navigation is fitted with the INMARSAT-A SESs capable of operation in both the INMARSAT and the OCEAN systems (9 of the Murmansk Shipping Company, 7 of the Far Eastern Shipping Company and 2 of the Northern Shipping Company).

As to Arctic coast radio stations, INMARSAT SESs are installed at Dikson, Pevek, Khatanga, Tiksi, Dudinka, Berengovsky, Anadyr, Nakhodka-1, Magadan-1, Provideniya. Fitted with SESs are also the Murmansk and Far Easten Shipping Companies.

PERFORMANCE AT LOW ELEVATION ANGLES

The feasibility of operation of satcom aids in the INMARSAT and OCEAN system depends upon satellite coverage areas. With the INMARSAT-A SES employed as a satcom station, the coverage boundary is deemed to be the line through which the elevation ($\in$) is not lower than 5° at any point. However, both operational experience and special experiments show that reliable communications can be provided also at lower elevation angles, down to and including 0° elevation.

Tests conducted by Russian experts on the nuclear-powered icebreaker "Siberia" and on the research ship "Professor Vize" via the INTELSAT V - MCSA IOR and MARECS B-2 AOR satellite transponders, respectively, have proved that the limit of the INMARSAT service area is the focus where $\varepsilon \leq 2$

Data on performance evaluation of satcom channels as obtained from the tests onboard the "Siberia" are given in Table 4.2.

At low elevation angles, performance of satcom aids may degrade due to the multipath effect, which is most pronounced at $4 \leq \varepsilon \leq 7$ elevation.

TABLE 4-2 Satcom Channels Performance Evaluation

SHIP POSITION	ELEVATION ANGLE	VOICE CHANNEL PERFORMANCE SCORED ON A 5-POINT SCALE	TELEX CHANNEL PERFORMANCE QBF,%
72°20' N 38°58' E	8	4	100
75°03' N 39°52' E	5	4	100
78°19' N 40°15' E	2.5	4	100
79°53' N 43°49' E	1	3	reception - 100, transmission is in errors
81°27' N 42°29' E	0	no reception	no reception
81°35' N 42°31' E	0	4	100
81°25' N 46°36' E	0	4	100

FURTHER DEVELOPMENT

Now in the final stage is the development of the INMARSAT third generation system INMARSAT-3. Third generation satellites are expected to provide global beam and five spot beams. Satellite power in L-band will be as high as 48 dBW. The launch of the third generation satellites is scheduled for 1995-1996.

Completed in Russia is the development of the Maraphon satcom system intended for providing services to any mobiles. The system will employ five geostationary satellites placed at 85°E, 25°W, 49°E, 128°E, 160°W.

To operate in the system, the Arcos and Mayak satellites will be launched in 1996. The Mayak high elliptic orbit satellites used in conjuction with the appropriate coast stations are expected to be capable of providing communications with mobile and remote objects located in the northern polar regions beyond the visibility of geostationary satellite transponders.

Commissioning of the Maraphone first phase system is scheduled for 1995, with the second phase system to be introduced in 1997. The Maraphone system is expected to be fully operative by late 1997.

New satcom systems will be considered at length in the next stage of this Project.

REFERENCES

1. Указания по связи на период арктической навигации на трассе Северного Морского Пути, Департамент морского транспорта, Москва, 1993

   ((1993): "Instructions for Communications on the Seaways of the Northern Sea Route over the Arctic Navigation Season", Marine Transport Department, Moscow)

2. (1991): "Regulations for Navigation on the Seaways of the Northern Sea Route", Head Department of Navigation and Oceanography, USSR Ministry of Defence, Moscow.

3. Михин Н.Д., Шигабутдинов А.Р. Оценка надежности и эффективности средств морской спутниковой связи. - В кн.: Развитие морской радиосвязи.- Л., Транспорт, 1988, с. 12-18, ЦНИИМФ

   (Mikhin N.D., Shigabutdinov A.R. (1988): "Analysis of Reliability and Efficiency of Maritime Satcom Facilities", Development of Maritime Radiocommunications, pp. 12-18, L., Transport, CNIIMF).

4. Володин В.И., Деревенько С.Б., Жарновецкий Ф.В. Определение характеристик многолучевого распространения радиоволн L- диапазона в каналах морской подвижной спутниковой службы.-В кн.: Развитие морской радиосвязи. Л., Транспорт, 1988, с. 138-145 ЦНИИМФ

   (Volodin V.I., Derevenko S.V., Zharnovetsky F.V. (1988): "Characteristics of Multipath Propagation of L-band Waves in Channels of the Maritime Mobile Satellite Service", Development of Maritime Radiocommunications. pp. 138-145, L., Transport, CNIIMF).

5. Fang D.J.,Ott R.H. (1983): "A Low Elevation Angle L-band Maritime Propagation Measurement and Modelling", Third International Conference on Satellite Systems for Mobile Communications and Navigation, June 7-9, 1983, Conference Publication Number 222, London and New York, IEE

I.1.2.5 INFRASTRUCTURE
SYSTEMATIZATION OF INFORMATION ON INFRASTRUCTURE

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SUMMARY

In 1993, the current state of the structure, functions, legal and technical aspects of NSR navigational infrastructural services were analyzed.

On the one hand there exists an enormous amount of theoretical, experimental and technical data about services of Arctic navigation; on the other hand, this information has a specific character due the policy of the former USSR. These data need to be supplemented and revised with a view to the requirements of international shipping.

KEY WORDS

CLASSIFICATION, ARCTIC SEAS, ICEBREAKER SUPPORT, INTERNATIONAL SHIPPING.

STATEMENT OF TASK

The purpose of research, within the frameworks of budget 1993, has been to order available information on infrastructure of the Russian Arctic from the perspective of maintaining international navigation on the NSR. This analysis has included icebreaking, pilotage and shore services; the acting ports, repair, supplying and bunkering bases; air, river, automobile access; medical services; mail service etc.

The information, necessary for maintenance of international navigation on the NSR should be defined, the existing and perspective channels of information service of operators and vessels be allocated, and conceptual approaches to decisions on the operational aspects of trade navigation in the Arctic be formulated.

This report analyses the organizational structure, function, normative base, hardware of services of infrastructure of maintenance of navigation on the NSR, and also their modern condition. Annex I provides historical overview.

On the one hand, a considerable body of theoretical, experimental, industrial material on Arctic navigation has been amassed. On the other hand, the accumulated material has a rather specific character, stipulated by the state ideology of the USSR, and needs essential revising and qualitative updating to meet today's requirements for maintaining international navigation.

INFRASTRUCTURE CONDITIONS

EXISTING NAVIGATION ORGANIZATIONS

Decision making on questions of trade navigation in Russian Arctic seas is the responsibility of the Administration of the NSR (NSRA), which is a structural division of the Marine Department (DMT) of the Transport Ministry of Russia and acts on basis of regulations authorized by government of Russia. NSRA executes the legal activity, develops and coordinates by established order the normative documents approved and enacted by order of Russian Minister of Transport in coordination with interested departments.

NSRA also executes the organizational activity of organizations, producing prospecting work on NSR and financed from the state budget - e.g. Hydrographic Office of DMT. As far as with the purposes of operative management of navigation the NSR is divided into Western and Eastern regions, the traffic in each region is managed by Marine Operations Headquarters of Western and Eastern sectors of the Russian Arctic. The work of Marine Operations Headquarters is led by NSRA. Accordingly, NSRA executes the perspective and current planning of marine Arctic operations, coordination of the activity of state divisions - oceanographic, civil aircraft etc. - participating in the maintenance of Arctic navigation.

The Marine Operations Headquarters of the Western sector of the Arctic (based in the port of Dikson) - structural division of Murmansk shipping company - organizes and provides navigation in the Western part of the NSR to 125°E. The Marine Operations Headquarters of the Eastern sector of Arctic (based in the port of Pevek) - structural division of Far-eastern shipping company - organizes and provides navigation from 125°E to the Bering Strait.

Each Headquarters includes a group of ice captains, an operative group, a scientific group (oceanographers of ice breakers, planes and helicopters of ice investigation, weather forecasters), one representative of Hydrographic Department for hydrographic and pilotage maintenance, experts of regional oceanographical and meteorological service, one representative of air division, as well as experts on repairs of navigating equipment, experts on rescue etc. Such staff makes possible to decide questions, connected with ice navigation, operatively.

The main responsibilities of Marine Operations Headquarters are the maintenance of safety of navigation in the region, organization of convoys, provision of icebreaking and pilotage services, checking of the implementation of measures on preventions of polar seas pollution. All ice breakers and transport vessels, located on the NSR, aircraft of ice investigation, radio stations and hydrobases are operatively subordinate to the Headquarters. The Marine Operations Headquarters are also responsible for record-keeping and analysis of marine ice operations and investigation of ice accidents.

NSRA or Marine Operations Headquarters can suspend the navigation in some sections of NSR in the case of obvious necessity.

If the vessel infringes the rules of navigation, it can be removed from the NSR.

INFORMATION SUPPORT

As mentioned, information support to navigation on the NSR historically was oriented solely to state USSR shipping companies operating under the control of the Soviet state system of trade navigation and carrying the freights for state enterprises. Therefore the decisions of problems of information support to NSR navigation were extremely simplified - the rules, plans, tariffs, freights, direction of vessels, allocation of planes, financing, reporting, transferring of information to vessels and all interested organizations - all this was developed, decided and operated by center in the part, in which the center thought this necessary, and only in the Russian language.

Clearly, such system of information support, its hardware, methods and language of information, cannot directly be applied to support international navigation. One of tasks of this project is to develop proposals for modifying the existing system of information support to meet the needs of international navigation.

ICEBREAKING SUPPORT

History. The 26 m steam tugboat *Pilot* with 85 i.h.p. engine is considered as a prototype of russians icebreakers. In 1864 M.O.Britnev, a merchant from Kronshtadt, truncated the bow of *Pilot* under the angle of 20°. This operation enabled the vessel to creep out on the surface of the ice and break it by its weight. In 1890 the theory of icebreaking was founded by publication of R.I.Runeberg's work on icebreaking vessel characteristics.

The icebreaker *Murtaja* (1200 i.h.p., 48 m length, 11 m width) was built in 1890 in Sweden for the pilot and lighthouse service of Finland. The *Icebreaker-I* equipped by a trim system was built in 1891 for the port of Nikolaev. The powerful icebreaker *Nadezny* (3500 i.h.p., 59 m length, 13 m width) was built in Denmark for the port of Vladivostok. A total number of about 40 steam icebreakers were constructed in the world by the beginning of 20th century.

Admiral S.O.Makarov put forward new ideas in the field of icebreakers building. The experimental icebreaker *Ermak* (6000 displacement, engine power 10000 i.h.p., length 93 m, width 21.6 m, draft 7.6 m, 4 propellers, heeling system) was built at Armstrong shipyard, Newcastle. Trials of *Ermak* carried out in 1898 during ice sailing near Spitzbergen showed the insufficient strength of its hull. The hull was reinforced but the following ice navigation in 1901 was also unfortunate. The attempt to reach Kara Sea by sailing around Novaya Zemlya was unsuccessful.

The needs of World War I required the prolongation of the navigational season to Arkhangelsk. The icebreakers *Sviatogor* (renamed to *Krasin* after the Revolution) and *Saint Alexandr Nevsky* (1000 h.p.), *Mikula Seljaninovich* and *Canada* (8000 h.p.), 3-propeller's *Kosma Minin* and *Kniaz Pozharsky* (6000 h.p.), *Tzar Mikhail Fiodorovitch* (5200 h.p.), 2-propeller's *Ilja Murometz* and *Dobrynja Nikitich* (4200 h.p.) were built.

The icebreaker *Krasin* became well-known after the rescue operation undertaken after the catastrophe of the dirigible *Italy* in the Arctic. This case altered the point of view on the use of icebreakers in the Arctic. The role of icebreakers was sometimes overestimated.

The first diesel-electric icebreaker *Imer* (10000 h.p.) was built in Sweden in 1932.

The first icebreaker with a welded hull *Raritan* was built in United States in 1939.

The construction of icebreakers with engine power of 10000 h.p. in USSR began in 1935.

Since the 1950s the power of icebreakers has increased, thereby rising the speed of ice convoys and extending navigational period. In 1959 the first nuclear-powered icebreaker *Lenin* was built, marking the beginning of new icebreaker,s era. Beside the considerable number of icebreaker's of usual type, 5 nuclear-powered *Arktika*-type icebreakers were built in 1974-1992, the last two - with engine power 55.1 MWt and some modernization. Due the use of nuclear-powered icebreakers, Arctic navigation became more long and safe. Since 1989, when *Kapitan Sorokin* -type shallow craft icebreakers were built, navigation on Yenisey up to Dudinka became round-the-year.

In 1977 the nuclear-powered icebreaker *Arktika* reached the North Pole through the ice cover. The next year, during the early spring its sistership *Sibir* convoyed the vessel *Kapitan Myshevsky* from Murmansk to the Bering Strait in 16 days.

In 1990 two shallow craft nuclear-powered icebreakers *Taimyr* and *Vajgatch* were put into service. In all, 17 arctic and open-sea icebreakers were put into service during last ten years in the USSR.

Ice convoy tactics. As usual vessels are directed by icebreaker through the ice in groups. There are two types of convoys - simple and complex. Simple convoys are led by one icebreaker, complex - by several icebreakers, where the main icebreaker makes the ice channel and the others, situated in different points of the convoy, help the vessels.

Convoy with a single vessel may exist only under extreme ice conditions.

The vessels move in convoy in a wake. Vessels with a weaker engines or hull are preceded by a stronger, wider vessels. The most feeble vessels must be placed just after the icebreaker, whereas stronger vessels directed by more experienced captains are usually situated at the end of the convoy. Outrunning is prohibited in convoys. The tugee must be ready at any time to break the tailrope and move at full speed astern.

There is some contradiction between the possibilities of icebreakers (thickness of the hull jacket 45 mm and 55.2 MWt engine power) and that of vessels (thickness 12 mm, power about 1.5 MWt). In connection with this there has been some discussion about the speed of convoys and interaction vessel/icebreaker.

Icebreaker support organization. All the 17 line Arctic icebreakers belonging to Murmansk and Far Eastern shipping companies are based in the port of Murmansk. This port has possibilities of icebreaker repair, crew training, nuclear fuel changing, etc.

All line icebreakers are under leadership of Marine Operations Headquarters during Arctic navigation while conducting convoys or working in the most dangerous points of the NSR.

Captains of vessels may obtain permission for free sailing from the shore centers or from the icebreaker captain. The recommended tracks and ice information must be added to such permission.

The master of any vessel intending to pass through the NSR must contact Marine Operations Headquarters and receive instructions on the place and order of convoy forming, icebreaker's name etc. Then he must to communicate with the captain of the icebreaker and follow his orders.

The master of the main icebreaker performs the control of the convoy. He defines the number of vessels in convoy and instructs the masters of vessels. All vessels must help the icebreakers in their duty for the safe and quick pass through the ice.

In the case of damage to a vessel, its crew must to show the distress signal according to International Code of Distress Signals, to take measures for damage limitation and by whatever means inform the captain of the icebreaker.

If any ship doesn't follow instructions of the icebreaker it may be refused in convoying until the order is carried out.

While moving in convoy all vessels must support the radiowatch by means of VHF-stations. All orders of the leading icebreaker must be repeated by vessels in the order of their convoy numbers. All the navigators in convoy should know the one-letter signals for communication with icebreaker. Any disturbances in communication are very dangerous under conditions of short convoy distances.

Tendencies of icebreaker building. Analysis shows us the following tendencies in the icebreaker building:

- icebreaker's power and ice speed increasing;
- research of new forms of hull for the ice navigation:
- engine improving;
- improving of the control automation;
- constructing the specialized icebreakers (e.g. shallow craft);
- research of the new materials for the corrosion and ice resistance decreasing.

PILOTAGE

The 1993 data on Arctic pilotage are not representative for purposes of demonstrating Arctic pilotage possibilities, due the recent depression in shipping. That is why data are given from 1988, systemized by regions from west to east.

Yenisey region. The pilot service of Yenisey is based in Igarka, and executes pilotage from the mouth of the Yenisey (Oshmarino) up to the ports of Igarka and Dudinka. There were 17 senior pilots and 17 pilots on the staff in 1988. The pilot service has a pilot vessel and a pilot boat. The port icebreaker and a helicopter may be used in case of necessity. Pilot operations were executed from the 16th of June to the 16th of November (153 days). Pilots carried on board the ships the sets of updated charts needed for safe passage. Igarka was visited by 205 vessels; Dudinka, by 131. A total of 621 pilot operations were carried out, including 361 between Oshmarino and Igarka, 231 Oshmarino-Dudinka, 27 Igarka-Dudinka. One case of stranding was registered during these operations.

Hatanga region. The pilot station is situated in the port of Hatanga. The pilot services cover the Hatanga and Anabar rivers and the Gulf of Hatanga. The distance between the Kosisty point in the Gulf of Hatanga and the port of Hatanga is 186 miles, between the point Horgo on the Anabar River and the Jurung-Haja - 65 miles. In 1988, 6 pilots conducted 46 vessels on Hatanga River from 30 July to 9 October, and 33 vessels on the Anabar River from 28 July to 27 September. During the 1993 navigational season, 56 vessels were conducted by 4 pilots.

Kolyma region. The pilot station is situated in the port of Zeleny Mys on Kolyma River. There are 10 pilots, a pilot boat and pilot vessel. 725 pilot operations were carried out in 1966, 578 in 1987, 557 in 1988, 374 in 1992, 284 in 1993. The navigation lasted 101 days in 1988 and 82 days in 1993.

AVIATION SUPPORT

Mastery of the Arctic was connected with hard efforts and considerable loss of human lives. Therefore with invention of plane immediately the idea to use this means in business of research and development the NSR was appeared. Centuries ago, the first balloon builder - the Portuguese monk Bartolomeo Gusmao - has indicated in 1709 that with the help of such apparatus it would be possible to open the near-polar countries. The well known polar researchers Peier, Nansen and Nordenskiöld were also the defenders of the idea of aircraft using in the Arctic.

The pioneer in Arctic air exploration was the Swedish engineer Salomon August Andre. The realization of his plan of flight over the North Pole in an unguided balloon *Eagle* was begun in 1897. This affair ended unfortunately. Andre and his two assistants were lost. Their bodies were found only in 1930.

The first Arctic plane flights were made by the Russian aviator Nagursky in 1914 while searching the vanished expedition of G.Sedov. These flights were carried out on the Farman hydroplane with a base in Krestovskaja Guba (Novaya Zemlya.). The famous Rual Amundsen reached the latitude of 87°43'N on board a plane in 1925. In 1926 Richard Byrd and F.Benneth reached the North Pole in the flight from Spitzbergen in 1926. Then Amundsen carried out the flight Spitzbergen - the North Pole - Alaska on board the dirigible *Norge* The staff and cargoes of the drift polar station of I.Papanin were delivered to the North Pole by four heavy planes in 1937.

Nowadays aviation is used widely for cargo and passenger delivering in the Arctic. There are airports near all the Arctic ports and landing strips near polar stations.

ARTIC PORTS

The Arctic ports of the NSR are the basic points of Arctic navigation. A detailed description of each Arctic port and of its opportunities is assumed to be presented in further work. Here only a brief survey of main ports of the NSR is given.

Amderma. The port of Amderma is situated in the south part of the Kara Sea near the Ugorsky Shar strait. Vessels may be unloaded only on the road. There are airport, hospital, post, telegraph and trunk-line. Fuel and other provisions are available only in exceptional cases.

Dikson. Dikson is situated in the SE part of the Kara Sea near the entry to the Gulf of Yenisey. The may be entered by vessels with maximum permitted draft of 11 m. The inner road provides a good anchorage. The entry to port is marked by the leading lines. Lifting capability of port unloading equipment is maximum 8 tones. The road boats may assist vessels while berthing and entering the port. Only minor repairs may be carried out. During navigation the rescue team and the radio navigational equipment repairing group are based in Dikson. Fresh water may be obtained. There are airport, hospital, radio relay line to Dudinka and radio navigational warning service.

Jamburg. New port constructed at the mouth of the river Nude-Mongotoepoko 10 miles to the south of Grdiny Point in Obskaja Guba. A channel with a depth of 5.5 m leads to the port. The port is equipped with floating and motor cranes. Hospital facilities available.

Dudinka. The port of Dudinka is situated on the Yenisey River 231 miles from the mouth. In general Dudinka is intended to meet the requirements of Norilsk Metallurgical Works. Up to ten vessels may berth at the same time. The road is 40 m deep. The port is equipped by gantry-cranes. There is tug assistance while berthing. Repair facilities. Diving assistance available. Fresh water may be taken from the river in the places indicated by medical authorities. Provisions may be obtained. Airport, hospital, post, telegraph are situated in Norilsk. There is the Dudinka - Norilsk railroad.

Igarka. Igarka, one of the oldest sea and river ports of the north of Russia, is situated 370 miles southward of the mouth of the Yenisey River. Depths alongside berths are 10-11 m. The port is equipped with gantry and floating cranes. Minor repairs are available. Fresh water may be taken from the river. Hospital and postal facilities are available. The airport is situated 1.5 km away.

Hatanga. The port of Hatanga is situated 115 miles from the mouth of the Hatanga River, which flows into the SW part of the Laptev Sea. Pilotage is executed by pilots of Hatanga Hydrobase. Depths in port are 3.5-8 m. Unloading equipment includes 3-8 t gantry-cranes and one floating crane. Tug assistance available. Divers may be called from the port of Tiksi. Only minor repairs. There are hospital, post and airport facilities in the town.

Tiksi. The biggest port of the NSR, Tiksi is situated in the south part of the Laptev Sea, near the mouth of the Lena River. Depths in the port are 5.4-10 m. The port is equipped with 25 t gantry-cranes. Repairing facilities. Bunkers and other provisions are available. Diving service. Navigational equipment repairs and navigational information are provided by Hydrobase. There are hospital, post, telegraph and airport facilities in the town.

Zelenomyssky. The Zelenomyssky port is situated 4.4 miles SSW of the Kolymskaja Strelka point. Pilotage to the port is compulsory. The port has the means for road discharging. Medical and postal assistance are available. Airport is situated in the town of Chersky, which has bus communication with the port.

Pevek. The port of Pevek is situated near the town of Pevek (10,000 inhabit.), administrative center of the Chaunsky region of the Chukotsky national district. There are hospital, post, bank and airport facilities in Pevek.

Providenija. The Providenija port is situated in Providenija Bay of the Chukotsky Peninsula. The depths in the bay are 30-35 m, near the berths - 9 m. Entry to port is marked by leading lines. Medical and tug assistance are available. The Providenija Hydrobase provides navigational information.

INFRASTRUCTURE OF HYDROMETEOROLOGICAL SUPPORT

Captains of vessels generalizing the experience of navigation in seas of Siberian shelf invariable marked the gravity and necessity of creation of points of regular supervision for natural conditions in Arctic seas. The main source of such supervision was and now is the network of hydrometeorological stations along the NSR. The stages of formation of this network, its feature on support to scientific and practical activity in the Arctic are in detail considered in the extensive literature. Here we note only that growth of network of polar stations is closely connected with the transport and industry development of the Far North. The greatest development came in the years before World War II, when the NSR Headquarters (GUSMP) system included 75 stations.

The creation of large stations at key sites of the NSR was accompanied by construction of air stations, primarily to support the needs of ice investigation, and other objects of infrastructure.

Significant transformations came after the war, concerning not only the network of polar stations, but also all infrastructure. In particular, in 1953 GUSMP was transferred to the Ministry of the Marine Fleet, and then abolished. As a result, the departmental infrastructures received the significant development. In the mid-1960s the regional radiocentres of GOSGIDROMET were created at Dikson, in Tiksi and Pevek, in ports of locations of Marine Operations Headquarters. Later these radiocentres were transformed in territorial Managements of GOSGIDROMET in Amderma, Dikson, Tiksi and Pevek. These managements have the powerful systems of communication, modern residential funds, transport and other elements of life-support for conditions of the Far North. However, recent years steady the decrease in the number of polar stations and of experts. The question of the future of hydrometeorological support infrastructure is not predictable.

INFRASTRUCTURE IMPROVEMENT

Detailed proposals for infrastructure improvement are given in other projects of INSROP.

The following special items could be mentioned here:

- The analysis of river pilotage in the Arctic should be made in view of the considerable number of safe pilot operations executed under severe conditions (shallow water and narrow passages).

  Aviation, hydrographic, meteorological and oceanographic support has been well organized in the past and needs no improvement, but rehabilitation.

Taking as a base the results of researches in 1993, the following works for INSROP should be carried out:

- research on the regions with compulsory and voluntary icebreaker support, improving ice convoys tactics according to the characteristics of different vessels;

- research on the ice categories of regions with compulsory and voluntary pilotage, including rivers. Legal aspects of pilotage. Improving ice-master practice. Combining the pilot and icebreaker services;

- analysis of the NSR infrastructure, its real possibilities and improvements needed to meet the modern requirements of international shipping.

INTERNATIONAL LANGUAGE

Currently the International Maritime Organization (IMO) is revising the Standard Maritime Dictionary and Sea-speak. CNIIMF participates in this work. It would seem useful to add to this document phrases specifically connected with the Arctic navigation, e.g. concerning communications vessel/icebreaker, vessel/plane, master/pilot, vessel/rescue service.

A set of such phrases was elaborated for IMO by CNIIMF in the past, tested in VTS and implemented on ice- and meteo-forecast maps. Results of this experiment should be collected and analyzed for future use in INSROP.

LITERATURE:

1. Белов М.И. История открытия и освоения Северного морского пути, т.IV, 1933-45 гг., Л., 1969, 612 с
(Belov M.I. The history of opening and usage of the NSR)

2. Зотин М.И. Развитие сети полярных станций. Проблемы Арктики, вып.1, Л., 1957
(Zotin M.I. The development of the Polar stations network.)

3. Арикайнен А.И., Чубаков К.Н.. Азбука ледового плавания. М., Транспорт, 1987, 222 с
(Arikainen A.I., Tchubakov K.N., ABC of ice sailing.)

4. Арикайнен А.И. Транспортная артерия Советской Арктики. М., Наука, 1984, 192 с
(Arikainen A.I. The transport artery of Soviet Arctic)

5. Белоусов М.П. О тактике ледового плавания. М.-Л., Изд-во Главсевморпути, 1940, 71 с
(Belousov M.P. About ice sail tactic)

6. Бузуев А.Я., Федяков В.Е. Современное состояние зарубежных и отечественных исследований ледяного покрова как среды судоходства. ВНИИГМИ- МЦД, 1982, 50 с
(Buzuev A.Ja., Fediakov V.E. Modern Soviet and foreign research on ice cover as sailing media)

7. Готский М.В. Опыт ледового плавания. М., Морской транспорт, 1961, 368 с
(Gotsky M.V. Experience of ice sail)

8. Захаров В.Ф. Льды Арктики и современные природные процессы. Л., Гидрометиздат, 1984, 136 с
(Zacharov V.F. Arctic ice and modern natural processes)

9. Лебедев В.П., Шильников В.И. Ледовая авиаразведка на службе у судоводителя. Л., Гидрометиздат, Труды ААНИИ, 1981, т.388, с.6-13
(Lebedev V.P., Shilnikov V.I. Ice aviation monitoring for navigation)

10. Майнагашев Б., Стоянов И. Скорость и безопасность плавания во льдах. Морской флот, 1974, N8, с.50-52
(Mainagashev B., Stoianov I. Speed and ice navigation safety)

APPENDIX 1

HISTORY OF NAVIGATION IN THE RUSSIAN ARCTIC

INTRODUCTION

The Northern Sea Route now represents the large shipping line and disposes large potential for the development hereafter. Its extent in dependence on chosen route makes 2200-2900 nautical miles. The NSR is not only important transport way, ensuring the life of the Arctic coast of Russia, but also the shortest marine route between countries of Europe and the Far East.

In the past the NSR was closed for passage of foreign vessels, last russian rules, regulating navigation on the NSR proclaim, that the NSR is opened for vessels of any ensign on an equal basis, provided conformity of vessel to technical, operational and other stipulated requirements.

During the 1992 navigational season, three foreign vessels were granted permission for transit carriage on the NSR.

The French vessel *L'Astrolabe* of "1A Super" class and 2200 t displacement left Murmansk on 6 August and, after visiting Igarka, arrived in the port of Providenija Bay. The average speed on the NSR was 11 knots. In several regions the vessel was accompanied by icebreakers of Murmansk and Far East shipping companies. The second vessel was a german yacht, converted from small fishing vessel and having no ice class. It could execute the navigation only on clean water from Narjan Mar to Igarka. The third vessel - *Lunni* of "1A Super" class and 22000 t deadweight from the Finnish company Neste, after receiving the allowance on passage, decided against the trip due to lack of sufficient quantity of freight.

International navigation on the NSR requires solving a series of problems. One of them is operative communication between vessel and Marine Operations Headquarters in the Arctic or the NSR Administration in Moscow. Besides, the majority of Arctic ports have only limited opportunities to supply foreign vessels with foodstuffs, fresh water, bunker, tugboats, repair etc. In extreme situations, minimal help can be rendered only by icebreakers and pilotage.

The experience of NSR operation permits us to assert that the transport vessels of *Norilsk* (Finnish made) type are capable of year-round navigation along all the NSR, tracking icebreakers of *Arctica* type. In the south-western part of Kara Sea, navigation is executed all the year, and carriage of freight on routes Murmansk- Arkhangelsk - Dudinka is provided by regular service with a fixed timetable. Recently, winter navigation on the line Murmansk - Cape Zhelanija (Novaya Zemlya) - Dikson has become possible.

In 1991 more than 200 russian vessels of various ice classes were engaged for Arctic carriage on the NSR, making about 900 trips. Representing an alternative to conventional routes through the Suez and Panama Canals, the NSR can bring the rather significant commercial profit under some conditions. If the NSR is to achieve the status of international shipping route it will be necessary to extend the navigational season as well as not to admit any sharp decrease of average speed of vessels on all the route, which needs the processing of technology of icebreaking fleet use.

THE INITIAL PERIOD OF ARCTIC EXPLORATION

The first documented travel to region near the Polar Circle was the travel of the Greek astronomer and geographer Pytheas in approximately 325 B.C.

One thousand years later, the british king Alfred the Great wrote about the travels of the Norwegian, Ottar from Helgeland, to the Barents and White Seas in 870-890 A.D. The cruise of Ottar may be regarded as a first attempt to master the north-east passage. Ottar managed to reach the mouth of Northern Dvina (or Varzuga), which was already densely populated.

The first known information about Russian presence on the polar coastal is given in Nestor's Chronicles, which tell that the Pechera and Ugra (low reaches of the Ob River) regions were under Novgorod jurisdiction. In the 14th century rights to these land were passed to Moscow.

The Russian presence on the coast of the White Sea can be traced to attribute to the beginning of 13th century. In 1342 the Novgorod boyar Luka Varfolomeev founded the town and fort Orletz on the Northern Dvina river, which became the residence of prince vicegerent. In 1435 the Solovetzky monastery was founded by the White Sea, which played the significant role in strengthening Russian positions in northern territories. In 1584 after the foundation of Arkhangelsk, Moscow state concentrated here its foreign trade. Russian seafarers sailed in the Arctic waters.

In 1556 the small ship *Searchtrift* commanded by Steven Borro left England in search of the north-east passage. It reached Kanin Nos point on 24 July and the mouth of the Pechora on 4 August. On the south-western coast of Novaya Zemlya it met the some Russian vessels. Borro met in Kola about 30 Russian trapping and fishing boats and in Mezen, about 20. Borro tried to enter the Kara Sea through Ugorsky Shar Strait, but met there compact ice and refused the intention. All subsequent English and Canadian expeditions also failed. Russia founded the town of Mangazeja at the mouth of the Ob. Chronicles said that in 1601 Mangazeja was visited by 4 Pomor boats, in 1610 - by 10, in 1613 - by 13 boats. From Ob to Yenisey the route went through the Taz inlet and then by tributaries. The first mention about visiting the Yenisey River dates by 1610. The same year russian explorers coming down the Yenisey from Turukhansk reached Pjasina by the sea. The small russian vessel successfully passed the inshore polinya between the ice fields and coast. This experience was used by Amundsen for the first time overcoming the north-east passage on the small vessel *Gjoa*.

Sea trading in the Arctic region developed, but in 1619 the russian government prohibited sailing to the Ob inlet and left only Arkhangelsk for international trading. This measure stopped trade mastery of the Russian Arctic and delayed the resolution of the NSR problem for 250 years.

The first Russian scientific expedition in the Arctic worked in 1733-1743 and was named "the Great Northern Expedition". There were 580 members in this expedition which carried out an enormous volume of work - charting and mapping the northern coast from the

White Sea to the mouth of the Kolyma, exploring Kamchatka, the Okhotsk Sea and a considerable part of Siberia and sailing to the north-western America and Japan. The functioning of this expedition was secret, which is why so little is reflected in historical documents. The great part of the expedition materials lie in archives, unpublished. The next expedition of 1764 had nearly the same destiny.

A new era in the history of polar navigation was opened in 1869, with Norwegian industrialists' trips in the Kara Sea, involving 24 vessels. In 1874, navigation in the Kara Sea was made by English captain Viggins. He 11 times conducted the steamships to the mouths of Ob and Yenisey and only once has not reached the purpose in 1875 on a small sail. Viggins came to conclusion that the establishment of regular steamship way between England and the Ob mouth was quite possible, and has proven it. The famous polar researcher A.N.Nordenskiöld had the same opinion. In 1878 he passed practically the whole northern sea route, reached the Chukchi Peninsula on the trapper steamship *Vega* and, having spend the winter, reached the Bering Strait. After opening the perfect anchorage named Dikson Day in honor of the sponsor of expedition, Nordenskiöld wrote: "I hope, that the harbor, at present empty, in a short time will be transformed into a gathering place for a great number of ships, which will promote relations not only between Europe and the Ob and Yenisey region but also between Europe and northern China".

Commercial shipping in the Arctic renewed in 1876, when A.Nordenskiöld conducted to the mouth of Yenisey the 400 ton steam vessel *Ymer* with the goods which were confiscated by local authorities under the pretence of lack of the custom. The first goods from Yenisey (graphite, fish, furs) were exported in 1877 by the captain D.I.Shvanenberg on the boat *Daybreak dawn*. This marked beginning of regular shipping to the mouths of the west Siberian rivers. After this the trips of trade vessels to Siberian rivers mouths became regular, as testified by the following table:

Years	No.of vessels	Years	No.of vessels
1876-1879	13	1910-1919	37
1880-1889	7	1920-1929	87
1890-1899	27	1930-1932	95
1900-1909	8		

The first more or less intense use of the NSR took place in 1893, when 1500 tons of rails were transported to Yenisey from Europe for the construction of trans-Siberian railroad. In 1905, 22 vessels transported 18,000 tons of cargoes despite of the great dangers to shipping resulting from the absence of aids to navigation and lack of information about ice conditions. In 1911 the Government decreed the construction of polar hydrometeorological radio stations and the first three came into operation in 1914.

ARCTIC DEVELOPMENT DURING THE SOVIET PERIOD

The development of shipping along the coasts of Siberia was hampered by the low economical level of the northern region, low grade of studies of the Arctic seas and rivers and the absence of aids to navigation. Attempts at mastering the Arctic without prior exploration often ended with the death of investigators.

After the Revolution of 1917 the development of the Arctic received a strong state base. On June 2, 1918 the Peoples' Commissar Council Decree on the organization of expeditions for study of the Arctic Ocean was signed by Lenin. In the middle of civil war in 1920 the Ob-Yenisey detachment created on the basis of this decree worked in the mouths of the Ob and Yenisey. In 1922 this group was reorganized into Management of safety of navigation support in the Kara Sea and mouths of rivers of Siberia (UBEKOSIBIR). To 1932 UBEKOSIBIR charted the entire Ob, Taz, Yenisey and part of Gydansky Bays, the lower reaches of the Ob River up to Salekhard and the Yenisey River up to Igarka. This enabled the preparation of navigation charts and pilot books.

In order to accelerate the rate of Russian Arctic development, in december 1932 the special transport-economic organization - Headquarters of the Northern Sea route (GUSMP) was organized. In 1933 the Hydrographic Management of GUSMP was organized. GUSMP was responsible for "... finally determining the sea route from White Sea to Bering Strait, to equip this way, to hold it in serviceable condition and to ensure safe navigation on this way."

The Directorate controlled two state shipping companies, polar aviation, the Institute of Polar Hydrology and Meteorology, the Research Institute of Arctic Geology, the Hydrographic Institute (future High Arctic Marine School after the name of adm. Makarov - VAMU) and the Arctic Marine School (LAU).

In 1938 special divisions were organized on all navigable northern rivers to provide the installation and reliable functioning of aids to navigation and ensuring of hydrographic survey. Hydrographic survey in the Arctic has been executed by constant expeditions. On the basis of their work, by 1949 large-scale charts.on regions of approaches to mouths of northern rivers and river atlases were edited.

From 1970, Soviet vessels began experimental trips to the port of Dudinka in autumn - winter period. Navigation support of these trips required essential changes in structures and operation of aids to navigation, because the ice changed the outlines of coast and the buoyage was removed before the sea freezing.

NAVIGATION SUPPORT

Aids to navigation of NSR during 1917-1941. Prior to 1917 aids to navigation of Northern Sea Route were practically absent.

During first 11 years after creation of UBEKOSIBIR, hydrographic survey was carried out and of aids to navigation were installed in Yenisey Bay and in the lower reaches of Ob River up to Salekhard and the Yenisey River up to port of Igarka.

To the moment of the Hydrographic Bureau creation, the aids to navigation of the NSR consisted of 42 lights and 44 landmarks installed near the coasts of Novaya Zemlya and in the mouths of the Ob and Yenisey. In other regions of the Russian Arctic such means were non-existent.

During five years after GUSMP creation, 15 vessels and icebreaking steamships sailed along the NSR. The delivery of éÉÇ-60 projectors for electric lights began. Radio beacons with rotating framework, designed for use by usual ship-spanned receivers, were installed in 1934 on the Belyj and Dikson islands. By the end of 1937 in Arctic straits and seas 2 radio beacons, 12 electric and 125 usual lights, and 233 landmarks had been installed. A total of 29 polar stations supported Arctic navigation.

During the period 1938-1941 the safety of navigation along the NSR was increased. For the first time acoustic means of fog signalling (pneumatic hooter on Stolbovoj Cape in the Strait of Matochkin Shar and nautophone on Lesovsky Cape in the Providenija Bay) were installed. Four additional electric lights were erected. Lights ensuring the safety of navigation in Kara Sea were installed in Nordenskiöld archipelago in 1940. Lightning equipment was installed on landmarks of the straits of Novaya Zemlya, Vilkitzkogo, Dmitrija Lapteva in the Providenija Bay and on the islands of Nordenskiöld Archipelago. Radionavigation support was strengthened by the organization of seven "remote" radio stations. The total number of radio stations used for navigation purposes was 38. Before the war with Germany, 301 units of various kinds of aids to navigation had entered into NSR operation (including 189 in the Kara Sea).

The NSR, 1941-1944. During the war GUSMP supported the war operations and work of the national economy in Arctic regions. By 1942 aids to navigation were rapidly installed on the Kotuj River (from bar to mouth), on the Lena River (from Jakutsk to Muostakh Cape) and on the Kolyma River. There were constructed 11 new and modified 5 lights, 1 radio beacon, 3 fog stations and light beacons in the Kara, Laptev, Chukchi and East-Siberian Seas. During the 1942 navigational season, 15 lights in the Chukchi Sea, 35 in the East Siberian and Bering Seas, 35 in the Kara Sea were installed as floating light buoys. During the navigation of 1944, the NSR was equipped with 5 fog signalling stations, 12 electric lights, 66 gas lights, 13 leading lights, 1 radio- and 8 light beacons.

Aids to navigation of the NSR, 1945-1985. After the war, aids to navigation on the NSR were rapidly restored to pre-war volume. Already in 1946 there were in operation 5 radio means, 9 acoustic, 11 attended lights, 160 automatic lights. In the region of Yenisey River mouth alone, there were in operation 13 optic automatic lights and 8 buoys. One of the achievement of polar hydrography was the installation of the powerful radio beacon with range of action of 200 miles on Buorhaja Cape in the Laptev Sea, which greatly promoted safe navigation in the south-east part of the sea.

However, navigational equipment of the NSR was still far from sufficient. Foreign made radio beacons installed along 19440 miles NSR coastline - one for each 4,000 miles - could not to satisfy requirements for reliable position fixing. Optic aids to navigation (one for 111 miles of coast) - obviously were not enough.

In the early 1950s, the low power automatic radio beacons îÉî-54 with a range of 10-12 miles were produced and installed in the Arctic. These beacons reliably executed the functions of danger marking aids, and did not require large costs of capital constructions - which was essential. Dry batteries supplied these beacons with power. In the late 1950s, when the opportunities of industry were increased, automatic radio beacons îÉî-61 (semi-conductor devices with a special dry battery "Znak" as power supply) were designed and from 1961 serially produced. The range of action of these radio beacons was 20-25 miles. These radio beacons were directed in the beginning by mechanical device, and from 1969 - by electronic device Çüî-1, which appreciably increased their reliability. By 1965 there was an average of one radio beacon for each 250 miles of Arctic coast.

In the 1960s the 100-mile-range automatic radio beacon was designed. Simultaneously its isotope power generator was ordered. This work resulted in the installation of completely automatic 100% reserved radio beacon ÇìÉî-1 with isotope power supply "Efir" in 1970 in difficult Arctic regions. From 1975 came the automatic complex radio beacon ÇìÉî-50 with double isotope power supply "Beta-î", which was one third less expensive than "Efir". The range of action of ÇìÉî1 was 100 miles. From 1976 Soviet industry began serial producing of the automatic complex radio beacon ÇìÉî-150 with an isotope power supply "Efir-M" with a 150-mile range. The automatic complexes ÇìÉî-50, ÇìÉî-1 and ÇìÉî-150 with isotope power supplies "Efir-î", "Beta-î" and "Efir-MA" were called to the old technic of the NSR and to decide the important social task - to reduce to a minimum the participation of persons in their service, especially important at extension of Arctic navigation to the autumn - winter period of severe polar frosts. These radio beacons work in total conformity with international rules, the main principle of which is the association of radio beacons in navigation groups. Radio beacon density of the NSR as a result of long-term efforts reached one unit per 20 miles of coast by 1976. However radio aids alone could not resolve the problem of safety of navigation in Arctic regions of the USSR. Therefore a parallel development and perfection optical aids was undertaken. In 1946-1986 the number of light and optical aids to navigation increased constantly. At the same time the gas lights were replaced by more effective and reliable electrical ones. The 6 Wt and 12 Wt flashing electric apparatus and the 2000 WT power supply were installed.

Since 1975 radioisotope power supplies have been used for lights. The greatest number of radioisotope power supplies was employed between Dikson and Dudinka to support the prolonged and around-the-year navigation. 50 radioisotope power supply were installed in the Arctic in 1977. Optical and light aids of navigation were erected along every 5 miles of the NSR.

Since the late 1950s, the vessels directed to the Arctic have been requested to be equipped with radars. The coasts in the Arctic have few conspicuous marks, which is why radar and visual aids of navigation are very useful. Construction of radar reflectors was based on radar survey. Radar reflectors which can be detected from 6-14 miles built every 5 miles along the coasts by 1977.

At the same time, considerable attention was paid to developing a landmark network useful for orientation in conditions of polar day. In the mid 1980s, there were landmarks in Arctic seas for each 6 miles of coast. In the majority they represented the solid wooden, partly metal and concrete lighthouse buildings.

Middle-range radio-navigational systems RSVT-1, BRAS, CHAIKA, MARS-75 were installed in 1960-1970. These systems cover all regions of the Russian Arctic, but may be used only by ships equipped by special receivers. These systems don not meet the needs of the international shipping.

THE COMMON ARCTIC

* The liquidation of many "cold war" restrictions in economic relations between Russia and the USA has enabled the opening of a large number of ports for trade carriages. Agreement has been reached on opening the ports of Kaliningrad, Vladivostok, Vanino, Taganrog, Korsakov, Magadan, Nikolaev on Amur, Anadyr and Dudinka for american vessels was reached. Restrictions on the categories of freights, which can transport American vessels, have also been relaxed.

It is expected, that the named ports (the two last of them are NSR ports) will be opened to visit not only by American but by all foreign vessels.

Type of aid	1933	1940	1945	1950	1955	1960	1965	1970	1975	1980	1985	1990	1993
Light	39	95	162	227	329	574	733	797	817	868	948	1000	953
Radio				15	16	39	45	60 1RNS	59 3RNS	68 4RNS	73 5RNS	46 3RNS	47 2RNS
Radar						129	291	423	521	646	752	836	844
Landmark	144	233	247	108	58	749	785	781	747	702	697	615	621

I.1.2.6 CREW TRAINING
CONCEPT FOR TRAINING OF CAPTAINS AND CREWS FOR ICE NAVIGATION.

KEY PERSONNEL

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SUMMARY

In 1993 the activities of Marine Research Simulation Centre were analysed.This also included NORCONTROL Training equipment; the data base of the ship's mathematical models, navigational areas and training tasks; elaboration of schemes of watch organization on board the ships navigating under different and specific ice conditions; programmes and methods of training for ice navigation provided at primary and secondary levels and their experimental use.

KEY WORDS

CREW TRAINING, MATHEMATICAL MODEL, SIMULATOR.

INTRODUCTION

The research conducted in 1993 was aimed at classifying the information related to training shipmasters and crew for ice navigation.

It should be noted that in the Soviet epoch bringing Arctic lands under cultivation was accompanied by providing special higher and secondary education for the personnel engaged in navigation in the Arctic region, at great expense to the gevernment. Nevertheless, a higher educational institution - a Hydrographic Institute - was created in Leningrad in 1940 in the system of the Main Department of Northern Sea Route attached to the Council of Ministers. In 1944 that institute was reorganized into the higher Arctic Marine School named after Admiral Makarov (now the State Marine Academy named after Admiral Makarov) with navigation, hydrograhic and hydrometeorological faculties. At the same time, a specialized secondary-education establishment was created in Leningrad: the Arctic School, with mechanical, radio and hydrometeorological departments. Most of today's masters of icebreakers, heads of merchant marine research institutes, managers of shipping companies, scientists and scientific advisers are graduates of the above educational establishments.

As the merchant fleet of the USSR was owned by the state, the training and certification of navigators was regulated in accordance with state legislation. This obviously had to reflect the character of a "shortage" economy.

It was only in the Soviet Union that courses and faculties for advanced training of managerial personnel were organized for operators, masters and chief mechanics. After 5 years of education the graduates were granted a certificate, without which navigators were not allowed to sail by port inspection authorities.

Such advanced training was combined with training of shiphandlers on electronic simulators. In 1983 the Marine Research Simulation Centre (MSRC) was created and attached to CNIIMF and the Baltic Shipping Company. Today it is one of the largest simulation centres fitted out with modern NORCONTROL and SEAGULL equipment supplied from Norway.The Centre, operated by highly skilled instructors and researchers and fitted with four bridges (two of them are equipped with night visual systems), has made a major contribution to upgrading the professional training of navigators. Within its approximately 10- year period of functioning, more than 4000 navigators have been trainedincluding navigators from Northern , Murmansk and Arctic Shipping Companies, masters of nuclear and diesel icebreakers - and granted internationally recognized certificates. The MSRC also provided training to several groups of masters and chief mates from Czechoslavakia and the DDR, and to students from World Maritime University. At present the following training courses can be offered:

- radar use and plotting, including navigation under ice conditions;
- use of automatic radar plotting aids (ARPA);
- shiphandling and manoeuvering;
- training of port pilots and deep sea pilots;
- training of operators of Vessel Traffic System;

- training of the ship's crew in shiphandling in certain regions of navigation, including Arctic regions.

These courses can be provided both in Russian and in English.
Training of ice pilots and operators in the use of GMDSS system in different navigational areas including Arctic region is currently under consideration.A detailed programme for training at MSRC of masters, chief mates and ice pilots in ship handling under ice navigation conditions will be given in the next report.

MSRC possesses a library which has in its stock 18 ship's models of different tonnage, some of them of ice - register class. The library is also stocked by more than 30 play areas, including such Arctic region as port of Archangelsk.

The MSRC training methods are used by practically all shipping companies which have simulator training centres.

Since 1993 MSRC has been a Full Member of the International Marine Simulator Forum. IMSF representatives have visited MSRC and accredited its programmes of simulation training to international standards.

In Russia many simulation centres have also been created to provide training for icebreakers' masters and officers.

In summary, it can be said that the task assigned by INSROP to provide special training for masters and crews of the ships sailing the Arctic waters is by no means a new one for this country, and there is all reason to expect that it can be handled successfully in the future as well.

Such training should take into account both theoretical aspects (navigational, hydrographic and hydrometeorological conditions of navigation, navigation aids, establishment of communication, arrangement of watch, etc.) and practical aspects of training on special simulators (radar, shiphandling, prevention of damage caused by ice, landing on ice, etc.). Development of programmes and procedures should be specified to provide training at shore centres and for ships not only on the primary, but on a higher level as well.

Conceptual approaches to training of masters and crew of arctic service ships

Until now in Russia there has existed a whole system of departmental standard documents regulating the conferment of ranks on ship officers and the certification of personnel. Such legal standardization has been intended exclusively for a unitary state system. Meanwhile, shipping companies are being organized on the basis of different forms of property. To attract labour to such companies,a number of organizations have been created in different regions of Russia to provide professional simulation training for seafarers. Their graduates have been granted the certficates "on behalf of the state", which, however, is not legal. Moreover,the prestige and interests of Russia are being harmfully affected by the fact that official supervision bodies oriented to large state-owned shipping companies have found themselves unprepared to resist the pressure of privately owned bodies engaged in such training and certification of personnel.

The process of attracting personnel to Russian merchant ships has complicated lately because of the massive outflux of crew to foreign ships. This phenomenon can be

explained mainly by economic difficulties experienced in this country, while foreign ships' crews receive higher wages.
A brief account of the phenomenon is given below. Firstly, in 1991-1993 Russian companies wrote off about
10-15 % of obsolete ships annually without replenishing the fleet with new ships. For 1994 it was planned that 90 ships be written off and only 14 new ones be supplemented. Accordingly, a large majority of crew of the ships which have been written off are very likely to take new jobs on foreign vessels, without impairing the operational safety of the remaining vessels.
Secondly, about 70% of the crew are assigned to foreign vessels by their own shipping companies . After their contracts expire, they then return to their companies. Here it should be pointed out that expeirence of the crew service on foreign vessels enriches their professional qaulifications considerably.
Thirdly, advancement of Russian officers in ranks came to a standstill because growth of the Russian fleet stopped. This was highly negative for the remaining chief mates as promotion to the rank of master became impossible. Mass lay -offs have since then given perspective that further promotions would be made.
Fourthly, the difference in payments of service rendered on Russian and foreign vessels is constantly decreasing. Taking into account that degree of labour exploitation on Russian vessels is not so intensive as that on foreign ones, the number of mariners who want to quit their jobs at home is lessenning day by day.
And, finaly, icebreaker crew do not take jobs on foreign vessels, due to specific character of their service.

It can be summarized then that the existing state system of professional training, composed of higher and secondary schools and colleges, institutes for advanced studies, courses of professional simulation training, cannot remain as it is and will inevitably be reorganized. On the whole, the system of advanced training should be transformed into scientific, industrial and educational training complex. In particular, personnel should be trained in adapting to the acquisition of new types, methods and means of activities.

The Russian national system of masters and crew training in general, and for Arctic service vessels as well, should not contradict the international conceptual approach to methods of such training, as long as Russia wants to integrate into the world community. This means adapting its social and legal institutions to methods accepted worldwide on the one hand, and meeting the requirements of generally accepted international standards, such as the International Convention for the Safety of Life at Sea and International Convention on Training and Certification of Seafarers and Watchkeeping, on the other hand.

In the transition to a mixed economy the spheres of state activities should be as follows: regulating conferment of ranks on seafarers and categories on other personnel involved in sea transportation; listing professional know-how to be acquired by all kinds of specialists of merchant marine; specifying conditions of granting licences under which a juridical or natural person may train seafarers; arrangement of graduation examinations preceeding granting of certificates and conferment of marine ranks and categories; qualification, assignment, removal of and payments to examinors; issuing, waiving, extending, legalization, suspension, approval, substitution, and registering qualification certificates; supervision of conformity of licensed persons and bodies dealing with training of seafarers; international recognition of seafarers' diplomas and certificates granted in Russia; completing of crews for Russian vessels.

MATHEMATICAL BASE

The mathematical base of simulator complexes used for training of seafarers in handling of the ships, including Arctic service vessels, should comprise the following components:

- controlled mathematical models of icebreakers and commercial vessels intended for sailing under conditions of Arctic navigation;

- mathematical models of external factors affecting the behaviour of the moving vessel coastline, ice, currents, drift, shallow waters, anchors and chains, pushing or tugging tugboats (icebreakers), with all models having the determined parametres;

- electronic charts for the NSR with appropriate navigational scale, having capacity equivalent to paper nautical navigational charts to be used while performing navigational tasks.

- simulators of modern navigational aids radars, GPS NAVSTAR receivers used to generate information;

- simulators of modern ship and shore communication equipment used to generate information;

- simulators of ship emergency equipment used for sealing of holes, as well as simulation testing of the hull;

- algorithms for carrying out simulation tasks.

It should be noted that CNIIMF, as one of the authors of the IMO Resolution A.601 (17) on Manoeuvring Characteristics of Vessels, has conducted field tests in the course of developing procedures for gathering the required information. CNIIMF has processed and stored in its database about 40 mathematical models of Russian commercial vessels of the "Arctica " type. CNIIMF has also been assisting shipping companies to provide simulation training, and has amassed a huge library of algorithms for carrying out simulation tasks.

I.1.2.7 VESSEL PERFORMANCE

COMPARISON OF ICE CLASSES OF SHIPS BUILT ACCORDING TO REQUIREMENTS OF DIFFERENT CLASSIFICATION SOCIETIES

KEY PERSONNEL

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SUMMARY

The main purpose ofthis work was to compare requirements for ice hull strengthening of Arctic ships built according to different national rules.

Calculations of the dimensions of frames and shell plating thickness in the area of ice belts were carried out for selected representative ships of the Russian Arctic fleet in conformity with Russian Register Rules and those of a number of leading foreign classification societies. the results of these calculations are presented in a number of tables.

KEY WORDS

CLASSIFICATION SOCIETIES, FRAME DIMENSION, SHELL PLATING, FRAMING, THICKNESS, ICE BELT, RULE REQUIREMENTS, SPACE, SPAN, HULL, ARCTIC FLEET, ICE LOADING.

INTRODUCTION

Integrating the Russian Arctic sea areas into the world transport and shipping system requires that several organizational and technical problems be solved. These are associated with the passage (including transit) along the Northern Sea Route of the ships of foreign shipping companies built for ice classes of different classification societies. Requirements specified by the leading foreign classification societies and by the Russian Register Rules for ice ships differ significantly both in classification principles and with regard to ice strengthening, power of machinery and other ship characteristics. In connection with the opening in near future of the NSR for international shipping, comparative analysis is needed of the requirements for ice performance of ships, in particular hull strength, as specified by different classification societies. These differencies give rise to substantial practical problems when ships constructed in accordance with different rules come within the territorial waters and economic zones of the Arctic basin, in particular in connection with the admission of ships to these territories, assigning of icebreaking support, and with the environmental protection of water areas.

This report is mainly devoted to comparing the requirements of different national rules concerning the strength of ice belt structures of ships intended for Arctic navigation.

THE MAIN PRINCIPLES OF CLASSIFICATION AND DESIGN OF HULL ICE STRENGTHENINGS ACCORDING TO LEADING CLASSIFICATION SOCIETIES

The principles underlying the requirements imposed for hull ice strengthenings considerably differ between the CASPPR, Russian Register and in a number of leading classification societies. There are differences in classification systems, requirements for machinery, extent of ice strengthenings and in principles of the calculation of ice loads as well as in the degree of ensuring environmental safety.

For example, the Canadian Rules for the prevention of pollution during Arctic navigation (CASPPR, 1972) specify strict requirements which are clearly lacking in other Rules, for the arrangement of fuel bottom and side tanks with the purpose of ensuring environmental protection of the Canadian Arctic in the event of emergency damages to ship hulls in ice.

Finnish-Swedish Rules were drawn up for ships sailing in the first-year ice of non-Arctic seas, intended principally for the Baltic Sea and basins close to it as far as ice conditions are concerned. They have been taken as a basis of rules for non-Arctic seas of the majority of European states, including German and British Lloyds, and Norwegian Veritas.

The main criterion for the division of ships into classes in many foreign rules is essentially the icebreaking capability - thickness of the level compact ice broken through by a ship moving in a continuous mode. All icebreakers and transport ships of Arctic navigation are combined in one classification series. Rules of the Russian Register like those of Canada (CASPPR, 1972) cover all the range of ice ships from ships, navigating in light conditions of non-Arctic seas (L3, L4) to linear icebreakers of LL2, LL1 classes capable of working all the year round in the heavy ice of the Central Arctic. Totally there are ten classes: L1-L4, UL, ULA, LL1-LL4. One special class (ULA) is assigned to transport ships designed for independent operation in Arctic ice without icebreaker support.

However, icebreakers and icebreaking transport ships incorporated into the Russian Register Rules do not form a common classification series. Only the classification of domestic icebreakers is associated with the icebreaking capability, this latter factor making it more complicated to establish of the correspondence between domestic and foreign classes. The basis of Russian Rules is the performance of task to ensure safety of a ship proper during its operation in ice; sizes of strengthenings specified by the Rules (1990) in force are not related to the requirements for environmental protection of the water area.

There is a tendency now in CASPPR and also within other classification societies towards expanding classification series, integrating cargo icebreakers and pure icebreaking ships without accurate fixation of icebreaking capability. In particular, this has been implemented in British and German Lloyds. In British Lloyds there are four Arctic classes: AC1 - h = 1 m; AC1.5 - h = 1.5 m; AC2 - h = 2 m; AC3 - h = 3 m. Seasons and time of operation of ships in the Arctic or Antarctic are not specially specified, but there are instructions on the meeting of CASPPR, 1978, requirements if a ship is intended for operation in the Canadian Arctic. Classification of ships of non-Arctic navigation and the requirements for hull ice strengthening are similar to the Finnish-Swedian Rules. In British Lloyds and Norwegian Veritas rules it is specified that if ship of a certain class is specially designed to work as an icebreaker, the class symbol is completed by the sign "icebreaker". A transport ship capable of navigating in compact ice of the thickness specified in the applicable class should have prefix "icebreaking" before type denomination (e.g.icebreaking tanker, bulker etc.). Class of the ship is chosen by a shipowner when ordering it, with a view to the ice conditions of its intended area of operation.

As to classification, British Lloyds Rules are close to those for Arctic ships suggested in the project of new CASPPR, 1989, where the number of Arctic classes is also reduced to four.

In the new edition of rules the relation of Arctic ice classes to the thickness of ice to be broken through is given in an enlarged form together with the characteristic of ice type where ship operation is intended, but without exact specification of boundaries of geographical zones or admissible duration of the navigational period:
CAC4, h = 1.2-1.8 m, thick first-year ice; CAC3, h = 2 m, thick first-year and second-year ice; CAC2, h = 2.4 m, multi-year ice; CAC1, h = 3.0 m, multi-year ice.

The highest CAC1 ice class is assigned only to icebreakers. Other classes include both icebreakers and icebreaking cargo ships. Ships of the first three classes may operate in the Arctic all the year round, but under appropriate ice conditions. Operation of CAC4 class ships is restricted by season.

Ships of CAC2-CAC4 classes operate in the Canadian Arctic Basin without any areal restriction, but taking into account actual safety margins of the hull structures. The draft of new CASPPR (1989) involves considerable changes in the main principles not only of classification, but also of the calculation of ice loadings, dimensions of framing and shell plating in the areas of hull ice strengthenings.

Earlier in CASPPR (as in several other rules, such as German Lloyds) design ice loadings were specified irrespective of hull shape and displacement. The new Draft Regulations are to a great extent free of the shortcomings of the former calculation scheme.

Concerning the distribution of the intensity of design ice loadings over the surface of the underwater hull portion, the Draft of new CASPPR comes close to the Russian Register Rules, where ice loadings have long been determined depending on the angles of inclination of frames and tangents to water lines in different hull areas. In present-day editions the coefficients of design data distribution by length (zones A, B, C - fig.1) are fairly close for both rules, as well as the ice belt/bottom loadings ratio - with the exception of the after end, where design loadings according to the Russian Register are to reach 75% of loadings on the forebody.

In the Rules of the Norwegian Veritas as well as in the Russian Register a separate classification is adopted for icebreakers. By contrast to the Russian Rules, however, icebreakers are divided not according to purpose, but by areas of operation; for Arctic icebreakers the class definition is supplemented with the term "icebreaker". Ships proper are divided into subclasses by thicknesses of ice to be broken through, and for each class of icebreakers the speed of breaking through ice by ramming is regulated.

The rules of the American Bureau of Shipping (ABS), 1986, contain a common classification series including also icebreakers and cargo ships. They specify areas, time and mode of operation of ice ships in the Arctic basin. Like the Canadian Rules those of ABS contain direct indications of ice conditions, but specifically mention the concentration of ice and give only a general evaluation of conditions - light, medium, heavy, extreme. Only the last estimate applies to ships of Arctic navigation working in ice 1 m thick and over. Areas of operation of ships in Arctic are specified in a very generalized way. For ships of A0, B0, C0 classes intended for operation in first-year ice, characteristics of ice conditions under which modes of navigation are not restricted (C0-light, B0-medium, A0-heavy) are given in combination with an indication of the thickness of ice to be broken through.

For CASPPR the coefficients of longitudinal distribution CF for zones A, B, C are equal to 1; 0.5; 0.8, while in the Russian Rules these values are 1; 0.5-0.6; 0.7-0.75 and in the Norwegian Veritas F = 1; 0.6; 0.6 (0.8 -icebreaker) accordingly for CASPPR - 0.3, in Russian Register 0.25-0.35, in Norwegian Rules - 0.25.

Close are also the ratios between design ice loadings on the hulls of ships of different classes, as specified by national rules for corresponding classification series:

CASPPR, 1989 - 1; 0.8; 0.6; 0.4 for CAC1 - CAC4 series;
Russian Register, 1990 - 1; 0.7; 0.5-0.57; 0.32-0.37 for LL1-LL4;
German Lloyd, 1992 - 1; 0.65-0.68; 0.75-0.79; 0.25 for Arc.1-4;
Norwegian Veritas - 1; 0.6.

Through development and mutual influence, the various national rules may in the end approach each other in the final results of their practical use. Separate deviations in the designation of dimensions, hull areas subject to strengthening, values of ice strengthenings proper, insubmersibility requirements etc., can be noted practically in all Rules.

However, the common character of the operation of transport ships in the Russian and American-Canadian Arctic, as well as the similarity of ice conditions on routes give every reason to determine certain quantitative relations between the requirements to hull ice strengthenings imposed by different classification societies. This assumption is confirmed by the results of preliminary calculations.

COMPARISON OF REQUIREMENTS FOR ICE STRENGTHENINGS OF SHELL PLATING AND HULL FRAMING FOR ICE CLASSES OF LEADING CLASSIFICATION SOCIETIES

In order to assess the possibility of comparing classification requirements of the Russian

Register with those of foreign classification societies concerning the hulls of ships intended for Arctic navigation, comparative calculations were carried out of dimensions of main hull members (framing and shell plating) for three representative ships. The dimensions and hull lines of these ships embraced practically the whole range of those used for cargo transport along the NSR and in the Arctic area of North America.

The ships selected had, over many years, regularly worked on the NSR. Their operation, including effects on the Arctic environment, has been fairly well investigated:

- m/s of *Norilsk* type (ULA, LxBxT = 159.6x24x5x9 m, D=25400 t, N=15.4 MW);
- d/e of *Amguema* type (ULA, LxBxT = 118.4x18.6x7.6 m, D=11300 t, N=5.3 MW);
- m/s of *Pioner* type (L1, LxBxT = 96x15.6x6.9 m, D=7250 t, N=2.4 MW).

Proceeding from the requirements for hulls of ice ships by the Russian Register Rules, 1990, German Lloyds, 1988, 1990, Norwegian Veritas, 1990, British Lloyds, 1989, American Bureau of Shipping, 1986, Canadian CASPPR requirements to the hulls of sea ships, 1972 and 1989 (draft), the design side ice loadings in the area of ice impact (ice belt) as well as corresponding design shell plating thickness values, moments of resistance and cross-section area of transverse framing were determined. To facilitate comparability of results, the same frame spacing (400 mm), yield point of steel (320 MPa) and design frame spans were adopted.

Calculations for icebreaking classes of the Russian Register (classes LL4-LL1) were made on the assumption that power of the propulsion plant is at least equal to minimal design values stipulated in the Register Rules, 1990, for icebreakers of these classes: LL4 (12000 MW); LL3 (22000 MW); LL2 (47800 MW). Corrections were also made of the parameters of the hull shape (frame and stem inclination angles) as applied to the traditional icebreaker shape, so as to bring them into harmony with indicated limitations as regards main engine power.

The comparison was made on the assumption that although the angles of inclination of frames to the vertical at a distance of 0.1 L from the forward perpendicular for the principal types of represented ships (*Norilsk* and *Amguema* types) were accordingly 31 and 37 deg., for ships of the same dimension but of icebreaker classes (icebreaker hull lines) this angle was 50 deg.

When calculating the framing (frames) of light ice class ships, account has to be taken of the difference in calculating schemes adopted in formulas for determining the section modulus of frames in the Rules of the Russian Register (RR) and in the American Bureau of Shipping (ABS) on the one hand and in other national Rules on the other hand, concerning the influence of side stringers and platforms. To take into account this factor, in the calculation of the dimensions of L4-L1 ships frames by the Rules of the Register and American classes a design frame span ships has to be taken larger than in other Rules. This will ensure comparability of calculation results (ratios of section modulus obtained from the Rules formulas).

Results of calculations are presented in tables 1 - 16, and in dimensionless form in tables 9 - 16.

These dimensionless values are obtained by dividing absolute pressure figures and connecting member dimensions by corresponding values determined for an icebreaking cargo vessel of ULA category in the Russian Register Rules. These tables clearly show the discrepancy between the quantitative changes of design loads and connecting member dimensions required by the rules. Therefore conclusions about the conformity of requirements of different national rules may be drawn only on the basis of the analysis of the ratio of dimensions of ice strengthenings determined by these rules.

It can be seen from the comparative tables that there is practically no absolute conformity of all ice strengthening parameters between classes of the Russian Register and foreign rules. This is primarily a result of differences in the requirements concerning after-end strengthenings. Relative increase in the dimensions of framing and shell plating in the after-end of the ice belt in the Russian Register Rules is associated with the domestic experience in operating icebreaking cargo ships and icebreakers during the astern run under complicated ice conditions. Best conformity in results is observed for forebody members.

Table 1

Classification society (ICE CLASS)	D = 25 000 t											
	Bow area				Middle area				Stern area			
	P	W	f	t	P	W	f	t	P	W	f	t
Russian Register, 1990 Power and angles for RR icebreaker classes									l = 2 m			
UL	2.33	447	26	19.8	1.16	325	16	14.0	1.16	325	16	14.0
ULA	4.56	500	69	27.8	2.28	283	37	19.7	3.19	396	52	23.3
LL4	6.08	746	136	32.1	3.65	395	43	24.8	4.56	560	82	27.8
LL3	8.78	1310	118	38.6	5.27	740	52	29.9	6.59	983	88	33.4
LL2	11.67	1904	141	44.4	7.00	1153	91	34.4	8.75	1428	106	38.5
LL1	12.36	2016	150	45.7	7.42	1114	117	35.4	9.27	1512	112	39.6
ABS Power 12 000 kW									l = 2 m			
A0	1.41	149		18.9	0.64	76		13.1	0.49	52		11.4
A1	1.91	205		22.5	0.95	115		16.3	0.95	102		15.7
A2	3.25	354		29.2	1.79	197		21.9	1.95	211		22.0
A3	4.78	527		35.3	2.77	308		27.1	3.10	341		27.5
A4	6.51	725		40.2	3.91	437		31.3	4.56	505		32.5
A5	7.83	877		43.5	4.70	528		33.9	5.87	654		36.4
Power 22 000 kW												
A0	1.41	151		18.9	0.64	76		13.1	0.49	53		11.4
A1	2.15	234		23.7	1.08	130		17.1	1.08	116		16.5
A2	3.67	405		30.7	2.02	225		23.1	2.20	242		23.2
A3	5.39	605		37.2	3.13	352		28.5	3.50	391		29.0
A4	7.35	833		42.4	4.41	499		33.0	5.15	579		34.3
A5	8.84	1008		45.9	5.30	603		35.7	6.63	751		38.4
Power 47 500 kW												
A0	1.41	153		18.9	0.64	77		13.1	0.49	53		11.4
A1	2.51	278		25.3	1.26	154		18.2	1.26	138		17.6
A2	4.28	482		32.8	2.35	266		24.6	2.57	288		24.7
A3	6.29	722		39.6	3.65	417		30.4	4.09	466		31.0
A4	8.58	996		45.3	5.15	593		35.2	6.00	692		36.8
A5	10.31	1206		49.1	6.19	716		38.2	7.73	897		41.2

NOTE TO TABLES 1-16: P - design ice loading, W - section modulus of frame, f - shear area of frame, t - thickness of shell plating l - frame span

Table 2

Classi-fication society (ICE CLASS)	D = 25 000 t											
	Bow area				Middle area				Stern area			
	P	W	f	t	P	W	f	t	P	W	f	t
GL Power 12 000 kW									l = 2 m			
E3 E4	2.62 2.62	874 983		26.1 26.1	1.15 1.35	383 507		18.0 19.3	0.88 1.01	293 380		16.0 17.0
Power 22 000 kW												
E3 E4	2.77 2.77	926 1042		26.8 26.8	1.19 1.40	398 526		18.3 19.6	0.91 1.05	304 395		16.2 17.3
GL'92 Power 12 000 , 22 000 , 47 500 kW									l = 2 m			
Arc1 Arc2 Arc3 Arc4	3.80 5.60 8.50 10.50	935 2153 3719 4594		29.1 35.3 43.5 48.3	2.50 3.80 5.50 6.50	615 1461 2406 2844		23.6 29.1 35.0 38.0	3.00 4.40 6.50 8.50	738 1692 2844 3719		25.8 31.3 38.0 43.5
RL Power 12 000 , 22 000 kW									l = 2 m			
1 A 1 AS AC 1 AC 1.5 AC 2 AC 3	4.51 4.70 5.89 9.27 12.57 17.29	392 441 1069 1700 1870 2040		21.0 21.4 31.9 39.8 46.3 55.1	2.17 2.65 3.77 5.95 8.04 11.33	187 239 687 1094 1203 1312		15.2 16.6 22.3 27.7 32.3 39.0	1.56 2.12 4.77 7.27 10.32 14.15	135 181 773 1229 1352 1475		13.2 15.0 24.4 30.0 35.6 42.5
Power 47 500 kW												
1 A 1 AS AC 1 AC 1.5 AC 2 AC 3	4.51 4.70 5.89 9.27 12.57 17.29	392 441 1044 1660 1826 1992		21.0 21.4 31.3 39.0 45.4 54.0	2.17 2.65 3.77 5.95 8.04 11.33	187 239 658 1049 1153 1258		15.2 16.6 21.6 26.8 31.2 37.7	1.56 2.12 4.77 7.27 10.32 14.15	135 181 741 1179 1296 1414		13.2 15.0 23.6 29.0 34.4 41.1

Table 3

Classi-fication society (ICE CLASS)	D = 25 000 t											
	Bow area				Middle area				Stern area			
	P	W	f	t	P	W	f	t	P	W	f	t
Russian Register, 1990 Power and angles for RR icebreaker classes									l = 2 m			
ULA	4.56	500	69	27.8	2.28	283	37	19.7	3.19	396	52	23.3
[illegible]	6.08	746	136	32.1	3.65	395	43	24.8	4.56	560	82	27.8
[illegible]	8.78	1310	118	38.6	5.27	740	52	29.9	6.59	983	88	33.4
LL2	11.67	1904	141	44.4	7.00	1153	91	34.4	8.75	1428	106	38.5
LL1	12.36	2016	150	45.7	7.42	1114	117	35.4	9.27	1512	112	39.6
CASPPR, 1989 Power 12 000 kW									l = 2 m			
CAC4	6.74	1254	70	25.1	4.50	627	35	20.5	4.50	627	35	20.5
CAC3	10.12	1881	105	30.8	5.75	941	52	23.2	5.75	941	52	23.2
CAC2	13.49	2509	140	35.6	6.74	1254	70	25.1	6.74	1254	70	25.1
CAC1	16.86	3136	175	39.8	8.43	1568	87	28.1	8.43	1568	87	28.1
Power 22 000 kW												
CAC4	6.86	1310	73	25.4	4.50	655	36	20.5	4.50	655	36	20.5
CAC3	10.28	1965	109	31.1	5.75	983	55	23.2	5.75	983	55	23.2
CAC2	13.71	2620	146	35.9	6.86	1310	73	25.4	6.86	1310	73	25.4
CAC1	17.14	3275	182	40.1	8.57	1638	91	28.3	8.57	1638	91	28.3
Power 47 500 kW												
CAC4	7.03	1387	77	25.7	4.50	693	39	20.5	4.50	693	39	20.5
CAC3	10.55	2080	116	31.4	5.75	1040	58	23.2	5.75	1040	58	23.2
CAC2	14.07	2773	155	36.3	7.03	1387	77	25.7	7.03	1387	77	25.7
CAC1	17.58	3466	193	40.6	8.79	1733	97	28.7	8.79	1733	97	28.7

Table 4

Classification society (ICE CLASS)	D = 25 000 t											
	Bow area				Middle area				Stern area			
	P	W	f	t	P	W	f	t	P	W	f	t
Norske Veritas (DNV) Power 12 000 kW									l = 2 m			
1A¯F	2.62	983		26.1	1.35	507		19.3	1.01	380		17.0
ICE 05	4.20	683	26	29.2	2.52	410	16	23.1	2.52	410	16	23.1
ICE 10	5.60	1192	49	34.5	3.36	715	30	27.2	3.36	715	30	27.2
ICE 15	7.00	1685	76	37.9	4.20	1011	45	29.8	4.20	1011	45	29.8
Polar10	7.00	1490	62	38.3	4.20	894	37	30.1	4.20	894	37	30.1
Polar20	8.50	2178	106	40.5	5.10	1307	64	31.8	5.10	1307	64	31.8
Polar30	10.00	2644	153	39.7	6.00	1586	92	31.2	6.00	1586	92	31.2
Power 22 000 kW												
1A¯F	2.77	1042		26.8	1.40	526		19.7	1.05	395		17.3
ICE 05	4.20	683	26	29.2	2.52	410	16	23.1	2.52	410	16	23.1
ICE 10	5.60	1192	49	34.5	3.36	715	30	27.2	3.36	715	30	27.2
ICE 15	7.00	1685	76	37.9	4.20	1011	45	29.8	4.20	1011	45	29.8
Polar10	7.00	1490	62	38.3	4.20	894	37	30.1	4.20	894	37	30.1
Polar20	8.50	2178	106	40.5	5.10	1307	64	31.8	5.10	1307	64	31.8
Polar30	10.00	2644	153	39.7	6.00	1586	92	31.2	6.00	1586	92	31.2
Power 47 500 kW												
1A¯F	3.05	1147		28.1	1.49	561		20.2	1.12	421		17.8
ICE 05	4.20	683	26	29.2	2.52	410	16	23.1	2.52	410	16	23.1
ICE 10	5.60	1192	49	34.5	3.36	715	30	27.2	3.36	715	30	27.2
ICE 15	7.00	1685	76	37.9	4.20	1011	45	29.8	4.20	1011	45	29.8
Polar10	7.00	1490	62	38.3	4.20	894	37	30.1	4.20	894	37	30.1
Polar20	8.50	2178	106	40.5	5.10	1307	64	31.8	5.10	1307	64	31.8
Polar30	10.00	2644	153	39.7	6.00	1586	92	31.2	6.00	1586	92	31.2

Table 5

Classification society (ICE CLASS)	D = 11 000 t											
	Bow area				Middle area				Stern area			
	P	W	f	t	P	W	f	t	P	W	f	t
Russian Register, 1990 Power and angles for RR icebreaker classes									l = 2 m			
UL	1.77	314	18	17.3	0.88	226	11	12.2	0.88	226	11	12.2
ULA	3.46	361	48	24.2	1.73	204	24	17.1	2.42	286	34	20.3
LL4	5.31	578	91	30.0	3.19	345	38	23.2	3.98	434	54	26.0
LL3	7.67	1025	79	36.0	4.60	647	46	27.9	5.76	769	59	31.2
LL2	10.20	1505	94	41.5	6.12	1007	79	32.2	7.65	1129	71	36.0
LL1	10.80	1595	100	42.8	6.48	973	102	33.1	8.10	1196	75	37.0
ABS Power 12 000 kW									l = 2 m			
A0	1.21	127		17.8	0.55	65		12.3	0.42	44		10.7
A1	1.71	181		21.5	0.86	102		15.6	0.86	90		15.0
A2	2.92	314		27.9	1.61	175		21.0	1.75	187		21.0
A3	4.31	469		33.9	2.50	276		26.0	2.80	303		26.4
A4	5.89	646		38.6	3.54	392		30.0	4.13	450		31.2
A5	7.10	782		41.8	4.26	473		32.5	5.33	583		34.9
Power 22 000 kW												
A0	1.21	128		17.8	0.55	65		12.3	0.42	45		10.7
A1	1.93	207		22.6	0.97	116		16.4	0.97	103		15.8
A2	3.30	358		29.4	1.81	200		22.1	1.98	214		22.1
A3	4.87	537		35.6	2.82	314		27.3	3.16	347		27.8
A4	6.65	740		40.6	3.99	446		31.6	4.66	515		32.9
A5	8.02	897		44.0	4.81	540		34.2	6.01	669		36.8
Power 47 500 kW												
A0	1.21	130		17.8	0.55	65		12.3	0.42	45		10.7
A1	2.25	245		24.1	1.13	137		17.4	1.13	122		16.8
A2	3.84	426		31.3	2.11	236		23.5	2.31	254		23.6
A3	5.68	639		38.0	3.29	371		29.1	3.69	413		29.7
A4	7.76	883		43.4	4.66	529		33.8	5.43	614		35.2
A5	9.35	1070		47.0	5.61	640		36.6	7.01	797		39.4

Table 6

Classification society (ICE CLASS)	D = 11 000 t											
	Bow area				Middle area				Stern area			
	P	W	f	t	P	W	f	t	P	W	f	t
GL Power 12 000 kW									l = 2 m			
E3	2.43	813		25.3	1.10	366		17.6	0.84	280		15.7
E4	2.43	915		25.3	1.29	485		18.9	0.97	364		16.7
Power 22 000 kW												
E3	2.57	860		25.9	1.13	379		17.9	0.87	290		15.9
E4	2.57	967		25.9	1.33	501		19.2	1.00	376		16.9
GL'92 Power 12 000 , 22 000 , 47 500 kW									l = 2 m			
Arc1	3.80	935		29.1	2.50	615		23.6	3.00	738		25.8
Arc2	5.60	2153		35.3	3.80	1461		29.1	4.40	1692		31.3
Arc3	8.50	3719		43.5	5.50	2406		35.0	6.50	2844		38.0
Arc4	10.50	4594		48.3	6.50	2844		38.0	8.50	3719		43.5
RL Power 12 000 , 22 000 kW									l = 2 m			
1 A	4.44	385		20.8	2.05	177		14.8	1.48	127		12.9
1 AS	4.62	433		21.2	2.50	226		16.2	2.00	172		14.7
AC 1	5.89	1045		31.3	3.77	672		21.9	4.77	755		24.0
AC 1.5	9.27	1662		39.0	5.95	1069		27.2	7.27	1202		29.5
AC 2	12.57	1828		45.4	8.04	1176		31.7	10.32	1322		35.0
AC 3	17.29	1994		54.1	11.33	1283		38.3	14.15	1442		41.7
Power 47 500 kW												
1 A	4.51	392		21.0	2.17	187		15.2	1.56	135		13.2
1 AS	4.70	441		21.4	2.65	239		16.6	2.12	181		15.0
AC 1	5.89	1077		32.1	3.77	690		22.4	4.77	776		24.5
AC 1.5	9.27	1712		40.0	5.95	1098		27.8	7.27	1234		30.1
AC 2	12.57	1883		46.6	8.04	1208		32.4	10.32	1358		35.7
AC 3	17.29	2054		55.4	11.33	1317		39.1	14.15	1481		42.6

Table 7

Classification society (ICE CLASS)	D = 11 000 t											
	Bow area				Middle area				Stern area			
	P	W	f	t	P	W	f	t	P	W	f	t
Russian Register, 1990 Power and angles for RR icebreaker classes									l = 2 m			
ULA	3.46	361	48	24.2	1.73	204	24	17.1	2.42	286	34	20.3
LL4	5.31	578	91	30.0	3.19	345	38	23.2	3.98	434	54	26.0
LL3	7.67	1025	79	36.0	4.60	647	46	27.9	5.76	769	59	31.2
LL2	10.20	1505	94	41.5	6.12	1007	79	32.2	7.65	1129	71	36.0
LL1	10.80	1595	100	42.8	6.48	973	102	33.1	8.10	1196	75	37.0
CASPPR, 1989 Power 12 000 kW									l = 2 m			
CAC4	6.30	973	54	24.3	4.50	486	27	20.5	4.50	486	27	20.5
CAC3	9.45	1459	81	29.8	5.75	729	40	23.2	5.75	729	40	23.2
CAC2	12.60	1945	108	34.4	6.30	973	54	24.3	6.30	973	54	24.3
CAC1	15.74	2431	135	38.4	7.87	1216	67	27.2	7.87	1216	67	27.2
Power 22 000 kW												
CAC4	6.36	1029	57	24.4	4.50	515	29	20.5	4.50	515	29	20.5
CAC3	9.54	1544	86	29.9	5.75	772	43	23.2	5.75	772	43	23.2
CAC2	12.72	2058	114	34.5	6.36	1029	57	24.4	6.36	1029	57	24.4
CAC1	15.91	2573	143	38.6	7.95	1286	71	27.3	7.95	1286	71	27.3
Power 47 500 kW												
CAC4	6.46	1109	62	24.6	4.50	554	31	20.5	4.50	554	31	20.5
CAC3	9.70	1663	92	30.2	5.75	831	46	23.2	5.75	831	46	23.2
CAC2	12.93	2217	123	34.8	6.46	1109	62	24.6	6.46	1109	62	24.6
CAC1	16.16	2772	154	38.9	8.08	1386	77	27.5	8.08	1386	77	27.5

Table 8

Classification society (ICE CLASS)	D = 11 000 t											
	Bow area				Middle area				Stern area			
	P	W	f	t	P	W	f	t	P	W	f	t
Norske Veritas (DNV) Power 12 000 kW									l = 2 m			
1A¯F	2.43	915		25.3	1.29	485		18.9	0.97	364		16.7
ICE 05	4.20	683	26	29.2	2.52	410	16	23.1	2.52	410	16	23.1
ICE 10	5.60	1192	49	34.5	3.36	715	30	27.2	3.36	715	30	27.2
ICE 15	7.00	1685	76	37.9	4.20	1011	45	29.8	4.20	1011	45	29.8
Polar10	7.00	1490	62	38.3	4.20	894	37	30.1	4.20	894	37	30.1
Polar20	8.50	2178	106	40.5	5.10	1307	64	31.8	5.10	1307	64	31.8
Polar30	10.00	2644	153	39.7	6.00	1586	92	31.2	6.00	1586	92	31.2
Power 22 000 kW												
1A¯F	2.57	967		25.9	1.33	501		19.2	1.00	376		16.9
ICE 05	4.20	683	26	29.2	2.52	410	16	23.1	2.52	410	16	23.1
ICE 10	5.60	1192	49	34.5	3.36	715	30	27.2	3.36	715	30	27.2
ICE 15	7.00	1685	76	37.9	4.20	1011	45	29.8	4.20	1011	45	29.8
Polar10	7.00	1490	62	38.3	4.20	894	37	30.1	4.20	894	37	30.1
Polar20	8.50	2178	106	40.5	5.10	1307	64	31.8	5.10	1307	64	31.8
Polar30	10.00	2644	153	39.7	6.00	1586	92	31.2	6.00	1586	92	31.2
Power 47 500 kW												
1A¯F	2.76	1037		26.8	1.40	525		19.6	1.05	394		17.3
ICE 05	4.20	683	26	29.2	2.52	410	16	23.1	2.52	410	16	23.1
ICE 10	5.60	1192	49	34.5	3.36	715	30	27.2	3.36	715	30	27.2
ICE 15	7.00	1685	76	37.9	4.20	1011	45	29.8	4.20	1011	45	29.8
Polar10	7.00	1490	62	38.3	4.20	894	37	30.1	4.20	894	37	30.1
Polar20	8.50	2178	106	40.5	5.10	1307	64	31.8	5.10	1307	64	31.8
Polar30	10.00	2644	153	39.7	6.00	1586	92	31.2	6.00	1586	92	31.2

Table 9

Classi- fication society (ICE CLASS)	D = 25 000 t											
	Bow area				Middle area				Stern area			
	P	W	f	t	P	W	f	t	P	W	f	t
Russian Register, 1990 Power and angles for RR icebreaker classes										l = 2 m		
UL	0.51	0.9	0.37	0.71	0.51	1.2	0.43	0.71	0.36	0.8	0.31	0.60
ULA	1.00	1.0	1.00	1.00	1.00	1.0	1.00	1.00	1.00	1.0	1.00	1.00
LL4	1.33	1.5	1.97	1.15	1.60	1.4	1.17	1.26	1.43	1.4	1.58	1.19
LL3	1.93	2.6	1.70	1.39	2.31	2.6	1.42	1.52	2.06	2.5	1.71	1.44
LL2	2.56	3.8	2.05	1.60	3.07	4.1	2.46	1.75	2.74	3.6	2.05	1.66
LL1	2.71	4.0	2.17	1.65	3.25	3.9	3.17	1.80	2.90	3.8	2.17	1.70
ABS Power 12 000 kW										l = 2 m		
A0	0.31	0.3		0.68	0.28	0.3		0.67	0.15	0.1		0.49
A1	0.42	0.4		0.81	0.42	0.4		0.83	0.30	0.3		0.68
A2	0.71	0.7		1.05	0.78	0.7		1.12	0.61	0.5		0.95
A3	1.05	1.1		1.27	1.21	1.1		1.38	0.97	0.9		1.18
A4	1.43	1.5		1.45	1.71	1.5		1.59	1.43	1.3		1.40
A5	1.72	1.8		1.57	2.06	1.9		1.72	1.84	1.7		1.57
Power 22 000 kW												
A0	0.31	0.3		0.68	0.28	0.3		0.67	0.15	0.1		0.49
A1	0.47	0.5		0.85	0.47	0.5		0.87	0.34	0.3		0.71
A2	0.80	0.8		1.10	0.88	0.8		1.17	0.69	0.6		1.00
A3	1.18	1.2		1.34	1.37	1.2		1.45	1.10	1.0		1.25
A4	1.61	1.7		1.52	1.93	1.8		1.68	1.61	1.5		1.48
A5	1.94	2.0		1.65	2.32	2.1		1.82	2.08	1.9		1.65
Power 47 500 kW												
A0	0.31	0.3		0.68	0.28	0.3		0.67	0.15	0.1		0.49
A1	0.55	0.6		0.91	0.55	0.5		0.93	0.39	0.3		0.76
A2	0.94	1.0		1.18	1.03	0.9		1.25	0.80	0.7		1.06
A3	1.38	1.4		1.43	1.60	1.5		1.55	1.28	1.2		1.33
A4	1.88	2.0		1.63	2.26	2.1		1.79	1.88	1.7		1.58
A5	2.26	2.4		1.77	2.71	2.5		1.94	2.42	2.3		1.77

Table 10

Classi-fication society (ICE CLASS)	D = 25 000 t											
	Bow area				Middle area				Stern area			
	P	W	f	t	P	W	f	t	P	W	f	t
GL Power 12 000 kW									l = 2 m			
E3	0.57	1.7		0.94	0.50	1.4		0.91	0.27	0.7		0.69
E4	0.57	2.0		0.94	0.59	1.8		0.98	0.32	1.0		0.73
Power 22 000 kW												
E3	0.61	1.9		0.97	0.52	1.4		0.93	0.28	0.8		0.70
E4	0.61	2.1		0.97	0.61	1.9		1.00	0.33	1.0		0.74
GL'92 Power 12 000 , 22 000 , 47 500 kW									l = 2 m			
Arc1	0.83	1.9		1.05	1.10	2.2		1.20	0.94	1.9		1.11
Arc2	1.23	4.3		1.27	1.67	5.2		1.48	1.38	4.3		1.35
Arc3	1.86	7.4		1.56	2.41	8.5		1.78	2.04	7.2		1.64
Arc4	2.30	9.2		1.74	2.85	10.1		1.94	2.66	9.4		1.87
RL Power 12 000 , 22 000 kW									l = 2 m			
1 A	0.99	0.8		0.76	0.95	0.7		0.77	0.49	0.3		0.57
1 AS	1.03	0.9		0.77	1.16	0.8		0.84	0.66	0.5		0.65
AC 1	1.29	2.1		1.15	1.65	2.4		1.13	1.49	2.0		1.05
AC 1.5	2.03	3.4		1.43	2.61	3.9		1.41	2.28	3.1		1.29
AC 2	2.76	3.7		1.67	3.53	4.3		1.64	3.23	3.4		1.53
AC 3	3.79	4.1		1.98	4.97	4.6		1.98	4.43	3.7		1.83
Power 47 500 kW												
1 A	0.99	0.8		0.76	0.95	0.7		0.77	0.49	0.3		0.57
1 AS	1.03	0.9		0.77	1.16	0.8		0.84	0.66	0.5		0.65
AC 1	1.29	2.1		1.13	1.65	2.3		1.10	1.49	1.9		1.02
AC 1.5	2.03	3.3		1.40	2.61	3.7		1.37	2.28	3.0		1.25
AC 2	2.76	3.7		1.63	3.53	4.1		1.59	3.23	3.3		1.48
AC 3	3.79	4.0		1.94	4.97	4.4		1.92	4.43	3.6		1.77

Table 11

Classification society (ICE CLASS)	D = 25 000 t											
	Bow area				Middle area				Stern area			
	P	W	f	t	P	W	f	t	P	W	f	t
Russian Register, 1990 Power and angles for RR icebreaker classes									l = 2 m			
ULA	1.00	1.0	1.00	1.00	1.00	1.0	1.00	1.00	1.00	1.0	1.00	1.00
LL4	1.33	1.5	1.97	1.15	1.60	1.4	1.17	1.26	1.43	1.4	1.58	1.19
LL3	1.93	2.6	1.70	1.39	2.31	2.6	1.42	1.52	2.06	2.5	1.71	1.44
LL2	2.56	3.8	2.05	1.60	3.07	4.1	2.46	1.75	2.74	3.6	2.05	1.66
LL1	2.71	4.0	2.17	1.65	3.25	3.9	3.17	1.80	2.90	3.8	2.17	1.70
CASPPR, 1989 Power 12 000 kW									l = 2 m			
CAC4	1.48	2.5	1.01	0.90	1.97	2.2	0.94	1.05	1.41	1.6	0.67	0.88
CAC3	2.22	3.8	1.51	1.11	2.52	3.3	1.42	1.18	1.80	2.4	1.01	1.00
CAC2	2.96	5.0	2.02	1.28	2.96	4.4	1.89	1.28	2.11	3.2	1.35	1.08
CAC1	3.70	6.3	2.52	1.43	3.70	5.5	2.36	1.43	2.64	4.0	1.69	1.21
Power 22 000 kW												
CAC4	1.50	2.6	1.06	0.91	1.97	2.3	0.99	1.05	1.41	1.7	0.71	0.88
CAC3	2.25	3.9	1.58	1.12	2.52	3.5	1.48	1.18	1.80	2.5	1.06	1.00
CAC2	3.01	5.2	2.11	1.29	3.01	4.6	1.97	1.29	2.15	3.3	1.41	1.09
CAC1	3.76	6.6	2.64	1.44	3.76	5.8	2.47	1.44	2.68	4.1	1.76	1.22
Power 47 500 kW												
CAC4	1.54	2.8	1.12	0.92	1.97	2.5	1.05	1.05	1.41	1.8	0.75	0.88
CAC3	2.31	4.2	1.68	1.13	2.52	3.7	1.57	1.18	1.80	2.6	1.12	1.00
CAC2	3.08	5.5	2.24	1.31	3.08	4.9	2.09	1.31	2.20	3.5	1.49	1.10
CAC1	3.85	6.9	2.80	1.46	3.85	6.1	2.61	1.46	2.75	4.4	1.87	1.23

Table 12

Classification society (ICE CLASS)	D = 25 000 t											
	Bow area				Middle area				Stern area			
	P	W	f	t	P	W	f	t	P	W	f	t
Norske Veritas (DNV) Power 12 000 kW										l = 2 m		
1A~F	0.57	2.0		0.94	0.59	1.8		0.98	0.32	1.0		0.73
ICE 05	0.92	1.4	0.38	1.05	1.10	1.4	0.43	1.18	0.79	1.0	0.30	0.99
ICE 10	1.23	2.4	0.71	1.24	1.47	2.5	0.80	1.38	1.05	1.8	0.57	1.17
ICE 15	1.53	3.4	1.09	1.36	1.84	3.6	1.23	1.52	1.32	2.6	0.88	1.28
Polar10	1.53	3.0	0.89	1.38	1.84	3.2	1.00	1.53	1.32	2.3	0.72	1.30
Polar20	1.86	4.4	1.53	1.46	2.24	4.6	1.72	1.62	1.60	3.3	1.23	1.37
Polar30	2.19	5.3	2.21	1.43	2.63	5.6	2.48	1.59	1.88	4.0	1.77	1.34
Power 22 000 kW												
1A~F	0.61	2.1		0.97	0.61	1.9		1.00	0.33	1.0		0.74
ICE 05	0.92	1.4	0.38	1.05	1.10	1.4	0.43	1.18	0.79	1.0	0.30	0.99
ICE 10	1.23	2.4	0.71	1.24	1.47	2.5	0.80	1.38	1.05	1.8	0.57	1.17
ICE 15	1.53	3.4	1.09	1.36	1.84	3.6	1.23	1.52	1.32	2.6	0.88	1.28
Polar10	1.53	3.0	0.89	1.38	1.84	3.2	1.00	1.53	1.32	2.3	0.72	1.30
Polar20	1.86	4.4	1.53	1.46	2.24	4.6	1.72	1.62	1.60	3.3	1.23	1.37
Polar30	2.19	5.3	2.21	1.43	2.63	5.6	2.48	1.59	1.88	4.0	1.77	1.34
Power 47 500 kW												
1A~F	0.67	2.3		1.01	0.65	2.0		1.03	0.35	1.1		0.77
ICE 05	0.92	1.4	0.38	1.05	1.10	1.4	0.43	1.18	0.79	1.0	0.30	0.99
ICE 10	1.23	2.4	0.71	1.24	1.47	2.5	0.80	1.38	1.05	1.8	0.57	1.17
ICE 15	1.53	3.4	1.09	1.36	1.84	3.6	1.23	1.52	1.32	2.6	0.88	1.28
Polar10	1.53	3.0	0.89	1.38	1.84	3.2	1.00	1.53	1.32	2.3	0.72	1.30
Polar20	1.86	4.4	1.53	1.46	2.24	4.6	1.72	1.62	1.60	3.3	1.23	1.37
Polar30	2.19	5.3	2.21	1.43	2.63	5.6	2.48	1.59	1.88	4.0	1.77	1.34

Table 13

Classification society (ICE CLASS)	D = 11 000 t											
	Bow area				Middle area				Stern area			
	P	W	f	t	P	W	f	t	P	W	f	t
Russian Register, 1990 Power and angles for RR icebreaker classes										l = 2 m		
UL	0.51	0.9	0.37	0.71	0.51	1.1	0.45	0.71	0.36	0.8	0.32	0.60
ULA	1.00	1.0	1.00	1.00	1.00	1.0	1.00	1.00	1.00	1.0	1.00	1.00
LL4	1.53	1.6	1.89	1.24	1.84	1.7	1.55	1.36	1.64	1.5	1.59	1.28
LL3	2.22	2.8	1.64	1.49	2.66	3.2	1.88	1.63	2.37	2.7	1.73	1.54
LL2	2.94	4.2	1.96	1.72	3.53	4.9	3.26	1.88	3.15	3.9	2.07	1.78
LL1	3.12	4.4	2.08	1.77	3.74	4.8	4.19	1.93	3.34	4.2	2.20	1.83
ABS Power 12 000 kW										l = 2 m		
A0	0.35	0.4		0.73	0.32	0.3		0.72	0.18	0.2		0.53
A1	0.49	0.5		0.89	0.49	0.5		0.91	0.35	0.3		0.74
A2	0.84	0.9		1.15	0.93	0.9		1.23	0.72	0.7		1.04
A3	1.25	1.3		1.40	1.44	1.3		1.52	1.16	1.1		1.30
A4	1.70	1.8		1.59	2.04	1.9		1.75	1.70	1.6		1.54
A5	2.05	2.2		1.72	2.46	2.3		1.90	2.20	2.0		1.72
Power 22 000 kW												
A0	0.35	0.4		0.73	0.32	0.3		0.72	0.18	0.2		0.53
A1	0.56	0.6		0.94	0.56	0.6		0.96	0.40	0.4		0.78
A2	0.95	1.0		1.21	1.05	1.0		1.29	0.82	0.7		1.09
A3	1.41	1.5		1.47	1.63	1.5		1.60	1.31	1.2		1.37
A4	1.92	2.1		1.68	2.31	2.2		1.85	1.92	1.8		1.62
A5	2.32	2.5		1.82	2.78	2.6		2.00	2.48	2.3		1.82
Power 47 500 kW												
A0	0.35	0.4		0.73	0.32	0.3		0.72	0.18	0.2		0.53
A1	0.65	0.7		1.00	0.65	0.7		1.02	0.46	0.4		0.83
A2	1.11	1.2		1.29	1.22	1.2		1.37	0.95	0.9		1.17
A3	1.64	1.8		1.57	1.90	1.8		1.70	1.52	1.4		1.46
A4	2.24	2.4		1.79	2.69	2.6		1.97	2.24	2.1		1.74
A5	2.70	3.0		1.94	3.24	3.1		2.14	2.89	2.8		1.95

Table 14

Classi-fication society (ICE CLASS)	D = 11 000 t											
	Bow area				Middle area				Stern area			
	P	W	f	t	P	W	f	t	P	W	f	t
GL Power 12 000 kW									l = 2 m			
E3	0.70	2.3		1.04	0.63	1.8		1.03	0.35	1.0		0.77
E4	0.70	2.5		1.04	0.75	2.4		1.11	0.40	1.3		0.82
Power 22 000 kW												
E3	0.74	2.4		1.07	0.65	1.9		1.04	0.36	1.0		0.78
E4	0.74	2.7		1.07	0.77	2.5		1.12	0.41	1.3		0.84
GL'92 Power 12 000 , 22 000 , 47 500 kW									l = 2 m			
Arc1	1.10	2.6		1.20	1.44	3.0		1.38	1.24	2.6		1.28
Arc2	1.62	6.0		1.46	2.19	7.2		1.70	1.81	5.9		1.54
Arc3	2.45	10.3		1.80	3.18	11.8		2.04	2.68	9.9		1.88
Arc4	3.03	12.7		2.00	3.75	13.9		2.22	3.51	13.0		2.15
RL Power 12 000 , 22 000 kW									l = 2 m			
1 A	1.28	1.1		0.86	1.19	0.9		0.87	0.61	0.4		0.64
1 AS	1.33	1.2		0.88	1.45	1.1		0.94	0.83	0.6		0.72
AC 1	1.70	2.9		1.29	2.18	3.3		1.28	1.97	2.6		1.19
AC 1.5	2.68	4.6		1.61	3.44	5.2		1.59	3.00	4.2		1.45
AC 2	3.63	5.1		1.88	4.65	5.8		1.85	4.26	4.6		1.73
AC 3	4.99	5.5		2.23	6.54	6.3		2.24	5.84	5.0		2.06
Power 47 500 kW												
1 A	1.30	1.1		0.87	1.25	0.9		0.89	0.64	0.5		0.65
1 AS	1.36	1.2		0.88	1.53	1.2		0.97	0.87	0.6		0.74
AC 1	1.70	3.0		1.33	2.18	3.4		1.31	1.97	2.7		1.21
AC 1.5	2.68	4.7		1.65	3.44	5.4		1.62	3.00	4.3		1.49
AC 2	3.63	5.2		1.92	4.65	5.9		1.89	4.26	4.7		1.76
AC 3	4.99	5.7		2.29	6.54	6.5		2.28	5.84	5.2		2.10

Table 15

Classification society (ICE CLASS)	D = 11 000 t											
	Bow area				Middle area				Stern area			
	P	W	f	t	P	W	f	t	P	W	f	t
Russian Register, 1990 Power and angles for RR icebreaker classes									l = 2 m			
ULA	1.00	1.0	1.00	1.00	1.00	1.0	1.00	1.00	1.00	1.0	1.00	1.00
LL4	1.53	1.6	1.89	1.24	1.84	1.7	1.55	1.36	1.64	1.5	1.59	1.28
LL3	2.22	2.8	1.64	1.49	2.66	3.2	1.88	1.63	2.37	2.7	1.73	1.54
LL2	2.94	4.2	1.96	1.72	3.53	4.9	3.26	1.88	3.15	3.9	2.07	1.78
LL1	3.12	4.4	2.08	1.77	3.74	4.8	4.19	1.93	3.34	4.2	2.20	1.83
CASPPR, 1989 Power 12 000 kW									l = 2 m			
CAC4	1.82	2.7	1.12	1.00	2.60	2.4	1.11	1.20	1.86	1.7	0.79	1.01
CAC3	2.73	4.0	1.69	1.23	3.32	3.6	1.66	1.36	2.37	2.6	1.19	1.15
CAC2	3.64	5.4	2.25	1.42	3.64	4.8	2.21	1.42	2.60	3.4	1.58	1.20
CAC1	4.55	6.7	2.81	1.59	4.55	6.0	2.77	1.59	3.25	4.3	1.98	1.34
Power 22 000 kW												
CAC4	1.84	2.9	1.19	1.01	2.60	2.5	1.17	1.20	1.86	1.8	0.84	1.01
CAC3	2.76	4.3	1.78	1.24	3.32	3.8	1.76	1.36	2.37	2.7	1.25	1.15
CAC2	3.67	5.7	2.38	1.43	3.67	5.0	2.34	1.43	2.62	3.6	1.67	1.21
CAC1	4.59	7.1	2.97	1.59	4.59	6.3	2.93	1.59	3.28	4.5	2.09	1.35
Power 47 500 kW												
CAC4	1.87	3.1	1.28	1.02	2.60	2.7	1.26	1.20	1.86	1.9	0.90	1.01
CAC3	2.80	4.6	1.92	1.25	3.32	4.1	1.89	1.36	2.37	2.9	1.35	1.15
CAC2	3.73	6.1	2.56	1.44	3.73	5.4	2.53	1.44	2.67	3.9	1.80	1.22
CAC1	4.67	7.7	3.21	1.61	4.67	6.8	3.16	1.61	3.33	4.8	2.25	1.36

Table 16

Classification society (ICE CLASS)	D = 11 000 t											
	Bow area				Middle area				Stern area			
	P	W	f	t	P	W	f	t	P	W	f	t
Norske Veritas (DNV) Power 12 000 kW									l = 2 m			
1A¯F	0.70	2.5		1.04	0.75	2.4		1.11	0.40	1.3		0.82
ICE 05	1.21	1.9	0.55	1.21	1.46	2.0	0.64	1.35	1.04	1.4	0.46	1.14
ICE 10	1.62	3.3	1.03	1.42	1.94	3.5	1.22	1.59	1.39	2.5	0.87	1.34
ICE 15	2.02	4.7	1.57	1.57	2.43	5.0	1.86	1.74	1.73	3.5	1.33	1.47
Polar10	2.02	4.1	1.29	1.58	2.43	4.4	1.52	1.76	1.73	3.1	1.08	1.49
Polar20	2.45	6.0	2.21	1.67	2.95	6.4	2.61	1.86	2.10	4.6	1.86	1.57
Polar30	2.89	7.3	3.18	1.64	3.46	7.8	3.76	1.82	2.47	5.5	2.68	1.54
Power 22 000 kW												
1A¯F	0.74	2.7		1.07	0.77	2.5		1.12	0.41	1.3		0.84
ICE 05	1.21	1.9	0.55	1.21	1.46	2.0	0.64	1.35	1.04	1.4	0.46	1.14
ICE 10	1.62	3.3	1.03	1.42	1.94	3.5	1.22	1.59	1.39	2.5	0.87	1.34
ICE 15	2.02	4.7	1.57	1.57	2.43	5.0	1.86	1.74	1.73	3.5	1.33	1.47
Polar10	2.02	4.1	1.29	1.58	2.43	4.4	1.52	1.76	1.73	3.1	1.08	1.49
Polar20	2.45	6.0	2.21	1.67	2.95	6.4	2.61	1.86	2.10	4.6	1.86	1.57
Polar30	2.89	7.3	3.18	1.64	3.46	7.8	3.76	1.82	2.47	5.5	2.68	1.54
Power 47 500 kW												
1A¯F	0.80	2.9		1.11	0.81	2.6		1.15	0.43	1.4		0.85
ICE 05	1.21	1.9	0.55	1.21	1.46	2.0	0.64	1.35	1.04	1.4	0.46	1.14
ICE 10	1.62	3.3	1.03	1.42	1.94	3.5	1.22	1.59	1.39	2.5	0.87	1.34
ICE 15	2.02	4.7	1.57	1.57	2.43	5.0	1.86	1.74	1.73	3.5	1.33	1.47
Polar10	2.02	4.1	1.29	1.58	2.43	4.4	1.52	1.76	1.73	3.1	1.08	1.49
Polar20	2.45	6.0	2.21	1.67	2.95	6.4	2.61	1.86	2.10	4.6	1.86	1.57
Polar30	2.89	7.3	3.18	1.64	3.46	7.8	3.76	1.82	2.47	5.5	2.68	1.54

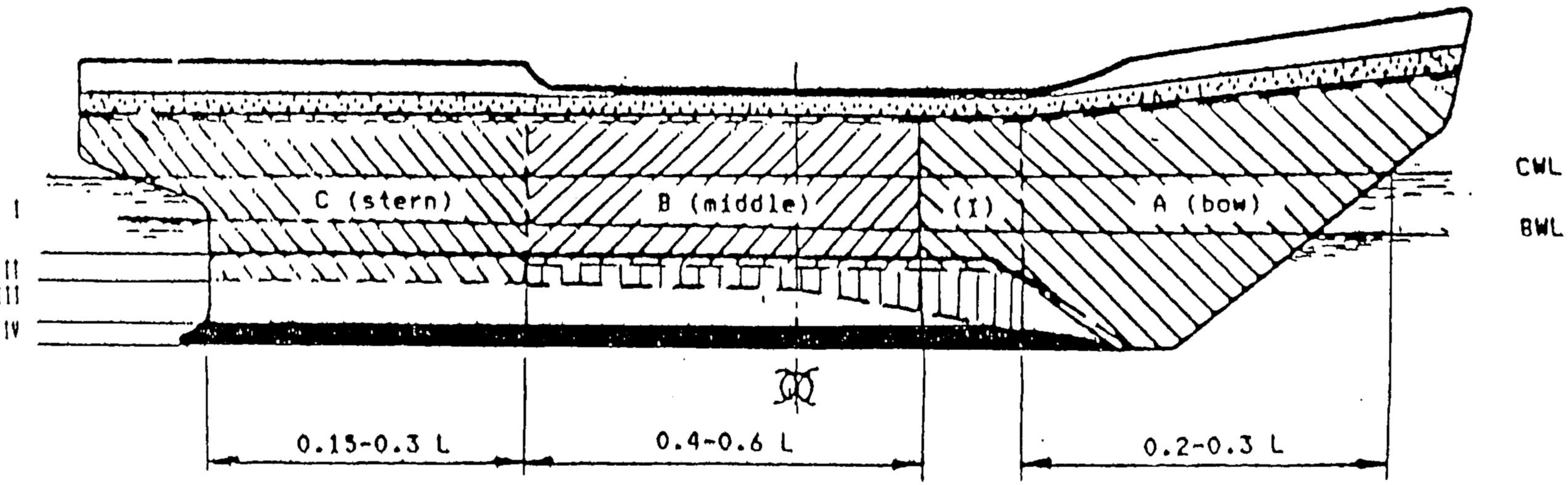

Fig.1 Distribution of ice strengthening of the hull. (Russian Register and CASPPR)

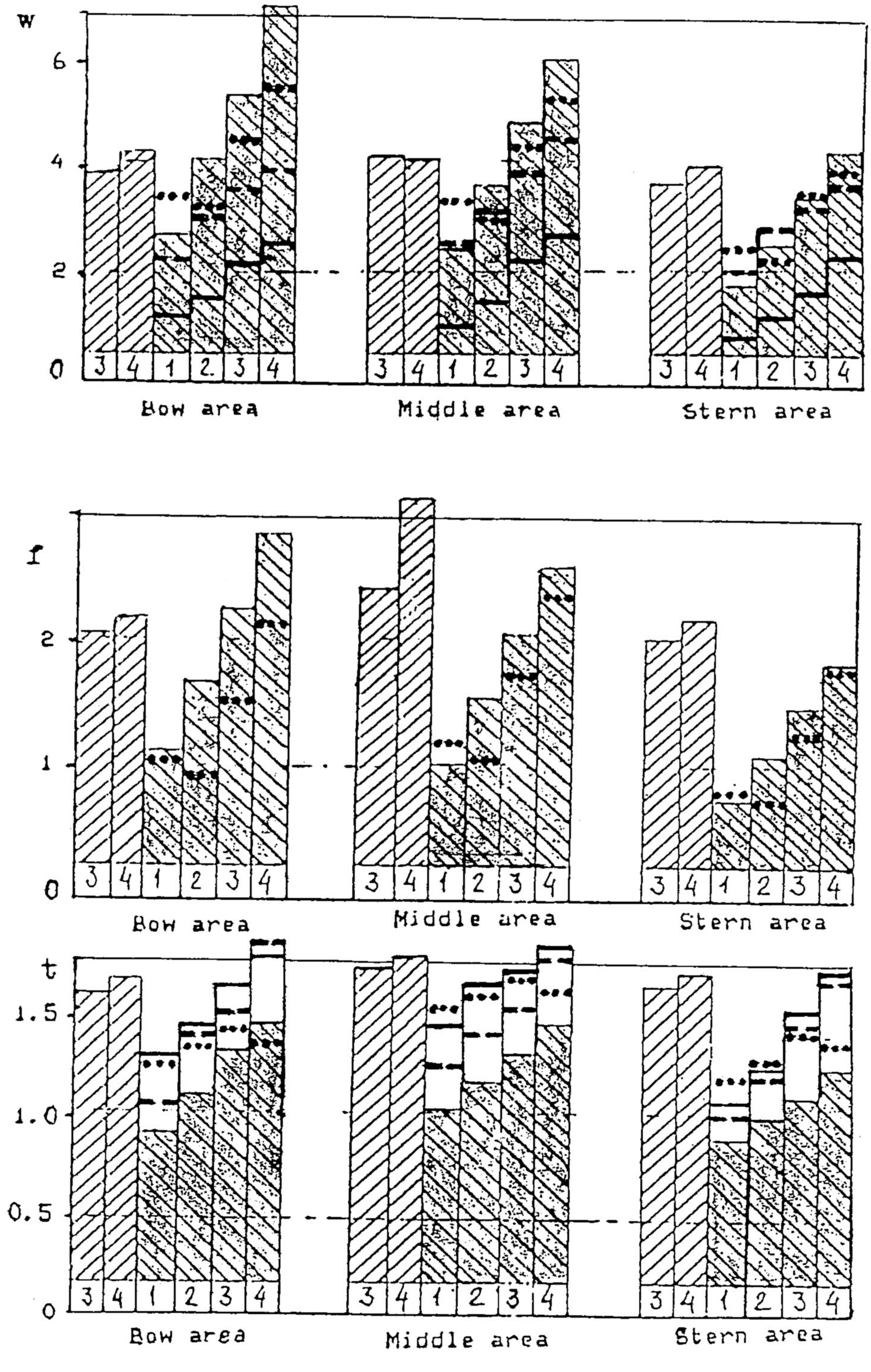

Fig. 2 Comparison of requirements of different Rules concerning plate thickness and ice belt framing of icebreaking ships at engine power of 47 500 kW, D = 25 000 t

1 -LL4 2 -LL3 3 -LL2 4 -LL1

1 -CAC4 2 -CAC3 3 -CAC2 4 -CAC1

—— ABS (A2-A5), ▬ ▬ RL (AC1-AC3), ••• DNV(ICE15-Polar30)

I.1.2.8 ICE ACCIDENT RATE
REGISTRATION AND ANALYSIS OF ICE ACCIDENTS

KEY PERSONNEL

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SUMMARY

In 1993, statistical data on ice accidents on the NSR and the state regulations on ice accident reports were systemized and analyzed. This research was performed for future improvement in the following directions:

- elaboration of principles for state regulation of the ice accidents interaction system;
- definition of ice danger regions;
- analysis of hydrographic, meteorological, ice-breaker, pilot and other services for life-saving and environmental protection purposes on the NSR.

KEY WORDS

CASUALTY, ICE DAMAGES, DANGER REGIONS, MARINE ACCIDENT.

INTRODUCTION

The purpose of this work, executed in 1993, was the preliminary arrangement of information on the accident rate of vessels sailing the NSR.

THE JURIDICAL-LEGAL BASE

According to the Code of Trade Navigation and the laws regulating trade navigation of the USSR (their parts not contradicting the laws of the Russian Federation), investigation of accidents is to be carried out by the harbour master, as authorized by the Minister of the Merchant Fleet in coordination with the Attorney-General, the Ministry of Defence and the Ministry of Fishing.

From 1957 till 1989, the Law concerning the investigation of marine accidents was in force in Russia. The aims of such investigation are to identify the circumstances under which the emergency occurred, its reasons and consequences, to investigate the question of staff guilt, and to work out proposals for the prevention of similar emergency cases.

In the clause of "Classification" the following is stated: "Damages to hull, rudder, screws, main and auxiliary gears, *caused not by crew actions, but within sailing in ice conditions,* are classified as ice emergency cases."

And under "The Investigation and Record-keeping of Emergency Cases" it is declared that: "In all ice emergency cases... upon ending the investigation, the necessary measures should be accepted for prevention of similar emergency cases hereafter, with appropriate registration of these measures." And further, the main point for the policy of those years:

> "Ice emergency cases...caused...not because of crew, should not be included in the general list of emergency cases."

On 29 December 1989, by order of the Minister of the Marine Fleet, a new "Rule about order of classification, investigations and record-keeping of emergency cases with vessels" (N118) replaced the previous one. This led to great changes in the statistics for 1989-90, only slightly related to actual ice casualties.

This new Rule introduced a series of innovations. In the first place, it contains concepts and definitions." An emergency case is an event (...) caused because of the effect of insuperable natural conditions or extreme heavy hydrometeorological conditions of navigation, various damages to the vessel's hull, of transported freight and/or change of its physical properties during marine shipping, stranding or grounding of vessel, hindering normal operation of vessel, damage to coastal buildings or aids to navigation by the vessel, damage to other vessel(s), loss of towed object or deck freight, winding of rope and/or networks on the propeller."

In the classification of emergency cases, the concept of "operational damage" is introduced. This is an emergency case "as a result of which **the damage to vessel within lawful actions of the crew during navigation in ice conditions** has occurred, irrespective of injuries caused and losses of seaworthy qualities."

As before, investigation of emergency cases is to be executed by the harbour master. The preliminary investigation is executed by the captain of the vessel, and if the case is then classified as an ice emergency case, the investigation materials are not to be passed to the harbour master. In investigating such emergency cases, supervision is to be carried out by the shipowner. At the same time, the captain of the vessel should immediately report to the shipowner about the emergency case; if it occurred in port, to the harbour master.

ANALYSIS OF JURIDICAL-LEGAL BASE

Because of state interests in the development of the NSR, special legal status was accorded to ice emergency cases. This is, as far as we know, as unique example of the recognition of usual trade risk in the former Soviet Union.

This, however, meant that masters of vessels and their shipowner would always seek to treat any accident as an ice emergency case, as this would automatically free them from responsibility.

In turn, the Ministry, reporting to the Communist Party officials on total accident losses, would seek to treat any ice emergency case as a case of mistake made by the master and crew.

As a result, the investigation and recording of NSR ice emergency cases, as well as the subsequent analytical and statistical data and their conclusions, do not reflect actual conditions. To the extent that the investigation of emergency cases laid the blame on the captain rather than on the administrator(s) who had failed to ensure proper preparation of the vessel for Arctic navigation, such investigation - and especially the conclusions - must be said to have more curiosity value than use value. According to political exigencies, vessel failures were announced variously as heroism, or as the result of crime on the part of the shipmaster.

This "heroic history" started with the wreck of the *Cheluskin* in the mid-1930s. Today it is difficult to explain to the new generation of researchers that this wreck occurred mainly because the commanders refused to let the vessel be towed by the icecutter *Litke* in the Bering Strait after it had almost run out of fuel while sailing the NSR. The *Cheluskin* was carried by ice back tot he Chukchi Sea, where it was crushed. Its commanders, however, were proclaimed heroes.

In the 1940s, the m/v *Kasachstan* wrecked in the ice. Its captain received a prison sentence of 10 years, only because his wife's presence aboard the vessel during the voyage and, in the judge's view, had devoted his attentions to her, to the detriment of ship safety.

More recently, the captain of the nuclear icebreaker *Lenin* - Ju. Kuchiev, who was alter to reach the North Pole - was blamed for standing int he insufficiently charted region near White Island. And in the investigation of the stranding of the m/v *Kandalaksha* in the Free Cuba Strait, which occurred when the vessel attempted to pass through ice close to shallow shorewaters, the word "ice" is not even mentioned in the conclusions. The wreck of the m/v *Nina Sagaidak*, which had crashed on the ice because of age and delays in getting underway in the Arctic, was presented as a case of heroism.

In our view, to obtain useful information, it is necessary to consult primary shipowner materials on construction and mechanism failures.

The official data on ice casualties will be presented in future reports. Official data from the Soviet period should be presented only after an explanation of the methodology. which differs considerably from that used elsewhere throughout the world.

THE ROLE OF THE HUMAN FACTOR

For centuries it was held that vessel casualty problems could be solved only by technical progress. Once vessels had been improved, together with their technical equipment, aids to navigation of marine route and charts, then failures would not occur. Accordingly, a large mass of documents of a technical nature were produced.

Yet statistics have shown that losses in the world trade fleet as a result of failures and accidents increased; moreover, pollution from hazardous substances grew, despite the major value of international agreements. From 1971 to 1980, the number of vessels that disappeared sank increased 1.3 times, and their total tonnage, by 1.5 times.

In the early 1970s, researchers established that technical progress was impeded by people, and the importance of the "human factor" was recognized. Some 75-80% of all failures occur--not only in navigation, but also in other areas of human activity like aerospace technology, military aircraft, automobile transport - because of the "human factor".

Work on international tools for regulation of the "human factor" culminated in 1978 with the creation of an international convention on the preparation and certifying of seamen and watchkeeping.

For correct evaluation of accident perspectives, information on the results of vessel inspection is highly significant. this is systematically published in the maritime press. The IMO Committee on the control of state ports has informed that in 1991, they examined a total of 14,379 vessels, under 107 flags. There has been an increase in the number of vessels with imperfect equipment. In all, 25,930 deviations from norms were ascertained, as against 22,623 in 1990.

Specific attention is paid to the problem of the qualifications and skill of ship crews. More than 90% of all marine accidents are in some way connected with mistakes made by crew members; nevertheless, insufficient attention has been paid to this problem.

At present, P&I - the biggest club in the world - is engaged in an intensive programme of testing vessels, with the purpose of dealing with the huge volume of claims connected with the "human factor", or human error. The UK Mutual Steam Ship Assurance Association has analyzed 1,444 incidents with total damage amounting to USD 784 million over a five-year period. Human error appears to have caused more than 60% of all claims. It has caused about 50% of damages to freight and pollution, 65 of traumas, 80% of damages to property, and 90% of the collisions.

The following points would seems to be of major value in considering the role of the human factor in marine casualty.

1. Initial data in defining the role of the human factor in marine casualty on the national level are those violations of national safety rules mentioned in the conclusions of the investigating bodies. However, there is considerable variation in national legislation here.

2. Navigation is a multi-factor process, in which the desired result can be achieved by various sequences of actions. In case of an accident, assessment of the correctness of the actions undertaken by the involved persons previous to the actual accident may be highly subjective, so that final interpretation of the violations of the national safety rules becomes subjective as well.

3. During any casualty the operational objects are the vessel, its devices, cargo, equipment - each component with its own technical and application characteristics. These characteristics are regulated by national technical rules, the requirements of the various classification companies, administration opinion, company policy and many other factors, all of which may differ essentially from country to country.

4. Thus it is clear that it is hardly possible to separate the role of the human factor from that of the "man-equipment-regulations" system. Accordingly, the presentation of national data on the role of the human factor in marine accidents as a basis for world statistics is doubtful.

The uncertainty concerning initial concepts and data, enabling the role of the human factor to be interpreted variously, necessitates a cautious attitude to any conclusions and proposals on this problem.

The consecutive unification of rules of safety, qualification and technical standards, communication procedures, technology of navigation, rules of cargo carriage, rules for making entries in bridge and engine logbooks, of investigation, classification and registration of marine casualties and other elements of human activity at sea is the most effective way to resolve the problem of the human factor in marine accidents.

Until a sufficient level of unification has been achieved, all data pertaining to the human factor on the international level should be considered only as useful information.

Historical experience shows that under all changes in vessels, types of cargo and rules of safety, one thing has remained unchanged in navigation: the necessity of taking decisions and of acting under conditions of incomplete information on the situation at hand. Therefore the problem of assessing the human features of candidates for each position in the marine hierarchy, in terms of conformity with professional requirements, is the next signification direction in resolving the human factor problem in marine accidents. Research in this direction should exclude the influence of the above-mentioned factors as they may vary abruptly.

APPLICATION OF THE RESULTS OF NATIONAL CONDITION STUDY TO THE ANALYSIS OF ICE DAMAGES TO VESSELS (undertaken by AARI)

In generalizing on the data on ice damage, the following should be taken into account:

- ice conditions and exact characteristics of ice over and other natural factors (visibility, wind, etc.);
- category of vessel in question, its condition (terms of operation) and kind of navigation in ice;
- skill of navigators (experience of work in ice, etc.).

A multi-factor approach to record-keeping in this field has been developed at AARI by P.Gordienko, A. Murzin and colleagues. As initial materials, use has been made of the reports of marine operations headquarters, data of AARI expeditions on vessels and icebreakers, information from dispatching reports, as well as the results of analyses of ice-accident rate by the Murmansk branch of the CNIIMF. The highest accident level has been found to occur in heavy navigation conditions. We may note the following general tendency, as shown in the table below.

Average number of vessels with ice damages
(% of total number of sailing vessels)
western and eastern regions of the NSR.

Type of ice conditions on route	NSR region	
	west	east
Hard	7.5 - 8.0	14.0 - 16.0
Middle	3.5 - 5.0	8.0 - 10.0
Light	1.0 - 1.5	1.0 - 3.0

The type of ice conditions is directly connected with the arrangement of the ice assembles and the ice in them (age, hammocking, forms, etc.), so general tendencies of ice-damage recurrence repeatability have been taken as a function of these natural factors. For example, the recurrence repeatability of failures and damages in the Aion ice assembly is almost twice as high as in the Novaya Zemlya ice assembly (46/28%).

Rather interesting is the chronology of ice failures and damages during the navigating period. The maximum is found in August - September, which is the most favourable period for shipping. Statistical data of repeatability of damages under various ice conditions indicate the following main reasons for the greater recurrence of ice damages in this period:

- existence of "remnants" of hammocking formations, as well as partially destroyed two-year ice, which has advanced underwater in conditions of limited visibility, within mistakes of manoeuvring, leading to stranding on such ice, with ensuing damage to hull and rudder-propeller complex;

- occurrence of a significant quantity of vessels with low ice categories on the NSR at this time;

- general increase in the number of vessels performing autonomous navigation on the NSR in the rare ice. Nevertheless, test data for the Eastern NSR show that in ice of 5/10 - 7/10 density the number of impacts and impact intensity is higher while sailing in convoy than in the independent sailing, though the speed advantage is only 1.5 - 2.0 knots;

- an increase in sailing speed, in particular when vessels are being towed after icebreaker in order to overcome short intervals with hard ice conditions.

As the number of vessels increase, so does the presence of navigators with low skill of ice navigation. Analysis of the navigation year 1980 shows that half the accidents happened with masters with ice experience of less than one year.

Fuller analysis of the data on ice damages accumulated is to be the subject of the next step in this research.
Objective evaluation of ice qualities and current condition of each vessel is extremely important for shipping safety.
The space and time dynamics of all elements of the natural environment considerably complicate the development of reliable methods for the description of vessel/ice interaction. However, research is now underway in this area. Methods of simulating the interaction of vessel with ice form the basis for analysis of such two main qualities of a vessel as ice maneouvring (i.e. ability to move with some "achievable" speed to overcome ice resistance) and ice strength (i.e. ability of ship constructions to resist ice impacts).

The hydrodynamic model of ice impact offered by Ju.N.Popov and D.E.Heisin has been advanced and complemented by work done by D.E.Heisin together with V.A.Kurdumov. Today it is widely accepted and adopted in Russia.

The other direction of work undertaken at AARI and directly related to valuation of efficiency of navigation consists of collecting and processing ice and hydrometeorological information on the NSR. Research an the reliability and efficiency of NSR navigation is based ont eh incorporation of results from work in both these research directions. It has made it possible to classify ice as the environment for navigation, to define the areas of application of various methods of ice-resistance evaluation.

REGISTRATION AND INVESTIGATION OF ICE ACCIDENT RATE

It seems expedient to organize the development of national documentation for the regulating of registration and investigation of marine accidents, including NSR ice emergency cases. Such documentation can be of limited applicability, i.e. legal only in the Russian Arctic region. It can represent part of the uniform Rule concerning registration and investigation of marine accidents, which is the most acceptable.

Concept. As a concept of such a Rule, we can offer the following:

1. The Rule should express the state requirements to any type of shipowner. It should contain only the state requirements.

2. The basic aim of a civilized state is the preservation of the lives of its citizens, and its environment. To this end, the state issues the requisite laws and regulations. Any other matters are the shipowner's business.

3. The state should have information about any marine accident. Time will show if this information is useful in the preservation of life and environment. It may become necessary to make modifications and additions to state requirements to vessel design, equipment, crew training, conditions of freight carriage etc. Hence the total registration of marine accidents should be done.

4. State interests can be protected only by investigation executed by an authorized state

body.

The shipowner, as the proprietor, in many cases may be interested in concealing the results of accident investigation. This, however, does not mean that the shipowner cannot independently investigate accidents with his vessels, for his own purposes.

Possible contents of the Rule. The Rule on marine accidents (ice accidents with vessels) registration and investigation should contain the following sections:
1 General provisions
2 The bodies of investigation
3 The order of investigation
4 The order of messages
5 Documents

General provisions. The general provisions should define the concept, purposes and order of reporting about marine accidents, their investigation and registration.

In our opinion, marine accidents are cases when:

.1 the condition of vessel or of its operation has caused serious vessel damages or threat of the following:
a) its safety, particularly the safety of persons aboard;
b) condition of the sea environment;

.2 the vessel sank, went missing or was abandoned by crew;

.3 vessel was seriously damaged or vessel or its freight caused considerable damage;

.4 as a result of vessel operation, the person was lost or missed;

.5 the help required by was not rendered in distress.

In the Rule the word "vessel" means: floating and submerged, displacing and dynamically supported means as well as any other floating objects (cranes, lights, docks, drilling installation, bathyscaphes, landings, platforms etc.)

It should be mentioned, that the Rule considers as "marine accidents with vessels" accidents which have occurred:
.1 in high sea and in the coastal waters in operative ranges of marine rules;

.2 in seaports, if the participant is a marine vessel;

.3 in high sea and in coastal waters in operative ranges of marine rules, if:
a) participant is a vessel with Russian ensign;
b) participant is a river vessel included in the ship

list of Russian register;
c) participant of accident holds the diploma of captain, ship officer, or marine pilot certificate given on behalf of the Government of Russia.

It should be indicated, that under action of the Rule are the accidents with vessels occurred:
.1 in national waters of Russia in operative range of marine rules irrespective of vessel ensign;
.2 in high sea and in national waters of other states, in operative range of marine rules, if:
a) participant is a vessel with Russian ensign;
b) participant is a river vessel included in the ship list of Russian register;
c) participant of accident holds the diploma of captain, ship officer, or marine pilot certificate given on behalf of the Government of Russia.

The Rule should precisely stipulate, that the purpose of registering marine accidents and of investigation is to prove and justify the connection, if any, between sea accident and possible defects in:
a) design or equipment of marine vessel;
b) qualification and condition of participants of accident, holding diploma of captain, ship officer or certificate of marine pilot given on behalf of the Government of Russia;
c) watch organization;
d) knowledge of physical and chemical properties of transported freight;
e) hydrometeorological, hydrographic, ice breaker pilotage or other support to safety of navigation.

It should be mentioned, that the state body authorized for supervision of safety of navigation executes the investigation of marine accidents of public interest:
.1 if Russia is obliged to conduct the investigation according to international agreement;
.2 if the person was lost or missed in accident;
.3 if the vessel was lost, missed or leaved by crew;
.4 if sea pollution or other damages are preliminarily evaluated in the sum of USD 500,000 or more (the sum should be proven);
.5 in the case if needed help was not rendered;
.6 in the case of Government or Parliament of Russia requirement;
.7 on the own choosing and for supervision.

It should be indicated, that if the participant of marine accident is a Navy or Frontier Guard ship of Russia, investigation is to be carried out with the consent of appropriate ministers; this can be refused for reasons of state security. In any case the Rule should not treat as marine accidents, these involving navy, frontier guard or police ships and boats only.

The Rule should mention that full marine accident registering is executed in the Ministry of Transport of Russia. The purpose of marine accidents registering is their ordering and integration for advance revealing of events and circumstances which can threaten human life at sea or environment, and their duly prevention.

Bodies of investigation. In this section it should be mentioned, that the initial investigation of marine accident and preparation of primary documents is executed by the captain of the vessel. He executes the total investigation of second-rate marine accidents within the limits defined by the Rule and shipowner instructions.

Conclusions on the results of investigation submitted by the captain to shipowner are to form the basis for the acceptance of insurance indemnification, as well as for shipowner sanctions to those involved in the marine accident.

The shipowner may execute investigations of marine accidents not connected with human loss or disappearance, sea pollution, wreck, vessel loss or missing or vessel abandonment by crew, with help not rendered in distress, damage not exceeding USD 500 000, may be executed by shipowner.

Obviously, marine accidents in the port waters should be investigated by the harbour master, and on his decision - by the shipowner.

The state body carrying out investigation of marine accidents of public interest, can be the Ministry of Transport of Russia. It has the right to investigate any marine accident occurring in any location with a vessel of Russian ensign, with vessels of any ensign in national waters of Russia or if the participant is a captain, ship officer or marine pilot holding a diploma given on behalf of the Government of Russia.

Order of investigation. The investigation should reveal whether marine accident was caused by:

.1 defects of vessel design or equipment;
.2 omissions during loading and fastening of freight, change of freight characteristics during carriage, omissions while operating the vessel;
.3 omissions when employing the captain, marine officers and other members of crew of the vessel;
.4 errors in the management of vessel or its operation;
.5 errors in the use of aids of navigation, marine charts and pilot books;
.6 infringement of navigational and environmental protection rules;
.7 omissions of pilot while piloting;
.8 defects in aids to navigation, vessel traffic regulation or notification equipment;
.9 defects of search and rescue services, as well as services of notification and communications.

During the investigation the efficiency of rendering assistance should be established, whether there was refusal in rendering assistance by the authorized bodies, officials or vessels.

Investigation is to evaluate the actions of those involved in accident, irrespective of the connection of these actions with accidents:

.1 whether the actions of participant were correct or faulty (faulty behaviour), taking into account the level of information which the participant had about situation;
.2 whether the actions of participant can be ascribed to the normal professional and trade risk;
.3 whether the participant of accident had the qualities necessary for completion of captain, marine officer or marine pilot duties.

The Rule should determine that normal professional and industrial risk allows actions to be undertaken by the person managing the vessel (captain, watch officer, pilot), within dangerous circumstances for the avoidance of greater damage to people, vessel and freight.

In our opinion, risk can be justified as "normal" if the following criteria all apply:

.1 risk should match the purpose;
.2 purpose cannot be achieved by usual actions not connected with the risk;
.3 risk should not be transformed in the damage causing;
.4 subjects of risk should be material objects, not persons.

Order of messages. The Rule should lay down the responsibility of captain and shipowner to inform Ministry of Transport of Russia immediately about any marine accident.

If the marine accident happened in the borders of Russian seaport, the harbour master should be also informed.

If the marine accident happened in foreign territorial waters, diplomatic embassy (of Russia) should be also informed for the reception of help and assistance. The representative of the Mutual Insurance Club should be also informed about the accident.

The conclusion on the results of investigation should be presented to the Ministry of Transport for ordering and systematization.

On arrival of vessel in port, captain and shipowner are obliged to present to the Ministry of Transport of Russia information on all failures of ship equipment or displacement of freight which were not canceled at sea. Concealment of such information is considered as an infringement of local rules, irrespective of the legal responsibility for results.

The documents. Captain of the vessel - participant of the marine accident makes the Ship technical act on marine accident, to which following is annexed (all or part from below-mentioned, used in Conclusion):

.1 extracts from ship log;
.2 extracts from engine log;
.3 extracts from radiocommunication log;
.4 copies or listings of ships recording devices data;
.5 route chart with the track;
.6 outlines, drawings, photos of damages;

.7 acts of underwater survey;
.8 inspection certificates by the inspector of classification society or independent surveyor;
.9 written explanations of participants and witnesses;
.10 copies of marine diplomas and certificates of the participants.

The Ministry of Transport of Russia shall publish data about accident rate and results of their analyses, executed on standard practice, annually in marine publications.

Detailed data on ice casualty are not included in this report. We plan to include the official and other data on the casualty of merchant vessels on the NSR as well as our comment and analysis in subsequent (1994-1996) reports.

1.1.2.9 SEARCH AND RESCUE

ARCTIC PERFORMANCE OF THE COSPAS–SARSAT SYSTEM

KEY PERSONNEL

Dr. E.Yakshevich, CNIIMF (Leader)
Dipl.eng. I.Bronitsky, CNIIMF
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Transl. O.Andreyeva

SUMMARY

Arctic performance of the COSPAS-SARSAT system has been investigated in the context of three factors: geographical, domestic and natural.

Basic characteristics of the system were evaluated. These included system timing, accuracy and reliability. The obtained values of the parameters were compared with those known for the system as a whole.

Investigations were based upon advanced theoretical and analytical methods, on simulated results and experimental data estimates obtained in actual conditions.

KEY WORDS

COSPAS-SARSAT, HIGH LATITUDES, SYSTEM TIMING, ACCURACY, RELIABILITY.

INTRODUCTION

At the XI Assembly of the International Maritime Organization (IMO) in 1979 it was determined that it was necessary to develop a Global Maritime Distress and Safety System (GMDSS) to improve communication systems, aids and procedures for the exchange of emergency information. This new system was to be based upon advanced maritime communication techniques, including satellite communications.

Within the framework of implementation of the GMDSS programme, joint development of a satellite system for detection and location of aircraft and maritime vessels in distress was started by the USSR, the USA, Canada and France back in 1979. The first satellite of the system, COSPAS-1, was launched on 30 June 1982 in the USSR, and international testing of the system started thereafter.

Following the successful establishment and pilot operation of the COSPAS-SARSAT system, an International COSPAS-SARSAT Programme Agreement was signed on 1 July 1988 in Paris by the governments of the USSR, the USA, Canada and France. This established a framework for long-term operation and development of the system. In 1992, Russia became the legal successor of the USSR also in this respect.

GENERAL

The nominal COSPAS-SARSAT space segment configuration comprises four satellites in circular near-polar orbits, of which two satellites are maintained by the USA and two by Russia. The COSPAS-SARSAT ground segment consists of Mission Control Centres (MCCs) and Local User Terminals (LUTs). LUTs receive data from the COSPAS-SARSAT satellites, process the data and transmit all the recovered information to the MCCs for delivery to SAR services. In 1993, there were 12 MCCs and 22 LUTs operating in the COSPAS-SARSAT system and 4 MCCs and 6 LUTs under testing. Most of the operational MCCs and LUTs (11 and 20, respectively) are located in the Northern Hemisphere. The end user equipment consists of an emergency radio beacon installed onboard ships or aircraft. In the event of distress, the beacon is activated manually or automatically, depending upon the situation, and transmits signal bursts providing distress alert and location information. 406 MHz beacons are now manufactured by some 30 companies in 10 countries and have been installed on about 500,000 maritime ships of different types and purposes, from pleasure craft to superliners. It is for shipowners to choose a beacon model suitable for their ships.

The COSPAS-SARSAT system is described in detail in [1-3]. A functional block-diagram is shown in Figure 9-1. The COSPAS-SARSAT Secretariat issues publications (2-3 per year) which contain operational information on the current state, further development and improvement of the system.

Recognizing the effectiveness of using the COSPAS-SARSAT system as a search and rescue tool, the IMO XVI Assembly decided to include the COSPAS-SARSAT beacon in the GMDSS outfit. From 1 August 1993, all GMDSS-compliant ships of 300 grt and above are required to carry 406 MHz radio beacons operating in the COSPAS-SARSAT system. A similar decision was taken in 1992 by the International Civil Aviation Organization (ICAO) for civil aircraft.

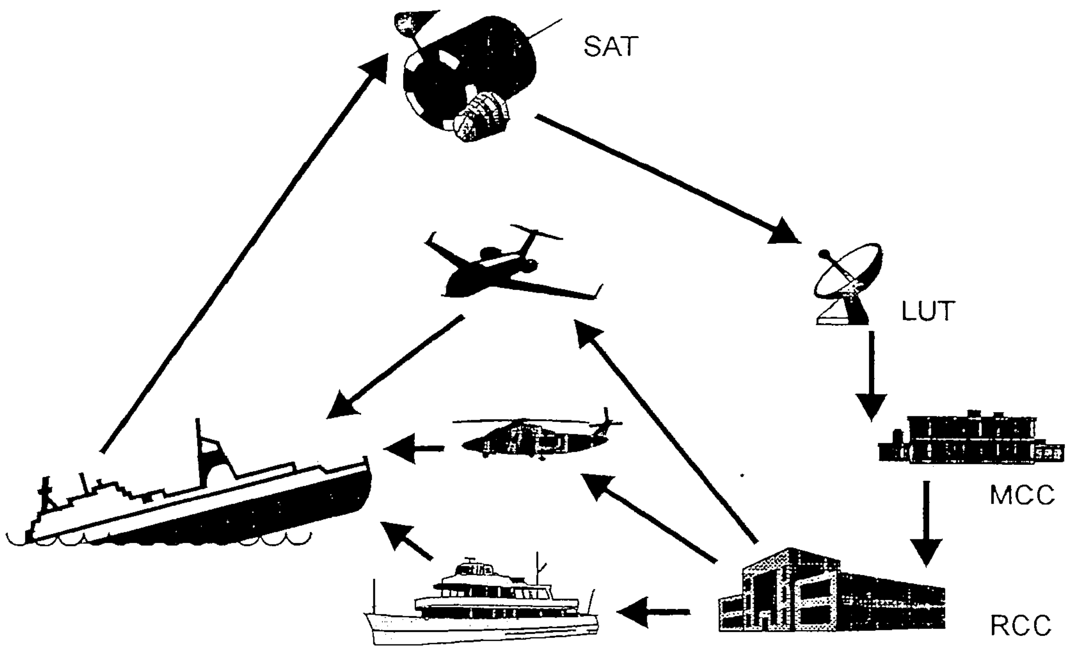


FIGURE 9–1 Basic Concept of the COSPAS–SARSAT System

Starting from 1982, the COSPAS-SARSAT system has been used in more than 1200 distress incidents, contributing to saving more than 3000 human lives worldwide. In the Arctic, the system has been used in the rescue of airplanes, helicopters, and sports and tourist groups. Fortunately, there has not been a need to employ the system for rescue of ships.

To evaluate the effectiveness of the COSPAS-SARSAT system throughout and to refine its performance characteristics, international tests were conducted in 1986 and 1990. Participating in the Exercise of 1990 were 20 countries. In the course of these tests, distress situations were simulated by activations of 406 MHz beacons evenly deployed at 25 sites over the world, from Spitsbergen to Antarctica.

This report presents the Exercise results relating to the Arctic. Furthermore, use is made of experimental data obtained during special tests conducted by Russian specialists in 1985 in the North-Eastern Atlantic at 64°- 71°. The objective of these tests was to evaluate the performance of domestic beacons operating from the sea surface, as well as the performance of all COSPAS satellites and ground facilities. There were 40 beacon activations over the 22-day tests. Overall beacon on time was 77 hours, with 195 "alert messages" received and processed. Involved in the tests was the Norwegian LUT at Tromsø. The system proved to be very efficient, and the beacons highly reliable, even when operating in severe environmental conditions (water temperature as low as +4°C, wave height up to 5 metres).

RELIABILITY

Operational reliability is essential for any technical system. In the case of the COSPAS-SARSAT system, reliability is understood as the probability that beacon alert messages will be received in the system and made available to an appropriate SAR service. As stated by IMO in 1987, this probability must be not lower than 0.99. All previous experience, both practical and experimental, shows that the COSPAS-SARSAT system is completely reliable in service, so that it is safe to say that the system provides reliability close to 1.00.

Here the beacon is the key element. Failure of any other elements - whether MCC, LUT and even satellite, all operating on a stand-by basis,- can result in short-time minor deterioration of system timing characteristics, but cannot cause non-reception or non-delivery of the alert message sent by the beacon in distress.

The COSPAS-SARSAT Steering Committee developed the performance requirements for beacons which were approved by IMO. Manufacturing of beacons is the responsibility of the companies concerned. However it is natural that the beacon models must receive COSPAS-SARSAT type approval certificates. The relevant standards and procedures are defined in the IMO and COSPAS-SARSAT documents. Here it should be emphasized that the Russian Regulations differ from the international ones as far as beacons are concerned.

In accordance with the requirements of the Maritime Register of Shipping of Russia, each ship must be fitted with two beacons. In addition to the conventional float-free beacon activated either automatically or manually, there is to be another beacon intended for manual operation only and placed in a navigation room available to ship personnel. For unknown reasons, the requirement for mandatory carriage of the survival manually-operated beacon has not yet been included in the international regulations, though the equipment has proved its efficiency in actual distress incidents. In this connection, it is worth recalling the loss of the Russian m/s *Polessk* in the Southern Atlantic in September 1993. Onboard were two beacons, conventional and manual. The survival manually-operated beacon was the first from which distress messages were received in the COSPAS-SARSAT system, making it possible to pin-point the ship in distress. Distress signals from the automatic beacon were received as late as 3 hours after the signals from the manual beacon.

There are strong grounds to believe that the survival manual beacon will be a more efficient aid to distress alerting in the Arctic than the conventional float-free beacon. It is reasonably safe to suggest that all ships sailing the NSR will be required to carry two beacons under future international regulations for navigation in the Arctic.

There is another point to be mentioned. All beacons are divided into the Class 1 and Class 2 devices, the former capable of operating at temperatures down to -40°C and the latter at temperatures down to -20°C. In accordance with international regulations, ships carry either Class 1 or Class 2 beacons. Meanwhile, the Maritime Register of Shipping prescribes the mandatory carriage of Class 1 beacons on all ships sailing in the Arctic.

Table 9-1 lists the companies producing the 406 MHz beacons approved by the Maritime Register of Shipping of Russia.

TABLE 9–1 Beacon Models Approved by the Russian Maritime Register of Shipping (as of December 1993)

Nr.	Company	Model	Class
1	Yaroslavsky Radio Eng. Works (Russia)	ARB-MKS "Afalina"	1
2	Musson Co. (Ukraine)	ARB-M	2
3	Musson Co. (Ukraine)	ARB-MK	2
4	Musson Co. (Ukraine)	COSPAS-ARB-MK1	2
5	Musson Co. (Ukraine)	Musson-501	1
6	ACR Electronics (USA)	RLB-23E	2
7	Graseby Nova Ltd. (UK)	RT 160M	1
8	IESM (France)	Kannad 406S	2
9	Japan Radio Co. Ltd. (Japan)	JQE-2A	1
10	Jotron Electronics (Norway)	TRON-30S	2
11	Lokata (UK)	406 H	2
12	Alden Eletronics Inc. (USA)	SATFIND-406	2
13	Bitova Electronic Co. (Bulgaria)	SEVT-406	2

Table 9-2 shows the Class 1 beacon models produced by foreign and Russian companies.

TABLE 9–2 Class 1 Beacon Models

Country	Company	Model	Type
Canada	MPR Teltech	L-1000	P
UK	Graseby Nova Ltd.	RT 160M	F
		RT 160	S
	Caledonian Aim Systems Ltd.	CPT-600M	F
France	CEIS-Espase	M 02	F
Japan	Japan Radio Co. Ltd.	JQE-2A	F
Ukraine	Musson Co.	ARB-PC	P
		Musson-501	F
Russia	Yaroslavsky Radio Engineering Works	ARB-PK1	P
		ARB-PK10	P
		ARB-MKS "Afalina"	F
		ARB-PKE "Excom"	P

F - Float-free (automatic and manual) S - Survival (manual only) P - Personal

Discussed below are some features of using the COSPAS-SARSAT system in the Arctic. The system operational characteristics essential for performance in actual distress incidents are described in [3]. Consideration is usually given to two basic characteristics: system timing, and accuracy.

TIMING CHARACTERISTICS

System operational efficiency is defined as the time from beacon activation until an RCC has received the associated distress data. The alert message from beacon to an RCC passes through several information channels, as shown in Figure 9-2. Each channel involves its time component, the size of the latter depending upon various factors.

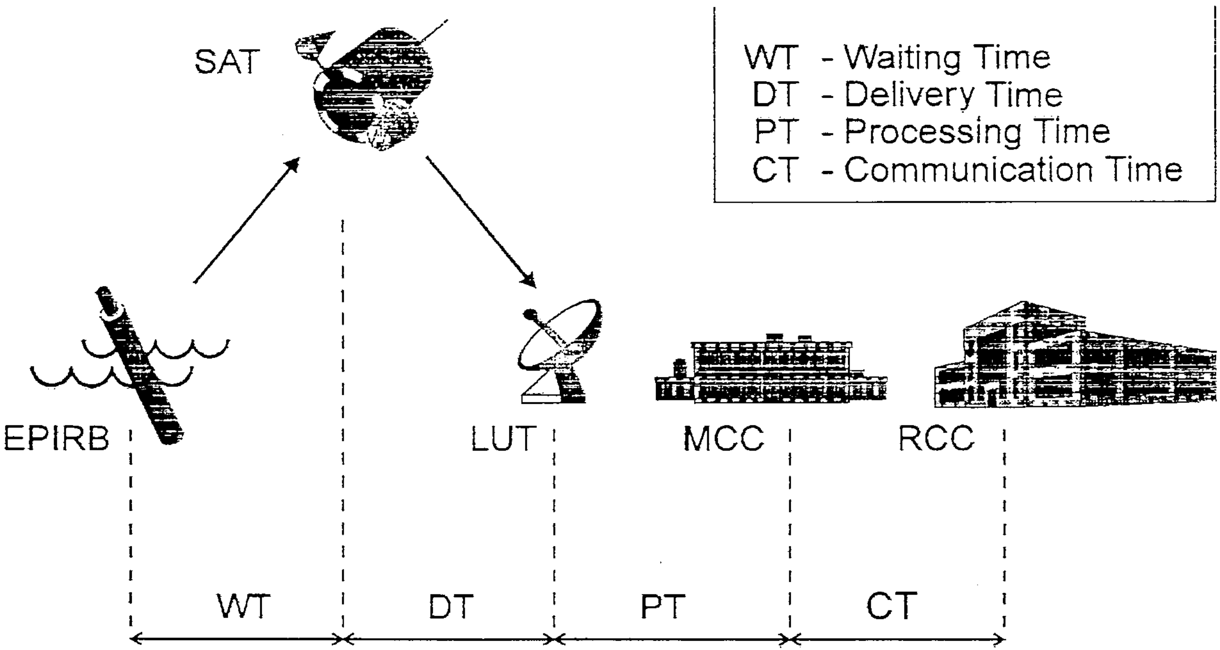


FIGURE 9–2 System Timing

The first component is the time elapsed from beacon activation until the beacon signal has been received by satellite, defined herein as Waiting Time, WT. WT depends upon the latitude of beacon location and the system configuration, i.e. satellite number and orbital parameters.

As already noted, the system employs four satellites placed in circular near-polar orbits. The basic orbital parameters are given in Table 9-3. Slight differences in orbital parameters make it possible to consider the system as consisting of homogeneous satellites.

TABLE 9–3 Satellite Orbital Data

ORBITAL DATA	SAT COSPAS	SAT SARSAT
Altitude	1000 km	830 km
Inclination	83°	99°
Period	105 min	102 min

An essential feature of low-orbit system is the lack of continuous observation of terrestrial objects: data reception from beacons is only possible in areas of mutual visibility. The rate of the passes of near- polar-orbit satellites depends directly upon the latitude of location. The satellite passes 5-6 times per day above any location at the equator and 13-14 times above the North Pole,i.e. on each turn.

WT versus latitude is shown in Figure 9-3.

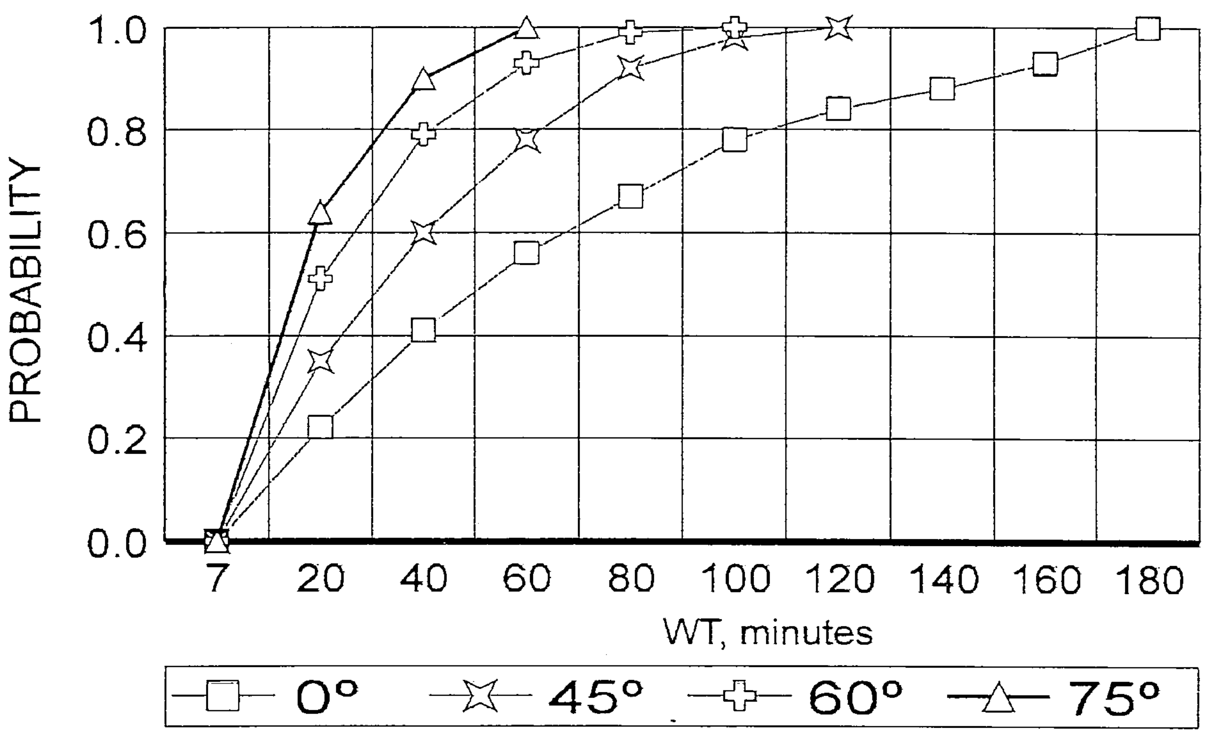


FIGURE 9–3 Waiting Time versus Latitude

WT in the Arctic region is at least 2-3 times lower than at middle latitudes. While WT causes an essential delay in the overall COSPAS-SARSAT system, this is not the case for the Arctic region, as may be seen from Figure 9-3.

The second component is the time elapsed from reception of beacon signals by satellite until the satellite time of closest approach (TCA) to the nearest LUT, defined herein as Delivery Time, DT. DT depends upon the spacing and number of LUTs. With current system configuration, DT is near to zero in the Northern Hemisphere. This is because, as Figure 9-4 shows, at least two LUTs are continuously within the real-time fields of view of satellites. Gaps in coverage in the Laptev Sea result in a limited capability for signal reception only at the frequency of 121.5 MHz.

The third component is defined as Processing Time, PT. This includes:

PT_1 - the time from satellite TCA until the LUT has received and processed the associated distress data. PT_1 depends upon the duration of satellite - LUT communications, and the performance of the LUT receiving and computer equipment. PT_1 can range from 15 minutes to 20 minutes.

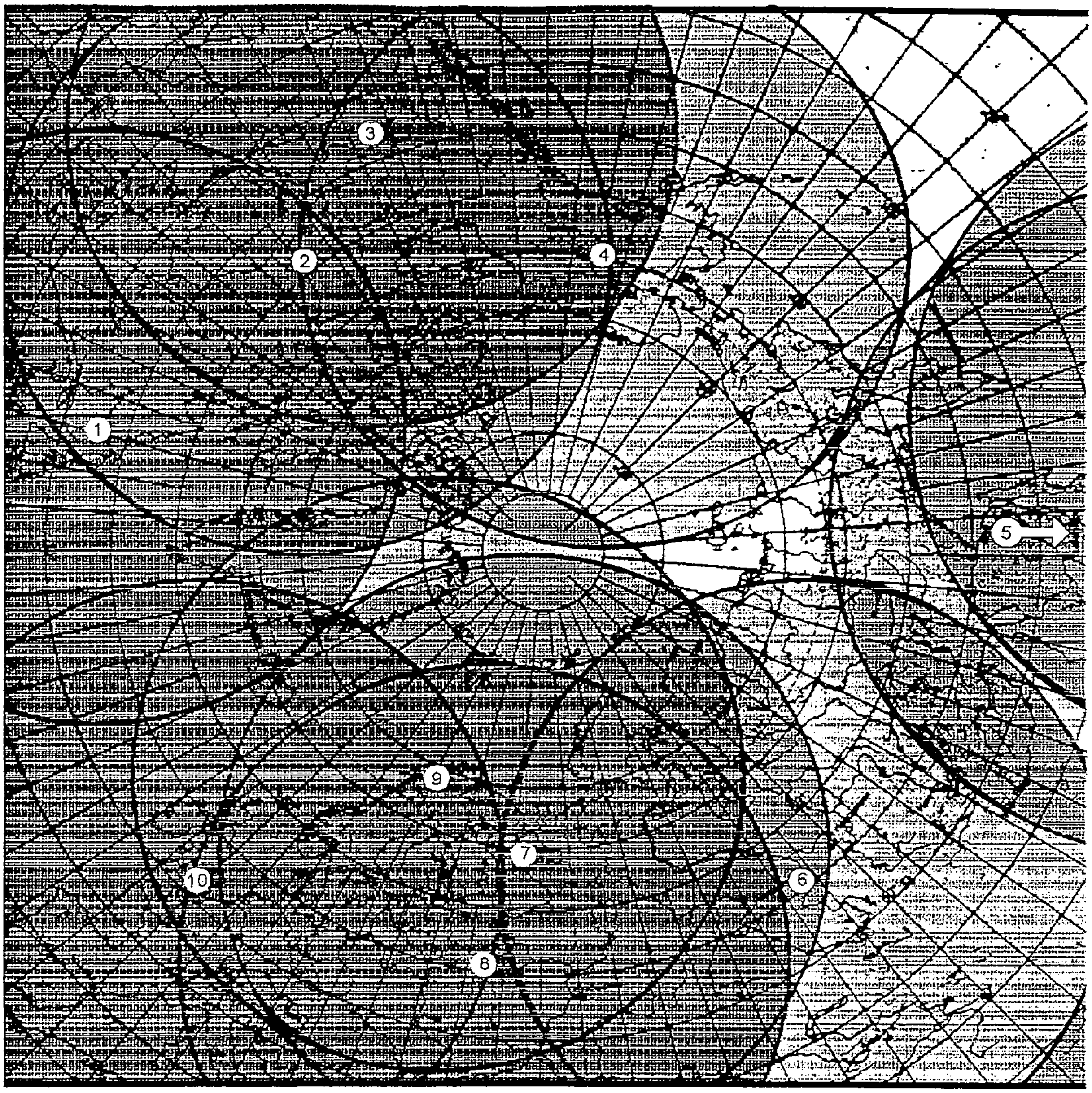
PT_2 - the time needed for distress data transfer from the LUT to an MCC. Used in the COSPAS-SARSAT system are leased high-performance telephone channels, so that PT_2 does not exceed 2 - 3 minutes.

The fourth component is the time needed to transfer distress data from an MCC to an RCC, defined herein as Communication Time, CT. CT depends on the performance of the terrestrial channels, rather than on the system itself. Used in the Russian Arctic is the departmental data network which employes high-quality leased communications channels and SATCOM facilities.

CT is the crucial value for the overall distress alerting system.

When a distress signal from a Russian ship has been received by a non-Russian LUT, the signal is relayed via an MCC of the country of LUT registration to the Russian MCC, to be further transferred to the Russian SAR services.

Table 9-4 shows the system timing characteristics obtained both in actual practice and in the course of international and national trials.



Satellite Visibility Area of Single COSPAS-SARSAT LUT
Satellite Visibility Area of Two COSPAS-SARSAT LUTs
Satellite Visibility Area of Three or More COSPAS-SARSAT LUTs

1. Goose Bay, Canada
2. Churchill, Canada
3. Edmonton, Canada
4. Fairbanks, USA
5. Nakhodka, Russia
6. Novosibirsk, Russia
7. Arkhangelsk, Russia
8. Moscow, Russia
9. Tromsø, Norway
10. Lasham, UK

FIGURE 9-4 Satellite Visibility Area of the COSPAS-SARSAT LUTs

TABLE 9-4 System Timing

COMPONENTS	T (probability = 0.9), minutes		
	Arctic Zone	Hemisphere	
		Northern	Southern
Waiting Time	40	70	70
Delivery Time	5	10	30
Processing Time	15	15	15
Communication Time	20	30	40
Total Time	60	100	120

LOCATION ACCURACY

The positioning techniques are in many ways similar to those employed in the TRANSIT and TSIKADA systems. They are based on measurements of Doppler frequency shift in a series of successive bursts. The information message for identifying the of object in distress is transmitted simultaneously with signals providing location determination. Thus, the system performs two basic functions - distress notification, and determination of distressed object location. At this juncture, it might be appropriate to note the following:

- in exceptional cases, distress notification containing only beacon identification but lacking location data is sufficient to initiate SAR operations;
- SAR operations can be initiated even when the location information available is has poor accuracy, i.e. the calculated location is greater than 20 km from the actual location;
- the current position of the object in distress can be further refined while the SAR operation is in progress;
- successive determination of location allows to calculate the drift and predict the movement and future position of the object in distress.

Thanks to system information redundancy, accuracy of initial determination of location is not so crucial, since the location information may be refined in the course of subsequent calculations. The higher is the accuracy, the higher is the efficiency of SAR operations. As defined in the system performance requirements, the location RMS error should not exceed 5 km (2.7 n.m.) with a probability of 0.9.

Mathematically, location accuracy will depend upon the number of bursts received by the satellite during beacon-to-satellite transmissions, as illustrated in Figure 9-5. Beacons transmit a burst of 0.5- second duration every 50 seconds, so up to 20 bursts can be received during beacon-to-satellite communication session. The number of bursts received depends upon two basic factors:

- beacon-to-spacecraft elevation angle;
- noise level in the area of measurements.

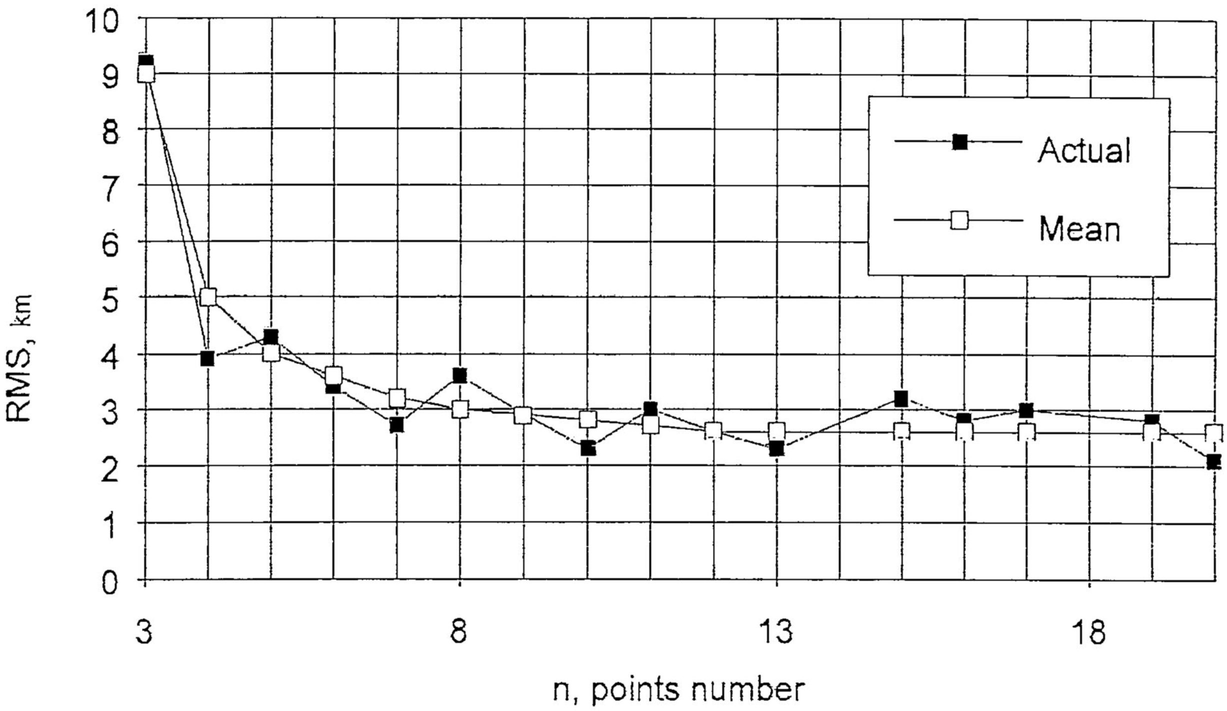


FIGURE 9-5 Accuracy versus the Number of Points (i.e. Bursts Hits Detected by the LUT)

Field research has shown that, as far as the noise level is concerned, the Arctic is a favourable area as compared with the European and African continents. In the course of tests in the Northern Atlantic, the accuracy of the calculated location of the beacon operating from sea surface, with wave height up to 5 m, was 1.5 times greater than that of the same type of stationary beacon operating in Moscow.

Geometrically, the number of the received bursts directly depends upon the elevation angle: the lower the angle, the shorter is the communication session. The peculiarity of near-polar orbits is that at high latitudes the maximum of the elevation distribution curve tends to increase. At latitudes 60° and higher, the minimum elevation angle cannot be at all below a certain critical value, which increases as the latitude becomes higher. Thus, at high latitudes the likelihood of poorly accurate calculated locations decreases.

It should be mentioned again that the actual performance of the system will depend heavily on the performance of the beacons operating within it. Though all complying with the COSPAS-SARSAT standards, various beacon models differ as far as performance is concerned.

To summarize: COSPAS-SARSAT performance in the Arctic is higher than elsewhere in the world, and the system shows promise of improving the efficiency of SAR operations in the region.

As stated before, the COSPAS-SARSAT system is an element of the GMDSS. The functioning of the GMDSS in the Arctic, as well as details on organization and logistics support of search and rescue through the region, will be described at later stages of this Project.

REFERENCES

1. Балашов А.И., Зурабов Ю.Г. и др. (1987 г.) Международная космическая радиотехническая система обнаружения терпящих бедствие. Москва. Радио и связь.

   (A. Balashov, Y. Zurabov et al. (1987) : "International satellite radiotechnical system for detection of persons in distress", Moscow, Radio and Communications)

2. Богданов В.А., Сорочинский В.А., Якшевич Е.В. (1987 г.) Спутниковые системы навигации. Москва. Транспорт.

   (V. Bogdanov, V. Sorochinsky, E. Yakshevich (1987): "Satellite navigation systems", Moscow, Transport)

3. IMO (1987): "Global Maritime Distress and Safety System", London

4. I. Bronitsky, R. Chernayev, A. Ivanov, E. Yakshevich (1986): "Experimental evaluation of the COSPAS-SARSAT system accuracy performance at low elevation angles", Innsbruck, 37th Congress of the IAF.

Appendix 2

August 1994

Review and Comment
on INSROP REPORT

I.1.2.1 REGULATIONS

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Dr. V. Peresypkin, CNIIMF
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The experts on regulations of the NSR are the authors, and they have been instrumental in helping to formulate and express the regulations which are typically written in a very elaborate style of the Russian language suitable for governmental use within Russia. The literal translation on a word-by-word basis of this language, into English, leads to sentences which are cumbersome, with excessive verbiage and words in improper order. Comprehension by an average English-speaking person is difficult. In English, the law includes precise definitions of certain words and phrases. These should only be used to mean the single idea or concept consistent with the legal definition of the word. Thus, it would appear that the services of a perfectly bilingual lawyer, trained in both Russian law and English law, would be helpful in the next editing stage of this report. Such a person would also be a valuable addition to the research team.

The listing of the pertinent international documents is very helpful. A footnote for each document should indicate the organization and address from which the document may be obtained.

The section in national documents is helpful in showing how voluminous they are, how they contain internal contradictions, and how the resolution of such ambiguity is left to the personal discretion of the on-scene person in authority. In the traditions of English law and regulations, some of the principles are (1) laws and regulations should be objective, with uniform enforcement for all, and interpretation by the courts, which follow established legal precedent; (2) the average citizen should be able to find out the law and to understand it, as written. An English-speaking master of a vessel is not able to be confident with respect to either one of these two criteria, nor is a shipowner. This difficulty must be resolved in order for transit voyages on the NSR to be commonplace.

The report should specifically address the following items: (1) Where and how can shipowners and masters of the vessels obtain a copy of <u>all</u> of the applicable regulations; (2) where and how can these be made available in English; (3) what is the author's present assessment of the progress in simplifying, abolishing, consolidating, and clarifying the regulations; (4) are the regulations becoming more complex?

The proposals on legal regulation improvements are welcome. Perhaps a working group, in which non-Russian shipowners or their nominees are heavily represented, should be convened to assemble specific suggestions for improvements and simplifications in regulations.

The reference list should be translated into English for the benefit of non-Russian-speaking readers.

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Reviewer

August 1994

Review and Comment
on INSROP REPORT

I.1.2.2 ROUTING

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The term "routing" implies the choice of the pathway for a ship transiting the NSR. The introductory discussions of this report are generally dealing with this theme, but the language is excessively long, extended, and cumbersome. When translating page 2-3 into English, for example, the word-by-word approach should not have been used, but rather the salient points should have been expressed briefly.

The section on the "most easy ice navigation route" gets to the heart of the mission of the report. The generalizations of page 2-5 to 2-6 are most welcome This section of the report should be expanded by the addition of more information and comment. Not only the trends or generalizations in route choice, but also some of the rare exceptions in route choice (and reasons for their choice) should be included.

Direct word-by-word translation from Russian into English has made pp. 2-7 to 2-10 longer than necessary; the salient points should be presented briefly. This appears to be a kind of generalized overview of material properly treated in other reports in the INSROP series, and, as such, is really quite far from the supposed main topic of this report, "routing." The final paragraph is really expressing recommendations and should be shorter, more direct and to the point. The reference list is welcome; translations into English would be helpful for non-Russian-speaking readers.

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W. M. Sackinger
Reviewer

August 1994

Review and Comment
on INSROP REPORT

I.1.2.3 NAVIGATION AND POSITION

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Trans. O. Andreeva

The introductory material on pages 3-2 to 3-4 is quite helpful and appropriate. The overview of the systems MARS, LORAN-C, CHAIKA, TRANSIT, TSIKADA, NAVSTAR, and GLONASS would be more complete if the positioning accuracy of each one of these systems were stated, perhaps in an expanded version of the very useful table 3-1.

A map which shows the locations of the 47 radio beacons, and the 200+ passive radar reflectors would be illustrative and useful. The impression is given on p. 3-8 that the 100 buoyant obstruction beacons are deployed only in the summer, are taken out in the beginning of winter, and are redeployed in the following summer. Perhaps this should be verified, if it is the correct interpretation, or the alternate explanation provided.

The interesting thermoelectric generators (RTG) of the Gorn and Gong types might have other uses, and so a specification listing for them would be useful.

The zones of the Northern Sea Route where shallow bathymetry is a potential hazard to shipping, and thus where the installation of a very accurate differential GPS system would be desirable, should be given in the form of a simple map. A future report should contain a complete design for a local, differential GPS system which is un-manned and which can be deployed in such critical locations.

This report has the proper scope and the appropriate level of exposition. It should be accompanied by an English version of the "Coastal Pilot" which gives maps and descriptions. The final English version needs improvement by a native-English-speaking editor. A listing of Russian background references would be helpful.

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Reviewer

August 1994

Review and Comment
on INSROP REPORT

I.1.2.4 COMMUNICATIONS

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Dr. L. Malakhov, CNIIMF
Transl. O. Andreyeva

In the pages 4-2 to 4-7, an introductory discussion of the communications methodology is important and helpful. Several questions arise, however, as one reads these pages. For example: (1) Is the term "radio relay channels" equivalent to the Eng ish term "microwave line-of-sight link" or does it imply lower (UHF or VHF?) frequency linkages? (2) In what bands are the radio links from the communications centers [Amderma, Dikson, Tiksi, Pevek, Shmidt Cape, Provideniya], to the radio stations Igarka, Dudinka, Khatanga, Kosisty, Tadibe-Yakha, Temp, Tchokurdah, Tchersky, Apapelkhino, and other radio stations on land? (3) Are these radio links line-of-sight? (4) Are these radio links disrupted by aurora storm activity? (5) Is it true that only MF and HF and VHF bands are available for routine communications between ships and the two categories of land stations? (6) Where are the portions of the route for which a ship is outside of line-of-sight for communications from any operating land station? [This should be presented in a map, with shaded sections or boundary zones for line-of-sight communications clearly indicated]. (7) The treatment coverage of the Northern Sea Route by satellite links is very informative. The access to ships, to major shoreline centers, and to service icebreakers and shipping companies, via INMARSAT is quite impressive. One contrast between INMARSAT and OCEAN seems to be that telephone direct dial service is normal with INMARSAT whereas operator assistance is normal with OCEAN. Could the authors comment on the feasibility of automatic direct-dial equipment for the future in the OCEAN system? Comments on the data transmission performance of the OCEAN telephone channel and the INTELSAT telephone channel would be helpful in planning for future use of computer-based systems for ships transiting the Northern Sea Route.

The description of the MARAPHON satcom systems and the ARCOS and MAYAK satellites, provides a glimpse of a hopeful future. The details such as ground (or shipboard) station antenna size, beamwidth, frequency, transmitter power, receiver sensitivity, and projected costs of purchase of a complete ground station would be very helpful in assessing the practicability of this newly-emerging system as viewed by the user of the Northern Sea Route.

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W.M. Sackinger
Reviewer

August 1994

Review and Comment
on INSROP REPORT

I.1.2.5 INFRASTRUCTURE

AUTHORS: Dr. A. Baskin, CNIIMF
Dipl.eng. S. Samonenko, CNIIMF
Dr. E. Kluev, GP DMT
Dipl.eng. A. Ushakov, NSRA
Dr. A. Buzuev, AARI

The stated purpose in the first sentence is to give orderly information on the present infrastructure along the NSR. As such, the extensive amount of text (pp. 5-4, 5-5, 5-7, 5-9, and Appendix 5-12, 5-18) devoted to the historical aspects is not within the scope of this report. While the historical material may be of academic interest to some future users of the NSR, it is no substitute for a lucid discussion of present infrastructure. Historical material should be deleted from the main part of the report and may all be collected in the Appendix, or, alternatively, it may be deleted, as much of it has been published elsewhere.

The discussion of the existing organizations, the present level of supporting personnel and equipment in the fields of pilotage, hydrometeorology services, communications, air logistics, repair facilities, berthing and offloading, emergency medical capabilities, fuel, fresh water, drydocks, icebreaker support, divers, and tugboats, are of utmost importance.

The short paragraphs presented for each of the Arctic ports only indicate whether some of these are available, but give no information on quantities, or on possible seasonality of the availability. It would be extremely helpful if the port infrastructure information were organized into a rather large table format.

In such a table, the services could be organized in columns and the names of the ports in rows. Each entry in the matrix could contain several crucial items about it, or the word "none". For example, the matrix entry for the column "hospital" and the row "Igarka" could indicate "26 beds, 3 physicians, minor surgery", if appropriate. Another example would be the column "air logistics", the row " Amderma", the entry "fixed-wing, helicopter, on floats, 24-hours", if appropriate. Recognizing that such services change month-by-month, the table should be dated and the months of the year when the services are unavailable should be included. This table undoubtedly exists in some form already today, and should be modified and included in the report.

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Reviewer

August 1994

Review and Comment
on INSROP REPORT

I.1.2.6 CREW TRAINING

AUTHORS: Dr. A. Baskin, CNIIMF (Leader)
Dipl. eng. S. Samonenko, CNIIMF
Dipl. eng. G. Chichev, CNIIMF

The introductory background is very helpful for the reader to begin to appreciate the importance which has been given to crew training in the Russian Federation, and the scope of the activities.

No mention was made, however, of whether any non-Russian ice pilots and operators have so far been trained at the MSRC, or whether MSRC is willing to accept students from other countries for this specialized training. If a shipping company from a country outside of Russia wishes to use the Northern Sea Route regularly, it would be prudent for the captain and first officer, at the least, to have some ice training of the quality given to Russian ice pilots at MSRC. Is this available to them? How long is a course, and what would be the approximate cost? This may represent an opportunity for MSRC.

Is there a Board of External Visitors, or equivalent, from outside of Russia, which periodically visits MSRC to evaluate and accredit the program to international standards?

What are the effects of the massive outflux of trained crew upon the operational safety of Russian vessels in the Northern Sea Route? If there is a problem emerging, what are some of the alternatives to cope with it?

A typical schedule for an ice pilot training episode, in the form of a table, containing subject categories and the number of instructional hours on each subject, would be illustrative of the program at MSRC as applied to NSR.

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W.M. Sackinger

Reviewer

August 1994

Review and Comment
on INSROP REPORT

I.1.2.7 VESSEL PERFORMANCE

AUTHORS: Dr. S.B. Karavanov, CNIIMF (Leader)
Dr. L.G. Tsoy, CNIIMF
Dipl. eng. Y.V. Glebko, CNIIMF
Transl. S. Ponomarev, CNIIMF

The authors are to be complemented for the quality of the English and for the direct manner in which they have approached the subject of comparison of the icebreaking vessel classifications of the several different classification societies and agencies.

The level of detail shown in the extensive tables will be useful for the specialized technical experts who will read this report.

For the non-Russian ship owner, the questions are: (1) what Russian classification equivalent will be given to a ship already built according to a specific non-Russian ice classification criteria; (2) will transit by a vessel certified by a non-Russian ice classification criteria be allowed on the NSR; (3) how can the construction of a new vessel be accomplished so that it meets both Russian and non-Russian ice classification criteria? These questions are not answered directly in this report, but some attempt should be made to answer them.

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Reviewer

August 1994

Review and Comment
on INSROP REPORT

I.1.2.8 ICE ACCIDENT RATE

AUTHORS: Dr. A. Baskin, CNIIMF
Dipl. eng. S. Samonenko, CNIIMF
Dipl. eng. A. Ushakov, NSRA

The literal translation of this report from Russian into English is an obstacle to its understanding, and major editing by a native-English-speaking editor is required at the earliest stage in its revision.

The historical remarks about the ice-related accidents, and the tendency for the reporting of all accidents to be attributed to ice, thus absolving the responsible crew, can be very helpful in judging the validity of early statistics for the 1957-1989 period. Such statistics are, unfortunately, not presented, but they should be presented, even if they have doubtful credibility. Once presented, the authors should then give their own best quantitative interpretation as to what part of the "ice-accidents" were truly caused by ice. Similarly, the discussion given on human factors, while it forms good background, should be followed by the authors giving the early statistics on such human-caused accidents on the NSR, and then give their own best quantitative interpretation as to what the "true number" of human-caused accidents actually were.

It is very valuable to see the statistics in the table, but the time frame over which they were accumulated should be given, and the actual number of ship sailings which took place and which are used as the basis for the table should be mentioned. The short paragraph on the ice damage in different months is quite important; all of the statistics should be broken down by month in the table, however, so that the reader can form possible valuable additional conclusions.

Quotation of statistics for the entire Russian Federation for 1991, while interesting, should be followed up with similar statistics for the Northern Sea Route only.

Reference is made to work in AARI by P. Gordienko, A. Murzin, and others. The work has undoubtedly resulted in some AARI internal reports, and those reports should be listed as completely as possible in a Reference list. Internal reports on this subject, prepared by CNIIMF staff, should also be listed in the Reference list.

The term "5-7 balls density" should be expressed in units more familiar to western ice experts, or should be defined in more detail.

The final section of this report is really a proposal for a framework of revised regulations on accident investigations. It has the appearance of being comprehensive and detailed, which is an advantage. From a technical standpoint, however, the investigation of accidents can learn from aircraft accident investigations in several ways. There could be, for example, a sealed "ship activity recorder" which would record all ship data on course, position, speed, engine parameters, hull vibrations and impacts, voice orders, radio messages, and even video images taken from the bow of the ship. Such a data logger could retain the last 10-20 minutes of data before an accident. This would provide objective evidence for analysis of all ship accidental events. On the legal side of the inquiry, the investigation proceedings could be required to be in public, with press attendance permitted, and with one of the members of the investigating panel being a representative of an international body which has a concern for the improvement of marine safety.

The prospect of implementing new accident investigation procedures should be mentioned; will such procedures required several years of deliberation before they are implemented?

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W.M. Sackinger
Reviewer

August 1994

Review and Comment
on INSROP REPORT

I.1.2.9 SEARCH AND RESCUE

AUTHORS: Dr. E. Yakshevitch, CNIIMF (Leader)
Dipl. eng. I. Bronitsky, CNIIMF
Dipl. eng. L. Yegorov, NSRA
Transl. O. Andreeva

The quality of English in this report is very impressive and the well-organized introduction and presentation of the COSPAS-SARSAT system is very well-done. System organization, reliability, equipment, and visibility area, are all well-presented.

The map (Figure 9.4) suggests that parts of the Laptev Sea are not covered by the system. Since the Laptev Sea is not covered by INMARSAT either, what sort of provision is presently made for ships in distress in the Laptev Sea to notify a Search and Rescue Command? What would be a more desirable solution in the future?

This report only deals with notification of the ship in distress. The crucial reason for the instigation of this project was to deal with the capability of the local and regional centers for rescue, along the NSR, to actually conduct and execute a successful search and rescue. What logistics support is available, in which centers, and with what time delay can it demonstrably be mobilized? Examples would be instructive.

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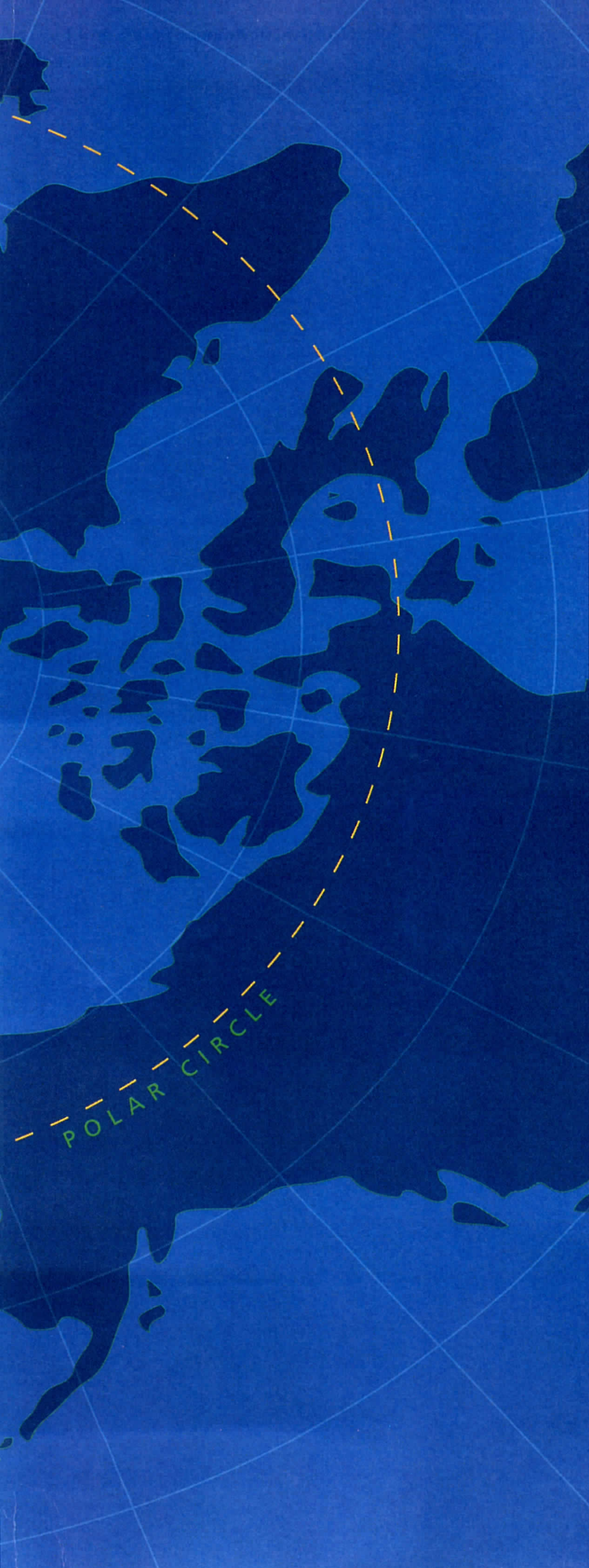
Reviewer



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 stockholding 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 multidisciplinary approach, entailing extensive cooperation with other research institutions both at home and abroad. The INSROP Secretariat is located at FNI.