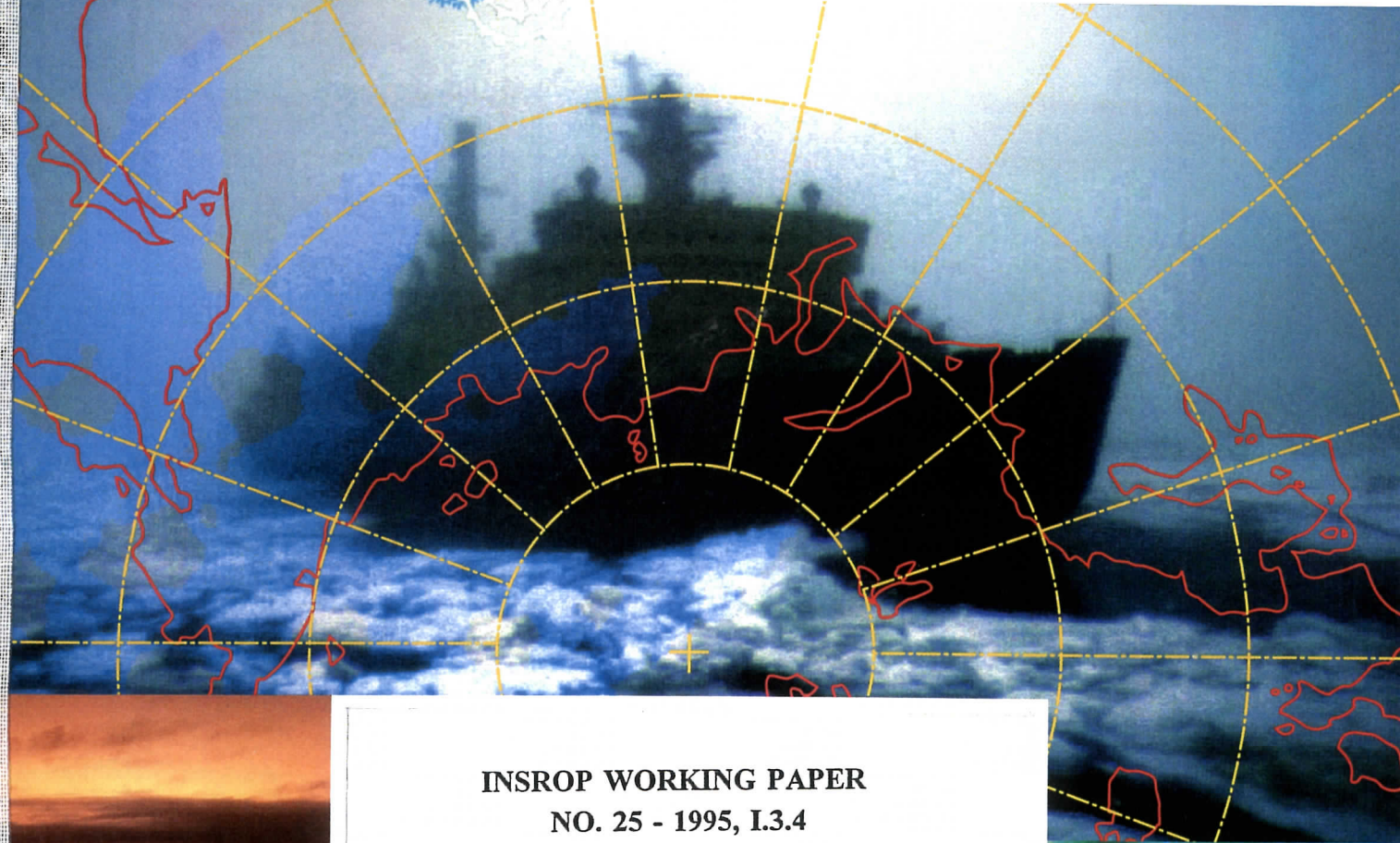

INSROP WORKING PAPER
NO. 25 - 1995, I.3.4

Design of Information System

Volume 1 - 1993 project work

Vladimir Grishchenko
and Eugene Yakshevitch 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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INSROP WORKING PAPER NO. 25-1995

Sub-programme I: Natural Conditions and Ice Navigation

Project I.3.4: Design of Information System.
Volume 1 - 1993 project work.

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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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SUMMARY

The project considers the questions related to the design of the information system for the support of the transit navigation along the NSR. The Russian automated ice-information system, its infrastructure, technical and information characteristics are described. A brief critical overview of ice information systems in other countries is presented. The proposals for the design of a general multifunctional information system for INSROP on the basis of the existing Russian system are formulated. It is suggested to separate the functions of the Norwegian and the Russian participants in the creation of the INSROP information system.

KEY WORDS: ICE INFORMATION SYSTEM, DESIGN, DATABASE, GIS, GIS-TECHNOLOGIES

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1 PREFACE

For ice and hydrometeorological support of transit navigation on the Northern Sea Route, an integrated ice-information system is suggested to be used. The system represents the totality of organizational, scientific-prognostication and operation subdivisions using specialized databases (SDB), methodological support and geoinformation technologies.

The Center of Ice and Hydrometeorological Information (CIHMI) functioning at the Arctic and Antarctic Research Institute (AARI) is suggested to be the main body of the system.

Integration of the System adapted to INSROP problems and geoinformation technologies developed by SINTEF will allow successful ipmlementation of the Project.

AARI - April 1994

2 INTRODUCTION

Developing the conception of integrated multi-functional information system INSROP to support ice navigation on the Northern Sea Route allows for analyzing the state-of-the-art of the problem in question, working out the direction of studies and plan for its realization.

The present report is the first stage of studies on creating an information system for support of transit navigation on NSR. It contains proposals on its conception and approaches to solve the problem. Research to be carried out in this area allows for:

A. Developing proposals on the conception of an integrated information system (the present report).

B. Developing technologies of functioning information system INSROP.

C. Integration of technologies for functioning information system developed within the framework of the program.

The system to be developed has to organically combine mutual insight into studies made by the parties-participants of Projects I and II as well as to make allowance for interest from other subprograms.

3 DESCRIPTION OF RUSSIAN HYDROMETEOROLOGICAL INFORMATION SYSTEM FOR THE ARCTIC

The presently available in Russia automated ice information system for support in the Arctic of transportation navigation and work on the shelf is based on the complex approach to the methods and means for collecting information on ice conditions, joint processing and analysis of inhomogeneous information obtained from remote sensing instruments installed aboard satellites, from ground and drifting (autonomous) observational stations, ice-breakers and ships, aircraft ice survey. The availability of spread network for collecting ice and meteorological information in the Arctic is maintained by an insufficiently developed system of bilateral communication and dissemination of information using, mainly, traditional ground channels.

The modern state is characterized by stages of reconstruction and improving the system by means of developing the detecting part and introducing technical means and technologies.

Nevertheless, the system functions as a unique information-controlling system in the framework of the Federal Service of Russia for Hydrometeorology providing elucidation of the conditions and conducting operations over the vast territory of the Arctic Ocean and the entire route of the NSR (Bushuyev,1991; Alexandrov, 1992).

The system is based on:

- spatially-spread regionally-organized network for collecting, analyzing and operational use of ice information with centers at stations at Dikson, Tiksi and Pevek;
- specialized research institute (AARI) engaged in studying the given problem, methodological supervision and coordination of efforts made for solving the problems;
- vailability in the structure of AARI of the Center for Ice and Hydrometeorological Information accomplishing routine information support in the interests of all users;
- high scientific level of studies on the ice regime in the Arctic Ocean;
- satisfactory base to forecast ice conditions;
- availability of certain experience in using the results of analysis and forecast of ice conditions for industrial purposes to solve certain navigation problems.

The availability of organizational structure for controlling over navigation in the Arctic on NSR in the shape of Headquarters for sea operations at Dikson and Pevek allows the successful use of ice operational and prognostication information to ensure the safety and efficiency of navigation.

3.1 Infrastructure of the system

The system consists of the Center for Ice and Hydrometeorological Information (St. Petersburg, AARI), regional subdivisions of Roshydromet - Territorial Administrations (Dikson, Tiksi, Pevek) communicating with each other by the channels of the automated system for data collection and transmission (ASDCT) of the Federal Service of Russia with the Center for Transmission of Information, Moscow. The scheme of information exchange is presented in Fig. 4.1 and 4.2.

3.2 The Center for Ice and Hydrometeorological Information (CIHMI)

It is designated for information support of navigation and national economy branches (geology, building, transportation) in the Arctic Ocean basin by means of regular collection, processing and dissemination of data on ice conditions including the data of routine meteorological observations and satellite data.

As a result of data processing the Center possesses and provides the user with information about the state of ice cover as well as forecasts of the state of ice cover, meteorological and hydrometeorological parameters.

The state of ice cover is described by a number of major navigation characteristics, such as:

- ice edge;
- multi-year ice boundary;
- age or thickness;
- concentration and the boundaries of its major gradations;

- leads, polynyas, fractures and other break ups in ice;
- degree of destruction;
- snow amount;
- pressure;
- amount of hummocking;
- direction and rate of ice drift, etc.

The quantitative expression of these and other characteristics is carried out in accordance with the scales of International Nomenclature of Sea Ice.

The basic shape of information about the state of ice cover presented to users is operational and prognostication ice maps. Along with maps, tables of data are used.

Ice maps are issued both for the entire basin of the Arctic Ocean and individual regions in different projections (Mercator's, stereographic). The technology is worked out for direct and reverse conversion of the formats of the system ALISA (automated ice-information system of the Arctic) and SIGRID.

The fact that initial information is obtained in asynchronism and is multi-channel causes the use of such methods and processing means as:

- accumulating and archiving asynchronous (and periodically coming) data;
- data extrapolation on the basis of models by individual characteristics of ice cover;
- complex processing of inhomogeneous data and joint editing of regional fragments of maps.

Only with availability of the complex of these means is the realization possible of primary functions of the system - issue of operational ice maps (in essence, it is the solution of the problem of short-range forecasting of 1 to 10 days).

The problems of long-range forecasting (from 1 to 12 months) are being solved with using additionally:

- improved meteorological and hydrological information;
- solved rather large volume of rated problems;
- extrapolation of obtained and calculated data for a corresponding period of time by special calculation schemes;
- creation and updating of ice data bank.

3.3 Sources of information

Information for compiling operational and prognostication ice maps comes from the following sources:

A. Satellites. Images are received at an autonomous information receiving stations of AARI or transmitted via ground and satellite channels from the Main Center for Data Receiving and Processing in Moscow. Information comes from the spacecraft "Meteor"in the infrared and visible ranges, "NOAA" with small resolution in the infrared and visible ranges, radar images from the spacecraft "Ocean-01". The information is applied to compile primary review ice maps according to the following technology:

- geographical gridding;
- image transformation into stereographic projections;
- interactive analysis and visual decoding of images by means of special package of applied software;
- formation of telegram file in the national format "Kontur".

The composition of hardware components

Hardware-software complex for receiving and processing of satellite information of CIHMI are provided by stations for receiving of information:

- a self-contained data receiving station has the following characteristics:

frequency range 135-138 MHz
satellites: NOAA (images in visible and IR-ranges)
Meteor (images in visible and IR-ranges)
Ocean-01 (radar images, images in visible range).

- complex for recieving HRPT information from NOAA satellites (at present, start-adjustment work is being carried out):
frequency range 1-7 GHz

- Satellite system for relaying images from SPA "Planet" (Moscow).

Processing of images is accomplished by IBM-PC-386.

Software

Software support (SS) for processing and decoding images includes:

- SS of planning communication sessions
- SS of acceptance and record of images into file
- SS of geographical timing and visual decoding

B. Meteorological and ice information transmitted by communication channels and automated System of Data Transmission (ASDT) of Federal Service.

Current hydrometeorological and ice information transmitted by the Hydrometeocenter of Russia (Moscow) comes to CIHMI by the system of ASDT and radio. CIHMI registers it, archives and processes to be used in analysis and compilation of meteorological and ice forecasts (Fig. 1.3.4.2). By channels of local computer network it is accessible for users at AARI.

C. Aircraft of ice reconnaissance

Aircraft of ice reconnaissance are equipped with side looking airborne radars or multi-frequency complex of radiophysical apparatus. They conduct ice reconnaissance when providing navigation for convoys and ships as well as route ice reconnaissance in high latitudes (regional or route ice maps). On route maps compiled aboard an aircraft, it is marked:

- route lines with arrows indicating the direction of flight;
- boundaries of visibility (visual or radar);
- elements characterizing the state of ice cover (symbols);

D. Icebreakers, ships.

They are not on the permanent staff of the system. Radiograms are accepted in locations where they are.

E. Drifting automated ice stations

Ice automated stations of the "Kondor" system are installed on the Arctic islands and ice surface and carry out information transmission by means of satellite "Ocean-01". Information is accepted at CIHMI.

3.4 Computer Center of AARI (CIHMI)

The Computer center of AARI represents a complex of central computers and information computing network. Information-computing network of AARI is designed to solve the most actual problems of information policy of AARI, provide interactions between available computing means at the institute, make it possible to use information links inside and outside AARI (Local network, 1993).

As for the functional aspect, the information-computing network of AARI has to provide solutions to the following problems:

- integration of computing means in subdivisions of AARI with the purpose of working out, testing and operation of software products in joint use within a subdivision;
- communications between subdivisions of AARI aimed at exchange of information when carrying out the projects of general institute direction;
- joint use of computing means of AARI to solve the problems of archiving and processing of information and creation of a national ice data bank.

The basis of LCN AARI (Fig. 4.3) represents the all-institute non-local network of AARI providing the interaction between divisions of the institute and joint use of computing resources. The family of local computing networks within the framework of subdivisions provides the exchange of data inside subdivisions, the use of network supplements and information exchange with the network of AARI.

Technical facilities of the Computing Center

The Local Computing Network is based on the experience of network developments by the Company DigitalEquipment Corporation giving the possibility of subsequent unlimited provision of the network with computing means without changing the base configuration.

The network configuration :

A. The central part of information-computing network:

- DECstation 5000-240 (RISC):

operative memory	128 Mb
disk space	1.4 Gb
monitor Sony Trinitron	20' resolution 1240x1024 256 colors

- SUN 4M (SPARC):

operative memory	128 Mb
disk space	1.4 Gb
monitor Sony Trinitron	20' resolution 1240x1024 256 colors

- graphic stations on the basis of IBM PC
- analogue-digital terminals Tatung

B. The main cable (two segments by 117 m connected by bilaterally earthed adapter):

- EO-BNE2B-MC Standard baseland 802.3/Ethernet cable
- 12-19817-01 2Line Tack-Jack
- 12-19816-01 Terminator 500HM 1W
- 12-21766-01 Clamp Grounding Screw MNT

C. Tier diplexer unit without a control over transmitted information. It consists of the device connecting with the main cable and a branch box for 8 paths to plugs of standard ThinEthernet:

- H4005 Baseband 802.3/Ethernet Transceiver
- EO-BNE3H-05 Tranceiver cable 5m
- DEMPR-MA Ethernet Multiport Repeater

D. Tier diplexer unit with a control over transmitted information. It consists of the device connecting with the main cable and a branch box with the information control - to ThinEthernet standart plugs:

- H4005 Baseband 802.3/Ethernet Transceiver
- EO-BNE3H-05 Transceiver cable 5m
- DECMR-MA DECRepeater 90C
- DEHUB-CB DEChub 90
- DEWGB-MA DECbridge 90

E. The family of cables connected to local networks via network plates with certain computing facilities:

- EO-H8243-A ThinWire PVC Spool
- EO-H8223 T-Connector ThinWire
- EO-H8224 Barrel Connector ThinWire
- EO-H8225 tERMINATOR tHINwIRE
- DE203-AA EtherWORKS 3 TURBO

The above information-computing network of AARI is stage-by-stage realized without stopping work of the available parts depending on information fluxes including direct joining up a new channel or phone (fibre-optical) exits into computer networks of any country.

Equipping computing facilities with communication sets is carried out within the framework of standard network provision Ethernet performing the support of transport protocols TCP/IP and the protocols of network level (NFS, TelNet, FTP); The choice of network software of a subdivision is determined by supporting their available software developments and requirements in information exchange with other subdivisions.

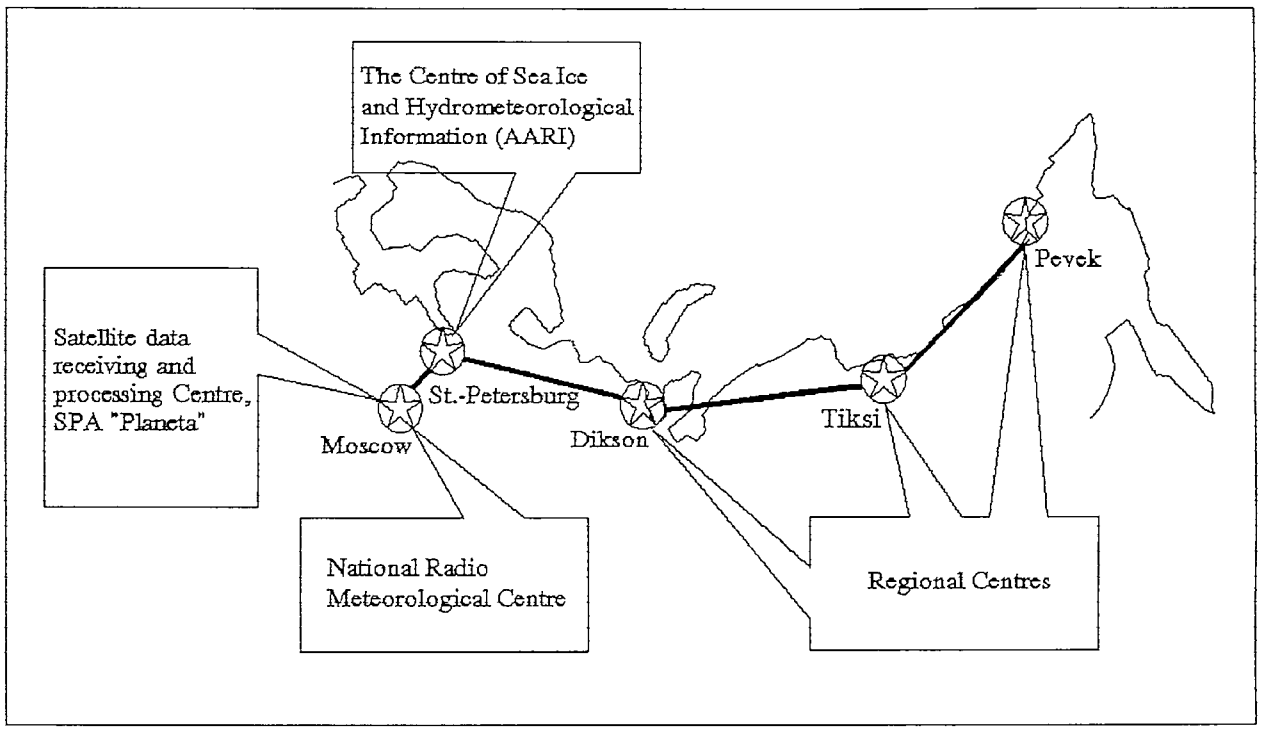

Fig. 1.3.4.1 Sea Ice & Hydrometeorological System infrastructure

3.5 Output information

The output product of the CIHMI is:

A. Routine maps of ice situation; survey maps compiled in the winter period (November-May) include the main elements: age and thickness of ice cover. In the summer period (June-October), survey maps are designated to determine the main characteristic-concentration. After finalizing ice reconnaissance ice boundaries are extrapolated between the stripes of observing routes and a routine map is compiled on which symbols refer to zones with similar characteristics rather than to sites on route. The map is passed either to users or via facsimile communication channels.

B. The survey map of ice situation over the Arctic Ocean . This map is formed by the results of generalizing primary ice observations;

- routine ice maps;
- primary survey ice maps;
- drift maps over the Arctic;
- polar station data;
- ships.

C. The maps of ice situation forecast. The ice situation forecast by computer by the numerical

method is being now solved for the two seas (Barents and Kara). At the present time to calculate ice situation forecast, two software are used (one for the winter and the other for the summer). For calculation the balance equations are used for momentum, mass and energy, taking account of statistic and empiric relationships. A description of the wind forecast for the ice model operation is presented in the Report under Project 1.6.1.

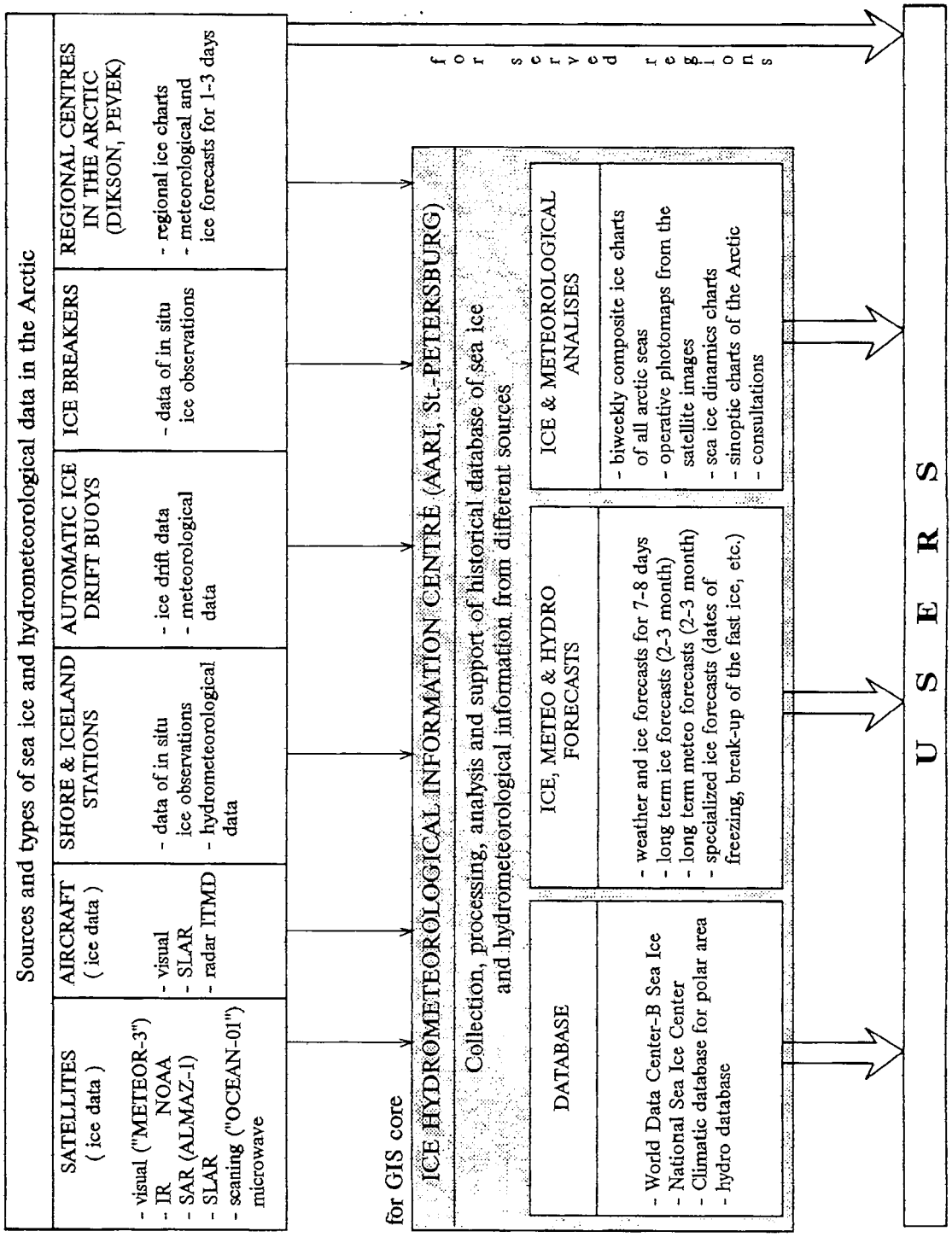

Fig. 1.3.4.2 BLOCK-SCHEME of Russian Automated Ice Information system for the Arctic

D. Routine information

The output production is sent to the headquarters of marine operations and is available on request.

3.6 Communication facilities

The results of information processing, as indicated above, are maps of ice situation of different types beginning with routine and terminating with 3 to 6 month-forecasts.

Users of this information are the headquarters of marine operations of the Ministry of Marine Fleet located in Murmansk, Arkhangelsk, Norilsk, Dixon, Tixi, Pevek as well as a number of organizations in Moscow and St. Petersburg. Routine delivery of information is carried out by means of AARI communication facilities and via rented channels.

3.7 National data bank

The national data bank is now functioning within CIHMI. The objects of preserving are MT-data of reports of expeditions and reconnaissances and cartographic information. At present data are being transferred from map-bases to machine carriers (strimmer stripes, diskettes) by means of digitizer of AO-format and specially developed software. Data bank is updated from routine data bank, as well as by information coming from international exchange.

3.8 International data bank

International data bank is the primary task out of those concerning establishing at AARI the World Data Center WDC-B "Sea ice". It is created in accordance with resolution 9 of Session of Commission for Sea Meteorology of the World Meteorological Organization (WMO) and Decision of Federal Service on improving centralized collection, processing, archiving, dissemination and exchange of data on sea ice to support functioning world global data bank on sea ice and meeting demands of national and foreign consumers. It is a structural research subdivision of AARI with data bank on sea ice operating in accordance with the "Guidebook on World Data Centers". The major operation functions are international data exchange on sea ice, its storage and transformation into international and national formats. They are as follows:

- collection, processing, analysis and systematizing data on

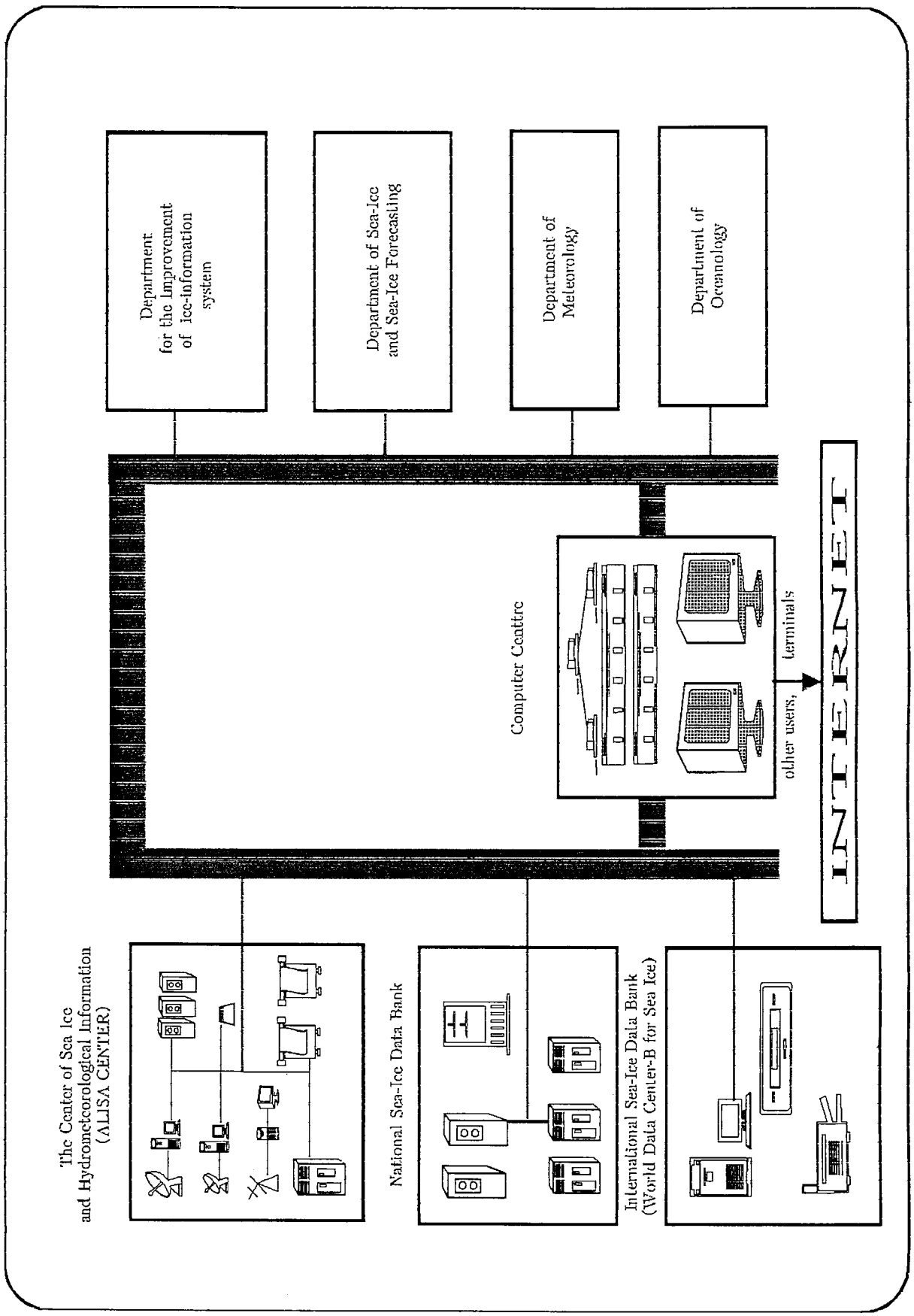

Fig. 1.3.4.3. AARI Local Computer network

sea ice in internationally-agreed formats;
- data exchange within the framework of international projects and programs;
- providing national and international consumers with information and data on sea ice;
- scientific-methodological work on estimating the quality and comparison of ice data obtained via the system of World global data bank (WGDB MT), developing new and improving the available technologies for data and information exchange;
- improving, developing and agreeing international formats for sea ice data exchange;
- preparing and dissemination of catalogues and other reference materials to data users in the system of WGDB;
- participating in national and international projects.

3.9 Territorial administrations

A. The subsystem of observations of actual ice and hydrometeorological situation consists of:

- network of polar stations;
- aircraft visual ice reconnaissance.

Network of polar stations provides regular coming on synoptic dates of information about actual state of meteo-and-hydrological parameters.

B. A communication subsystem includes:

- radiocommunication of polar station network;
- service ASDCT (radiobureau, facsimile operating room, transmitting and accepting stations);
- station accepting satellite information.

Radiocommunication with polar stations is carried out mainly in MW-range.

Satellite information is received from satellites "Meteor", "NOAA" and "Ocean-01"

C. The processing subsystem includes:

- processing of meteorological information;
- processing of oceanographic information;
- processing of satellite information;
- processing of ice information.

Processing of satellite information is carried out visually by

decoding meteorological and ice parameters.

Processing of ice information is conducted by a few stages:

- processing of ice reconnaissance according to the zone of responsibility;
- compiling the survey of ice situation;
- generalizing ice situation 2-3 days in advance and transmitting it to AARI;
- compiling decade ice surveys.

In the internavigation period, in addition to ice forecasts, recommendations are compiled on admissible loads on ice. The main consumers of information according to the zone of responsibility are:

- production association of sea transport conducting during navigation sea transportation in the coastal zone of the Laptev Sea and the East-Siberian Sea;
- shipping company conducting cabotage in the coastal zone of the Laptev Sea and on rivers of Sakha-Jakutia, to sea ports Tixi and Pevek, the Chuckchee Autonomous Area of Magadan Region, water area of the East-Siberian and Chuckchee Seas and the Anadyr Bays of the Bering Sea.

4 BRIEF ANALYSIS OF FOREIGN ICE-INFORMATION SYSTEM

At present almost all countries conducting economic activities in polar regions have national services (centers) of ice support.

Among them are, for example, Ice Center Environment Canada (ICEC) located in Ottawa, Center for Ice Reconnaissance and Ice Information in Greenland (IC) on the basis of AF in Narssarssuak, Ice Center of the US (NAVY/NOAA JOINT CENTER), Sweden and Finnish Ice Services, etc. A detailed information about the structure of centers, their tasks, kinds and regions of ice support can be found in (WMO 574, 1981) and later publications. Below is brief information about data support of a number of centers (services) in the beginning of the 1980s.

Denmark. (Governmental Icebreaker Service, Danish Meteorological Institute). The Icebreaker Service provides ice support in Danish water , channels, bays. Information sources are: the results of visual and radar observations from aircraft, satellites, meteorological maps. Output information: Ice maps (1:1 000 000), messages about ice conditions; forecasts are developed irregularly.

Finland. (Finnish ice service under the Institute for Marine Research). Information sources: data of ground observations from coastal stations; irregular visual observations from aircraft; satellites. Output information: maps on actual and forecasted ice conditions (1:1 000 000). Forecasts for 30 hours on velocity and direction of ice drift, regions of movement and change in ice concentration.

Iceland. (Icelandic meteorological Administration). Sources of information: visual observations from light-houses and coastal meteorological stations, radar observations from ships. Visual and instrumental radar survey; satellites. Output information: ice maps on actual maps (1:2 500 000) in the 65-69 N and 11-28 W zone, monthly surveys, annual report.

Canada. (Service of Atmospheric Research, Administration on the Environment in cooperation with Canadian Coastal Defence). Complete routine support in the Arctic is carried out during the period of time from the middle of June to the end of November. Information sources: satellites, visual and instrumental survey, ship data, coastal stations. Output information: maps of analysis of ice conditions (1:1 000 000), current ice maps (1:2 000 000), survey weekly maps (1:4 000 000), seasonal surveys, daily ice forecasts, three-day forecasts, 30-day forecasts, seasonal forecasts.

USA. (NOAA, coastal defence and MSF). Sources of information: ground observations, observations from ships. Aircraft ice reconnaissance with using radar and radiophysical observations. Satellite data are also widely used. Output information: Maps of Ice Patrol (twice a day), weekly map of Alaska waters, 7-day forecasts, 30-day forecast.

Ice-information systems (or sets of certain technologies) used in these services (centers) were created to provide certain national interests over individual regions of the Arctic (and other) basins. Ice-information systems for collection, processing and transmission of information to consumers. In these terms they can be considered the systems of one class. Development and improvement of systems occurred as the circle of solvable problems expands under the conditions of intensifying man's activity in polar regions. In recent years there is predominating tendency to using satellite information both in routine ice support and in creating specialized databases. This is caused by increasing resolution of board apparatus as for applying geoinformation technologies.

In spite of their common topical contents these systems differ by configuration, technical and software facility use, databases, communications and output consumer's production. Considerable differences are intrinsic to national ice-information systems including the extent of their integration and multifunctionality, which pre-determines their classifying to the systems of different order.

Not dwelling on the detailed analysis of certain ice-information systems with the aim of comparative determination of their advantages and disadvantages, levels of complexity, functional features, the extent of correspondence of constructions to basic principles of systems engineering, let us mention that, as we think, none of these systems can be used for complex solution of problems of the INSROP Project at the modern science-technological level to provide efficiency and safety of transit navigation on NSR. The above cannot be eliminated by simple modernization of certain ice-information systems without changing one of the most important components of the ideology of their construction - the principle of regionalism not meeting the tasks of managing such an inhomogeneous macroobject as NSR.

Along with this, individual subsystems, blocks, technologies as well as the experience of operation of existing ice-information systems, have to be used with building integrated multifunctional system for providing transit navigation on the NSR.

5 PROPOSALS FOR DEVELOPING MULTIFUNCTIONAL INFORMATION SYSTEM INSROP

5.1 Requirements to multifunctional information system

The system of ice and hydrometeorological support within the Project INSROP is to represent an integrated system of control over technological process of support of navigation on NSR. It should be based on the systems for data processing, whose major goal is automation of information processes and improving the form and organization of their implementation.

In this case an object for control is the totality of transport forces and means intrinsic to units carrying out sea shipping. Resources of the system are the totality of knowledge about the natural environment of the Arctic transformed into substantiated recommendations designated for making decisions at different organizational levels.

The complexity of proposed system is due to:

- a large number of spatially distributed inhomogeneous elements of the system;
- a high extent of their relationship in elucidating ice and hydrometeorological situation;
- considerable territorial extent of the object in question;
- uncertainty of the results obtained in the course of implementing planned operations (the degree of probability);
- non-stationarity of geophysical processes.

The long-term experience of ice navigation with operating the Russian ice information system revealed a number of aspects associated with the necessity to modernize by providing the following functions:

- routine support: changing economic and legislation relations among the subjects of subsystem (AARI, Federal Service, TAHMS), shipping companies, departments and private companies);
- information support: regulating information fluxes and preparing information;
- hardware: technical facilities for automating implementation of basic information processes (collection, transmission, processing of information) as well as standard-reference support for reliability of operation;
- geophysical support: Models, methods, algorithms and their

substantiation for solving problems in corresponding functional subsystems and implementing corresponding information processes in the system (models of processes, numerical calculation schemes, forecasts with different periods in advance);
- software: a complex of program products and instructions.

A feature of the system of a given type is the fact that the controlled object (subjects of transportation mechanism) are not the objects of control by which information support is provided. In other words, they are not a medium whose state is permanently controlled over.

In operation, the complexity of building and operation has been revealed, caused by:

- the necessity of organizing control on the quasi-real time scale to qualitatively describe the process:
- the probability character of the estimating environmental behavior because of inadequate knowledge of the mechanism of formation of hydrometeorological and ice situation;
- a high extent of automation of collection, processing and presentation of results for making decisions.

Adapting the system to solving problems of INSROP has to provide:

Confidence: a feature of the system is to provide the correspondence of control results to adequate description of the object under observation. It depends on a number of factors, namely:

a. methodological component caused by the laws of distribution of the values of output parameters of the object under control (verification skill of forecasts, their accuracy). It supposes formation and keeping of specialized database and their permanent updating);

b. list of controlled parameters (and requirements to them) determining the depth of control and the extent of solving navigation problems. In addition, to their complex representation by the law of users an advanced interface is to be developed;

c. periodicity of updating information about the state of environment. It is determined by the regulations of exchange of output data and requirements to databases.

Instrumental component of confidence:

a. reliability and precise characteristics of information are

determined by precise characteristics of instrumental means and methods for database formation;

b. methods for organizing control;

c. ways for mastering of data. It assumes using geoinformation technologies best promoting mastering of inhomogeneous data.

To estimate the extent of correspondence of major indicators of the quality of ice and hydrometeorological situation, the followise is necessary:

- choice and unification of the general collection system taking into account the diversity of output parameters of environmental state as an object under control. It assumes the identity of information sources, means and methods for its processing in different structural units of the system;
- general methodology for estimating control;
- estimating adequacy of output data to user requirements. It assumes permanent feedback with users, improving methodologies for support and conducting research and studies;
- choice and substantiation of quantitative structure of subsystems for collection of information. Changing the structure of system objects at different levels: the number of subdivisions, their interaction;
- optimization of indicators of speed of response including communication channels. Using communication means providing acceptable dates of information circulation;
- determining expedient extent of automation. Automation should be applied to those technological processes whose time cycle of implementation is most critical in the general technological chain of support.

It should be taken into account that control over navigation and decision-making is of a hierarchical character allowing for combining centralized control with autonomous parts.

5.2 Introductory statements about the conception of the united information system INSROP

The conception of the information system is based on the principles of system statements: succession of system, modulatory method of its building, automation of technological processes on the basis of prospect geoinformation technologies, using routine communication with users and inside the system and other information systems and databases.

Differentiation of the system by the kinds of support: strategic, routine and tactical. The problems of strategic level are to be solved by the objects of navigation and headquarters of marine operations and consist in the formation of the composition of convoys, ice support, choice of routes and terms of transportation operations. In this case, survey maps of ice situation over the region of sea operations and adjoining water areas are used as well as forecasts with different periods in advance. Solution of tactical problems associated with direct movement and maneuvering convoys in ice requires the most detailed ice information. For this purpose, large-scale ice maps, aircraft and helicopter observations are to be used.

A detailed working out and agreement of the conception of the information system will be accomplished in 1994.

5.3 The role and tasks of the Russian national hydrometeorological information system within the multifunctional information system INSROP

It is assumed that the indicated statements of the conception can be realized on the basis of the existing Russian ice information system by using advanced geoinformation technologies and databases developed in the interest of the INSROP Project by the sides-participants. In this aspect the system is to be uniting for all the subjects of the program. This proposal, in our opinion, is optimum and allows solution of the problems of the INSROP Project with least losses.

5.4 Navigational and Hydrographic Database

Navigational and hydrographic data (NHD) includes a wide range of maps, guides, manuals and other documents intended for provision of efficient and safe operation of maritime craft. It is a matter of urgency to develop an automatic information system in which all NHD would be concentrated, and to offer the advanced methods and aids for access thereto to the users. The problem is of particular importance as far as the Arctic is concerned, in view of the expected participation of the international shipping. Prior to the development of the GIS system, the problems and difficulties involved should be identified.

Firstly, it is necessary to identify the information to be included in the NHD. This will be the following:

- navigational nautical and river charts and plans;
- special reference and auxiliary charts (bathymetric, geomagnetic, gravimetric, climatic, etc.);
- pilot sailing directions, including infrastructures;

- lights and marks;
- radio beacons and other radionavigation facilities;
- guides for sailing in special conditions;
- data on communications systems and radio stations;
- tide tables;
- special publications, catalogues, etc.

This information was collected, generalized and formed over several centuries and is currently presented on paper carries. Private data banks on certain elements were developed by various organizations. However, the information contained is not always complete and is intended for limited applications. That is why this information can be used only as a primary source in compiling the NHD and is subject to further refinement, augmentation and formalization.

An organization responsible for preparation and updating of navigational and hydrographic guides for sailing the Russian Arctic is the Hydrographic Department.

The NHD users will be various organizations whose activities are connected, in one form or another, with navigation in the Arctic. The main users will be:

- shipping companies;
- marine operations headquarters;
- SAR services and centres;
- scientific and research institutes;
- planning and surveying organizations;
- harbour and pilot services;
- hydrographic bases and pilot master teams;
- marine and land scientific expeditions;
- building companies;
- educational institutions;
- ships.

It is obvious that there is a wide area of NHD applications - from scientific purposes to practical tasks, such as traffic management and on-board utilization. With this in view, the database information should be universal and complete in order to satisfy the needs of all user categories. The main difficulty is that each user category will expect to find in the database just what it needs and each user has its own needs. The system should be adapted to the needs of various users, and its database should be designed with account taken of potential demands of the users. In further stages of the investigation, formats for each user category should be specified.

It is of prime importance to keep the NHD at the up-to-date level. The NHD is sensitive to times. The database content should be augmented by inclusion of new information, with a capability of

refining all information at any time being provided. An updating period may be different for various elements. The most stringent requirements are imposed on the navigational charts and guides which should be updated every week in accordance with international maritime standards. To provide the updating capability, a special unit with its own NHD should be included in the database.

Details on the electronic navigational charts and the associated databases are discussed in Project I.4.1.

A further important factor affecting the database design is that ships will be among the users, that requiring special systems for data exchange being employed together with conventional channels used in international data networks. Currently available for support of navigation in the Arctic are two such systems, INMARSAT and Ocean, which are described in detail in Project I.1.2.4.

Considered in the Norwegian report "Physical Environment Database" is a concept of information classification based on using the object (e.g., port, ship, river, etc.) as a key element. Whatever the system concept might be, the initial documents referred to above should be retained in the database as an official source of information.

In addition to the ice, weather, navigational and hydrographic information, directly relating to the GIS concept, there are some other information databases required for international shipping. Of particular importance is the ships' performance database. As far as the Russian fleet is concerned, such databases are used by all shipping companies, including these in Murmansk, Arkhangelsk and Vladivostok. A general database containing information on performance of all Russian ships is available at the Main Computer Centre of the Department of the Maritime Transport of Russia. Among the main users of this database is the State Maritime Rescue Coordination Centre. Unfortunately, the databases currently available are not unified and are incomplete. Because of this, they can not satisfy in full measure the needs of NSR navigation. A universal database containing complete information on ship performance is needed for a wide range of users and for various applications.

5.5 Proposals for joint development and creation of united multifunctional information system INSROP

For future work on the Project it is expedient to consider a number of questions associated with its realization.

A. At present the Russian side has a permanently actin ice information system and long-term experience for support

navigation on the route of NSR.

Specialized data banks on sea ice are being developed on the basis of National and International data banks including information over the long-term history of elucidating ice situation on the water area of the Arctic Ocean.

Technical re-equipment of CIHMI AARI is now being conducted. Local computing network with powerful computing means, National and International data banks can become the basis for their use in the INSROP Project.

When creating specialized software for processing data, its archiving in data banks, specialists of AARI use GIS-technology. However, no experience is available in using modern geoinformation systems.

Within the Project it is suggested to carry out the following division of functions to reach a greater effect:

a. The Russian side can be responsible for the tasks of adaptation of available technical facilities, software, methodology and databases;

b. The Norwegian side can concentrate attention and efforts on developing software and methodological support for GIS;

B. It is necessary to develop requirements to communication facilities. At present AARI is able to exchange data with participants of the Project within the INTERNET network. However, for failure-free functioning system at the levels of territorial administrations it is necessary to provide reliable communications among the Russian modelers of the system.

In this connection it is appropriate to consider the questions of using satellite communication channels both of Russian conversion systems and international systems of satellite communication.

C. For data exchange and using available information it is expedient to consider regulations of exchange, develop its protocol and create developed interface of user allowing work with databases.

D. The proposed, as a central for user, geoinformation system ARC/INFO will solve only a group of tasks. Representing a vector-based precision cartographic system it can be used as SCDB (System for Control over Databases) and the means for creating (updating) databases. Bearing in mind that a portion of satellite information in

elucidating ice and other situations and creating databases is quite great, it is expedient to consider the question of using in the Project one of the raster-based GIS (e.g., SPANS or ERDAS).

6 CONCLUSION

The results of work on the project 1.3.4 in 1994 allow making the following conclusions:

- Russia has a permanently-acting ice-information system for support of the Arctic navigation;
- In individual blocks of the system, GIS-technology and modern computing facilities are used, which make allowance for the possibility of adaptation in the system of certain commercial GIS, its individual modules or modules of individual GIS;
- Russian ice-information system can be taken as the basis when creating a multifunctional integrated system for information support of the INSROP Project;
- To implement the INSROP Project further optimization of the proposed system is advisable.

For this purposes it is proposed:

- to develop requirements to a multifunctional information system for ice and hydrometeorological support taking into account interests of all the participants of the Project and potential users;
- to additionally consider the question of choosing certain GIS, its modules or modules of different GIS;
- to adapt the software developed by the Norwegian side to the technical facilities available at AARI and structural blocks of ice-information system (with their possible change and modernization).

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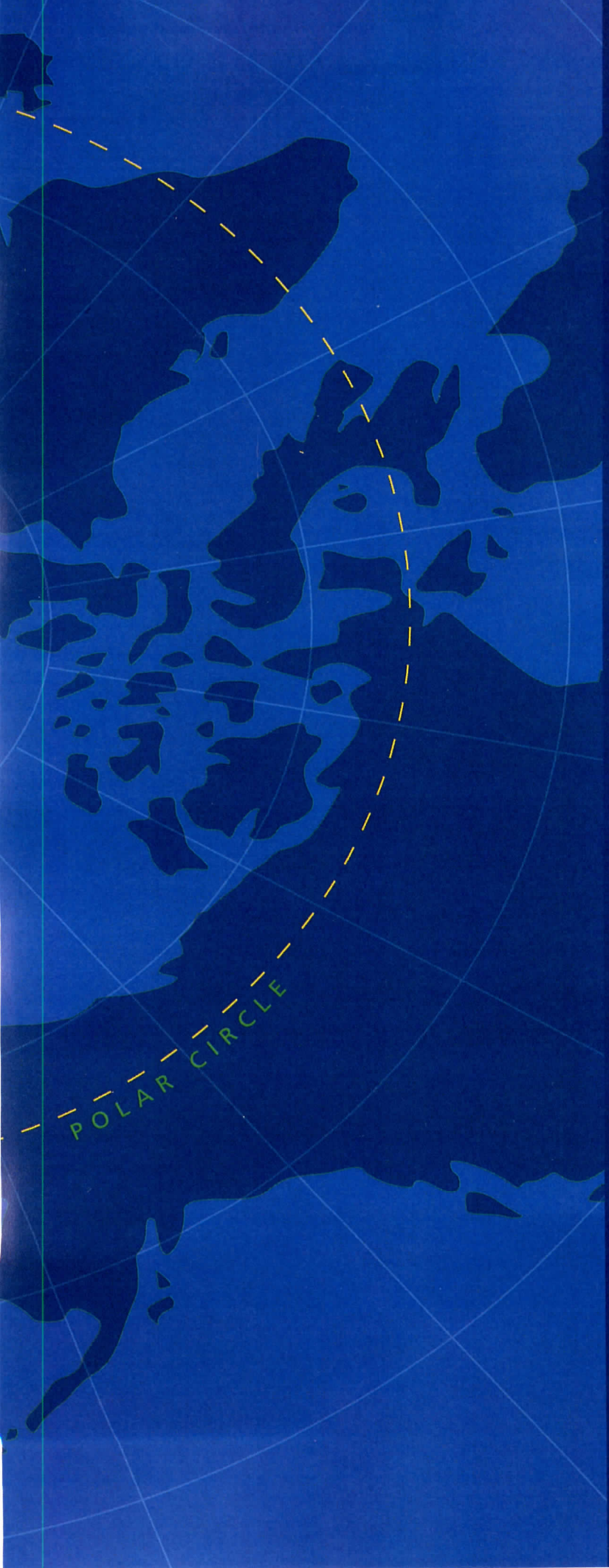

The three main cooperating institutions of INSROP

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

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

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