Cold Regions Engineering Research and Development: Future Needs

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Geothermal Service of Canada

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Division of Seismology and Geothermal Studies

Earth Physics Branch

Department of Energy, Mines and Resources

1978

Cold Regions Engineering Research and Development

Alan Judge

On 28th February and 1st March, 1978, I participated in a meeting at NRC to discuss engineering R and D needs for resource development and associated transportation and communications in the north for the next decade. The meeting was one portion of a study being undertaken for MOSST by NRC. Overall the study has a mandate to determine the needs of both industry and government for national capabilities, expertise and facilities for cold regions engineering research and development. By cold regions are meant those areas north of the southern limit of discontinuous permafrost including the arctic islands and the waters between and the ice-affected waters offshore of the east coast. NRC have established a committee under Dr. Lorne Gold to guide the study and to assist in the preparation of the final report. Appendix 1 shows a flow chart of the present study and the relation of the February meeting to the total study. Appendix 2 lists those present to discuss basically the engineering R&D needs of northern resource industry and relevant government regulatory authorities.

Those on the initial list of participants were invited to submit written briefs prior to the meeting. The briefs were circulated to attendees before the meeting allowing the actual meeting to discuss only the essential details. I did not prepare any advance brief as my participation was invited only at the last minute as an observer since we do not have a direct role in either resource production or regulation. Each of the individual briefs is attached in Appendix 3. However, rather than place them strictly in order of the agenda I have split the submissions into those received from industry, by industry (mining, oil and gas, transport, communications), and those received from the government regulatory bodies by the same general divisions.

The meeting commenced with a brief description of the history of the study by Lorne Gold and how the present workshop fitted into the complete package. The end product will essentially provide MOSST with identified deficiencies in R&D needs, recommended mechanisms for filling the immediate gaps and ensuring that future R&D needs will be met together with a list of performers and their capabilities. Don Stewart representing the northern people stressed that his government is responsible for people and services in the north rather than the resource industries which largely remain under federal control. Those industries do, however, generate communities and bring money to the north. In a social sense the territorial government is very concerned at the high cost of importing southern technology to solve northern problems and favours an indigenous local "soft" technology approach. Stewart in addition perceives a liaison and coordination problem between scientist and programme manager (technology transfer). One wonders how the contradictions might be resolved between a resource industry using state-of-the-art technologies to produce profitably interacting with communities based on simple, locally derived technologies.

Graham and Douglas described mining industry perceived needs for the north. The three most important items raised were waste disposal, the costs of energy and the difficulties of transport of the concentrate. Graham based on his experiences at Nanisivik cited it as an example. Of the possible tailings disposal sites i.e, a fjord, dammed pond or natural freshwater lake, the lake was chosen because insufficient baseline information was available on the long term marine circulation in the fjord system or on the performance of an artificial pond and dam on the permafrost. Loken suggested that the ultimate solution is to reduce the toxicity of the tailings at source. Stewart commented on the already high concentration of heavy metals in the northern food chain. Dry tailing disposal is not practical because of the high average wind levels. Considerable northern experience has been developed by different mining companies but no adequate mechanisms of technical information exchange currently exist. Mining companies are heavy energy users and yet northern locations may be confronted with costs of 10¢ per Kwh. Any possible ways of reducing these costs (the nuclear option specifically was mentioned) could improve the viability of northern operations. Russian experience with diesel generators mounted on barges, wind systems, indigenous coal and oil and gas supplies and the geothermal option were all discussed. Transportation presents very real problems not least of which is the cash flow situation for a coastal mine shipping ore only one or two months in the year. In the hinterland, and Douglas had a map showing the defined ore bodies between Yellowknife and Bathurst Inlet, the problems are immense if roads or railways are to be constructed. It was noted that once large ice-breakers are available Canadian transportation routes may adopt the Russian approach of constructing road and rail systems to arctic coastal ports rather than constructing more Dempster or Mackenzie Valley highways linking north and south. Long term alternatives such as giant balloons were also raised. Other areas in mining discussed were those associated with permafrost (geophysical exploration, drilling, blasting, drift-wall stability) and those associated with extreme ambient temperatures (ore handling, open-pit operation of machinery). Loken raised the question of revegetation of tailings areas mentioning that his group has prepared a bibliography on northern revegetation and is currently implementing a research programme to investigate northern species. Graham raised again the problems of coordination and information transfer between government and industry.

Onshore oil and gas developments expect few problems in exploration or production. Judge raised the difficulties of seismic analysis to detect small structures beneath permafrost and in a more serious vein the as yet unsolved problems of production through unconsolidated frozen sediments. Hemstock cited the Prudhoe Bay experience although admitting the period of experiment to be short and the ground conditions to be different. Nixon stressed how little is known about the structural performance of the production string surrounded by a thaw bulb. Judge stressed how little we know about the properties of permafrost and how inadequate our assessment tools are. The lack of knowledge on the performance of man-made islands in the offshore and the question of frost heave development around chilled buried pipelines was raised.

Peckover discussed some aspects of northern railways particularly the very high initial capital costs and the very high traffic volumes required to make mineral transport profitable; citing the "Arctic Oil and Gas by Rail" report as an example. The active R&D on northern rail is very small at present although key areas to examine would be: 1) new construction machinery to reduce initial costs, 2) materials research for improved low temperature performance, 3) road bed stability (thaw-settlement of degrading permafrost) and 4) non-standard rail systems (wide gauge, electrification, etc.).

Radforth described off-road transportation systems in minute detail together with descriptions of the various research needs and committees addressing them. In general those present did not perceive an enormous need in this area. Current government regulations prevent geophysical exploration in the summer months and limit cross-country travel. Conditions are such that helicopter transport is competitive in cost and speed and thus off-road transport is really only likely to fulfill a supporting role. Such transport is of more significance to the activities of northern communities and to the military. Health and safety are of considerable concern for currently available equipment (hearing loss resulting from skidoo usage).

Representing the oil and gas industry, Franklin raised the problem of transporting oil rigs between locations. Currently in the Arctic Islands operators need to wait for freeze-up to construct Hercules strips. A very large lighter-than-air aircraft could speed up the moving process and extend the season. The small market and the lack of in-place technology present problems. In addition a need is perceived for Vertol's with increased capacity and range of operation.

Communications was an area where much of the necessary technology is available but requires application. Industry complained about the very high cost of satellite communications. Kruus suggested this to be a result of under-utilization. Chow suggested major problems to be in the availability of skilled technical people in the north and the economics of northern communication. Stewart pointed out the need for cheap communications systems for northern residents particularly for hunters and trappers.

Considerable discussion centered around weather reporting (remote interrogable stations etc.) a topic which was raised again in connection with the offshore and, out-of-context, on underice underwater communication systems.

At this point the subject area switched from the onshore to the offshore. Hanus made a very lengthy and comprehensive report on the status and research needs for arctic shipping. O'Rourke followed this with a detailed description of the design and function of the Arctic Marine Locomotive. The different approaches of government and industry in developing arctic shipping were discussed, leading to questions of the mechanisms by which R&D can be conducted. Hyrasko pointed out that industry has been very negative towards the M.V. Arctic. Graham pointed out that industry will use if rates are competitive (i.e. no input to R&D). In contrast CanMar is proposing to construct the AML and cooperate with government on ice research. There seemed to be no major R&D problems as the instrumentation of each vessel leads to progressive improvement of future vessels. Of more concern were ancillary questions on route selection, ice conditions, ice control and management. Questions on the proprietary nature of joint government: industry investigations on sea-ice will need resolution. At present ice patrol information can be transmitted directly from aircraft patrol to the ship. As the number of ships involved increases and the volume of information available expands (with implementation of new radar systems) a central ship guidance office with ice and meteorological information will be necessary and presumably it will remove some of the individual action currently carried out by ship's captains by recommending shipping lanes. Considerable upgrading of navigational systems will also be required.

Drillships have a rather different problem in that they are required to maintain precise positions for long periods. Presently such operations are only permitted at specified times of the year and when the seas are ice-free. O'Rourke described a need for much greater emphasis on studies of sea-ice to support a lengthened drilling season and the design of eventual production platforms. Required are models of the behaviour and movement of both the shorefast ice and the polar pack, baseline data of sea-ice properties and the development of a capability to describe the relevant parameters of ice using remote sensing methods. Methods of reducing ice pressures on production platforms are also relevant to keeping harbours free of ice and reducing ice pressure on ship hulls. Production platforms may be peculiar to the Beaufort Sea as water depths in the Arctic Islands and the East Coast may necessitate subsea production systems. Franklin described Panarctic's success in drilling from ice-strengthened platforms and described their need for studies on ice behaviour and movement which would enable them to extend drilling operations to 100 miles offshore. Petrocan is apparently investigating a large air-cushioned vehicle drilling platform for Arctic use. Berenger described Eastcan's interests in extending the exploratory drilling season into periods of ice-covered waters. O'Rourke summarized the needs for improved technology to handle oil spills. The requirements can be summarized as portable handling systems, methods to dispose of oil emulsions, the development of igniters, the possible creation of open-water areas in which oil could be collected and burned. Canada's expertise in ice-covered waters technology is not very high. A reasonable science base is available as is the operational engineering requirement, but remote sensing instrument technology, drilling systems technology and ice engineering technology is available largely in the United States.

Smith pointed out that unless safe production is ensured LNG's, AML's and other transportation systems are of no value. EMR sees very serious engineering R&D needs associated with the subsea production systems envisaged for the East Coast of Canada. He stressed the need for submersibles capable of construction, repair and control of such systems, the need for adequate sub-sea communications systems to control the flow of hydrocarbons through sub-sea pipelines and the need for adequate geotechnical studies prior to construction. Judge described some areas of inadequacy of geotechnical tools and some of the tasks EMR is taking to sölve them, e.g. the funding of high resolution seismic system development. This led to a discussion of the inadequacies of geophysical tools both surface and downhole in evaluating the subsurface, particularly in the presence of permafrost conditions.

Feldman and Midwinter summarized the required research needs for the safe construction of offshore production systems and pipelines emphasizing the importance of ground conditions, permafrost and scour conditions. Midwinter continued to discuss onshore pipelines as he had missed the first day's session. His emphasis geotechnically was on slope stability, frost heave and thaw settlement although he spent a much greater period taling about pipe integrity, fracture propagation and metallurgy. He claimed all expertise lay with Batelle Labs in U.S. and British Gas so Smith and Judge mentioned CANMET and Judge described the programme in a Treasury Board submission of which NEB was not aware.

The various environmental issues raised during the course of the meeting were summarized by Kruus. He stressed that better baseline information will lead in general to less rigid environmental conditions and to lower costs to the resource industries. Palliser saw a need to separate the short and long term research needs which touched off a discussion of the requirement by industry to produce a return on the exploration investment as rapidly as possible contrasted with a general unwillingness to undertake R&D research until a viable resource is proven. Wilkinshaw pointed out that the prospect of resource development is the key to driving northern R&D whether good or bad.

Finally Kivisild on behalf of the Steering Committee attempted to summarise some of the major concerns expressed. These are tabulated below:

Land-based

	Mining	exploration in permafrost tailings disposal information exchange power units for remote areas
	Oil & Gas	frozen ground geophysical interpretation transportation
Transport -	Railways	thaw settlement equipment design
	Off-road	fast rubber-tired transport system
	Pipelines	metallurgy thaw settlement frost heave
	Environment	increasing awareness additional observational networks improved terrain protection study of snow properties
	Communications	satellite systems underutilised

Off-shore

Mining	?
Oil & Gas - Exploration	extension of drilling longer season and greater water depth ice management design of structures - bottom founded / ice platforms
Production	extended development of systems - artificial islands sub-sea systems, pipelines, tunnels
Transport - ice management	information dissemination ice properties harbours transportation routes systems of management impact on structures

research programme using new vessels

Environment	ice forecasting forecast dissemination models of ice behaviour measurement of ice properties
Communications	sufficient to ensure safe operation

COMMENTS

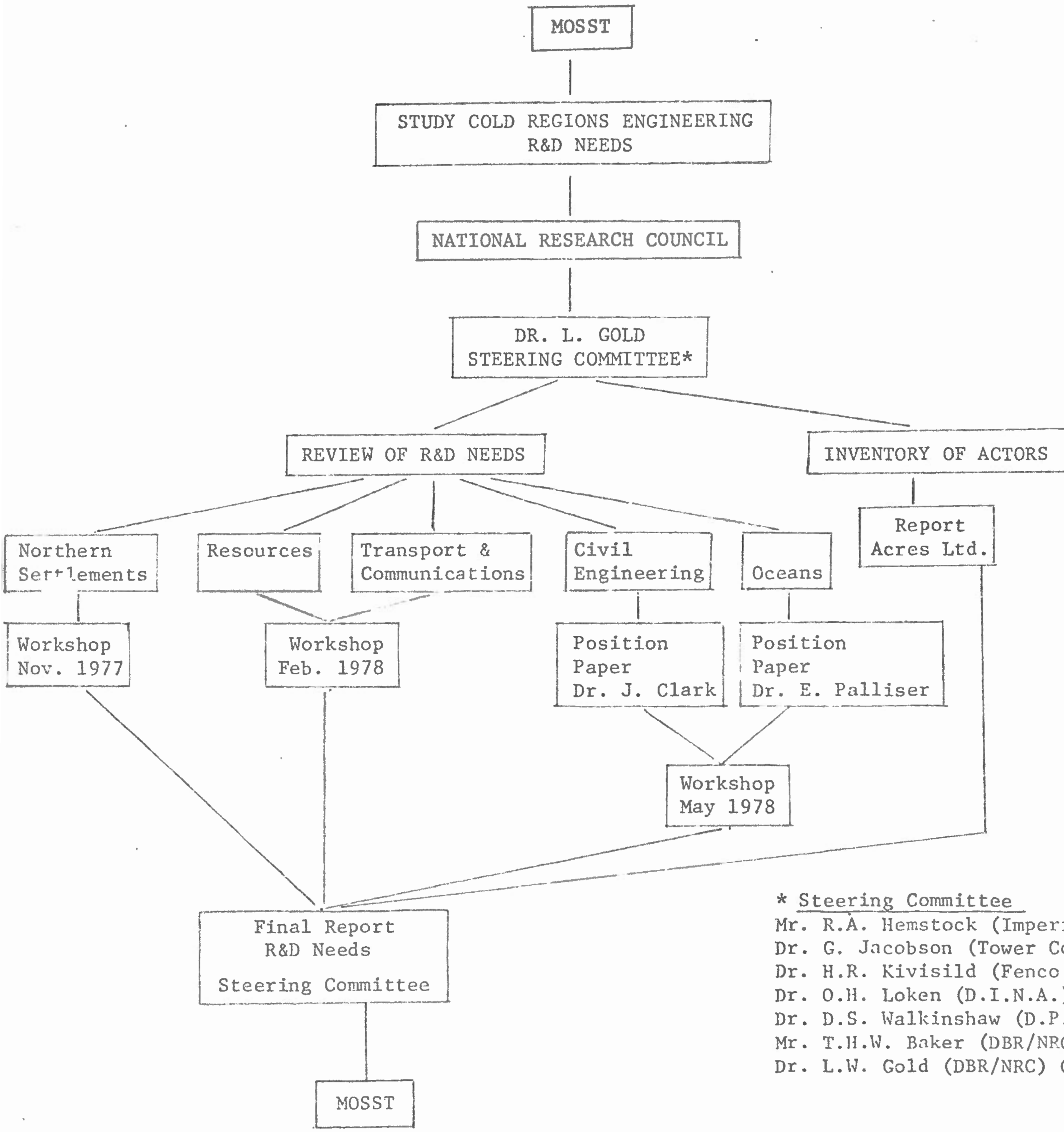
The two most obvious features present in the north but which are not present elsewhere are: 1. waters ice-covered for large portions of the year and 2. permafrost in the subsurface soils and rocks. Problems that relate to these features are unique to northern Canada and a small number of other northern countries. A fair amount of time at the workshop was spent discussing problems resulting from the remoteness of northern locations, the low ambient temperatures encountered and the need to drill for and produce hydrocarbons from deep waters; none of the above of which are uniquely northern engineering problems. The workshop, through bringing together industry and government regulatory authorities, neglected the role of scientific research which forms the missing third corner of a triangle. The researcher adds an important additional perception in identifying problem areas. Although the May meeting will enable researchers to input to the final report, the lack of regulatory officials or resource company personnel will limit the corss-pollination process known as technology transfer, already identified as a problem area. We have, in the past, found that our ad hoc permafrost and gas hydrate meetings in Calgary have been rewarding and lievely because they attempted to bring together scientist, regulatory engineer and the producer. Nobody knows whether MOSST will react to the final report, which by that time will have absorbed many man-years of meetings, with proposals to increase R&D funds to fill identified deficiencies or with implementation of any other of the recommendations. The very obvious research needs arising from the current workshop are: 1. A need to be able to describe sea-ice so as to assess its thickness, age and engineering properties, its spatial distribution and its response to changing oceanographic, bathymetric and climatic conditions. Methods are needed for the assessment to be done by remote sensing methods from aircraft or satellites. 2. A need to describe permafrost and its behaviour in terms of its physical and engineering properties and its response to thermal, hydrological or chemical impulses. Methods of reliable assessment by simple geotechnical and geophysical surface and boreholes techniques are needed. Mathematical models which confidently predict the response of the permafrost to external impulse are additional needs.

The second of the two items describes roughly what we are attempting to do. I heard nothing at the meeting that would suggest that we were looking at the wrong problems or that the problems will be any less severe than we have previously envisaged. In the submissions from government oil and gas regulatory bodies questions regarding the long-term performance of artificial islands, of integrity under thaw settlement of casing strings, the effects of freezeback and the design of onshore and sea-bottom pipelines were raised. Industry in addition raised questions involving the identification and quantification of permafrost and gas hydrates on- and offshore, the prevention of excessive shoreline erosion where pipelines are brought ashore, the design of offshore production systems, and improvements in the existing technology in soil geology and geophysics. The submissions by the mining industry were rather more disappointing reflecting the absence of the Iron Ore Co. who have many years of permafrost experience at their Schefferville operation and the lack of any direct role of D.I.N.A. in mining R&D. The lack of a coordinating function by D.I.N.A. in this area meant that R&D needs identified tended to be mine rather than mining specific. It is good to see the beneficial aspects of permafrost being noted e.g. Graham's comment on the Arvik mine.

In summary an interesting workshop which certainly succeeded in describing the very great challenge that the north presents. I look forward to the third part of the trilogy in May when the performers get to outline their aspirations and perceptions for the north.

APPENDIX 1

FLOW CHART OUTLINING STUDY



* Steering Committee

Mr. R.A. Hemstock (Imperial Oil Ltd

Dr. G. Jacobson (Tower Co. Ltd)

Dr. H.R. Kivisild (Fenco Ltd)

Dr. O.H. Loken (D.I.N.A.)

Dr. D.S. Walkinshaw (D.P.W.)

Mr. T.H.W. Baker (DBR/NRC) Sec.

Dr. L.W. Gold (DBR/NRC) Chairman

APPENDIX 2

INVITED PARTICIPANTS IN

FEBRUARY WORKSHOP

APPENDIX 2

COLD REGIONS ENGINEERING RESEARCH AND DEVELOPMENT

Invited participation to meeting to discuss engineering R&D for resource development and associated transportation and communications.

DATE: 28th February and 1st March 1978

PLACE: Main Conference Room, M-20, DBR/NRC

TIME: 0900 hours

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Eastern Petroleum Operators Association	Calgary (D. Berenger)
Arctic Petroleum Operators Association	Calgary (B. White)
Federal Commerce and Navigation Co. Ltd.	Montreal (G. Hanus)
E.P. Graham Mining Consultants Ltd.	Toronto (E.P. Graham)
Canadian Marine Drilling Ltd.	Calgary (J.C. O'Rourke)
Panarctic Oils Limited	Calgary (L.J. Franklin)
Cominco Limited	Yellowknife (R.P. Douglas)
Geotechnical Consultant (railways)	Vaudreuil (F.L. Peckover)
Consultant (off-road transport)	Bracebridge (J. Radforth)
Pallister Resource Management	Calgary (A.E. Pallister)
R.M. Hardy & Associates	Calgary (J.F. Nixon)
Transport Canada (Research & Development Centre)	Montreal (M. Brenckmann)
Transport Canada (Arctic Transportation Agency)	Ottawa (M.G. Hagglund)
National Energy Board	Ottawa (C.D. Midwinter)

Government of NWT	Yellowknife (D. Stewart)
Fisheries & Environment Canada	Ottawa (E.F. Roots) (J. Kruus)
Department of Indian and Northern Affairs	Ottawa (I.M. Feldman) (J.M. Patterson)
Department of Energy, Mines and Resources	Ottawa (R. Smith) (A. Judge)
Communications Research Centre	Ottawa (S.M. Chow)
Ice Central AES	Toronto (W.E. Markham)
DBR/NRC	G.H. Johnston
DBR/NRC	R.M. Frederking

****

COORDINATING COMMITTEE

Mr. R.A. Hemstock	(Imperial Oil, Calgary)
Dr. G. Jacobsen	(Tower Company, Montreal)
Dr. H.R. Kivisild	(FENCO Consultants Ltd., Calgary)
Dr. O.H. Løken	(Department of Indian and Northern Affairs, Ottawa)
Dr. D.S. Walkinshaw	(Department of Public Works, Ottawa)
Dr. L.W. Gold	(Chairman - DBR/NRC)
Mr. T.H.W. Baker	(Secretary- DBR/NRC)

APPENDIX 3

AGENDA AND SUBMISSIONS FOR

FEBRUARY WORKSHOP

NATIONAL RESEARCH COUNCIL OF CANADA

STUDY ON
COLD REGIONS ENGINEERING
RESEARCH AND DEVELOPMENT

Resource Development and Transportation
and Communication Meeting

28 February and 1 March 1977

AGENDA

1. Introduction

2. Land-based activity

Mining - exploration
- production

Oil & Gas - exploration
- production

Transportation - railway
- off road
- pipeline

Environmental concerns -
- standards of performance required
- capability to conform to requirements

Communications

3. Offshore

Transportation - ship

Oil & Gas - exploration
- production
  - surface systems
  - subsea systems
- pipeline

Mining

Environment - ice forecast
- standards of performance required
- capability to conform to requirements

Communications

27/2/78

LIST OF SUBMISSIONS TO

COLD REGIONS ENGINEERING RESEARCH AND DEVELOPMENT

GOVERNMENT REGULATORY AGENCIES

1. General - Kruus (D.O.E.)
   - Stewart (N.W.T.)
2. Mining - Patterson (D.I.N.A.)
3. Oil and Gas - Woodward (D.I.N.A.)
   - Smith (E.M.R.)
   - Midwinter (N.E.B.)
4. Transportation - Brenckmann (D.O.T.)
   - Markham (D.O.E.)
5. Communications - Chow (D.O.C.)

INDUSTRY

1. Mining - Douglas (COMINCO)
   - Graham (Consultant)
2. Oil and Gas - O'Rourke (CANMAR)
   - Wright (Gulf)
   - Franklin (Panarctic)
   - Buemi (Eastcan)
3. Transportation - Peckover (Railway consultant)
   - Hanus (Federal Commerce & Navigation)
   - Radforth (Venture Technical Services)
4. Communications - Scrimes (Foothills)

Fisheries and Environment Canada
Pêches et Environnement Canada

February 20, 1978

Your file Votre référence

Our file Notre référence

Lorne W. Gold
Chairman
Coordinating Committee on
Cold Regions
Engineering Research
National Research Council
Division of Building Research
Montreal Road
OTTAWA, K1A OR6

Dear Lorne:

I attach notes that might be relevant to the discussion on Cold Regions Engineering Research and Development on 28th of February. I really feel a poor substitute for Fred's personal involvment, but hope that I can nevertheless make some contribution.

Yours truly,

Jaan

Jaan Kruus, Ph.D.

JK/js
cc: E.F. Roots
W.E. Markham

Fisheries and Environment Canada
Relationships to Resource Development in
Cold Regions and Associated Transportation and
Communication

Notes by Jaan Kruus, 1978-02-17

Fisheries and Environment Canada has responsibilities in areas of:

1) regulation, approval, monitoring and
2) provision of services.

1) In the regulatory area, DFE manages the Federal Environmental Assessment and Review Process for federal projects and acts often in a consultant capability to other government departments and industry in providing information and analysis.
   Various acts form the basis of pollution control regulations which are enforced nationally by DFE.

   Research needs for properly carrying out the mandate in this work relate to:
   - better understanding and capability to predict impacts on Northern Environments from resource development and associated transportation activities.
   - development of technologies capable of minimizing adverse environmental impact both from normal resource development and transportation activities and from accidents associated with these activities.

2) In the area of services, the base-line or climatological information services and typical research needs are tablulated below:

Information	Research Need
Ice Climatology	Compilation and analysis of existing information; development of archival and information retrieval systems.
Oceanography	Better understanding of the dynamics of arctic water masses and their relationship to ice, weather, and arctic biology.
(Weather) Climatology	More dense network of climatological stations in arctic and the surrounding ocean; derivation of climatic information from remotely sensed data and unattended stations; efficient data processing and retrieval.

"Bio-physical" Inventory	Development to derive reliable inventories in the most efficient way by combining new technologies with traditional surveys.
Wildlife inventory and habitats: arctic botany	Establishment of limits acceptable for various species; population dynamics; inter-species competition and dependence.
Hydrographic charts	New technologies for charting in ice-covered waters; more rapid and economic chart production.

The above information is needed by industry or other departments to:

a) specify engineering designs (e.g. ice, weather)
b) estimate operational limitations (e.g. oceanography, climate, ice hydrography)
c) provide baseline information on the environment for impact analysis

Other types of service relate to provision of environmental information on present and expected conditions of weather, ice, and oceanographic variables.

Research needs in this area relate to:

- better real-time data acquisition and distribution systems
- new means of measurement
- models capable of accurate local prediction
- better long-term forecasting by modelling regional and hemispheric dynamics.

PLEASE QUOTE FILE 12 426 303

(1)

GOVERNMENT OF THE NORTHWEST TERRITORIES

CANADA

N.R.C. D.B.R. RECEIVED FEB.24.1978 22187 1

ATTENTION LWG

ANSWER & FILE

Yellowknife, N. W. T.
X1A 2L9
22nd February, 1978

Dr. Lorne W. Gold
Assistant Director
Division of Building Research
National Research Council
Ottawa, Ontario
K1A 0R6

Dear Dr. Gold:

I much appreciated receiving Mr. Baker's letter of February 15 with attachments related to the workshop on February 28 and March 1.

My input to this workshop will be less than that made by Larry Elkin to the first one, since the Government of the Northwest Territories does not have responsibility for or specific expertise in resource development. However, we do have a great interest in resource-related technology. Solutions to many of the problems raised in the material Mr. Baker sent me would be of direct benefit to the people of the Territories. We also of course have much to gain from viable resource-based industries.

Following are examples of technological needs common to both industry and northern people:

1. Economical energy, water supply, and waste disposal systems for remote locations.

   The high cost of utilities is a major factor in keeping northern people from being truly self-reliant. Most native northerners live in rental housing supplied by government. If they owned their own houses very few of them could afford to pay for their utilities at the extremely high costs now prevailing in the north. In addition, the lack of adequate water and sewage systems is often a serious threat to health.

2. Transportation, including air, marine, and land.

   There has been a marked improvement in air transport to communities in recent years, with better airstrips and navigational aids, but there is still room for further improvement. The extremely high cost of all goods brought in affects the standard of living of residents and the viability of small businesses. In the Arctic, construction materials arrive by sealift after the good building weather is over.

....2

Mr. Radforth outlines a need for off-road vehicles of various sizes. There is a need in the Arctic for a light vehicle for hunting and personal transportation, more rugged than the ski-doo now used and offering better protection to the operator.

3. Communications.

Again there have been marked improvements in recent years, partly as a result of the Anik satellites, but any technological developments introduced for industry would also be applicable to other users.

The real point to be made is that the needs of industry and the needs of the people have enough in common that both should be considered in most research projects in this field.

Environmental protection, including disposal of mining wastes, is another matter of concern to northern people. Although not primarily an engineering question, there is an urgent need to obtain sound base-line data on the level of heavy metal and other contaminants throughout the north. If this is not done in advance of development there is a real danger that the resource industries will be blamed for contaminants that are of natural origin.

For both industry and the people the overall problem is very much one of economics. With some exceptions, present technology would allow us to do whatever we want to do if cost were not a factor. However, southern technology when used under northern conditions often results in horrendous costs. As a result, resource industries may not be viable and living conditions are often unsatisfactory. What we need are practical ways of doing things in the north at reasonable cost.

While clearly there is a need for new technological developments, there is an even greater need for making better use of the technology that now exists. Certainly on the government side there has been too great a gulf between the applied scientist and the program manager who is responsible for the structures that are built and the programs that are delivered. As a result, neither the scientist nor the program manager can do his job as effectively as he otherwise might. I hope that we can look for ways of eliminating this gulf, and that this series of workshops will provide a start.

Yours sincerely,

Don Stewart

Donald L. Stewart
Science Adviser

Indian and Northern Affairs | Affaires indiennes et du Nord

P.O. Box 1500,
Yellowknife, N.W.T.,
X1A 2R3.
February 14, 1978.

Your file Votre référence

Our file Notre référence N-1165-342

Mr. J. Patterson,
Chief,
Mining Division,
Northern Non-Renewable
Resources Branch,
Northern Affairs Program
DIAND,
400 Laurier Avenue West,
Ottawa, Ontario.
K1A OH4

Cold Regions Engineering R&D

The following is in response to your memorandum of January 19, 1978.

I would expect that the best source of problem identification in this area would be the companies involved, however as a number of company representatives already form part of the committee I will assume that contact has been made with them through other means. Our thoughts on this matter are as follows:

1. Dry Drilling -

   This technique has considerable economic advantage and is being used at Nanisivik with encouraging results so far. However, it could hardly be said that the technique has been satisfactorily developed for all applications and could use more investigation.

2. Rock Mechanics -

   There is a need to investigate the rock mechanics of consolidated rock formation in permafrost and unconsolidated frozen formations in the presence and absence of moisture. At present we are learning by trial and error at Nanisivik, which in itself is not bad, but the transportability of the experience is limited.

3. Tailings Disposal -

   The tailings disposal systems at Nanisivik was a solution to a problem in the time available but it did little to further disposal technology in the north having used what southern environmentalists might have considered one of the least satisfactory solutions, a natural lake.

...2

During the debate that led up to the selection of West Twin Lake the problems with dyking systems in permafrost were elaborated upon at great length. There may come a time and location when a lake will not be available and other solutions will have to be found.

Personally I believe we should be looking for solutions that take advantage of the cold conditions rather than trying to adapt south of 60° techniques to northern latitudes.

4. <u>Personal Safety and Protection Apparatus</u> -

Cold weather does not always permit the wearing of personal protection equipment that can be used in warmer areas. Face masks for example can be uncomfortable to the point of being useless. Developments in the area of what might be called a "halo of warm air" emanating from the helmet may be feasible in some areas.

4. <u>Ventilation Heating</u> -

The costs of heating circulation air in mines can be a considerable added cost in areas where the costs of operating are already high. Ways of recovering waste heat could be investigated. In addition the heating of air is a constant source of potential production of fumes and gases that could be detrimental to mine workers. Most heating units may be properly certified within themselves, but inevitably heating systems incorporate combinations of equipment resulting in compromisesand violations of the conditions under which certification was made. Investigations in this area leading to codes of good practices would be useful.

6. <u>Underground Milling and Living in Mines</u> - NORTHRIM.

At present one of our mines, Terra is moving the entire operation underground. We have little to go on as to the advisability and acceptability of this procedure which may be alleviated by structural investigation.

I hope this will be helpful to you.

M.J. Morison
Assistant Director
Non-Renewable Resources

c.c. M. Brown

(4)

Indian and Northern Affairs
Affaires indiennes et du Nord

OTTAWA, Ontario K1A 0H4
January 25, 1978

Your file Votre référence
Our file Notre référence

Dr. L.W. Gold,
Assistant Director,
Division of Building Research,
National Research Council,
OTTAWA, Ontario,
K1A 0R6.

Dear Mr. Gold:

Cold Regions R&D

In the absence of Dr. Woodward, I am responding directly to your request of December 29, 1977 for the department's input into the identification of the R&D needs of the mineral exploration, development and production industry in Canada's North. During the course of Territorial mineral exploration, approximately fifty million dollars was spent in 1977, and mineral production, about two hundred million dollars in 1977, the mining industry continually carries out applied research directly related to operating in Canada's North. I am sure that senior personnel at the mine sites as well as the many northern mining contractors could provide valuable insights into specific R&D projects to assist the development of Canada's North. However, industry and government agree that in general terms the future of Territorial mineral development, now as in the past, depends basically on the costs of power and transportation.

Power is generally the single greatest operating cost of isolated producing mines regardless of whether the power is produced by water, coal or oil. Any R&D leading to significantly more efficient systems, and lower costs, would be of immense benefit to northern mineral production. Areas of possible R&D could include solar and wind power, which I understand is already being carried out by the NRC, small scale hydro-electric generators for use in the Arctic climate and the efficiency of oil fed electric generators.

Transportation has been and continues to be the single largest stumbling block in the development of isolated Territorial mineral deposits. This is of course, particularly true with respect to those which would produce low value concentrates such as iron, copper, zinc, lead and nickel. For instance, Texasgulf Inc. recently carried out a transportation study for a relatively high grade copper-zinc-lead-silver deposit located in the Barrens about 225 air miles north of Yellowknife. The study indicated that the operating costs of

.../2

transporting zinc concentrates to a smelter in Trail, B.C. was about twice the cost of producing the concentrates thus making the project uneconomic. R&D leading to a more valuable mine product perhaps by the use of mini-smelters, coupled with more reasonable power costs, and with more efficient ground, air, and/or water transportation could lead to the development of more Territorial mineral deposits.

In addition to the more general areas discussed above, R&D in the following specific areas could possibly benefit the mining industry.

1) Exploration diamond drilling in permafrost is slow, expensive and commonly frustrating largely because of the potential of freezing the rods in the hole. R&D could possibly lead to better equipment and consequently a better chance of satisfactorily completing drill holes.

2) The dry underground drilling in permafrost now being carried out at one underground mine creates a special situation, currently in hand, with respect to workers exposed to dust. However, R&D into dust collectors and suppressors may be warranted.

3) Ammonium nitrate and fuel oil solutions for blasting do not work as well in cold weather and perhaps new and better blasting solutions could be devised. In addition it is reported that the storage of this material over long periods of time as required by the seasonal nature of supply can create problems unless carefully watched.

4) Waste disposal both that of communities as well as that of the mines in permafrost areas.

5) Methods of transporting energy source materials and methods of conducting, storing and transmitting developed energy.

I note that Dr. Woodward has asked Max Feldman to represent the Oil and Gas Engineering Division. I or if necessary one of my staff will be pleased to represent the Mining Division at the meeting to be held in Ottawa, February 28 and March 1, 1978.

Yours sincerely,

Jack M Patterson

Jack M. Patterson,
Chief,
Mining Division,
Northern Non-Renewable
Resources Branch.

Indian and Northern Affairs — Affaires indiennes et du Nord

Dr. L.W. Gold,
Assistant Director,
Division of Building Research,
National Research Council,
OTTAWA, Ontario,
K1A 0R6.

OTTAWA, Ontario K1A 0H4
January 20, 1978

Your file Votre référence
Our file Notre référence

Dear Lorne:

Cold Regions R&D

In response to your letter of December 29, 1977, we have identified the following as oil and gas engineering problems upon which R&D should be carried out:

A. DRILLING

1. Effects of alternating stresses on ice platforms

Panarctic Oils Limited has developed a system of preparing ice platforms in the offshore areas of the Arctic Islands for supporting the machinery used in exploration for hydrocarbon resources. These platforms could be subjected to alternating stresses due to natural forces (currents, wave action ... etc.) or artificial forces related to attempts of freeing stuck pipe by directly pulling or jarring. The effect of such forces on the integrity of the ice structures is not fully understood.

2. Effect of ambient temperature on man-made islands

Imperial Oil Limited (and other Operators) utilized the idea of building an artificial island in the offshore areas (off the Mackenzie Delta) from materials dredged locally to construct a foundation that could be utilized for drilling operations on a year-round basis.

Should operations last for a relatively long period, what would be the effects of ambient temperature specially with regards to creating permafrost conditions that could cause freezing of fluids existing in casing annuli? How fast and how far would be the depth of penetration of such permafrost conditions?

...2

3. Protection of wellhead and blowout prevention equipment (BOP) used for offshore exploration in the Beaufort Sea area

   a) Due to ice-scouring (generally in water depth less than 180' based on studies conducted by EMR) the BOP and wellhead have to be protected against the possibility of such natural forces. The height of the BOP stack is about 35 feet; what would be the most adequate system to protect this equipment, and what is the maximum sea water depth at which protection is required?

   b) The second part of this problem is connected with the loose unconsolidated formation at the ocean floor in the Beaufort Sea area and the existence of permafrost in certain offshore areas. These conditions lead to subsidence of the top portion of the hole supporting wellhead and related casings and pressure control equipment. What would be the best approach to supporting this equipment at the mud line in a way that would prevent such subsidence?

4. Development and design of an offshore platform for ice-infested and/or deep waters

   As development of the offshore areas proceeds there is an increasing need to operate in more hostile environments. Accordingly, there will be a need in the forseeable future to erect various kinds of offshore structures in support of these developments; all manner of structures will be required - drilling platforms, production platforms, single point moorings, flare towers and personnel support centres. These must operate where resources are found, and such locations might include ice infested waters with floes or icebergs, in shallow or deep water on or beyond the continental shelves.

   Design and development of such structures is needed now, well in advance of the need to build them, since considerable lead time is necessary with these "state of the art" developments.

5. Effect of permafrost on cementing of surface casing(s) and freeze-back of casing annulus fluids

   The heat generated from cement slurries used in bonding surface casings to formations results in melting of permafrost and deterioration of hole conditions across such sections. The subsequent freeze-back of annulus fluid could cause excessive stresses on casing strings. New technology is required to avoid such problems.

B. PRODUCTION SYSTEMS

In general, to this time, offshore exploratory drilling is conducted on a seasonal basis whereas a production system, in order to be economical, will have to operate on a year-round basis. Conditions which will make this difficult in certain of the offshore areas are sea bottom scour by ice and winter ice movement.

...3

1. Construction of a monopod production platform to withstand polar ice pack and ice pressure ridges up to 60 feet thick in 200-400 feet of water, conditions that exist in parts of the Beaufort Sea, is extending this concept to the limit of technology. Either this technology will have to be extended or submarine production systems will need to be used.

2. There are numerous companies involved in the design, construction and testing of subsea production facilities (Exxon's Subsea Production System, Subsea Equipment Associates, Lockheed Petroleum Services, and Chevron's 'Diverless Subsea Completions System' and Elf Aquitane) for use in other parts of the world.

   These subsea facilities will have to be modified mainly because a production platform will probably be located some distance, possibly in excess of 50 miles, from the subsea facilities.

   a) No seafloor power sources have been developed to supply power at levels above approximately 100 watts for periods of a week or longer. Adequate technology exists for short seafloor power cable runs (approximately 10 miles). However, losses due to charging currents are excessive for long submarine AC cables. Reasonable transmission efficiency and cost can be achieved with HVDC cables but undersea power conditioning equipment for converting DC to AC at the load terminal needs extensive investigation and development.

   b) Wellhead controls and through the flowline (TFL) workover completion systems will require more development to ensure efficient operations and ensure that potential uncontrolled flows of hydrocarbons will be prevented.

C. PIPELINES

1. It may be necessary to bury pipelines to a depth of 20-30 feet in permafrost beneath the Beaufort Sea in water depths up to 150 feet in order to protect the pipeline from damage due to ice scouring. The capability to 'ditch' in this environment does not yet exist.

2. It will be necessary to insulate an oil pipeline buried in a subsea permafrost environment such as the Beaufort Sea. A satisfactory insulation material and a method for the application of field joints will be required.

3. A special fendering system will be required to protect all floating construction equipment from ice.

4. Design for frost heave mitigation, particularly in shallow permafrost areas, is not completely satisfactory based on the results of the recent hearings into the Northern Pipelines proposals.

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5. Subsea gas gathering lines need to be heat traced in order to prevent the formation of hydrates. This technology must be extended so that it can be applied to relatively long subsea pipelines.

D. GENERAL

1. Sources of potable water in the Arctic Islands will need to be developed to support full scale production in that area.

2. Cold climate energy sources e.g. both dry cell and wet cell type batteries need to be developed.

3. Portable shelters for welding pipeline, drilling seismic shot holes and diamond drilling etc. are required to improve efficiency of these operations in cold regions.

I have asked Max Feldman to represent the Oil and Gas Engineering Division at the meeting to be held on February 28 and March 1, 1978.

Yours sincerely,

H.W. Woodward,
Director,
Northern Non-Renewable
Resources Branch.

I have asked Jack Patterson, Head, Mining Division 2-2711 to transmit something similar re: mining engineering and in my absence next week, he will respond direct.

Harry W.

Energy, Mines and Resources Canada — Énergie, Mines et Ressources Canada

Energy — Énergie

(8)

Your file Votre référence

Our file Notre référence 1135-J17-1

Sir William Logan Building
580 Booth Street
Ottawa, Ontario K1A 0E4

February 15, 1978

Dr. L.W. Gold
Assistant Director
Division of Building Research
National Research Council
Ottawa, Ontario
K1A 0R6

Dear Dr. Gold:

Re: Cold Regions Engineering Research and Development

This is in response to your letter of December 28, 1977 and a subsequent telephone conversation with Dr. Smith in which you request that the Resource Management and Conservation Branch identify the major engineering problems and the basic research and development needs associated with the transportation and communication aspects of resource development activities in both onshore and offshore cold regions. The attached list summarizes the major problems in the fields of transportation and communication together with the research and development needs. I trust these will be of assistance in your study.

I have taken note of the recommendation put forward by your Committee and contained in your letter that "a study be carried out also on the anticipated needs for underwater systems for exploration, development, production and transportation of resources in ice-covered waters" and that the study be carried out by EMR and DINA. Due to lack of manpower we have not attempted to do anything on this matter; however, I intend to discuss it with our colleagues in DINA to see if we can jointly dedicate the resources to attack the problem.

As we discussed, I believe a careful clear definition of the engineering research and development work that needs to be done in order to permit the safe and efficient development of the oil and gas resources in cold and ice-covered regions

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Dr. L.W. Gold February 15, 1978

is very important. It will not only permit institutions like your own to better use its talents in the public interest but will also give private Canadian companies an opportunity to prepare themselves to provide the expertise that will be needed to develop resources in those areas. In this respect, I trust that in your study the true engineering aspects will be emphasized. I feel that in some cases there is a tendency to steer engineering effort into environmental studies. I do not disagree with the need for and the value of environmental studies and certainly believe that good engineering, almost by definition, minimizes environmental impact. However, it should be recognized that studies of the environment and of engineering research and development needs are two different things.

Dr. Smith will be available to assist at the February 28 - March 1 meeting here in Ottawa.

Yours sincerely,

G.R. Yungblut, Director
Operations and Conservation
Division
Resource Management and
Conservation Branch

Att.

RESEARCH AND DEVELOPMENT NEEDS RELATED TO TRANSPORTATION AND COMMUNICATION IN COLD REGIONS

1. The capability for under-ice navigation of manned and unmanned submersibles is inadequate. Therefore a need exists to develop reliable under-ice navigational systems and procedures for submersibles, both manned and unmanned. Such vehicles will be valuable in activities such as underwater inspections, monitoring and repair operations associated with subsea oil and gas production facilities and offshore pipelines, if they can be safely used.

2. There presently exists an inadequate capability in the air transportation sector to respond quickly with personnel and equipment for distances exceeding 100 miles where adequate landing facilities are not available. The need therefore exists to develop either new types of air transport vehicles or to improve existing air carriers such as helicopters, vertical take-off and landing fixed-wing aircraft. This would provide a means to respond to events such as accidents or failure of equipment which require immediate action and would also reduce the costs of working in isolated locations.

3. There is a need to develop appropriate communication systems and equipment that can be used to control subsea production systems, flowlines and underwater pipelines and that can be operated effectively from remote stations under all weather conditions and during any ice-covered period.

4. There is a need for research into ice-breaking so that ice-breaking cargo carrying vessels can be designed and built that can work efficiently in the Arctic and between the Arctic and southern ports.

5. There is a continuing need to develop more suitable materials such as non-metallic high-strength composites and to improve the integrity and reliability of materials presently being used in cold regions. Such improvements would be of benefit to any transportation means (ships, land and air vehicles, production systems, pipelines).

Dr. Raymond J. Smith
Operations and Conservation Division
Resource Management and Conservation Branch

February 14, 1978

NATIONAL ENERGY BOARD
OTTAWA, ONTARIO
KIA OE5

CANADA

OFFICE NATIONAL DE L'ÉNERGIE
OTTAWA, ONTARIO
KIA OE5

February 14, 1978

Dr. Lorne W. Gold,
Assistant Director,
National Research Council,
Division of Building Research,
Montreal Road,
Ottawa, Ontario.
K1A OR6

Dr. Gold:

I wish to thank you for your invitation to assist the study committee in identifying the problems of interest to the gas industry in the north. As you have requested, I have prepared a brief description of the problems that will be faced by northern projects that are currently "in the works" and others which are still in the conceptual stage.

I hope that this information will be of use and I look forward to seeing you at the meeting on February 28th.

Yours truly,

C.D. Midwinter
Assistant Director
Gas Pipelines Group

Attach.

Pipeline Projects

As you are no doubt aware, the National Energy Board is currently involved with the Foothills (Yukon)-Alcan pipeline project and will, in the near future, begin hearings with respect to the Polar Gas application. Thus, for the immediate future, the problems relating to the construction and operation of pipelines in cold regions are the most important to the Board.

Following is a summary of the previously identified problems which must be solved in order that these pipeline projects can be successfully constructed and operated. It is entirely possible that some of the problems may already have usable and proven solutions of which we are not yet aware.

(A) Soils

(1) Slope Stability: It has been repeatedly brought to our attention, both in the literature and during the Mackenzie Valley hearings, that permafrost terrain is very susceptible to slope failure particularly if the surface of the sloping terrain is disturbed. The maintenance of the integrity of a buried pipeline depends upon choosing the most stable route possible and taking steps to insure the continued stability of the entire right-of-way. From the information available to us, it appears that some of the "solutions" employed by Alyeska in stabilizing permafrost slopes, particularly cut slopes, were not satisfactory. Additional work appears to be necessary in this area.

(2) Thaw Settlement: While the mechanism of thaw settlement is well understood, the success of methods used to predict the magnitude of settlement, or more precisely, methods that have application along a pipeline many miles long, are not as reliable as might be desired. In addition, unless drilling is directed at suspicious areas, the limited number of test holes that it is practical to drill along a pipeline route will miss some important segments of the right-of-way. Thus, there are two main items that must be investigated; first, to improve the methods of calculating the thaw settlement potential from bore hole samples or logs and second, to find a reliable method of detecting permafrost by remote sensing and if possible, determining if the permafrost is ice rich.

(3) Frost Heaving: There have been a number of theories (usually conflicting) put forward to the Board regarding the nature of frost heaving. Recent developments at the National Research Council seem to indicate that none of the theories, or design principles, put forward to the Board have application to a chilled buried pipeline. If a northern, chilled, buried pipeline is to be successfully operated in the long term, practical methods of controlling frost heaving must be developed or the problem must be shown to be unimportant.

(4) Strength of Frozen Soils: The strength of frozen soils and the long term reaction forces that can be generated and maintained in frozen soils as a result of upward movements or upward thrusts of a buried chilled pipeline was one of the contentious issues in the Mackenzie Valley Pipeline Hearing. In addition, some reliance has been placed on the long term tensile strength of frozen soils, particularly frozen gravel. Some additional work must be done to determine the long term strength of frozen soils in tension and shear and to determine their creep rates at various temperatures. While this may require a great deal of experimentation due to the great variability of soils and variations in the other variables such as water content and temperature, the resulting correlations need only be accurate to within ± 20%.

(5) Foundations: For a northern pipeline, there will be a requirement for a large number of foundations for such equipment as compressors, mainline valves and electrical generators, many of which will have to be built in permafrost areas. Since there is generally some leeway in choosing the location of these structures, it will generally be possible to find reasonably stable ground on which to locate them. However, this may not always be the case. In the instance of main line valves that may weigh in the order of 100,000 pounds and must be placed in locations remote from power sources etc, what would normally be acceptably thaw stable soil may not be acceptable for the pipeline (viz. a valve weighing 70,000 to 80,000 pounds, plus the foundation, sinking 6 inches while the pipe, tied in to both sides, is restrained by "thaw stable" material). Similarly, the allignment of compressor sets with the prime movers must be maintained, in spite of any loads placed on the attached piping due to settlement. Methods must be found to either eliminate significant settlement or to design the structures to be insensitive to it.

(6) Excavation in Permafrost and Muskeg Areas: During the Mackenzie Valley hearings, a great deal was said about the "Super Ditcher". This was a very large wheel ditcher that was being developed by CAGPL to dig a pipeline ditch in all permafrost soils except bedrock. If such a machine were to be built (and I am not sure that one ever was actually constructed), it would represent a much more economical method of trench excavation than blasting followed by backhoes.

In Muskeg areas, the subsurface material is extremely soft and wet and of a soupy consistancy. Excavating a deep trench, i.e. 10 ft or so, would result in sloughing in of the ditch sidewalls. Since this type of terrain can only be worked on in the winter when the ground is frozen, the limited time available for construction dictates that work begin as soon as the surface is solid enough to support heavy equipment. In at least the early portions of the construction season, the frost will not have penetrated to the depth of the ditch bottom.

Some suggested methods of constructing in this type of terrain have included piling a gravel berm over the trench site the year before construction is to begin and permitting the weight of the gravel to consolidate the muskeg thus reducing the tendancy of the walls to collapse. However, this is an expensive procedure. Some work should be done to develop a more economic way of creating a "clean" ditch in unfrozen muskeg terrain.

(B) Pipeline

(1) Fracture Control: Ductile fracture propagation control for the large diameter, high pressure pipelines operating at low temperature is under intense investigation by pipeline companies, and pipe manufacturers in many countries including Canada. It is anticipated that there is a limit where the ductile fracture propagation can be arrested by the materials properties alone. From this point on, a special crack arresting device will have to be developed, tested and installed on the pipelines. Further research into the fracture arresting mechanisms and crack arresting devices related to the Alaska Highway Pipeline Project and Polar Gas Project will be required.

(2) Field Welding: With the development of new high strength high toughness pipeline steels and numerous new girth welding processes and methods, a better measure of weldability of line pipe steel as well as the steel for pipeline components will have to be developed.

An independent comparative study of weld quality and suitability of the automatically welded joints would have to be performed before the automatic welding system or systems are approved for the major northern project.

Pipeline industry requires guidelines in respect to the evaluation of the acceptability of the defects associated with the girth weld, longitudinal weld and the body of the pipe. In this research, consideration has to be given to the new welding and manufacturing methods, non-destructive testing methods and fracture mechanics methods.

Importance and requirements as well as testing methods of the fracture toughness of the weld and that affected zone also requires further investigation.

(3) Corrosion Control: Not a great deal is known about the danger of corrosion of pipelines,or the effectiveness of conventional cathodic protection practices in permafrost terrain.

(4) Valves for Low Temperature Operation: Remote, unheated instalations on a pipeline such as mainline valves and the associated equipment, such as valve operators and automatic actuation devices, have never been exposed to such extremes of operating conditions in conventional gas pipelines. Even in the case of the Alyeska oil pipeline, the oil is run warm in the pipe, keeping the valve at near normal temperatures (as compared to the gas pipeline where the gas is purposely chilled). Some work should be done to ensure that remote equipment can be relied upon to operate in the arctic winter environment.

(5) Stress Analysis: In conventional pipeline design, the pipeline can be assumed to be fully restrained in the ground. This greatly simplifies the stress analysis of a pipeline system. In the case of a chilled pipeline undergoing differential frost heaving or a warm pipeline undergoing differential thaw settlement, the stress analysis becomes very complicated and involves the structural behaviour of the surrounding soils. Naturally, the properties assumed for these soils will have a bearing on the resulting calculated pipe stresses (see (A), (4) above). Once a realistic set of soil properties is available, a very rigorous stress analysis will have to be undertaken to insure that the stresses that will be induced in the operating pipeline will not cause failure and that there is an adequate factor of safety in the design. Such a stress analysis might best be handled by a finite element stress anslysis computer program capable of handling thermal and mechanical stresses, fairly large deflections, as well as both elastic and plastic behaviour including creep. If such a program is not currently available, work on developing it should begin.

(C) Submarine Pipelines

(1) Pipelines in Northern Waters: The Board currently has before it an application by Polar Gas to construct a pipeline from the Arctic Islands to the Canadian mainland. Such a pipeline, if approved, must cross several deep channels through which pack ice moves each year. It would be very desirable if some independent work were done to evaluate the ice conditions and to establish a set of parameters that would be useful for designing these crossings, (for example, what is the frequency or return period of ice of sufficient depth to damage a submarine pipeline placed at a given depth). There are a number of subjects in which the Applicant has been the only major investigator.

(2) Submarine Repairs: In the event that a "Polar Gas type" of pipeline were to be constructed and damage to the pipe were to be done by moving ice in deep water, a method of repair will be necessary. The development of a method of recovering and repairing such a pipeline under nearly all ice and weather conditions would be necessary. Research is needed in developing such techniques.

(3) Offshore Production in Northern Waters: Oil and gas production from undersea wells of conventional design might well be interrupted by ice scour damage. Development of a subsea wellhead that is both accessable for servicing and secure from ice damage will be necessary before areas, such as the Beaufort Sea, can be produced.

(4) Subsea Pipeline Construction: As the Board has never dealt with an undersea pipeline, it has little knowledge of the techniques or capabilities that exist for constructing them. While this may not be a subject for original research to be done, a review of the literature and the current "state of the art" would be useful to the Board as well as other regulatory bodies.

(D) Miscellaneous

(1) Sewage Disposal: In a construction camp or small settlement in the north, the disposal of human waste is a problem. It is difficult to make a septic system work properly in permafrost and disposing of wastes on the surface or in rivers and lakes can cause serious pollution due to the low rate of decomposition in the northern climate. In smaller settlements it is not economic to build a large sewage treatment plant and in some cases the volume of waste is not sufficient to prevent settlement ponds from freezing solid in the winter. Some economical method of sewage disposal has to be developed before too much damage is done to the environment.

(2) Snow Roads and Gravel Work Pads: In the Mackenzie Valley Hearing, snow roads were put forward as a method of constructing on the tundra that would leave the surface vegetation largely undamaged and thus avoid many of the problems of permafrost degradation due to surface disturbance. This method was used in the construction of the Alyeska oil pipeline with success but apparently at considerable cost ("apparently", because Alyeska is attempting to sell its experience and is not making its cost data public).

Another method of constructing in permafrost terrain that was advanced in the Mackenzie Valley Hearings was the use of thick gravel work pads to insulate the permafrost and to minimize disturbance of the soil surface. This technique was also used in the Alyeska project, and in some cases in conjunction with strofoam insulation. While this method was successful, the availability of gravel did not pose a problem in Alaska whereas it could be a problem in the Mackenzie Valley and other parts of the Canadian north. Some work should be undertaken to either improve the economics of snow road construction or to discover a third alternative.

(3) Oil Pipelines: It is possible that at some time in the future a northern crude oil pipeline will be constructed. One of the problems with crude oil, particularly heavy grades of crude, is that at low temperatures it becomes very viscose and difficult to pump. The Alyeska pipeline relies on the size of the pipeline and frictional losses to maintain the flowing temperature. However, it is unlikely that a Canadian oil pipeline from the north would be as large or would carry as great a flow as the Alyeska pipeline. Because of this, other techniques for maintaining the pumpability of the oil would have to be developed.

(E) Communications

The communications requirements for an arctic pipeline are divided into three main areas as far as electronic communications are concerned. These are:

(1) Telemetry and Remote Control: This involves acquiring data from compressor stations and metering facilities along the pipeline and remote control of these facilities from a control centre. This can be accomplished by satellite relayed signals or by land line or microwave networks.

(2) Voice and Telecommunications: There would be a requirement for voice communication between the control centre and staff at the district offices and at compressor stations and between staff in the field and district offices. Communications between the control centre and other locations would probably be part of the communications network in (1) above. Communication between the district offices and field staff would probably be done with mobile radios and a system of repeater stations, although this could be done using an earth satellite.

Written communications could be handled by telex or something similar and it could form part of (1) above.

(3) Monitoring: During the Mackenzie Valley Hearing, the need to monitor the pipeline and the surrounding terrain became apparent. It is possible to use radio transmitters at remote points to transmit data from such instruments as piezometers, inclinometers, thermistors, etc. to a control centre where the signals would be processed automatically.

The major requirement for research in this area is to determine if the available equipment can withstand the extremes of the environment in the north or, if it cannot, to develop equipment that can.

(F) Properties of Natural Gas

The pipelines proposed to be built in northern Canada have been different from previous pipelines in that the operating pressures are considerably higher and the operating temperatures somewhat lower (e.g., CAGPL - 1680 psig at 0°F compared to 936 psig at 70-80°F for other pipelines). At these conditions, the gas is in the so called "dense phase". In some of the designs, and in the case of the Foothills (Yukon) pipeline in particular, the operating conditions are in the dense phase region but can be very close to the two phase envelope depending on the gas composition. A reduction of either temperature or pressure under these circumstances could result in retrogressive condensation of hydrocarbon liquids. Liquids are intolerable in a modern gas pipeline because of the damage that they do to compressor equipment.

Thus, it is quite important that the gas being transported be maintained at a composition that will not result in this sort of problem. The methods of calculating the points at which dense phase becomes two phase are not, to the Board's knowledge, as accurate as they might be and a composition deemed to be safe, from a calculation, may not be in reality. Additional work could be undertaken to improve the correlations for this region of the phase envelope.

Transport Canada
Development

Transports Canada
Développement

Your file Votre référence

Our file Notre référence

February 27, 1978

Dr. L. W. Gold
Assistant Director
National Research Council
Division of Building Research
Ottawa, Canada
K1A 0R6

Dear Dr. Gold:

I will be pleased to participate in the workshop of February 28 to March 1 on Cold Regions Engineering R & D. Attached is a precis of some of the points which I would like to raise at this workshop.

Yours sincerely,

M Brenckmann

M. Brenckmann
Associate Director

MB/bk

Encl.

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ARCTIC TRANSPORTATION ENGINEERING

A statement of all the problems associated with the engineering aspects of transportation systems in being or proposed, in the Canadian Arctic would be too extensive for easy comprehension. Transportation is, however, an essential service for any Arctic development project, whether it be in exploration, construction, resource shipment, personnel movement or any other phase, and the Arctic poses a number of special problems to transportation systems in this region.

This brief note addresses the general problems, many of which are common to all modes, and suggests areas where R&D would be beneficial without attempting to single out precise problems.

The terrain itself, particularly in areas of permafrost, has a fundamental effect on elements of infrastructure, and the effect of terrain on the permanence of these works or the need for high maintenance or repair is one area to be explored.

Conversely, the system has some impact on the terrain, with consequential effects on wildlife, etc., and better understanding of the total impact would be most beneficial, as this would lead to the establishment of finite limits within which the construction and operation of systems could operate.

Cold and darkness affect the operation of mechanical and electric equipment, or the personnel who operate and maintain it. This suggests a high degree of reliability coupled with simplified or reduced requirements for operation and maintenance.

Snow and ice problems are expected to be of the same kind encountered, say, in Ontario or Quebec, but of more severe duration and with more damaging consequences. This aspect concerns both vehicles and infrastructure.

Isolation introduces the desirability of automation of control, signalling, guidance and other systems where the use of operators is not essential. This leads to the need for high reliability, self-inspection devices, failure warnings and self-contained power supplies. Even the loading and unloading of resources can be automated in some cases, as can the inspection of wheeled vehicles by means of "drive through" positions.

A most important element is the need to know exact vehicle location, and this gives rise to the requirement for a simple but accurate navigation system, preferably one that can be used by all modes. The use of satellites opens up great possibilities. Closely associated with navigation is a system to permit the quick recognition of vehicles in distress and to facilitate whatever remedial action is necessary. Practically all the previously mentioned factors: terrain, cold, darkness, isolation, snow and ice, add emphasis to the requirement for safety and may call for special measures.

The use of rivers, lakes and salt waterways introduces a multitude of problems in marine transportation, mainly related to the necessity to operate through ice fields the year round. In general these problems relate to the design of ships' structures and propulsion systems, the operation of ships in ice and the need for more knowledge on the properties of Arctic ice.

A reduction in the need for transportation through the use of local resources represents another possibility for investigation. This embraces such matters as energy, water, food, fuel and building materials. Perhaps the study of the way local residents have survived on local resources without the benefit of advanced technology would be informative.

As a final suggestion, the use of a cold weather laboratory to investigate construction and other problems related to permafrost might permit the acquisition of knowledge more quickly than is possible now, and the use of mathematical simulation would enhance R&D on this subject even more.

Environment Canada | Environnement Canada
Atmospheric Environment | Environnement atmosphérique

Your file Votre dossier

Our file Notre dossier 1165-36/N39

4905 Dufferin Street,
Downsview, Ontario,
M3H 5T4.

February 17, 1978

Mr. Lorne W. Gold,
Assistant Director,
National Research Council Canada,
Division of Building Research,
OTTAWA, Ontario, K1A OR6.

Dear Lorne,

Attached is the brief statement you requested of the Engineering Studies I would like to bring before the Committee next week. I am sorry for the delay in submitting it, but have been away from the office repeatedly this month.

Yours sincerely,

Bill

W.E. Markham,
Director, Ice Branch,
Central Services Directorate.

Encl.

AE – 1001

R&D NEEDS FOR COLD REGIONS ENGINEERING STUDIES
FROM THE POINT OF VIEW OF AES ICE BRANCH

The major requirement for study is related to communications of ice data from the Ottawa area to ships at sea and as a corollary from airborne aircraft back to Ice Central in Ottawa.

In the near future, a dedicated broadcast channel for relay of ice charts will become necessary as the scale of data increases when SLAR becomes the primary sensor. A station in Eastern Canada could probably serve the Great Lakes, Gulf of St. Lawrence, Grand Banks, Labrador Coast, and the Hudson Bay route. After penetration of the auroral zone into Arctic waters, it is desirable to have a single northern broadcast which would serve the whole area from Beaufort Sea to Davis Strait. There may be a need to use data compression techniques instead of standard facsimile format. MOT T&E Branch will be concerned with these problems.

A second and perhaps lower level need would be an updated study on the trafficability of ice. Some work was done over twenty years ago on this subject but its modern application may be open to question. A comprehensive reference document on the subject would be useful.

Matters of real concern to ocean engineering which are allied to AES activities are more details on the mechanism of ridging,the structure and frequency of ridges, and also the measurement of pressure in ice. I expect, however, that these items will have been raised by other contributors. Similarly, the development of dependable (and low cost) automatic weather reporting stations is already being studied. These relate to a less direct need for an expanded and/or improved weather reporting network which then impacts on the design of both onshore and offshore structures.

Government of Canada Gouvernement du Canada

Department of Communications Ministère des Communications
Communications Research Centre
Shirley Bay, P.O. Box 11490
Station H, Ottawa, Ont. K2H 8S2

Our file: CRC 6000-22

15 February 78

Dr. L. W. Gold
Assistant Director
Division of Building Research
National Research Council
Montreal Road
Ottawa, Ontario K1A 0R6

Dear Dr. Gold:

Thank you for your invitation to take part in the meeting starting February 28. I look forward with interest in learning more about the problems of resource development in the Canadian North.

I am enclosing a suggestion for a study to improve the knowledge base in connection with our activities at CRC which might be of interest to you and the committee.

Yours truly

Sherman Chow

Sherman Chow
Communication Systems Consultant
Communication Systems Development

SMC:cg
Enclosure

The Communications Research Centre of the Department of Communications is actively pursuing several programs for improved communication systems for the remote areas.

The objectives of these programs are to design, develop and test radio equipments and systems which can provide improved service under the constraints of environmental and economical conditions existing in the Canadian North. These systems include inexpensive mobile and fixed radio services within and beyond the line-of-sight as well as the more elaborate satellite system.

These new systems can provide a wide variety of services including voice, data and television. These new systems are an improvement over the existing ones in the sense that they require a lower level of skill to operate and to maintain. This is made possible by the introduction of new developments in electronics which permits sophisticated features to be incorporated into equipment of suitable size.

One common feature of all these electronic equipments is the requirement for reliable power sources. The development in this area has not kept pace with other developments in electronics.

A study to acquire a comprehensive knowledge base on power sources seems to be in order. This study should cover both presently available types as well as types likely to be practical in the near future.

(3)

Rm. 206
Building Res. 32480
FEB 15 1978

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COMINCO NG YK
AD NG NWT FEB 15/78 9:55A

LORNE W GOLD
ASSISTANT DIRECTOR
NATIONAL RESEARCH COUNCIL
GOVT. OF CANADA OTTAWA

I WOULD LIKE TO RAISE TWO POINTS FOR DISCUSSION AT THE FEBRUARY 28 MEETING.
RESOURCE DEVELOPMENT IN THE COLD REGIONS IS CONSTRAINED BY MANY ITEMS OF WHICH TWO SEEM TO BE PRESENT MOST OF THE TIME.

1. POWER GENERATION. THE COST OF POWER GENERATION WITH FOSSIL FUELS CONTINUES TO RISE. ARE OTHER TYPES OF GENERATION SUCH AS SMALL NUCLEAR PLANTS OR WIND UTILIZATION WORTHY OF STUDY.

2. TRANSPORTATION - A LARGE AREA BETWEEN YELLOWKNIFE AND THE ARCTIC COAST HAS A NUMBER OF MINERALIZED AREAS THAT COULD BE DEVELOPED IF A MEANS OF MOVING THE PRODUCT TO MARKET WAS AVAILABLE. HOW MUCH STUDY HAS BEEN GIVEN TO RAILWAYS - MONO RAILS, DIRIGIBLES, ROADS, ETC.?

R P DOUGLAS
COMINCO LTD
YELLOWKNIFE

1 winter roads.
2 Texas Gulf: find transport cost 2x mining costs.
3 Sea transport systems – Arctic ...

MR GOLD IS WITH DIV OF BUILDING RESEARCH
PLS FORWARD IF NOT AT THIS NUMBER

ƺ
NRC LIB OTT

(2)

Bus. (416) 362-1229 Res. (416) 923-1201

E. P. GRAHAM, P.Eng.

Consulting Mining Engineer
1513-25 Adelaide St. East
Toronto 1, Ontario

February 9, 1978

Dr. Lorne W. Gold
Assistant Director
National Research Council
Division of Building Research
Ottawa, Canada K1A 0R6

Nanisivik

Dear Dr. Gold:

Enclosed is the summary paper requested by you for distribution prior to the meeting to be held February 28th and March 1st.

Yours very truly,

E.P. Graham

E.P. Graham, P.Eng.

EPG:b

RESEARCH AND DEVELOPMENT

FOR

COLD REGION MINING

February 9, 1978

E.P. Graham, P.Eng.
Consulting Mining Engineer

I N T R O D U C T I O N

In response to a request by Dr. L.W. Gold, Chairman of the Co-ordinating Committee set up by the National Research Council, this brief paper points out some mining-oriented areas where R & D could be useful.

Present day environmental concerns have resulted in a substantial tightening of regulations governing all industry. The impact on mining has been severe. In cold Northern Canada, where the environment is judged to be fragile and slow to heal, R & D will be welcomed to identify valid concerns and to propose workable solutions.

* * * *

S U M M A R Y

These are a number of mining enterprises located north of the permafrost line in Canada and in other parts of the world that have learned to cope with the conditions imposed by nature with innovation and determination. In so doing a large volume of experience data will have been developed. Thus a first move would be to gather and co-ordinate these data as a base for R & D. Also the experienced operators of the mines will be able to point out areas where R & D would be most helpful.

A list of these areas will include tailings disposal, drilling and blasting techniques in frozen rock on surface and underground, the effect of thawing on rock formations, new mining methods for permafrost conditions, adequate temporary communication, land and marine construction generally, transportation by sea, air and land, and the effect of the long winter darkness on individuals and communities.

The following comments are offered in areas pecular to mining.

1. TAILINGS DISPOSAL

Traditional methods of tailings disposal such as 'stacking' or impounding behind dams have been refined by recycling process water, thus drastically reducing the volume of effluent. This method was rejected for the Nanisivik operation on North Baffin Island because of the unknown effects on permafrost of the relatively warm mass of tailings. The mining company sought permission for submarine disposal, but this was rejected by the authorities in favour of disposal in a natural basin on land, occupied by a fresh water lake. During the negotiations it became evident that much R & D was needed in this area which is basic to any northern mining operation.

2. DRILLING AND BLASTING

Water fortified by calcium chloride is used for diamond drilling in permafrost, and is an expensive and corrosive way of cooling the diamond bit and flushing out the cuttings. R & D might discover a better technique.

Development headings in frozen ground have used this same antifreeze system. When Nanisivik was faced with having to drill and blast 2000 tons per day of rock with a temperature of 9° F, this system was rejected and a method of dry drilling was developed which meets rigid dust control requirements. R & D would indicate if the Nanisivik method is portable to other mines, and would help in developing improvements in hardware and techniques.

Asbestos Corporation, at their Asbestos Hill property in Northern Quebec, have found that open pit ore in frozen ground exhibits unique fragmentation behaviour. Nanisivik has rejected high explosives in favour of the much cheaper and safer ammonium nitrate-fuel oil blasting agent, which can be transported north as fertilizer and oil, then mixed on site. R & D would co-ordinate the experience of mining companies and promote further development.

3. THAWING PERMAFROST ROCK

Experience at Nanisivik shows that different rock types and textures react differently to warm ventilation currents. In one area, up to two feet of "sugary" pyrite backs gradually crumbled and fell during the short summer when ventilating currents were above freezing. Other massive pyrite and dolomite areas were unaffected.

At Cominco's Arvik property on Little Cornwallis Island, many ice inclusions in the rock suggest that, in southern climates, this would be an extremely wet mine with relatively weak ground. Co-ordination of existing knowledge and further study would be useful.

4. NEW MINING METHODS

A number of ideas and proposals have been advanced to incorporate freezing techniques as ground support into new mining methods for underground mines in permafrost. There is very little actual experience in this area, so it is an obvious field for R & D.

5. COMMUNICATION

The experience at Nanisivik demonstrated the great gap between unreliable radio communication and the present telephone, television and data transmission facilities by satellite. R & D could be useful in bridging this gap, so vital to the development and construction phase of any project.

6. GENERAL

The other areas listed in the Summary are not unique to mining but are very important fields for further study.

Respectfully submitted,

E.P. Graham, P.Eng.

February 9, 1978

C O P Y

NRC Admin Ott

CANMAR CGY
IS DR. GOLD AT THIS NUMBER
YES
THX
FEBRUARY 14, 1978

ATTN: DR. L. GOLD
NATIONAL RESEARCH COUNCIL, OTTAWA

FURTHER TO YOUR LETTER TO US CONCERNING YOUR ARCTIC RESEARCH AND DEVELOPMENT MEETING ON FEBRUARY 28, 1978, WE ACCEPT YOUR INVITATION TO ATTEND AND DOME WILL BE REPRESENTED BY MYSELF. THE FOLLOWING ARE THE MAIN ITEMS DOME IS PLANNING WHICH MAY BE OF INTEREST TO YOU:

1. DRILLING EARLY AND LATE IN THE BEAUFORT SEA (I.E. BREAKING OUT OF SHOREFAST ICE, DRILLING IN FIRST YEAR PACK ICE UP TO END OF DECEMBER).

2. DRILLING WITH SHIPS IN SHOREFAST ICE THROUGHOUT THE WINTER IN THE BEAUFORT SEA AND ARCTIC ISLANDS.

3. DRILLING SYSTEMS TO DRILL YEAR ROUND IN FIRST YEAR AND SOME MULTI-YEAR ICE AND ITS IMPLICATIONS FOR RELIEF WELL BACK UP ANYWHERE IN THE ARCTIC.

4. DOME'S AML (CLASS 10 ICEBREAKER) TRANSPORTATION POTENTIAL AND USE AS A SEISMIC EXPLORATION VESSEL.

5. BEAUFORT SEA OIL PRODUCTION SYSTEM.

6. TANKER TRANSPORT OF OIL AND GAS FROM THE BEAUFORT AND ARCTIC ISLANDS.

7. ICE MODELS OF THE ARCTIC PACK AND SHOREFAST ICE.

8. REMOTE SENSING TECHNIQUES FOR DRILLING, PRODUCTION, AND TRANSPORT OPERATIONS FOR SHIPS AND PLATFORMS OPERATING IN ICE.

J.C. O'ROURKE
ENVIRONMENT AND RESEARCH DIRECTOR
CANADIAN MARINE DRILLING LTD.
C/O DDOME PETROLEUM LIMITED

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PHONE 403-232-5200*
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V

GULF OIL CANADA LIMITED

P.O. BOX 130, CALGARY, ALBERTA T2P 2H7 • TELEPHONE (403) 268-1110
EXPLORATION AND PRODUCTION DEPARTMENT

February 14, 1978

National Research Council
Division of Building Research
Montreal Road
Ottawa, Ontario
K1A OR6

Attention: Dr. L. W. Gold

Dear Lorne:

With reference to your letter of December 21 and our subsequent meeting here in Calgary, I am forwarding a brief summary of the needs related to cold regions resource development, transportation and communication that the A.P.O.A. would like brought to the attention of the Committee. The timing of the February 28 - March 1 meeting may conflict with an upcoming field program in the Arctic in which case, Mr. J. C. O'Rourke, who will be representing Dome/Canmar, will present the A.P.O.A. material.

Yours very truly,

B. Wright

B. D. Wright
Co-ordinator
Oceanographic Research

BDW/dq
Encl.

Gulf

Research and Development Needs

In the following, a number of research and development needs relevent to the engineering problems associated with cold regions resource development are identified in general terms. This listing is not intended to be all inclusive but rather to form the basis for discussions at the upcoming meeting.

Permafrost and Gas Hydrates

1. Methods of identifying and determining the extent and thickness of permafrost both onshore and offshore

2. Methods of preventing thaw subsidence around well bores and pipelines both onshore and offshore

3. Methods of preventing shoreline erosion where pipelines come ashore in permafrost areas.

4. Methods of identifying and quantifying gas hydrates both onshore and offshore.

Sea Bottom Scouring By Ice

5. Methods of identifying the frequency and depth of sea bottom scouring by ice to assess the risk of scour damage to subsea facilities

6. Methods of burying subsea wellheads, flowlines and offshore pipelines to protect them from ice scour

7. Methods of deep water excavation to protect subsea facilities from ice scour

Ice Data Collection and Forces

8. Improved methods to measure the draft of pressure ridges and icebergs from the sea floor for data collection needs on extreme features and as a warning system around offshore facilities

9. Improved methods to measure (rather than infer) the thickness of sea ice, pressure ridges and icebergs from aircraft.

10. Improved remote sensing techniques and platforms for high resolution, all weather data collection on ice, waves and weather

11. Improved methods to accurately measure short term movements of both the landfast and pack ice in remote areas.

12. Improved knowledge of the ice behavior and associated forces during large scale interactions with structures of various shapes

13. Improved instrumentation on existing and proposed offshore structures to provide the necessary data on ice structure interactions and forces.

Operations

14. Improved forecasting including weather, waves and ice movement, breakup and freeze-up

15. Improved and more frequent all weather remote sensing information in real time on ice, weather and waves to improve forecasting and allow environmental monitoring around offshore facilities.

16. Improved data handling, processing and transmission systems to transfer data from instruments and sensors in remote regions

Miscellaneous

17. Improved documentation and cataloging of research information in a standardized manner possibly at a central Canadian facility

18. Improved communication and information exchange between researchers and engineers involved in cold regions problems with possible exchanges of government and industry personnel for limited periods.

panarctic oils ltd

LINDSAY J. FRANKLIN
Vice-President
Operations

703-6th AVENUE S.W., CALGARY, ALBERTA • P.O. BOX 190 • T2P 2H6 • PHONE (403) 269-0311 • TELEX 038-24687

(12)

February 3, 1978

Dr. Lorne W. Gold
Assistant Director
National Research Council Canada
Division of Building Research
Ottawa, Canada
K1A 0R6

Dear Dr. Gold:

I will be pleased to participate in the meeting called for February 28 to March 1 to define the problems associated with engineering aspects of resource development in cold regions.

In the eastern Arctic, where our exploration activity occurs, attention is concentrating increasingly in the offshore areas and the emphasis on offshore activity is expected to continue. Accordingly the problems of most urgent concern are related to ice movement.

In the first instance we are concerned with ice movement effect on offshore exploration drilling. Fundamental information is required as to:

A. The cause of ice movement - winds, phase of moon, currents, temperature

B. Anticipation of traumatic movement - development of a system by strain measurement, or similar observation, to forecast ice movement

C. Magnitude of ice displacement

D. Nature of ice displacement - measurement/observations to determine if displacement is in sudden large movements or steady minor movements for which mechanical accommodation might be developed.

We are also concerned with bottom scouring resulting from ice keels. For the security of bottom founded subsea structures we see a need for information on:

A. Maximum depth of ice keels

B. Probability information on frequency of ice keels intersecting specific locations at specific depths

C. Forces exerted by ice keels

.... 2.

panarctic oils ltd

Dr. Lorne W. Gold
Assistant Director
National Research Council

February 3, 1978

At this juncture it appears unlikely that independent offshore production facilities will be installed; accordingly the need for transport of product across the shoreline is evident. Information in respect of the frequency and nature of forces that might be anticipated from ice impinging on the shore is required for development of shoreline protection facilities.

I look forward to participation in this study and to the useful exchange of ideas that may be expected to result.

Yours sincerely,

PANARCTIC OILS LTD.

L. J. Franklin
Vice-President, Operations

LJF/dk

(13)

TOTAL EASTCAN EXPLORATION LTD.

TOTAL

CABLE ADDRESS: EASTCAN
PHONE: (403) 264-9770
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BOX 9720
BOW VALLEY SQUARE 1
1600-202 6th AVENUE S.W.
CALGARY, ALBERTA
T2P 2W6

February 14, 1978
Ref: E-3942/117-16

Dr. L.W. Gold
National Research Counsil
Division of Building Research
Ottawa, Ontario
K1A 0R6

Dear Dr. Gold,

Herewith enclosed please find a summary of our thoughts regarding the fields of research to be encouraged.

As I explained to you on the phone, neither Mr. D. Duff nor myself are able to be present at this meeting and we regret this very much.

Possibly, Mr. D. Berenger will attend. Mr. Berenger is well aware of the environmental conditions of the offshore Labrador Coast and the related problems.

I would like to take this opportunity to reiterate the need of a new and specific technology to be applied to the development of a hydrocarbon field in ice infested waters. This technology does not yet exist and it represents a great opportunity for Canada to be first in this domain.

Yours truly,
TOTAL EASTCAN EXPLORATION LTD.

Ph. Buemi
Resident Engineering Manager

PB:fh
Encl.
c.c. Mr. G. Dohy, Chairman E.P.O.A.

NATIONAL RESEARCH COUNCIL

MEETING OF FEBRUARY 28 & MARCH 1, 1978

PREPARED BY Ph. Buemi
H. Poulon

February 9, 1978

1. ENVIRONMENT

This paper will deal exclusively with problems associated with the engineering aspects of an oil or gas field development, including transportation and communication, in the Canadian East Coasr, Offshore Labrador. The area of interest is situated approximately between 61^{o} North and 50^{o} North.

In order to better appreciate the problems encountered by resource development Offshore Labrador, we feel it is necessary to give a short summary of the specific environmental conditions prevailing in the area.

Generally speaking, little or no data was available only a few years ago on waves, wind, ice, icebergs, currents, sea bed, etc... Total Eastcan, Operator for a group of companies composed of Amerada Minerals Corporation of Canada Ltd., Aquitaine Comapny of Canada Ltd., AGIP Canada Ltd., Gulf Oil Canada Limited, Sun Oil Company Limited, Total Petroleum (North America) Ltd. and Total Eastcan Exploration Ltd., has, among other works, conducted a certain amount of research directed towards data acquisition of environmental conditions in this region.

Environmental conditions are very severe in the Labrador Sea area. Indeed, the sea is covered with an ice pack 6 months of the year. It can extend as far as 150 miles form the coast and drifts from North to South under strong winds (extremes of 150 to 200 Km. per hour every winter) and currents. Within the ice pack are trapped some Arctic floes and icebergs. They have to be considered by their mass and resistence, as one of the most hazardous components of the winter environment.

Ice thickness in March-April can attain 3 to 5 meters for first year ice and as much as 20 meters for Arctic floes.

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Sea conditions are relatively good in July and August, to deteriorate badly in October and November where significant wave height can be more than 10 meters. Currents vary greatly with place and depth. Maximum speeds of .75 to 1 meter per second has been observed.

Icebergs are present all year round. They mainly come from West Greenland and drift along the Labrador Coast at a mean speed of 10 to 15 Km. per day. The mass of a medium sized iceberg is about 1 million tons. Icebergs of more than 30 million tons have been seen offshore Labrador.

It happens that some large icebergs get grounded after scouring the bottom to depths of several meters.

More than 1000 icebergs drift through 60^{o} N Latitude every year. Their number is maximum from April to July and minimum from November to Janaury.

During the April to July months, the flux through 60^{o} N Latitude is about 130 - 150 icebergs per month compared to 30 - 60 for 50^{o} N Latitude.

In a few words, we could say that : in the summer time, the Labrador Sea is comparable to the North Sea but infested with icebergs.

In winter time, the conditions of the Labrador Sea are comparable to those of the Arctic but with drifting ice or pack that contains multi-year floes and icebergs.

II NEW TECHNOLOGY

Those are the general environmental conditions that will guide the engineers in search of a solution to develop an oil or gas field off the coast of Labrador, but better knowledge of the environment is required.

Some instruments have to be developed in order to acquire more data on ice and icebergs.

- A system to measure and transmit data on ice thickness
- A system to measure the draft of icebergs (data on iceberg draft is necessary to calculate the risk of iceberg scours in a given place)
- An alarm system that will detect icebergs with draft superior to a given dimension
- A remote sensing system to detect and monitor multi-year floes, icebergs and ice distribution is required.

An improvement of the existing technology in soil geology, geophysics and bathymetry is required. materiel type – [illegible]

Regarding the production facilities we can benefit from experiences in the offshore, but the specific environmental conditions of the Labrador Sea require the development of a new technology.

Several schemes have been investigated to produce oil and gas and could be divided into three groups with regard to their feasibility and the time of the year during which they can be operated.

- In the short term group, we find the floating installations which have to be disconnected when there is risk of collision with a iceberg, and which have to be removed from their location at the freeze-up and sheltered until the time the sea is again free of ice.

- In the medium term group, we find the same type of installations as in the short term with the addition of facilities permitting to remain on the location until the ice pack reaches a fair thickness. In order to extend the duration of production time, equipment like ice cutters, ice breakers or other means have to be developed. Interested firms should strongly encourage the continuation of the study and test of the ice cutter which is being studied by some oil companies within the A.P.O.A. frame.

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- In the long term group, we will find all kinds of permanent facilities which allow continous production all year long. We have to mention various typed of artificial islands such as :

  a) concrete island
  b) rock island
  c) sand island
  d) or even artificially maintaind ice islands

  or production facilities entirely buried under the sea bed,
  or tunnel connecting the field to the coast,
  or to an island where the production facilities would be located

Some of the last schemes are probably not as utopian as one would think, but their credibility still remains doubtful.

The important point is to prove the feasibility of a concept. To do this, it is necessary to go to model tests after a theoretical study has been completed. Facilities for model testing should then be available.

Pipelines to the coast could be necessary. A technology has then to be developed in order to protect the pipeline from the icebergs that scour the soil and also to service the pipe if necessary during the ice covered sea season.

Protection could be found by burying the pipe, but today, there does not exist a burying machine that could dig a trench in the bouldery soil deep enough to protect the pipe from the scours.

III TRANSPORTATION AND COMMUNICATIONS

In order to perform its function in good conditions on the Labrador Coast, an oil exploration company requires a good network of communication and transportation.

The operations area is defined as being located up to 320 Km. from the coast. If we consider the normal range of the more popular large helicopters (400 - 700 Km.), we see that with a normal safety factor, we require a well equipped base approximately every 400 Km. along the Labrador Coast. For this reason, Total Eastcan chose CARTWRIGHT, HOPEDALE and SAGLEK BAY as bases.

A well equipped base should offer the following facilities :

- Hotel or buildings to accommodate 60 persons in comfort and 100 persons in case of emergency.
- Airport with a good instrument landing system (ILS), capable of receiving all types of turboprop planes and of supplying them with gas or kerosene.
- Hook up to the Canadian Telephone Network.
- Good radio equipment for communication with planes or helicopters.
- Small weather center.
- Safety and Rescue Patrols.
- Installation of a small harbour with wharf and facilities to load and unload boats (for solid and liquid cargo).
- Good roads between harbour, airport and settlement.
- Small hospital and medical facilities.
- Hook up to either the Federal or Provincial Power Network, or a small power plant.

We believe that if the exploration companies become successful in their research, these bases will grow larger and larger, subsequently attracting suppliers and contractors.

(5)

Report for Steering Committee for the Study of
Cold Regions Engineering Research

RESOURCE RAILWAYS IN THE NORTH

prepared by

F. L. Peckover, Eng.
Railway Geotechnical Consultant

Vaudreuil, Quebec
13 February 1978

RESOURCE RAILWAYS IN THE NORTH

This report is an assessment, prepared at the request of the Chairman of the Steering Committee for the Study of Cold Regions Engineering Research, of the potential of resource railways in the Canadian North. It is based on a review of engineering problems associated with the construction, operation and maintenance of railways in cold regions. Particular note is made of problems for which solutions are not yet available.

It will be taken for granted that the reader is familiar with northern climate and permafrost conditions, as well as construction principles and logistics in the North. The role that railways may be expected to play in northern resource development is discussed.

Sources of Information

Until quite recently, many of the opinions offered in an assessment such as this would have been based on extrapolations and guesswork. However, the Arctic Railway Study (1974)* has provided an engineering feasibility analysis of the concept of a railway to move large quantities of Arctic oil and gas southward. The study was based on the detailed and thorough considerations of a team of railway specialists and consultants assembled for the purpose. The resulting report is looked on as providing a realistic up-to-date appraisal of a high capacity railway operation in sub-Arctic and Arctic conditions. The report concludes that, although costs are substantial, the construction and equipping of such a railway is technically feasible and that it can be reliably operated and maintained.

Many of the opinions in this assessment are based on the Arctic Railway Study (ARS) report, at the same time recognizing that the "average" resources railway in the North will be vastly different in scale and operation than that conceived in the Study.

Information on railways elsewhere in northern regions is scarce. In the U.S.S.R., as road and water transport are apparently well developed in cold regions, no railway runs further north than the southern boundary of the zone of continuous permafrost. The ARS probed available information on Russian experience with northern railways and found little of specific significance in comparison with experience already available in Canada.

* Refences are listed at the end of the report.

Canadian Railway Operations in Cold Regions

In Canada there are at present several precedents for railway operation in cold regions. All operate in conditions which are similar in some climatic respects with the North:

- The Hudson Bay Line of Canadian National Railways, completed in 1928 and operated continuously since then, crosses extensive discontinuous and continuous permafrost areas to its northern terminal at Churchill, Manitoba (Charles 1959).
- The Quebec North Shore and Labrador Railway, completed in 1954, crosses extensive areas of discontinuous permafrost to its northern terminal at Schefferville, Quebec (Pryer 1966).
- The Great Slave Lake Railway of Canadian National Railways, completed in 1964, passes into the discontinuous permafrost zone in its northern part en route to Hay River and Pine Point, N.W.T. (Charles 1965).
- Main lines of both Canadian National (CN) and Canadian Pacific (CP) Railways north of Lake Superior pass through areas as cold in extreme temperatures as the North.

As an indicator of relative operating conditions it may be said that, compared with these rail lines collectively, a railway in the North would probably not have colder extreme temperatures or appreciably higher wind chill factors; nor, for the month of January, would it have appreciably colder mean daily temperatures or higher average wind speeds. However, it would probably have a considerably longer duration of very cold temperatures.

As standard North American equipment and operating procedures are used on all these rail lines (not without some difficulties), the experience accumulated on them is of some relevance and will be referred to in the consideration of Arctic resource railways.

The Concept of an Arctic Resource Railway

A resource railway in the North will probably be used to transport products such as mineral ore or concentrate, or possibly oil or coal, over a distance ranging from a few to a few hundred miles. The volume of traffic will range upward from a few cars a day.

The ARS findings permit the concept of such a railway with a single track layout and passing tracks if required, giving a practical capacity of up to 12 trains a day in each direction [1]. Unit trains

[1] From CN and CP operating experience in extreme cold weather conditions north of Lake Superior.

with heavy cars will probably be used [2]. Train lengths can be up to 50 cars, a limitation imposed at present by the operation of standard air brake systems in extremely low temperature conditions as discussed below. Train speeds will be moderate, say 30 to 50 miles per hour, to reduce wear and tear on track and equipment, thus reducing both the amount of track maintenance required and the incidence of shock loadings and brittle fractures, discussed below. Traffic control may be by a standard block signal system supplemented by train radio and a microwave system if required. Conventional locomotives and cars may be used, subject to modifications as discussed below.

With this concept, the choice of components of the railway system to suit conditions in the North can be considered.

Route Selection

The ideal northern railway requires the minimum distance between terminals; minimum gradient and curvature; minimum involvement with difficult terrain and interference with environmental, drainage and ground thermal regimes; and, of course, minimum costs of construction and maintenance. The choice of an optimum practical route requires consideration of all these factors.

In the matter of allowable gradients, railway locations differ greatly from those for highways and even more from those for pipelines. Economical operation of a resource railway requires a gradient not exceeding about 2 per cent. This imposes a natural limitation on the selection of a railway route, increasing in severity with the ruggedness of the topography. With the need to avoid cuts in permafrost ground, railways are not well suited to traverse rough terrain in the North. However, in gently rolling areas and along river valleys, no such penalty is imposed.

Gradient limitations also affect to some degree a railway's capability of avoiding areas of thermal or environmental sensitivity. On the other hand, due to their controlled nature, the operation and maintenance of a railway probably have less impact on the environment than a highway.

Building transportation routes on fill in the North is a recognized means of protecting against degradation of permafrost, as well as providing improved drainage and assisting in snow drift control. Due to flat gradients, large amounts of suitable fill materials are required for the construction of railway grades, although they are narrower (24 or 26 ft. at the top) than highway grades. Route location must take borrow requirements into account, and also the need for sufficient high quality rock for track ballast.

[2] Unit trains are made up of similar cars and moved as units back and forth from loading to unloading points to eliminate terminal switching and simplify handling.

Permafrost Considerations

In route selection and track design and maintenance, the effect of permafrost degradation must be considered. Although track can be shimmed temporarily to compensate for differential frost heaving or settlement, continuing settlement of the track requires the addition of ballast under the ties. Settlements due to the adjustment of the permafrost regime to the new conditions imposed by a railway fill will tend to be concentrated in the first 3 to 5 years after construction. Slow orders, winter shimming and summer grade raising may be required during this period. However, it is unlikely that traffic will be endangered or stopped if planning for the necessary remedial work is done in advance.

Of more economic importance is the continuing settlement of embankments in areas of discontinuous permafrost. This is occurring on the Hudson Bay Line 50 years after construction and shows every sign of continuing for decades. A regular program of track lifting is required at scores of distinct locations, one of which is shown in Figure 1. A recent study identified the culprit as thaw settlement under track in the transition zones between non-permafrost peatlands and permafrost peat plateaus. No economical means has yet been found to reduce the maintenance involved. In the meantime traffic continues, generally at 30 miles per hour.

The cumulative effect of such thaw settlement is seen in Figure 2 on an Inco rail line near Thomson, Manitoba, which was abandoned four years before the photo was taken. These examples show the continuing need for study of

- Means of identifying areas where it is not economically practicable to maintain the permafrost regime under a transportation route,
- Means of predicting the rate of thaw settlement resulting from a given design of fill, and
- Economical means of reducing that rate under an operating route.

Details of the Railway System

It seems evident that, from Canadian railway experience to date in cold weather conditions, a rail system suitable for the North is a matter of adapting standard equipment and methods rather than devising new ones. This was the conclusion reached by the ARS.

There is no need to depart from standard track and gauge. The use of continuous welded rail would keep track maintenance costs down. Creosoted wood ties have a long life in the North and allow the shimming of settling and frost heaving track, which is not possible with concrete ties. Crushed rock ballast of good quality is needed

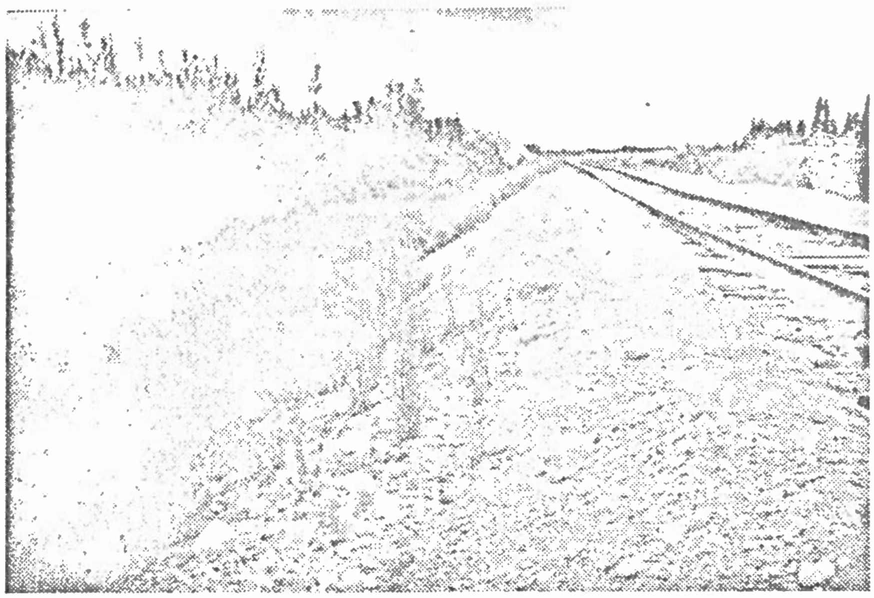

Figure 1. Irregular track surface and fresh ballast show the operating problem created by thaw settlement in discontinuous permafrost on the Hudson Bay Line.

Figure 2. Photo taken in 1975 showing thaw settlement on Inco spur line near Thomson, abandoned in 1971.

to carry heavy axle loads, with granular subballast to spread the loads to the subgrade.

Track switches may be power operated by remote control and must therefore be kept free of snow in winter. In forested cold areas, oil-fired switch heaters are found to be satisfactory in CN and CP practice. In windswept areas, air jet switch cleaners are required to keep the snow moving through the switch. These are being tested in Canada at present. The tests should be continued under conditions applicable to the North.

Traffic control by the block signal system, with signal lights mounted on towers or signal bridges, has already performed well in conditions similar in temperature and blowing snow to those in the North, for moderate train speeds. No basic changes in the system seem necessary.

The layout of terminals should recognize the problem of snow and blowing snow to reduce operating and maintenance problems. To reduce drifting of snow under cars during loading and unloading, track should if possible be laid out in line with the prevailing wind, and spaced apart to allow the operation of off-track equipment for snow removal.

The effect of the construction and operation of a proposed railway on the environment will need special study during the planning stage. Final route location, adequate provision for the preservation of wildlife and fish, minimum interference with native people, and plans for handling spills of cargo will all depend on the findings of such studies.

Rolling Stock

Reliability and efficiency of operation are of basic importance in both motive power and car equipment for a railway in the North. High utilization of equipment is customary in unit train operations and in northern operations the maintenance, servicing and supply of parts will all be more costly than usual. At the same time, it is evident that problems of train equipment operation in cold weather are not insuperable as grain cars and heavily loaded ore cars now operate to Churchill and Schefferville in conditions nearly as severe as those elsewhere in the North.

Two main considerations for selection of metals with suitable properties for service on a northern railway are temperature and fatigue life. Steels change from ductile to brittle at low temperatures. Fatigue will aggravate brittle failure problems in both vehicle and rail components where a high level of traffic is maintained. The ARS recommended that present railway equipment should be reviewed to eliminate details promoting fatigue failures such as abrupt changes in section (notches, sharp radii, etc.). Chemical and engineering properties of steel should also be studied and particular attention paid to welding and heat-treating practices.

These precautions apply of course to all highly utilized mechanical equipment operating outdoors in the North. Equipment components supplied to a manufacturer's own specification should be checked, bearing in mind the special requirements for northern service. Where equipment such as railway cars are manufactured for a particular service in the North, the buyer can set his own design and specifications. If the rolling stock is operating "in captivity" on an isolated railway, the owner has even more freedom of choice in design than on a railway which interchanges cars with the North American rail system which imposes certain features and regulations.

Unit trains are generally found to be most economical when heavy cars are used. However, such cars increase the amount of track maintenance required. In the North where the season for maintenance-of-way work is short, some compromise in car weight may be required to optimize operating plus maintenance costs.

A particular cold weather problem to which no general solution has yet been found is the unloading of cargo which has frozen to the inner surfaces of railway cars. Admixtures have been used where a product such as a concentrate is processed and shipped. Infra-red heating or heavy vibration have been used at the unloading terminal. Further research and testing is required on the problem, but so far each product needs individual study.

Locomotives

The particular needs for locomotives operating in northern conditions were closely studied in the ARS. It was found that the standard type of locomotive with a diesel engine, electrical control, and traction equipment as now supplied may be used, but with special consideration of some particular systems and areas which will be sensitive to severe climatic conditions.

A fully enclosed and insulated body will be necessary to protect the crew and give ready access to interior components. The cooling system should be separated into primary and secondary sections to do away with the need for radiator shutters and their controls. Air for combustion and cooling must be filtered. While the filtering methods used on high horsepower locomotives are adequate for normal needs, severe icing and hordes of black flies in some parts of the North will require modifications to the inertial air filter.

All locomotives may be equipped with turbochargers to prevent any direct discharge of exhaust gas. The possibility of rail-originated fires will therefore be slight, reduced further by the use of composition brake shoes on all rolling stock.

Some improvements in locomotive design which would prove useful in northern conditions are currently being studied by locomotive builders. An example is the improvement of traction gear cases to allow the use of Arctic grade lubricants without leakage.

If trains of longer than 50 cars are to be operated, the standard railway air brake system needs modification for extreme cold weather operation. Improvements are under test and the Quebec North Shore and Labrador Railway has successfully operated 225-car unit trains in temperatures below -40°. Welded air lines and screw-type hose fittings were used. Air drying equipment with compressors and after-coolers at the discharge of compressors would improve operation of the brake system. Tests should be continued.

Maintenance of Plant

Surfacing and ballasting of track, which is done almost entirely by semi-automatic equipment, may be heavy in the first years of operation, in effect extending the construction period. After this, the amount of track maintenance should reduce to a regular amount, depending on the volume of traffic and the amount of continuing degradation of permafrost. Maintenance of bridges, buildings and signals may be done according to current practice with allowance for northern seasonal factors. Culverts subject to winter icing will require special attention.

Rail transport will be much less sensitive to some winter problems, such as limited visibility due to fog, haze or blowing snow, than other forms of transport. However, northern weather will create problems with track inspection and maintenance. With short summers and long severe winters, scheduling of maintenance programs requiring outside work will be most important. Major track maintenance will be done with double shift work during the long summer daylight hours and extra staff will be required for this. A high degree of mechanization will be used to reduce discomfort and hazards in cold weather work. Some jobs such as track shimming which cannot be mechanized will be hazardous for section men in winter, and must be minimized by leaving the track in good condition at the onset of winter and reducing speeds if the track becomes rough.

Wind chill will require controlled work scheduling and exposure times, with emergency operations only during some periods of the winter. Track patrols in protected patrol cars will be required on a regular year-round basis. Locomotives and wayside crew shelters must be equipped to protect personnel.

In winter months there will be little need for snow removal with the raised track grade and few cuts. Snow fences and other means to control drifting may be used to advantage. At points where drifting is severe, snow sheds may be needed. In terminals, track maintenance equipment used in summer can often be used directly or converted for snow removal in winter.

In train operations it will be important to ensure that a train is not stopped for any appreciable time during periods of blowing snow, becoming immobilized by snow drifting around the wheels. It may be necessary to add extra locomotives to trains during such periods.

When derailments occur, the quantities spilled will be small as it is uncommon that more than a few cars are involved at one time. However, means will have to be on hand to retrieve the derailed equipment, clean up any contaminating material, and if possible restore the insulating properties of the ground affected.

In considerations of maintenance staffing, it is worth noting that for many years CN has used both Indian and Inuit personnel in various maintenance capacities on the Great Slave Lake Railway, the Hudson Bay Line and elsewhere.

Research Needed

In this assessment of resource railways in the North, various engineering problems were identified. The studies required to solve these problems are listed below as an indication of the research required if Arctic railways are to be practicable and economic. It is noted that some of these studies have important implications for other types of transportation and activity in the North:

chips & wood material, insulation – thermopiles?

- Means should be developed to predict the amount and rate of thaw settlement under a transportation route, and to reduce this rate by economical means.
- Studies should be continued to develop automatic track switch cleaners which are reliable in northern use.
- Metallurgical and associated studies should be made to optimize the design and use of equipment subject to high utilization in cold temperatures.
- Problems of unloading material frozen in railway cars should be studied.
- Manufacturers of diesel electric locomotives should be encouraged to develop various modifications as outlined previously to ensure reliable operations in northern conditions.
- Tests should be continued to adapt the standard railway air brake system to reliable operation in extreme cold weather. This improvement will be required for trains over 50 cars in length.

Potential Role of Resource Railways in the North

The research tasks listed may be grouped into those required for a reliable, viable railway operation and those that would improve the economy of the operation. No technical barriers are foreseen among the tasks in the first group. As the ARS concluded, with the help of appropriate studies a railway in the North is technically feasible and can be reliably operated and maintained.

In planning the necessary studies, however, sufficient lead time must be provided to test the proposed solutions in the field where test cycles are imposed by weather cycles. As existing Canadian railways operating in cold areas will stand to benefit from the improvements which are developed, it seems reasonable to assume their cooperation in conducting the necessary field trials.

The economy of a rail operation in the North is a matter for consideration and comparison with other modes of transportation on individual projects. Assuming technical feasibility, it may be said that, as in normal climates, a northern railway will be favoured for hauling large amounts of bulk materials over intermediate and long distances. The capital required for equipment and set-up operations will favour road transport where product quantities and haul distances are not large. Rough terrain will also increase the relative cost of building a railway. On the other hand, environmental considerations may favour a rail line.

In operation, the guidance and restraint provided by rails and signals make rail traffic better able to cope with northern hazards such as blowing and drifting snow, whiteouts and prolonged darkness than other forms of transport. A well-equipped, efficient system is required, however, operated by staff who are thoroughly experienced in northern conditions.

Vaudreuil, Quebec
13 February 1978

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Railway Geotechnical Consultant

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COLD REGIONS ENGINEERING RESEARCH AND DEVELOPMENT

OTTAWA - FEBRUARY 28 & MARCH 1, 1978

SHIPPING IN THE ARCTIC

The Fednav Group, through its operating company, Federal Commerce & Navigation Ltd. of Montreal, has been continuously involved in Arctic shipping for about thirty years and is presently active in this area through several subsidiary and associated companies.

These companies are involved in actual as well as potential marine transportation projects. This work includes cargo solicitation and transport, the management and operation of vessels under contract, and commercial studies of existing and potential shipping services. There is some engineering research and development involved with the studies, but this detailed work is prepared by consultants.

FEDERAL COMMERCE & NAVIGATION LTD.

FCN has undertaken a number of economic studies incorporating some engineering design work. They were prepared for either internal use or for selected clients involving specific projects. The operational estimates and commercial calculations were prepared by company staff and the engineering work was undertaken by selected naval architects.

During the last six years the following major studies have been prepared:

1. "The Regular and Unrestricted Shipment of Lead/Zinc Concentrates from Little Cornwallis Island to Europe" (December 1972) submitted to Cominco Ltd., Toronto, by FCN on behalf of Resolute Shipping Limited.

2. "The Movement of Lead and Zinc Concentrates out of Strathcona Sound, Baffin Island" (January 1973) submitted to Watts, Griffis and McQuat Ltd., Toronto, by FCN on behalf of Resolute Shipping Limited.

3. Preliminary work leading toward the development of the Arctic Class 2 bulkcarrier m.v. "Arctic" (1970-1976).

4. "Polar Gas Pipeline Study - Transportation Logistics" (January 31st, 1974) submitted to the Polar Gas Project Consortium, Toronto.

.../2

5. "The Year Round Shipment of Crude Oil from Bathurst Island, N.W.T. to Nova Scotia" (February 13, 1976) submitted to Dome Petroleum Limited, Calgary, by FCN on behalf of North Water Navigation Ltd.

6. "The Nine-Month-Per-Year Shipment of Iron Ore Concentrates from Ungava Bay, Quebec to Cape Breton, Nova Scotia" (March 15, 1976) submitted to International Iron Ores Limited, Toronto, by FCN on behalf of North Water Navigation Ltd.

7. "Arctic Petro-Carriers Project - The Shipment of Liquefied Natural Gas from Melville Island to the Eastern Seaboard" (see Melville Shipping Ltd.).

RESOLUTE SHIPPING LIMITED

This subsidiary ship owning company has been active in the Eastern Arctic for the last six years during the annual summer (July-October) resupply operations. These involve the transport of government supplies to remote communities as well as cargo for commercial activities, i.e. oil or gas exploration. RSL has used a variety of vessels to carry these cargoes, including small general cargo ships, landing craft and barges. RSL consolidates the cargo and loads it onboard the vessel, then transports it and supervises its discharge at the destination site.

ARCTIC TRANSPORTATION LTD.

ATL is a tug and barge company, located in Calgary, and has as its parents: Genstar Marine Limited of Montreal, Federal Commerce & Navigation Ltd. of Montreal, and Crowley Maritime Corp. of San Francisco. Its activities include tug support and survey work for drilling operations in the Mackenzie Delta, and general cargo delivery along the Mackenzie River. ATL also has an icebreaking barge, built in Japan in 1977, which will be used in the Mackenzie Delta/Beaufort Sea area for ice-management work and perhaps for an experimental voyage through the North West Passage. An associated company, Moosonee Transportation Ltd., also operates a tug and barge service but in the area of James Bay and Hudson Bay.

MELVILLE SHIPPING LTD.

MSL is the project manager for the Arctic Petro-Carriers Project, part of the Arctic Pilot Project to transport Liquefied Natural Gas (LNG) from Melville Island to the Eastern Seaboard. The partners in MSL are: Canada Steamship Lines Limited and Federal Commerce & Navigation Ltd., both of Montreal, and Upper Lakes Shipping Ltd. of Toronto. MSL completed the first part of the study in September, 1977 and advised that navigation from Melville Island to the Eastern Seaboard on a year-round basis is practicable, that two Arctic Class 7 icebreaking LNG Carriers of about 140,000 cubic metres capacity and approximately 200,000 horsepower can be built and the whole operation can provide a realistic tariff per MCF.

MSL - con't

MSL is presently undertaking a second phase of the project which involves more analysis of the computer projections, with its goal being a complete detailed set of specifications for the final vessel design, along with details of operating considerations and financial and economic calculations. This phase is planned for completion by July, 1978.

NORTH WATER NAVIGATION LTD.

NWN is composed of the same three partners as in MSL. However, this company is involved with the design, present construction and future operation of the Arctic Class 2 icebreaking bulkcarrier m.v. "Arctic". This ship will be in service by early June 1978 and will operate in the Arctic and other ice-covered regions. The ship is owned by Canarctic Shipping Company Ltd. and is being fully instrumented by NRC to record how it operates in ice-covered waters.

Of the companies and their activities described above, the ones most closely associated with engineering research and development are Melville Shipping Ltd. and North Water Navigation Ltd. In terms of R & D work to be undertaken during the next five years, the major beneficiary would be the Arctic Petro-Carriers Project because its operations are planned for commencement in 1981/82. The results of the m.v. "Arctic" testing program will form a part of this input. Therefore, the attached remarks on Service Operations and Vessel Design are primarily applicable to the APC Project.

George F. Hanus
Arctic Projects
Federal Commerce & Navigation Ltd.

SERVICE OPERATIONS

NAVIGATION

1. How effective are Omega, Loran C and Satellite Navigation Systems north of Latitude 70? Systems are now guaranteed south of that Latitude. Apparently Bedford Institute is doing some work with Omega Systems.

2. Navigation aids (radar reflectors, racon beacons, light beacons, radio direction finders) along proposed routes, e.g. coast of Greenland, south coast of Bathurst Island, Byam Martin Island and Melville Island.

3. Improve charts along Greenland coast and all other areas sparsely sounded but where more shipping will be expected.

4. APC vessels will probably be fitted with an Integrated Navigation System (INS) which will use an onboard computer to read positions from several sets of navigation equipment, i.e. Omega, Doppler Log, compass, Sat. Nav., Loran C, etc., and determine ship's position. Also will have collision avoidance radar.

5. Develop a sonar unit to detect low-lying icebergs and their depth. Apparently Westinghouse is doing some work in this area.

6. Investigate extending Decca chains to cover the Arctic to allow a very close navigating capability.

7. Continue work on remote sensing equipment, i.e. satellite, plane overflights, so that ship's master will ultimately receive accurate ice coverage and types of ice along the ship's route, by facsimile or photographs.

COMMUNICATION

1. A study of general communication problems in the Arctic, and methods of improving communication, since the morse key is still the most reliable method.

2. Improve the reception of telex and facsimile information onboard ships.

3. APC intends to use the Telesat satellite communication system and the Anik satellite, but big antennas are required, though by 1982 an 'L' band system will require smaller and thus more manageable antennas.

CARGO LOADING/UNLOADING

1. Study methods of keeping dock faces, and the area immediately adjacent to the dock wall, clear of ice by using air bubbler, waste heat or other ice management techniques. Also, see how a ship's air bubbler could help reduce ice at the berth.

2. Ensure cargo loading/unloading equipment has enough reach to load/unload a ship several feet away from the berth due to severe ice conditions. This may be easy with bulk cargoes using conveyor belts or cranes for general cargo, but more difficult for LNG Carriers.

MOORING

1. Study the effect of extreme cold weather on the behaviour of personnel and the type of mechanical equipment needed to back them up.

2. Investigate the effect of the cold weather on the safety and working life of the ship's wires and polypropylene ropes, and develop a reliable device to shoot the heaving lines ashore in the cold operating conditions.

3. Check the reliability of mooring aids such as a Doppler system at Arctic berths.

SAFETY

1. The effects of spilled or sprayed LNG on ice and on the ship's hull should be studied.

2. Investigate the effects of spilled oil over or around ice floes.

3. Methods of abandoning ships with a high freeboard in the Arctic, e.g. airplane chutes should be considered.

4. Develop or modify Arctic survival equipment to include it in small inflatable double skinned dinghies, i.e. self-warming food, clothing, heating, etc.

5. Prepare or adapt Arctic survival courses, which now exist in Calgary, to educate marine personnel.

TRAINING

1. Institute a program to train technical personnel, in particular electrical engineers, since there is a severe shortage of these people.

2. Train all navigating personnel on an aircraft type simulator in simulated Arctic ice conditions, either on a modified unit now in New York or a purpose system in Canada.

3. Training of personnel in actual ice navigation on CCGS vessels, and training in ice observation and interpretation from the Atmospheric Environmental Service is very important.

VESSEL DESIGN

1. Melville Shipping Ltd. is studying the following areas to arrive at the best vessel design for the Arctic Petro-Carriers Project.

   - Structural strength
   - Stability in open water and ice
   - Manoeuvring in ice
   - Docking procedure and mooring equipment
   - Propeller design
   - Rudder design
   - Influence of the environment
   - Vibration
   - Navigation assistance and guidance
   - Safety
   - Optimization of hull shape
   - Optimization of hull structure
   - Optimization of power plant

2. Most interesting MSL study is the optimization of the power plant which will involve a dynamic simulation of 10 propulsion systems (4 prime movers, 4 electric transmissions and 2 propeller designs).

3. Would require tests in NRC hydrodynamic tank of a series of aft body shapes with several propellers to determine their wake characteristics and interaction with ice. Also, do a series optimization of hull forms and efficiency of bubbler systems.

4. NRC should get an ice tank and carry out scientifically oriented model testing, as opposed to strictly commercially oriented work, but still provide some competition to existing ice tanks and build up experience.

5. Study mechanical properties of ice and how it affects ship transit by varying the friction factor of the ship's hull, also using sloped sides and a wedge shape.

6. Engineering studies should also cover the effect of cold weather operations on materials (steel) and corrosive, if any, effects of Arctic waters on weld zones, e.g. Finnish shipyards, steel mills and government apparently have developed more corrosion resistant steel for use in ice.

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NORTHERN OFF-ROAD TRANSPORT AND REQUIREMENT FOR RESEARCH AND DEVELOPMENT

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NORTHERN OFF-ROAD TRANSPORT AND

REQUIREMENT FOR RESEARCH AND DEVELOPMENT

Expected Need for Cold Regions Off-road Transport During the Next 5 - 10 Years

Off-road transport methods and equipment for use in the Canadian North have evolved within a combination of constraints, including time, cost, type of payload, volume of traffic, environmental limitations and restrictions, and availability of alternative transport methods. Tracked, wheeled, and, to some extent, air cushion vehicles are used to transport personnel, equipment, supplies, and a few raw materials on missions where the frequency of travel over the same route does not justify building roads, where the payloads and distances are not appropriate for air transport, or where work, such as seismic exploration or pipeline construction, must be performed continuously along the route. Payloads vary from 1 to 60 tons for individual vehicles, and trains of sleds hauled by heavy tracked vehicles carry hundreds of tons at speeds up to about 15 km/h.

As early as 1970, concern for the environmental effects of vehicular traffic on vegetation and permafrost led to the development and implementation of Arctic Land Use Regulations. This legislation now restricts most off-road vehicle traffic in the North to the winter season, when freezing temperatures and snow cover protect the ground surface from scuffing and compaction.

A major portion of northern off-road transport has, until now, been related to oil and gas exploration. Ten years ago, this traffic was concentrated in northern Alberta and Mackenzie District. Since then, it has moved steadily northward into the Arctic Islands and onto the frozen sea between the islands. The use of wheeled vehicles with large "Terra-Tires" initially for seismic work, and more recently for hauling oilfield equipment and supplies, has partly replaced the use of tracked vehicles for these purposes. This development reflects the change in terrain conditions from soft, wet summer conditions in the south, requiring the high mobility of tracks, to frozen hard terrain with light snowfall accumulations during the winter farther north. Here, equipment with large tires has adequate mobility, and wheeled vehicles are generall cheaper to operate and maintain than tracked vehicles.

Another form of off-road transport has been sleigh-haul operations carried out during the winter, notably in northern Manitoba, and in the Mackenzie Valley. Although "off-road" in the strict sense of the term, these operations follow fixed established routes, largely along frozen rivers and over lakes.

Finally, remote telecommunications and power transmission facilities require periodic maintenance. Often, access can be provided most economically by helicopter, but there is some use of light off-road vehicles for transport of maintenance personnel and tools.

It seems reasonable to assume that during the next five to ten years, the requirement for cold regions off-road transport in Canada will continue to be related mostly to development of natural resources, especially gas and oil, and also to installation and maintenance of telecommunications systems. Until now, the emphasis has been on exploration. In the future, pipelines will be needed to transport gas and oil already discovered, and new off-road equipment will be needed to help build and maintain the pipelines and associated facilities. Overland transport will be required, for example, for huge quantities of large-diameter pipe, as well as for equipment, supplies, personnel, housing, and repair facilities. Some of this equipment has already been designed, and a few examples have been built, like the 70-ton Magnum pipe carrier by Canadian Foremost Ltd.

Part of the shift of emphasis from exploration to maintenance of pipelines and communications facilities will involve greater need to handle emergencies - malfunction of remote compressor and pumping stations, pipeline leaks, fires, and oil-spill clean-up. This may involve overland travel of considerable distance when weather conditions and lack of daylight preclude the use of helicopters. Even when large helicopters can be used to airlift personnel and tools like welders, there will be a need for local use of light utility vehicles with higher mobility than a 4 x 4, 3/4 ton truck, for heavier mobile equipment for hoisting, and for emergency shelter for repair crews.

Contemporary off-road vehicles have already demonstrated their ability to operate year-round throughout Canadian cold regions. Within the limitations of cost, time, payload, environmental restrictions, and availability of alternative transport methods. The challenge that remains is to improve the effectiveness of off-road transport by making vehicles which are faster, cheaper, more productive, and more reliable. This increased effectiveness must be realized primarily in an environment of low temperatures, rough, frozen ground, and snow depths of less than 1 m. Also, for the function of dealing with emergencies in remote locations, environmental restrictions may be ignored or waived in the presence of a greater threat of an explosion, fire, or oil spill. As a result, there will be a need for vehicle mobility over huge expanses of wet organic terrain (muskeg), such as that found west of Hudson Bay, during summer conditions. Even vehicles having amphibious capability may be needed.

Research and Development Requirements

The focus of R&D to meet these needs should be the development of off-road equipment that can, as compared with contemporary vehicles, travel faster, cheaper, more reliably with larger payloads and/or less fuel consumption. This equipment must also be designed, within practical limits, to minimize terrain disturbance.

One of the first steps in the R&D process should be to acquire a better knowledge and definition of the vehicle operating environment as a guide to future vehicle design. While vehicle designers are reasonably familiar with northern terrain in qualitative terms, they need more quantitative information about terrain properties, and also about how to use terrain data in the design process. Snow, peat, and soil strength still have not been adequately, if at all, measured and mapped so that the vehicle mobility required for particular geographical areas can be properly specified. Terrain surface roughness can be measured and used as quantitative data to improve vehicle suspension system design, but this has not yet been attempted in this country!

Classification of snow in terms that would allow us to predict its trafficability still eludes us. We have not even been able to decide which parameters should be included in a snow trafficability classification system.

There is information in other countries like Sweden about snow and terrain trafficabilty classification, but this information needs to be collected, refined, and adapted to our own requirements. The Radforth Muskeg Cover Classification System and Airform Pattern System still have a great deal of undeveloped potential for use in predicting trafficability of muskeg, but until quantitative measurements of mechanical properties of peat specifically related to loads imposed on it by off-road vehicles are taken on a broad scale, and correlated with the various classes, this potential will not be realized.

The most critical shortcoming of contemporary off-road vehicles, with very few exceptions, is that they can only travel slowly (less than 15 km/h) over rough ground. The limitation is usually the discomfort of the operator experiencing a rough ride, rather than the mechanical ability of the vehicle to withstand the punishment. A small increase of just 10 km/h in the rough ground travel speed would pay huge dividends in the productivity of off-road vehicles. Development of better suspension systems for vehicle chassis, cabs, and seats, partly through the use of quantitative terrain roughness data, is the main hope for improvement in this area.

The search for better traction, lower rolling resistance, and increased durability when operating at low temperatures on all terrain including rock, sand, mud, muskeg, snow, and ice, should be continued. Tire and track designs still have room for improvement.

Consideration should be given to development of new vehicle configurations, specifically for high-speed, all-weather, emergency access to remote sites. It may be, for example, that work now underway for the Canadian Military on a Medium Marginal Terrain Vehicle (MMTV) could be extended to adapt that concept for civilian use.

New vehicles, components, and materials developed by private industry should be tested and evaluated, as soon as they appear on the market, with respect to their potential for reducing the cost and increasing the productivity of off-road equipment. Concepts now appearing on the market, such as the Martin Track and the recently developed Sasquatch snow vehicle, should be thoroughly tested in cold regions and when successful, potential users should have access to the test results. This would enable equipment users to compare the tests conditions with their own operating conditions to help them decide if there would be a place for this new technology in their operations.

Several off-road vehicles have been developed in other countries for use in cold regions, and these types of vehicles have not yet been introduced to Canada on a large scale, if at all. Examples occur in the Soviet Union, Sweden, and the United States such as the ZIL-E-167, Sno-trak, and Twister. There may be opportunities to adapt some of these high-mobility concepts to our own environment and, in doing so, avoid a lot of trial-and-error development which has already been carried out elsewhere.

In conclusion, if these ideas and others like them are to be implemented effectively, there will be a need to coordinate the R&D effort, assess its progress, establish new goals periodically, and make the results available to the end users in useful form. The suggestions made here for establishing new R&D efforts were made keeping in mind the need ultimately for more useful hardware which will help to minimize the cost of working in and developing our cold regions. Some of these ideas are already receiving attention from other groups in both Canada and other countries, so it is clear that there is already a need to assemble and make known on at least a national scale the results of new off-road transport R&D effort.

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February 14, 1978

Dr. L.W. Gold
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Dear Lorne:

I thank you for your recent correspondence and must apologize for the tardiness of my reply. I'm afraid I just got caught up in a rash of meetings, etc. and, before I knew it, the middle of February was upon me.

I am glad that you were able to talk to Don Bruce and Murray Fyfe as you were able to confirm my comments during our very pleasant meeting. Also, while I regret not having an opportunity to meet your committee later in the month, as I stated previously my presence would be a waste of time and money under the circumstances.

Enclosed you will find a brief summary of telecommunications resources in the north for your record. I believe the comments of Madame Sauve, also attached, gives some indication of future developments.

Thank you for this opportunity to contribute, even though negatively, to your committee and I look forward to meeting you again in the future.

Yours very truly,

Wallie

W.R. Scrimes, P.Eng.

WRS:keg

Enclosures: 2

TELECOMMUNICATIONS RESOURCES IN NORTHERN CANADA

INTRODUCTION

Reliable telecommunications facilities are essential ingredients for the economic developments of any area. The writer was invited to contribute input relating to the availability of modern telecommunications in northern Canada for a study on resource development undertaken by a committee of the Division of Building Research, National Research Council, Ottawa.

The purpose of the study is to explore the areas of technical concern impending resource development in the north and recommend research activity in an effort to resolve these technical problems. In general, the area being considered is that area north of the 60th parallel which includes the Yukon Territory, Northwest Territories and the Arctic Islands. Northern Quebec and Labrador should also be included in this study area.

This brief paper shall endeavour to summarize the state of the telecommunications arts in the areas being considered and provide an indication of future requirements in the North.

HISTORY

Time does not permit a review of the interesting early developments in northern communications. However, some facts that resulted in the early placement of a communications network in the NWT are worthy of note here.

The first radio circuit in the North, from Dawson City to Mayo, Yukon Territory, was established in October, 1923, by the Royal Canadian Corps of Signals at the request of the Department of Interior - the predecessor of the present Department of Indian and Northern Affairs. Up to this time, the only communication out of the Arctic was by a single telegraph line running from Dawson City to Hazelton, British Columbia. Later that year, an effort was made to establish a wireless station on Herschel Island but the supply ship sunk and a supply barge floundered so the attempt was abandoned. In 1925, a station was established at Aklavik with a sub-station being operated on Herschel Island during the navigation season. The sub-station was closed permanently when Herschel was no longer a winter harbour for the whaling fleets. Stations were subsequently set up at Fort Smith and Fort Simpson.

Army signals then designed the first really effective system by establishing a terminal in Edmonton. Thus began the Northwest Territory and Yukon Radio System which remained in existence until 1960 when the Department of Transport took over the network. The system was re-named the Northwest Communication System and was operated by the Canadian National Railway. Today, this upgraded system is part of the Canadian National Telecommunications.

In the late '50's the U. S. Defence Department installed a microwave system for Alaska defence along the Alaska Highway through Canada, terminating in Fairbanks. The Canadian portion was operated by N. C. S. and resulted in the updating of their land line system. The facilities are being continuously upgraded by CNT. The CNT expanded their northern facilities in the late '60's with the installation of a microwave system linking the communities down the MacKenzie Valley from Hay River to Tuktoyaktuk, NWT. A lateral around the western shore of Great Slave Lake to Yellowknife and north to Port Radium and Lady Franklin Point, Victoria Island, linked these locations to the south.

Communications have not developed to the same extent in the Eastern Arctic as they did in the Western Arctic. However, significant improvements are being made since the advent of the Canadian domestic satellite program operated by Télsat Canada.

Telecommunications Development

How does a telecommunications facility become established, particularly in the North? An analysis of the few historical events included will show that the development of northern natural resources could only be accomplished economically if a more than minimum communications were provided. Again, as time will not permit exploring the need in detail, it is sufficient to say that early on, at least in the Western Arctic, the public and private sectors recognized the necessity of establishing meaningful communications facilities on a co-operative basis. The need was determined, not by social necessities, but rather from economic requirements.

For example, the telegraph line from Dawson City to Hazelton had an obvious economic reason for its existence - the Klondike gold mining operations. The effort to establish a radio station on Herschel Island was prompted by the needs of the whaling fleet. The microwave system along the Alaska Highway was dictated by North American defence commitments. The MacKenzie Valley system resulted from the needs of oil and gas exploration and expanded materials transportation down the MacKenzie River. In virtually every case, the demands of industry and to a lesser extent, that of government dictated the telecommunications needs and those communities located within or adjacent to the center of northern resource development became eventual beneficiaries.

This analysis of the northern communications development probably accounts for the much slower development of the Eastern Arctic communications. Unfortunately, because industry and economics dictate the needs, the Eastern Arctic communities have suffered as a consequence compared to their western neighbours.

The advent, in 1973, of the "Anik" series of Canadian domestic satellites and the first such system in the world, have, for the first time, made it possible to serve native communities with reliable communications to and from the South. In the last five years, educational, medical and entertainment services, audio and visual, are being installed in isolated northern communities. These services are being provided from Federal Government funding through the CBC and numerous government agencies.

On a test installation sponsored by Tèlsat Canada, an earth satellite station is presently operating from Eureka, Ellismere Island, 80° latitude north. The "Anik" series of satellites can cover virtually all of Canada and thus provides limitless coverage for any form of telecommunications employing the latest state of art techniques.

Conclusions

From the foregoing it is apparent that Canada enjoys the luxury of having the most modern telecommunications facilities available, but naturally at a price. With these resources, business and industry can determine what their economic needs must be and provide private funding to accomplish their aims. Naturally, the social development will advance at a much slower rate because it is totally dependent upon public funding.

In consequence, provided industry and business take a realistic approach to their telecommunications planning, their requirements can be adequately provided.

Unlike many other facets of northern resource development, citing land transportation as one example, technical advancement in telecommunications resources is being fostered and expanded by vast R & D efforts within the industry itself, worldwide.

Finally, the writer believes that there are many other areas related to resource devleopment that require the efforts of organizations such as the National Research Council and such being the case, can attack these areas and be confident that the telecommunications field is meeting the needs of northern development.

Attached is a copy of a recent statement by the Honourable Minister of Communications to the electronics industry which indicates the awareness of the needs in Canada and a forecast of the planning being developed by the public sector.

COMMUNICATIONS

Review of DOC activities 1977

By the Honourable Jeanne Sauve, Minister of Communications

The single most important development in communications in 1977 was the tabling in Parliament of new communications legislations in March. By consolidating and clarifying existing federal legislation, it was designed to streamline Federal Regulation of Telecommunications in Canada and make it more responsive to rapidly changing technology and to provincial concerns.

The legislation, to be known as the Telecommunications Act, is expected to be re-introduced in the current session of the House.

The proposed act will establish a clear demarcation between the functions and responsibilities of the government and the CRTC. It will also allow provincial governments to contribute to the development of National Telecommunications Policy.

The Act will not, however, alter the basic mandate of the Department of Communications to promote the development of efficient communications systems and facilities accessible to all Canadians. The Department will continue to regulate the radio frequency spectrum, promote research and development in communications, and develop policies and programs in the public interest.

A number of other significant developments marked 1977.

In January, I announced a program designed to ensure that every community in the Northwest Territories will have basic local and long-distance telephone service within a few years. Under the Northern Communications Assistance Program, the Federal Government will contribute about 9 million dollars to cover the capital costs of the communications facilities between communities required to bring in reliable long-distance phone service. Bell Canada and CN Telecommunications will invest a similar amount in capital and operating funds for local exchanges and for operating the circuits between communities over the same period of time.

Canada's experimental HERMES satellite program has now completed about 80 per cent of its social and technological experiments. The satellite is designed to develop the technology and explore the use of new satellite communications services. The planned two-year life of the 60 million dollar, high-powered communications satellite may be increased by another year for further experimentation. The success of HERMES ground station antennas, among the smallest in the world, has been proved many times over. The lessons learned through HERMES will influence the development of new communications services, particularly in remote areas.

A Canadian-sponsored plan for guiding the development of direct broadcasting satellite systems, of which HERMES is a forerunner, to serve the Americas was agreed to at the 1977 World Administrative Conference (WARC) in Geneva.

Concern for the future of Canada's space program prompted the Governor-in-Council in November to vary a CRTC decision not to approve a proposed agreement whereby Telesat Canada would become a member of the Trans-Canada Telephone System (TCTS). The Governor-In-Council approved the proposed agreement on the grounds of broad government policy to foster satellite communications services for Canadians.

In conjunction with that decision, we will be reviewing the ownership of satellite earth stations to identify instances where non-Telesat ownership could be in the public interest. At present Telesat directly owns all stations in its system.

On a more down-to-earth level, the number of channels available to General Radio Service (GRS, or CB as it is commonly known) users expanded from 22 to 40 in 1977. More than 600,000 Canadians hold licenses for GRS radios.

The growth in the service has caused some problems including crowding of channels (which prompted the channel increase), interference with TV reception and electronic home entertainment devices, and ignorance of or lack of respect for the regulations. To alleviate these, the Department is, among other things, encouraging design improvements in consumer electronic appliances affected by GRS transmissions and is planning for more stringent technical specifications for GRS equipment. In addition the Department has a program to encourage user awareness of and adherence to GRS regulations through an information program and a nation-wide series of seminars.

Although newer communication services continue to come on stream, other services are experiencing decline. In August, the Department released a report on the public message telegraph service which says the decline is expected to continue, putting further strain on the future of the service.

Operating costs of the domestic telegraph service operated by CNCP Telecommunications exceeded revenues by an estimated 3 million dollars in 1975 and by a forecasted 5 million dollars in 1976. The study concluded that the service, however, remains a valuable option in the range of telecommunications available to Canadians and to some an important service difficult to replace.

In 1978, we expect to receive comments from interested parties on our proposals, contained in a discussion paper released in December, for changes to the radio frequency band betwen 406 and 960 Mhz. This band is crucial for the allocation of future TV channels, mobile radio stations and number of other important services to Canadians. Our proposals have been made to prepare for the 1979 WARC in Geneva at which time there will be the first general revision of international allocations made at all frequency levels since 1959 and which will largely determine what the spectrum looks like till the end of the century. Ω