

J. PALMER

SOME THOUGHTS ON
THE CONCEPT OF HF SATELLITE
VOICE COMMUNICATIONS AND
RADIO BROADCASTING FOR
CANADA'S FAR NORTH

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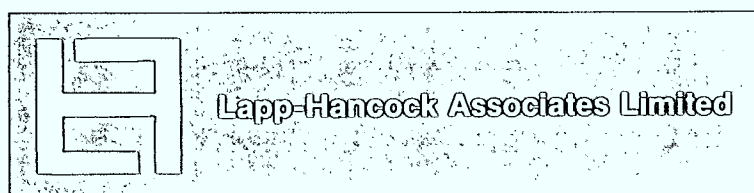
SOME THOUGHTS ON
THE CONCEPT OF HF SATELLITE
VOICE COMMUNICATIONS AND
RADIO BROADCASTING FOR
CANADA'S FAR NORTH

A Presentation Made to
C.R.C.

By

Kenneth E. Hancock
of
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October 1985



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PRESENTATION TO CRC - 31st OCTOBER 1985

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SOME THOUGHTS ON THE CONCEPT OF HF SATELLITE VOICE
COMMUNICATIONS AND RADIO BROADCASTING FOR CANADA'S FAR
NORTH

- CANADA IS CURRENTLY EXCELLENTLY SERVED BY
COMMUNICATIONS SATELLITES EXCEPT IN THE FAR NORTH

- SOME REASONS FOR POOR FAR NORTH COVERAGE:
 - GEOSTATIONARY ORBIT GIVES LOW LOOK ANGLE OR
IS BELOW HORIZON

 - SPARSE POPULATION

 - TELECOMMUNICATIONS NEEDS OF POPULATION DO NOT
JUSTIFY, AND ARE NOT MET, BY EXPENSIVE FIXED
EARTH STATIONS ACCESSING THE MARGINAL ANIK D
SIGNAL.

- FUTURE MSAT WILL NOT IMPROVE SITUATION

HOW ARE NORTHERN COMMUNICATIONS NEEDS CURRENTLY MET

- IN MAJOR CENTERS:
 - HIGH LATITUDE "FRONTIER STATIONS" PROVIDING TELEVISION AND RADIO VIA REBROADCAST STATIONS
 - THE NATIONAL TELEPHONE AND SWITCHED DATA SERVICES
- OUTSIDE OF MAJOR CENTERS:
 - HF RADIO FOR VOICE COMMUNICATIONS
 - SHORT WAVE (HF) BROADCAST SERVICE
 - TV-NIL
 - DATA - NIL (EXCEPT FOR EXPENSIVE EXPERIMENTAL HF DATA LINKS)

BRIEF REVIEW OF ADVANTAGES AND DISADVANTAGES OF
TERRESTRIAL HF COMMUNICATIONS

ADVANTAGES

- LONG RANGE
- SIMPLE EQUIPMENT
- INEXPENSIVE
- CAN BE MOBILE,
TRANSPORTABLE OR
FIXED

DISADVANTAGES

- MAKES USE OF IONOSPHERE
GIVING POOR PROPOGATION
RELIABILITY
- LIMITED BANDWIDTH
- BAND VERY CROWDED
- UPPER END OF BAND SELDOM
USEABLE DUE TO IONOSPHERIC
CONDITIONS

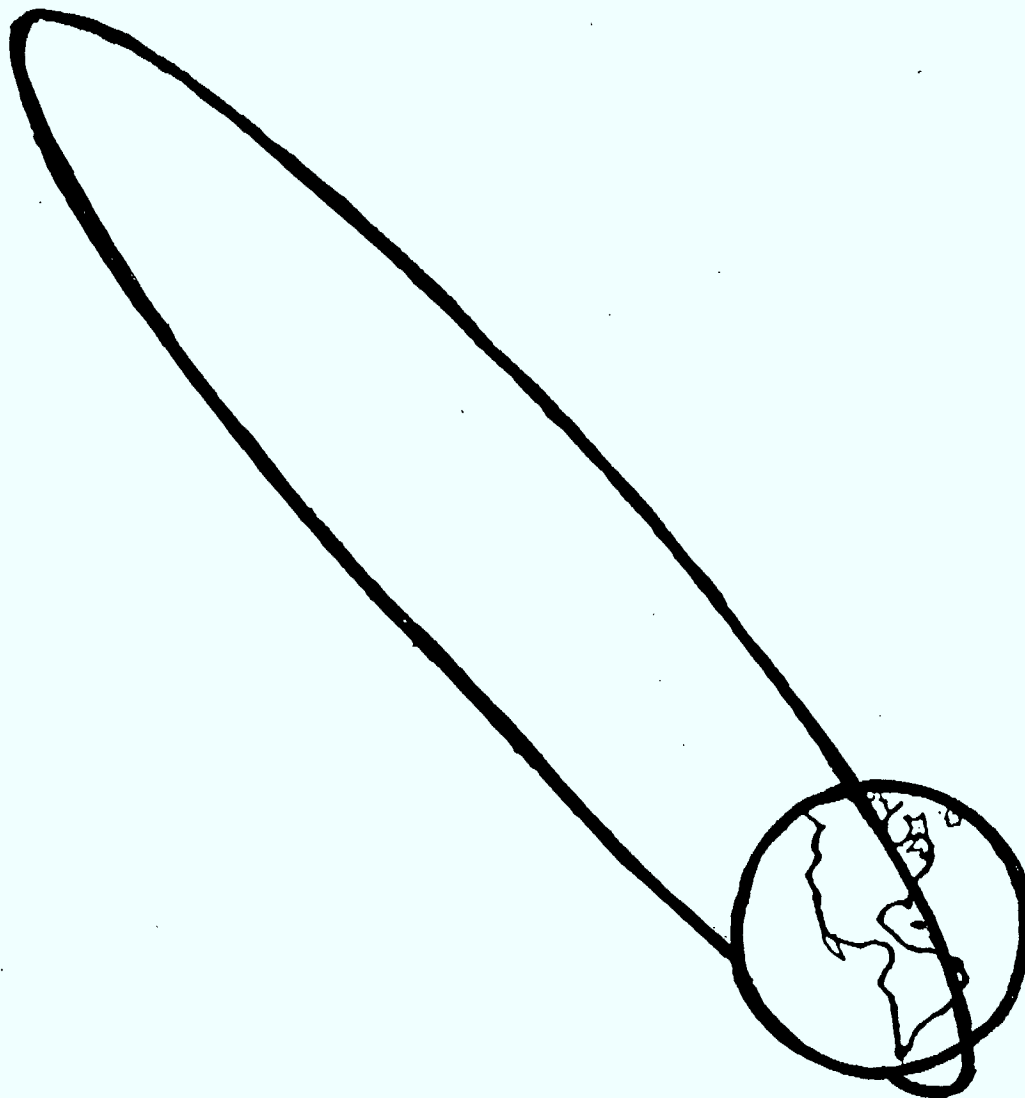
THE MOLNIYA ORBIT
AN ALTERNATIVE TO THE
GEOSTATIONARY ORBIT
FOR NORTHERN SATELLITE
COMMUNICATIONS

WHAT IS A MOLNIYA ORBIT?

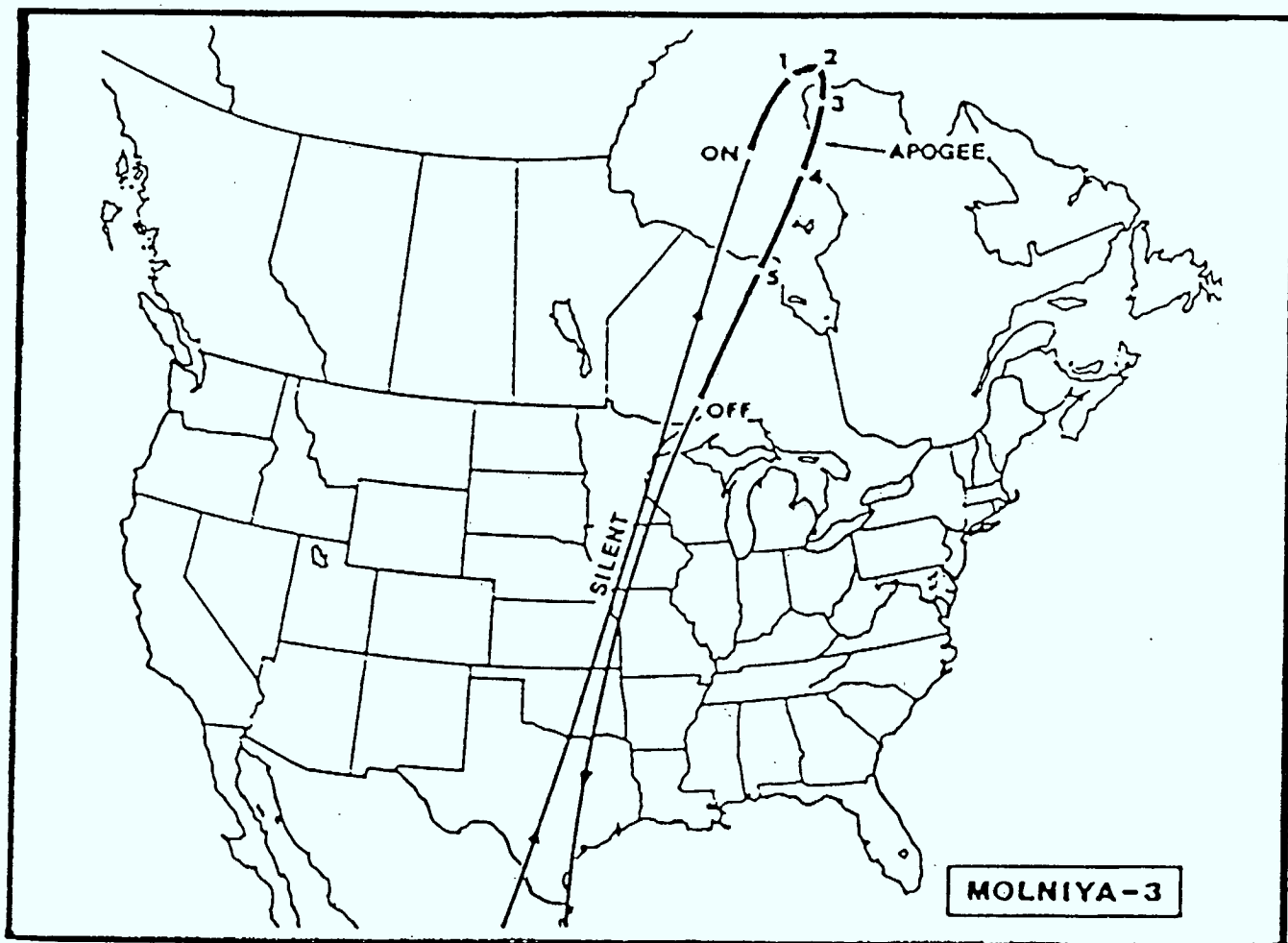
- HIGH INCLINATION 12 HOUR ORBIT (SATELLITE APPEARS AT SAME TIME EACH DAY)
- HIGHLY ECCENTRIC
- SERVES HIGH LATITUDES AND ARCTIC AREA
- SIX HOUR OPTIMUM COMMUNICATIONS PERIOD
- FOUR SATELLITE CONSTELLATION REQUIRED FOR 24 HOURS SERVICE
- MATURE (RUSSIAN) TECHNOLOGY
 - 100 MOLNIYA SATELLITES LAUNCHED SINCE 1965
 - 12 STANDBYS CURRENTLY PROVIDE 3 FULL TIME NETWORKS

LINGUISTIC NOTE: MOLNIYA IS RUSSIAN FOR LIGHTNING OR
FLASH

A SKETCH OF A MOLNIYA TYPE ORBIT



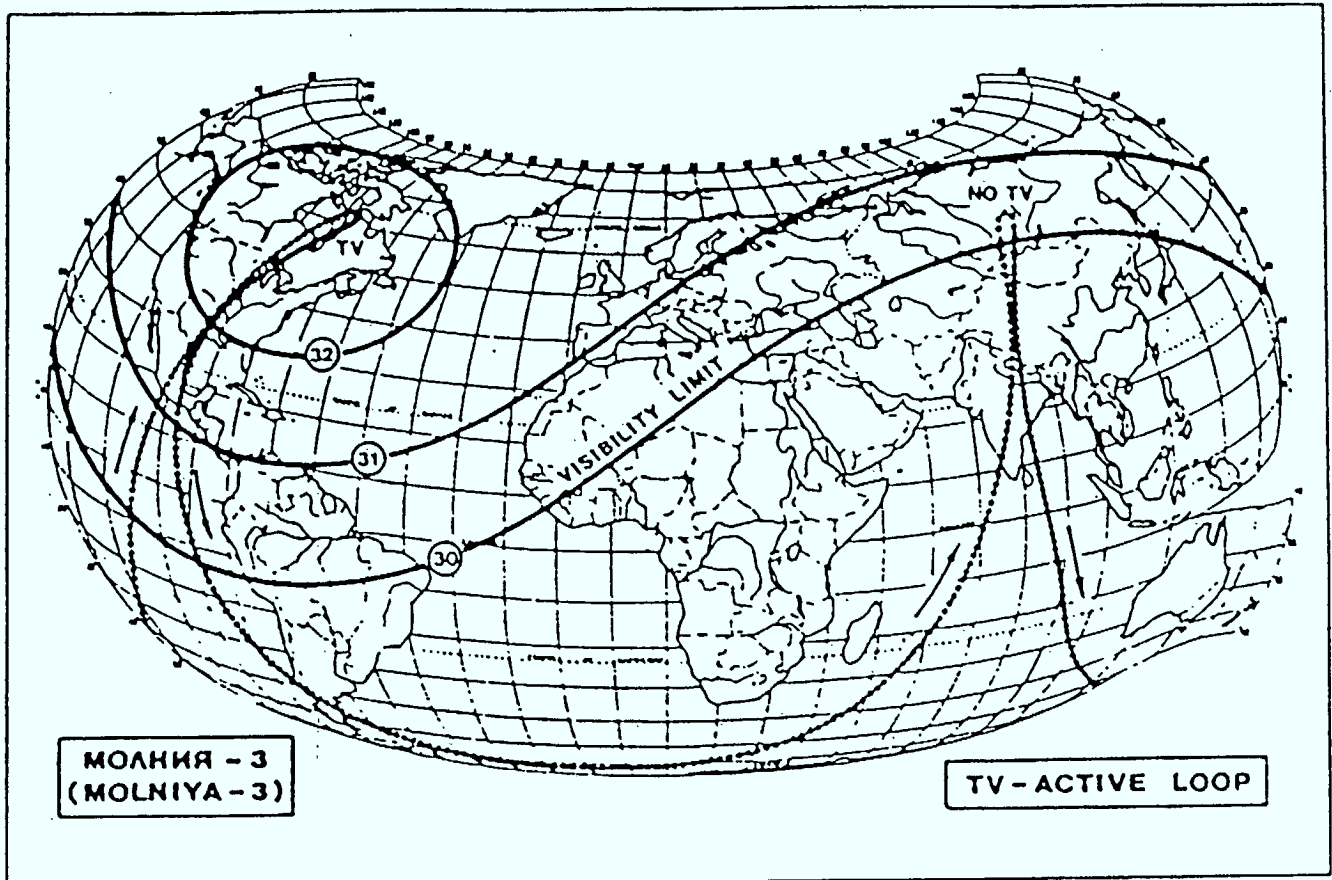
TRACK OF A CURRENT MOLNIYA-3 (RUSSIAN) SATELLITE*



The slow-moving loop at apogee makes Molniya appear to stand still.

* FROM S. BIRKILL

COVERAGE OF A CURRENT MOLNIYA-3 (RUSSIAN) SATELLITE*



* FROM S. BIRKILL

ORBITAL ELEMENTS OF MOLNIYA 1BF

INCLINATION	62.83 DEGREES
NODAL PERIOD	736.13 DEGREES
SEMI MAJOR AXIS	27007 kms
PERIGEE HEIGHT	627 kms
APOGEE HEIGHT	40631 kms
ORBITAL ECCENTRICITY	0.741
ARGUMENT OF PERIGEE	288 DEGREES

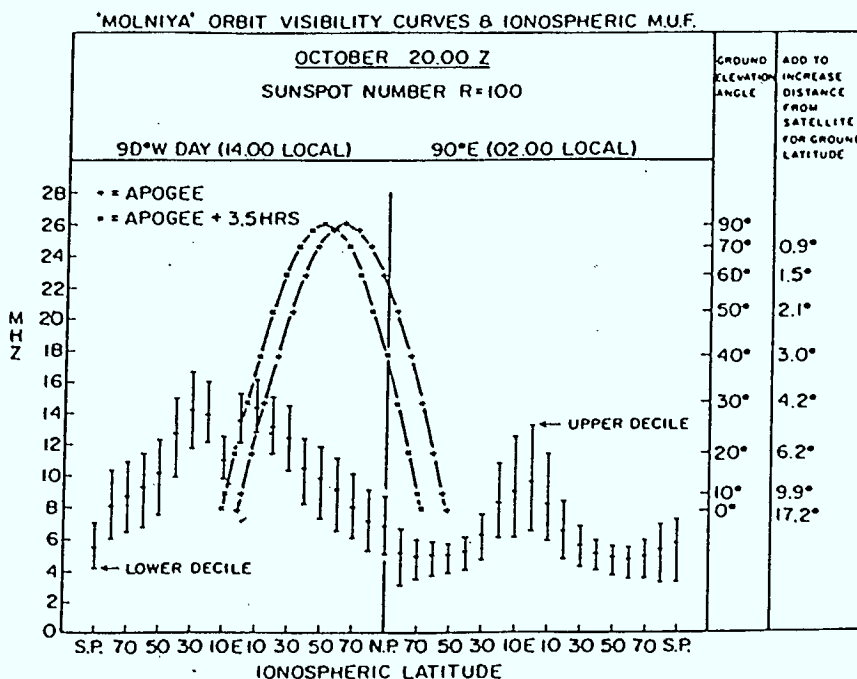
SOME ADVANTAGES OF THE MOLNIYA ORBIT

- ORBITS ARE STABLE IN ARGUMENT OF PERIGEE THUS
STATION KEEPING FUEL CONSUMPTION MINIMIZED
- FOR A GIVEN PAYLOAD, LAUNCH CAPACITY REQUIRED
IS SMALLER THAN AT FOR A GEOSTATIONARY ORBIT
- SUITABLE FOR LAUNCH FROM A NORTHERN (CANADIAN)
SITE
- NO COMPETITION FOR ORBIT
- SLOW APPARENT MOVEMENT (VIEWED FROM A NORTHERN
EARTH STATION) MAKES IT SUITABLE FOR WIDE BEAM
ANTENNA CONFIGURATIONS
- SAME DAILY ORBITAL TRACK
- WOULD SERVE ALL OF THE CANADIAN NORTH

CONCEPT OF SOUND BROADCAST HF SATELLITE IN MOLNIYA

ORBIT FOR NORTHERN SERVICE

- PUT FORWARD BY PHILLIPS, STEPHENSON AND OTHERS
- 26 MHZ BROADCAST BAND USUALLY ABOVE TERRESTRIAL MAXIMUM USABLE FREQUENCY



Critical F region frequencies (2000 hrs UTC, sunspot number 100, October) against $(26 \cos \theta)$ and satellite elevation for apogee and apogee + 3.5 hours for Molniya orbit satellite.

* FROM D.G. STEPHENSON

- LITTLE SUPPORT FOR CONCEPT, PROBABLY DUE TO DECLINING COMMERCIAL USE OF HF RADIO AND LITTLE PROSPECT OF FINANCIAL VIABILITY FOR NORTHERN MARKET
- NASA FUNDED STUDIES FOR POTENTIAL VOICE OF AMERICA USE

SO WHAT IS NEW?

- RUSSIANS AND USAF ALREADY USING MOLNIYA ORBIT
- STEVENSON, PHILLIPS, NASA ETC HAVE LOOKED AT IT FOR HF AND UHF SOUND BROADCASTING AND HAVE NOT FOUND STRONG SUPPORT

* * *

ARE WE OVERLOOKING THE OBVIOUS?

- THE USE IN CANADA OF MOLNIYA ORBIT SATELLITES FOR RELIABLE HIGH LATITUDE MOBILE HF COMMUNICATIONS
- IF FEASIBLE, SOME OBVIOUS USER OPERATIONAL ADVANTAGES ARE:
 - CAN USE MOST HF TRANSMITTERS AND RECEIVERS ALREADY IN USE IN NORTH, NO EXPENSIVE RE-EQUIPMENT REQUIRED
 - WOULD GIVE FULL NORTHERN AND POLAR COVERAGE
 - COMPLETELY MOBILE AND TRANSPORTABLE
 - SIMPLE TO USE, NO RETRAINING REQUIRED
 - POTENTIAL FOR HIGHLY RELIABLE, 24 HOUR SERVICE

CONSIDERATION OF THE USE OF THE
HIGH FREQUENCY BAND FOR
A MOLNIYA ORBIT COMMUNICATIONS SATELLITE

- HF BAND - 3 MHz to 30 MHz

NOTE:

TERRESTRIAL USE OF 25 TO 30 MHz SEVERELY LIMITED
BY IONOSPHERE (MAXIMUM USEABLE FREQUENCY OR MUF)

- CURRENT CANADIAN FREQUENCY ALLOCATIONS FOR THIS
SPECTRUM SEGMENT:

- 25.070 to 25.210MHz	MARITIME MOBILE
- 25.210 to 25.550MHz	<u>FIXED:</u> <u>MOBILE</u> (Except Aeronautical)
- 25.550 to 25.670MHz	RADIO ASTRONOMY
- 25.670 to 26.100MHz	<u>BROADCASTING</u>
- 26.100 to 26.175MHz	MARITIME MOBILE
- 26.175 to 27.500MHz	<u>FIXED:</u> <u>MOBILE</u> (Except Aeronautical)
- 27.500 to 28.000MHz	<u>MOBILE</u> - fixed
- 28.000 to 29.700MHz	AMATEUR - AMATEUR SATELLITE
- 29.700 to 30.005MHz	<u>MOBILE</u> - fixed
- 30.005 to 30.010MHz	<u>MOBILE:</u> <u>SPACE RESEARCH</u> fixed

SOME OTHER POTENTIAL ADVANTAGES

- WOULD MAKE EFFECTIVE, RELIABLE USE OF A SEGMENT OF SPECTRUM CURRENTLY DIFFICULT TO UTILIZE RELIABLY
- PEACEFUL AND INNOVATIVE NEW CANADIAN SPACE INITIATIVE
- SATELLITES COMPARATIVELY LOW COST
- PAYLOAD TECHNOLOGY MATURE
- SATELLITE ANTENNA COULD USE MATURE CANADIAN 'STEM' SYSTEM
- HIGH PROFILE, POTENTIALLY LOW COST CANADIAN SYSTEM
- WILL ASSIST IN ADDRESSING SOVEREIGNTY ISSUES
- SATELLITES COULD BE DESIGNED, MANUFACTURED, TESTED (LAUNCHED?) IN CANADA

SOME OTHER POTENTIAL ADVANTAGES

- WOULD BUILD UPON CRC'S PREVIOUS WORLD CLASS
SATELLITE AND PROPAGATION WORK
- WOULD LIKELY BE OF INTEREST TO
ALASKA
SCANDINAVIA
JAPAN
WITH POSSIBILITY OF A JOINT VENTURE
- COULD POSSIBLY ALSO BE USED TO CARRY HF OR VHF
BROADCAST TRANSMITTER
- POSSIBLE SEARCH AND RESCUE APPLICATIONS
- USEFUL FOR MARITIME AND AERONAUTICAL APPLICATIONS
IN ADDITION TO PRIME LAND FIXED AND MOBILE USE
- SPACE RESEARCH FREQUENCY ALREADY ALLOCATED IN BAND
- COULD BE USED FOR DATA (MEDIUM SPEED) AS WELL AS
VOICE

SOME POTENTIAL USERS OF THE SERVICE

- NATIVE PEOPLES AND COMMUNITIES
- SHIPPING (INCLUDING COAST GUARD)
- LOCAL AND REGIONAL AIRLINES AND PRIVATE AIRCRAFT
- INDIAN AND NORTHERN AFFAIRS
- SECRETARY OF STATE (DIRECTORATE OF NATIVE CITIZENS)
- D.O.C.
- R.C.M.P.
- OIL AND OTHER EXPLORATION COMPANIES
- MINING COMPANIES
- FISHERIES AND OCEANS
- BROADCASTERS (C.B.C.; RADIO QUEBEC; KNOWLEDGE NETWORK)
- EXTERNAL AFFAIRS
- PARKS CANADA
- ATMOSPHERIC ENVIRONMENT SERVICE

BUT IS IT FEASIBLE? - SOME POINTS TO CONSIDER

ALTHOUGH THERE IS CONSIDERABLE EVIDENCE OF TECHNICAL
VALIDITY OF THE CONCEPT, A BROAD SCOPE FEASIBILITY STUDY
IS NECESSARY TO IDENTIFY LIKELY TECHNICAL, SOCIAL,
INDUSTRIAL AND POLITICAL IMPACTS AND THUS PROVIDE A
BASIS FOR FURTHER CONSIDERATION SHOULD FEASIBILITY BE
PROVEN.

SOME MATTERS TO BE CONSIDERED IN A FEASIBILITY STUDY

- TECHNICAL FEASIBILITY
 - PROPAGATION AND LINK BUDGETS
 - USE OF CURRENT GROUND EQUIPMENT
 - GROUND ANTENNA REQUIREMENTS
 - "BALL PARK" PAYLOAD REQUIREMENTS
 - SPACECRAFT BUS REQUIREMENTS
 - SPACECRAFT ANTENNAS
 - VHF ALTERNATIVE
 - I.T.U. SPECTRUM ALLOCATION PROBLEMS
 - "BALL PARK" LAUNCH REQUIREMENTS
 - VOICE AND DATA CAPACITIES
 - COVERAGE TRADE OFFS

- INDUSTRIAL IMPACTS
 - SPACE SEGMENT (PAY LOAD)
 - SPACE SEGMENT (BUS)
 - GROUND SEGMENT
 - OPERATIONAL MANAGEMENT
 - LAUNCH REQUIREMENTS

SOME MATTERS TO BE CONSIDERED IN A FEASIBILITY STUDY

- SOCIAL IMPACTS
 - NATIVE USERS
 - INDUSTRIAL USERS
 - TRANSPORTATION USERS
 - GOVERNMENT USERS
 - POSSIBLE BROADCAST USERS
- ECONOMIC IMPACTS
 - EFFECT ON NORTHERN ECONOMY
 - COMPARATIVE COST EFFECTIVENESS
- POLITICAL IMPACTS
 - EFFECT ON NATIONAL SPACE PROFILE
 - POSSIBILITY OF INTERNATIONAL JOINT VENTURE

WHERE DO WE GO FROM HERE?

- CRC DECISION AS TO WHETHER THE CONCEPT IS WORTH PURSUING FURTHER
- IF SO, CONSIDERATION OF A FEASIBILITY STUDY (BY LAPP-HANCOCK ASSOCIATES LIMITED) TO FURTHER INVESTIGATE IN-DEPTH, THE FEASIBILITY, IMPLICATIONS, AND COST OF THE CONCEPT
- CONSIDERATION OF FUNDING APPROACHES FOR:
 - FEASIBILITY STUDY
 - FURTHER INVESTIGATION BY CRC AND INDUSTRY SHOULD THIS BE JUSTIFIED BY THE RESULTS OF THE FEASIBILITY STUDY
- SOME POSSIBILITIES FOR FEASIBILITY STUDY FUNDING
 - CRC "END OF YEAR" BUDGET ALLOCATIONS
 - UNSOLICITED PROPOSAL
 - MULTI-CLIENT STUDY (PRIMARILY WITHIN THE FEDERAL GOVERNMENT) BY LAPP-HANCOCK ASSOCIATES LIMITED

SOME SOURCE DOCUMENTATION USED

- D.G. STEPHENSON; "HIGH LATITUDE SOUND BROADCASTING FROM SATELLITES"; PP347 TO 353, CANADIAN AERONAUTICS AND SPACE JOURNAL, VOLUME 30, NUMBER 4, DECEMBER 1984
- STEPHEN BIRKILL; FROM RUSSIA WITH LOVE"; SATELLITE DEALER PP 172 TO 179, NOVEMBER 1984.
- E.J. PHILLIPS, P. KNIGHT; "THE USE OF THE 26 MHz BAND FOR SATELLITE BROADCASTING"; PP 1 TO 9, BBC RESEARCH PUBLICATION, BBC R&D 1980/5.
- J. CHAPLIN, H.H. FROMM AND C. ROSETTI;
"BROADCASTING OF RADIO PROGRAMS BY SATELLITE DIRECT TO PORTABLE/VEHICLE RECEIVERS"; PP 77 TO 81 ESA BULLETIN NO. 37 FEBRUARY 1984.
- "TABLE OF FREQUENCY ALLOCATIONS 9KHz TO 275 GHz"; NATIONAL TELECOMMUNICATIONS BRANCH, DEPARTMENT OF COMMUNICATIONS

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