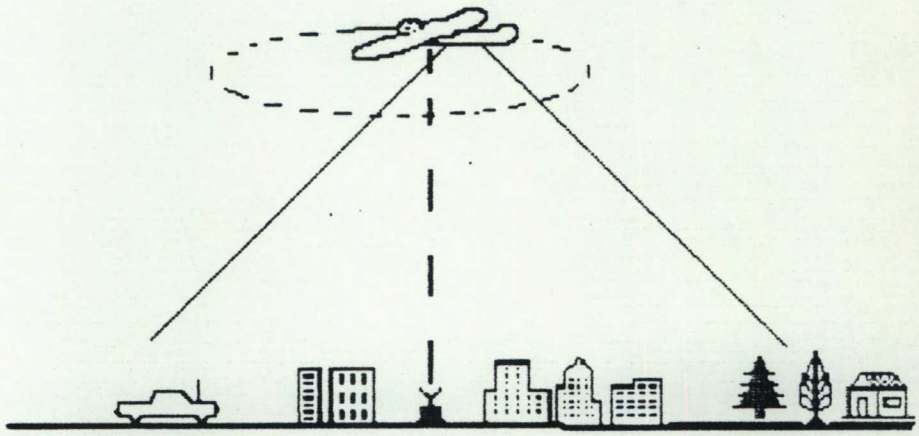
REPORT: SPECTRUM CONSIDERATIONS FOR SHARP

(A Research Discussion Paper)

Task 1: Examination of Proposed Scenarios for Integration with Existing/Planned Uses of Spectrum



SHARP

DSS Contract: 12ST.36001-4-1788

FOR: DEPARTMENT OF COMMUNICATIONS

FROM: ANDREW T. SCHINDLER & ASSOCIATES INC.

NOVEMBER 22, 1984

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November 22, 1984.

Department of Supply & Services,
Department of Communications

Attention: Mr. G. Chan, Scientific Authority, DOC
Ms. E. Audet, Procurement Manager, DSS

Subject: Contract No. RN: 36001-4-2788

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Entitle : Spectrum Impact on SHARP (Task 1)

We are pleased to submit ten copies of Task 1 Report, a research discussion paper on Spectrum considerations for SHARP. The ATS contributors to Task 1 have been Hans von Baeyer, Gerry F Perrin and myself.

The Task II Report will be submitted by December 15, 1984. Please find enclosed invoice.

Yours truly,

ANDREW T. SCHINDLER & ASSOCIATES INC.

A. T. Schindler,
President.

ATS/ds
Encls.


National Capital
Provincial or Territorial Capital
[redacted]
Bathymetric contours (in metres)
Lambert Conformal Conical Projection, Standard Parallels 49° and 77°
Modified Polyconic Projection North of Latitude 80°
1973
QUEEN ELIZABETH ISLANDS
ELLESMERE ISLAND
GREENLAND (DENMARK)
ICELAND
Arctic Circle
International Date Line
ALASKA (UNITED STATES OF AMERICA)
Melville Island
Banks Island
Devon Island
DISTRICT OF FRANKLIN
VICTORIA ISLAND
BAFFIN ISLAND
YUKON TERRITORY
NORTHWEST TERRITORIES
DISTRICT OF MACKENZIE
DISTRICT OF KEEWATIN
BRITISH COLUMBIA
ALBERTA
MANITOBA
ONTARIO
QUEBEC
NEWFOUNDLAND
ISLAND OF NEWFOUNDLAND
Queen Charlotte Islands
Vancouver Island
Southampton Island
Cape Churchill
Cape Tatnam
Belcher Islands
Anticosti Island
U.H.F
Radius 500 km
S.H.F.
300 km
EHF
100
UNITED STATES OF AMERICA

SPECTRUM CONSIDERATIONS FOR SHARP

(A Discussion Paper)

1. EXAMINE PROPOSED SCENARIOS FOR THE POSSIBLE INTEGRATION OF SHARP COMMUNICATION SERVICES WITH EXISTING/PLANNED USES OF THE RADIO SPECTRUM

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SUMMARY OF TASK I FINDINGS

The spectrum requirements of proposed SHARP applications are discussed in relation to the existing allocation of frequency bands. As a result the following conclusions were drawn:

VHF FM Broadcasting

Take from list of SHARP Applications and satisfy needs in rural areas by transferring the service to SHF FM direct-to-home service.

UFH AM Broadcasting

Take from the list of SHARP applications and satisfy rural needs by transferring to SHF FM direct-to-home service.

Radio Paging

Consider services for paging according to the newly proposed allocation table for the 890 - 960 MHz range, in particular the band 929 - 932 MHz.

Narrow-Band Two-Way Fixed and Mobile Connections

Any frequency allocation for SHARP in the 806 - 960 MHz band is difficult to obtain, (Canada/U.S. cellular systems development) though the newly proposed plan for the 890 - 960 MHz portion leaves some possibilities.

It is suggested that mobile service should also be considered in the EHF region though under conditions of reduced coverage. Systems parameters would have to be subject to a separate study.

SHF FM TV Broadcasting

Under the particular conditions of siting SHARP systems in Canada SHF broadcasting is likely to be possible in the 11.7 to 12.7 GHz band which is partly allocated to satellite-broadcasting services.

Two-Way Video, Up and Down-Links, and Long-Haul Trunks Along Strings of SHARP Platforms

These services fall under the category of fixed links for which frequency allocations are available throughout the upper SHF and the lower EHF parts of the spectrum,

Effect of the SHARP Microwave Power Beam

Spectrum implications of the SHARP microwave power-beam and the rectenna are subject to Task reports II and III.

1.1 Preliminary SHARP Characteristics, Proposed Communication Systems and Frequency Bands

1.1.1 General Concept

The SHARP (Stationary High Altitude Relay Platform) concept is based on the use of a lightweight, pilotless airplane, flying in a circular pattern of about 2 km. radius at a height of 21,000 m. (70,000 ft.), and carrying a platform for telecommunications equipment, which serves as a relay station for a variety of telecommunication services.

The aircraft remains on station for long periods of time with power for propulsion and payload supplied from the ground by a narrow microwave beam, received at the platform and converted into DC power. Control and supervision of aircraft and payload functions is accomplished through microwave up and down links.

1.1.2 Radio Coverage

From the SHARP platform the radio horizon is at a distance of

$$d \approx 3.5\sqrt{Kh}$$

d in km, h in metre
K = ratio of the effective earth radius to true earth radius (due to atmospheric refraction)

with K = 1 and h = 21 km. (70,000 ft.)

d = 500 km. (approx.) and

with K = 1.33 (average refraction conditions)

d = 600 km. (approx.)

As an operational range for VHF and UHF frequencies one can therefore assume an area with radius 500 km. At higher frequencies (SHF/EHF) the fading range at zero elevation angle can be excessive due to local obstruction so that a minimum elevation angle of 3^{o} to 4^{o} should be assumed. This leads to a maximum operational range for SHF/EHF services of about 300 km. radius (a diagram of elevation angle versus coverage area is attached in Appendix 1 and Reference (I).

As far as coordination distances for interference calculations and minimum distances for frequency re-use are concerned atmospheric refraction has to be considered, leading to minimum distance values of at least 600 km. In a string of SHARP sites frequency re-use would require at least 1200 km. separation between the two respective sites, unless topographic conditions provide some shielding.

As far as the range of signal strength over the coverage area is concerned, SHARP characteristics reflect terrestrial conditions rather than those of geostationary satellites. Whereas for satellites the freespace path loss is almost constant over the coverage area, SHARP signals vary, according to distance from the centre of coverage, by 23 db out to the 300 km. limit, or by 28 db minimum out to the edge of coverage (500 km.). This can be modified by appropriate shaping of the vertical pattern of the platform antenna.

Similarily, the elevation angle under which a ground station can "see" the SHARP platform varies from 90° (directly underneath the platform) to 0° at the edge of coverage, whereas elevation angles

for satellite services vary little over large coverage areas.

A further consideration in defining the operational range of SHARP applications has to do with the circular movement of the SHARP aircraft. Directly underneath the platform this movement extends over an angle of about $\pm 6^{\circ}$, diminishing as the distance from the centre increases. Therefore, for services using highly directive ground station antennas, e.g. in the SHF/EHF ranges, the directivity of non-tracking ground station antennas located near the central portion of the coverage area, has to be sufficiently low to allow for the effect of the platform movement. This means reduced gain in the centre area, which, however, is compensated by the increased signal strength due to minimum path losses. However, the reduced directivity may need consideration in up-link interference calculations.

In some proposed scenarios the central portion of the SHARP coverage area is left out altogether (SHARP antenna pattern) so that the remaining coverage area is that of an annular ring zone

between, say, 100 km. and 300 km. radius from the centre point. The missing centre zone can be covered by adjacent SHARP sites which would be spaced about 200 km. apart from each other (see Fig. 1). In this case the above mentioned range of free-space signal strength in the annular zone would vary by only about 10 db.

1.1.3 Possibilities for Re-use

With the relatively large radio coverage of SHARP platforms goes the condition that distances at which co-channel interference can be avoided as a result of spatial separation are large compared to conventional terrestrial systems. With the radio horizon at 600 km. from the SHARP location, frequency re-use within a 600 km. range would be possible only under special topographic shielding conditions.

For strings of SHARP sites with overlapping coverage areas re-use of all frequency allocations would require a minimum distance between two SHARP sites of at least 1200 km.

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However, within SHARP systems frequency re-use is possible for individual services (one-way or two-way) within the general coverage area, by dividing the horizontal platform antenna pattern into radial sectors, and assigning the same frequency or set of frequencies to alternate sectors. For example, the horizontal patterns may be divided in eight 45^{o} sectors with alternating frequencies, resulting in a fourfold frequency re-use, or eighteen 20^{o} sectors resulting in a ninefold frequency re-use. Instead, repetition of a set of frequencies may be arranged for every third sector in order to increase the spatial separation of sectors carrying the same frequency.

There are, of course, design problems regarding sidelobe and backlobe coupling of sectors which have to be considered relative to the dynamic range (pathloss, fading etc.) of the signals to be expected. Also platform stabilization is required to account for the circular movement of the SHARP aircraft, banking etc. However, sectoral

frequency re-use appears to be one of the tools of multiplying available frequency spectrum occupation in SHARP systems.

1.1.4 Proposed Communication Systems and Frequency Bands

The following communication services have been proposed or discussed for possible application in local, regional or national SHARP systems (the list is not supposed to be comprehensive, it is based on available documentation).

- FM sound broadcasting
- UHF AM TV broadcasting
- Radio paging
- Two-way voice and data services with fixed and mobile terminals
- FM TV broadcasting services (similar to DBS)
- Two-way video services
- Up and down link connections to and from base-stations
- Longhaul trunking along strings of SHARP sites

These services will be discussed, including their frequency spectrum occupancy, in the following sections.

1.1.4.1

FM Sound Broadcasting

This service to the general public would have to make use of the standard broadcasting frequency band 88 - 108 MHz, which is divided into 100 slots of 200 KHz bandwidth. The present system with FM transmitters near population centres leaves gaps in rural areas which could be filled with SHARP based services.

Technically, broadcasting regulations would require EIRP values at the SHARP platform of about 35 dbW for urban service and 9 dbW for rural service at a range of 300 km. from a platform (Ref. 2). With a 10 dbi antenna on the platform this would require RF power of 300W per channel for urban service, while .8W would suffice for strictly rural customers.

The large frequency re-use distance of over 1200 km. between SHARP centres would allow not more than 3 frequency repetitions across Southern Canada (Ref. 3), and would require a large number of channels per platform to satisfy regional and local needs, or in conjuction

with the existing system, would restrict SHARP to a few channels filling out existing gaps. This, however, would run into difficulties of finding channel allocations, again because of the large re-use distances, as discussed in further detail in section 1.2.

1.1.4.2

UHF/AM TV Broadcasting

Conventional TV broadcasting in the UHF band using SHARP platforms would have the advantage of being able to reach rural areas outside population centres. However, similar to the FM sound broadcasting case (preceding section) the large frequency re-use distance would require a large number of channels per platform, which because of power and weight requirements on the platform would exceed initial payload limitations.

The frequency allocations for this case would have to be in the standard terrestrial TV broadcasting band, 470 to 806 MHz.

The required RF power per channel in the upper UHF band would be in the order of at least six KW for a 2 dbi transmitting antenna, or one KW for a 10 dbi antenna (Ref. 4) in order to meet broadcasting regulations at 300 km. distance from the SHARP centre.

For service at the edge of coverage (500 km.) the power requirements would be above 2.5 KW per channel. This together with the problems of compatibility with existing systems (discussed below in section 1.2 makes UHF/AM TV broadcasting not an attractive choice for SHARP application.

1.1.4.3

Radio Paging

The large coverage area makes SHARP attractive for radio paging services, which could be extended at low cost to rural areas. However, exclusive spectrum assignments would be needed in view of the large frequency re-use distances. The frequency band generally used for this purpose is in the 138 - 174 MHz range which in Canada is allocated with certain exclusions to Fixed and Mobile services.

A preliminary analysis (Ref. 5) indicates that on the platform RF powers in the 10 to 100 Watt range would be required for each 200 bps channel for service to the edge of coverage (500 km.).

1.1.4.4

Two-Way Voice and Data Services with Fixed and Mobile Terminals

Narrowband two-way services for fixed and mobile terminals have been proposed for SHARP using the 806 to 890 MHz mobile, "fixed and mobile satellite" frequency band. Because of the line of sight characteristics of SHARP systems the RF power balance is favourable. For example, for an omni-directional antenna on the platform , a 10 dbi antenna at the ground terminal, and a 300 km. range, transmit power of only 60 mW per 5 KHz channel is required, including margins for propagation and noise degradation (Ref. 5).

Frequency re-use by sectoral division of the

horizontal pattern of the SHARP antenna (see above section 1.1.3) would lead to multiplication of the number of available channels, as well as increased antenna gains.

Further, the choice of modulation (narrow band FM, SSB, or digital) affects the spectrum utilization. As an example (Ref. 3) with 200 5 KHz SSB channels per sector and 18 sectors the total number of available channels per platform would be 3600 in a bandwidth of 2 MHz per direction.

With regard to the choice of modulation SSB would provide the best spectrum utilization and a gradual degradation of quality with decreasing signal strength. However, at sufficiently high signal levels above a threshold level a requirement for toll quality (interconnection with the DDD network) appears to favour wider band methods such as narrow band FM. The latter is used in cellular radio systems for mobile telephony.

The minimum distance for frequency re-use of at least 500 km. is, of course, valid as in all other SHARP

applications. A string of SHARP sites with overlapping coverage zones (Fig. 1) would require at least 5 different sets of frequencies, before the same sets could be re-used. The total spectrum requirement would then be 5 times 2 MHz = 10 MHz per direction, or 20 MHz for the two-way system covering an area of about 600 x 1000 km.

1.1.4.5

FM TV Broadcasting Service

This service provided through SHARP platforms would be based on the existing Direct Broadcasting Satellite (DBS) technology, and would use the same modulation and channel arrangements. A passband of 500 MHz would be provided on each platform, each accommodating about 25 TV channels. The frequency range considered for this purpose is the same as that for DBS service, i.e. in the 11.7 to 12.7 GHz range for the down-links.

The required EIRP would be only 15.7 dbW (Ref. 6) for a range of 300 km., which would require not more than 4W transmit power per channel, assuming

1 metre receiving antennas as in the case of the proposed DBS system. (For SHARP systems at 12 GHz the effect of the circular movement of the aircraft would require smaller antenna sizes for locations directly underneath the platform (see Section 1.1.2), which would be compensated by higher signal strength)

The up-link has been considered to be at higher frequency bands such as the 30 - 40 GHz band.

1.1.4.6

2-Way Video Services

2-Way video service has been suggested for SHARP application as a means of giving rural dwellers access to low cost video phone and video retrieval services.

The up and down-links between the SHARP platform and the individual customers represent individual fixed links, handled on the platform by a common antenna. In order to increase the number of links

extensive use of sectoral splitting of the horizontal coverage pattern has been suggested, so that multiple frequency re-use becomes possible (see Section 1.1.3).

The spectrum considered so far is in the 18 to 22 GHz band, with a spectrum requirement for 100 FM video channels (one-way) of 25 MHz each, i.e. 2.5 GHz per direction (Ref. 3). From the point of view of radio performance a preliminary analysis (Ref. 7), including a margin of 20db for propagation reliability (99.95%) and assuming 4^{o} beam width of the customer's antenna (about 35 cm. diameter), indicates that r.f. power in the order of 4 W per channel is required in both directions for distances up to 300 km. As mentioned earlier, customers located underneath the platform would have to use smaller antennas to allow for the SHARP aircraft movement, but without penalty in signal strength because of increased field strength. With segmentation of the platform antenna a central zone underneath the platform may have to be left out altogether, to be covered by adjacent SHARP sites. (See Section 1.1.2 above).

1.1.4.7

Up and Down-Link Connections

Up and down-link connections to and from the SHARP platform are required as command and control links for all aircraft and payload functions, and for carrying the voice, data, and video signals for the various services. The frequencies so far considered are at EHF in order to accommodate total passbands of several GHz.

Because of the short distance to and from the platform and the large elevation angle no difficulties other than atmospheric absorption and scattering are anticipated. Frequency re-use in separate near vertical beams has been considered. (Ref. 3)

1.1.4.8

Long Haul Trunks

On long strings of SHARP platforms the lateral

transport of services can make use of platform to platform long haul links which can be kept in their entirety at sufficient height above ground that excessive signal losses due to rain etc. can be avoided. This opens up an application of frequencies as high as 90 to 100 GHz (Ref. 3) although extreme requirements will be placed on platform stabilization (stabilities better than 0.1 degree, Ref. 7).

1.2 Compatibility of SHARP Frequency Bands with Existing Radio Spectrum Allocations

1.2.1 VHF FM Broadcasting Band

The provision of this service through SHARP platforms is discussed in Section 1.1.4.1.

The present allocation of frequencies covers 100 slots of 200 KHz bandwidth in the band 88 to 108 MHz. Station assignments in Canada have been worked out in agreements with the United States (for stations in the border areas), and over 2000 stations with ERP values up to 350 KW are listed in the Canadian FM Broadcasting Allotment Plan (August '84). It is unlikely that any exclusive channel can be found for use on a system covering areas as large as those of SHARP (500 km. radius). Sharing of frequency allocations between terrestrial and SHARP services on the same channels is not possible. Because of the likely penetration of SHARP coverage into U.S. territory Canada/U.S. agreements must be observed (with SHARP locations 200 km. north of the border there is still a penetration into U.S. territory of 300 to 400 km).

If considered for SHARP application, a total re-allocation of channels (some terrestrial, some SHARP) would have to be worked out, which, because of the large SHARP coverage area, would almost certainly end up with considerably fewer station assignments than at present, but with improved service in large rural areas.

1.2.2 UHF AM TV Broadcasting

The provision of this service through SHARP platforms is discussed in Section 1.1.4.2.

The present spectrum allocation covers 56 6 MHz channels from 470 to 806 MHz. Station assignments in Canada have been worked out in agreements with the United States (for stations in the border areas) and close to 900 stations are listed in the Canadian Television Channel Allotment Plan (March '84 Sharing of channels between SHARP and conventional services in the same coverage area is not possible. SHARP application would therefore require exclusive channel assignments. Because of the large SHARP coverage area and likely penetration into U.S. territory, it is unlikely that any appreciable

numbers of channels could be found for SHARP use. Similar to the FM sound broadcasting case a total re-allocation plan would have to be worked out in which the number of conventional broadcast stations would be considerably reduced, but certain gaps in rural coverage closed.

1.2.3 Radio Paging

This service was briefly discussed as a possible SHARP application in Section 1.1.4.3.

The present frequency band used for paging services is in the 138 - 144 MHz band for fixed, land mobile, and space research applications. Available channels are widely used, shared use by SHARP and conventional services on the same channel is impossible, and penetration of SHARP coverage into U.S. territory would make exclusive allocations difficult to obtain.

The shortage of VHF channels has lead in the U.S. to the opening of a new band between 929 and 931 MHz (120 channels of 16.6 KHz per channel) which, in Canada falls into the 928 - 942 MHz allocation

for "fixed", mobile and radio location services.

The whole 890 - 960 MHz allocation table in Canada is under review and proposed changes including allocations for mobile - satellite and amateur services have been published. The band 929 - 932 MHz is listed for "paging" in the newly proposed allocations (see Appendix).

1.2.4 Two-Way Voice and Data Services with Fixed and Mobile Terminals. Services of this kind were discussed as SHARP applications in Section 1.1.4.4.

The 806 to 890 MHz band, proposed for SHARP, is allocated in Canada for "mobile, fixed, and mobile satellite" services. In a newly proposed allocation table two 20 MHz areas (825 to 845 and 870 to 890 MHz) are reserved for cellular mobile services and three slots (821 - 825, 845 - 851 and 866 - 870) are reserved (possible use by MSat). The bands 806 - 821 and 851 - 866 MHz are allocated to C/T services.

MSat is planned to cover the continent with 2 U.S.

and 4 Canadian overlapping beams to provide public mobile radio, mobile telephone and data services to mobile and transportable terminals.

A preliminary study (Ref. 8) indicates that from the point of view of radio performance SHARP platforms in an appropriate configuration could provide services equivalent to MSat service, although the individual SHARP coverage area (300 km. radius) would be much smaller than those of MSat beams. Up-link power would be considerably smaller, but network management and interconnect arrangements more complex.

Unless taking the place of MSat the present 806 - 890 MHz allocations do not allow for additional mobile services. However, the newly proposed allocations for the 890 - 960 MHz band leave some room for fixed and mobile services (see also Section 1.2.3).

1.2.5 FM TV Broadcasting Services

In discussing this service for SHARP applications

(Section 1.1.4.5) reference was made to "Direct to Home Satellite Broadcasting" and the possibility of using allocated satellite - broadcasting bands for SHARP. In terms of ITU definitions SHARP systems are terrestrial and not satellite systems (see footnote).

The 11.7 - 12.7 GHz band, mentioned in Section 1.1.4.5 is at present allocated to:

11.7 - 12.2 GHz	fixed-satellite (space to earth) broadcasting-satellite subject to international agreement
12.2 - 12.7 GHz	fixed, broadcasting, broadcasting-satellite.

The Canadian DBS system will probably use the 11.7 - 12.2 GHz portion of the band for the down-links and 17.3 - 17.8 GHz for the up-links. Canada is

Footnote: ITU Definitions:
Broadcasting-Satellite Service: A radiocommunications service in which signals transmitted or retransmitted by space stations are intended for direct reception by the general public.
Space Station: A station located on an object which is beyond, is intended to go beyond, or has been beyond, the major portion of the earth's atmosphere.

divided into 6 regions, served by 6 satellites, each equipped for the full 500 MHz pass bands, and including left and right hand circular polarization.

It has been suggested that SHARP services could make use of DBS up and down-link frequencies since SHARP platforms would be deployed at some distance north of the populated areas near the borders with northward pointing up-links, and with down-links which for the majority of users would also come from a northerly direction. This apparent compatibility or frequency sharing would have to be further investigated.

Apart from the use for SHARP of DBS bands, the 12.2 - 12.7 GHz band appears to offer possibilities for SHARP broadcasting down-links although the full 500 MHz spectrum may not be available. Up-links could be in the band 14.5 to 15.2 GHz allocated for fixed services.

1.2.6 Two-Way Video Services (Discussed in Section 1.1.4.6)

1.2.7 Up and Down-Links (Base Station to SHARP, and SHARP to Base Station), As Described in Section 1.1.4.7

1.2.8 Long-Haul Trunks Along Strings of SHARP Platforms As Described in Section 1.1.4.8

All these services are "fixed" services, and make use of the spectrum in the upper SHF or the lower EHF range. There appear to be no basic incompatibility problems with present allocations.

1.3 Alternative SHARP Frequency Bands Which Harmonize and Enhance Existing Communication Systems

The main attraction of the use of SHARP platforms as relay points for telecommunication purposes is the availability of line-of-sight conditions over areas which are large compared to conventional terrestrial systems, but smaller, and involving considerably shorter path lengths, than geostationary satellite services. In general these conditions allow SHARP systems to use higher frequency bands than conventional systems. However, the elevation angles for links to points in the outer reaches of SHARP coverage are small and increased fading ranges as well as multipath problems (specular reflection) are to be expected. High directivity of the ground based antennas is therefore required, which can be used on links to fixed locations, but not to mobile terminals. With the exception of mobile services it appears that the advantages of the SHARP concept can best be utilized by operating in the SHF/EHF bands of the radio spectrum. In line with these considerations the following suggestions were developed to overcome the problems outlined in Section 1.2.

1.3.1 VHF FM Sound Broadcasting

There may be advantages from the programming point of view, of using SHARP for a very small number of conventional VHF FM channels for regional coverage. The difficulties of finding exclusive channels of regional coverage in the present situation would favour the transfer of this function to the SHF band in form of FM SHF services along with the proposed FM SHF TV services (similar to DBS) discussed in Section 1.2. With that transfer the gaps in rural coverage of FM sound broadcasting could be closed.

1.3.2 UHF AM TV Broadcasting

Similar to VHF sound broadcasting there is a need for better coverage in rural areas. However, it is unlikely that with local services provided as at present channels for exclusive SHARP coverage can be found. In addition, UHF AM TV transmission presents some excessive power and weight problems for the SHARP platform at least as conceived for its early implementation. The transfer of this

function to the SHF FM TV type of service (similar to DBS) would be a more attractive solution.

1.3.3 Radio Paging

As outlined in Section 1.2.3 paging through SHARP platforms is likely to fit into the newly proposed allocation table for the band 890 - 960 MHz. The specific slot allocated to paging is 929 - 932 MHz.

1.3.4 Narrow Band Two-Way Fixed and Mobile

The originally considered band 806 to 890 MHz band is filling up rapidly for terrestrial cellular systems, provisions for MSat and other services, all coordinated with U.S. allocations. The question remains, whether SHARP mobile services might be considered to replace MSat, or another slot in the newly proposed allocation plan for the 890 to 960 MHz band would be preferable as an alternative (see Annex). It appears that the total band 806 - 960 has possibilities so that a shift to other bands may not be imperative.

However, coordination with the United States would certainly present major problems. As far as other allocations for terrestrial mobile services are concerned there are no provisions in the 1.5 GHz band. The only other allocation below 20 GHz is in the band 2300 - 2450 MHz, where with the exception of the first 10 MHz, aeronautical mobile services have a priority.

However, it should be mentioned here that the general suitability of the SHARP concept for the use of frequencies in the SHF/EHF range may also be applied to mobile services, though for reduced coverage areas. As long as elevation angles are sufficiently large (say above 10^{o} corresponding to a coverage area of 100 km. radius) near-horizon problems of fading range, multipath effects, rain absorption etc. could be kept within tolerable limits, so that frequencies in the upper SHF and the EHF ranges could be used for mobile service. A list of available frequency ranges above 20 GHz, allocated for mobile services, is attached in the Annex. Such use would, of course, not correspond to the present concept of SHARP wide area service,

but it may represent a cost-effective solution in extension of strictly terrestrial mobile systems. A study of the systems aspects of such a SHARP application appears to be warranted.

1.3.5 SHF FM TV Broadcasting

Although SHARP services would by ITU definition fall under the category of terrestrial services, rather than satellite-broadcasting, the use of satellite-broadcasting frequencies in the 11.7 to 12.7 GHz band under the specific condition of SHARP deployment north of the populated zone of Canada, warrants investigation.

1.3.6 Two-Way Video Services, Up and Down-Links and Long Haul Trunks Along Strings of SHARP Platforms

Two-Way video services, up and down-links and long haul trunks along strings of SHARP platforms fall under the category of fixed links for which allocations in the upper SHF and the EHF are available. A list of "Fixed Service" Allocations between 15 and 75 GHz is attached in the Annex.

1.3.7 Spectrum Aspects of SHARP Microwave Power Beams

The spectrum implications of the microwave high-power beam supplying electrical power to the SHARP aircraft have so far not been mentioned. Frequencies of 2.45 and 5.8 GHz have been proposed for this beam. Its possible effect on SHARP communication functions, and on external communication services is the subject of subsequent Task reports.

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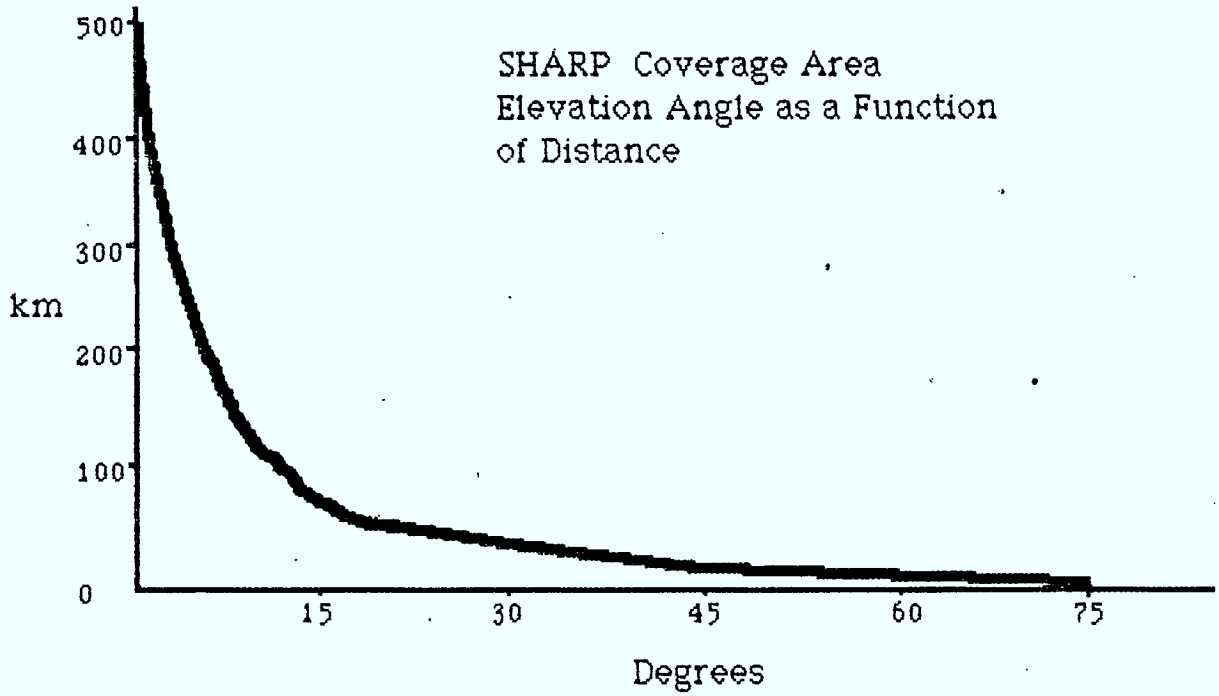
SOW-Requirements, Cost Comparisons
Analysis, Socio-Economic Impact Analysis

Discussions held during preparation of this report in the period 20 October to 19 November, 1984.

Chan, Palmer & Hunt		re Project Start-up Meeting
A. Lillemark		re System
J. D. Palmer	CRC	re systems concepts
G. Chan		re cellular systems, MSAT
M. Hunt		re spectrum policy UHF
W. Longman		re spectrum policy SHF
D. Netterville		re spectrum satellite communications and RARC 83
V. Rawat		re spectrum policy 806 - 960 MHz
W. D. Hindson	CRC	re SHARP systems calculations
R. J. Bibby (by telephone)	CRC	re SHARP spectrum compatibility


SHARP Coverage Area
Elevation Angle as a Function
of Distance
500
400
300
km
200
100
0
15
30
45
60
75
Degrees

ANNEX 1

Table of Frequency Allocations

Upper SHF and Lower EHF Bands

Fixed Service

GHz

17.7 - 18.1
18.1 - 18.6
18.6 - 18.8
18.8 - 19.7
21.2 - 21.4
21.4 - 22
22 - 22.21
22.21- 22.5
22.5 - 22.55
22.55- 23
23 - 23.55
23.55- 23.6
25.25- 27
27 - 27.5
27.5 - 29.5
31 - 31.3
36 - 37
37 - 37.5
37.6 - 39.5
39.5 - 40.5
40.5 - 42.5
42.5 - 43.5
47.2 - 50.2
50.2 - 50.4
50.4 - 51.4
54.25- 58.2
59 - 64
65 - 66
71 - 74
74 - 75.5

Table of Frequency Allocations

Mobile Service — Upper SHF and Lower EHF Bands

GHz

21.2	21.4
21.4	22
22	22.21
22.21	22.5
22.5	22.55
22.55	23
23	23.55
23.55	23.6
25.25	27
27	27.5
27.5	29.5
31	31.5
36	37
37	37.5
37.5	39.5
39.5	40.5
40.5	42.5
42.5	43.5
43.5	47
47.2	50.2
50.2	50.4
50.4	51.4
54.25	58.2
59	64
65	66
66	71
71	74
74	75.5

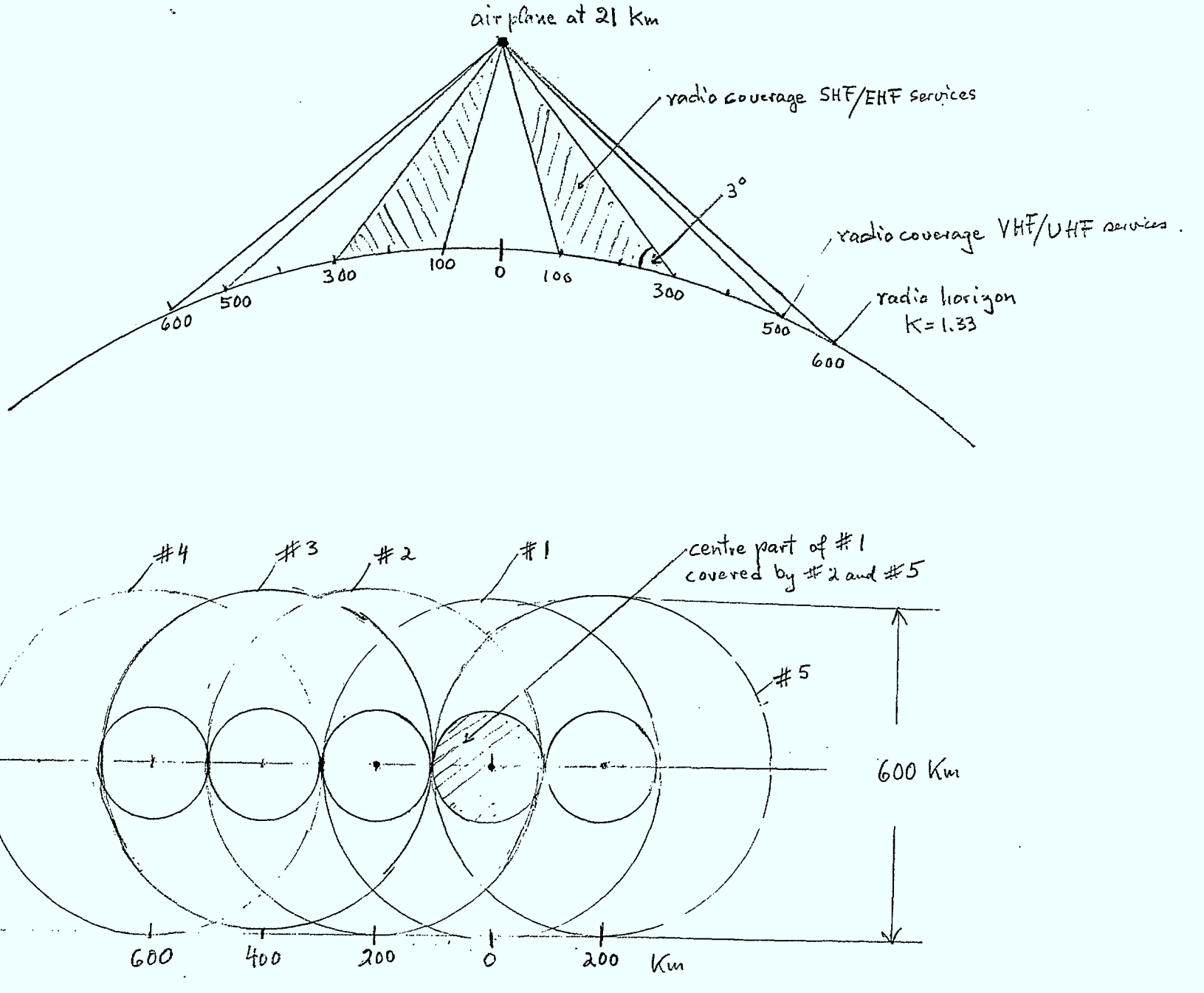

airplane at 21 Km
radio coverage SHF/EHF services
3°
radio coverage VHF/UHF services
radio horizon
K = 1.33
600
500
300
100
0
100
300
500
600
#4
#3
#2
#1
#5
centre part of #1
covered by #2 and #5
600 Km
600
400
200
0
200
Km

Fig. 1

add

A4, A5, F1, F2, F3, F4, F5). Before operating in this band amateur licensees are required to consult with their local DOC district office to ensure interference will not be caused to other services operating in the band as per Section 45 of the General Radio Regulations Part II given in TRC 25.

Reason: To confirm the continued secondary status of the Amateur Service but to expand the utilization from the A3E, F3E (A3, F3) emissions currently permitted. If this proposal is accepted, use of the additional emissions could not begin until necessary amendments to the schedules of the General Radio Regulations, Part II are made.

3.1.6 ~~3.2.1~~ ~~Impact~~ of Mobile Services

delete

~~With the allocation to the mobile Service in the band, consideration must be given to the possible introduction in the longer term future of conventional mobile services domestically in the 900 Mhz band, and in the shorter term to the introduction of certain internationally compatible mobile services such as air/ground public correspondence, *personal radio service, etc.~~

add

Following the addition of mobile services to the International Table of Frequency Allocations at the 1979 WARC, consideration was given to the need for the introduction of mobile services domestically. Consultations on certain internationally compatible mobile systems proposed to operate in this band were also undertaken.

It was proposed in March, 1983 that the bands 896-902 MHz and 937-943 MHz be used for air/ground public correspondence and personal radio service on a primary basis. Fixed service users operating in these bands were notified by the publication of Canada Gazette Notices

add

DGTN 001-83/DGTR 001-83 and DGTN 003-83/DGTR 002-83 that if these services were implemented, protection would cease no earlier than April 1, 1985. If approved for introduction, the release of the final radio system policies for these two services will specify the dates on which protection to existing fixed radio systems will end.

Reason: An experimental air/ground public correspondence service has been implemented in the U.S. and at present, plans are underway for the implementation of a complementary experimental service in Canada. Both the U.S. and Canada are also evaluating the possible introduction of a new personal radio service.

delete

~~Effective with the release of the 1-10 GHz policy, new systems or extensions of existing systems in the 890-902 MHz/928-942 MHz band will be licensed only on a non-standard basis. In addition, systems which are non-standard as a result of frequency diversity will remain non-standard even if they modify their operation to operate on a non-diversity basis in these bands.~~

~~Future mobile policy proceedings may determine that certain segments of the 890-902/928-942 MHz band will not be used by mobile services, in which case existing and new fixed systems may be accommodated. In the long term however, it is possible that restrictions on the fixed service may have to be extended to other portions of the 890-960 MHz band.~~

add

In the band 929-932 MHz, use by single frequency mobile service operations including radio paging operations is standard. Fixed service use of this band is non-standard and such systems are subject to modification or replacement if they block the entry of standard systems [no earlier than two years after the effective date of a proposed radio system policy on the use of this band].

Reason: The band 929-932 MHz is currently being used in the United States for radio paging systems including nationwide systems. Interest has been shown in Canada for a similar type of nationwide paging service, for a Canada/US common paging service, and also for other single frequency operations. Therefore Canada has entered into discussions with the U.S. agencies for an equitable sharing arrangement in the border areas. The results of these negotiations and specific proposals for the implementation of Canadian mobile usage of this band including paging operations will be presented in a subsequent Standard Radio Systems Plan (SRSP). To the extent that these paging systems may be developed on a Canada/U.S. compatible basis, only a two year rather than a five year protection period after release of this policy is proposed.

add

Effective with the release of this policy, the Canadian Table of Frequency Allocations is modified as shown in Table 1 such that the band 890-896 MHz is allocated to the mobile and mobile satellite services on a primary basis and to the fixed service on a secondary basis. However, no assigments will be made to these or any other services until a further policy proceeding is completed. Meanwhile this band will be held in reserve.

Reason: This band has been proposed for expansion of Cellular, or Conventional and Trunked terrestrial mobile service or for a follow-on to the MSAT Mobile Satellite system paired with the band 845-851 MHz. Until these possible new demands are more fully specified, no new assignments will be made in the band.

add

Similarly the bands 932-937 MHz and 943-947 MHz are allocated to the mobile service on a primary basis and the fixed service on a secondary basis; however, no new assignments will be made to either service until a further policy proceeding is completed. Meanwhile these bands will be held in reserve pending the identification of future needs. One such potential need is the provision of spectrum for cordless telephone usage.

TABLE 1

Frequency band	ITU Allocation*	Canadian Allocation	Canadian usage
890-896 MHz	FIXED MOBILE except aeronautical mobile Radiolocation	~~FIXED~~ Fixed MOBILE except aeronautical mobile Radiolocation C25 MOBILE SATELLITE	Reserve ~~Fixed Links~~
896-898 MHz	"	~~FIXED~~ Fixed MOBILE except aeronautical mobile Radiolocation C25	Air Ground Public Correspondence ~~Fixed Links~~
898-902 MHz	"	"	Personal Radio Service ~~Fixed Links~~
902-915 MHz	FIXED Amateur Mobile except aeronautical mobile Radiolocation	FIXED Amateur Radiolocation C25 C26	Fixed Links Amateur Government of Canada (Shipborne radars)
915-916 MHz	"	"	~~Fixed Links~~ Multipoint Communications Systems Amateur Government of Canada (Shipborne radars)
916-928 MHz	"	"	Fixed Links Amateur Government of Canada (Shipborne radars)
928-929 MHz	FIXED MOBILE except aeronautical mobile Radiolocation	FIXED MOBILE except aeronautical mobile Radiolocation C25	Multipoint Communications Systems ~~Fixed Links~~

add

C25 - The use of the radiolocation allocation is limited to operations of the Government of Canada shipborne installations. In peacetime, no radiolocation operations are permitted within 150 km of Canada's coastline in the bands, 890-902 MHz and 928-942 MHz.

C26 - Government of Canada shipborne radiolocation service is permitted within 150 km of the East and West coasts, Arctic Ocean and Hudson and James Bays and up the St. Lawrence River as far as Rimouski on pre-cordinated channels.

TABLE 1

Frequency band	ITU Allocation*	Canadian Allocation	Canadian usage
929-932 MHz	"	~~FIXED~~ Fixed MOBILE except aeronautical Mobile Radiolocation C25	Paging/Single Frequency Operations ~~Fixed Links~~
932-937 MHz	"	"	Mobile Reserve ~~Fixed Links~~
937-941 MHz	"	"	Personal Radio Service ~~Fixed Links~~
941-942 MHz	"	"	Air/Ground Public Correspondence ~~Fixed Links~~
942-943 MHz	FIXED, Mobile	~~FIXED, Mobile~~ MOBILE, Fixed	Air/Ground Public Correspondence ~~Fixed Links~~
943-947	"	"	Mobile Reserve ~~Fixed Links~~
947-956 MHz	"	FIXED, Mobile	Fixed Links
956-960 MHz	"	FIXED, Mobile	Studio Transmitter Links Fixed Links

*International footnotes are not included in the Table.