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SOFTWARE STATUS AND FURTHER REQUIREMENT
FOR
RARC-83
BROADCASTING-SATELLITE PLANNING STUDY
SPACE PROGRAMS

DEPARTMENT OF COMMUNICATIONS

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SOFTWARE STATUS AND FURTHER REQUIREMENT FOR RARC-83

BROADCASTING-SATELLITE PLANNING STUDY

1. INTRODUCTION

The Department of Communications (DOC) has for several years played an aggressive role in the development of a broadcasting-satellite service (BSS) for direct-to-the-home broadcast of television. As part of this program DOC is presently preparing for the 1983 Regional Administrative Radio Conference (RARC) which will plan the BSS in the 12 GHz band for ITU Region 2 (North and South America, the Caribbean, and Greenland). To aid in the development of computer software tools to facilitate Canadian and Region 2 Planning of the use of the 12 GHz band for a BSS the Space Program Directorate of DOC let a contract in May of 1979 to Sharon Professional Services to provide the services of a computer systems analyst and a senior computer programmer. This report is an evaluation, problem definition and specification of the software required for the synthesis and analysis of a BSS in Region 2.

The proposed software can be used to generate draft plans in preparation for RARC 83. Furthermore, to the best of our knowledge, Canada is the only administration in Region 2 which is currently developing a sophisticated computer planning tool to help plan the BSS; U.S. activity is expected in this area but they are at an earlier stage of development at the moment. Therefore, there is a good possibility that the Canadian software package could be adopted by the International Frequency Registration Board (IFRB) of the ITU and become the official RARC 83 computer planning tool.

With modifications and additions the software could also assist in the international planning of the fixed-satellite service which is scheduled for 1984 and 1986.

2. BACKGROUND INFORMATION

In 1977 the World Administrative Radio Conference (WARC) drew up a detailed frequency allotment plan for the downlink portion of a broadcasting-satellite service for Regions 1 and 3 (Europe, Africa, Asia and Australia).

In May 1983, a Regional Administrative Radio Conference (RARC) will convene to draw up a detailed plan for a broadcasting-satellite service, both downlink and feeder-link, for Region 2. The steps in developing a plan for a braodcasting-satellite service include the following:

(i) the identification and quantification of the set of parameters required to specify both the satellite transmitting and earth-station receiving portion of a broadcasting-satellite system in the 12 GHz band. Similar parameters must also be defined for the feeder-links which will operate in the 17 GHz band.

(ii) the identification of service areas with corresponding optimum elliptical beams (see Section 3.1 for the parameters which define such a beam). For a given service area the optimum elliptical beam is different for each permitted orbit location. (In practise, shaped beams will undoubtedly be used but an elliptical beam is assumed for planning purposes to simplify the process.)

(iii) the assignment of channels, orbit locations, and polarizations such that:

a) the desired grade-of-service is achieved within each service area when small, individual-reception antennas are employed and,

b) interference levels into every other service area and into other regions are within limits specified.

(iv) the examination of the impact of the planned broadcasting-satellite service and terrestrial services in the same frequency-band in all three ITU regions.

The above points are all of a technical nature. However, whether a given plan is acceptable or not often depends on political considerations as well. For example, countries may wish to share mutual spillover or, on the contrary, may wish to not be able to receive the signal of another administration. This problem is dealt with in Section 4.1.3 Planning Constraints.

Based on the planning experience gained at WARC 77 and in order to prepare for RARC 83, it is deemed desirable to develop a computer tool to aid with the planning for the following reasons:

(i) there is a complex interaction of the many parameters which are involved in arriving at a plan.

(ii) a large number of service areas (approximately 70 for Region 2) must be planned simultaneously.

(iii) the planning process must be fast so that several plans can be generated and evaluated. In particular, many interim plans for various scenarios must be examined before a final plan is submitted to RARC 83.

(iv) the planning process must be flexible so that widely different scenarios and special requests from administrations can be evaluated.

(v) since the orbit/spectrum resource is limited, a plan must be optimal to the extent that it makes the best use of this limited resource with respect to agreed upon criteria. Optimization problems usually lend themselves to computer solutions.

Because of the complex nature of the planning process and the large number of factors, not always of technical nature, that must be taken into account, the planner will always play the central role and as such must, at all times, maintain control. It is not envisaged that the planning process will become fully automated but that the planner will use the computer programs as a tool knowing what their limitations are. For example, the planner may want to fine tune a preliminary computer output or force the programs into certain planning modes. The computer planning tool should be designed with this concept of machine-planner interaction in mind.

3. STATUS OF WORK

The minimum usable computer planning tool as described in Table 2 of an earlier report[1] has been implemented. This system is composed of 3 modules (see Figure 1, Appendix A):

3.1 OPTCOV

For planning purposes each administration defines the territories within its jurisdication which are to be serviced by a beam or beams delivering the required number of TV channels. Each such territory is called a service area and can be defined by the geographical coordinates (longitude and latitude) of the vertices of a polygon which satisfactorily approximate the shape of the territory. A convex polygon is derived from the vertices of this polygon (which may be either concave or convex) and the smallest elliptical beam which originates at the specified orbit location and illuminates the convex polygon as seen from the satellite is found. This elliptical, satellite-transmitter beam is specified by the following parameters:

(i) satellite longitude

(ii) aiming point (boresight) of satellite transmitting antenna

(iii) semi-major axis of ellipse

(iv) semi-minor axis of ellipse

(v) orientation of major axis (with respect to the equator)

(vi) the power fed to the satellite transmitting antenna in order to obtain the specified minimum required power-flux-density at all points within the service area.

Furthermore, allowances must be made for the following factors:

(i) tolerances in satellite station-keeping, attitude-control and beam-pointing.

- these factors increase the size of the required ellipse.

(ii) the atmospheric attenuation.

- this factor is taken into account by specifying that a given minimum power-flux-density must be achieved at all points for a given percentage of time (usually 99% of the worst month). To overcome this attenuation, more power must be delivered to the satellite transmitting antenna.

(iii) receiving antenna elevation angle.

- this constraint limits the arc on which the satellite for a given service area must be located in order to ensure that the elevation angle at any point in the service area does not fall below the specified minimum (20° for most of Regions 1 and 3).

(iv) eclipse protection.

- to ensure that the solar panels of the satellite are not subject to sun eclipse before midnight local time the satellite should be located approximately 10° west of the westernmost point in the service area. This further limits the arc on which the satellite may be located. Eclipse protection is required when the operational requirement assumes that the satellite power is in excess of what can be supplied by batteries of reasonable weight.

The computer program OPTCOV written by G. Chouinard of the CBC(2) takes all of the above factors into account and generates the required elliptical beams. This program has been transferred from the University of McGill IBM 370/158 computer to the CRC Xerox Sigma 9 computer and some updating and modifications have been carried out.

3.2 DISCRIM MATRIX

As a starting point for any synthesis (see Section 3.3 SYNTHESIS) information regarding the mutual interference between the transmissions serving the different service areas must be available. In particular, it is useful to know which service areas are most likely to be subject to significant mutual interference due to their geographical position and the shape and the dimension of their beams. This information is obtained from the transmission discrimination matrices. If the index i denotes an interfered-with service area and the index j denotes an interfering service area then the co-polar and cross-polar transmission discrimination ratios, ${}_{c}D_{ij}$ and ${}_{x}D_{ij}$ respectively, are defined for the least favourable point in the interfered-with service area as follows:

$$ {}_{c}D_{ij} = \frac{\text{wanted co-polar power-flux-density}}{\text{interfering co-polar power-flux-density}} $$

$$ {}_{x}D_{ij} = \frac{\text{wanted co-polar power-flux-density}}{\text{interfering cross-polar power-flux-density}} $$

These quantities are put in the form of square matrices and called (co-channel) co-polar and cross-polar transmission discrimination matrices respectively and serve as the starting point for the synthesis (3,4). The matrices are generated under the following assumptions:

(i) all service areas are assumed to be served by the same frequency (co-channel)

(ii) the receiving antenna discrimination is not taken into account

(iii) all transmissions are assumed to orginate from the same orbital position which is usually taken to be some median position on that portion of the geostationary arc visible to the region under consideration.

Points (ii) and (iii) arise from the following considerations:

Because the satellites are located approximately 6 earth radii above the surface of the earth the angle between a given boresight and a test point is approximately constant irrespective of where on the visible arc of the orbit the satellite is located. This means that the interference situation on the ground remains approximately constant irrespective of the choice of orbit position and therefore allows a separation of the effects of the discrimination obtained from the satellite transmitting antenna and the discrimination obtained from the small, individual - reception, earth-station receiving antenna.

A computer program called DISCRIM MATRIX to generate the co-polar and cross-polar transmission discrimination matrices has been designed, coded and tested. This module accepts the output from the OPTCOV module and provides an input to the SYNTHESIS module.

3.3 SYNTHESIS

With the service areas and their corresponding optimum elliptical coverage beams for each allowable orbital position defined, the synthesis problem can be stated as follows:

How are channels, orbital positions and polarizations assigned to service areas so that the mutual interference is reduced to an acceptable level and the use of the spectrum/orbit resource maximized with respect to some agreed upon criteria.

NOTE: In generating the optimum elliptical coverage beams and transmit powers before entering the synthesis routine, we have already ensured that the desired grade-of-service is achieved.

A computer program which implements the synthesis approach of T. O'Leary(3) has been designed, coded and tested. Following this approach channels are initially assigned to different service areas on the basis of "worst interferor best choice" as obtained from the co-polar transmission discrimination matrix. To further reduce interference the polarization and orbital positions are assigned simultaneously using the cross-polar transmission discrimination matrix and the co-polar and cross-polar characteristics of the receiving antenna. The method described above is deemed to be the best of the methods published to date. See reference (6) for a justification of this opinion.

If the number of allowable orbital positions and the number of channels initially assigned are both large many possible plans may be produced by the computer program. Since the analysis of a plan is expensive, it is not feasible to analyze a large number of plans. The planner has several options available to decrease the number of plans to be examined:

(i) decrease the number of assignable channels to meet the specified set of requirements

(ii) decrease the number of orbital positions allowable

(iii) impose further constraints on channels, orbital positions, and polarization (see Section 4.1.3.2)

(iv) perform a pre-analysis comparison of plans generated.

In order to compare the relative merits of different plans without a complete analysis (point (iv) above) the transmission discrimination matrices are modified to reflect the assignment of channels, orbital position and polarization as well as the inclusion of the earth station receiving antenna discrimination to obtain a matrix of margins for all the service areas considered in pairs. By considering the margins, the following quantities can be defined and used to compare different plans:

(i) the largest minimum single entry C/I ratio

(ii) the largest aggregate C/I ratio

(iii) a weighted sum of C/I ratios

It must be remembered that adding the powers of all the interferences into service area i, say, gives a very pessimistic evaluation of the protection margins since each term was calculated for the least-favourable receiving point in service area i for the interference caused by service area j. For example, if two interfering service areas are situated to the east and the west respectively of a large interfered-with service area, the least-favourable point for the overall interference could be neither of the two least-favourable points with respect to each of the individual interfering signals.

4. PROBLEMS IDENTIFIED

The implementation of the minimum usable computer planning tool as described in Table 2 (1) has been an aid in the evaluation and further refinement of the requirements for the desirable computer planning tool as described in Table 1 (1). In addition, considerable valuable input has been received from RARC-SWG-A1 which is composed of representatives from DOC, CBC, CRTC and contract personnel. Based on this specific software tasks have been identified and are described in the following. The time estimate given below in Table 1 is contingent upon a continued high level of input from RARC-SWG-A1. A simplified block diagram of the computer planning tool with the tasks of Section 4.1 incorporated is shown in Figure 1, Appendix A.

4.1 SOFTWARE DEVELOPMENTS - SPECIFIC TASKS

4.1.1 OPTIMUM BEAM COVERAGE PROGRAM (OPTCOV)

An existing program fits an optimum elliptical beam to a set of geographic points identifying a particular service area. This beam fitting process takes account of satellite station-keeping, attitude-control and beam-pointin tolerances. Given the climatic zones of the geographical points the program also computes the required satellite transmit power such that a given minimum power-flux-density is achieved at all points for a given percentage of time.

TASKS

1) Refine and update the above program to accommodate batch processing and closed-loop operation should this latter mode be subsequently required.

2) Design output file data-base format to interface with other system modules.

4.1.2 TRANSMISSION DISCRIMINATION MATRIX PROGRAM (DISCRIM MATRIX)

A completed program evaluates the carrier-to-interference level between any two service areas assuming that all service areas are co-channel, either co-polar or mutually cross-polar, and all served from the same orbit location. These matrices are the basis for several synthesis approaches.

TASK

Refine and update existing program to interface with the optimum beam coverage program above and the synthesis program described below.

4.1.3 SYNTHESIS PROGRAM (SYNTHESIS)

A method described by O'Leary(3) has been coded. This method, judged to be the best of the published methods, nevertheless has several drawbacks and deficiencies. This section identifies the areas that need improvement and suggests possible solutions.

4.1.3.1 GEOGRAPHICAL CONSIDERATIONS AND SYSTEMS PARAMETERS

In applying any synthesis program it is important that the geography peculiar to the Region be taken into account. In the case of Region 2, there is a large number of closely spaced small service areas concentrated in Central America and the Caribbean with fewer larger service areas in North and South America. For planning purposes, the same number of channels are distributed to each service area although this does not necessarily guarantee an optimal use of the orbit/spectrum resource i.e. there may be "holes" in the plan which would allow some service areas to be allotted extra channels. The presence of these holes means that combinatorially there are a great many ways to make the assignments of channels, orbital positions and polarizations. Therefore, a large number of possible plans may be generated but since the analysis of a plan is expensive, the number of plans to be analyzed must be reduced.

The technical parameters applicable to Region 2 unless otherwise stated are assumed to be the parameters obtained from the Final Acts of the 1977 BCSAT WARC (12).

TASK

Determine how to adopt the existing (O'Leary) synthesis program for Region 2 so that only a small number of plans have to be analyzed. This may involve a combination of 4.1.3.2 Planning Constraints, 4.1.3.7 Partitioning a Planning Region and 4.1.3.8 Pre-Analysis Evaluation

4.1.3.2 PLANNING CONSTRAINTS

These constraints apply to the assignment of a channel, orbital position and polarization and therefore should be an input to the synthesis program. For either technical or political reasons assignments to 2 or more service areas may have to be made under some combination of the following 6 constraints:

a) same channel
e.g. superstation

b) different channel
e.g. to aid in eliminating mutual spillover

c) same polarization
e.g. adjacent service areas may want to share mutual spillover

d) different polarization
e.g. adjacent service areas may not want to share mutual spillover

e) same orbital positions
e.g. service areas are to be served from the same satellite

f) different orbital positions
e.g. to aid in eliminating mutual spillover

As a further example, if it is required to beam programs to service areas A, B and C from the same satellite then the same orbital position must necessarily be assigned to each service area. (This might be the case, for instance, in specifying that several beams seeing different parts of Canada be from the same satellite.) These are primary constraints. Since the 3 service areas are to be served from the same orbital position it is known a-priori that contiguous service areas cannot be assigned the same channel with either co-polar or cross-polar polarization. These are secondary constraints.

For a given planning exercise it must be verified that the given set of constraints is logically consistent i.e. some cons-traints logically imply other constraints and all constraints given should be consistent.

TASK

Implement planning constraints.

4.1.3.3 CHANNEL ADJACENCY AND PROTECTION RATIOS

The way the channels are arranged is an important input to the synthesis program since this determines which channels are adjacent and consequently subject to adjacent channel interference. The parameter which is a measure of this interference is the adjacent channel protection ratio. The measure of interference of channel X into channel Y, say, depends on whether X is upper adjacent or lower adjacent to Y and also on the carrier spacing. It is useful to input this information into the synthesis program and this can be done via the protection ratio matrix (5).

TASK

Adapt program to accept channel adjacency patterns and corresponding protection ratios.

4.1.3.4 INITIAL ASSIGNMENT OF CHANNELS TO SERVICE AREA

All synthesis methods reviewed to date develop plans based on only one assignment of channels to service areas. The rule by which these assignments are made one at a time may appear optimal for the first few such assignments but may preclude a plan which is globally optimal. The O'Leary/Christensen synthesis method (6) suggests 2 ways of overcoming this major difficulty.

TASK

Adapt program to implement O'Leary/Christensen synthesis method (6).

4.1.3.5 ITERATIVE SYNTHESIS OF A PLAN

It may be advantageous to use another plan as the starting point of a synthesis. This plan may have been derived either manually, by some other program or even by this program itself. If the plan is derived from the program itself, then for the 2nd iteration it may be useful to further subdivide the allowable orbital spacings, say. By stripping the polarization from the plan used as an input we can simultaneously iterate to a plan which is optimal over polarization and orbital positions for a given assignment of channels to service areas. This can be done through the proper use of planning constraints, orbital spacings and the allowable orbital positions matrix and may be repeated as many times as required. It must be remembered that the solution produced is a local optimum and not necessarily a global optimum (since only one assignment of channels to service areas is considered).

If the initial orbital positions are given then the adaptation of the method of Bove and Tomati (8) as suggested by Chouinard (5) will give all the solutions which are optimal over polarization, assignment of channels to service areas and small perturbatio to the initial orbital positions. The number of solutions produced may be a problem.

The above two methods may be used to complement each other in arriving at a plan.

TASK

Adapt (O'Leary) program to synthesize a plan iteratively.

4.1.3.6 FEEDER-LINKS

As pointed out by Ken Brown in a memorandum to R.R. Bowen and R. Amero dated July 24, 1979 many questions with regard to feeder-link planning still remain unanswered. We could, for example, do uplink and downlink planning together to meet an overall link single-entry and aggregate C/I specification. However, in order to proceed with the development of the computer planning tool certain assumptions will initially have to be made. The Europeans, for example, assumed that the feeder-link noise contributed 0.5 dB to the overall noise budget.

For feeder-link planning we can use a combination of the following:

(i) use up positive margins of downlink budget i.e. design overall link rather than downlink only.

(ii) increase power on the uplinks which are excessively interfered with over and above the minimum power required.

(iii) spread co-located satellites apart by a small amount to take advantage of the earth-station transmitter discrimination.

TASK

Adapt program to accommodate the effects of feeder-link interference.

4.1.3.7 PARTITIONING A PLANNING REGION

Due to computer memory and execution-time limits the computer planning tool developed to date may not be able to synthesize a plan for ITU Region 2 in one run only. As suggested by Ken Brown it may initially be necessary to break Region 2 into several smaller areas, synthesize a plan for each of these smaller areas and then fit these plans together. The adjustment of the interfaces between those smaller areas would appear to be the major difficulty. This problem could be minimized if the smaller areas are judiciously chosen taking the geography of the service areas into account.

However, it would appear that there is a natural partition between North and South America for 2 reasons:

a) There is a relatively large geographical separation between the bulk of the service-areas for North and South America connected by only smaller service areas in Central America and the Caribbean. Small service areas are potentially not severe interferors and hence there is some "de-coupling" between North and South America.

b) The optimal orbital locations for the service areas of North America are different from the optimal orbital locations for the service areas of South America.

Furthermore, the judicious application of the Planning Constraints may limit the number of possible assignments to be checked and consequently the only partitioning required may be that between North and South America. It should be remembered that the Planning Constraints are under direct control of the planner and as such represent a powerful tool for directly influencing a plan.

On the other hand the number of service areas could increase significantly if, due to a high traffic requirement, several service areas are duplicated in order to obtain an above average number of channels each.

TASK

Investigate the feasibility of partitioning a planning region.

4.1.3.8 PRE-ANALYSIS PLAN EVALUATION

From initial computer results it would appear that most synthesis procedures will generate a great many plans. Some of the reasons for this phenomenon are:

(i) a large number of allowable orbital positions are considered.

(ii) C_1, the number of channels required to provide each service area with one program, is larger than the minimum value required where

$$C_1 = \text{int}\left(\frac{C}{t}\right)$$

with C = the total number of channels available

t = the number of channels assigned to each service area

and "int" means the integral part of

(iii) C_1 can take on only integer values. Therefore, the minimum C_1 possible for the given channel spacing may produce a plan with many "holes" whereas a small increase in the channel spacing may allow the use of $C_{1new} = C_1 - 1$ which implies $t_{new} = t + 1$ i.e. an extra channel could be delivered to each service area. This means that fewer combinations of channels, orbital positions and polarizations are allowed and consequently fewer plans are produced.

(iv) the same number of channels are distributed to each service area regardless of the geography of the Region.

NOTE: The variable C_1 arises in regular channel distributions. For a further discussion of regular channel distributions see (4) and (5).

Since the analysis of a plan is expensive, it is not feasible to analyze a large number of plans. If it is not possible or desired to reduce the number of plans by the methods described in Section 3.3 then different plans may be compared on their relative merits as outlined in Section 3.3.

TASK

Incorporate the criteria which assess the relative merits of a plan as described in Section 3.3.

4.1.4 ANALYSIS PROGRAM

Regardless of how a BSS plan has been synthesized the real level of interference between satellite transmission ($^{C}/I$ ratios) must be calculated. This is referred to as the analysis of a plan. It must be remembered that the pre-analysis evaluation program produces a very pessimistic estimate of the aggregate $^{C}/I$. Presently 3 analysis programs are available:

a) The computer system OFUS (9)

b) The computer program written by J.R. Trenholm of the CRTC (10)

c) The computer program BROUIL (under development by G. Chouinard of the CBC).

For the purpose of analyzing a Region 2 plan it would appear easier to adapt either (b) or (c) especially in view of their smaller size and more specialized application. We also need a simplified analysis for a closed-loop operation which would subsequently lead to a rapid turnaround capability (see Figure 1, Appendix A).

TASK

Adapt and update existing analysis programs to be compatible with overall software structure.

4.1.5 REPORTS AND PRESENTATION PROGRAM

This program would extract the required information from a computer run and generate useful summary reports, tables, graphs, etc., and evaluate various plans against a set of criteria.

TASK

Design, code and test report generation program.

4.1.6 TRANSFERABILITY OF SOFTWARE

There is a potential need to transfer the software package developed for the DOC Xerox Sigma 9 computer to other machines. In addition there may be a need to transfer the package to the host country of the 1983 RARC if the computer system being developed is accepted as the main planning tool.

TASK

Continuously monitor software development to facilitate a possible transfer.

4.1.7 VARIATIONAL ANALYSIS

With the software tools under development several trade-off analyses are conceivable. For example the effects of varying the following parameters, either singly or in combination, on overall system capacity and efficiency could be investigated:

1) Orbital spacing.

2) Receiver antenna diameter.

3) A mix of low and high power satellites.

4) Eclipse protection (this is potentially a most significant factor since, if batteries can be accommodated to give full or partial service, the available orbit for any particular service area is increased dramatically permitting much more extensive use of crossed beam geometry).

5) Satellite antenna pattern (the WARC '77 specified 30 dB side lobes, subsequent developments have found this to be difficult to achieve).

6) Channel plan (adjacency patterns as indicated in Section 4).

7) Restrictive constraints (per Section 4).

8) Large beam versus several small beams.

9) Fixed versus transportable uplink earth-stations, etc.

In addition the "cost" of various system constraints such as station-keeping, availability (uplink and downlink), quality of service, and inter-regional interference etc., could be investigated.

TASK

Provide software support for individual performing the variational analysis.

4.1.8 MISCELLANEOUS

TASKS

1) Perform computer program modifications to reflect advances in technology.

2) Liaise with personnel who may be awarded a University Research Contract to apply operations research techniques to the synthesis of a Broadcast Satellite Service plan.

3) Assess information gathered during forthcoming European visit.

4) Final revision of software and documentation.

5) Input to contributions to various international fora e.g. CCIR, CITEL, IEEE Conferences, Special Seminars.

5. ESTIMATED RESOURCES

5.1 MANPOWER REQUIRED FOR SOFTWARE DEVELOPMENTS

The time estimated for a computer systems analyst and a computer programmer to complete the software development tasks defined in Section 4 is given in Table 1.

5.2 SYSTEM STUDIES

A satellite communications engineer will be required for a period of at least 1 year to perform and document the variational analysis and associated system studies.

5.3 MAINTENANCE AND UPDATING

There will be a further need for continued software support after the tasks in Table 1 have been completed. The time required will depend on user reaction, required modification, outcome of variational analysis and available alternate software support. The effort required up to RARC-83 could fall anywhere between 50-150 man-days. The split between computer systems analyst and computer programmer cannot be specified at this time. Furthermore, it is not possible to forecast the amount of software support required to modify the broadcast satellite service planning tool to facilitate possible fixed satellite planning that may be required in the 1984-86 time-frame.

TASK		Manpower required in man-days	
		Computer Systems Analyst	Computer Programmer
4.1.1	Optimum Beam Coverage Program	15	15
4.1.2	Transmission Discrimination Matrix Program	30	40
4.1.3	Synthesis Program		
1)	Region 2 Requirements	10	5
2)	Planning Constraints	20	20
3)	Channel Adjacency	20	20
4)	O'Leary/Christensen Approach	20	25
5)	Iterative Synthesis Capability	30	20
6)	Feeder Links	20	20
7)	Partitioning a Planning Region	30	20
8)	Planning Criteria	20	20
4.1.4	Analysis Program	40	40
4.1.5	Reports and Presentation Program	40	50
4.1.6	Transferability of Software	15	10
4.1.7	Variational Analysis	5	20
4.1.8	Miscellaneous	15	5
	TOTAL	330	330

TABLE 1: Manpower requirements to implement tasks specified in Section 4.

5.4 HARDWARE

The computer resources specified in DOC document # PRO/C/2.2.5.1.4.1 is meeting our present needs. However, for rapid turnaround capability, a faster computer would be a great asset as RARC-83 approaches.

5.5 MISCELLANEOUS

Further requirements are a map table and a secure storage facility for printouts, documentation, manuals, plots and reference material.

6. RECOMMENDED COURSE OF ACTION

1) Contract the services of a computer systems analyst and a computer programmer to perform the tasks outlined in Table 1.

2) Engage an engineer with experience in satellite communications to perform the variational analysis described in Section 4.1.7.

3) Maintain liaison with experts in the planning field and related disciplines. In particular, investigate the possibility of applying the techniques of operations research to the synthesis problem.

4) Provide the planning team with permanent facilities for storage of printouts, documentation, etc.

7. IMPLICATIONS OF NOT PROCEEDING

Recommendations 1) and 2) above must be addressed if the objective of producing a viable computer planning tool is to be achieved. Such a planning tool is essential to Canada's 83 RARC preparations. Failure to implement recommendation 3) may result in an outdated or inferior planning tool while failure to implement recommendation 4) may mean lost time due to misplaced outputs, manuals, etc.

8. BENEFITS TO CANADA

Benefits could accure to Canada since the following goals are expected to be achieved by developing expertise in the planning area:

1) protect and further Canada's interest in a domestic broadcasting-satellite service.

2) assist in developing a broadcast system which is more responsive to the unusually large regional, cultural, and ethnic diversities and at the same time facilitate the distribution of national services resulting in an increased Canadian identity,

3) ability to provide a Canadian alternative to the possible widespread spillover of interfering signals from other administrations,

4) encourage the Canadian production, broadcast, and possibly cable industries to use and develop this new service to extend the scope and coverage of their present services,

5) demonstrate a high level of competence internationally with a view to encouraging possible future markets for hardware and technology for the Canadian manufacturing industry, and

6) develop expertise in the computer assisted planning area which will be relevant to other communications requirements including the possible necessity of planning the fixed-satellite service in 1986, domestic allocation of radio, TV, and mobile channels, etc.

9. CONCLUSION

The implementation of the above recommendations will give Canada a powerful planning tool with which to prepare for RARC 83 and enable DOC to fulfill its mandate.

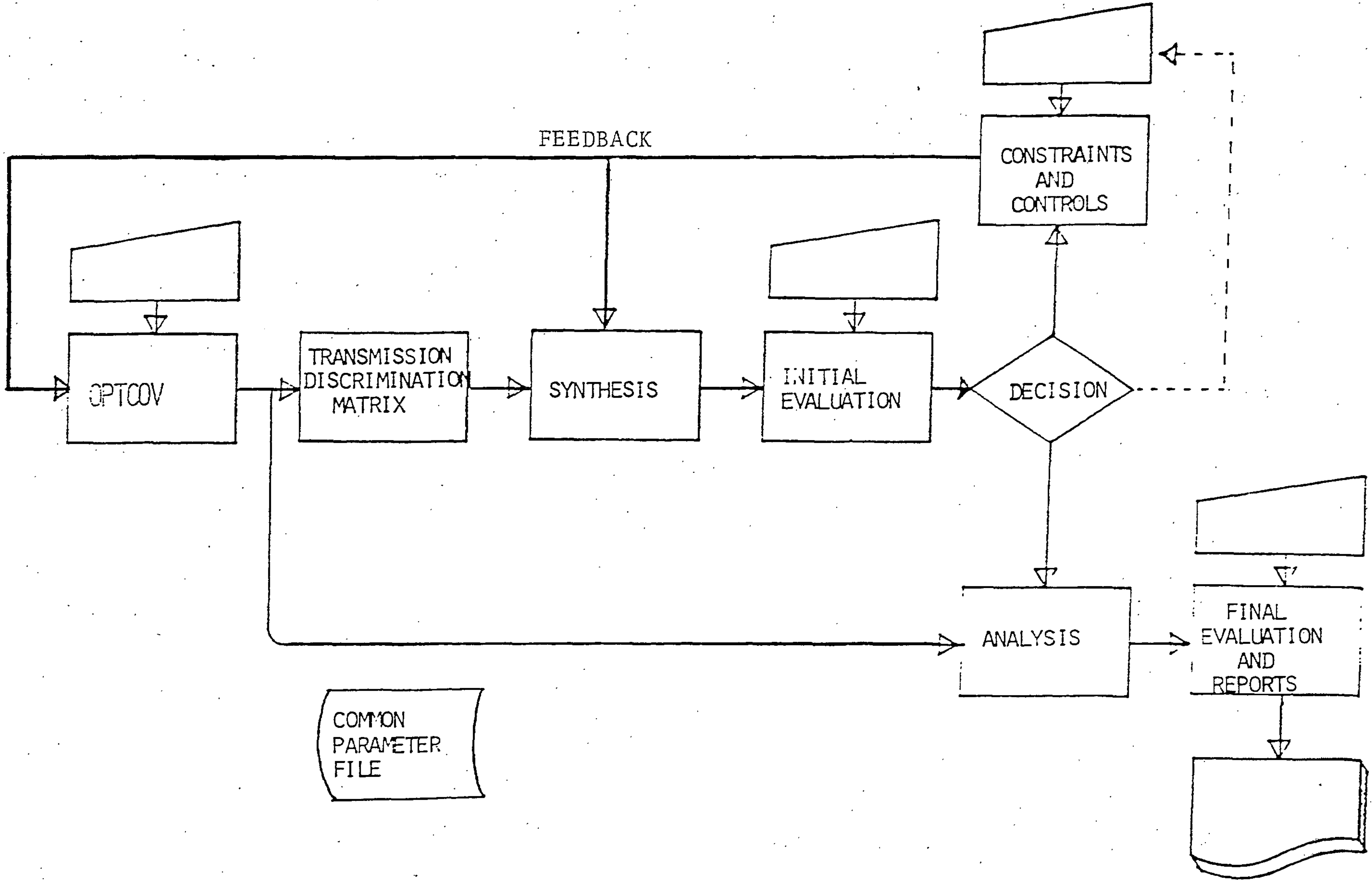

FIGURE 1 SIMPLIFIED BLOCK DIAGRAM OF COMPUTER PLANNING TOOL

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