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Capabilities, Limitations, and Use of BC SAT-R2 Conference Software

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INTRODUCTION

The computer software developed for the BC SAT-R2 Conference has certain capabilities and limitations, which are described in the first two parts of this paper. The method of use is given in the last section.

SOFTWARE CAPABILITIES

The software package developed for the BC SAT-R2 Conference has the capability, when used interactively by a skilled planner, to produce both down-link and feeder-link plans. The planning process begins with the requirements (as submitted by administrations) and ends with a printed description of a plan. Figure 1 shows the process schematically. Of course, it may be possible that certain combinations of requirements and technical parameters may not yield a workable plan.

The capabilities of the various software elements follow.

Requirements File

The requirements file contains the data supplied by administrations. Software associated with the requirements file produces a Requirements Report for verification of the data entry.

Technical Parameters File

This file contains input technical data specified by the individual administrations or agreed upon by the Conference. Major elements are antenna gain characteristics, channelization schemes, protection ratios, and protection ratio templates. The technical parameters are capable of being easily changed to match the decisions of the Conference.

Ellipse Program

The ellipse program calculates minimum area ellipses to provide the administration-specified service areas with constant carrier-to-noise ratios under conditions of rain attenuation on the down-path. Feeder-link service area ellipses can also be calculated. Ellipses calculated are sized to account for the specified spacecraft antenna pointing and rotational errors.

Additional software operating on the ellipse information has the capability to produce elliptical beams plotted on service area maps and to produce a global view of Region 2 with all ellipses plotted.

ARCSGEN Program

The available orbital arc for each service area is calculated by ARCSGEN, subject to constraints on elevation angle and eclipse time.

Orbit Separation Matrix Program (GENSEP)

This program has the capability of calculating matrices of the pair-wise orbital separations required between satellites serving different service areas. These matrices are useful in either manual or computer-aided synthesis of plans.

Synthesis Programs

The three synthesis programs implemented in the software have the capability of synthesizing down-link plans, with the interactive participation of a planner. Plans produced have specified satellite positions, frequency assignments, and polarizations. Software associated with the synthesis programs is capable of producing plan maps and plan layout reports, which summarize the key elements of developed plans. The synthesis software also has the capability of performing a simplified analysis of carrier-to-interference ratios on the down-links. Up to 125 service areas can be used in the synthesis programs, and results can be calculated at up to 20 polygon points within each service area. Co-channel and adjacent channel interferences are calculated, with the number of adjacent channels included being a variable chosen at the planner's option.

The individual synthesis programs have different capabilities.

The synthesis program CAPSYN presents the planner with a menu of possible actions to enable a plan to be generated. These actions may be performed in any order and as often as the planner requires. The planner may modify all or part of a plan, retain or override constraints, investigate parts of a plan, or simply format a plan derived by any other means for further analysis and processing. This program is interactive and user friendly, execution time is determined solely by the skill and experience of the planner since, apart from the above local optimum searches, no decisions are made by the computer. The program CAPSYN synthesizes downlink plans only. A small number of regular channel families can be used. Each service area may use a different set of technical parameters.

The minimum impact synthesis algorithm MISYN automatically assigns orbits, channels and polarizations, subject to planner specified constraints of multiple channel families per service area, linked service areas served from the same satellite longitude, pre-assignments, etc. Having set up the planning problem and determined a suitable starting point the planner has no further control on the assignments. However, the advantage of this routine is its speed - typically less than five minutes per synthesis. Thus several scenarios can be tested and compared in a short time. The MISYN program accepts constraints between families of assignments, such as orbital position constraints. Also, irregular channel spacings are allowed.

The program BRSYN is used only to synthesize down-link plans. BRSYN makes channel and polarization assignments based on the power addition of

worst-case single-entry interferences in a service area, a computation very similar but not identical to calculating aggregate interferences at each test point. In BRSYN, orbit positions are pre-specified, and the skill of the planner is a necessary ingredient in synthesizing a plan.

The synthesis programs can be used to synthesize plans using the several planning approaches that were discussed by the CCIR Conference Preparatory Meeting and the Panel of Experts preparing for the BC SAT-R2.

Scenario File

The plans developed by the synthesis programs have the capability of being coupled to the analysis program via a complete plan description designated as the scenario file. Most elements of the plan are read into the scenario file automatically, however a few must be entered by hand. The scenario file has override capabilities on most of its elements to provide the capability for easy change to the characteristics of a scenario to be analyzed.

Analysis Program (SOUP 5)

The analysis program has the capability of determining the total carrier-to-interference ratio (C/I) at any test point at any channel frequency taking into account all interfering transmissions from broadcasting satellites, including both the feeder-links and the down-links and including interferences that are co-channel, adjacent channel, and second adjacent channel. These calculations can be done for up to 160 service areas, 1,600 feeder-link transmitter sites and 4,800 earth station receiving sites. The C/I's calculated are compared to specified protection ratios to determine the margin at each test point. A positive margin indicates that the protection ratio is exceeded; a negative margin indicates that the C/I is less than the protection ratio.

The calculations performed for each test point have technical parameters that are variable for each service area. Rain attenuation and other propagation effects can be taken into account. Either circular or linear polarization can be used. Additional quantities calculated include power flux density, received power and spacecraft power.

The analysis calculations are capable of being run for any planning approach. The channel assignments resulting from any particular planning approach are represented by the appropriate channel families with only one interference category permitted per channel family.

Analysis of a complete plan on a channel-by-channel basis can be performed by multiple runs of the analysis programs. The identification of the required channel families may become both complex and tedious. An alternative method of calculation is to perform N separate runs if the BSS bandwidth is divided into N channels. Each run would have at most five channels represented, the co-channel and the two upper and two lower adjacent channels, for each service area.

Analysis of a plan with different channel bandwidths would require multiple runs as for the channel-by-channel analysis above. The identification of the required channel families in this case would be more complex.

Sensitivity analyses (investigations of the effects of changing parameter values) can be obtained through the performance of multiple computer analysis runs and the comparison of results.

Rotational errors and satellite station-keeping errors are not taken into account in the analysis program. Multiple analysis runs with spacecraft pointing and positioning errors can model these effects.

Output Reports

The output reports produced are capable of completely describing a plan and the results of the calculations associated with that plan. The summary of a plan is contained in the down-link plan layout and the feeder-link plan layout. Other output reports contain more detail that is useful to the planner as he attempts to improve the plan.

SOFTWARE LIMITATIONS

The software developed for BC SAT-R2 does have some limitations in its ability to represent plans with full accuracy. The major limitations are cited in the following sections.

Synthesis Program Limitations

(1) Only down-link interferences are included in the C/I calculation.

(2) Aggregate C/I is not used in the synthesis programs. Instead, individual C/I's are compared to a single entry protection ratio. However, the simplified analysis routine does compute aggregate C/I.

(3) The modelling has limited flexibility in that service areas are required to have a common antenna characteristic, a common television standard, and other common technical characteristics.

(4) Procedures for optimum use of the three synthesis programs have not been determined.

(5) A limitation of the CAPSYN synthesis program is that it is interactive and requires decisions by the planner during its execution. This results in planning sessions at the computer of several hours or more.

(6) MISYN produces "good" plans, but not necessarily optimum plans. The "goodness" of the solution depends on the skill of the planner.

(7) BRSYN requires the orbital positions to be pre-specified. Thus, manual changes are required to examine plans with different satellite locations.

After a synthesized plan is passed on to the SOUP 5 analysis program, limitations 1, 2 and 3 may be overcome by completely describing the plan in the corresponding scenario.

Analysis Program Limitations

(1) The percent of worst month is the same value for both the feeder-link and the down-link. There may be a desire to have better performance on the feeder-link. This limitation could be overcome by performing separate runs for the feeder-link and the down-link, then manually combining the results.

(2) If blocks of frequencies are assigned without specifying channelizations, that approach is modelled throughout the region, i.e., a mixture of blocking and specific channel assignments cannot be analyzed in a single analysis run.

(3) When channel families are assigned, a typical frequency (either the lowest, the highest, or the mean) is chosen to represent all members of the family. This causes small errors in the analysis because of the frequency dependence of the model. Small errors are considered acceptable in the development of a plan. A subsequent, detailed, channel-by-channel analysis can give exact results.

(4) Only a single up-link satellite receive beam per service area can be modelled in the analysis program. To investigate a multibeam feeder-link antenna appraoch such as steerable or switched spot beams, would require multiple analysis runs.

Output Report Limitations

The principal limitation on the output reports is the inability at the present time to automatically combine results of multiple analysis runs into a single output report.

USE OF THE CONFERENCE SOFTWARE TO DEVELOP PLANS

During the BC SAT-R2, it is envisioned that the following approach might be used to develop tentative plans for evaluation and consideration by the Conference Planning Committee.

The Conference software requires skilled individuals to use it and to interact with it in an efficient manner. Four types of skills are required.

(1) Planning - Developing initial and modified plans to be evaluated and tested.

(2) Technical support - Translating a plan into a set of computer input data that accurately represents that plan.

(3) Data processing - Entering the data into the software system and running the programs.

(4) Analyzing - Evaluating the computer results.

These skills will exist in the technical secretariat (IFRB staff) supporting the Conference, with the assistance of software and computer experts from the administrations.

Facilities to be used will include the ITU computer with its disc storage and high speed printer output. CRT terminals located at the Conference site will allow users to run the software package.

The sequence of major activities in the development of a plan is shown in Figure 1. Primary inputs are the requirements, as submitted by administrations. The planner inputs the technical parameters to be used in the plan. Ellipses are calculated by the data processor. Service area maps with ellipses plotted on them and the global view of Region 2 may be used as data checks. If the planner has not already done so, he may choose to use the ARCSGEN program to provide the information on the available arc for each service area. The orbital separation matrices are calculated to provide guidance for an initial attempt at a plan. Throughout this process, the planner may be assisted, as necessary, by a technical support person or a data processor who has an understanding of the software system.

The planner then generates an initial plan, using his past experience, manual synthesis techniques, or other methods. The initial plan is input to the synthesis program by individuals performing the technical support and data processing functions. The person performing the plan synthesis uses his best judgement to select the appropriate synthesis routines. Repeated use of the synthesis routines results, hopefully, in a continually improving plan. At appropriate points, the synthesizer (planner) may select to produce a plan map or a plan layout report as a printed record of the improved plan.

After development of an appropriately "good" plan, the synthesis program output is fed to the scenario file in preparation for a detailed analysis by the program SOUP 5. Appropriate inputs to the scenario file are provided by the technical support person to completely describe the plan. Operation of the analysis program calculates the C/I and margins at all test points. Upon examination of the output reports, the planner and the analyst may decide to modify the scenario to improve the plan. This modification process may only modify the scenario, or the feed-back loop may go back to use the synthesis program again.

The process described assumes a start from a crude initial plan. In practice, the experienced planner may have a fairly good plan that he might wish to enter directly into the scenario file.

Through repeated operations like those just described, either a workable plan is developed, or it is concluded that some basis characteristic, for example, the earth station receiving antenna discrimination, must be changed to reach a workable plan. It is expected that the Conference Planning Committee will exercise the judgement needed to recommend changes needed to result in an acceptable plan.

The expected software use, as described in this paper, is a preliminary view. It will be left to the resourcefulness of the users of the software package to determine the most effective approaches to be used at the Conference.

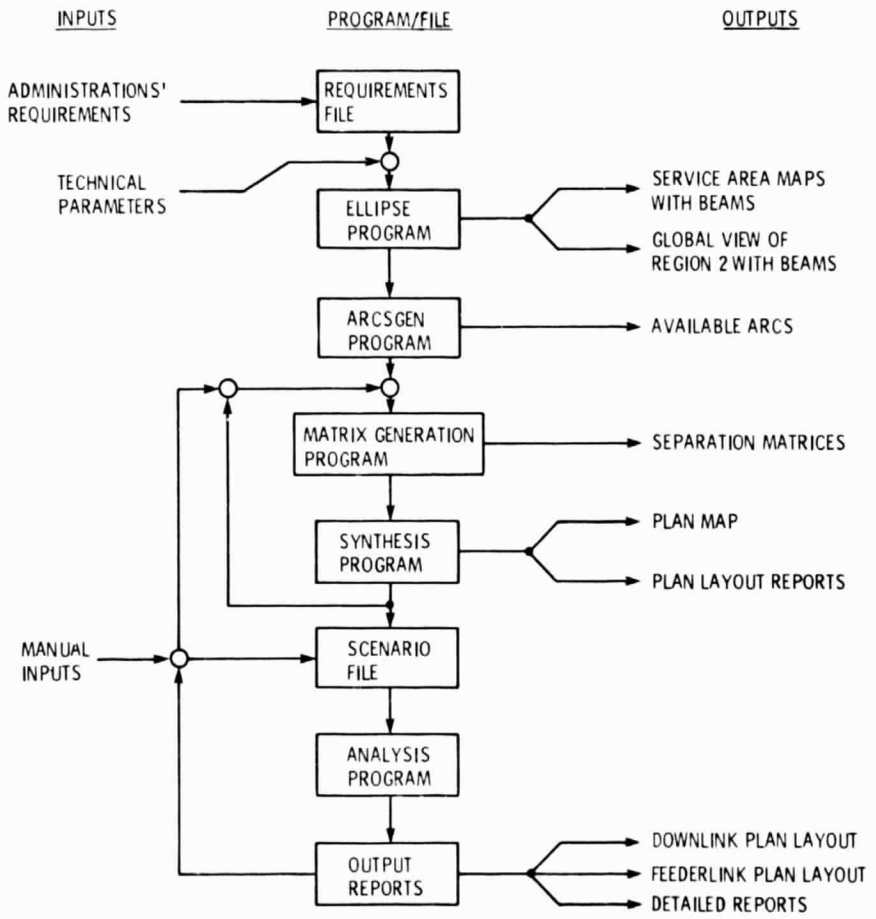

Figure 1. - Use of software.