Único exemplar

BRAZILIAN EDUCATIONAL RADIO AND TV EXPERIMENT ON ATS F

Experiment Proposal — May 1970 revision

LAFE-109

Submitted by the

Comissão Nacional de Atividades Espaciais (CNAE)

to

National Aeronautics and Space Administration (NASA)

PR — Conselho Nacional de Pesquisas
Comissão Nacional de Atividades Espaciais
São José dos Campos — SP — Brasil

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PRESIDÊNCIA DA REPÚBLICA
CONSELHO NACIONAL DE PESQUISAS
COMISSÃO NACIONAL DE ATIVIDADES ESPACIAIS
São José dos Campos — São Paulo — Brasil

The issue of this revised proposal was authorized by the undersigned, and is meant as a basis for a Brazilian educational experiment using the ATS-F Satellite.

Fernando de Mendonça
Scientific Director

PRESIDÊNCIA DA REPÚBLICA

CONSELHO NACIONAL DE PESQUISAS

COMISSÃO NACIONAL DE ATIVIDADES ESPACIAIS

São José dos Campos — São Paulo — Brasil

11 May 1970

Ref.: C.643-DC/70

Mr. Arnold W. Frutkin
Assistant Administrator for
International Affairs
NASA - 400 Maryland Ave., S.W.
Washington, D.C. 20546
U.S.A.

Dear Mr. Frutkin,

Attached please find our proposal "Brazilian Educational Radio and TV Experiment on ATS-F", May, 1970 revision for consideration, study and, hopefully, concession of satellite transponder time.

More than simply a block of satellite time for Brazil, the experiment will be of value to NASA and the U.S.A., as one more instance of the peaceful use of space for the good of man. Also, given that both the U.S.A. and Brazil are in the same hemisphere, the initial check-out of some of the spacecraft equipment could be made with the beam turned to Brazil, thus avoiding possible interference problems in the frequency congested Northern Hemisphere.

Besides that, propagation measurements over the duration of the experiment would give NASA a wealth of data on the subject, not to mention the measurement and recording of signal level variations, that could be correlated with atmospheric and ionospheric conditions, polarization rotation, dispersion and other propagation phenomena. Either at different times from the Brazilian educational broadcasts or simultaneously, using other frequencies, experiments in frequency sharing, color TV etc, could also be made.

All of the foregoing would only require the setting up by NASA of appropriate equipment in selected Brazilian sites.

India-Brazil relationships are of mutual cooperation, issuing not only from the personal acquaintance between the heads of the programs but also from the realization that both countries can profit by collaboration. Even before the April 1970 UN meeting where it was suggested an exchange of personnel of developing countries engaged in applications programs, CNAE had written to the head of its Indian counterpart suggesting just that.

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The aims of the experiments are basically different: India aims at community viewing for adult instruction in agriculture, health and birth control; the Brazilian experiment emphasizes classroom instruction, measurement of pupil's retention of different types of broadcast media, texts, etc.

As a matter of fact it might be worthwhile to have a **complete** Brazilian receiving equipment set up in India and, vice versa, one of their sets put up in Brazil for evaluation of both systems.

Please note that the 34 months now shown for system definition, equipment design and development and equipment manufacture reflect a "worst case" situation and have two built in cushions: the possibilities of ordering some of the equipment outside of Brazil and a lee-way of some three months in the definition and design phases.

Summing up, the proposal as now presented is flexible enough to take care of NASA's convenience, but it is the starting point of an earnest effort to improve the lot of Brazilians through U.S. developed space technologies.

Sincerely,

F de Mendonça

Fernando de Mendonça
Scientific Director

1.0 INTRODUCTION AND SUMMARY

1.1 Introduction

This proposal presents the plans as delineated by the Brazilian National Commission for Space Activities (CNAE), to cooperate with the US National Aeronautics and Space Administration (NASA) in the performance of an Educational Broadcast Experiment utilizing the NASA ATS-F Spacecraft and ground facilities provided by Brazil. It is the intent of this document to facilitate a specific agreement between NASA and CNAE for cooperation on the experiment based on current technical and planning activities underway in Brazil and the planned capabilities of the Spacecraft. This proposal supersedes and updates the Experiment Proposal "Brazilian Educational Radio and TV Experiment on ATS-F or G" submitted by CNAE to NASA in July 1968. It incorporates the latest plans and developments, so as to bring the proposal in line with current planning. It also emphasizes the unique features and importance of the experiment in the advancement of educational broadcast technologies. The experiment uses a balanced mix of radio and TV, as well as serves as the development prototype for the ultimate nationwide Brazilian educational system. This proposal furnishes the information required by NASA memorandum change 4 to NHB 8030.1A, Section C.

The ATS-F Experiment is planned to serve as the development prototype system for the SACI Project which will make educational opportunity available to all Brazil through a government owned geostationary satellite, broadcasting, to all of the country, carefully prepared TV and Radio instructional material. As the first demonstration of the total system approach including pre-programmed educational material, uplink,transmitter, satellite transponder, ground receivers and classroom displays in the real environment of a developing nation, it will serve as a model for other projects to utilize advanced technologies in educational systems. The particularly unique feature of the proposed experiment is the use of a balanced mix of radio and TV instructional programs. This planned mix is expected to result in the most cost-effective means of utilizing advanced technology in presenting educational programs. It will also utilize the available RF spectrum in a near-optimum manner.

The SACI program includes three steps, somewhat independent of each other, but all leading to the ultimate objective:

a. A CNAE/Stanford University link through the ATS-3 satellite.
b. Broadcast to 500 (or more) instructional centers in the state of Rio Grande do Norte, from ATS-F satellite - the object of this proposal.
c. The nationwide broadcasts from the Brazilian owned and operated educational satellite.

As far back as 1966, the idea of an educational satellite for Brazil was conceived. At that time a few CNAE graduate students at the Electrical Engineering Department of Stanford University participated in the study of an educational satellite, meant for developing countries. The study resulted in the ASCEND Report (Stanford University, 1967).

Inspired by that concept, CNAE presented the idea of a Brazilian satellite to the National Research Council, at Rio, in late 1967, and issued in May 1968, a three volume feasibility study for a complete system, the "Project SACI" (CNAE, São José dos Campos, 1968). In June 1968, at the request of the Brazilian Ministry of Foreign Relations, a mission of UNESCO experts came to CNAE and produced the report "Preparatory Study of the Use of Satellite Communication for Educational Development in Brazil" (COM/WS/86, UNESCO, November 1968). After that, SACI Report no. II was published in July 1969, and no. III in February 1970.

Concious of both the incomplete development of aerospace systems capability and the time dependent value of improved education in Brazil, but recognizing the exhaustively demonstrated competence of US firms in space system implementation, CNAE has contracted for systems management consulting services with a major private American space systems organization in defining the SACI Program in detail including the steps necessary to carry out the proposed ATS-F Experiment.

The Brazilian Constitution recognizes education as the right of every individual and as a duty of the state (Article 176) to make this a reality, the government's Strategic Plan for Development stresses the aim of a grade school education for all Brazilians.

Decree 65.239, published in page 8168 of the 29 September 1969 "Diário Oficial" - the official daily of Government acts - created a committee, of 5 cabinet level members, to study and implement the application of new technologies to the Brazilian educational system. Because of the importance of this step, the decree is included in total in the next section.

1.2 Establishment of Interministerial Commission

FREE TRANSLATION OF DECREE CREATING AN INTERMINISTERIAL COMMISSION TO ESTABLISH GUIDELINES FOR A PROJECT ON AN ADVANCED SYSTEM OF EDUCATIONAL TECHNOLOGIES FOR BRAZIL

(Page 8168 of "Diário Oficial" - Brasilia 29 September 1969)

Decree nº 65.239 - 26 September 1969

Creates the technical and administrative structure for the elaboration of the project for an Advanced System of Educational Technologies, including radio, television and other media, and sets up other measures.

The Ministers of Navy, Army and Military Aeronautics, using the powers of article 1 of Institutional Act no. 12, of 31 August 1969, combined with article 83, item II, of the Constitution, and

Considering the priority given, by the Strategic Program for Development, to the preparation of an integrated system for the formation of human resources for the development, within the norm that read; "The universalization of new pedagogical methods in the Brazilian schools must constitute an important point of the reformulation of teaching. The use of radio, television, cinema and other modern communications techniques will constitute an integral element of the educational system, limited only to constraints that may exist in given areas";

Considering that the present Brazilian educational system has no capability, in the short run, for satisfying the ever growing exigencies of the economic, social and cultural development of the country, and that the high illiteracy index constitutes a limitation to the potential utilization of labor and to the democratization of opportunities;

Considering that it is indispensable, the modification of traditional curricular work, as well as the training of lay teachers and the improvement of the remaining ones in the new pedagogical techniques, to the end of obtaining a more productive utilization of the school work and a reduction of the indexes of failures and drop-outs from the system;

Considering that the use of a new educational technology, through an integrated system of television, radio and other educational techniques would make it possible to reach all the potential school population of the country and would ensure a permanent educational service for adults;

Considering that, in a preliminary analysis, Brazil offers particularly favourable conditions to the use of that new technology and specially of an integrated system of television as an instrument of teaching, in comparison with the traditional systems, taking into account: that the present teaching net reaches a relatively small portion of the population, as per the educational indexes still found at the various levels; that educational TV is cheaper and more efficient when directed at large masses and that is has greater impact in a country like Brazil, which still needs to significantly improve, in quantity and quality, the level of classroom teaching and of teacher formation; and that educational TV will make it possible to reach a portion of the population until now not reached by the school system;

Considering the need of basic studies to verify the application of said new techniques to the traditional system of teaching, in all grades, to the end of getting a better match of the educational process to the needs for social and economic development.

Concerning the indispensable need of nationwide guidelines, not only to avoid dispersion of resources and duplication of action, but also to channel the use of the new educational technologies to the best interests of the country;

Considering that the system of educational radio and television may serve, also, for any and all forms of training and to improve the system of communications, offering services of high interest in all areas, decree:

Article 1: There is hereby created an Interministerial Commission composed of the Ministers of Planning and General Coordination, of Education and Culture. of Communication, and of the Treasury, as well as the President of the National Research Council. The purpose of the Commission, under the Presidency of the Minister of Planning and General Coordination, is to establish the general guidelines of an integrated policy for the application of new educational technologies to the nation, and to decide on implementation measures suggested by the technical coordination group created under Article 2 below.

Article 2: To assist the Commission, there is created a Technical Coordination Group composed of representatives of the Ministry of Planning and General Coordination (IPEA)*, the National Telecommunications Council, the Federal Education Commission, the National Space Commission (CNAE)**, and the Brazilian Foundation Center of Educational Television.

Article 2.1: The coordination of the technical group will be effected by one of the members designated by the President of the Interministerial Commission.

Article 3: The commission will be provided with an executive secretariat charged with administrative services. Its structure and functions will be proposed by the Coordinator of the Technical Group and approved by the commission.

Article 4: The main objectives of the commission are to:

a. evaluate the reports and studies elaborated by the technical coordination group;
b. mobilize the financial, human and material resources necessary to prepare the project that is the objective of this decree;
c. promote in close collaboration with national, foreign and international organizations the activities that are found necessary for the commission to fulfill its responsibilities; and

d. keep the public informed on the development of an Advanced Educational Technologies System.

Article 5: The Technical Coordination Group will have the following principal responsibilities:

a. to elaborate the studies and reports necessary to create an integrated educational television and radio network;
b. to promote the study of all pertinent legislation and present recommendations to the commission;
c. to establish with national, foreign and international organizations, well as with other educational television and radio groups in the country, the necessary working relationships to assure good progress in the work activities, and;
d. to define the structure, composition and operational procedures of the executive secretariat provided for in Article 3.

Article 6: The Technical Coordination Group, when undertaking the study of specialized technical matter, may, with the commission's authorization, create the necessary specialized technical groups.

Article 6.1: To this end, whenever necessary, the commission may requisition personnel from the direct or indirect administration.***

Article 7: The commission periodically will present progress reports and the Technical Coordination Group will adopt, as it concludes its work projects, provisions within its work area, to implant the measures approved by the commission.

Article 8: The present decree will be in force on its publication and any previous conflicting regulations are revoked.

* - IPEA: Instituto de Planejamento Sócio-Econômico Aplicado
** - CNAE: Comissão Nacional de Atividades Espaciais
*** - Direct Administration means organizations that are just under the President of Republic, and indirect the others.

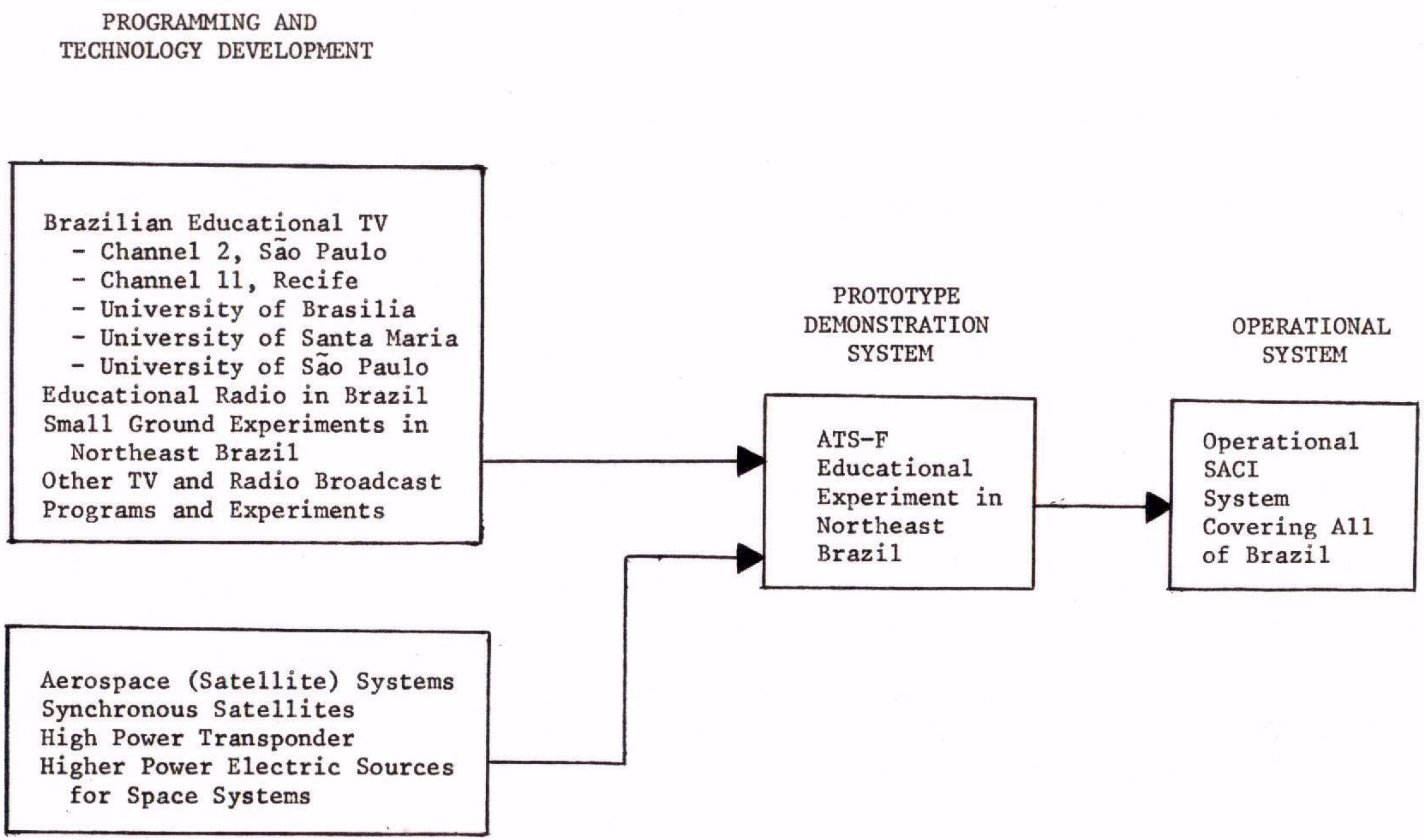
1.3 Summary

The operational SACI System, which has as its goal the provision of educational opportunity for all Brazil, is planned for implementation in the mid 1970's. Most of the technologies to be used, including programmed instruction, have been tested by many current or completed programs. The proposed ATS-F experiment, then, acts, as the system development prototype which brings the technologies together to demonstrate their compatibility and effectiveness as a whole. Figure 1.3-1 is a block diagram illustrating the role the proposed experiment would play in the total SACI Project. The SACI Project would not be stopped if time with the ATS-F is not available. However, the benefits of the proposed experiment to the planned operational system are so significant that much planning and initial experiment design efforts are currently underway at CNAE in antecipation of an agreement with NASA.Among the expected benefits, the most important items include the practical demonstration of the use of new technologies for the direct benefit of the people, and the opportunity to develop, in small scale, the equipments, organizations and programming that will lead to a technically and economically feasible nation-wide system which Brazil so badly needs.

It is most desirable to have time in the ATS-F satellite because the expected educational benefits to the area are valuable per se.

As a matter of fact, after a January 1970 meeting of the Northeastern states secretaries of education, convened by SUDENE, the enthusiasm for this experiment was such that the secretaries now have decided to allocate funds to set up receiving sets in their own states.

The program of education proposed for the ATS Experiment includes the use of one TV channel, 8 radio channels. These will be combined and transmitted to the satellite for broadcast to 500 school sites in the state of Rio Grande do Norte. Technical studies, based on ATS-F characteristics, have shown the feasibility of the receiving equipment and reduced the cost. The number of channels is limited by the capacity of generating software. The additional capability built into the transmitting and receiving equipment may eventually be brought into use, including the capability for facsimile and slow scan TV experiments.



Project SACI block diagram (Fig. 1.3 - 1)

The planned education allows for up to three hours of television and six or more hours of radio, per day, to cover the five years of grade school.

In addition three hours per day could be utilized for literacy training, three for vocational training, three for teacher training (plus three training hours of TV on Saturday), and three hours per day of radio for administrative instructions. It is clear that the proposed schedule allows for much flexibility, to the point that the broadcast time could be reduced to just the grade school and teacher training broadcasts and still achieve meaninful results.

Cost analyses, based on costs at existing Brazilian studios, show the total cost for preparation of software (broadcast programs and coordinated pupil workbooks) will be about 1.430,300 dollars.

The nominal cost of ground hardware including transmitting station, receivers and classroom equipment is estimated at 1,700,000 dollars on the basis of costs in the U.S. This estimate may vary somewhat due to the pioneering character of the experiment.

Feasibility and cost of equipment production in Brazil are being investigated since last year. These costs for ground equipment have been part of planned funding for CNAE since adoption of the concept and can be accommodated without external funding. Therefore, this proposal is addressed to establishing the feasibility and value of the proposed experiment so that a working agreement for cooperation between NASA and CNAE on the use of the ATS-F satellite can be implemented.

The schedule detailed in Section 6.0 shows the plan for preparation of the software and procurement of the hardware now being implemented by CNAE, its contractors and other Brazilian agencies. This schedule has been developed to be responsive to an anticipated launch of ATS-F in late 1972, and thus Brazil will be ready for this joint experiment at the first possible opportunity that NASA could make time of the satellite available.

The implementation of the ATS-F Experiment described herein would thus provide a major step in the utilization of space communications for education and would support a giant step forward for the people of Brazil.

2.0 OBJECTIVES, SYSTEM REQUIREMENTS AND EXPECTED BENEFITS

The proposed ATS experiment is planned to be implemented in the State of Rio Grande do Norte in the Northeast section of Brazil. The differences in environment there, and in the people themselves, present a wide range of problems, concentrated in a region small enough to be used for a controlled experiment. The success of the work can be counted on because of the interest and enthusiasm of the local agencies. Sample testimonials of such enthusiasm and interest are included in this proposal (only the most influencial agencies are cited in the appropriate sections in order to avoid making them unduly lengthy).

To better **understand** the relationships of the proposed experiment to the long range Project SACI, the project and its goals are described in the sections below, followed by the objectives and specific requirements (functional and educational) selected for the ATS experiment.

2.1 Project SACI Description

This project has a its ultimate goal a Brazilian owned and controlled geostationary educational radio and TV Satellite to provide universal educational opportunity for Brazil. In the off-school hours the satellite might be used by EMBRATEL for transmission of data and other paid traffic within the country as a source of revenue.

CNAE has applied the "Systems Engineering" concept to its role of initiation of the project and integration of the operation and, currently, has the cooperation of Stanford University, of Rio Grande do Norte State Government and a host of other entities.

The generally sequential steps that comprise Project SACI are:

1. "Phase A", which will consist of receiving, in S.José dos Campos, selected seminaries broadcast from Stanford University and transmitting from here programs on Brazilian culture. A proposal for the use of the ATS III satellite has been recently approved by NASA.

2. "Phase B", the experiment which is the subject of the present proposal.
3. "Phase C", a Brazilian owned satellite intended to cover the entire nation. In this country-wide phase, the contents, programming, distribution and supervision of instructional material (software) will be under the Ministry of Education, as also the teaching body; technical operation of the broadcast system (hardware) will be under the Ministry of Communications, as per the Brazilian law; and the coordination of the whole might properly be assigned to the Ministry of Planning and Economic Coordination. This phase is planned to be implemented in five years.

A project like SACI requires intense effort, besides co competent and adroit interfacing, To handle this, CNAE is building up its interfacing group with sociologists, economists, and educational specialists of doctor's level.

CNAE has the funds for experimental phases "A" and "B", and through this proposal is only negotiating the use of satellite time.

Phase "C" will require the involvement of all the country. A major step in this direction is Decree 65.239, quoted in full in the beginning of this proposal. The second and fourth sections of its opening "consideranda" echo the basic SACI premises by stressing the deficiencies of the conventional educational system and the need to use new educational approaches and advanced educational technologies. In fact, even if time were not of critical importance, still the mere expansion of the present system would be a practical impossibility from the economical point of view.

On the other hand the educational TV and radio broadcasts from a synchronous satellite will make it easy to have the best teaching available anywhere in the country at the cost of installing the receiving equipment and training a monitor from among the local people. (This is important because one of the present problems is that people from cities refuse to move into the interior areas and people from these areas, if brought to cities and trained as teachers, usually do not go back).

The satellite coverage is more complete than even a full coverage ground microwave network, if it existed, because the latter is essentially a point-to-point operation. In addition, a satellite for country-wide coverage can be built and put into orbit in much less time than microwave links could be set up all over Brazil. This saving in time is crucial to a developing country because of present explosive evolution in advanced countries.

Sparsely settled, the vast interior of Brazil presents serious installation and operational difficulties to overland links (in the Amazon region narrow bandwidth troposcatter equipment is being installed due to technical difficulties in the erection of long repeater chains) and involves costs that increase greatly with distance.

The subject of frequency allocation is important. Therefore, Decree 65.239 included the National Council of Telecommunications (CONTEL) in the Technical Coordination Group, for the express purpose of clearing frequency allocation problems, for CONTEL is the representative of Brasil in ITU and CCIR.

The satellite system will take advantage of the existing 4,000,000 plus urban TV receivers through retransmission by local stations. Therefore, satellite broadcasts will not dispense with existing educational TV stations; on the contrary, their own programs will be enriched with those coming via satellite.

Summing up, the satellite system will introduce a "step function" in the Brazilian school system, not just by expanding its capability, but by using to the full the methods of preparation and presentation of the instructional material so as to make it more effective. This improvement in software will be valuable "per se" and is already underway in the preparations for the ATS experiment.

2.2 ATS-F Experiment Objectives and Requirements

2.2.1 Objectives

The prime objectives of the proposed ATS-F Experiment are as follows:

1. To demonstrate (in smaller scale) a total system prototype of the ultimate SACI operational system.
2. To develop, demonstrate and quantitatively avaluate a balanced mix of TV and radio for education, each used in its most advantageous instructional area.
3. To develop satellite-compatible ground hardware with the participation of Brazilian industry, as a prototype for operational hardware.
4. To develop an installation and maintenance organization to serve as a prototype for the ultimate operational system.

It is difficult to quantify beforehand how much the ATS Rio Grande do Norte experiment will mean to that region and to the advancement of space broadcast and educational techniques in general. One of the problems of the new technologies is their being accepted - their very "newness" makes it easy for opponents to ask for supporting data that just does not exist. Thus, an additional objective in this experiment will be to generate such data - controlled data, - in a 53,015 km2 state with 1.3 million inhabitants.

The solution found to management and coordination problems, in an environment lacking facilities that are usual in more developed countries, will be useful to others as well as the operational SACI system. The improvements in teaching material can also be shared with others and data on actual costs will provide a firm basis for estimates. The research that has already started on the equipment for the ground segment will contribute to the production of lower cost good quality equipment.

The experiment is so valuable that it would be worth doing even if there were to be no nation-wide SACI. On the other hand, everything done in the ATS-F experiment preparation, implementation etc., can be regarded as useful to the operational system, no matter what the relative timing between them turns out to be.

2.2.2 Ground Equipment Technical Requirements

The requirements of the ground communication system to be furnished and emplaced by Brazil to operate with the ATS-F satellite are a result of the interaction of several factors:

1. The location, number and desired features of the receiving terminals.
2. The cost of purchasing and installing the receiving terminals.
3. The characteristics of the satellite relay link equipment.

Brazil will establish a system consisting of one ground transmission terminal and 500 to 1000 receiving terminals: 500 of them will be installed pursuant to this experiment and all others above that number will be installed by spontaneous decision of the governors of the Northeastern states.

The basic requirements are as follows:

(1) One transmit terminal - located in Brazil

(2) Receive terminals - located at 500 to 1000 schools in the State of Rio Grande do Norte and other states of the Northeast

(3) Signal mix

One TV channel (video and audio)

Up to 15 voice channels for instructional and administrative purposes.

(4) Capability of operating in complete compatibility with the characteristics of the ATS-F System.

(5) Signal characteristics:

a. TV: TASO Grade 2 (33.5dB) minimum

b. Audio Channels: Output signal quality (S/N) 30 dB minimum

(6) Receive Site Equipment - Capability to receive the signal as retransmitted by the ATS-F transponder and separate the signal components.

(7) Classroom Equipment - Audio and video equipment for each classroom as defined by the specific school characteristics and educational programming.

2.3 Programming Objectives and Requirements

2.3.1 Objectives

The general educational objectives of the experiment are:

1. Improvement of educational opportunities in that area.
2. Quantitative evaluation of effectiveness of the new educational technologies including assessment of a balanced mix of radio and TV.
3. Cost/effectiveness studies of the new media (radio and TV), based on hard data collected in the Brazilian environment.
4. Actual field experience in all aspects of as comprehhensive prototype system involving people, special agencies, local authorities, environmental variety etc.
5. Development of programming techniques, capabilities and cost analyses that will serve in decision making for the operational system.

These objectives single out the proposed experiment as unique in the world. It requires a total systems approach: The school programs will influence the design of the ground equipment, which will also have to take into account the constraints imposed by the satellite. The findings of the follow-up on the work will feed back into the system and influence the educational approach to be taken on the operational system.

More than just setting up equipment, the experiment will require securing support from local people and authorities, mainly on the basis of motivation. Problems in actual management and control will arise, and techniques of day to day coordination of operations, with sometimes less than adequate means of transportation and communications, will have to be envolved.

The experiment will concentrate most of its effort on formal grade-school level, with additions as selecred by state educational authorities. This will permit comparing the different media among themselves, and comparing with the results from control schools which will not have the receiving equipments but will be teaching the same subjects by previous methods. Parameters observed will include enrollments, drop-outs, failures and relative grades, among others.

Subjects will be Portuguese , Social Studies, Science and Mathematics,with lessons actually prepared by teacher teams of the State Secretary of Education in consultation with graduate educational technologists made available by CNAE.

While the preferred experiment time would be 3 or more hours per day over an extended period, any reasonable regular schedule of time available would be acceptable. The experiment plans and education courses are flexible enough to accomodate significant variations to the desired 3 hours per day.

3.0 TECHNICAL CONSIDERATIONS

Preliminary analyses have been performed to establish the technical feasibility of conducting the Project SACI experiment utilizing the ATS-F satellite. These analyses are continuing and will, in the near future, result in the complete specification of the ground equipment to be used in this experiment.

3.1 ATS-F Characteristics

The available data on the planned ATS-F System have been assembled to be used as the technical constraints on the design of the experiment. It is recognized that the satellite characteristics may change prior to the expected launch in Nov 1972. Therefore, the experiment ground equipment was analyzed over a range of values to assure that a compatible design was practical over the range of possible changes **anticipated in** the satellite. Table 3.1-1 shows the parameter values of the satellite used for the nominal ground equipment design.

TABLE 3.1-1 ATS-F TRANSPONDER CHARACTERISTICS FOR ITV

		UPLINK	DOWNLINK
Frequency (GHz)		6.350, 6.150	0.850
Bandwith (MHz)			
- 1dB		25	25
- 3dB		40	40
Antenna			
Type	Horn	Deployable Paraboloid	
Half-power beam width, (degrees)	12.	0.4	2.6
Diameter (feet)	-	30	30
Gain (dB)	22.6	49.9	33
Polarization	Linear	Linear	RCP
Receiver			
Noise Figure of system		7.8 dB	

	UPLINK	DOWNLINK
Transmitter		
Type		Five, solid-state 20-watt amplifiers
Oscillator Stability (Long Term)		3×10^{-6}
Efficiency		43.5% overall
RF Power Out (Nominal)		80 watts
On-axis ERP		51,0 dBw
Orbit Position	100^{o}W to 20^{o}E	
Orbit	Geostationary, max. inclination ≃ ≃ 1.14^{o}	

3.1.1 Frequency Utilization

The present ATS specifications permit use of either UHF or C-band frequencies for the downlink ITV signal mix. The composite video and audio signal will be transmitted to the satellite on a frequency of approximately 6.15 GHz (C-band). The signal will be received at the satellite, translated in frequency to approximately 850 MHz (UHF-band), amplified and retransmitted to the 500 experiment schools in Rio Grande do Norte.

The selection of the UHF band for the downlink was made because the relatively high effective radiated power (ERP) of the satellite at UHF using the 30-foot antenna (51.0 dBw) and the 2.6 degree beam width of the antenna will insure excellent reception throughout the state of Rio Grande do Norte with a minimum of costly equipment on the ground. The use of a C-band frequency for downlink using the 30-foot antenna provides inadequate ground area coverage (0.4 degree HPBW). Use of the alternate Earth Coverage Antenna for a C-band downlink while providing adequate area coverage is very limited in gain (22.6 dB) and would require prohibitively costly ground equipment.

3.1.2 Orbit Considerations

In preparing this proposal, the following satellite orbit locations were assumed:

Launch through Day 270	- At 93^{o}W Longitude
Day 270 through Day 295	- Move to 57^{o}W Longitude
Day 295 through Day 315	- At 57^{o} W Longitude

Day 315 through Day 365 - Move to 15°E Longitude
Day 365 through Day 730 - At 15° E Longitude

The effects of a 1.14 degree inclination were also analyzed. With the spacecraft placed in this orbit at 15°E longitude, the apparent diurnal motion at the transmitting site would be ± 1.45 degrees in azimuth from a true azimuth of 84.8 degrees and ± 0.25 degree from a true elevation of 29.1 degrees (see Figure 3.1-1a).

3.1.3 Duty Cycle Considerations

The planning of the daily broadcast time periods in close conjunction with the other ATS-F experiments is an important factor in the feasibility considerations. Maximum flexibility in integration with other experiments is possible since satellite power available will permit concurrent operation on a non-interference basis and maximize the calendar time available for this educational experiment without seriously constraining other experiments.

On the basis of latest available data, indications are that it will be possible to operate the UHF transponder on the ATS-F at the end of the second year of flight, along with the basic science package for measuring the environment, as well as providing power for housekeeping functions, on a continuous 24-hour basis. Since only three hours per day are being planned for the educational programming, the potential for scheduling the broadcast experiment time without serious impact on other experiments is quite realistic.

The power available to the load at the end of two years is estimated at almost 400 watts during the summer solstice (worst case). Using approximately 184 watts for the UHF transponder and 90 watts for housekeeping, a total of 274 watts are required. This leaves approximately 126 watts minimum for the environment measuring instruments (estimated at 60 watts) and/or other experiments which it may be desirable to operate continuously during the same time as the broadcast experiment.

The one exception to this power capability is, of course, during eclipses occurring over a two-week period at the vernal and autumnal

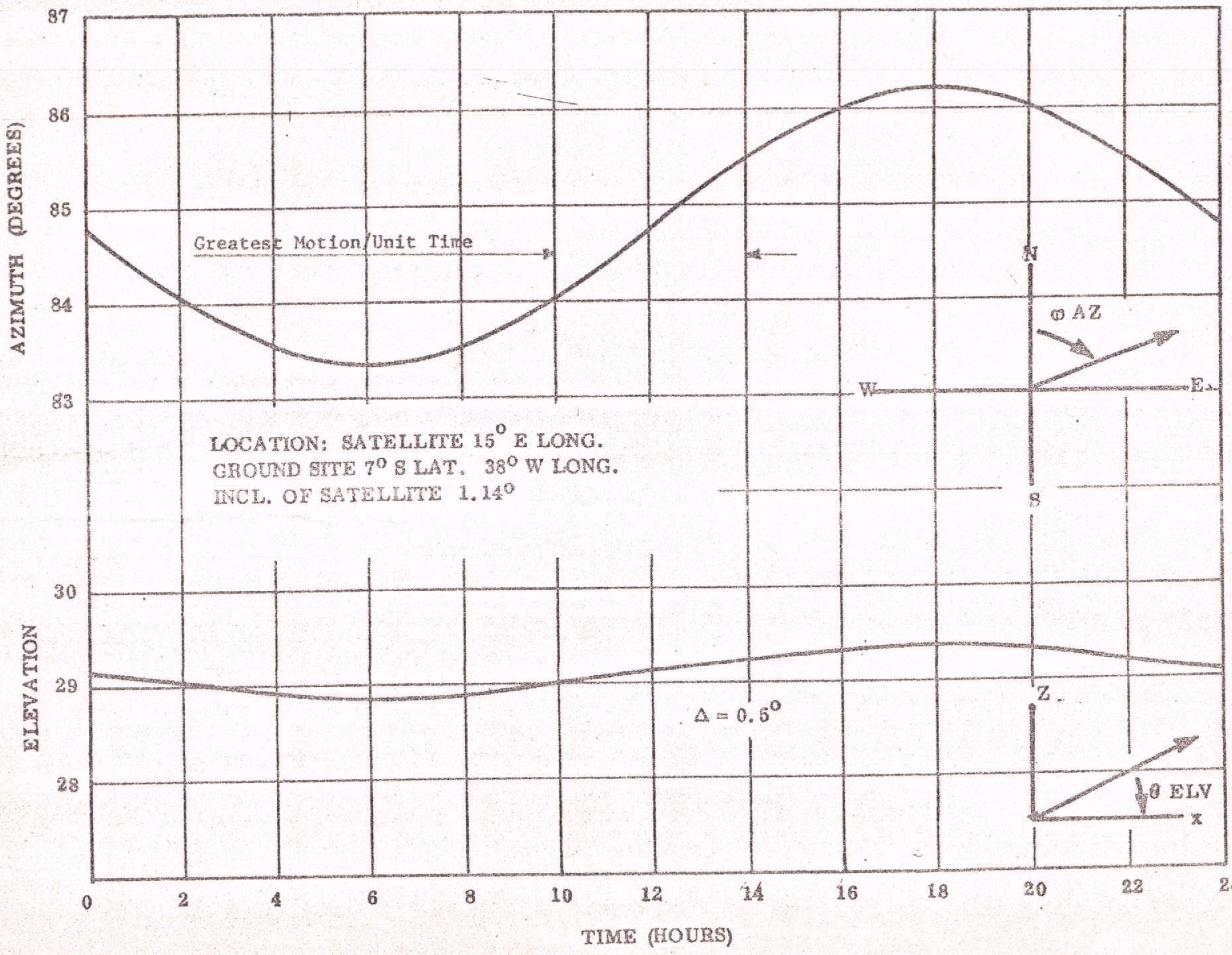


Fig.3.1-1a - Relative Motion of the Satellite in Azimuth and Elevation

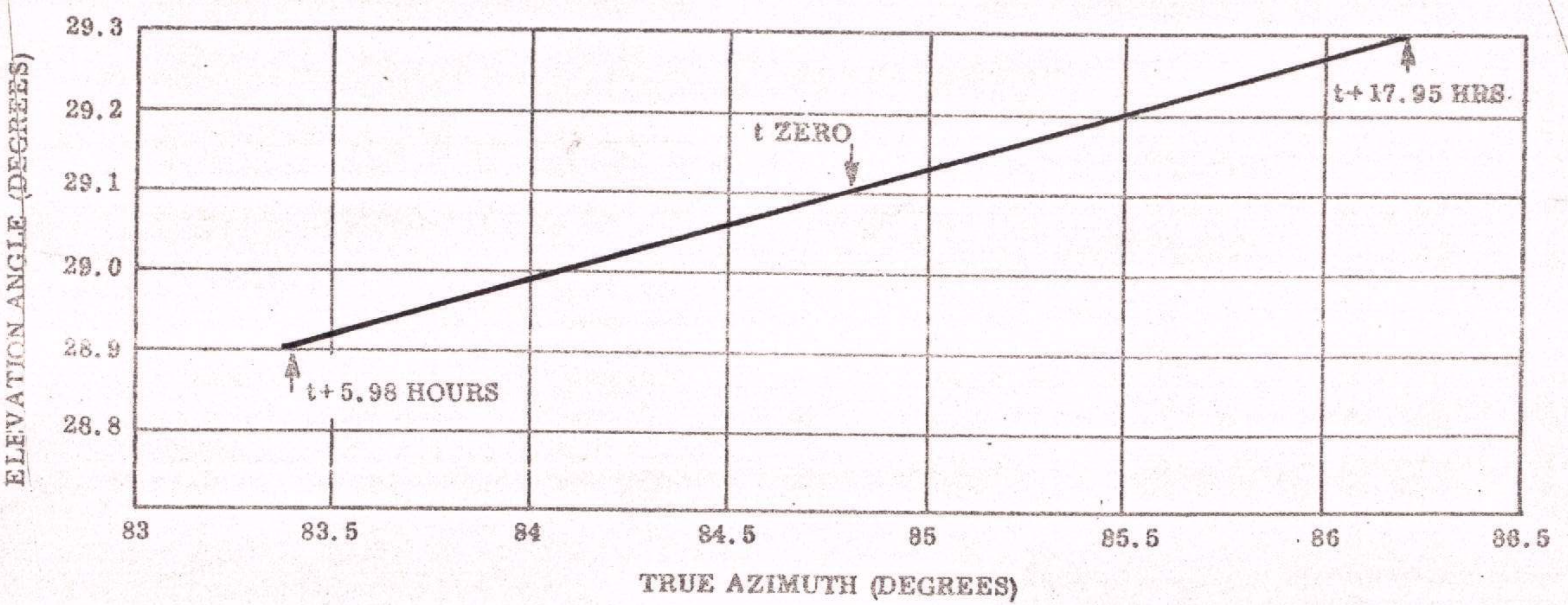


Fig.3.1.1.b - Elevation Angle as a Function of Azimuth with respect to the transmitting site.

equinoxes. However, since the eclipse occurs around local midnight, no problem would arise as the broadcast experiment is not scheduled anywhere near eclipse time, even allowing for the different planned positions of the satellite.

3.2 Link Calculations

This section presents an analysis of the transmission system to be used with the ATS-F satellite. From this analysis, performance requirements for the various equipments were determined and specified.

3.2.1 Downlink

A summary of the downlink calculations is given in the link calculation sheets in the next pages. A discussion of each of the elements of this table is given in the following paragraphs.

1. EFFECTIVE RADIATED POWER (ERP)

The ERP specification value for the ATS-F UHF transponder is 51.0 dBW on axis. Hence, preliminary system design is being based on this value. If future circumstances dictate a change in satellite ERP, the requirements for the ground receiving equipment will be modified to accomodate the change.

2. ANTENNA PATTERN/COVERAGE LOSS

The coverage loss is defined as the decrease in signal power at the edge of the coverage area, as compared with the point on the antenna axis. The coverage area of interest in this case is the state of Rio Grande do Norte. Example pattern contours for two extreme orbit positions for the ATS-F are shown in Figures 1 and 2. It is seen that the 1 dB contours extend well beyond the state of Rio Grande do Norte. Even if the satellite were stationed at the same longitude as Natal (35^{o}W) and with the center of the beam pointed at Natal, all areas of Rio Grande do Norte are within 0.67^{o} of the beam axis, which is less than 0.7 dB below peak antenna gain.

DOWNLINK CALCULATION SHEET

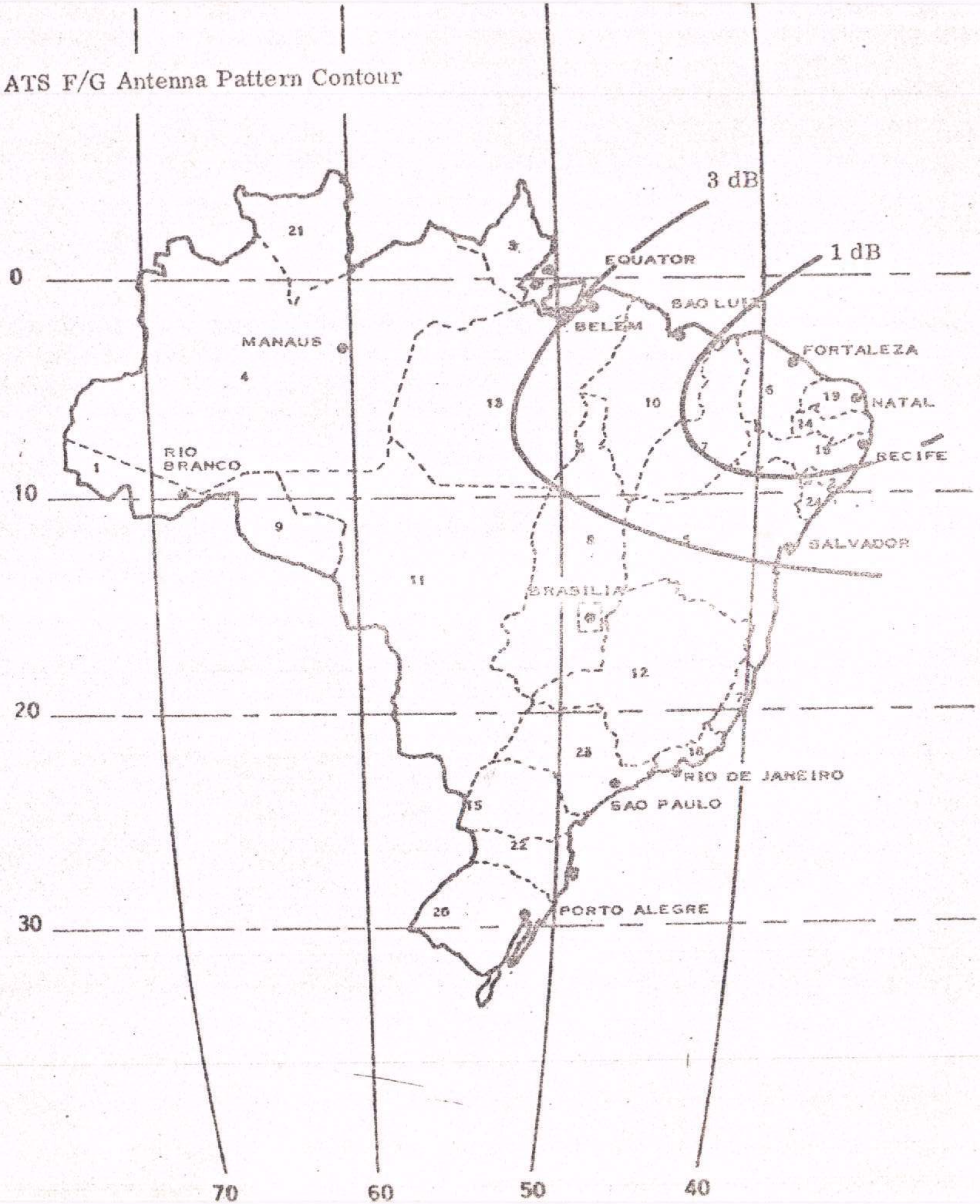
Item No.	Item Title	System Assumption	Gain (dB)	Loss (dB)	Power (dBW)
1	Effective Radiated Power				51.0
2	Antenna Pattern/Coverage Loss			0.7	
3	Free Space Loss	From Extreme Satellite Location		182.8	
4	Atmospheric Losses	Negligible at this Frequency		-	
5	Transmitting Antenna Pointing Losses	Boresight and Attitude Control		0.4	
6	Receiving Antenna on-Axis Gain	Nominal Gain	23.6		
7	Polarization Mismatch	Circular Polarization on Both Antennas		0.7	
8	Receiving Antenna Pointing Losses	Mechanical Pointing		0.3	
9	Net Losses			161.3	
10	Carrier Power at Antenna Terminals				-110.3
11	Antenna Noise Temperature	$336^{o}K$			
12	Receiver Noise Temperature	Noise Figure=3.8dB: $406^{o}K$			
13	Ground Antenna Line Loss	Converter at Antenna Vertex $20,6^{o}K$		0.3	
14	Receiver and Line Noise Temperature at Antenna Terminals	$454.6^{o}K$			
15	System Noise Temperature Referred to Antenna Terminals	$790.6^{o}K$			
16	Receiver IF Noise Bandwidth	25MHz			
17	Receiver Noise Power ($N_R = KT_SB$)				-125.6

Continuation

Item No.	Item Title	System Assumption	Gain (dB)	Loss (dB)	Power (dBW)
18	IF C/N Ratio	15.3 dB			
19	Video Bandwidth				
20	Modulation Index	2.125			
21	Modulation Improvement Factor		22.3		
22	De-Emphasis and Weighting Improvement		10.2		
23	Receiver Output S/N Ratio	47.8 dB			
24	Margin Above Threshold	5.3 dB			

ATS F/G Antenna Pattern Contour

1. ACRE
2. ALAGOAS
3. AMAPA
4. AMAZONAS
5. BAHIA
6. CEARA
7. ESPIRITO SANTO
8. GOIAS
9. GUAPORE (RONDONIA)
10. MARANHAO
11. MATO GROSSO
12. MINAS GERAIS
13. PARA
14. PARAIBA
15. PARANA
16. PERNAMBUCO
17. PIAUI
18. RIO DE JANEIRO
19. RIO GRANDE DO NORTE
20. RIO GRANDE DO SUL
21. RORAIMA
22. SANTA CATARINA
23. SAO PAULO
24. SERGIPE



SATELLITE LOCATION: 15^{o}E
POINTED AT NATAL, BRAZIL

f = 850 MHz

θ_a 1 dB = 1.6^{o}

θ_a 3 dB = 2.8^{o}

1. ACRE
2. ALAGOAS
3. AMAPA
4. AMAZONAS
5. BAHIA
6. CEARA
7. ESPIRITO SANTO
8. GOIAS
9. GUAPORE (RONDONIA)
10. MARANHAO
11. MATO GROSSO
12. MINAS GERAIS
13. PARA
14. PARAIBA
15. PARANA
16. PERNAMBUCO
17. PIAUI
18. RIO DE JANEIRO
19. RIO GRANDE DO NORTE
20. RIO GRANDE DO SUL
21. RORAIMA
22. SANTA CATARINA
23. SAO PAULO
24. SERGIPE

SATELLITE LOCATION - 100^{o} W
BEAM CENTER LOCATION - 7^{o} S, 38^{o} W

f = 850 MHz
1dB = 1.6^{o}
3dB = 2.8^{o}

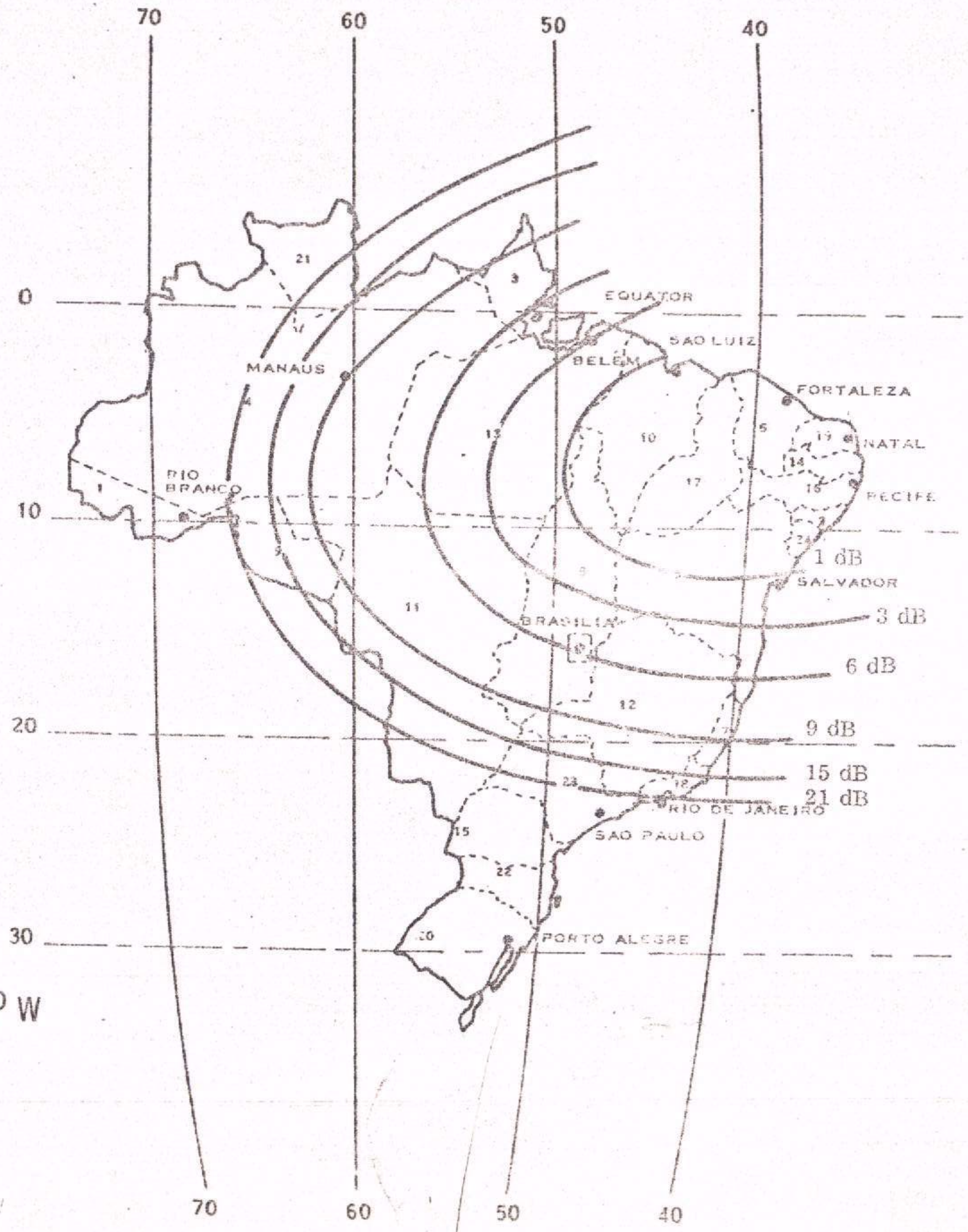


FIGURE 2

3. FREE SPACE LOSS

The free space loss is given by

$$\text{Free space loss (db)} = 37.8 + 20 \log f + 20 \log d$$

where

f = Frequency in MHz

d = Distance in nautical miles

For the subsatellite point, from a synchronous orbit, $d = d_{ss}$ = 19,300 nautical miles. Thus, for a frequency of 850 MHz

$$\text{Free space loss} = 37.8 + 20 \times 2.93 + 20 \times 4.29 = 182.2 \text{ dB.}$$

For other relative locations of satellite and ground stations, the range increases. A curve showing change in path loss referred to satellite position in longitude with the beam centered at 38°W is shown in Figure 3. It is accurate to within 0.1 dB for any ground station within 10 degrees of the equator.

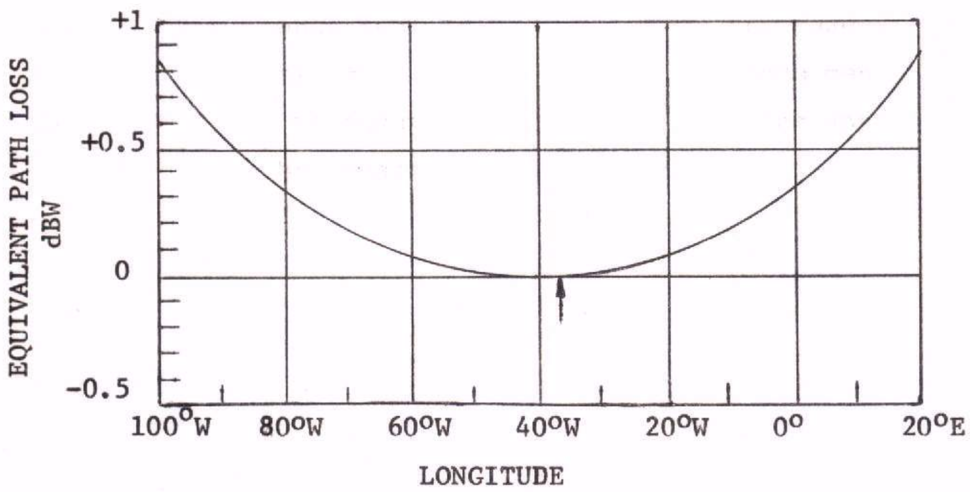


Figure 3 - Change in Equivalent Path Loss as a Function of Longitude (Zero dBW refers to loss from a satellite directly overhead to a 38°W Ground Station)

At the extreme longitudinal positions of the satellite, the increase in path loss is approximately 0.6 dB. Thus the maximum value is

Free space loss = 182.2 + 0.6 = 182.8 dB.

4. ATMOSPHERIC LOSSES

These losses include: ionospheric absorption, tropospheric absorption, Faraday rotation, refraction loss and precipitation absorption.

Data available indicate that for 850 MHz these losses may be neglected.

As to fading, which is severe in the mid-latitudes and in the so-called "high frequencies" (3 to 30 MHz), it can also be neglected in this experiment, which involves Rio Grande do Norte at 6^{o}South and 850 MHz. On the other hand a unique opportunity for research exists in this case.

5. ANTENNA BEAM POINTING LOSS - BORE SIGHT AND ATTITUDE CONTROL

An analysis recently has been made of the ATS-F RF beam pointing error using normal spacecraft attitude control. By combining random errors (sensor and alignment errors) and deterministic errors (attitude control errors and thermal distortion), the 3σ value of RF beam pointing error is 0.183^{o}.

This means that the extreme portion of the state of Rio Grande do Norte will be illuminated by that part of the satellite beam which is 0.853^{o} off axis, rather than 0.67^{o} (see Paragraph 2). This results in an additional loss of 0.4 dB due to beam pointing error.

6. GROUND ANTENNA GAIN

Low cost for a given gain is the major design criterion for the ground antennas. The optimum design, then, would be one which minimizes dollars per db gain. Preliminary design and modeling work indicates that the cost/performance tradeoff is fairly constant for designs which yield

25 to 40 percent antenna efficiency. Higher efficiencies require tighter reflector and alignment tolerances and/or sophisticated feeds. Lower efficiencies poorly utilize the aperture which results in more structure for a given gain. Accordingly, an efficiency of 30 percent has been assumed to estimate nominal antenna gain, with forty percent efficiency as an upper bound. The resulting values of gain for a 10-foot parabola at 850 MHz are then:

	Nominal	Optimistic
Gain	23.6 dB	25.0 dB

7. POLARIZATION MISMATCH

Both the ATS-F UHF antenna and the ground receiving antennas will be circularly polarized, resulting in a slight loss because of less than a perfect match between the two. The expression for mismatch loss is:

$$\frac{P}{P_{max}} = \frac{1}{2}\left[1 + \frac{2\,\varepsilon_2}{\varepsilon_2^2 + 1} \cdot \frac{2\,\varepsilon_1}{\varepsilon_1^2 + 1} + \frac{\varepsilon_2^2 - 1}{\varepsilon_2^2 + 1} \cdot \frac{\varepsilon_1^2 - 1}{\varepsilon_1^2 + 1} \cos 2\alpha\right]$$

where

ε_1 = ellipticity (axial ratio) of Antenna 1

ε_2 = ellipticity of Antenna 2

α = angle between major axes of the two antennas.

The specification on the ATS-F UHF antenna is for an axial ratio of less than 2.5 dB (ε = 1.75) within the -3 dB contour. Although it can be expected that the axial ratio will be much lower within the -0.7 dB contour which encompasses all of the state of Rio Grande do Norte, the value of ε = 1.75 will be used as a worst case value in the calculations.

The ground receiving antenna with its greatly simplified feed aseembly, as compared to the ATS-F, can be expected to have an axial ratio no greater than ε = 1.75.

The maximum loss due to polarization mismatch, as calculated from the above equation, is less than 0.7 dB.

8. GROUND ANTENNA BEAM POINTING LOSS

Pointing of the ground antenna can be accomplished by geometric alignment to the spacecraft coordinates. It is estimated that the antenna axis can be pointed to a given set of coordinates to within ± 0.75 degree. The original parabola boresight accuracy will be about ± 0.2 degree and the maximum boresight error due to wind loading will be about ± 0.4 degree.

Variations in look angle of the satellite as seen from the receiving sites are illustrated in Figure 3.1.1. Note that the greatest change of position of the satellite with respect to time takes place at the mid-point between the two extremes. Even if the transmitting period occurs during the three hours centered at this mid-point of the apparent position, a fixed receiving antenna would see a satellite motion of only $\pm 0.6^{\circ}$. (Sidereal drift of the satellite could make it necessary to reposition the antenna periodically).

The composite effects of the pointing errors for the 10-foot paraboloid at 850 MHz are summarized in the table below.

Error Contributor	Pointing Error (Degrees)
Geometric Alignment	± 0.75
Boresight Error	± 0.2
Wind Loading	± 0.4
Spacecraft Motion	± 0.6
Root Sum Squared Error	1.1

The loss resulting from 1.1° pointing error is less than 0.3 dB.

9. NET LOSSES

This step is a computational convenience, to summarize the losses between the transmitter antenna and the receiver antenna terminals, so that the carrier power can be determined. It consists of adding together the free space losses, atmospheric losses, receiving antenna pointing losses and polarization mismatch losses, and subtracting from them the receiving antenna on-axis gain.

10. CARRIER POWER AT ANTENNA TERMINALS

The carrier power at the antenna terminals is computed by subtracting from the transmitter ERP (Item 1), the total net losses (Item 9).

11. GROUND ANTENNA TEMPERATURE

This analysis provides an estimate for the noise temperature of the 10ft ground antenna at 850 MHz. At his frequency the principal noise contributors are as follows:

	Degrees Kelvin	
	Max	Min
Sky	300	40
Indigeneous	815	0
Ground	290	290

Considering the indigeneous noise to appear in the region below 10 degree elevation, a -14 dB edge illumination and a 30% efficiency, it can be shown that the antenna temperature is given by

$$T_A = 0.40 \left[1.75\ T_S + 0{,}12\ T_I + 217.5 \right] \ ^{o}K$$

The various combinations of T_A may then be tabulated as follows:

	ANTENNA TEMPERATURE (in ^oK)	
T_S \ T_I	Max	Min
Max	336	297
Min	144	115

The condition of maximum indigenous noise temperature is equivalent to a suburban environment in the United States. Although the conditions in Rio Grande do Norte are generally expected to be much less severe a value of 336°K for antenna temperature will be taken as a conservative value.

It is realized here that the effect of the sun as it passes through the receiving antenna beam has been left out. This will occur twice a year and will last for about 20-30 minutes each day for an 8 to 10 day period. The noise increase during this period will be from three to five dB. In this case, even entire cut off of the signal is of no great importance because flexibility of class schedules can take care of the 30 minute silence during 10 days.

12. GROUND RECEIVER CONVERTER NOISE TEMPERATURE

The receiver under consideration has a low noise preamplifier followed by a mixer and IF amplifier. A converter noise figure of 3.8 db can be obtained by the use of a UHF transistor preamplifier followed by a balanced mixer that has a low conversion loss. As an example of a low noise transistor to achieve this performance, transistor type KD5201 has been designed in a circuit to produce a noise figure of 1.7 db and gain of 16 db at an operating frequency of 1 GHz. This transistor is guaranteed by the manufacturer to have a maximum noise figure of 3 db at 1GHz

The overall receiver noise figure is defined as:

$$F_o = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 \, G_2} = 2.4 \text{ (3.8 db)}$$

where

F_1 - noise figure of preamp, numerically equal to 2.
G_1 - gain of preamp, equal to 30
F_2 - noise of mixer, equal to 5
F_3 - noise of IF, equal to 3.16
G_2 - gain of mixer, equal to 0.25

Effective noise temperature $(F_o - 1)\ T_o = 406^oK$.

13. GROUND ANTENNA TO CONVERTER LINE LOSSES

A coaxial cable similar to RG 9 will be used to connect the antenna to the converter. The use of an unbalanced line is convenient for connection to a preamplifier which has inherently unbalanced input. The cable run from the feed to the vertex of the reflector will be less than five feet resulting in a total cable loss of less than 0.3 dB.

14. RECEIVER AND TRANSMISSION LINE NOISE TEMPERATURE AT ANTENNA TERMINALS

The receiver and transmission line noise temperatures at the antenna terminals may be computed by use of the following expression:

$$T_S = T_A + \frac{L}{1-L} T_{RF} + \frac{1}{1-L} T_E$$

where

T_A = Antenna noise temperature

L = Normalized percentage of energy which is absorbed by the line. (L = 1 - Power Out/Power In).

T_{RF} = Ambient temperature of receiver RF components (290°K for most practical systems)

T_E = Effective noise temperature at receiver (= (F-1) 290, where F = receiver noise figure expressed as a power ratio).

The terms $\left[(L/1-L)\ T_{RF} + (1/1-L)\ T_E)\right]$ give the transmission line and receiver temperatures at the antenna terminals. Addinig T_A to this value gives the system noise temperature at the antenna terminals.

15. SYSTEM NOISE TEMPERATURE REFERRED TO ANTENNA TERMINALS

As described in the preceding paragraph, the system noise temperature at the antenna terminals is obtained by adding Items 11 and 14.

16. CONVERTER RECEIVER IF NOISE BANDWIDTH

Since the quality bandwidth (between -1 dB points) of the ATS-F UHF transponder is specified as 25 MHz, the system RF bandwidth will be constrained to this limit. The receiver then will be designed for an IF noise bandwidth of 25 MHz.

17. RECEIVER NOISE POWER

The receiver noise power is given by the expression

$$N_R = KT_SB$$

where

N_R = Receiver noise power (watts)
K = Boltzman's constant = 1.38×10^{-23} joule/°K/Hz
T_S = System noise temperature (°K)
B = System (IF) noise bandwidth (Hz)

18. INTERMEDIATE FREQUENCY (IF) CARRIER-TO-NOISE (C/N) RATIO

The IF C/N ratio is determined on the db scale by subtracting the receiver noise power determined in Item 17 from the carrier power at the antenna terminals, calculated in item 10. In FM systems, it is usually specified that the C/N ratio be nearly at, or well above, the threshold value for the particular modulation index being used. This is based on the common assumptions that the system is unusable below threshold. Therefore, the system will be designed for adequate margin to preclude operation near or below threshold (For a complete discussion of margin see Paragraph 24).

19. VIDEO BANDWIDTH

The video system considered here is one with a bandwidth of 2.5MHz. Adding the 15 audio channels at 100 KHz spacings produces a total signal bandwidth of approximately 4 MHz. The composite signal is used to modulate the carrier.

20 MODULATION INDEX

The baseband signal consists of a composite video and multiple audio signals, with a modulating baseband frequency (f_m) of 4 MHz, which frequency modulate a single carrier (Paragraph 19). A maximum RF bandwidth of 25 MHz has been established (Paragraph 16). Using Carson's rule to determine the maximum allowable modulation index (β), we obtain

$$25 \text{ MHz} = 2\ (\beta + 1)\ 4 \text{ MHz}$$

giving a β of 2.125.

21. MODULATION IMPROVEMENT

Starting from the basic definition of signal-to-noise ratio (Paragraph 23)

$$(S/N)_o = 6\beta^2 \frac{B_{rf}}{f_m} \frac{C}{N_o B_{rf}} I,$$

we define the modulation improvement (M_I), as the excess over the carrier-to-noise ratio, $C/N = C/N_o B_{rf}$ in the input bandwidth, excluding the improvement factors. Thus,

$$M_I = 6\beta^2 \frac{B_{rf}}{f_m}$$

or in db

$$M_I = 7.78 + 20 \log \beta + 10 \log (B_{rf}/f_m)$$

When one or more aural subcarriers are multiplexed with the video signal into the same carrier, the overall deviation is, in general, not equal to that due to the video signal alone. However, the fact that the video baseband is much wider than the aural subcarrier bandwidths tends to make the overall deviation arise primarily from the video signal. Prior to committing the system design to hardware procurement, the actual value of modulation improvement to be expected from such a composite baseband will be verified experimentally.

22. DE-EMPHASIS AND WEIGHTING IMPROVEMENT

In the standard (CCIR) definition of picture quality, as measured by the signal-to-noise ratio, a number is included for the effect of noise weighting. If de-emphasis is also used, the effects are not additive but may be taken into account by considering the joint effect as deriving from a filter whose transfer function is the product of the weighting and de-emphasis curves. These curves[1] are different for different line systems and the consequent improvement also depends on baseband bandwidth, as well as

1. CCIR, Doc. of the XIth Plenary Assembly, Oslo, 1966; Vol.V, Rec.421-1; Vol. IV, Rec. 405

modulation method. For the system considered here, the combined noise weighting/de-emphasis factor in approximately 12.5 dB. The factor for noise weighting alone is 10.2 dB. A decision as to whether pre-emphasis/de-emphasis will be employed is being deferred at the present time; consequently the value of 10.2 dB is being used in the preliminary system design. A final value will be experimentally derived before freezing the hardware design.

23. RECEIVER OUTPUT S/N DEFINITION

The receiver output signal-to-noise ratio (SNR) will be defined as the "peak video signal-to-noise" ratio. This is in accordance with CCIR definition where "peak video signal" is the white-to-blanking level. This level varies somewhat, but a convenient number to take is $\sqrt{2}/2$ of the peak-to-peak amplitude. With the above assumptions, the output SNR can be written as:

$$(S/N)_o = 6\beta^2 \frac{B_{rf}}{f_m} \frac{C}{N_o B_{rf}} I$$

where

- β = $\Delta f/f_m$, is modulation index
- Δf = Peak frequency deviation due to video signal
- f_m = Baseband (video) bandwidth
- B_{rf} = RF (or IF) bandwidth (according to Carson's rule)
- N_o = Receiver one-sided noise spectral density
- C = Carrier power
- I = Improvement due to various factors (e.g., noise weighting, pre-emphasis and de-emphasis).

The factor $C/N_o B_{rf} = C/N$ is the RF carrier-to-noise ratio which must exceed the first threshold for linear operation. The above equation is then conveniently written in db as:

$$(S/N)_o = 7.78 + 20 \log \beta + 10 \log (B_{rf}/f_m) + 10 \log (C/N) + I$$

The link calculation formula, therefore, is the sum of items 18, 21, and 22.

The final assessment of the usability of the signal is to be made according to the picture quality that it provides. The quality grading used is shown in the following listing:

Picture Grade	TASO SNR (db)	Weighted Output SNR (db)
CCIR 0	NA	56
TASO 1	44.5	45.1
TASO 2	33.5	34.1
TASO 3	27	27.6

The TASO grades are defined with respect to input SNR as the ratio of "radio frequency rms signal during sync peaks divided by the rms noise voltage over a 6-mc channel". The CCIR grades are defined with respect to output weighted SNR as "peak-to-peak signal (i.e., white to blanking) to rms weighted noise".

24. SYSTEM MARGIN

In the system design of a communications link it is important that, at every stage of the design, an amount of margin be included which is appropriate to that stage, i.e., consistent with the degree of confidence in the values of the link parameters. The system analyzed here has constraints which prevent the completely free adjustament of parameters to achieve the desired performance (output S/N ratio) at FM threshold; hence, it is necessary to examine both margin over threshold and performance margin.

The output S/N ratio of 48.3 dB determined in this analysis is well above that required for an "excellent" television picture. Therefore, in the present case it is much more important to assure sufficient margin over threshold. For a modulation index of 2.125, the theoretical threshold is at a C/N ratio of approximately 9 dB. Measurements made by GE (during the realization of a contract between NASA and GE for the development of low cost converters) indicate that a practical threshold of 10 db can be obtained with a good converter front-end. Therefore, a minimum margin of 5 dB over this practical threshold of 10 dB is considered necessary to assure confidence that the eventual performance will be as desired. The analysis here has, in every instance, used worst case values. Hence, the calculated margin of 5.3 dB is adequate. In any case receiver and antenna design are still in a stage that allows for alterations to accomodate variations of the above margin as additional experimental data is obtained.

3.2.2 Uplink Calculations

The Uplink transmitting station may take either of two configurations, depending on the antenna employed in the satellite receiver subsystem. This may be the 30-foot paraboloid or a horn antenna. The present proposal takes the former configuration as a baseline and analyses the latter as an alternative.

If the satellite receiver uses the horn antenna, a large transmitter antenna will be employed and tracking will have to be provided to account for both the diurnal motion and sidereal drift. If the 30-foot dish is employed for reception, a smaller transmitter antenna, with a wider beam, accommodating the diurnal motion of the satellite within its contour, will be adequate. The necessity of tracking is thereby eliminated and periodic adjustments will be made for the sidereal displacement.

The calculations are summarized below and tables 3.2-2 and 3.2-3 show the pertinent figures.

3.2.2.1 Baseline Configuration

Free space loss is calculated using the formula presented in the previous section. At 6.15 GHz, the result in the worst situation is 200.0 dB.

Atmospheric losses can be significant at this frequency. Using Holzer's method("Atmospheric attenuation in Satellite Communications", Microwave Journal 3.65), it can be shown that the cloud attenuation can be as high as 2 dB and rain attenuation due to scattering as much as 1 dB. Atmospheric attenuation is approximately 0.2 dB, giving a total for atmospheric losses of 3.2 dB. A model of the tropical atmosphere is shown in Figure 3.2.2-1.

The gain of the ATS-F 30-foot antenna a 6.15 GHz is specified to be 49.9 dB, and feed losses are specified to be 1.8 dB. A total loss of 3.0 dB was considered to include the mentioned feed losses plus pattern/coverage losses of the ground antenna and the satellite's antenna.

The net losses, computed from the above, are 156.3 dB.

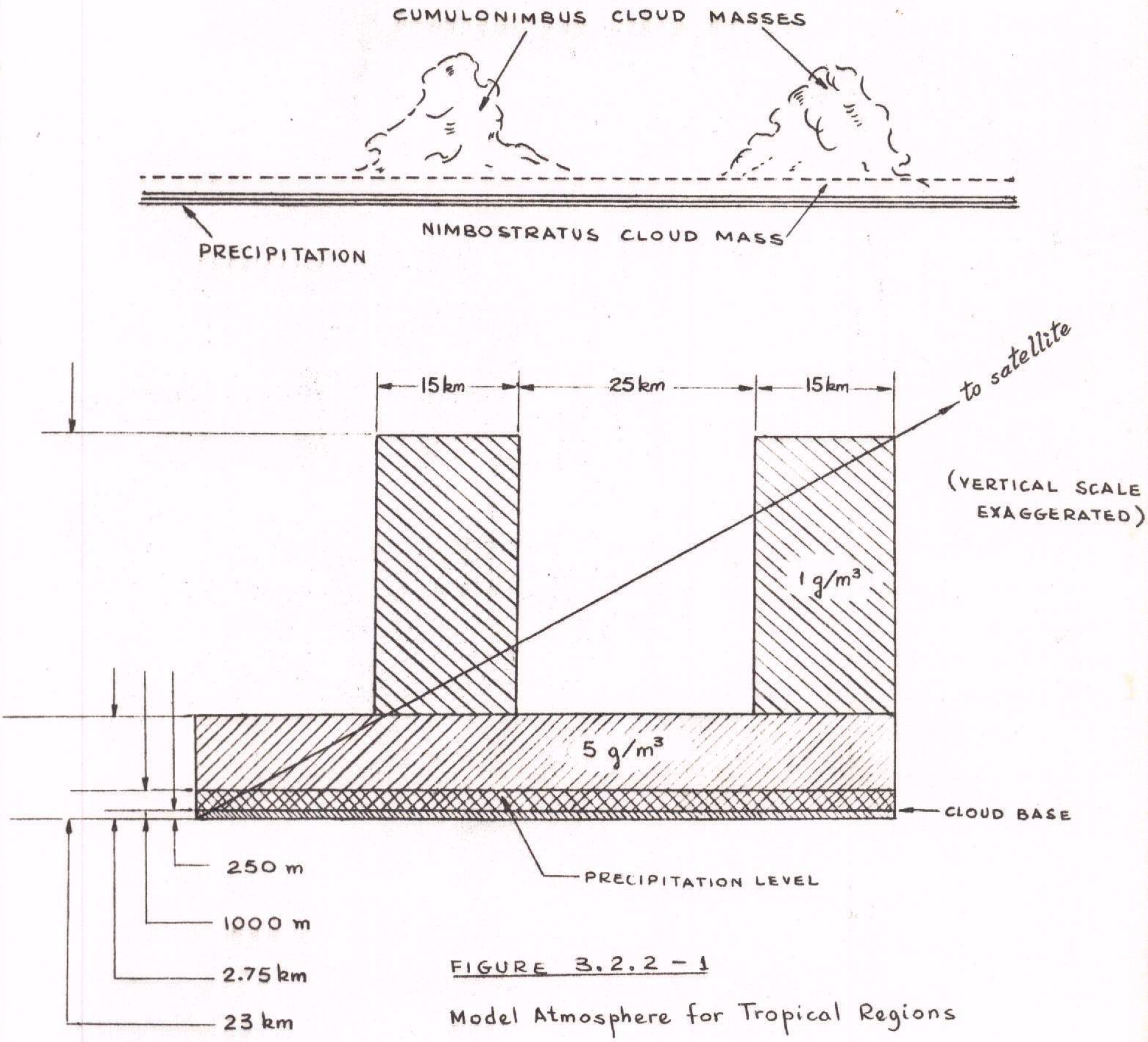


FIGURE 3.2.2 - 1

Model Atmosphere for Tropical Regions

The noise figure of the ATS-F 6150 MHz receiving system is specified as 7.8 dB. Using a 40 MHz receiver noise bandwidth, the receiver noise power is found to be -120.2 dBW.

A design carrier to noise ratio of 20 dB for the uplink was chosen, which is sufficient to maintain the integrity of the 15 dB CNR on the downlink. Thermal noise in the ground receiving system will be increased by only 1 dB under these conditions.

The necessary carrier power at the receiving system's input is, therefore,-100.2 dBW. This finally results on a required on-axis effective radiated power of 56.1 dBW for the ground transmitting system.

To accomodate the diurnal motion of the satellite without tracking it was chosen to use a standard 4-foot antenna, providing a gain of 34.7 dB. The beamwidth of approximately 3 degrees is sufficiently wide for the purpose, and pattern/coverage losses resulting from absence of tracking are consistent with the margin specified in the previous calculations.

The required RF power at the antenna is, thus, 21.4 dBW. Adding 1.5 dB for waveguide losses, the transmitter power output requirement becomes 22.9 dBW, or 195 watt. Standard designs are available at the 1 kilowatt level, and these may permit a smaller antenna to be used. If it becomes desirable to utilize the satellite in some other operational manner, i.e., other than in a continuous 3-hour period, the standard design will provide more than enough power margin to cover the entire satellite motion. In this case, the antenna would be pointed at the midpoint of the satellite track.

3.2.2.2 Alternate Configuration

The gain of the satellite's horn antenna at 6.15 GHz is specified as 22.6 dB. Free space loss and atmospheric absorption loss remain unaffected, and the additional 3-dB will again be considered, allowing for satellite waveguide attenuation and antenna pattern/coverage losses. The net losses thus add to 183.6 dB.

The receiver system noise power may be expected to undergo a reduction, due to the lower antenna temperature of the horn, as compared with the paraboloid. The same value of -120.2 dBW was used in the calculations.

For the same design carrier-to-noise ratio of 20 dB the carrier power at the receiver is again -100.2 dB and the required effective radiated power is now 83.4 dB.

One possibility of meeting this requirement includes the use of a 30-meter parabolic refletor, which will be installed at CNAE in 1971. This antenna can be expected to provide a gain of 63 dB at the uplink frequency, and a tracking system would be necessary. The same transmitter specified in 3.2.3.1 could be used and it would actually exceed the RF power requirement by 1 dB. A minor increase in the free-space and atmospheric losses, due to eventual location of the ground transmitter in the state of S.Paulo, is covered by this margin.

TABLE 3.2-2

Satellite receiver using 30-foot dish.

	Gain (dB)	Loss (dB)	Power (dBW)
free space attenuation		200.0	
atmospheric losses		3.2	
receiver antenna gain	49.9		
satellite feed loss		1.8	
antenna pattern/coverage losses		1.2	
net losses		156.3	
receiver noise power			-120.2
design CNR	20.0		
carrier power at receiver			-100.2
on-axis ERP			56.1

TABLE 3.2-3

Satellite receiver using horn antenna

	Gain (dB)	Loss (dB)	Power (dBW)
free space attenuation		200.0	
atmospheric losses		3.2	
receiver antenna gain	22.6		
satellite feed loss and antenna misalignment		3.0	
net losses		183.6	
receiver noise power			- 120.2
design CNR	20.0		
carrier power at receiver			- 100.2
on-axis ERP			83.4

3.3 Ground Equipment

Descriptions of typical ground station equipment, both up-link and down-link, are given in the following paragraphs.

3.3.1 Up-Link Configuration

A block diagram of the transmitting station, which may be located in Rio Grande do Norte, is shown in Figure 3.3.1-1. Note that it shows a receiving antenna assembly, IF Amplifier, and demodulator - the same equipment as in a standard school receiver site. This is to permit actual on-the-air monitoring of the signal quality.

The other equipment shown is described functionally below:

1. Antenna - A parabolic antenna with a linearly polarized feed and pressurized waveguide. It is designed for one kilowatt, continuous duty.

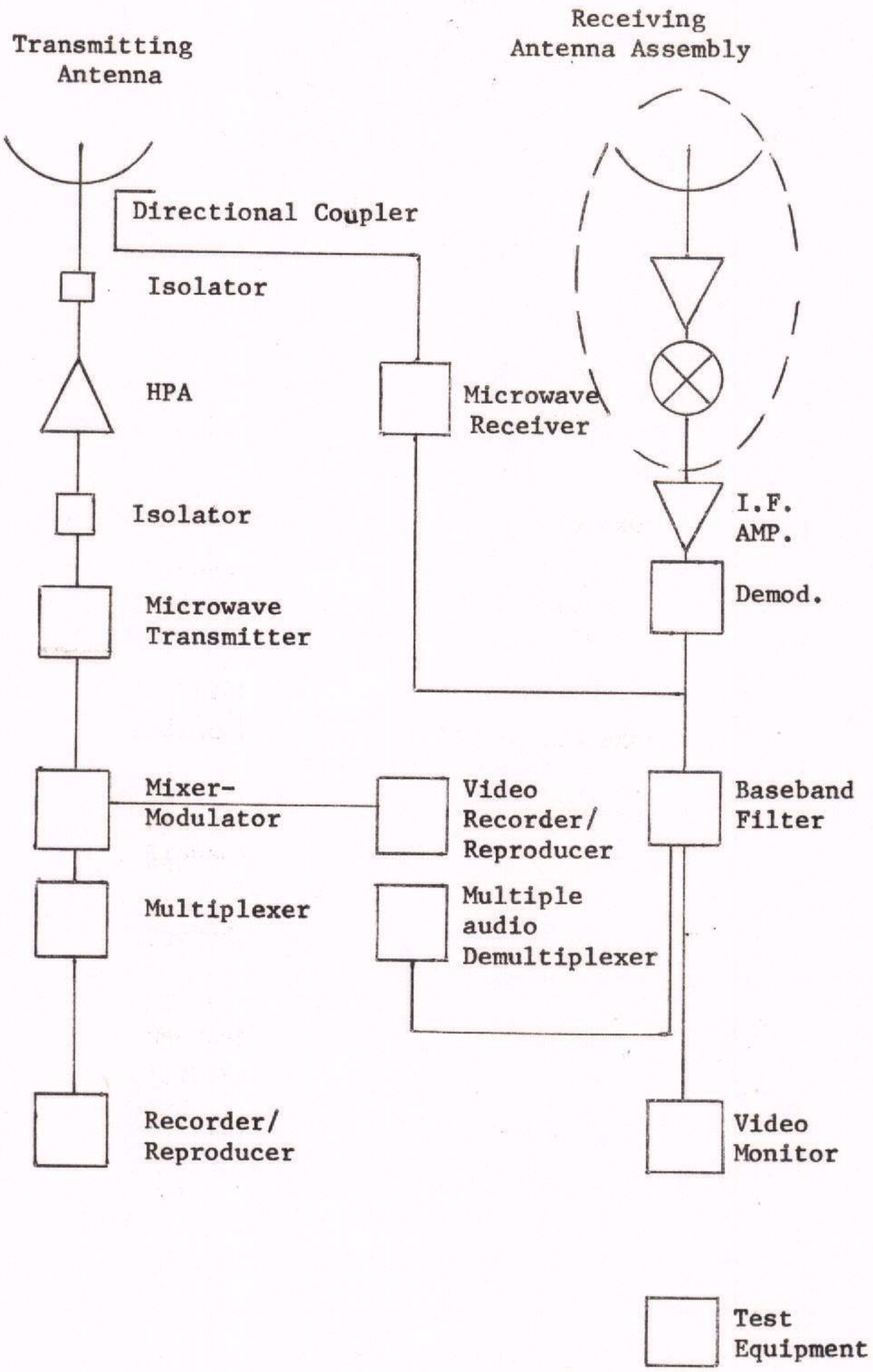


Fig.3.3.1-1 Experiment Transmitting Station

2. Directional Coupler - This provides 60-dB of isolation to an output connector for power measurement and continuous transmitter monitor ing.
3. Microwave Receiver - Used to provide a comparison between the transmitted signal and the "received" signal, permitting an exact measurement of the degree and/or quantity of distortion and noise introduced into the transmitted signal by the satellite and the transmission medium. It is also used (with appropriate test equipment) to facilitate other system measurements.
4. Isolators - These provide necessary isolation between exciter and amplifier, and amplifier and antenna. They prevent undesirable VSWR's and other line perturbations from being reflected back into and possibly demaging, the units which they follow.
5. HPA - This is the "high-power amplifier" which boosts the 1-2 watt signal from the exciter to the 500 watt RF output.
6. Microwave Transmitter - It is the exciter which generates the signal. It and the modulator are generally in one package.
7. Video Recorder/Reproducer - This unit provides the recorded TV signal for the modulator.
8. Multiplexer - This unit compiles the audio channels into a format suitable for the system.
9. Mixer-Modulator - Here the video and audio signals are combined into a baseband signal which will modulate the Microwave Transmitter
10. Baseband Filter - This receive unit splits out the video signal from the multiplexed audio signal.
11. Demultiplexer - Just the opposite of the Multiplexer. It permits monitoring of each individual channel for noise, distortion, and errors, since it presents these channels exactly as they are in each school.
12. Video Monitor - This is used to monitor the quality of the transmitted picture.
13. Recorder/Reproducer - This unit is a multi-track unit which can either record or reproduce lesson material.

3.3.2 Receiving Site Configuration (Schools)

School Sites

Examples of the three types of schools to be equipped with receiving equipment for the ATS-F experiment are as follows:

- Rural - isolated classroom - This is a single classroom school which will be sub-divided into three rooms for the experiment.
- Suburban - isolated school - Contains three classrooms.
- Urban - grupo escolar - Contains many classrooms and has four grades and at least four teachers.

School Equipment

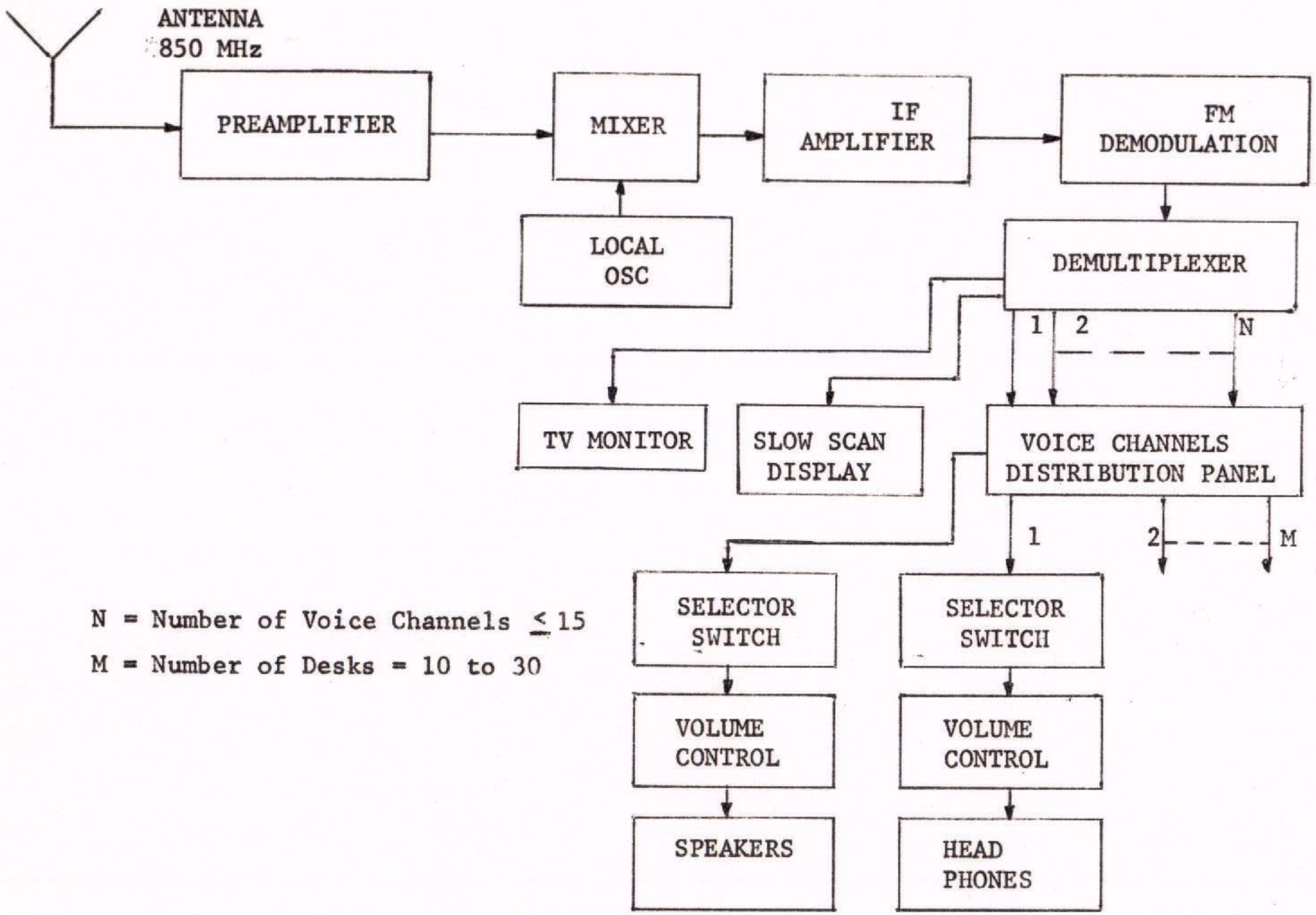
Several different methods of baseband composition and signal transmission have been investigated. An analysis, now in process, to select the final design will be fully compatible with the ATS-F transponder. The requirement calls for up to fifteen audio channels, conventional TV channel and one slow scan TV channel.

A block diagram ofthe equipment to be located at the school sites is shown in Figure 3.3.2.

Plans are for a typical school site to have one classroom equipped with a speaker and individual head phones for each of the desks. The student will be able to select any of 15 audio channels and adjust the volume. Another classroom will be equipped with a TV set and a loud speaker, while the thrid classroom will be equipped with a speaker. At some of the locatinns, the third classroom may also have slow scan TV.

The antenna will probably be a 10 foot parabolic dish (final choice will be based on cost studies currently in process).

The preamplifier, mixer local oscillator, and a broadband amplifier will be located at the antenna. The entire antenna assembly will be mounted either on a roof-top (if the building can stand the load) or on a mount to raise it above ground level to avoid damage. Power to the electronic assembly, as well as the converted signal from it, will be carried on a single



N = Number of Voice Channels $\leq$ 15

M = Number of Desks = 10 to 30

Figure 3.3.2 - Simplified Down-Link Site

piece of coaxial cable or low-loss twin lead. Decoupling at each end will provide the necessary isolation.

The equipment located in the school room consists of baseband signal processing equipment, and baseband signal distribution which is routed to each of the classrooms.

4.0 SOFTWARE CONSIDERATIONS

4.1 Current Educational TV and Radio Activities

TV and Radio have been used for some time in Brazil as aids for education by the federal and the state governments. However, such uses have been of an isolated character, with very few cooperative efforts or exchanges of experience. This has led to the repetition of some basic learning efforts and a lack of unity of effort in the national picture. Project SACI is designed to bring about a nationally unified effort in depth using the best available educational material and techniques.

Both radio and TV, as used up to now in education, have depended on resources locally available at a given time. Radio equipment, for instance, being less expensive than television is quite extensively used in the country. (Cheap bettery receivers can be found practically everywhere). Television, on the other hand, is only found in large urban centers and their peripheries, where commercial TV has taken hold, serving something like 4,000,000 receiving sets.

The following is a qualitative description of the use of TV and Radio in the present Brazilian educational situation:

4.1.1 Educational Radio

The use of radio in educational broadcasting in Brazil began before the use of educational TV. In the Northeast, the Service for Rural Assistance (SAR, after the initials of the title in Portuguese) has contributed to the spread of literacy in the rural areas, where its efforts are concentrated. Another agency, SIRENA - for National Education Radio System - has developed and applied its plan for literacy (but only in 70 counties in Brazil). The MEB (Basic Education Movement), through agreements with SAR has also carried out several literacy campaigns.

About 70% of the existing educational radio programs are concentrated in the coastal strip of Brazil which already enjoys a comparatively good conventional educational system. The educational situation in the interior, on the other hand, is painfully deficient.

In spite of their merits, the educational radio efforts so far have suffered from drawbacks such as difficulties in the way of producing good programs, lack of proper interchange of programs among stations and, principally, deficiencies in following up effects of the broadcasts on student progress in quantitative terms. Also, very few experiments have reached into the interior, where the need is greatest.

The studies of Project SACI indicate, in this respect, a decisive advantage from the nationwide viewpoint because the satellite broadcasts can go with equal ease to any and all areas - rural and urban - of the whole country. Thus, all of the interior can profit from educational broadcasts of the same high quality as available to urban areas.

4.1.2 Educational TV

Closed Circuit Educational TV: ETV is emerging as an important factor in higher learning institutions, like medical schools and others. It makes it possible for all students to watch as if from close up the microspaces so common in anatomy and odontology classes. The usual setup is a closed circuit network and the results in terms of students learning are reflected by grade averages higher than 80%.

As of now, CNAE has first hand information on closed circuit ETV in the following institutions:

University of Brasilia
University of Santa Maria
University of São Paulo

It is also planned to obtain information on closed circuit TV from the universities of Manaus, Goiás, Curitiba,and others.

Open Circuit Educational TV: Open circuit ETV broadcasts cover accelerated high-school, adult education, including literacy classes, and cultural and artistic subjects.

The major effort in open circuit ETV is being made by the

São Paulo state owned Anchieta Foundation, which went on the air operationally in mid-1969, on Channel 2. Its accelerated high-school program has an audience of 120,000, as gauged by the weekly sale of text brochures. These are printed and sold by a large São Paulo publishing house, under an agreement with Anchieta Foundation, but the course contents are under the control of professors of the University of São Paulo.

The Anchieta Foundation's next step is the preparation of a literacy program for radio broadcast. It has already entered into agreements with almost all of the counties of the state of S.Paulo for the actual broadcasting. A business administration course, at college level, it also being planned.

The Anchieta Foundation owns one of the best equipped production centers in Brazil, with studios capable of producing first class educational programs, and it has placed all of its facilities at the disposal of CNAE and the SACI Project.

Also in S.Paulo city, there is the course for Cultural Communicatinns, which trains the specialists needed by the University of São Paulo closed circuit TV and by the Anchieta Foundation.

At Recife, state of Pernambuco, there is the other Brazilian open circuit ETV station, which actually started broadcasting before its S.Paulo sister. It has broadcast language courses (French and English), accelerated high-school courses, ballet and electricity at the industrial technician level. Its capabilities have also been put at the disposal of CNAE for the Rio Grande do Norte experiment and the operational SACI program.

The state of Maine, USA has just donated a 50 KW black and white TV station to Rio Grande do Norte, its siter-state in Partners of the Alliance. The equipment is being prepared for shipment.

Other existing programs like that of the Father Landell de Moura Foundation in Rio Grande do Sul also have accelerated high-school, literacy and adult education courses. This Foundation is very active in promoting workshops and symposia of interested organizations and CNAE has been invited and has attended its meetings, which are excellent opportunities to put forward the SACI idea.

In the state of Maranhão, a program using closed circuit TV in 35 classrooms, with only the pupils in attendance, has given first-class results in teaching accelerated high-schoool courses. On the strength of such success, the state governor has ordered a full fledged open circuit ETV program which is in process of installation.

This picture is completed by the recent strengthening of the Brazilian Foundation Center for TVE, which was included in the Technical Coordination group created by Decree nº 65239, This Foundation has the job of producing programs and coordinating educational TV throughout Brazil. It has entered into a written agreement with CNAE, which is building and equipping a complete modern studio for training and programming, which will be staffed and run by the Foundation. CNAE has acquired the land and ordered the equipment, including video tape recorder/reproducers with color capability. The studio should be ready by July 1970.

Our researches on educational activities require continued contact with the several existing ETV stations and surveys through questionnaires will supply quantitative data on:

Equipment
Personnel, including wages and skills
Facilities for producing didatic programs
Costs
Results of experiments with new techniques
Problem areas in the several regions.

Besides keeping in touch with what goes on in Brazil, correspondence is maintained with some 70 outside institutions that work in the field of educational broadcasting.

4.2 Software Programming Plans for the ATS-F experiment

The work necessary to produce the software required and to plan for the operation and management of the program has been planned out and is described in the following sections:

4.2.1 Preparation of teaching material (software) and personnel training

Plans are already being implemented in these areas which make use of the studios and trained personnel of the Anchieta Foundation, in the state of São Paulo, the Course for Cultural Communications at the University of São Paulo,the studios of the ETV station at Recife, and the new studio being built and equipped by CNAE which will be operated by the Brazilian Foundation Center for TVE.

The program is so structured as to give "on the job" training, by experienced personnel, to new personnel while they are jointly involved in the preparation of didactic material.

4.2.2 Making Cost/Benefit Studies

Cost/Benefit studies of a theoretical nature have been and are still being made. This work is scheduled to continue until July 1970, when refinement of the estimates will begin using the latest data then available. The aim of these studies is to make comparative cost/benefit analyses between the existing educational system and the ATS-augmented educational system (also called the experimental system).

These studies involve the following tasks, which are underway at the present time:

- Data collection in Rio Grande do Norte on the existing education system: number of pupils and teachers; physical condition of schools; expenditures; results obtained. The data will be used to obtain a cost effectiveness ratio of the existing system.
- Estimate of experiment costs:

Cost of equipping pilot studio by CNAE; cost of training program for personnel; cost of preparing didactic material; comparison between investments in the existing educational system and investments in the ATS augmented system.

4.2.3 Development of the Experimental Procedures

One of the major tasks in this area is to assemble and check out a dynamic mathematical model to be used to evaluate the results of the ATS educational experiment. This task is almost complete at this date.

Two other current tasks are:

- The selection of the school sample for the experiment, on the basis of selected significant parameters. This includes both the schools to be included in the experiment and the control schools in Rio Grande do Norte. This work is well underway.

- Refinement of experiment preparatory activities: during 1970 and 1971 integrated teams of statisticians, educational technologists, sociologists, teachers and computer personnel will refine the evaluation measures from the standpoint of educational performance of pupils, cost/benefit ratios and community involvement, i.e., local leadership participation.

Pre-testing of the methods, measurements procudures, etc. resulting from this work will be possible by use of a closed circuit radio-TV link from the studios at CNAE, operated by the Brazilian Foundation Center for TVE, to a nearby municipal school, under the terms of a CNAE/São José dos Campos County cooperative scheme (PLAMCA).

4.2.3.1 Selection of the Sample Schools

The educational TV and radio programs relayed by the ATS-F satellite will be received by a representative sample of schools in 37 counties chosen from the 150 counties in the state of RGN. The sample schools and the required number of control schools will be selected using the results of a survey (just completed) of the facilities of the 150 counties which listed all the educational, commercial, cultural, and state and national government facilities in each county.

The criteria for county - and later - school selection are to select schools representative of the various socio-economic levels existing in the state of RN. This will make possible comparisons of the effectiveness of the existing educational system and the ATS augmented system at the various socio-economic levels.

After the socio-economic data was collected on each of the 150 counties, it was put into a computer program together with weighting factors assigned to the various resources available in each county. This computer program prints out lists of counties having any desired combination of resources (schools, government agencies, etc) or lists by total weighted resource number, etc.

There are actually 35 counties plus the cities of Natal and Mossoró in the sample. These two cities belong in a class by themselves because of their large and varied populations, their extensive school systems and other resources. From this subset the actual school sample will be chosen.

Two school control groups will be formed. The first will consist of schools in the various socio-economic strata which will use the present or conventional educational methods used in the several areas. The second will use conventional educational methods with the improved instructional material used for the ATS-F system, but without radio or TV. Both control groups will be given the same evaluation tests as the experimental set. The possible comparisons are obvious.

The experiment will produce the following data:

<u>Educational Performance</u>: through periodic tests of learning and retentiveness;

<u>Educational Performance x Pupil Situation:</u> so that the results can be checked against special conditions of the students such as socio-economic status, and available study time. To this ends, a questionnaire will be filled out by each student at the beginning of the school year.

<u>Educational Performance x Teaching Media</u>: whereby the three school

groups will be compared, i.e.,

conventional school

conventional school plus improved classroom material

schools in the ATS-F Experiment.

Local Leadership Participation: through the assignment of specific tasks to local inhabitants and periodic checks on their performance.

Cost/Benefits: as noted elsewhere, the ratios "cost/benefit" will be compared for the three groups of schools, taking into account investments made and educational performance.

Additional Collaboration with Other Agencies

From topic 4.1 it is clear that the planning for the experiment will have to include as much collaboration from other agencies as possible.

The key to this collaboration at the level of the Federal Government is the Decree 65.239 (see Section 1.0) which is, in itself, the result of close cooperation between CNAE and the Ministry of Planning, for the original draft was a joint product of the two and several other Government agencies.

In cooperation with the Ministry of Education, CNAE has already entered into an agreement with the Brazilian Center for Educational Television Foundation, which will staff and run an instructional and pilot programming center that CNAE is building and outfitting completely, with color capability included. A closed circuit link to a public school near CNAE, will allow instructional programs to be tested and evaluated. (Equipment delivery to the center is proceeding in schedule and operations should start by July). The executive director for the center has already been recruited as has a skeleton staff, so that actual work can begin as soon as the equipment is in place. A list of items ordered is in the next page, some of which are already being delivered:

2 Vidicon Professional TV Cameras, transistorized, Maxwell model CVPE-68/1, complete with:

- Viewfinder
- Processor
- Remote Control
- 11" Video Monitor with Sync type MV-11/01
- Regulated Power Supply
- Cabling, earphone for operator, dolly, tripod, etc.

2 Zoom lenses CANON C-16, 25/100 mm, F-8

2 Metal Consoles for 11" Video and Waveshape monitors

2 Video Commutator CVT-6, with 6 channels

3 Video Distributor DVT-63/1

1 Regulated Power Source DC-FRT 115/18

1 Sync Generator

1 Sound Table MS-5-CA complete with power supply

1 Studio Signaling System 24-VDC

4 Acoustical Columns with three speakers each

2 Record Players with Pre-Amplifier

2 Microphones PHILIPS types EL-6042/50 and EL-6025/00
Boom and stands for microphones

1 Vidicon Professional TV Camera, transistorized, MAXWELL CVPF-68/2

- Films, including
  - Processor
  - Remote Control
  - 11" Video Monitor with Sync type MV-11/01
  - 25 mm Lens
  - Cabling etc.

1 Optical Multiplexer MOP-02, with prisms

1 Metal Support for Telecine Equipment

1 Metal Console for Video and Waveshape Monitors

4 Waveshape Monitors MFO-3T

1 Internal Communications System with Selector, Two-Way Remote Positions, etc.

6 Video Monitors, 11" MV-11/01, with Sync and Power Supply
10 Video Monitors, 23" MVCF - 23/01
1 Amplifier Sound Monitor AMST - 10/68
1 Plumbicon Camera complete with cabling, etc.
1 CANON Lens set for vidicon CVPE - 68/1 MAXWELL Camera, with 25,50, 75 and 100 mm lenses.
20 Floodlights 1000W
6 Spotlights 2 000W
15 Spotlights 1 000W
15 Spotlights 500W
20 Tripods
20 Pantographs
1 Switchpanel for 60 circuits
1 Set of Spare (100% supply) and full accessories
1 Ampex Videotape Recorder/Reproducer Model VR - 1200 B High/Low Band 60 Hz 525 Lines including:
  - Color Processing Amplifier, Mechanical
  - Spare Parts, Intersync Solid State
1 Set of Ampex Monitor Accessories, plus "Time Element Compensator", Electronic Editor Mark III, etc.

The studio and ancillary rooms occupy a covered area of 6 400 square feet.

In the Northeast the close cooperation with the Federal University of Rio Grande do Norte has resulted in several written agreements. The Rector of the University has more than once appeared before Congressional committees to speak in favor of Project SACI.

The head of the Human Resources Division of the influential SUDENE - the federal Superintendency for the Development of the Northeast - has visited CNAE and has sent a group of his staff to CNAE. He has invited CNAE to send representatives to the meeting of State Secretaries of Education that was called by SUDENE and convened in January, 1970.

The Rio Grande do Norte State Secretary for Education and Culture has written, on December 1969, a letter communicating to CNAE his intent to collaborate in the experiment.

The State Council for Education, also of Rio Grande do Norte, has asked CNAE to nominate a representative to sit in on the council's committee that is framing a three-year educational plan for the state.

The state power utility company - COSERN - and the state telecommunications company - TELERN - have made available to CNAE the use of their transmission network and repeater sites.

The site development agency - COFERN - has joined in the cooperation scheme.

The executive director of Universitary TV, channel 11, at Recife visited CNAE in November, 1969, to discuss details of a collaboration plan.

The mayor of Campina Grande (Paraîba) also is very interested in collaborating with CNAE and the school of engineering has made its computing center available to CNAE.

As recently as December, 1969, the SAR - Service of Rural Assistance - which since 1961 has operated three educational radio stations - at Natal, Caicó and Mossoró - has entered into an agreement with CNAE which will assure the integration of this program into the ATS-F experiment.

A portion of the educational material for the ATS-F Experiment is scheduled to be produced in 1970. By use of several software radio broadcasting stations and a TV repeater to extend the range of the educational TV station in Recife, educational broadcasting will begin in the Northeast section of Brazil in the 1971 school year (February to November 1971). The cooperative efforts of the universities and government agencies in the Northeast - mentioned in previous paragraphs - will make possible this pilot experiment, reaching perhaps 20 percent of the schools, to be included in the ATS-F experiment in 1972-73. In this program, the organization for administering the ATS-F Experiment will be checked out and altered if necessary.

Also, the educational material programmed for the ATS-F Experiment will be used and evaluated, thus producing a high level of confidence in a successful operation of the much larger ATS-F Program.

Last, but not least, CNAE has sparked and entered into a three-way agreement with the Federal University and the Rio Grande do Norte State Government which will result in the installation, by July of this year, of a medium size computer in Natal for joint use by the three entities.

5.0 COST ANALYSIS

This section describes the costs that are associated with the ground portion of the proposed experiment.

A summation of the total costs are presented along with a breakdown of the hardware costs, (uplink transmitting equipment and downlink receiving equipment) and the software costs (preparation and use of program materials) as well as appropriate funding for system engineering, design, and integration. Also presented is a summary discussion of the funding approach at CNAE that will assure adequate funds to prepare for and complete the experiment. Note again that this proposal is not a request for funding but only for the use of experiment time with the ATS-F satellite. This section is presented primarily to delineate the total cost problem and to illustrate the realistic approach being taken by CNAE.

5.1 Ground Equipment Cost Analysis

These costs are for a transmitting site equipment located in Natal and all the equipment (receivers, demultiplexers, etc) at the 500 schools located in the state of Rio Grande do Norte.

5.1.1 Transmit Site

In Table A, below, the transmitting site equipment is listed. Since all the ATS-F spacecraft housekeeping functions will be performed by NASA, no telemetry, tracking and command ground station equipment need be provided by CNAE. Only the equipment that is actually necessary for the transmission of the Instructional material to the ATS-F satellite will be supplied.

TABLE A

UPLINK TRANSMIT STATION

Item	Min.	COST	Max.
Antenna C-Band 4.5 meter diameter Manual Position Mount Waveguide Feed (into station)	5,500		6,000
Directional Coupler		400	
C-Band Microwave Receiver		2,000	
Isolator		150	
C-Band Amplifier 500-1000 watts	23,000		25,000
C-Band Exciter - Transmitter 2 to 3 watts output		2,000	
Fifteen Channel Multiplexer	12,000		20,000
Video Recorder/Reproducers		35,000	
Audio Recorder/Reproducers 15 channels each unit		4,500	
TOTAL US$	84,550		95,050

The above represents the most critical link in the hardware chain and any single failure within this link results in downtime in the experiment.

In order to minimize the probability of such outages, the following standby equipment (Table B) will be duplicated at the uplink transmit station.

TABLE B

REDUNDANT EQUIPMENT FOR THE UPLINK TRANSMIT STATION

Item	Cost		
C-Band Amplifier 500-1000 watts	23,000	to	25,000
C-Band Exciter Transmitter 2 to 3 watts output		2,000	
Fifteen Channel Multiplexer	12,000	to	20,000
TOTAL US$	27,000	to	47,000

In addition to the above, there will be located at the transmitting station the equipment listed in Table C. This is essentially a set of the same types of equipment that will be located at each of the schools.

TABLE C

UHF EQUIPMENT AT THE TRANSMIT STATION

Item	Cost		
Antenna UHF 10 ft. Diameter RHCP		47	
Preamplifier, Mixer, IF, Demodulator		200	
Coax Cable into Station		3	
Demultiplexer/Distribution	900		5,000
Standard TV Receiver		150	
Audio Channel Selector } Earphones }	160		200
Slow Scan TV Display		250	
Facsimile		2,000	
TOTAL US$	3,710	to	7,850

The Transmitting Station would require both special purpose as well as general purpose test equipment. The equipment will be primarily used for the daily checkout and maintenance of the station. This equipment is listed in Table D.

TABLE D

TRANSMITTING STATION TEST EQUIPMENT

Item		Cost
Link Analyzer		7,200
Noise Test Set		4,000
Oscilloscope		1,500
Signal Generator		250
RF Millivoltmeter		400
Multimeters, VRVM		450
Misc. Microwave Test Equipment		1,000
Soldering Irons, Tools, etc.		200
TOTAL	US$	15,000

From a summation of the totals of Tables A, B, C, and D, the total cost of the equipment located at the transmitting station is US$140,260 to US$ 164,900.

The above represents the cost of the equipment if purchased in the U.S. To the above must be added the cost of transportation charges and insurance. For these, the best estimate is approximately 16% of the purchase price. Therefore, the cost of the Transmit Equipment delivered on site is US$ 162,690 to 191,270. Additional cost associated with the transmitter station is for the building, its facilities and personnel. These costs are shown in Table E on the next page.

TABLE E

TRANSMIT STATION FACILITIES

Item	Cost
Building - 480 sq. ft. $7 per sq. ft.	3,360
Air Conditioning, 5 tons	4,800
Furniture and Fixtures	1,000
Operating Costs	1,500
TOTAL	US$ 10,660

The following personnel (Table F) will be required to operate and maintain the facility.

TABLE F

TRANSMIT STATION PERSONNEL

Item			
Engineer - 6 to 12 months	2,800	to	5,600
Technician - 6 to 12 months	2,250	to	4,500
TOTAL	US$ 5,050	to	10,100

The cost of installation and checkout labor is covered in the above estimate.

5.1.2 Receive Sites

The equipment located at each of the 500 receive sites (schools) is as shown in Table G. The costs figures presented are based on estimated U.S. production costs for the quantity of each item necessary to equip 500 schools. A program is underway to determine the cost of the same equipment if manufactured in Brazil.

TABLE G

RECEIVE SITE EQUIPMENT

Item		
Antenna and Support Structure	47	23,500
RF Electronics (Preamplifie Mixer, IF, Demodulator)	200	100,000
Coax Cable into School	3	1,500
Baseband Signal Processing Equipment	900-5000	450,000 to 2,500,000
Baseband Signal Distribution	160-200	80,000 to 100,000
Student "Console" Items Standard TV Receiver	150	75,000
Slow Scan TV Display (10 schools)	250	2,500
Facsimile (5 schools)	2,000	10,000
TOTAL		US$ 742,500 - 2,812,500

These estimates are still subject to improvement because the design has not yet been "frozen".

A case in point, for instance, is the contemplated use of slow-scan TV.

5.2 Programming Cost

This estimate of programming cost assumes:

(1) A one-year preparatory period

(2) An experimental period consisting of 240 day school year (40 weeks of 6 days from Monday to Saturday)

(3) Three hours per day of television programming, (with some repetition)

(4) Eighteen total hours a day of radio programming, with repetition.

(5) 1 TV channel

(6) Eight (8) audio channels will be used as follows: two (2) for primary courses, one each for literacy, vocational, teacher and administrative instruction and two (2) to be held in reserve.

(7) Primary, literacy, vocational and administrative instruction will be given five (5) days per week. Teacher training will be given 5 days per week on an audio channel and one day per week on the TV channel.

(Table 2 in next page shows a detailed time schedule).

TABLE 2 PROGRAMMING TV AND RADIO CHANNELS

CHANNELS	8:10	8:20	8:30	8:40	8:50	9:00	9:10	9:20	9:30	9:40	9:48	9:56	10:04	10:12	10:20	10:28	10:36	10:44	10:52	11:00	
TV	1st Math	3rd Math	2nd Math	4th Math	5th Math	1st Port	3rd Port	2nd Port	4th Port	5th Port	1st Soc.	3rd Soc.	2nd Soc.	4th Soc.	5th Soc.	1st Sc.	3rd Sc.	2nd Sc.	4th Sc.	5th Sc.	NOMINAL OR TOTAL – MINIMUM
Ra(1)	2nd Math	2nd Math	1st Math	1st Math		2nd Port	2nd Port	1st Port	1st Port	Adm Ins	2nd Soc.	2nd Soc.	1st Soc.	1st Soc.	Adm Ins	2nd Sc.	2nd Sc.	1st Sc.	1st Sc.	Adm Ins	NOMINAL OR TOTAL – MINIMUM
Ra(2)	4th Math	4th Math	3rd Math	3rd Math		4th Port	4th Port	3rd Port	3rd Port	Adm Ins	4th Soc.	4th Soc.	3rd Soc.	3rd Soc.	Adm Ins	4th Sc.	4th Sc.	3rd Sc.	3rd Sc.	Adm Ins	NOMINAL OR TOTAL – MINIMUM
Ra(3)	5th Math	5th Math				5th Port	5th Port	Adm Ins	Adm Ins	Adm Ins	5th Soc.	5th Soc.	Adm Ins	Adm Ins	Adm Ins	5th Sc.	5th Sc.	Adm Ins	Adm Ins	Adm Ins	NOMINAL OR TOTAL – MINIMUM
Ra(4)	T	E	A **A**	C **N**	H D	E	R'	S	 **A**	 D	 **M**	T	R	A	I **I**	N **N**	I **S**	N	G		NOMINAL OR TOTAL
Ra(5)	R	E	S	E	R	V	E					R	E	S	E	R	V	E			NOMINAL OR TOTAL
Ra(6)	R	E	S	E	R	V	E					R	E	S	E	R	V	E			NOMINAL OR TOTAL
Ra(7)	A	D	U	L	T							L	I	T	E	R	A	C	Y		NOMINAL OR TOTAL – SUPLEMENTARY
Ra(8)	V	O	C	A	C	I	O	N	A	L		T	R	A	I	N	I	N	G		NOMINAL OR TOTAL – SUPLEMENTARY

Math = Mathematics
Port = Portuguese

Soc = Social Studies
Sc. = Science

Adm Ins = Administrative Instruction

5.2.1 Capital Equipment

Following are the capital equipment costs for establishing the Programming Center at CNAE in São José dos Campos:

1. Studio ($35,000) videotape recorder ($76,000)	$ 111,000
2. Soundtape Recorders, 15 at $500	7,500
3. Soundtape (1200 hours for general studio use and short term storage) ($2 per hour)	2,400
4. Video tape (600 hours for general, short-term storage use, etc., at $150/hour)	90,000
TOTAL	**$ 210,900**

5.2.2 Project SACI Personnel

The following costs are estimated for Project SACI planning and supervisory individuals:

1. A Radio and a Television Director	$ 20,000
2. Two Educators to co-ordinate programs	20,000
3. 4 Technicians	20,000
4. 3 Secretaries	12,000
5. Assisting staff in programming of work books: Designer, programmer, graphics, local teacher, consultants	32,000
6. Training Abroad - (airfare plus maintenance allowance for 20 people)	40,000
TOTAL	144,000

5.2.3 Tape Preparation

Following are the material and time costs of preparing the educational tapes:

1. Primary Course (grade school)

Primary course with the following subjects: Portuguese, Mathematics Social Studies and Science.

a. Cost of the TV programming

We are going to use a channel with 15 hours per week that will transmit 50 classes of 10 minutes each and 50 classes of 8 minutes each for the 5 grades and the four subjects (see table 2). The estimated cost of a minute of TV class instruction in US$ 14.25, according to information from Channel 2. S.Paulo, based on 6 months of experience. So, the cost of an hour will be:

(14.25) (60) = $855,00

Therefore, the cost will be:

(15h/week) (40 weeks) ($855,00) = 513,000

b. Cost of the Radio Programming

We will need three channels, each with 15 hours available per week. These channels with provide the following (see table 2):

50 classes of 20 minutes duration

50 classes of 16 minutes duration

15 hours of administration instruction per week (see item 5)

Preparations costs

The cost of a minute of preparation of a class is $1.25, then the cost of an hour will be:

($1.25) x (60) = $75.00

Therefore, the cost will be:

(30 hours) (40 weeks) (75.00) = $90.000

Total cost of preparing primary courses:

$513,000 + 90,000 = 603,000 (1)

2. Literacy Instruction

We need a radio channel with 15 hours a week.

Analogously, considering the cost of a minute of preparing a class, we have:

(15 hours) (40 weeks) ($75.00) = 45.000 (2)

3. Vocational Training

For vocational training, to be decided jointly with state authorities, we foresee three distinct series of training.

For 15 hours a week available by a radio channel, we estimate that the cost will be:

(15 hours) x (40 weeks) ($75.00) =$45.000 (3)

4. Teachers Training

In order to train the teachers we will make use of radio and TV channels.

Radio part, as for vocational training,

$ 45.000 (4)

Cost of the TV part

It will be possible to use three hours per week of the TV channel already allocated, every Saturday.

Therefore, the preparation cost will be:

(3 hours/week) (40 weeks) ($855.00) = 102.600 (5)

Total costs of teachers training:

$45.000 + 102.600 =$147.600 (4) + (5)

5. Administrative Instructions

For these we will use the remaining the 15 hours of the three radio channels discussed in item 1b. Therefore the preparation cost will be:

(15 hours/week) x (40 weeks) ($75.00) = $45.000 (6)

5.2.4 Additional Administration Costs

1. Printed material for the students:
   500 instruction centers, 30 students each, at an average of $5.00/student-year, we have:

   (15,000) ($5,00) = $75,000

2. One year, 10 supervisory persons at 3.600 per year = 36,000

3. Extra pay for extra responsibility of instructional center teachers at $100/teacher-year 50,000

4. Evaluation team, 6 persons at $400/month 28,800

   Total Additional Administrative Costs $ 189,800

5.2.5 Programming Cost Summary

The total programming costs for a 500 ground station system are estimated to be $1,430,300 (See in page 5.13, "NB" after "TOTAL SOFTWARE COSTS").

5.3 Cost Estimate Summary

The costs detailed in the previous sections are summarized in Table 5.3-1 for better visibility of the total Experiment Program. The programming costs are based on actual Brazilian salaries and on specific Brazilian experience in programming educational material such as that of the Channel 2 Studio in São Paulo, so there is a high confidence in the validity of the cost estimates. The hardware cost estimates were obtained through vendor contacts in the U.S. by NCAE's system consultants for the specific equipment to be used. The cost of the system engineering, design, integration, and installation is also indicated since this is the effort required to coordinate and lead the hardware procurement.

It is recognized that the minimum value of total cost shown in Table 5.3-1 is somewhat optimisic . However, CNAE's plans account for sufficient funding even if the costs approach the very conservative maximum value of approximately 4.95 million dollars.

TABLE 5.3-1 - Cost Summary

Software and Programming Costs	U.S. Dollars	
Studio including equipment (Brazilian Center of ETV Foundation at CNAE)	210.900	(a)
Salaries and training of planning and integration personnel at CNAE	144,000	(b)
Programming of:		
Primary Education Courses	603,000	
Literacy Instruction Courses	45,000	
Vocational Training Courses	45,000	
Teachers Training	147,600	
Administrative Instructions	45,000	
Total Programming Costs	885,600	(c)
Administrative Costs		
Classroom Workbooks	75,000	
Supervisory & Evaluation Personnel	114,800	
	189,800	(d)
TOTAL SOFTWARE COSTS (a) + (b) + (c) +(d)	1.430,300	

NB - An additional $3,000,000 will be spent for preparation of "programmed instruction" texts, as part of the studies in the application of new educational technologies to the Brazilian school system.

Table 5.3-1 - Cont.

Hardware & Engineering Costs

Transmit Station		
Prime Equipment	84,550 - 95,050	A
Back-up Equipment	37,000 - 47,000	B
UHF Monitor Equipment	3,710 - 7,850	C
Test Equipment	15,000	D
Transportation, insurance, etc (to site)	22,430 - 26.370	
Building	10,660	E
Salaries	5,050 - 10,100	F
Total - Transmit Station	(178,400 -212,030)	
Receive Site Equipment	(742,500 - 2,812,500)	G
HARDWARE - TOTAL	920,900 - 3,024,530	
System Engineering, Design, Integration and Installation	300,00 - 500,000 (estimated)	
Total Equipment Costs	1,200,900 - 3,524,530	
TOTAL BRAZILIAN (SOFTWARE & HARDWARE) COSTS	2,631,200 - 4,954,830	

(See mention of additional $3 million in NB under 5.2.5 of page 5.13).

5.4 Funding Considerations

From its own five-year plan, drawn up in 1968, CNAE has available funding equivalent to approximately one million dollars for the ATS-F experiment. As estimated costs become more definite, additional funding will be procured, as the accomplishments of the organization have given it a strong credibility, both in Brazil and outside. This reputation is supported by accomplishments including the following facts:

The Brazilian Bank for National Development has granted in 1969 the equivalent of two million dollars for equipment. The title to it remains with the bank but CNAE will have the instruments installed in its premises for permanent use, free of charge.

Topping it all, it should be pointed out that the Brazilian Government has established 26 high priority projects, of which four are on the areas of communications for educational use, earth resources survey with remote sensing, geodesy using space techniques and systems analyses, as proposed by CNAE. These four alone amount to over 40 million dollars for the next three years.

Another CNAE proposal has also received full support and will mean a financing of over 10 million dollars, put up by the Brazilian Government.

As a sequel to the UNESCO mission visit to CNAE, a special envoy from the World Bank came to S.José dos Campos to gather first-hand information on the SACI Project and, because of having been favorably impressed, was kind enough to share with us some of his knowledge on the financing of projects in general.

The Brazilian industry is keenly interested in this experiment, to the point that industrial concerns with main offices in Europe have offered actual training to CNAE personnel, free of charge, besides making it a point to maintain contact by sending their representatives to S.José dos Campos for personal talks.

It is worthwhile to emphasize the enthusiasm of local organizations and authorities of Rio Grande do Norte, Paraíba and Pernambuco, who have pledged actual support to this project. This means help that might otherwise have to be paid for, and then with no assurance of complete cooperation by other involved organizations.

6.0 ATS-F EXPERIMENT PROGRAM PLAN

6.1 Main Guidelines

As an indispensable preliminary to the appreciation of the chronograms of this section the experiment's guidelines are summed up below as:

1. To bring to Brazil as soon as possible the advantages of a System of Advanced Educational Technologies.
2. To establish one more instance of fruitful collaboration between U.S. and Brazil in the peaceful use of outer space.
3. To promote the transfer of as many new technologies to the Brazilian industry as possible.
4. To carry through to completion another project that requires careful integrated management of complex activities, involving several agencies and individuals scattered in a rather large area.

Assuming that the ATS-F launch will be in late 1972, the planned school broadcasts may appropriately start in the beginning of the Brazilian school-year, i.e., in March 1973. Of course, from 1st February 1973, short time operation for the opening of channels and other testing should take place. Also, from launch date to the 1st of February very small time slots would be used for testing the installation.

The above considerations fit in with the time estimates shown for the design, development and manufacture of the equipment in Brazil, although it should be pointed out that, if necessary, six months can be cut from the time shown by having certain items made outside of Brazil.

From the educational point of view the several pre-ATS-F efforts are already creating an awareness of the need for the new technologies, for improved testing of students' progress and last, but most important, the idea of this satellite experiment has generated in the region a wave of enthusiasm and hope.

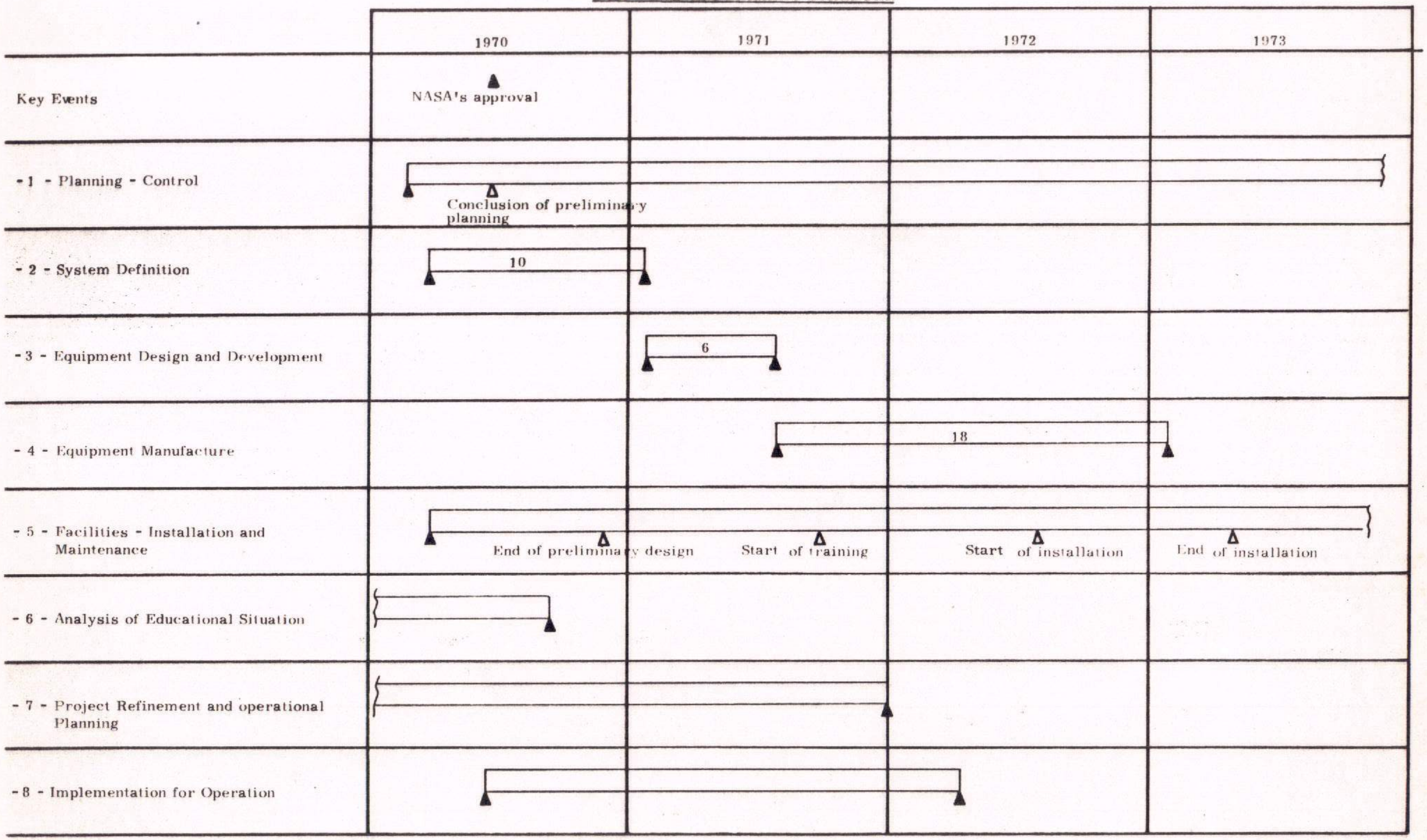
6.2 Chronograms

The five charts that follow are:

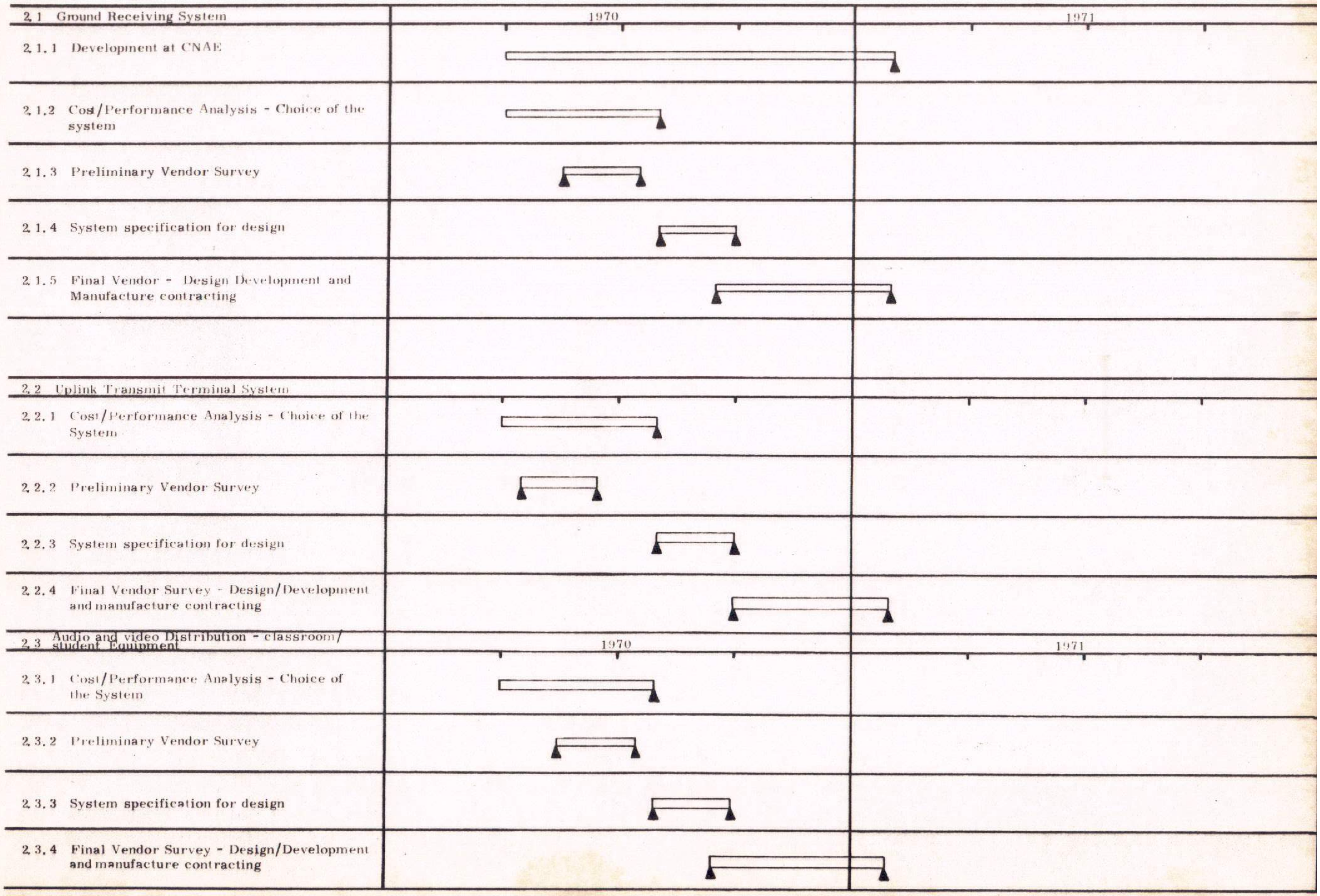
- Master schedule
- System Definition Schedule
- Equipment Design, Development and Manufacture Schedule
- Facilities, Installation and Maintenance Schedule
- Educational Software Schedule.

The planning work continues on an iterative base so that new facts can be taken into account for frequent up-dating of the schedules. Therefore, the charts now presented picture the planning as it appears at the time of this writing.

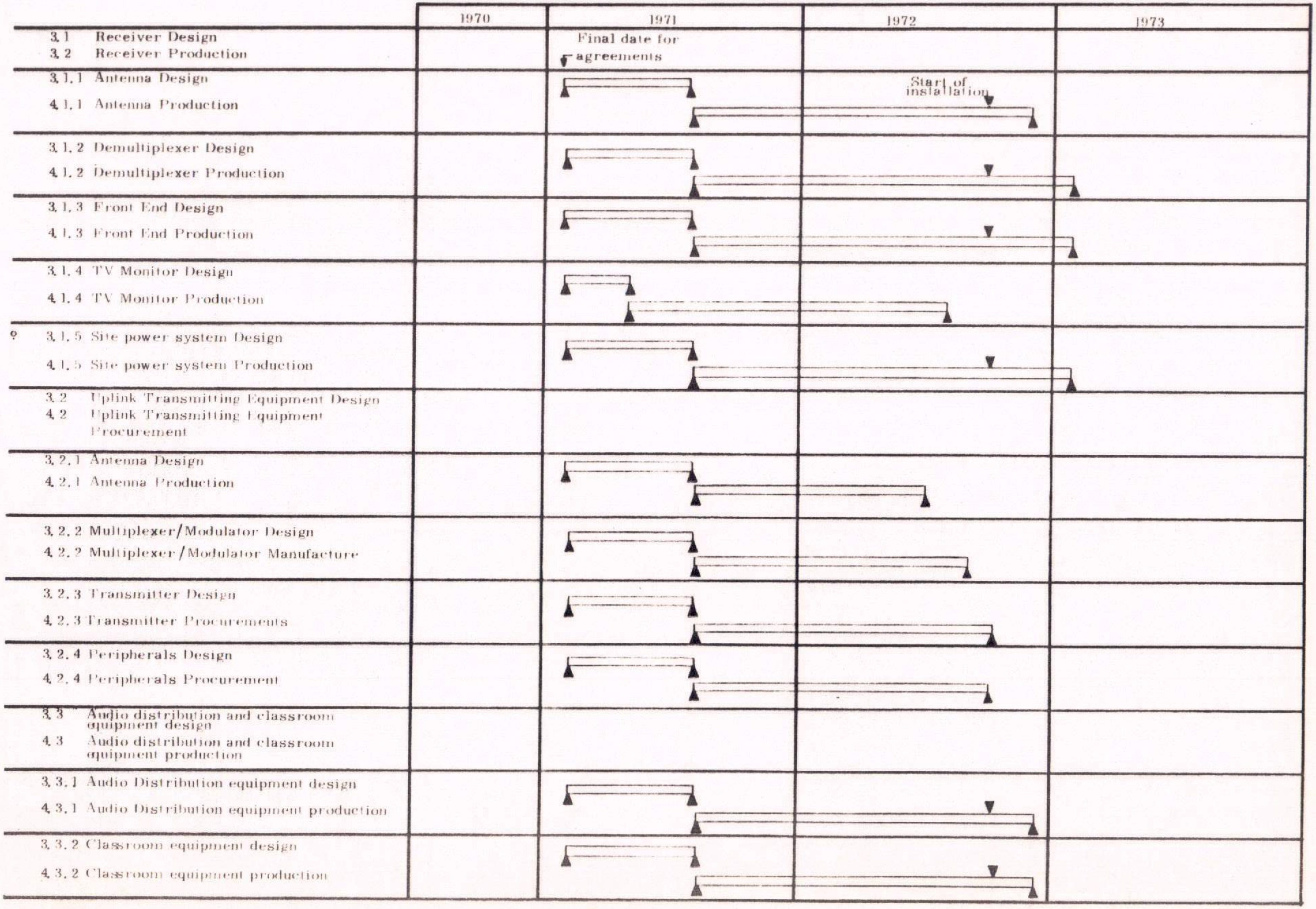
SACI - ATS EXPERIMENT SCHEDULE



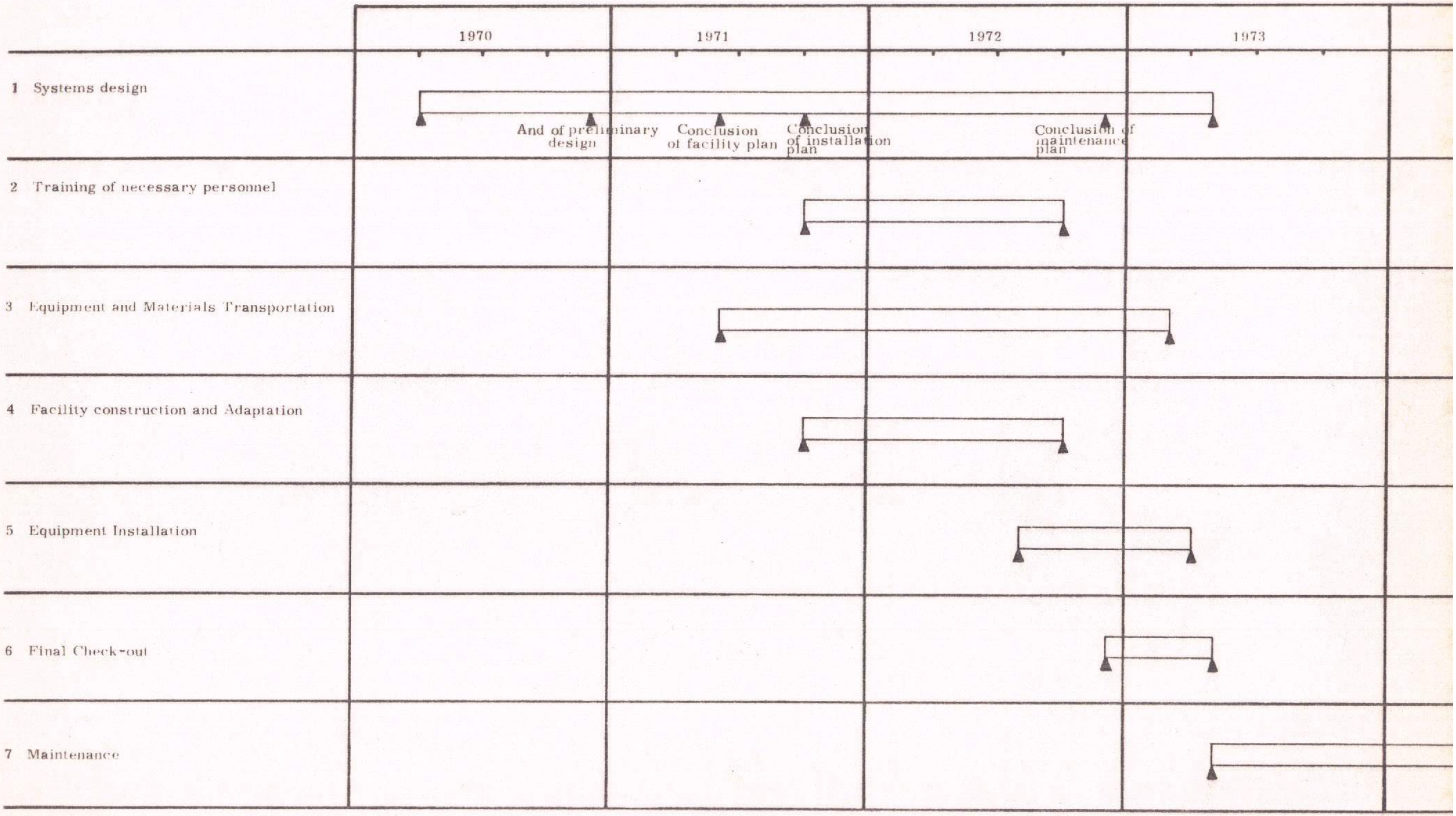
SYSTEM DEFINITION



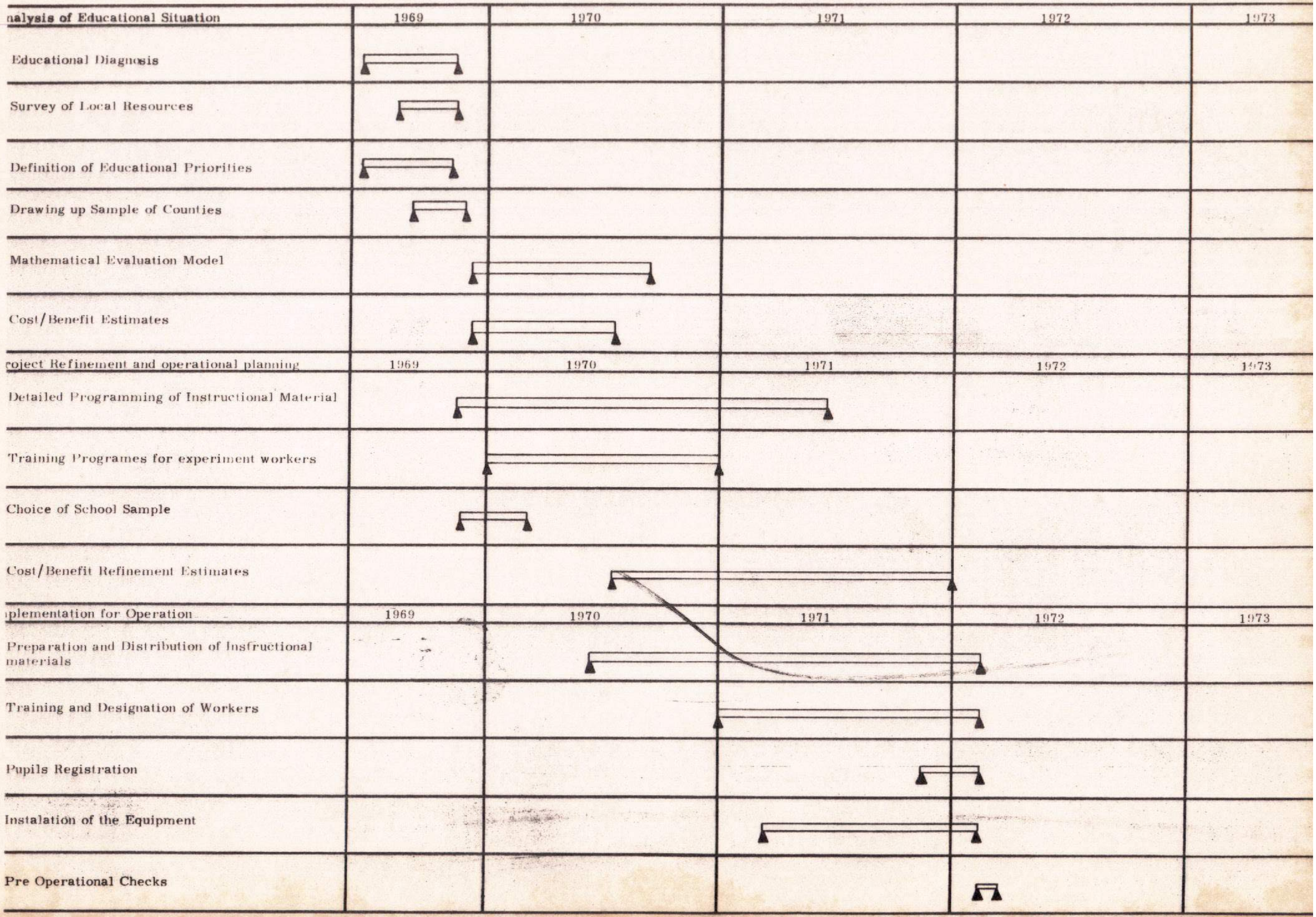
EQUIPMENT DESIGN DEVELOPMENT AND MANUFACTURE



FACILITIES - INSTALLATION - MAINTENANCE



EDUCATIONAL SOFTWARE SCHEDULE



6.3 Use of PERT for the ATS-F Experiment

1. PERT Planning Philosophy

The CNAE approach to PERT applications is to use the excellent interrelationship and description powers of PERT to establish an integrated project plan; then to use this plan as a source of measuring points for project control. Management overview and reporting will be accomplished with summary PERT networks and schedules. Any replanning activities will be based on the detailed planning networks.

2. Current CNAE PERT Capability

CNAE is currently using the routine PERT operating capability of the Burroughs B-3500 computer. CNAE's Systems Analysis Group is handling the software improvements and computer processing for Project SACI. The B-3500 PERT program produces conventional PERT reports and also a bar-chart print-out for phasing and slack analysis.

Both the hardware and software groups of Project SACI are currently preparing network revisions and computer input sheets for updating of the initial PERT runs. Thus a general understanding of network preparation is being developed by the sociologists and engineers assigned to the project. In addition to this general knowledge of PERT, the PP&C function of the CNAE ATS-F Project Team is proceeding into the PERT planning services to any area of the project.

3. Consideration of Advanced PERT Techniques

CNAE has been gathering information and an understanding of PERT techniques used in the United States and in England for project planning and control. For example, the PMS (IBM) PERT system is used by the British Aircraft Corporation and the Mark III (Boyan) System is used by the General Electric Space Division. The PMS System is a modularized PERT, and PERT COST System. The Mark III System is a new computerized technique for integration of project activities in accordance with PERT logic, but in addition it provides automatic plotter drafting of schedules with manpower and cost overlays.

4. PERT Planning Staff

The CNAE Program Planning and Control (PP&C) function for the ATS-F Project will be staffed with 5 or 6 people in addition to the PP&C leader. Of these 5 or 6, a minimum of 3 will be planning engineers who are capable in PERT, scheduling and other planning techniques. Two of these 3 are already active in the PP&C function.

5. Management Control Room

CNAE is implementing the Management Control Room approach to create a focal point for ATS-F project information and meetings. The area for the Control Room has been assigned, chart requirements have been established, and baseline display and control data is now being prepared. Summary PERT networks as well as control milestone schedules will be displayed and updated in this room. Also, progress data from the Control Room will be directly usable for status reports to NASA.

6. Structuring of PERT and Other Planning Documents

To ensure preparation of comprehensive, structured plans for the project, a Work Breakdown Structure and Experiment Mission Functional Flow Block Diagram (FFBD) are being prepared as a framework for all plans. The preliminary FFBD has been prepared and PERT activities are being keyed to this diagram to identify any gaps or redundancies.

6.4 Interface Definition & Control

1. Nature of the ATS-F Project Interfaces

To accomplish the ATS-F Experiment of objectives, many participants in project activity are required, not only to provide project services, but also to achieve a unity of mind in this new educational technology area via multiple-agency participation and exchange of ideas. The numbers of participating agencies for the experiment will be large - perhaps more than 50.

However, by properly recognizing the significance of interface planning and control, CNAE expects to blend in into the experiment, in an orderly timely fashion, the support of all the interested agencies through the time tested device of written agreements.

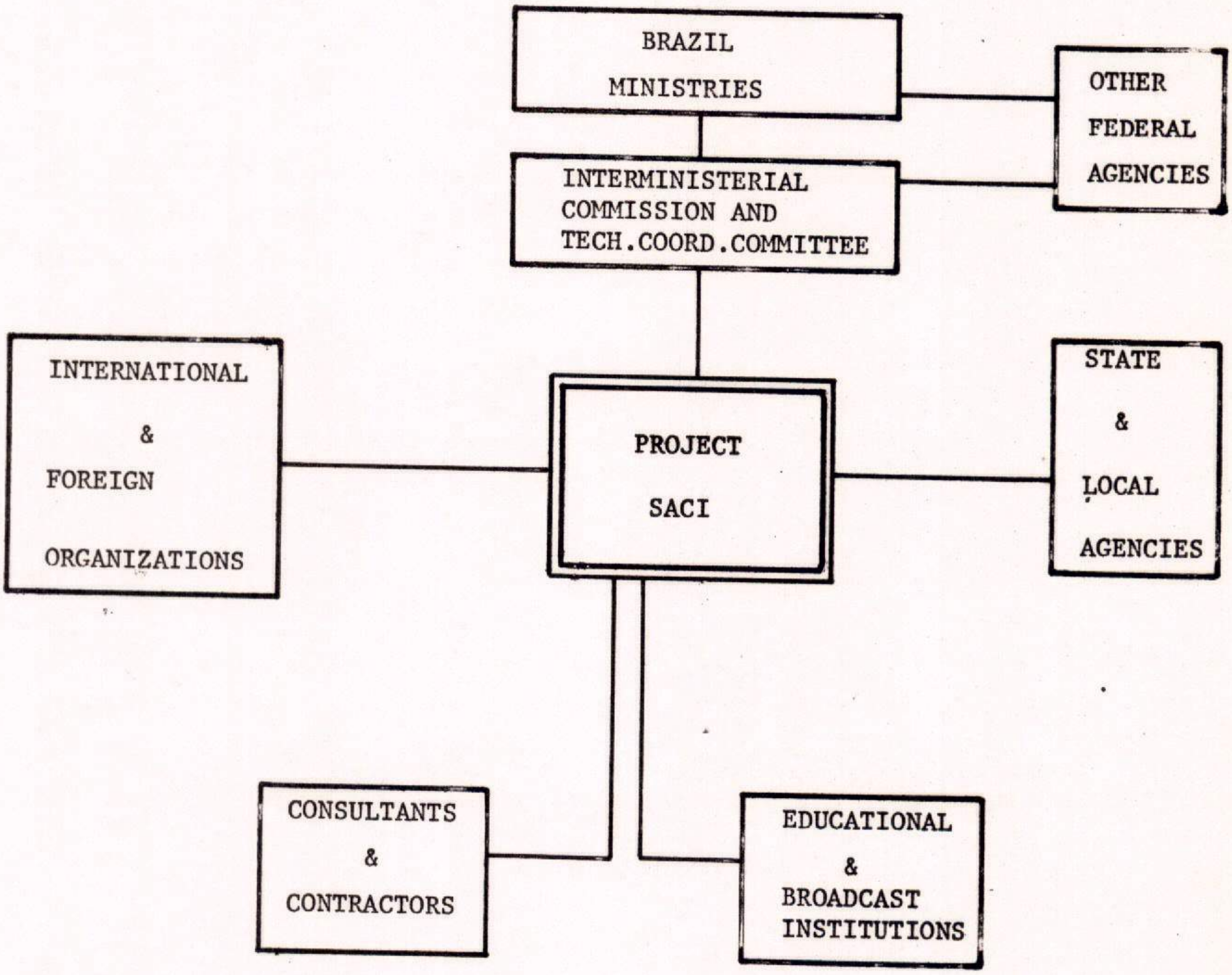
2. Definition of Interfaces

The participants to the ATS-F Experiment have been grouped as shown in figure of next page to provide a basic framework for definition of interfaces. Within each group, efforts are underway to list the agency, to identify the support function, and to identify the agency and CNAE interface representatives for each interface. In the software area, a matrix format is being used to identify the specific sub-functions which each educational agency will be requested to provide.

3. Interface Agreements

As each project support function is defined, meetings are being schedules with candidate participating agencies to clarify the roles which they will play in the project. As an example,meetings are being scheduled with TELERN, (the telephone company in Rio Grande do Norte) to establish some aspects of their participation in installation and maintenance of ground receiving equipment for the experiment. After establishment of informal agreements, the appointed interface representatives will prepare definitive interface agreements which satisfy project requirements.

PROJECT SACI INTERFACES



7.0 CNAE FACILITIES AND PERSONNEL

7.1 CNAE Project Experience

CNAE has been developing and performing research projects since its inception in March 1963. The CNAE capability for planning and implementing a project of the scope of the ATS-F Experiment thus stems from its experience in staffing, directing and executing a number of projects in basic and applied **space** research. Brief descriptions of them are given below:

7.1.1 CNAE Basic Research Projects

Project MATE: This is a study of the geomagnetic field, and is executed in collaboration with Stanford University and AFCRL (U.S.). Three magnetometers have been installed for this project, one in São José dos Campos - S.P., one in Baurú - S.P., and one in Fortaleza - Ceará. Through an agreement with the University of Braunschweig, Germany, nine variographs are being installed along a line extending from São José dos Campos to Belém (Pará). These will determine the location of the magnetic equator and measure variations in the equatorial electrojet. This project also provides assistance in the installation and analysis of data from rocket-launched sensors.

Project MIRO: This project has two sectors. The first studies cosmic absorption by the ionosphere in the layer between 25 and 100 kilometers. The objective is a survey of profiles of ionic densities and temperatures. The second sector measures parameters of the neutral atmosphere between 30 and 90 kilometers using laser radar.

Project TELA: This project is dedicated to the construction of payloads for stratospheric balloons, including radiation detectors of various types and associated telemetry equipment. The purpose is the study of the precipitation of charged particles and radiation in the South Atlantic geomagnetic anomaly.

Project OBRA: This project studies atmospheric noises that originate from electrical discharges and cause interference in radiocommunications in the frequency band 3 to 30 MHz.

Project SAFO: This is research in the upper atmosphere through the use of rocket-launched instrumentation. This project provided support for the Apollo project in the early stages through BB IV rocket launches for radiation measurements.

Project RASA: This project measures electron content of the ionosphere through the Faraday and Doppler effects. It also measures scintillations in signal transmissions from artificial satellites.

Project RADA: This project measures solar explosions and prominences, photographing them continuously in the H-alpha band, for subsequent analysis and exchange of data with other solar observatories.

Project SONDA: This project undertakes ionospheric soundings using electromagnetic waves of variable frequency. Its activities include soundings from the earth's surface and upper level soundings. The former aims to determine the lower part of the ionospheric profile and the latter, the higher level profile by means of data received from the Alouette series of satellites.

Project BEMA: This project studies wave propagation in the 3 to 30 MHz VLF band. There are two kinds of experiments: the first uses earth stations that receive signals emitted by a net of stations spread out over the earth, permitting not only a study of VLF, but also the behaviour of the lower ionosphere. The second uses rocket soundings. The experiment is basically the same but in this method it is possible to investigate continuously from the earth's surface to the upper atmosphere.

Project LUME: This project analyzes luminescence in the upper atmosphere. By means of an earth station, studies are made of the variation in photochemical radiation from the principal elements constituting the upper atmosphere. The studies then seek correlations with the variation of ion content of the diverse layers of the ionosphere.

Project ASTRO: This project develops studies of cosmic X-radiation, identifying the galactic emission sources and energy levels. The studies also obtain additional spectral information on previously discovered sources. The experiments include rocket launches and these are undertaken in collaboration with the University of California at Berkeley. Two payloads, that worked successfully, were partly built at CNAE and launched from CLFBI in 1969.

Project EXAMETNET: This is a meteorological project that uses sounding rockets to obtain temperature, pressure, and wind data to levels higher than those achievable by radiosonde and below those of satellites. The aim is a latitudinal coverage through launches from stations situated in different latitudes - from Chamical in Argentina to Wallops in the U.S. and Fort Churchill in Canada, and including Natal in Brazil.

Project POEIRA: This project studies microscopic particles of extraterrestrial origin. Samples of this material are collected between the levels of 70 and 160 kilometers by means of recoverable, rocket launched instruments. Through analysis of the spatial and temporal variation in the distribution of these particles, from their dynamics, and from their physicochemical properties, we intend to reach deductions about their origin and about the composition of the solar system.

7.1.2 CNAE Applied Research Projects

Project MESA: This project includes meteorological studies based on cloud cover photographs and infra-red images. The project also includes the development of receiving equipment and development of the photographs transmitted by meteorological satellites of the ESSA and NIMBUS series. The data collected permits the preparation of weather maps and forecasts of considerable confidence for a period of 24 hours. The maps also provide a realistic presentation of the cloud systems. This project maintains close contact with the Meteorological Office of the Ministry of Agriculture, and CNAE has furnished assistance to that office.

Meteorological information has been obtained from other states by teletype, recently installed. A network of meteorological satellite receiving stations will soon be installed, under CNAE auspices. It appears worth emphasizing that the meteorological receiving stations was developed at CNAE. A similar station was also built here and is installed at the University of Baurũ, as a result of an agreement between that university and CNAE.

Project SERE: This project uses remote sensors (presently on aircraft and later on satellites) for surveys of natural resources, and involves the fields of hydrology, geology, mineralogy, agriculture, oceanography, etc. Three major phases of the project have already been completed. Phase A, accomplished in 1968, consisted basically of personnel training in the U.S. for 14 scientists and professional persons, not only from CNAE but also from "users agencies",i.e., the Ministries of the Navy, Mines and Energy, Agriculture, Army, from the Secretary of the State of São Paulo, from the Institute of Oceanography of the University of São Paulo, and from Petrobrãs.

Phases B and C were undertaken jointly with the organizations noted above and consisted of the selection and development of truth sites (i.e., known sites, the images of which will serve for identification of similar features of unknown sites) in Brazil, and their aerial survey by instrumented NASA aircraft, in July 1969. The results obtained were quite significant. The next step will include instrumentation of a Brazilian aircraft, now being acquired, and the establishment of a group for the processing and reduction of data at CNAE. A complementary phase of the project will consist of operational flights by Brazilian aircraft.

Project SACI: This project is described in Section 2 of this proposal.

7.2 CNAE International Cooperation Experience

In all of its activities CNAE has collaborated closely with counterpart organizations of various countries. Some examples follow:

<u>U.S.</u> From its early beginnings CNAE has had joint activities with NASA. Such activities have been most rewarding and represent a most remarkable set of examples of fruitful U.S. collaboration with another country. The activities range from "small" research projects, to efforts like the 1966 solar eclipse work, coordinated in Brazil by CNAE, to the Remote Sensing Project that has involved training and participation of Brazilian user's agencies under the aegis of CNAE. Against a background of over seven years of collaboration, the present ATS-F proposal is one more link - although a very important one - in a long chain of solid achievements.

<u>France</u> CNAE continues cooperating with CNES in X-Ray measurements using sounding balloons in the South Atlantic ("Brazilian") Geomagnetic Anomaly. It is also collaborating with that French agency in the operation of the Fortaleza (Ceará, Brazil) satellite tracking station.

<u>Germany</u> With organizations in Germany, CNAE has collaborated in the installation, in Brazil, of stations for geomagnetic measurements. In addition, several rocket experiments have been performed jointly.

Other <u>Nations</u> CNAE has also maintained scientific relations with Canada, Austrália, Argentina and various other countries. During this year, professors of the University of Saskatchewan (Canada) will come to teach at CNAE's graduate courses.

<u>International Symposia</u> Associated with its research, CNAE has periodically hosted international symposia, with scientists from all parts of the world. An example is the September 1965 II International Symposium on Equatorial Aeronomy, attended by about 200 scientists for ten days.

In November 1966, CNAE coordinated all of the efforts for observation of the solar eclipse of that month. More than 500 scientists and technicians from many countries participated; some 800 tons of equipment were installed at Praia do Cassino, Rio Grande do Sul. A subsequent symposium, at CNAE auditorium in February, 1968, analyzed the data obtained during the observation period.

7.3 Outside Assistance Available to CNAE

In addition to the organizational and facility resources available within CNAE, there are a number of other sources of educational and industrial technical assistance being used by CNAE to enhance its capabilities. Such support in the educational area has been described in Section 4. Organizations which have been or will be of assistance to CNAE in the hardware area are exemplified by the following list:

IBRAPE - transistors, capacitors, resistors, etc.
SIEMENS DO BRASIL - telecommunications, telephinic links
MAXWELL - TV transmission and studio equipment
TELEFUNKEN - television receivers
ROBERT BOSCH DO BRASIL - telecommunications and electronics
PHILCO - television receivers and transistors
GENERAL ELECTRIC - television receivers
INBELSA - communication equipment
PHILLIPS Radio and TV - television receivers
R. SONTAG - ferrites and cup cores
D.F. VASCONCELOS - carburetors (possible antenna component manufacture)
UNIVERSITY OF SÃO PAULO - microelectronics pilot laboratory.

Project SACI engineers have verified that Brazilian industry is capable of manufacturing most of the necessary hardware, both for the Rio Grande do Norte experiment and for the operational program. Except for the microwave mixerdiodes, step-recovery diodes, and possibly some high wattage transistors, all components either are presently being fabricated here or could be, if the appropriate raw material were imported.

Mr. D.F.Vasconcelos (president of the company of the same name) has offered his full support in producing a prototype casting for the mixer-feed assembly of the ground receiver front end.

Also, the PHILLIPS group of companies has offered their support to the project. The PHILLIPS companies represent every aspect of the electronics industry in Brazil, since they build components, consumer equipment (TV's, radios, phonographs), and sophisticated telecommunications equipment. In between SACI engineer visits, PHILLIPS has sent an engineer to São José dos Campos to keep abreast of our work.

Further, GE-Brazil has visited CNAE and is willing to make a nationwide survey of costs, technical capability, and maintenance requirements for the ATS-F experiment and the final SACI program.

7.4 CNAE Facilities

The installations at CNAE in São José dos Campos comprise 8,000 square meters of floor space.

In addition to the Auditorium Building (1400 m^2) which includes the secretarial offices, a print shop, and research offices, there are the Research Buildings (550 and 1764 m^2 respectively), restaurant, motel, garage, and warehouse.

Also included in CNAE's facilities are:

An Electronics Laboratory of 485 m^2, where scientific equipment for rocket and stratospheric balloon payloads are prepared and the equipment for signal reception from artificial satellites, measurement of cosmic noise, etc., is installed. Design rooms, a parts and equipment storeroom, and research offices are also included in this building.

The Laser Projects Laboratory is 100 m^2, and contains the MATE and LUME Projects. The research group of these projects has at its disposal a laser radar, a ground stations for variation study of photochemical ray emission of upper atmosphere principal elements, and an automatic recording **magnetometer (ASMO) for geomagnetic field** measurements.

The Computer and Analysis Sector, 840 m^2, contains a 3rd generation Burroughs B-3500 computer and associated key punch, plotting and other peripheral equipment. Also included in this building are the data reduction and research offices. Since the initial installation, the computer system has been expanded to include an auxiliary memory (magnetic disc) capacity of 20 million characters, tape reader (1000 characters per second), a magnetic tape unit (4 tapes for 9 channels) and program plotter.

A further expansion of the Computer Facility has been planned for 1970. This expansion will provide for the increase of nucleus magnetic memory to 280,000 digits, an increase in auxiliary memory to 30 million characters, four more tape units, 2 more printers, and an analog computer EAI-580, not to mention another digital computer to be used in the SERE Project and in the computer applications of the Systems groups to be initiated.

The Library has 600 m^2 and contains 50 small reading and study rooms, a large office, and six group study rooms. The library includes 5000 volumes of scientific and cultural works and a collection of 190 subscriptions of various periodicals. The works are, in the greater part, specialized in the fields of research in which CNAE is interested. The library is annually increased by approximately 1000 new volumes and subscriptions.

The TV Studio, 600 m^2, (currently under construction) will contain complete equipment for organization and elaboration of educational programs, such as video tape, telemovies, cutting table, etc.

The Mechanical Shop, 300 m^2, is equipped with specialized machines for mechanical work required in the development of projects. Here the payload structures for rockets and balloons are prepared and tested for later space launching. A modern design section is also included.

The Radiation and Photo Laboratory. This laboratory is now under construction as part of continuing CNAE facility development plans.

7.5 CNAE Personnel and Project Organization

7.5.1 CNAE Personnel

For the development of its broad program of basic and applied research, CNAE has a scientific staff that is significant in both quality and quantity.

The basic research projects utilize about 20 to 30% of the resources and the remainder is spent in applied research. A group of researchers is assigned to each project. The specific function of this group is to work intensively for original results, in the case of basic research, and for specified goals in the case of applied research.

At the present time CNAE has some 320 employees of whom 170 are university graduates working full time under the orientation of 12 researchers at the doctoral level and 12 with Masters degrees in Science. In addition to the 170 full time researchers, there are 50 assistants, with university degrees, who work part time.

Not counted in the numbers above are five engineers on short-term work-study assignments abroad and another 36 studying abroad full time for doctoral degrees.

Due to the non-existence in Brazil of educational centers with programs to train and graduate persons in many of the CNAE program areas, it has become necessary to provide such training within CNAE itself. To bring out the potential of selected engineers, meteorologists, and physicists graduating from the best Brazilian universities, concentrated post-graduate courses are given at CNAE. These lead to the Master of Science (MSc) degree in fields related to the researcher's field. Degrees are granted in Space Science, Communications, Computer Science, Systems Analysis, and Meteorology. Researchers completing the Masters Degree may qualify for and are encouraged to pursue doctoral courses abroad, through agreements maintained with international organizations. In the near future doctoral courses will be given at CNAE.

By 1973 CNAE plans to have graduated 200 scientists at the doctoral and masters levels. It is important to note that the researchers who received their masters degrees at CNAE are obtaining the highest average grades in the doctoral programs at Stanford University.

To complete its objectives, CNAE has used the most modern techniques in systems engineering. Since the initiation of activities, CNAE has tried to equate its functioning and structure in terms of systems analysis. With the experience accrued in this field, the objectives of this type of activity were expanded through the creation of a Systems Analysis Group. This group can give assistance to other governmental organs and also private entities. It will utilize Systems Analysis techniques and methods which can be adapted and applied in the most efficient manner possible to national problems. Started officially in 1969, with the initial task of planning and optimizing CNAE's internal systems, it relies on collaboration of engineers, aconomists, sociologists, pedagogists, systems scientists, computer scientists, who work together with the state and municipal government in the planning and carrying out of state and municipal programs. In 1970, the systems group will be increased by 100 people, 10 of whom will be PhDs.

7.5.2 Project SACI Personnel

The SACI staff has grown substantially. The project started in 1967 and as of 1968 had only 4 engineers, which number increased to 20 in 1969 and in 1970 has grown to about 40 persons. Disciplines represented include engineers, sociologists, educators, and economists. In addition, the project receives technical support from 20 experienced space and systems engineers of the General Electric Company Space Systems Organization and from the BAC, with two engineers at CNAE and a backup group of six senior engineers in Bristol, England.

Besides the support of external groups and because the project deals with advanced technologies, SACI personnel are being sent abroad regularly for training. Some examples follow:

> Four engineers have just returned from a course in satellite earth receiving stations at the GPO, England. This study included a period of work and experience in an English satellite receiving station.
>
> One engineer who worked with Project SACI in 1968 is undertaking doctoral sutides in systems analysis at Stanford University.
>
> Other SACI personnel will spend work-study periods at GE in Valley Forge regularly throughout 1970; a mathematics professor with the project will undertake research and graduate studies in modern educational technologies at Stanford; and it is expected that additional personnel will be able to pursue training with the General Post Office, Britain. An active in-house training program exists for the SACI staff.

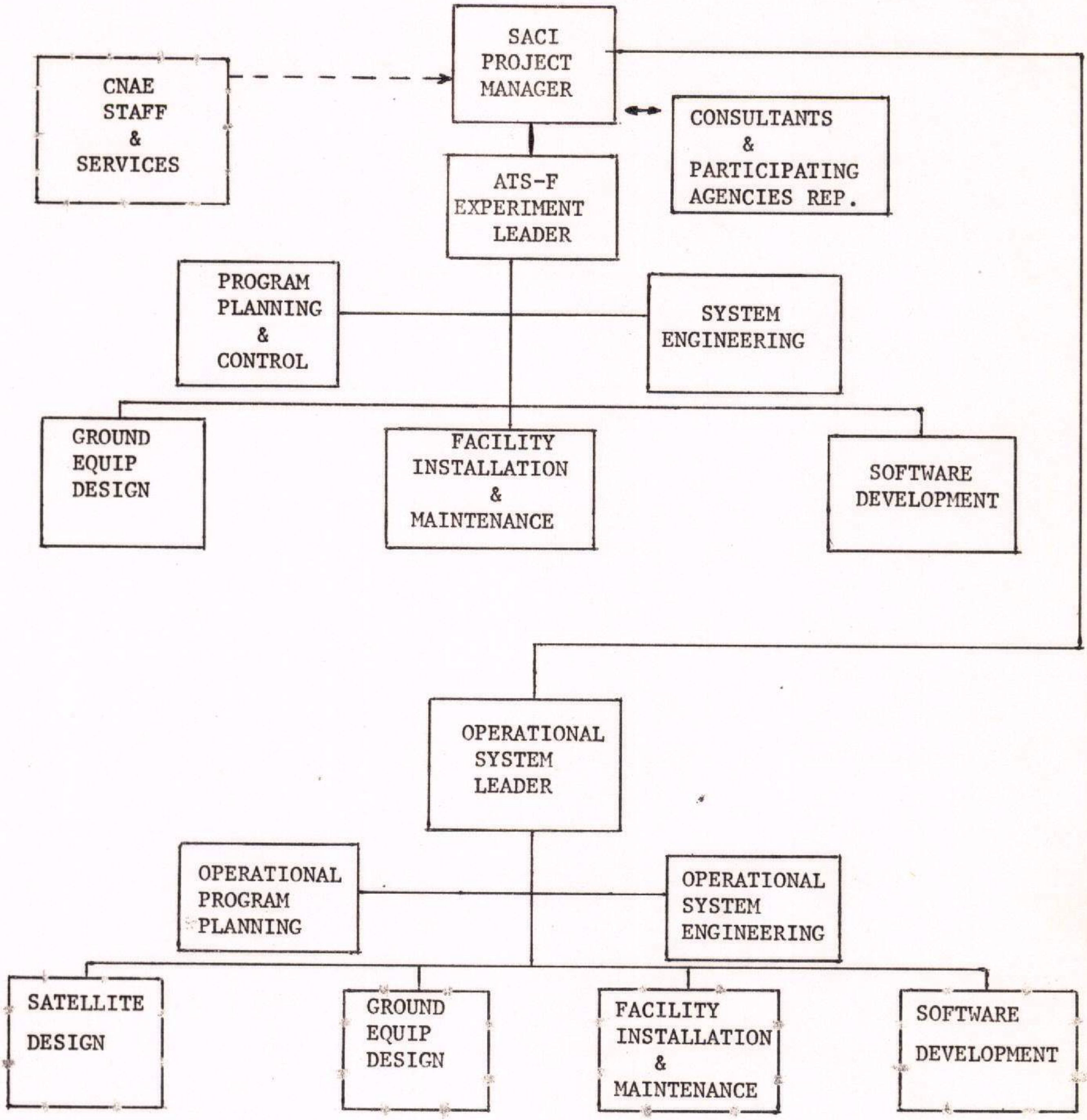
7.5.3 Expanded CNAE Organization Structure for the ATS-F Project

1. Development of Expanded Project Structure

Until recently CNAE has been using task assignments to full time or part time SACI personnel as a means of preparing ATS-F plans. The level of project activity has however, so increased that the project structure shown in the next page, has been implemented and staffed.

2. Assignment of Functional Responsibility

Before arriving at this organization structure, about 140 candidate project functions were identified, and fitted into logical groups. These groupings then were sorted into project functions and used to estimate



PROJECT SACI ORGANIZATION
(ATS-F & OPERATIONAL SYSTEM)

staffing requirements. Assigned project personnel are now able to implement their responsibilities within the guidelines of the detailed functions allocated to their project area. Position guides have been prepared to clarify the role of each team member. The functional responsibilities adapted from the candidate function list is shown in Table 1.

TABLE 1

Adopted Function & Subfunction Breakdown for CNAE Project Organization (ATS-F Operations)

Program Planning & Control

- Planning
- Cost
- Data Management
- Reports
- Management Control Room
- Management System
- Training & Personnel Services Coordination

System Engineering

- Program Requirements
  - Ground System Requirements
  - Educational Requirements
  - Satellite Requirements
- System Design
  - Experiment Design
  - Receive Equipment Design
  - Uplink Design
  - Educational Equipment Design
  - System Test
- System Analysis
  - Reliability
  - Cost Modeling and Analysis
  - Value Engineering
- Equipment Interface Definition & Integration

- Other Responsibilities:
  - Liaison
  - Design Review
  - Coordination of Engineering Decisions

Ground Equipment Design

- Antenna Design (uplink and downlink)
- UHF Receiver Design (including front-end electronics)
- Multiplexer/Demultiplexer Design
- Audio Distribution Design
- Television Receiver Design
- Uplink Equipment Design
- Power Source Design
- Materials, parts & processes Engineering
- Quality Assurance & Control
- Equipment Procurement

Other Responsibilities:
- Human Factors
- Safety
- Reliability
- Producibility
- Maintainability

Facility Installation & Maintenance

Facility Preparation
- Facility Design
- Facility & Power Survey
- Facility Modification or Construction
- Field Supervision & Inspection
- Facility Documentation & Training

Equipment Installation & Checkout (I & C/O)
- Installation Design
- Field Installation and Checkout
- I&C/O Documentation & Training
- Test Equipment for I&C/O
- I&C/O Supervision & Inspection

Maintenance
- Spares Analysis & Requirements
- Maintenance System Design
- Maintenance Engineering
- Maintenance Facility Equipment
- Equipment Repair, Disposition; Preventive Maintenance
- Maintenance Documentation & Training
- Field Communication Services

Logistics Services
- Warehousing and Staging
- Shipping and Receiving
- Transport
- Logistics Documentation & Training
- Procurement of standard items & supplies
- Logistics Facility Survey & Requirements

Software Collaboration

- Experiment Design
- Data Survey, Research & Archive
- Facility & Equipment Requirements
- Training
- Software Production Coordination
- Experiment Evaluation