PROPOSTA À
ADMINISTRAÇÃO NACIONAL DE AERONÁUTICA
E ESPAÇO (NASA)

PARA

UM CIRCUITO EXPERIMENTAL VIA SATÉLITE ATS-3 ENTRE A COMISSÃO NACIONAL DE ATIVIDADES ESPACIAIS (CNAE) DO BRASIL E A UNIVERSIDADE DE STANFORD NOS ESTADOS UNIDOS.

ABRIL DE 1969

Submetido pela
COMISSÃO NACIONAL DE ATIVIDADES ESPACIAIS (CNAE)
e pelo
CENTRO DE ASTRONOMIA POR RADAR
LABORATÓRIO DE RÁDIO CIÊNCIA
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Proposta Conjunta para uma ligação via Satélite ATS entre a Universidade de Stanford e a Comissão Nacional de Atividades Espaciais(CNAE), Brasil.

A. INTRODUÇÃO

À medida que aumenta a capacidade de gerar potência nos satélites síncronos de comunicações, a variedade de seus usos também cresce. A ligação direta entre duas ou mais organizações por meio de circuitos de média capacidade se encontram entre os usos que se tornarão econômicamente vantajosos pela família de satélites Intelsat IV. Isto é viável atualmente usando-se as grandes e dispendiosas estações terrestres do Intelsat II juntamente com repetidoras desses centros de recepção até as organizações. Entretanto, com os níveis de potência do Intelsat IV, existirá também a possibilidade de transmissão e recepção direta nas organizações usando muito menores e menos dispendiosas estações terrestres. Mesmo em países com sistemas de comunicações terrestres bem desenvolvidos, essas pequenas estações serão econômicamente atraentes. Em países em desenvolvimento elas serão ainda mais vantajosas e em muitos casos talvez a única alternativa viável.

Êsse tipo de serviço poderá ser utilizado por várias organizações, mas seus usos mais variados se encontrarão entre as organizações educacionais. Nesse caso essas ligações poderiam ser usadas para compartilhar aulas, seminários, ou colóquios, para coordenar pesquisas ou projetos de estudo conjunto, ou para trocar facilidades de computação. Para as universidades norte-americanas êsses usos poderiam enriquecer programas levados a efeito em cooperação com universidades estrangeiras. Estas, por outro lado, adquiririam muitos dos benefícios das universidades norte-americanas sem a despesa de enviar seus alunos aos Estados Unidos nem o perigo de expô-lo ao"brain drain".

Embora êsses benefícios façam as ligações diretas via satélite atraentes para muitas organizações, ainda existe um grande número de perguntas a serem respondidas antes que tais usos sejam propostos para o Intelsat IV. Existem perguntas de natureza técnica sôbre o custo e a facilidade de operação dos terminais terrestres, sôbre o custo relativo de maior potência no satélite vs. maior sensibilidade do receptor, e sôbre a interferência que tais estações de terra experimentarão devido a satélites muito próximos em órbita síncrona. Existem também perguntas sôbre as relações sinal-ruído necessárias para qualquer desses usos e o efeito do tempo de retardo sôbre os mesmos.

Finalmente, é necessário às organizações educacionais um maior estudo para definir a real utilidade de programas que possam ser levados através dessas ligações.

É para responder a essas perguntas que nós propomos estabelecer uma ligação de média capacidade (nos dois sentidos) entre a Escola de Engenharia da Universidade de Stanford e a Comissão Nacional de Atividades Espaciais (CNAE) em São José dos Campos, São Paulo, Brasil. Essa ligação experimental usaria o satélite de comunicações ATS III em um programa regular de 1 1/2 a 2 horas por dia, dois a três dias por semana durante um período de três a seis meses.

Durante êsses períodos, cursos e seminários seriam compartilhados entre as duas organizações, e facilidades de computação seriam trocadas. Os membros do Instituto de Pesquisa em Comunicações de Stanford juntamente com o grupo sócio-econômico do Projeto SACI (CNAE) avaliariam o desempenho e as limitações das ligações. Os membros do laboratório de Rádio Ciência de Stanford em colaboração com o grupo de Engenharia do Projeto SACI (CNAE) determinariam teórica e experimentalmente os aspectos técnicos e econômicos das estações de baixo custo do satélite em comparação com outros métodos de prover semelhante serviço.

A Joint Proposal for an ATS Satellite Circuit Between Stanford University and Commissão Nacional de Atividades Espaciais (CNAE), Brazil

A. Introduction

As the power capabilities of synchronous communications Satellites increase, the variety of satellite uses also grows. Among the uses that will be made economically attractive by the Intelsat IV family of satellites is the direct linking of two or more institutions by two-way medium bandwidth circuits. This of course is feasible today using large and expensive Intelsat II ground stations plus ground relay from these communication centers to the institutions. But with Intelsat IV power levels, the possibility will also exist of transmitting and receiving directly at the institutions using much smaller and much less expensive ground stations. Even in countries with extensive ground communications systems, these small stations may be economically attractive. In developing countries, they will be even more attractive and in many cases may be the only feasible alternative.

Many different kinds of institutions will have uses for this kind of service, but the most varied uses may be found among educational institutions. For these institutions such links could be used to share formal lectures, seminars, or colloquia, to coordinate research or joint study projects, or to share computation facilities. For United States universities such uses could enrich programs carried out in cooperation with foreign universities. The foreign university, in addition, would be able to have their students acquire many of the benefits of education at the United States universities without the expense of sending them to the United States and the danger of exposing them to the "brain drain".

While these kinds of benefits will make direct small-terminal satellite links attractive to many institutions, there still are a number of questions that must be answered before such use can be seriously proposed for Intelsat IV. There are technical questions on the cost and ease of operation of the ground terminals, on the relative cost of more satellite power vs. more receiver sensitivity, and on the interference that such ground stations will experience between two satellites closely spaced in synchronous orbit. There are also questions on the required signal to noise ratios for any of the contemplated uses and the effect of time delay on these uses. And for educational institutions, more study is needed to define the real usefulness of the programs that could be carried over such links.

It is to answer these questions that we propose to establish a two-way low bandwidth link between the School of Engineering at Stanford University and the Comissão Nacional de Atividades Espaciais (CNAE) in São José dos Campos, São Paulo, Brazil. This experimental link would use the ATS III communications satellite on a regular schedule 1 1/2 to 2 hours per day, two to three days a week for a period of three to six months.

During these periods, courses and seminars would be shared between the two institutions and computation facilities would be linked together. Members of Stanford's Communications Research Institute together with CNAE's SACI Socio-economic staff would evaluate the performance and limitations of the communications links. Members of Stanford's Radioscience Laboratory in collaboration with CNAE's SACI Engineering Staff would theoretically and experimentally determine the technical and economic aspects of the low-cost satellite stations in comparison with alternative methods of providing similar service.

B. Aspects to be Considered

A number of different aspects will be consdiered in the study. Some of the information that is needed will come from the existing literature but much will come from preparations for the experiment and analysis of the results. The study will include consideration of the following topics.

1. The Optimum Station Sensitivity

Increased antenna size and decreased receiver temperature increase the sensitivity and the cost of receiving stations. Curves will be compiled to define the optimum choice of receiver and antenna for any desired sensitivity. These curves may then be used with pricing schedules for satellite power to find the optimum combination.

2. Satellite Isolation

A major disadvantage of small stations is reduced satellite isolation. A large antenna has a narrow beam and can therefore be pointed at one satellite and not see interfering signals from a nearby satellite in synchronous orbit. As ground antennas become smaller and less expensive, their beam widths increase and satellite spacing may also have to increase. This may seriously reduce the total communications potential of satellites. On the other hand, the need for separation may be reduced by reducing S/N requirements of the small stations. Investigation will also be made of the possibility of using two or more small, low-cost antennas in an interferometer array to achieve the collecting area of a medium sized antenna and the effective beam width of a large antenna.

3. Achieving a Signal to Noise Ratio

For satellite relay to telephone circuits the specified signal to noise ratio is between 50 and 60 db even though the desired ratio for the entire circuit is far less. This is necessary since noise on the circuit is usually contributed by many additional sources, such as terrestrial microwave relays, booster amplifiers, and switching circuits.

It is technically feasible to reduce the contributions of these other systems by improved design and allow the satellite link to contribute a greater share of the total noise. However, in a general telephone link this would be economically infeasible since all relays, amplifiers, switches, etc. would have to be replaced at tremendous cost of time and money.

With direct links between institutions, additional sources of noise are minimized and the individual units generating this noise can be improved at reasonable cost. It may therefore be possible to accept lower satellite signal to noise ratio for direct service.

4. Requirements for Signal to Noise Ratio

Also of concern in the signal to noise calculations are the acceptable noise levels for the various uses. Lecture material, signals for electronic blackboards or narrow band facsimile machines and data transmission between computers may all require different signal to noise ratios. Equipment for the experiment would be designed for the most stringent requirements but provided with controllable noise insertion to evaluate the effect of different noise types and levels on the various services.

5. Transmission of Lectures

Among the services which will be tested is the transmission of a regularly scheduled lecture course and an occasional seminar. Electronic blackboards will be used to convey handwritten information and the two-way voice link will be used to provide question and answer capability. Tests will be conducted to estimate the effectiveness of learning in the remote classroom and the effect on the instructor and class in the live classroom. Effects of the synchronous satellite time delay and of a range of noise levels will be evaluated during the lectures.

6. Transmission of Data

Two-way computer links will be established through the satellite to demonstrate the ability to transfer blocks of data and to operate simple teletype terminals remotely. Computer aided education programs, developed at Stanford's Institute for Mathematical Studies in Social Science, will be run through the teletype terminal.

7. Organizational Requirements

Although the lecture and computer uses of the communications links will be only on a temporary basis, many of the problems inherent in organizing a permanent service will be encountered. The severity of these problems and the techniques used to overcome them will be recorded.

C. Stanford's Experience in Communications and International Programs

Stanford University has many different programs that will provide the background and experience necessary to carry out the proposed experiment.

Technical background includes extensive research in radio electronics, communications theory, and space science carried out in the Radioscience Laboratory. Present research in this laboratory includes design and fabrication of a low-cost microwave receiver and antenna for use with ETV Satellites and design and fabrication of an unmanned scientific laboratory to relay signals from Antarctica to the United States using synchronous communications satellites.

Past studies in the School of Engineering have included ASCEND, a design of Educational Television Satellite Systems for Brazil, India and Indonesia, and SAINT, a design of an International Telecommunications Satellite System.

Stanford's School of Engineering has also implemented a program to relay lecture material to Aerospace and Electronic firms in the San Francisco area. Preparation and implementation of the program provided experience in many of the technical and organizational areas present in the proposed experiment. Extensive experience also exists at Stanford in the evaluation of innovative communications and educational techniques. The Institute for Communications Research has for several years been involved in the installation and evaluation of ETV in Colombia and in the use of ETV in other areas. The Institute for Mathematical Studies in Social Science also has extensive experience with computer supplements to education, using teletypes in the classroom connected to a central computer. This experience will provide both organizational and technical support for the proposed experiment.

In addition to the technical and organizational experience, Stanford has a long history of International activities. Foreign students from all over the world are enrolled in graduate and undergraduate programs. Stanford also has eight campuses in foreign countries which are attended for at least a half year by most undergraduates. And in many different schools, Stanford professors conduct research in cooperation with foreign institutions. While these activities will not be directly involved with the proposed experiment, they will be able to provide estimates of the different kinds of services that satellites could provide for educational institutions.

The proposed experiment with the ATS Satellite is limited both in scope and man-power. However, with the experience at Stanford in communications and related fields, it will be possible to identify the most critical aspects for experimentation and demonstration and to relate the results to the more general use of future communications satellites.

D: CNAE's Experience in Space Programs

The Comissão Nacional de Atividades Espaciais (CNAE) has been working since 1963 in the fields of space science and technology. It has monitored and used satellite signals from various projects such as the ESSA weather satellites, ATS-III, ALLOUETTE, etc.

Receivers, transmitters, and telemetry systems have been built in its laboratories in São José dos Campos and were sucessfully used in balloons and sounding rockets.

In 1966 CNAE established the basis of a project called SACI which aims at the utilization of space technology for educational purposes. Several reports have been published and an engineering staff was formed especially for this work.

Most of the CNAE projects were and still are made with international cooperation. NASA's Office of International Affairs can confirm CNAE's performances in a number of research projects.

E. A History of Cooperation between Stanford and Commissao Nacional Atividades Espaciais

In a cooperative experiment such as the one being proposed it is important that the two institutions be able to work efficiently together. In this specific proposal it is also important that close cooperation between Stanford and Commissão Nacional de Atividades Espaciais (CNAE) will make this possible.

Graduate courses in Engineering are offered at the CNAE Graduate School facility in São José dos Campos. Many of these courses are to some extent modeled after those offered in the Electrical Engineering department at Stanford. The course topics are very similar and in several cases the text books used are the same. It has been a regular practice for students to be sent by CNAE to receive the Ph.D degree in Electrical Engineering at Stanford. Some of the technical courses are taught in English to prepare them for their studies in the United States. This situation will obviously minimize the difficulties in sharing lecture material between the two institutions.

In addition, research carried out by CNAE and Stanford's Radioscience Laboratory is of mutual interest and will provide suitable topics for joint seminars.

As a group, the graduate students sent by CNAE have done better academically than any other group in Stanford's Engineering Graduate Program. This, and personal visits to CNAE have given Stanford confidence in the quality of the work being done there. There should be no problem in establishing the necessary close technical cooperation between the two ends of the satellite communications link.

Finally, close personal communications and understanding is invaluable in organizing an experiment of this type. Dr. Fernando de Mendonça, Scientific Director of CNAE, received his Ph.D degree from Stanford's Electrical Engineering Department, worked here as a visiting scientist, and has since maintained close contact with the University. Several persons from Stanford have visited CNAE in the past year and more visits are planned in the future. Additional cooperation will be provided by having at least one of the graduate students involved at Stanford be from the group of CNAE students presently working towards their Stanford Ph.D degrees.

These mechanisms should ensure maximum communications and cooperation between both ends of the proposed experiment. While links to other countries or even to other institutions within Brazil would certainly be feasible and valuable, the history of cooperation between Stanford and CNAE points to this combination as likely to yield the most valuable results. It is true that many of the organizational problems of direct communications links will be reduced by this choice. However, the effect of the additional problems can be estimated after the experiment. This would seem better than adding problems to the proposed experiment and increasing the probabilities of administrative impasses.

F. Proposed Satellite Schedule

The satellite proposed for the experimental communications link is the ATS-III synchronous satellite. The satellite would be visible from both Stanford and CNAE when it is positioned over the equator approximately between longitudes 50° West and 120° West.

It is planned to transmit a regularly scheduled lecture course through the satellite. Since the lecture will normally take one hour, it would be advisable to schedule regularly two hours of satellite time. This will allow sufficient time to establish the satellite link and to ensure that all equipment is operating properly. With regular operations, the additional hour would also be used for technical tests and for computer link ups. The two hours should begin no sooner than 7:00 a.m. at Stanford and no later then 8:00 p.m. in Brazil. These limits are shown in Pacific Standard Time, São Paulo Time, and Universal Time in Table I.

The lecture course could be scheduled either for Monday, Wednesday, and Friday, or for Tuesday and Thursday.

The experiment should be scheduled to run at least one quarter year, to allow a complete course to be shared, preceeded by a month of intermittent tests with the satellite link. Valuable information would also be derived by continuing the experiment through a second quarter year. If the proposal receives early approval, work with the satellite could start as early as mid-August 1969 to broadcast material during the quarter ending at the end of December 1969. Otherwise, the experiment could begin in early December 1969 for the quarter January through March 1970.

Table I

Acceptable Times for Beginning of 2 Hour Satellite Use

Note: Brazil decides each year whether or not to use daylight savings time.

(a) If Brazil does not use daylight savings time

DATES	STARTING TIME	STANFORD TIME (PST)	SÃO JOSÉ DOS CAMPOS TIME	UNIVERSAL TIME
November through April	Earliest	7:00 am	12:00 noon	15:00
	Latest	3:00 pm	8:00 pm	23:00
May through October	Earliest	7:00 am	11:00 am	14:00
	Latest	4:00 pm	8:00 pm	23:00

(b) If Brazil does use daylight savings time

DATES	STARTING TIME	STANFORD TIME (PST)	SÃO JOSÉ DOS CAMPOS TIME	UNIVERSAL TIME
November through March	Earliest	7:00 am	1:00 pm	15:00
	Latest	2:00 pm	8:00 pm	22:00
April	Earliest	7:00 am	12:00 noon	15:00
	Latest	3:00 pm	8:00 pm	23:00
May through October	Earliest	7:00 am	11:00 am	14:00
	Latest	4:00 pm	8:00 pm	23:00

G. Equipment Needed

Two alternative configurations of equipment needed for the proposed experiment are shown in the block diagrams of Figures I and II. These are intended to work with the 6-4 GHz repeater system of ATS-III in the direct frequency shift mode or in the multiple access mode.

Several antenna sizes have been considered to allow communications with voice channels or with the narrow band facsimile systems. Study is also continuing to determine the feasibility of using two or more smaller reflectors in an array.

The characteristics and link calculations for the two systems are shown in Tables II and III. It should be noted that at this time the choice of actual hardware is not decided. Study is continuing to find the optimum combination from a performance and cost standpoint. The equipment in both systems shown is "off the shelf" hardware and can be obtained for minimum cost and delay. Any alternative systems that are considered will also be "off the shelf" to maintain the low cost necessary for the experiment.

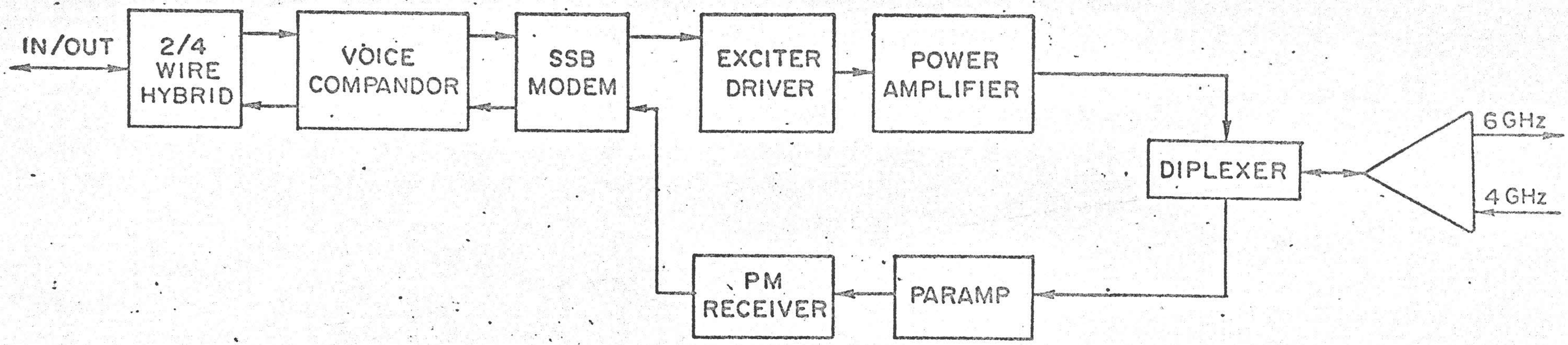

Figure I Block Diagram of Ground Station for Two-way Voice Channel

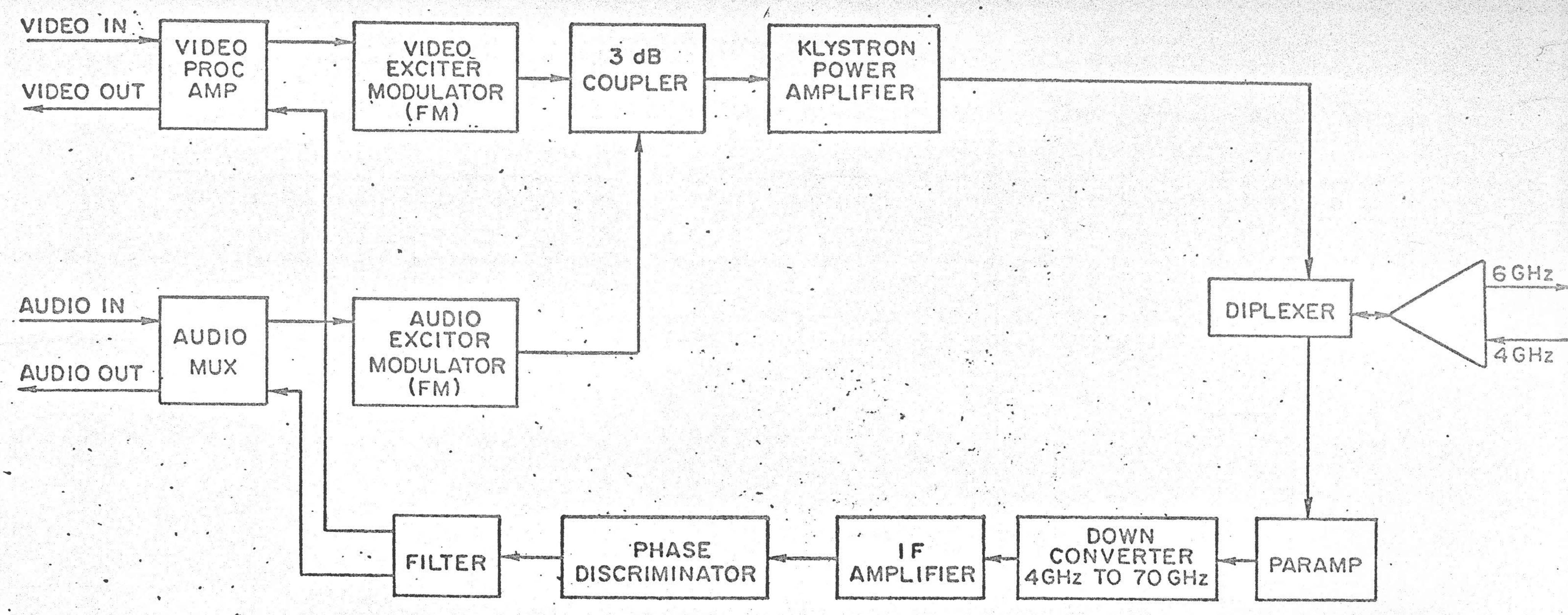

Figure II Block Diagram of Ground Station for Two-way Audio and Facsimile Channel

Table II

DUPLEX VOICE GROUND TERMINAL - multiple access mode -
(a) Up-Link Calculation

Transmitting Average Power	54.5	dbm
Diplexer Loss	-0.5	db
Ground Antenna Gain (14 foot dish)	46.0	db
Space Attenuation	-200.8	db
Receiving Antenna Gain	17.4	db
Off Beam Loss	-2.0	db
Satellite transmission liner and Diplexer loner	-1.6	db
Received Subcarrier Power	-87.0	dbm
Receiver Noise Figure	6.2	db
Receiver Noise Power Density	-169.0	dbm/Hz
Channel Bandwidth	34.9	db
Receiver Channel Noise	-134.1	dbm
Received Subcarrier/Noise	47.1	db

DUPLEX VOICE GROUND TERMINAL - multiple access mode -
(b) Down-Link calculation

Satellite ERP	52.2	dbm
Beam Loss	-2.0	db
Space Attenuation (22.000 NM 4.17 GHz)	-197.1	db
Ground Antenna Gain (14 foot dish)	42.7	db
Received Carrier Power	-104.2	dbm
Effective Receiver Noise Temp. ok	18.8	db
Receiver Noise Power Density	-179.8	dbm/Hz
Receiver Bandwidth	64.7	db
Receiver Noise Power	-115.1	dbm
Carrier to Total Noise	10.9	db
Test Tone/Fluctuation Noise	20	db
	15	db
Overall System Test Tone/effective S/N	35	db

Table III

VIDEO PHONE GROUND TERMINAL - frequency translation mode -
(a) Up-Link Calculation

Transmitter average power (280 watts)	54.5	dbm
Diplexer Loss	-0.5	db
Ground Antenna Gain (8 foot dish)	41.0	db
Space Attenuation (22.000 NM -6.3 GHz)	-200.8	db
Satellite Antenna Gain	17.4	db
Off Beam Loss	-2.0	db
Diplexer and Miscellaneous loner	-1.6	db
Received Carrier Power	-92.0	dbm
Receiver Noise Figure	6.2	db
Receiver Noise Power Density	-169.0	dbm/Hz
Receiver Bandwidth	54.0	db
Receiver Noise Power	-115.0	dbm
Carrier/Noise Ratio	23.0	db

VIDEO-PHONE GROUND TERMINAL
(b) Down-Link Calculations

Satellite ERP	52.2	dbm
Space Attenuation (4.17 GHz)	-197.1	db
Off Beam Loss	-2.0	db
Ground Antenna Gain (8 foot dish)	38.0	db
Received Carrier Power	-108.9	dbm
Effective Receiver Noise Temp. Ok	18.8	db
Receiver Noise Power Density	-179.8	dbm/Hz
Receiver Bandwidth	55.2	db
Receiver Noise Power	-124.6	dbm
ATS to Ground Carrier to Noise	15.7	db
Up-Link Contribution	-0.8	db
Total Carrier to Noise	14.9	db
FM Improvement	16	db
Signal to Noise	30.9	db

H. Stanford's Experiment Team

The experiment will draw on experience from many different parts of the University. Principal responsibility for conducting the experiment and analyzing the results will lie with:

Dr. Bruce Lusignan - Associate Professor - Electrical Engineering Department

Dr. Wilbur Schramm - Director, Institute for Communications Research

Dr. Patrick Suppes - Director, Institute for Mathematical Studies in Social Science

Dr. Donald Grace - Associate Dean, School of Engineering

Coordination of the technical aspects with the education program at Stanford will be under the guidance of:

Dr. Joseph Pettit - Dean, School of Engineering

The work will be done by three graduate research assistants with the help of a full time technician. Additional technical support may be expected from the engineering firms supplying the equipment.

Lecture meterial and seminars to be transmitted from Stanford to CNAE will be prepared by Stanford professors. While they will participate in the experiment, they will do so at no cost to the project.

I. CNAE's Experiment Team

The main responsibility for the experiment at CNAE will lie with Dr. Fernando de Mendonça, Scientific Director of CNAE. Mr. Alberto Franco who is in charge of the Applied Research Program will act as an internal coordinator.

The technical aspects of the experiment will be handled by the SACI PROJECT staff.

Engineering

Jorge de Mesquite, (EE), Project Manager

José Eugênio Guisard Ferraz, (EE)

José Torquato Pedrosa de Sousa, (EE)

Luiz Roberto Ferreira da Costa, (EE)

Henrique Erlich, (EE)

Thadeu Rache Corseuil, (EE)

Cesar Rômulo Silveira Neto, (EE)

José Guilherme Ornelas de Souze, (EE)

Arry Carlos Buss Filho, (EE)

José Penha de Assis, (EE)

Rubem Buchhoez Ferreira, (EE)

Socio-economic aspects:

Edith Wehmuth Ragonha

Tereza Dejuste

Maria José Leme

Besides, the experiment will have available all the facilities and staff of 120 Engineers and 15 Technicians.

J. Stanford's Cost Estimate
1 August 1969 through 3 July 1970

I.	**Direct Salaries**		
	Principal Investigator		
	Professor Bruce B. Lusignan 1/8 time academic year 1/4 time summer		$2,670
	Co-Investigators		
	Professor Wilbur Schramm 1/10 time all year		3,070
	Professor Patrick Suppes (as needed)		
	Professor Donald Grace (as needed)		
	Dr. Joseph Pettit (as needed)		
	Student Research Assistants (3) 50% time academic year 100% time summer		12,600
	Electronic Technicians (2) 8 man-months		5,600
	Computer Programmer 1/8 time		980
	Secretarial and Engineering Support (Services at $4.15 per hour)		2,900
	Direct Salaries		27,820
II.	Staff Benefits 11.6%*		3,410
III.	University Overhead		15,860
IV.	Direct Costs		
	Expendable Materials	$1,950	
	Computer		
	IBM 360/70 3 hours @ $480/hour	1,440	
	Sigma 5 20 hours @ 60/hour	1,200	
	PDP 9 24 hours @ 27/hour	650	
	Travel		
	1 Round-trip East Coast	330	
	1 Round-trip Brazil	1,000	
	Report Costs	1,200	
	Direct Costs (less Communications Equip.)		7,770
	Total Cost (less Communications Equip.)		54,860
	Less University Non-Federal Participation		-1,650
	Total Funds Requested from NASA		$53,210

*11.6% through 8-31-69, 12.3% thereafter

Estimated cost for the two alternative systems are $52,000 for the system of Figure I and $62,000 for the system of Figure II. These cost are estimates of the purchase price of the hardware. Since most of the equipment is standard the possibility also exists of leasing it for the 9 months or 1 year necessary at a cost significantly below its purchase price. Additionally, since several suppliers are interested in the experiment as demonstration of additional uses of their products, it is probable that the necessary equipment could be donated or loaned for the experiment. These possibilities raise questions that can only be answered by NASA in conjunction with the experimenters and hardware suppliers.

The project cost to NASA would run a minimum of $53,000, assuming equipment would be loaned or donated, and a maximum of $115,000, assuming the equipment would be purchased.

K. CNAE's Cost Page

These figures are included for information only. Costs for CNAE will be borne by the Brazilian government.

	U$
The cost of the "Projecto SACI" staff (14 persons) working during 6 months, half time period.........	21,000
The cost of the auxiliary team (4 persons)........	3,000
The equipment costs will be the same as Stanford's	
costs plus transportation....................	80,000
overhead..................................	12,000
support and report costs....................	2,000
coordinating trip...........................	2,000