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OPTIONS FOR INPE-ESA DATA COMMUNICATION INTERFACING - PRELIMINARY VERSION

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14. Abstract/Notes

The main purpose of this report is to identify and characterize the options for interfacing INPE and ESA data communication systems for cross-support in future space missions. Four options are identified and characterized in this report as a result of the work developed in collaboration between INPE and ESA technical personnel.

15. Remarks *This report is based on the work executed with cooperation between ESA/ESOC and INPE/DCA technical personnel, in Darmstadt, W. Germany, during the Fall of 1984.*

SUMÁRIO

O propósito principal deste relatório é o de identificar e caracterizar as opções para interfaceamento entre os sistemas de comunicação de dados do INPE e da ESA, para apoio cruzado em missões espaciais futuras. Quatro opções foram identificadas e caracterizadas neste relatório, como resultado do trabalho desenvolvido com a colaboração entre o pessoal técnico do INPE e da ESA.

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1. INTRODUCTION

The main purpose of this report is to identify and characterize the options for interfacing INPE and ESA data communication systems for cross-support in future space missions. On the side of INPE the REDACE System (Data Network for Space Control) will have available interfaces for connection with ESA and other space agencies. On the side of ESA there is the so-called Satellite Ground Support Network composed by: ground stations, satellite control centers and a network control center.

The options for the interface presented in this report are div ded into two groups:

. Direct connection between a ground station of one agency and a control center of the other agency. This connection does not need to use the protocol of the data network of the agency which owns the ground station. There is only one option characterizing this group, the so-called **Option 1 - Throughput Mode**.

. Connection between both data networks: the REDACE System of INPE and the Data Packet Switching System (DPSS) of ESA, using a protocol. There are three options in this group, the so-called **Option 2 - X.25 access by MCR** (Multiprocessor for Network Communication); **Option 3 - X.25 access by Protocol Converter**: **Option 4 - X.28 access to DPSS.**

This report is the result of a joint work executed by two engineers of DCA/INPE with support of the Ground Systems Engineering Department staff of the Directorate of Operations of ESOC/ESA, in Darmstadt, West Germany, in the fall of 1984.

The options for the interfaces presented above were based on SESA (1981, 1983 and 1984), ESA (1981 and 1982) and BERGAMINI et alii (1984).

2. INTERFACING OPTIONS

2.1 - OPTION 1: THROUGHPUT MODE

2.1.1 - GENERAL DESCRIPTION

This option offers the possibility of receiving Telemetry (TM) at the ground station of one agency, to be transmitted to the control center of the other agency. This type of TM transmission avoids the use of the data network of the agency which supports the receiving ground station (ESA, 1982). Therefore, the string of bits received from the satellite,by ground station,is promptly transmitted to the user agency, without any intermediate data treatment.

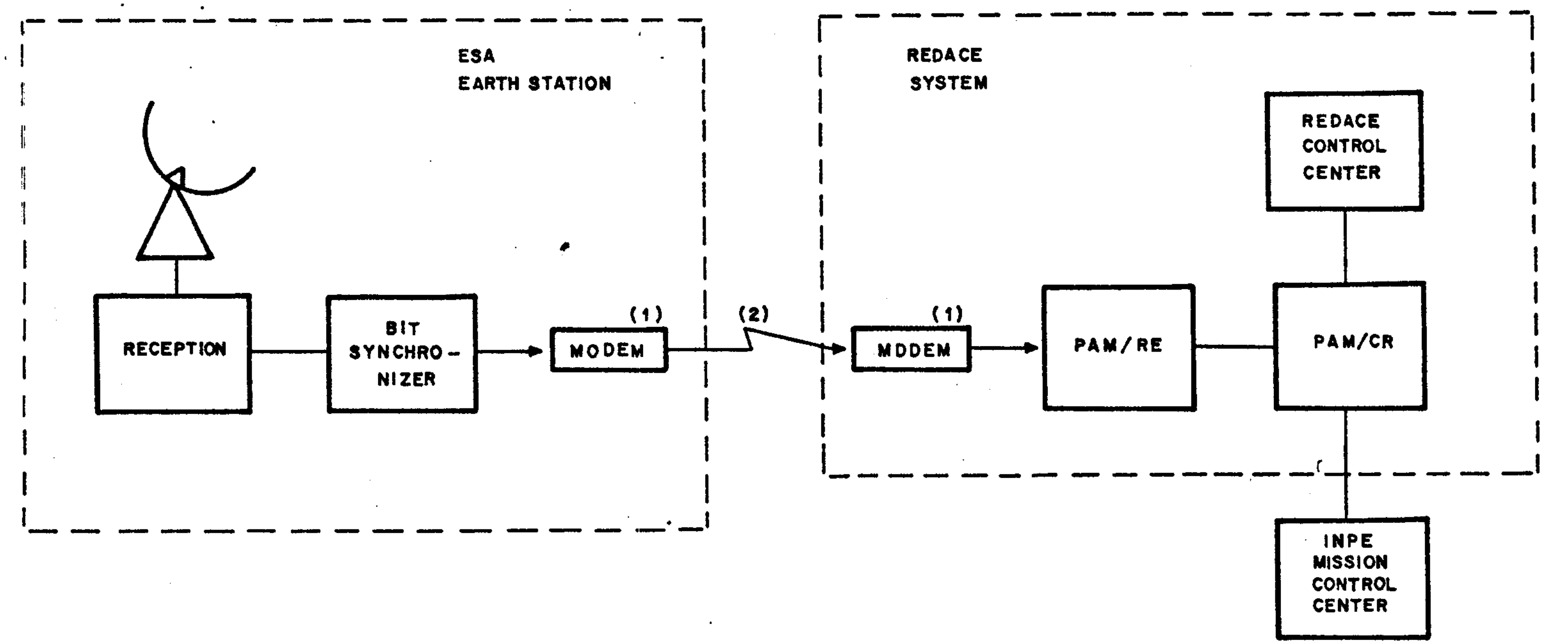
In this option, other means of communications (telephone, telex, etc.) would have to be considered, although not in real-time, for supporting Telecommand (TC), Ranging and Antenna Control.

At this moment, only the support by ESA ground stations would be under consideration.

2.1.2 - DETAILED DESCRIPTION

The scheme in Figure 1 represents the connection of an ESA ground station with the REDACE System,for this option. Through the physical connection of the ESA ground station Bit Synchronizer with the Message Processor and Logger/External Network (PAM/RE) of the REDACE System there would be only the flow of TM data. This characterizes a "simplex" data connection that would not be supported by any error detection and/or recovery service.

The "clock" output at the Bit Synchronizer does not have sufficient stability to serve as a "clock" input to the modem. Therefore, this "clock" will not be used for the modem.



(1) MODEM CLOCK HAS TO BE GREATER THAN TWO TIMES THE DATA RATE.

(2) IN THIS CASE THE DATA LINK HAS NO PROTOCOL.

LEGEND : PAM : MESSAGE PROCESSOR AND LOGGER

RE : EXTERNAL NETWORK

CR : REDACE SYSTEM CENTER

Fig. 1 - INPE-ESA Interface: Throughput Mode

A good synchronization recovery from the string of bits received by the PAM/RE could be obtained if the modem "clock" is at least twice the Bit Synchronizer transmition data rate. The This TM data rate would, then, suggest a 9600 bits/sec. data rate for the modem; this would mean more than four times the down link TM data rate. The PAM/RE, by means of its data communication interface connected to the receiving modem, will have to recover the original NRZ-L TM data string.

After this TM string data recovery, the PAM/RE will have to search for the TM frames, contained in this same string. The same PAM/RE will, then, use the PRIME (INPE Protocol for Space Mission) protocol, as defined for REDACE System, to send this TM frames to the Mission Control Center.

In this option the Telecommand (TC) blocks would be transmitted up-link from the ESA Station Computer or from its Mission Control Center.

All the TC data would be previously stored in one of those ESA facilities, as strings of bits, with identifying appended codes. Obviously, before each INPE satellite capture by an ESA station, these TC strings of bits would be stored at the proper ESA facilities.

These TC related data could be sent from INPE to ESA only by using other means of communications, like telex or mail. These same restrictions and service alternatives would be extended if Ranging and Antenna Control services are to be requested by INPE to ESA, as well.

2.1.3 - REQUIREMENTS FOR IMPLEMENTATION

The main requirements for implementing this option are:

a) Implementation in the PAM/RE of the software for recovery the string of bits originally received by ESA ground station;

b) Provision, in the chosen ESA ground station, of a physical connection to receive the INPE satellite downlink TM string of bits, at the output of the Bit Synchronizer;

c) Provision of storage service availability at ESA Mission Control Center or Station Computer for the TC bit strings to be sent uplink for the INPE satellite;

d) Verifying the reception and transmission of compatibility of Telemetry, Telecommand and Ranging between ESA ground stations and INPE satellite;

e) Establishment, at INPE and ESA, of operational and administrative routines for cross-support.

2.1.4 - TECHNICAL ANALYSIS

The following observations are pertinent:

a) Considering the data output of the Bit Synchronizer of the ground station the Telemetry (TM), data would be received by the PAM/RE with minimum delay, although without any error recovery capability;

b) It is not possible to receive a high telemetry data due to the modem speed limitation in the international communication link;

c) Real time telecommands can not be sent from INPE Mission Control Center;

d) Low complexity and relatively low cost implementation;

e) The proposed configuration would permit only one ESA ground station connection at a time, for each physical link.

2.2 - OPTION 2: X.25 ACCESS BY MCR

2.2.1 - GENERAL DESCRIPTION

This option proposes the connection of the INPE REDACE System to the ESA Data Packet Switching System (DPSS) (SESA, 1981, 1983 and 1984) by means of X.25 protocol connections.

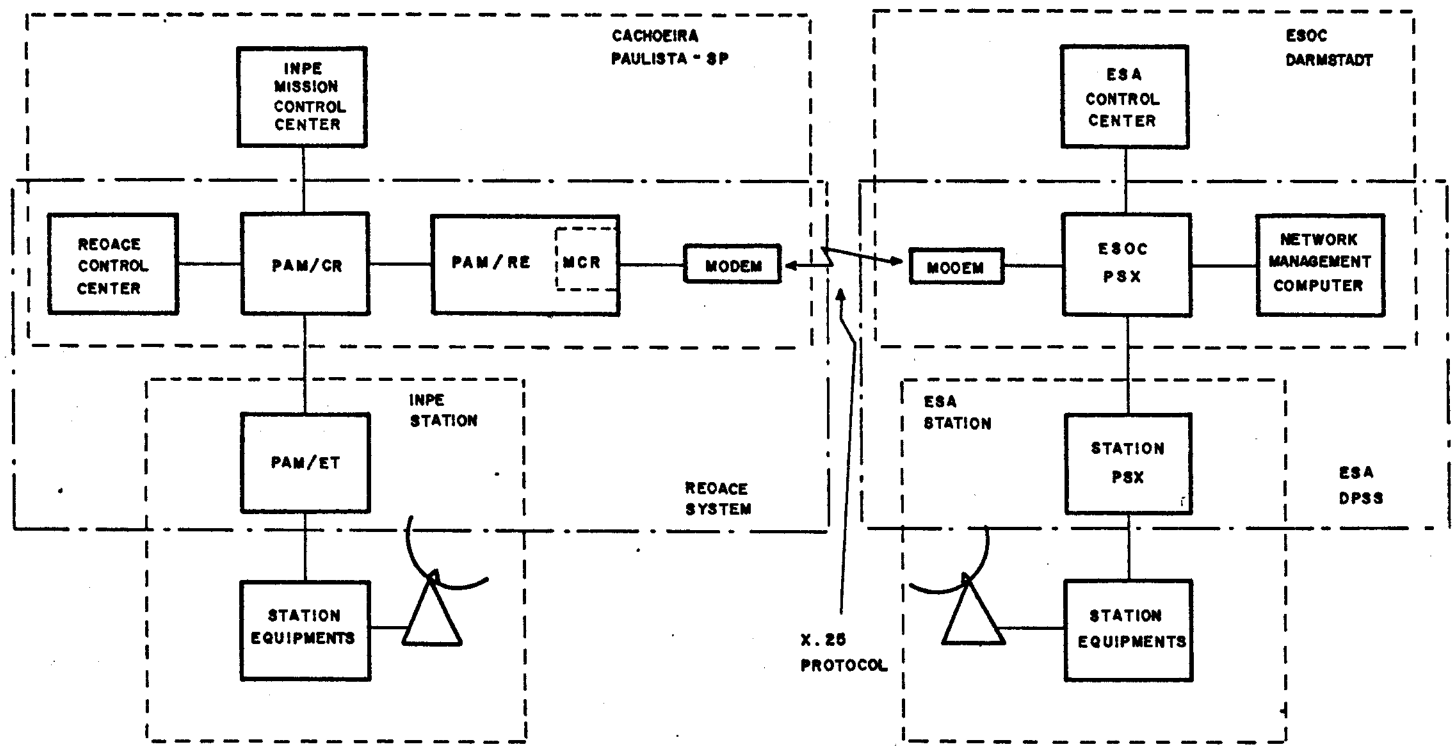
In the REDACE System the Multiprocessor for Network Communication (MCR) would have the X.25 data communication protocol implemented in it. (Bergamini et alli 1984)

This option would permit an user of the REDACE System to communicate with any ESA DPSS host system and vice versa.

2.2.2 - DETAILED DESCRIPTION

The basic scheme of Figure 2 represents the interface of the REDACE System with ESA DPSS, for this option. This same figure does not represent all the nodes of the two data communication networks, but only those needed for demonstrating how the cross-supported service to be offered by a ground station would be configured.

The ESA DPSS is composed of many nodes who interconnect their ground stations with its Control Center. The access to this system by an user is made by means of the X.25 protocol. The basic idea of this option relies in making the REDACE System to access the ESA DPSS as one of its users. The same principle would hold if the REDACE System is to be accessed by ESA DPSS. The PAM/RE of the REDACE System is the equipment which would implement the protocol



LEGEND:

PAM	:	MESSAGE PROCESSOR AND LOGGER
CR	:	REOACE SYSTEM CENTER
ET	:	EARTH STATION
RE	:	EXTERNAL NETWORK
PSX	:	PACKET SWITCHING EXCHANGE
OPSS	:	DATA PACKET SWITCHING SYSTEM

Fig. 2 - INPE-ESA Interface: X.25 Access by MCR

mapping for permitting the correct message routing in its domain.

Figure 3 represents the details of the PAM/RE. Its MCR would access the ESA data communication network according to the X.25 protocol. On the other side, this same MCR is to implement the REDACE System INPE Protocol for Space Missions (PRIME). Besides, the PAM/RE should store a "routing table" that would permit, for instance, INPE Mission Control Center to be connected by a data communication link with an ESA ground station. Each time a new end-to-end data communication link is to be established,the "routing table" must be properly loaded in the PAM/RE, under the supervision of the REDACE Control Center (CCR). If another end-to-end data link connection is to initiated, the "routing table" would guarantee the uniqueness of an end-to-end data connection, whatever services are to be cross-supported between INPE and ESA end users.

This option could cross-support telecommand, telemetry, ranging, antenna control, etc. services. However, an application level protocol would have to be implemented for the exchanging of operational messages associated with each specific service to be offered. For instance, if a ranging service is to be cross-supported, the agency proprietary of the ground station would command their equipments and would send to the user agency the results that would be obtained with the execution of this service. Another example: if an antenna control service is to be executed by the proprietary agency, the requested information would be sent by the user agency through the data connection. It should be clear that an end-to-end connection could simultaneously cross-support more than one service.

The ESA protocol (data formats, etc.) for supporting services to be offered by a ground station is defined in the ESA documment named Station Data Interchange Document, edited by the Ground Systems Engineering Department of the Directorate of Operations/ESOC (ESA, 1982).

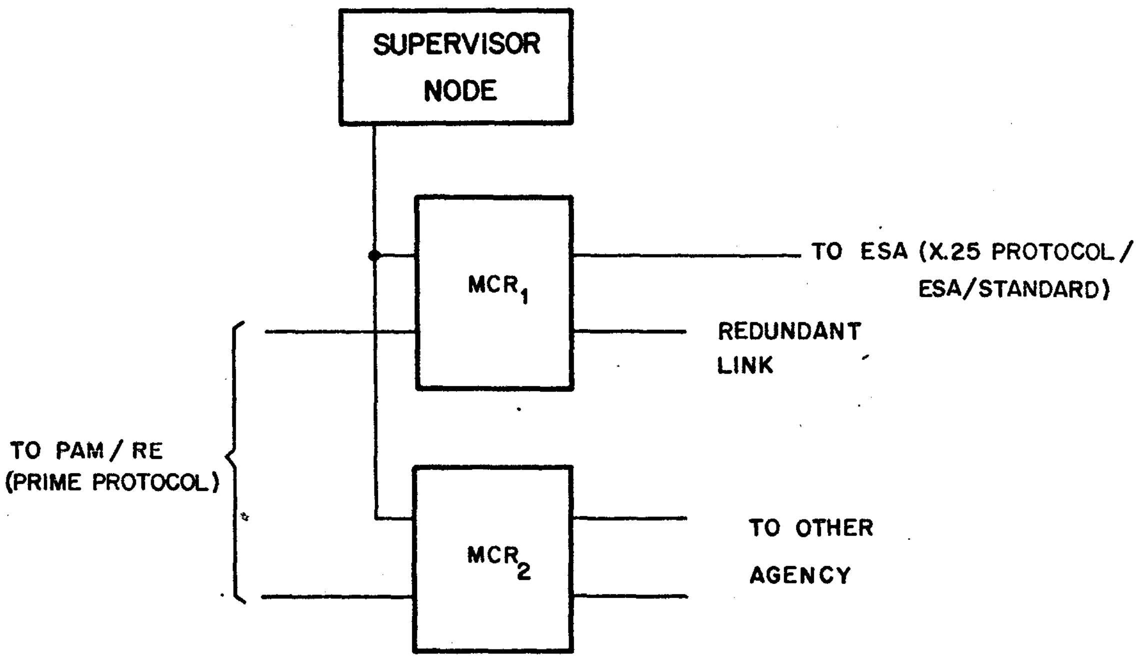


Fig. 3 - Basic configuration of the PAM/RE

2.2.3 - REQUIREMENTS FOR IMPLEMENTATION

The main requirements for implementing this option are:

a) Study in detail the X.25 protocol utilized by the ESA DPSS;

b) Development of the software to implement the X.25 protocol in the MCR;

c) Development of the software to be implemented in the PAM/RE, which will permit the message routing between both networks;

d) Adaptation of ESA ground station services to cross-support INPE Mission Control Center;

e) Development of the software in the INPE CCM, CCR and PAM/RE to permit the utilization of the services offered by the ESA ground stations;

f) Verifying the reception and transmission compatibilities for Telemetry, Telecommand and Ranging between ESA ground stations and INPE satellite;

g) Establishment, at INPE and ESA, of operational and administrative routines for cross-support.

2.2.4 - TECHNICAL ANALYSIS

The following observations are pertinent:

a) Telecommand, Telemetry, Ranging and Antenna Control services, normally offered by a ground station, could be cross-supported;

b) There would be sufficient reliability in this option, considering that its data links would be protected by protocols with error recovery capability;

c) It would be possible to perform the communication between any ESA DPSS and REDACE System users;

d) The already existing MCR hardware is compatible with the X.25 protocol implementation, although its software would have to be developed;

e) For each end-to-end data communication connection simultaneous service could be offered.

2.3 - OPTION 3: X.25 ACCESS BY PROTOCOL CONVERTER

2.3.1 - GENERAL DESCRIPTION

This option proposes the utilization of the X.25 protocol in the long distance data link, which would be connected to the ESA DPSS System,from INPE REDACE System.

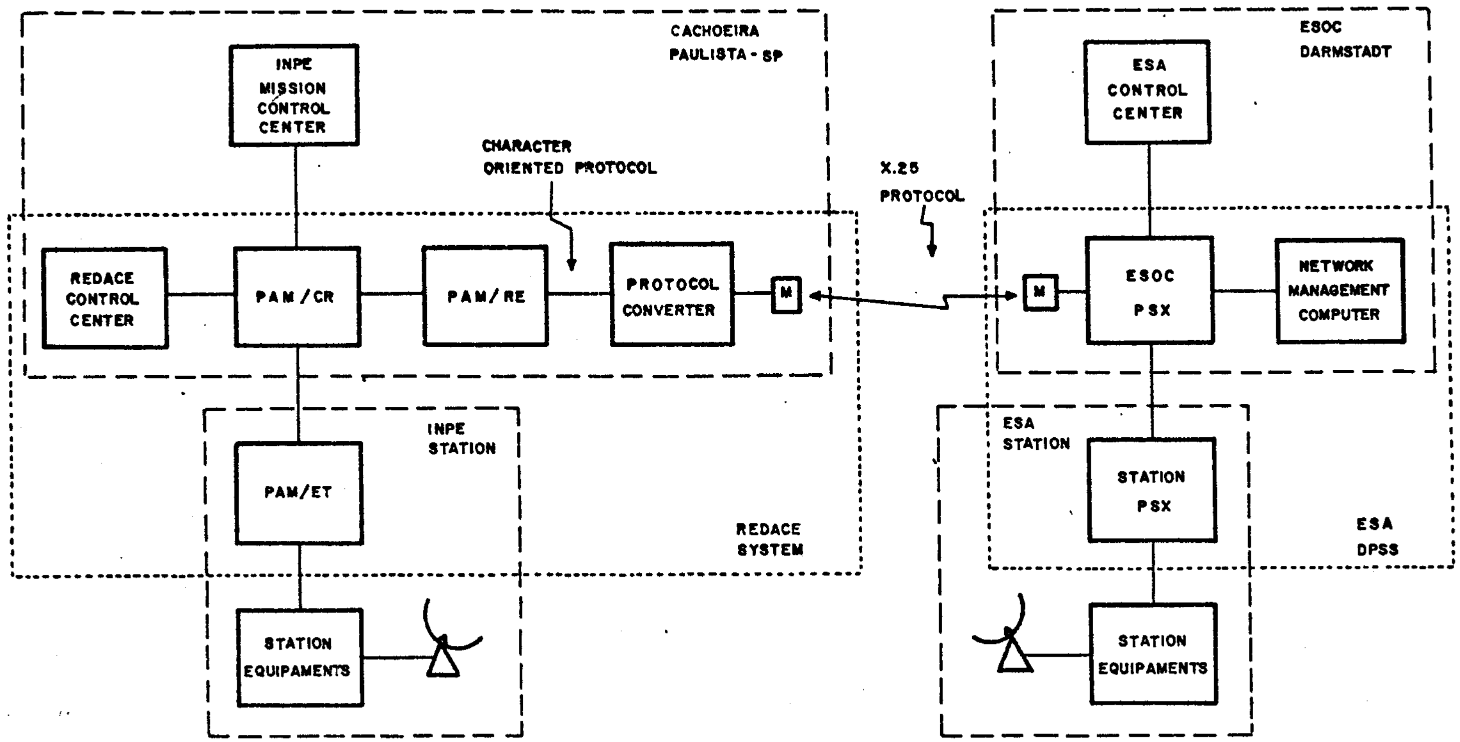
There would be only one main difference between this option and option 2 (X.25 access by MCR). This difference concerns the utilization of a data protocol converter between the INPE PAM/RE and the ESA/ESOC Packet Switching Exchange (PSX). This converter should implement the X.25 protocol in its output port to be connected to the international data link, while supporting a character oriented protocol in its output port,to be connected to the PAM/RE.

This option would also support a single end-to-end data connection that would permit the execution of simultaneous services.

2.3.2 - DETAILED DESCRIPTION

The scheme of Figure 4 would represent the data connections between the REDACE System and the ESA DPSS, that would utilize a long distance data link,based on the X.25 protocol.

An important feature of this option is the utilization of a protocol converter which would have to be acquired in the market.



LEGEND:

PAM	:	MESSAGE PROCESSOR AND LOGGER
CR	:	REDACE SYSTEM CENTER
ET	:	EARTH STATION
RE	:	EXTERNAL NETWORK
M	:	MODEM
PSX	:	PACKET SWITCHING EXCHANGE
DPSS	:	DATA PACKET SWITCHING SYSTEM

Fig. 4 - INPE-ESA Interface: X.25 Access by Protocol Converter

The protocol converter equipment should, on one side, observe the X.25 standard compatible with the version utilized by ESA and, on the other side, should observe a simplified protocol based on the X.28 standard. The converter equipment should permit the simultaneous establishment of more than one service between INPE and ESA networks. It is understood that the maximum number of virtual channels of the protocol converter is limited by the number of permitted physical character oriented connections.

Comparing Figure 2 with Figure 4 it can be observed that from the point of view of ESA there would be no difference between options 2 and 3. Therefore, all the services to be cross-supported and their operating modes would be maintained for both options.

In order to support Telecommand, Telemetry, Ranging and Antenna Control services, a protocol converter with at least four character oriented physical connections for the PAM/RE should be utilized. Figure 5 represents a connection scheme for the PAM/RE and the protocol converter. In this case the MCR should have a character oriented physical interface. As a result, the character oriented software to be implemented in the MCR will be fairly simple and could not support error recovery and flow control in its protocol.

2.3.3 - REQUIREMENTS FOR IMPLEMENTATION

The main requirements for implementing this option are:

a) Selection,for acquisition,of a protocol converter equipment compatible with the X.25 protocol, as utilized by ESA;

b) Development of a software to be resident in the MCR for its data connection with the protocol converter;

c) Development of the software to be implemented in the PAM/RE which will permit the message routing between both networks;

d) Adaptation of ESA ground station services to cross-support INPE Mission Control Center;

e) Development of the software in the INPE CCM, CCR and PAM/RE to permit the utilization of the services offered by the ESA ground stations;

f) Verifying the reception and transmission compatibilities for Telemetry, Telecommand and Ranging between ESA ground stations and INPE satellite;

g) Establishment, at INPE and ESA, of operational and administrative routines for cross-support.

2.3.4 - TECHNICAL ANALYSIS

The following observations are pertinent:

a) Telecommand, Telemetry, Ranging and Antenna Control services normally offered by a ground station could be cross-supported;

b) There would be sufficient reliability in this option, considering that its data link would be protected by protocols with error recovery capability;

c) It would be possible to perform the communication between any ESA DPSS and REDACE System users;

d) With the utilization of a protocol converter, the software to be developed for the MCR will be much more simple than that which would implement the X.25 protocol;

e) The protocol converter would have a limited number of logical channels which would connect the REDACE System with the ESA DPSS. If the number of logical channels is, for instance, equal to four, probably there would be no limitation in the system performance,as a whole.

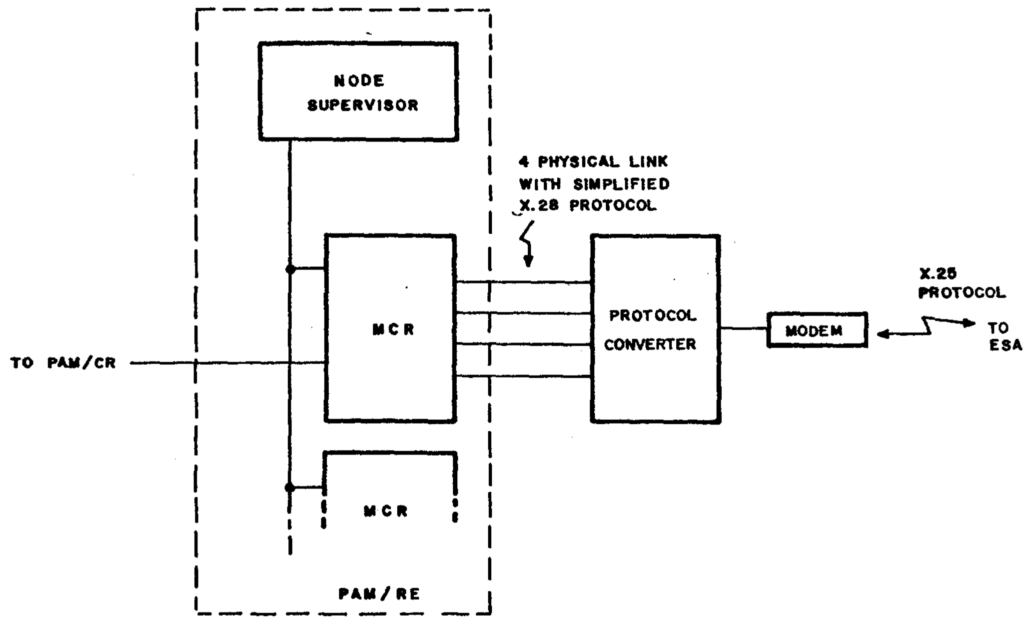


Fig. 5 - Physical connections of the Protocol Converter

2.4 - OPTION 4: X.28 ACCESS TO DPSS

2.4.1 - GENERAL DESCRIPTION

In this option the INPE REDACE System would be (PAD). This solution would imply that the data communication international link should be the character oriented X.28 protocol (SESA, 1983).

The PAM/RE of the REDACE System would have to give support for the gateway and data routing between both networks.

2.4.2 - DETAILED DESCRIPTION

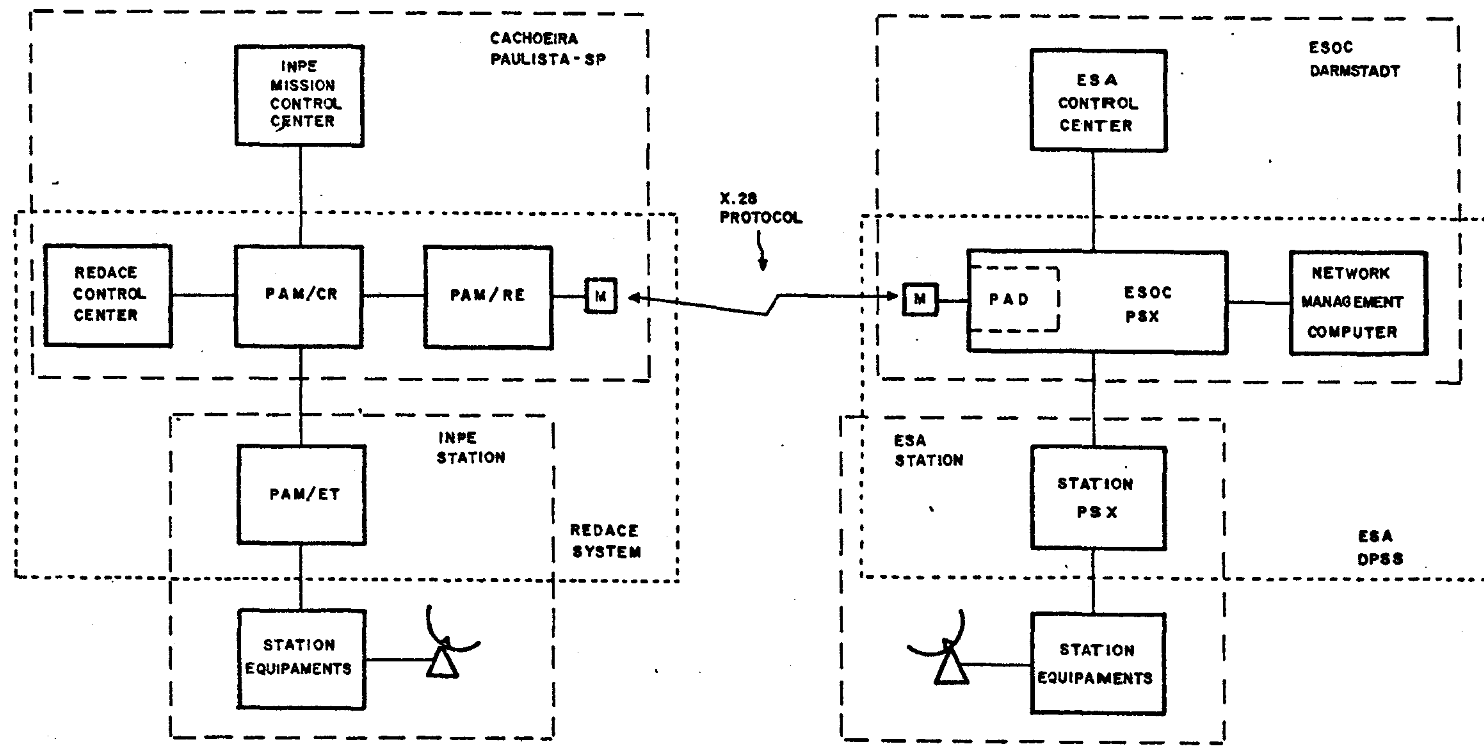
The scheme of Figure 6 represents what would be the connection of the INPE REDACE System with the ESA DPSS, by utilizing a PAD with the PSX, at ESOC.

This type of data connection would operate with a data rate lower (normally limited to 1200 bps) than those connections which operate with the bit oriented communication protocol.

The PAM/RE should implement X.28 protocol to access the ESA DPSS. Conversely, this connection would also permit the REDACE System access by the ESA DPSS.

In this option, comparing with option 2 and 3, there is a difference only in the connection of the PSX of the ESOC with the PAM/RE of the REDACE System.

The routing of data and the application level protocol would be the same for these three options (2, 3 and 4). In the same way, data communication between any two end-to-end users of both networks would be cross-supported.



LEGEND:

PAM	:	MESSAGE PROCESSOR AND LOGGER
CR	:	REDACE SYSTEM CENTER
ET	:	EARTH STATION
RE	:	EXTERNAL NETWORK
M	:	MODEM
PSX	:	PACKET SWITCHING EXCHANGE
DPSS	:	DATA PACKET SWITCHING SYSTEM
PAD	:	PACKET ASSEMBLER DISASSEMBLER

Fig. 6 - INPE-ESA Interface: X.28 Access to DPSS

Each physical connection with X.25 protocol would permit only one active virtual channel at a time. As a result, there could be necessary to use a higher number of physical connections between both networks for simultaneous support of the services that could be offered by the ground station.

2.4.3 - REQUIREMENTS FOR IMPLEMENTATION

The main requirements for implementing this options are:

a) Availability of a Packet Assembler Disassembler (PAD) at the PSX of ESA/ESOC;

b) Verification and provision, if needed, of more than one physical link for cross-support between the ESA/ESOC PSX and INPE PAM/RE;

c) Implementation of the X.28 protocol in the MCR of the INPE PAM/RE;

d) Development of the software to be implemented in the PAM/RE which will permit the message routing between both networks;

e) Adaptation of ESA ground station services to cross-support INPE Mission Control Center;

f) Development of the software in the INPE CCM, CCR and PAM/RE to permit the utilization of the services offered by the ESA ground stations;

g) Verifying the reception and transmission compatibility of Telemetry, Telecommand and Ranging between ESA ground stations and INPE satellite;

h) Establishment, at INPE and ESA, of operational and administrative routines for cross-support.

2.4.4 - TECHNICAL ANALYSIS

The following observations are pertinent:

a) For an end-to-end connection all types of services can be offered, although not simultaneously;

b) The reliability of the long distance data link between both networks is low due to absence of error recovery procedures in the X.28 protocol;

c) Lower data rates would have to be used in the X.28 international long distance connection;

d) This option, in principle, is less attractive than options 2 and 3.

3 - CONCLUSIONS

The four analysed options furnish the very basic information necessary for the next phase of this project: the Evaluation Phase. In this next phase one of these four options would be recommended, with some additional analysis on the implications that its development would amount to (chronogram, cost, etc.)for effective implementation. After the Evaluation Phase, the work would continue with the next phase: the Decision. Upon Decision, the Development Phase would be executed, resulting in the desired,final, Operations Phase.

The Options 2 and 3, based on X.25 protocol for the long distance international data link segment between both agencies, seem to be the most attractives, when compared with options 1 and 4 which do not provide resources for error recovery in this segment.

The effective conclusion of this work for connecting INPE and ESA networks would be possible only if a formal Memorandum of Understanding is celebrated between both agencies.

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