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OPTIONS FOR INPE-CNES DATA COMMUNICATION INTERFACING PHASE 1: PRELIMINARY STUDY -

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14. Abstract/Notes

This report presents the result of the initial data collecting phase (Preliminary Phase) to determine interconnection options between the REDACE System ("Sistema de Rede de Dados para Controle Espacial") of INPE and the "Réseau de Stations 2 GHz" of CNES. The final objective to be attained with this continuing work is the cross-support for Space Missions between CNES and INPE.

15. Remarks *This report is the result of a cooperative work executed by the technical staffs of INPE/DTC/DCA and CNES/ESO/DA.*

SUMÁRIO

Este relatório apresenta o resultado da fase inicial de levantamento de dados (Fase Preliminar), que tem como objetivo a determinação das opções de interconexão entre o Sistema REDACE ("Sistema de Rede de Dados para Controle Espacial"), do INPE, e a "Rede de Estações 2 GHz" do CNES. O objetivo final deste trabalho, em andamento, é o de viabilizar o apoio cruzado entre o CNES e o INPE em Missões Espaciais.

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1. INTRODUCTION

The Brazilian Institute for Space Research - INPE (Instituto de Pesquisas Espaciais) develops its Data Network for Space Control, the so called REDACE System (Sistema de Rede de Dados para Controle Espacial). Gateways for data communications with external data networks are being considered in the development of the REDACE System. These gateways are expected to provide cross-support in space missions between INPE and other space agencies (Bergamini 1984).

In particular, this project presents the various options for connections between the Réseau de Station 2 GHz (CNES 1984a) of the Centre National d'Études Spatiales - CNES and the REDACE System of INPE. The facilities of the "Réseau de Stations 2 GHz" are composed of earth stations, a data communication network, the so-called "Système de Transmission de Données Digitales - STDD" (CNES 1984a) and several control centers:

- CCS Centre de Contrôle Spécialisé (dedicated control center);
- COR Centre d'Opérations Réseau (network operations control center);
- COO Centre d'Orbitographie Opérationnelle (operational orbit computation center);
- SDM-Service de Détermination des Manoeuvres (maneuver determination service).

The effective implementation of this project is expect to observe the following five phases: 1) Preliminary Phase; 2) Evaluation Phase; 3) Decision Phase; 4) Development Phase; 5) Operation Phase.

The Preliminary Phase of this project comprises the study of the characteristics of both data networks (INPE and CNES) and their options for data communication interfacing. This report represents the result of this phase of the project. Each option for interfacing is presented with a technical analysis.

Three options for data communication interfacing were identified. The first option does not properly characterize a gateway between INPE and CNES networks, considering that it would implement a *Direct Connection* between a CNES earth station and the REDACE System. This option would be solely intended for support, by CNES, to INPE's space missions.

The second and third options characterize data connections between the networks of both agencies and could be utilized for cross-support in space missions of the two agencies.

The second option is the *Connection with ETTD*, which is characterized by the local connection of a CNES data terminal equipment (ETTD - Equipement Terminal de Transmission de Donnēes) with the External Connections System (SCE) of the REDACE System to be located in Brazil.

The third option is the *Connection with MCR* which is characterized by connecting a Multiprocessor for Network Communications (MCR), of the REDACE System, to a CNES ETTD equipment, to be located in France.

2. INTERFACING OPTIONS

2.1 - DIRECT CONNECTION

2.1.1 - GENERAL DESCRIPTION

This option would be implemented by means of a direct connection between the so called External Connections System (SCE) of the REDACE System and the CNES (ground) Station, bypassing the CNES Digital Data Transmission System - STDD (Systēme de Transmission de Donnēes Digitales). This option would only support the use of CNES Stations by INPE.

c) Specification and development of the pertinent software to be resident in the SCE System.

d) Evaluation of the up link and down link telecommunication compatibility (frequency, modulation, etc.) for cross-support.

e) Memorandum-of-Understanding between both agencies, establishing the services to be supported by CNES to INPE.

2.1.4 - TECHNICAL ANALYSIS

This option would solely support the TM service. It does not provide CNES support, for Ranging and Telecommand Services which could, otherwise, be essential services for INPE.

Another critical aspect is the fact that INPE's satellite is expected to have a down-link data rate of 2.000 bits/s, which would require a data transmission rate of 9600 bits/s. for the MODEM connected to the CNES Primary Synchronizer. Considering that no protocol is to be used in the long distance data link between the MODEMS, for such a fairly high data rate (9600 bits/s.), this communication channel would present a high error data rate, without possibilities of error recovering.

It is worthwhile to mention that this is an option of notable technical simplicity and low cost.

2.2 - CONNECTION WITH ETTD

2.2.1 - GENERAL DESCRIPTION

In this option, an ETTD equipment would be utilized to connect the REDACE System to the STDD System (CNES 1984b), providing a fully compatible connection between both systems.

i.e., the ETTD located in Brazil may be programmed with a source/destination code reflecting the supported project. If the project changes, this code can be easily modified (PROM). Of course in this configuration the block structure and its content will have to comply with CNES formats.

INPE user project will have a specific source/destination code chosen in agreement with CNES, and the supporting CNES stations (Figure 3) will use their own source/destination codes.

b) INPE providing a station tracking support to a CNES project.

In this configuration the problem is slightly more complex depending upon whether the support being provided includes, simultaneously, one or several stations.

If using a single station, the ETTD in Brazil is to be considered like that ETTD supporting a CNES station. This ETTD in Brazil will have to interface with the SCE (INPE responsibility). The format and content of the network and message header of the incoming an outgoing blocks have to comply with CNES specifications in order to be correctly handled by the communications system. The block information field (BIF) can be specific of the INPE systems if agreed upon between requesting and supporting agencies.

If using more than one station during a support to the same project, i.e., several stations connected to the same ETTD during a particular phase, it is necessary to define and to implement a mechanism which allows to identify which station is connected, at a specific time to the system. This is relatively simple for the data going out of the stations (like TLM) because the source code is generated by the sender system or subsystem and not checked by the ETTD. However, it is more complicated when going into the station (like CMD), because the destination code is checked by the ETTD and is unique, but the incoming command block has to be routed to the appropriate station among several. It can be done by the REDACE System according to directives provided by the user project via voice and/or TTY, but it will be INPE's

responsibility to provide the correct configuration. Another solution would be a single source/destination code for all INPE stations for incoming and outgoing data. In this case the identification of the real and, the problem to route correctly the CMD data would be the same as above.

There are probably other solutions. The purpose of these remarks is not to define the solution, but only to outline the problem.

In the configuration, where INPE tracking stations support a CNES project, there is also an important point to consider, which is the correct flagging of the PF1 and PF2 status bits indicating if an error occurred in the leg INPE station - ETTD (in Brazil). It will be INPE's responsibility to deliver to the ETTD: either error-free data encapsulated in CNES blocks or CNES block with encapsulated data and corresponding status bits set correctly for indicating if the data is in error or not.

It is remembered that the ETTD does not generate any data block. All the blocks have to be generated by the subsystem which provides the service and sometimes it could be difficult to "simulate" this block, if the concerned subsystem was not designed for this purpose. As an example it is the command block, which is tightly dependent of the station command encoder, and vice-versa, for checking the correctness of CMD parameters and generating the CMD echo block.

So, it will have to be very careful concerning this problem for determining where and how the blocks will be generated, i.e., at the earth station or at the SCE.

The scheme of Figure 4 represents the proposed connection for this option. This proposal would permit the simultaneous utilization of diversified services such as telemetry, telecommand, ranging, etc.

2.2.3 - REQUIREMENTS FOR IMPLEMENTATION

a) Acquisition by INPE of two ETTDs (one for spare) compatible with the STDD.

b) If simultaneous services, from INPE to CNES, and vice-versa, are desired, a third ETTD unit should be acquired with associated PROM spares.

c) Development of the software to be resident in the SCE System for proper implementation of this option.

d) Development of the software to be resident in the Mission Control Center Computer for proper implementation of the data formats to be utilized in some of the predicted services, such as ranging, doppler, ephemeris, etc.

e) Contracting of an international private data communication link.

f) Evaluation of up link and down link telecommunications compatibility (frequency, modulation, etc.) for cross-support.

g) Memorandum-of-Understanding between both agencies, establishing the services to be supported by CNES and INPE.

2.2.4 - TECHNICAL ANALYSIS

This option would enable the concurrent and reciprocal execution of all the predicted services (telemetry, telecommand, etc.) that could be requested either by INPE or CNES. It has also the advantage of minimizing the software development, considering that the compatibility of the ETTD with the STDD would already be guaranteed and that a relatively simple software would have to be implemented in the SCE System.

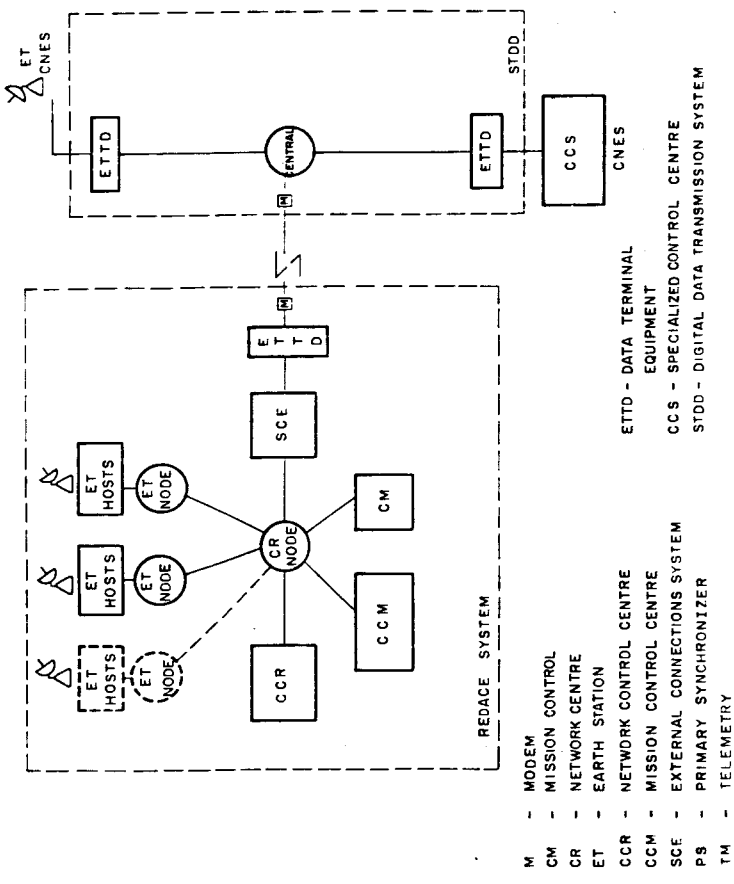

Fig. 4 - INPE-CNES interface: connection with ETTD.

2.3 - CONNECTION WITH MCR

2.3.1 - GENERAL DESCRIPTION

This option characterizes a connection of the REDACE System's SCE to the STDD System, by means of a Multiprocessor for Network Communication (MCR) connected to an ETTD. A MCR located at CNES and connected to the ETTD would be remotely connected to the SCE, in Brazil. In this case, a long-distance data link with error recovery capability would be provided between the SCE and the MCR.

2.3.2 - DETAILED DESCRIPTION

It can be observed in Figure 5 that the MCR as well as the ETTD would remain in the CNES facilities, such that the MCR - ETTD and the ETTD - STDD (Central) connections would be in short distance.

The SCE-MCR-ETTD data communication path would operate in a full-duplex mode, with data rates up to 9600 bits/s. The MCR - ETTD connection would have to observe the maximum data block flow permitted by the ETTD, as established by CNES documentation (CNES 1984).

In the SCE-MCR long distance international data link, a link level protocol (in the ISO/OSI reference model sense) would be implemented. In this case, the data contained in the link level protocol would carry a CNES block, excluding the original HDLC envelope. This link level protocol would be based on the INPE Protocol for Space Mission (PRIME).

In the MCR-ETTD and ETTD-STDD (central) link segments, the data would naturally flow according to the CNES HDLC protocol, carrying the CNES data blocks.

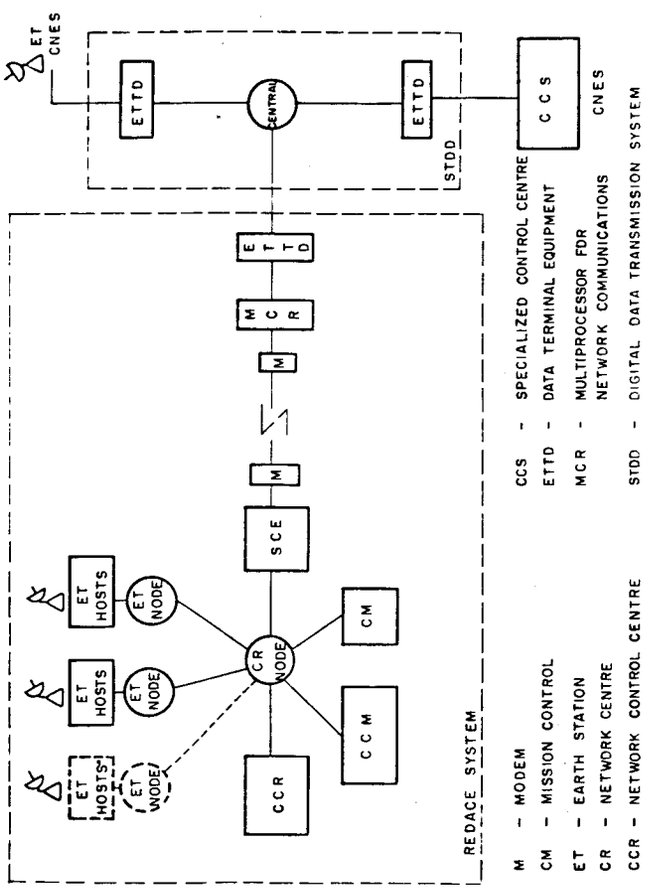

Fig. 5 - INPE-CNES interface: connection

This option would permit the simultaneous utilization of the data link by various services (telemetry, telecommand, ranging, etc.) predicted for cross-support.

In this case, the REDACE System, which includes the MCR, would be represented by a unique address of the ETTD with respect to the STDD. The format field of the CNES block would differentiate a set of subaddresses to be associated with the different services, at the output of the ETTD connected to the MCR. On the other hand, the STDD would represent a host to the REDACE System, so that the SCE would guarantee the proper routing of data for both networks by means of a mapping table previously loaded in it by the REDACE System Network Control Center (CCR).

The Mission Control Center of the user space agency will have to observe the data formats of the cross-supporting station for its local services, like ranging, and others (CNES 1984c). The SCE would not support any data processing for these services.

2.3.3 - REQUIREMENTS FOR IMPLEMENTATION

a) Acquisition of two ETTD's (one for spare) compatible with the STDD.

b) If simultaneous services from INPE to CNES, and vice-versa, are desired, a third ETTD unit should be acquired with associated PROM spares.

c) Development of the specific software to be resident in the SCE System for proper implementation of this option.

d) Development of the specific software to be resident in the MCR, solely for implementation of the link level of the PRIME protocol.

e) Development of the specific software to be resident in the Mission Control Center computer for proper implementation of the data formats to be utilized in some of the predicted services, such as ranging, doppler, ephemeris, etc.

f) Evaluation of up link and down link telecommunications compatibility (frequency, modulation, etc.) for cross-support.

g) Contracting of an international private data communication link.

the services to be supported.

2.3.4 - TECHNICAL ANALYSIS

This option permits the simultaneous utilization of all the services (telemetry, telecommand, etc.) that could be cross-supported by both agencies.

This option would aim at an increase in the data transport reliability by using a data communication protocol with error recovery capability in its long distance international data link segment. The only advantage of this solution is the theoretical recovering of error-free data in both ways. However, it will be necessary to examine, in details, this solution when the expected communications protocol is defined and, also, when the station systems specifications are known, in order to verify the compatibility between CNES "throughput" concept, INPE communications protocol, besides the INPE earth station systems specifications. The error-free communication would not yet be globally assured because the data link segments of the STDD, which does not support an error recovery protocol, are more susceptible of errors, considering that such data links are those of urban, short distance type. However, it has to be outlined that the CNES network system is designed to be operated through circuits with M. 1020 specifications.The standard quality of these circuits is such that a system with error recovery capability seems not to be mandatory. Moreover, if the requested line rate is 9.6 kbps and if the data line quality is marginal the transmission speed can be decreased (if compatible with the rate of the useful data to be transmitted). Standard MODEMS transmission rates are 2400, 4800, 7200 and 9600 bps. The speeds selectable in the ETTD are 600, 1200, 2400, 4800, 7200 and 9600 bps.

The inconvenience of this configuration is to have to operate and mantain the INPE MCR System in CNES, Toulouse.

3. CONCLUSIONS

This final version of The Preliminary Phase accounts for two main modifications. The first concerns feedback received from CNES personnel with respect to a better explanation of the ETTD equipment and CNES STDD System. The second one concerns the REDACE System, which has been subject to a complete redefinition of its architecture, as adopted in May 1986, as well as in consideration to its protocol (the so called PRIME protocol), whose specifications are about to be defined (December 1986).

The three options which were analysed furnish the very basic information necessary for the next phase of this project, the Evaluation Phase. In this next phase one of these three 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, it will be possible to begin the next phase, the Decision Phase. Following the Decision Phase, the Development Phase would be executed, resulting in the conclusive Operation Phase.

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