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"CONCEPTS FOR CONNECTIVITY AND INTEROPERABILITY OF WORLD SPACE DATA NETWORKS - INPE PROPOSAL TO CCSDS/PANEL 3"

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12. Revised by

Ricardo C.O. Martins

9. Authorship *Eduardo Whitaker Bergamini*

Responsible author

13. Authorized by

Nelson de Jesus Parada
Director

14. Abstract/Notes

Concepts are presented for an architectural end-to-end reference model based on the identification of classes of applications and products to be offered by services required to exchange data in operational support of space data systems. An Internetwork Transfer Frame (ITF) structure and basic concepts of a protocol are proposed for operational interconnection of data networks. The upward compatibility of these concepts with the higher layers of a standard data interchange structure (SDIS) model is also considered, based on INPE proposal to CCSDS/PANEL 2. Implementation aspects of the proposed model are also presented with respect to INPE's network.

15. Remarks **Contribution to be presented at the Panel 3 meeting on Electronic Communications of the Consultative Committee on Space Data Systems - CCSDS, to be held in Lanham, Maryland, USA in May 16-17, 1983'.*

1 - INTRODUCTION

An end-to-end reference model at physical and system levels is proposed to identify what are considered to be the physical entities and their typical interconnections within the context of a unique space agency, and ou of its context, as well. This is represented in Figure 1.

Classes of Applications and Products which justify the exchange of data are suggested, based on the proposed end-to-end reference model.

An example of a Standard Data Interchange Service (SDIS) comprehending an internetwork service is suggested, as illustrated in Figure 2.

The identification of the physical entities and interconnections, in the context of INPE ground system, is given in Figure 3, with details of its REDACE System internetwork interfaces, as seen in Figures 4 and 5.

An Internetwork (gateway) Transfer Frame - ITF structure is proposed for data exchange among data networks of space agencies, as introduced in Figure 6. A header is proposed for the Internetwork (gateway) Transfer Frame - ITF. The ITF header format is represented in Figure 7, and their fields are defined in the following text.

The basic format of a Standard Data Interchange Structure - SDIS, as proposed by INPE to CCSDS/Panel 2 is shown in Figure 8. It is expected that SDIS messages would occupy the data field of an ITF. As a result, the ITF is expected to have a data communication treatment similar to that of the transport and link layers of the ISO/ANSI open systems reference model (de Jardins, 1982). Some characteristics of a session layer are expected to be incorporated to the internetwork protocol. All these properties are considered in the basic state diagram suggested for the internetwork protocol of Figure 9.

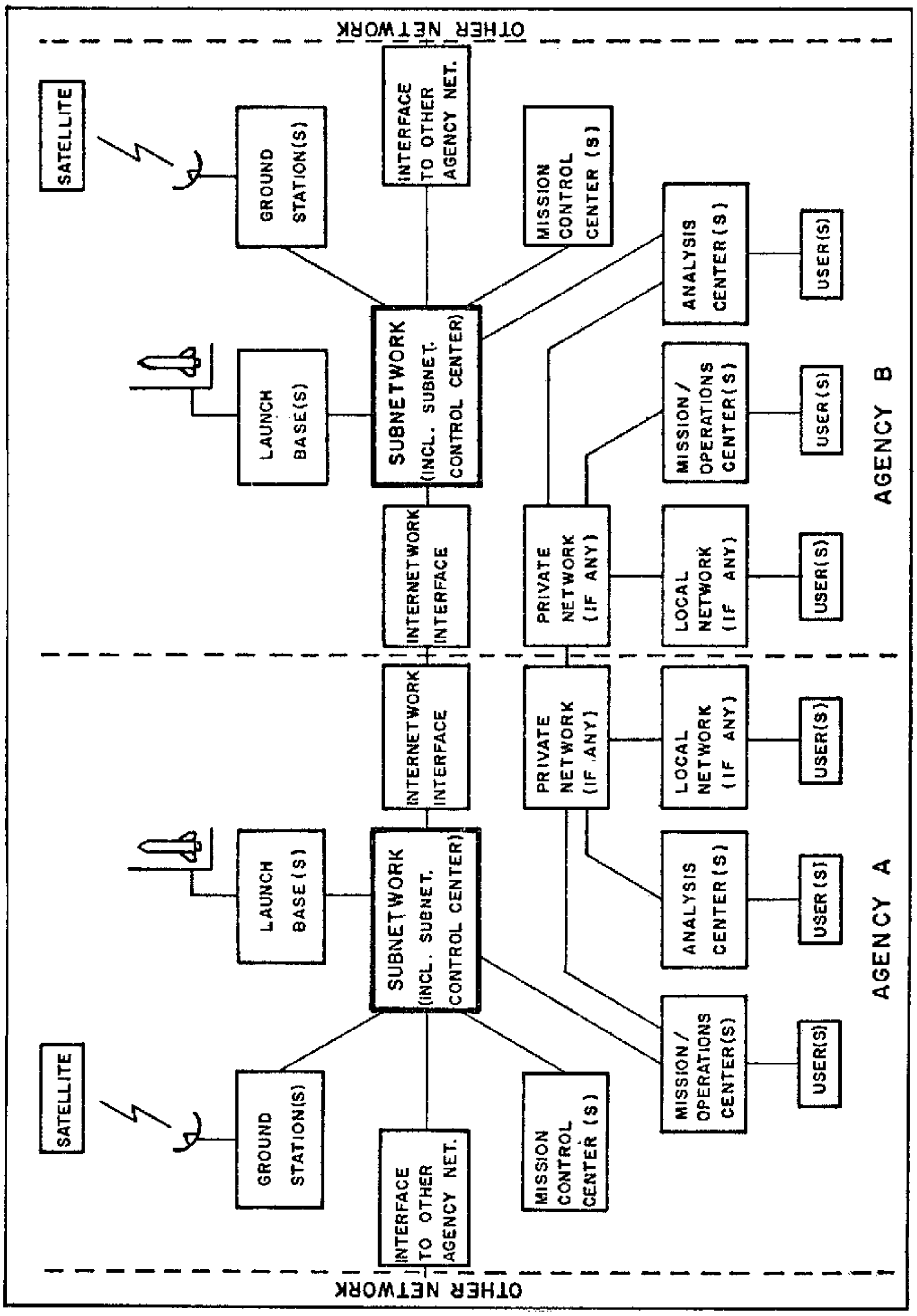

FIGURE 1 - END-TO-END REFERENCE MODEL: PHYSICAL AND SYSTEM LEVEL.

2. CLASSES OF APPLICATIONS WHICH COULD BE CONSIDERED WITH OPERATIONAL INTERCONNECTION OF GROUND DATA NETWORKS

- Real Time, Near Real Time or Delayed Space Mission Data Routing (Routine & Emergency Operations):
  - Pre-Launching Phase
  - Injection Phase
  - Acquisition Phase
  - Operational Phase
- Data Collection & Acquisition (Payload or related)
- Data Dissemination & Distribution (Payload or related)
- Electronic Mail:
  - Message
  - Text
  - Report (Service or Payload Related Data)

3. PRODUCTS WHICH COULD BE CONSIDERED WITH OPERATIONAL INTERCONNECTION OF GROUND DATA NETWORKS

- TELEMETRY AND TELECOMMAND DATA
- TRACKING AND RADIOMETRIC DATA
  - RANGING
  - RADIO LINK
- EPHEMERIS DATA
- PAYLOAD RELATED DATA (METEOROLOGICAL, OCEANOGRAPHY, REMOTE SENSING, GEODESY AND OTHER SCIENTIFIC PRODUCTS):
  - RAW
  - PRE-PROCESSED/CALIBRATED
  - ANALYSED
    - IMAGES/MAPS
    - TIME SERIES
    - EMERGENCY (SAR, NAVIGATIONS, OTHERS).

4. OPERATIONAL SERVICE EXAMPLE

The scheme of Figure 2 could represent a typical end-to-end cross-support service between two agencies, involving three classes of applications:

1. DATA COLLECTION & ACQUISITION FROM THE ANALYSIS CENTER TO THE MISSION/OPERATIONS CENTER;

2. DATA DISSEMINATION FROM THE MISSION/OPERATIONS CENTER (DATA BASE) TO THE ANALYSIS CENTER;

3. ELECTRONIC MAIL BETWEEN THE TWO END-TO-END PHYSICAL ENTITIES.

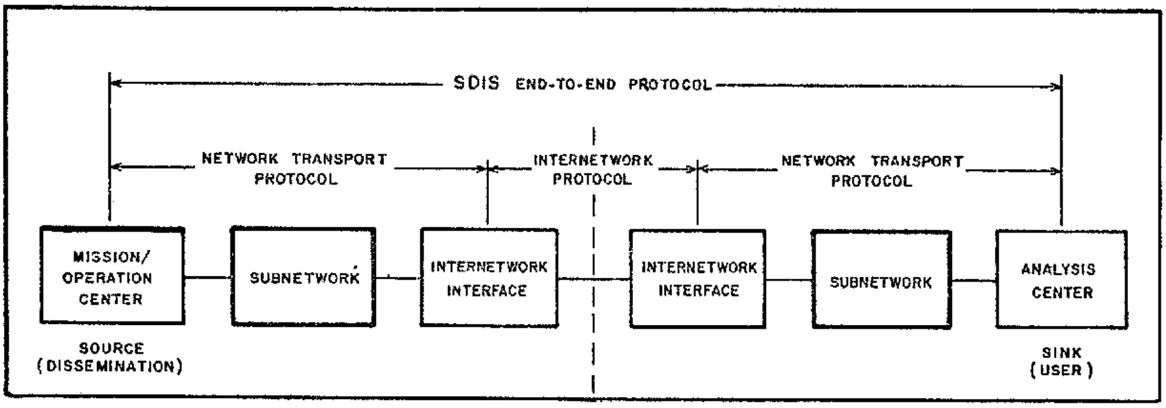

FIGURE 2 - EXAMPLE OF A SDIS SYSTEM END-TO-END SERVICE.

5. INPE's REDACE SYSTEM (GATEWAY) INTERCONNECTION TO OTHER NETWORKS

INPE is developing its space data network denominated REDACE system (Bergamini, Jan. 1982). The basic topology of this network is represented in Figure 3.

More detailed information, concerning the Message Processor and Logger (PAM/RE), is given in Figures 4 and 5. The PAM/RE is expected to implement the physical (gateway) interconnection between the REDACE System and the other space agencies networks. The PRIME protocol, which will be implemented in the REDACE system, will be adapted for interfacing with the gateway protocol to be implemented in the Gateway Message Processor and Logger (PAM/RE). The PAM/CEA (see Figure 3) is also expected to have a gateway to Kourou Launching Base.

The same basic interconnection scheme could be considered with INPE's Data Collection and Dissemination Network, the RECODI System (Bergamini, Oct. 1982), through one of its nodes. However, the RECODI System, as a private network, is expected to implement a different service conception, directed to information storage and retrieval in data bases. The RECODI system will have a protocol conceptually different from the PRIME protocol, to be implemented in the REDACE System.

In any case it is expected that the gateway service will be managed not only by the network gateway node (for instance, a PAM in the case of INPE's REDACE System), but by the network control center, as well.

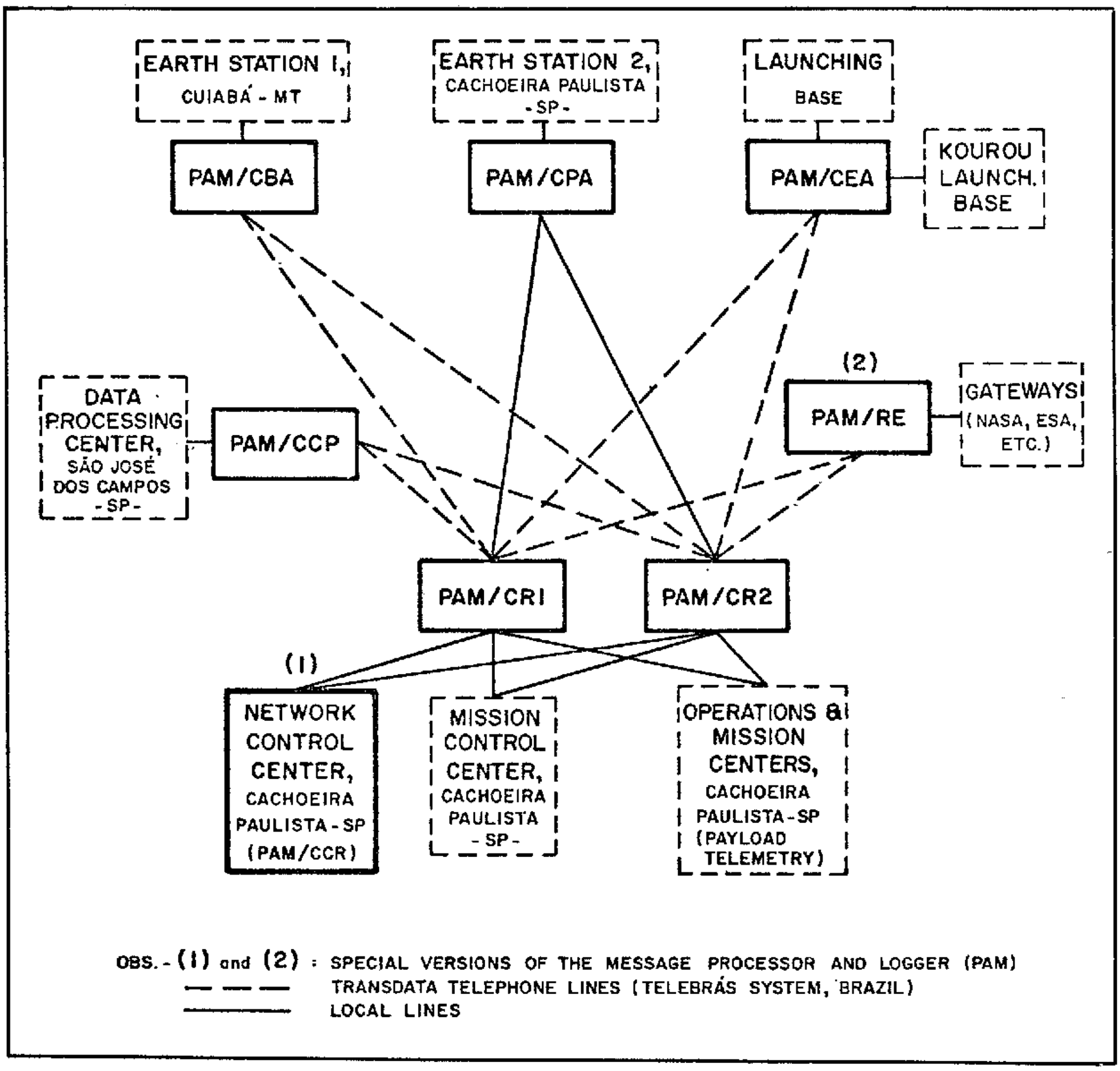

FIGURE 3 - THE REDACE SYSTEM.

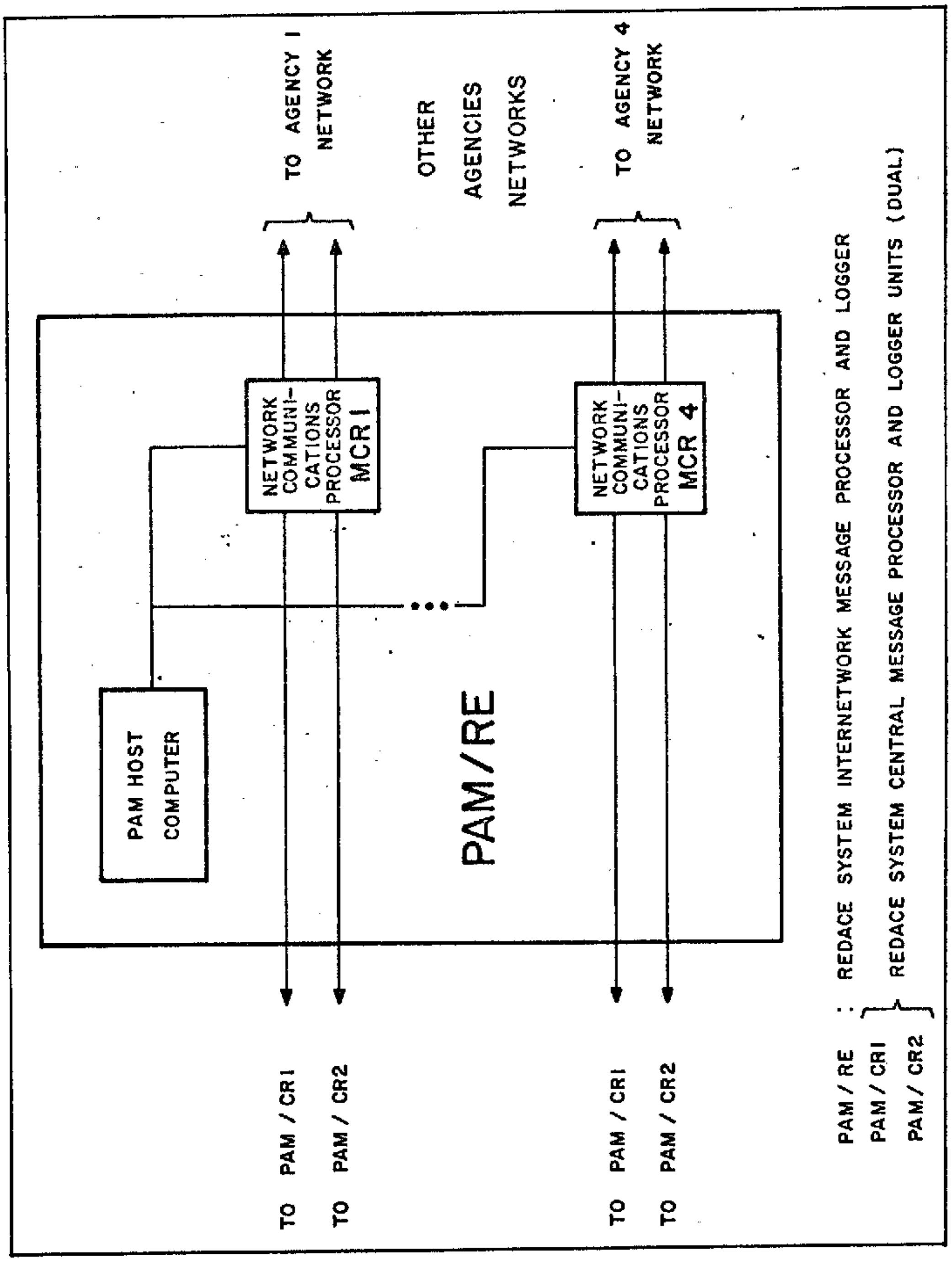

FIGURE 4 - REDACE SYSTEM INTERNETWORK (GATEWAY) INTERFACES.

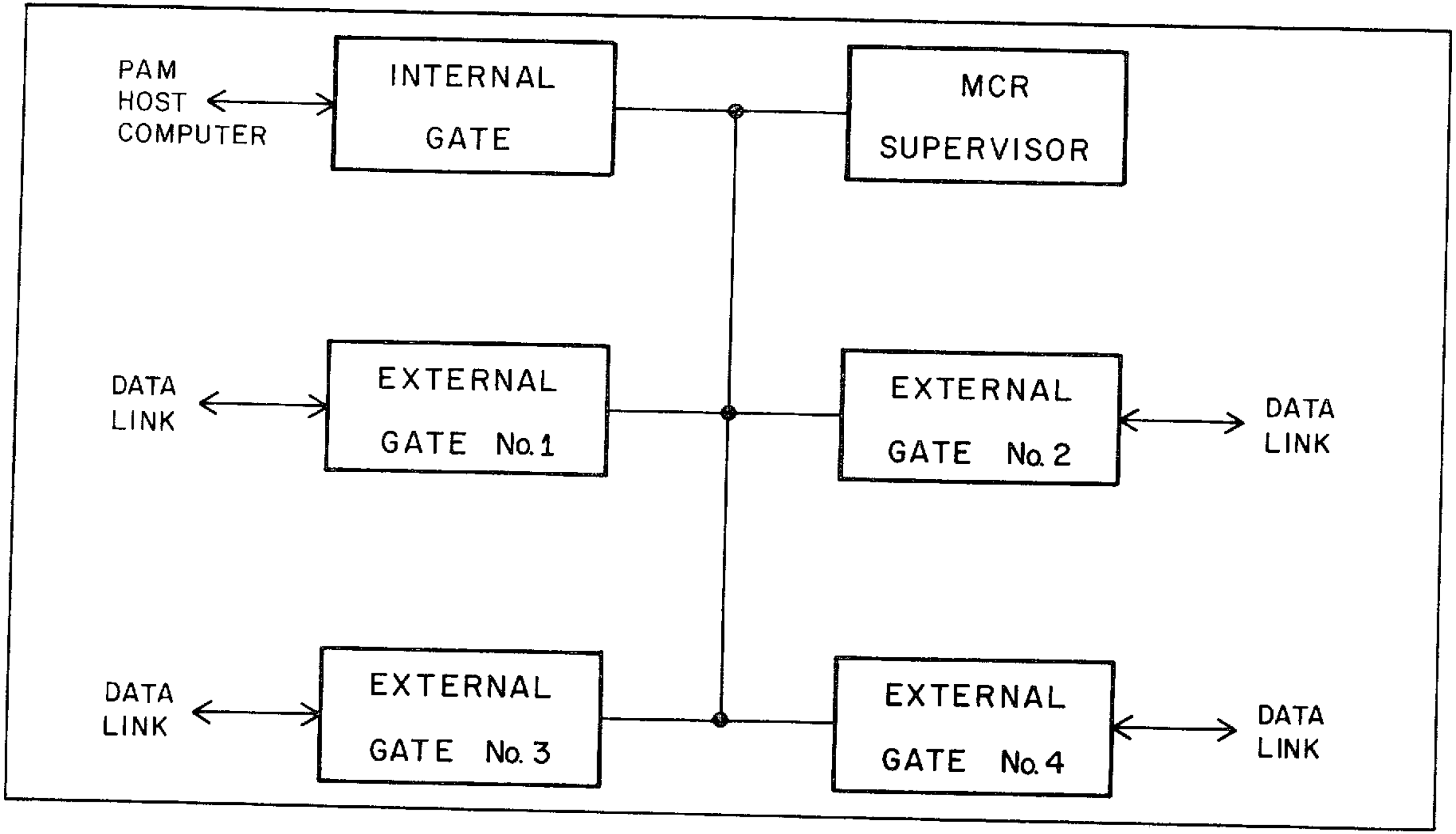

FIGURE 5 - THE (REDACE SYSTEM) NETWORK COMMUNICATIONS PROCESSOR - MCR.

6. THE INTERNETWORK (GATEWAY) TRANSFER FRAME - ITF

The basic Internetwork Transfer Frame - ITF proposed in Figure 6 is a byte (octet) oriented information unit, in the sense that no bit transparency is expected to be used within each ITF. The ITF is not expected to flow within the subnetwork of INPE's REDACE System. The ITF is proposed with provisions for a data communication protocol which would present transport, link and (to some extent) session layers characteristics. The SYNCHRONIZATION CODE and the INTERNETWORK TRANSFER FRAME HEADER are defined in the next section. The ITF FRAME ERROR CONTROL field is suggested to be of the CRC/HDLC type.

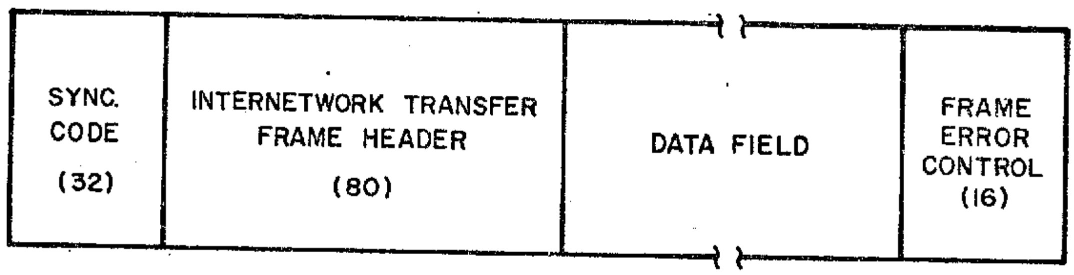

FIGURE 6 - INTERNETWORK (GATEWAY) TRANSFER FRAME - ITF.

SYNC. CODE	ITF ID. (16)					CROSS SUPPORT MISSION (16)		FRAME CONTROL (16)		SEQUENCE CONTROL (16)			LENGTH CONTROL (16)	
	TYPE	SOURCE NET	DESTINA-TION NET	PRIO-RITY	LINK	ID. No. (12)	T.B.D. (4)	TYPE	TRANSFER SERVICE	FRAME LENGTH	SEQUENCE FLAG	SOURCE SEQUENCE COUNT	LENGTH FLAG	MESSAGE LENGTH IN FRAME
						(OR)								
						ID No. (16)								
(32)	(2)	(5)	(5)	(2)	(2)			(8)	(8)	(3)	(2)	(11)	(1)	(15)

FIGURE 7 - INTERNETWORK TRANSFER FRAME (ITF) HEADER FORMAT.

7. THE INTERNETWORK TRANSFER FRAME (ITF) HEADER

The proposed ITF header is, to some extent, related to the SDIS (Panel 2) proposal. This is expected to be true to the extent that, in some instances, the internetwork protocol would need to make use of the SDIS header information. This would be the case when it is desired to route the information contained in the ITF data field to the proper destination in the network or, possibly, to a third network. The following definitions are given for each field of the proposed Internetwork Transfer Frame (ITF) Header Format, which is presented in Figure 7.

· SYNCHRONIZATION (SYNC.) CODE (32 bits):

The code to be utilized for synchronous data communication could be, for instance, the same proposed for the NEWG packet telemetry (Hooke, Jan. 1982) model: 14624175645 (octal notation; most significant character first). In this sense, the internetwork link could be eventually implemented through a satellite radio link.

· INTERNETWORK TRANSFER FRAME ID. (16 bits):

·· TYPE (2 bits):

The binary value 11 is proposed for defining the ITF Header Format. Other three possible values (binary 00, 01 and 10) are undefined.

·· SOURCE NETWORK (5 bits):

Defines the (sub)network of the space agency which transmits the current frame. The frame originator could not be a host of this same transmitting (sub) network.

.. DESTINATION NETWORK (5 bits):

Defines the (sub) network of the space agency which receives the current frame. The frame could not be destinated directly to a specific host of the receiving (sub) network.

Obs.: The possibility that an ITF be transmitted through an intermediate (sub) network is not discarded, if the internal protocol of this intermediate network can provide this type of service.

.. PRIORITY (2 bits):

Four levels of priorities can be allocated to each service to be provided between two specific interconnected networks. The binary value 00 would be allocated to the higher priority service and 11 to the lowest priority one. The policy for allocating these servicing priorities would be conditioned to the specific needs of each cross-support mission and, to some extent, to the specific traffic limitations of each involved (sub) network.

.. LINK (2 bits):

Designates the specific link being used by the interconnection (gateway) for the current ITF.

. CROSS SUPPORT MISSSION (16 bits):

Two possibilities defining this field of the header are proposed, as a recommendation:

.. ID. No. (12 bits):

Defines a Cross Support mission unique designation number, without identifying the global/local/ sender/receiver (Kramer, 1982) of the ITF.

.. T.B.D. (4 bits):

Definition to be determined. Could be used for error control.

or,

.. ID. No. (16 bits):

Defines a Cross Support mission unique designation number which includes the identification of the global/local sender/receiver (Kramer, 1982) of the ITF.

. FRAME CONTROL (16 bits):

.. TYPE (8 bits):

Defines the commands, information or combined command/information frames utilized by the protocol in order to execute each demanded service. Also defines control for opening and disconnecting the data link.

.. TRANSFER SERVICE (8 bits):

A serial number, different of zero, which uniquely designates each service being executed within a session. Protocol Commands or Information Frames solely related to link connection/disconnection or session opening/ closing should use the value zero in this field.

. LENGTH CONTROL (16 bits):

.. LENGTH FLAG (1 bit):

If value is equal zero implies that the next (if any) message in the data field begins in the byte appointed by the contents of the MESSAGE LENGTH IN FRAME. Otherwise, if LENGTH FLAG is equal to one, the data field of the frame contains a FREE length message, limited by the value specified in the MESSAGE LENGTH IN FRAME field.

.. MESSAGE LENGTH IN FRAME (15 bits):

Defines the byte where the next message (if any) contained in the data field is located, if length flag is equal to zero. In this case, if the current message has its first segment in the data field, i.e., if the SEQUENCE FLAG is equal to 10 the MESSAGE LENGTH IN FRAME will, in particular, designate the first byte (usually the first byte) of the data field where the current message starts. If the data field contains a continuation segment of the current message, the value of the MESSAGE LENGTH IN FRAME can be irrelevant (with a do not care value) or can be made, for instance, equal zero, by default.

. SEQUENCE CONTROL (16 bits):

.. FRAME LENGTH (3 bits):

A code which defines the frame length of the current service. Depending on the nature of each service, a specific length may be more appropriate in order to minimize the overhead of the link utilization. The following frame, lengths are proposed:

CODE		No. OF BITS IN FRAME
000	————	8192
001	————	6144
010	————	4096
011	————	2048
100	————	1024
101	————	512
110	————	128
111	————	FREE (See LENGTH CONTROL)

.. SEQUENCE FLAG (2 bits):

Defines if frame contains unpartitioned (11), first (10), continuation (00) or last (01) partition of the current (SDIS) message, in its data field.

.. SOURCE SEQUENCE COUNT (11 bits):

Defines the current frame (cyclic) counting number, within a session. The same counting sequence could, therefore, contain frame numbers pertaining to more than one service.

8. BASIC CONSIDERATIONS TOWARD AN INTERNETWORK (GATEWAY) PROTOCOL

The proposed Internetwork Transfer Frame - ITF format is expected to provide an internetwork (gateway) protocol with characteristics embedding resources at the level of link, transport and, to some extent, session layers. A protocol with such characteristics is believed to be sufficient to provide a gateway service between two space agencies (sub) networks which, in general, are expected to have different protocols. It would also be expected, although not necessarily, that the data field of the ITF would contain Standard Data Interchange Service (SDIS) messages, possibly of the basic type proposed in Figure 8 (part of INPE proposal to CCSDS/PANEL 2 by Bergamini and Martins, April 1983). It is implied that, in general, the SDIS messages would have to be partitioned for transmission and composed in reception by the ITF protocol.

The scheme of Figure 9 is a proposal for the basic state diagram which would structure the protocol for internetwork (gateway) data communications. The link layer characteristics of this protocol would be mostly related to the connect/disconnect link states of the protocol. The session opening and closing states would be related to the session layer of the protocol. The transport layer of the protocol is expected to be related to the data transfer service(s) to be supported. The complete processing of internetwork data transfer would have to include the interface, "mapping" protocol, which would have to make the ITF information compatible with the internal protocol and data formats of each (sub) network.

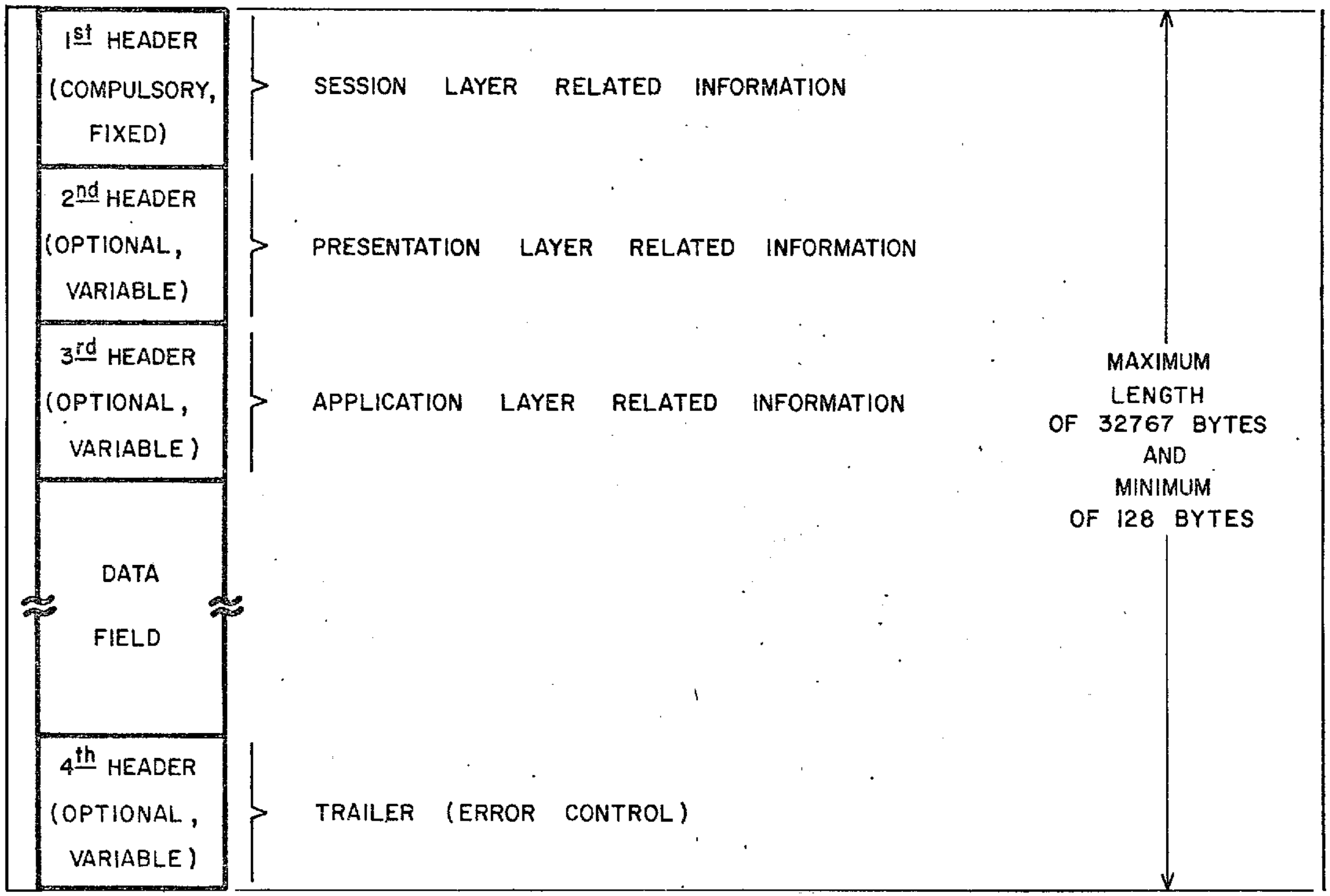

FIGURE 8 - SDIS BASIC MESSAGE FORMAT.

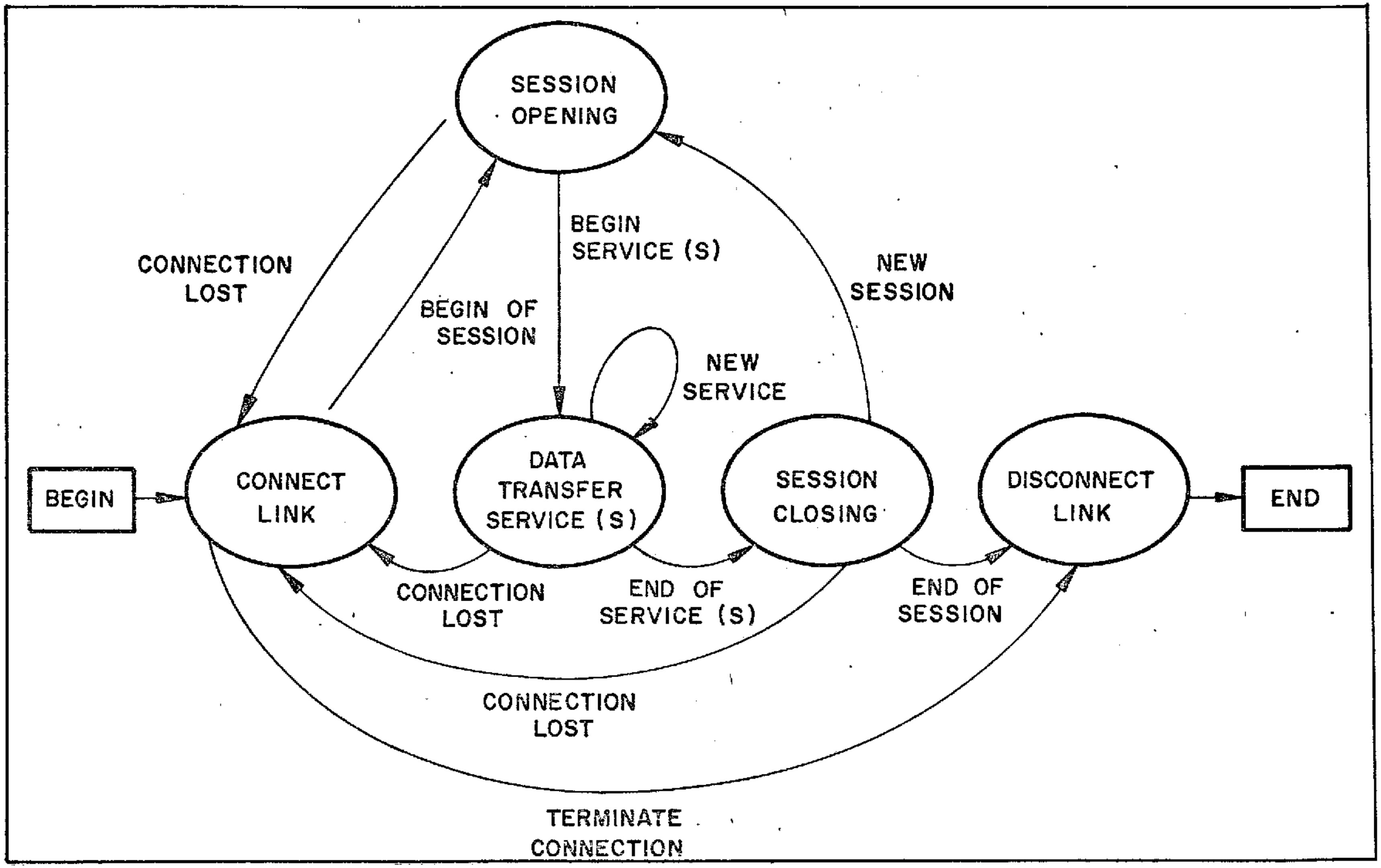

FIGURE 9 - STATE DIAGRAM OF THE MAIN PHASES FOR A CHANNEL INTERNETWORK DATA COMMUNICATION PROTOCOL.

9. CONCLUSIONS

The purpose of this concept paper is to propose basic guidelines to be considered for consensus with other contributions which are expected to be proposed in the CCSDS/PANEL 3 meeting on Electronic Communications. This work reflects predicates of INPE communications network which are currently under development. Aspects related to service management, architecture and gateway protocol which would lead to operational interconnection of ground data networks have been considered in this work.

10. ACKNOWLEDGEMENTS

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