

Space data and information transfer systems — Telecommand — Command operation procedures

ICS 49.140

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee ACE/67, Data and information transfer standards for civil space applications, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the ISO title page, pages ii to iv, pages 1 to 65 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

This British Standard, having been prepared under the direction of the Engineering Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 November 1998

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Amendments issued since publication

Amd. No.	Date	Comments

Contents

	Page
National foreword	Inside front cover
Foreword	iii
Text of ISO 12173	1
Text of CCSDS 202.1-B-1	4

INTERNATIONAL STANDARD

**ISO
12173**

First edition
1998-08-01

Space data and information transfer systems — Telecommand — Command operation procedures

*Systèmes de transfert des informations et données spatiales —
Télécommande — Procédures pour les opérations de télécommande*



Contents

	Page
Foreword	iii
1 Scope	1
2 Requirements	1
3 Revision of publication CCSDC 202.1-B-1	2

Descriptors: Navigation systems, flight control, space data systems, data processing, information interchange, telecommunications, telecommand, data transfer, communication procedure, system architecture.

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 12173 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 13, *Space data and information transfer systems*.

1 Scope

This International Standard gives the detailed specification of the logic required to carry out Command Operation Procedure-1 (COP-1) on the transfer layer. Its purpose is to provide a common basis for the development by space agencies of compatible internal standards in the field of spacecraft telecommanding.

2 Requirements

Requirements are the technical recommendations made in the following publication (reproduced on the following pages), which is adopted as an International Standard:

CCSDS 202.1-B-1, October 1991, *Recommendation for space data system standards — Telecommand — Part 2.1: Command operation procedures*.

For the purposes of International Standardization, the modifications outlined below shall apply to the following pages of publication CCSDS 202.1-B-1.

Pages i to iv

This part contains information which is relevant to the CCSDS publication only.

Subclause 1.2

This subclause is relevant to the CCSDS publication only.

Page vii

Add the following information to the references indicated:

[2] Document CCSDS 201.0-B-1, January 1987, is replaced by CCSDS 201.0-B-2, November 1995, which is equivalent to ISO 12171:1998.

[3] Document CCSDS 202.0-B-1, January 1987, is replaced by document CCSDS 202.0-B-2, November 1992, which is equivalent to ISO 12172:1997.

[4] Document CCSDS 203.0-B-1, January 1987, is equivalent to ISO 12174:1998.

3 Revision of publication CCSDS 202.1-B-1

It has been agreed with the Consultative Committee for Space Data Systems that Subcommittee ISO/TC 20/SC 13 will be consulted in the event of any revision or amendment of publication CCSDS 202.1-B-1. To this end, NASA will act as a liaison body between CCSDS and ISO.

Consultative Committee for Space Data Systems

RECOMMENDATION FOR SPACE
DATA SYSTEM STANDARDS

TELECOMMAND

PART 2.1
COMMAND OPERATION PROCEDURES

CCSDS 202.1-B-1
BLUE BOOK

OCTOBER 1991



CCSDS RECOMMENDATION FOR TELECOMMAND: COMMAND OPERATION PROCEDURES

Authority

Issue:	Blue Book, Issue 1
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	Orlando, Florida
	USA

This Recommendation reflects the consensus technical agreement of the following member Agencies of the Consultative Committee for Space Data Systems (CCSDS):

- British National Space Centre (BNSC)/United Kingdom
- Canadian Space Agency (CSA)/Canada
- Centre National d’Etudes Spatiales (CNES)/France
- Deutsche Forschungsanstalt für Luft- und Raumfahrt (DLR)/Germany
- European Space Agency (ESA)/Europe
- Instituto Nacional de Pesquisas Espaciais (INPE)/Brazil
- National Aeronautics and Space Administration (NASA)/USA
- National Space Development Agency of Japan (NASDA)/Japan
- Central Research Institute of Machine Building (TsNIIMash)/USSR

The following observer Agencies also concur with this Recommendation:

- Australian Space Office (ASO)/Australia
- Central Research Institute of Physics (CRIP)/Hungary
- Chinese Academy of Space Technology (CAST)/People’s Republic of China
- Danish Space Research Institute (DSRI)/Denmark
- Department of Communications/Communications Research Centre (DOC/CRC)/Canada
- Institute of Space and Astronautical Science (ISAS)/Japan

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Washington, DC 20546
USA

CCSDS RECOMMENDATION FOR TELECOMMAND: COMMAND OPERATION PROCEDURES

Statement of intent

The Consultative Committee for Space Data Systems (CCSDS) is an organization officially established by the management of member space Agencies. The Committee meets periodically to address data systems problems that are common to all participants, and to formulate sound technical solutions to these problems. Inasmuch as participation in the CCSDS is completely voluntary, the results of Committee actions are termed **RECOMMENDATIONS** and are not considered binding on any Agency.

This RECOMMENDATION is issued by, and represents the consensus of, the CCSDS Plenary body. Agency endorsement of this RECOMMENDATION is entirely voluntary. Endorsement, however, indicates the following understandings:

- Whenever an Agency establishes a CCSDS-related STANDARD, this STANDARD will be in accord with the relevant RECOMMENDATION. Establishing such a STANDARD does not preclude other provisions which an Agency may develop.
- Whenever an Agency establishes a CCSDS-related STANDARD, the Agency will provide other CCSDS member Agencies with the following information:
 - The STANDARD itself
 - The anticipated date of initial operational capability
 - The anticipated duration of operational service
- Specific service arrangements shall be made via memoranda of agreement. Neither this RECOMMENDATION nor any ensuing STANDARD is a substitute for a memorandum of agreement.

No later than five years from its date of issuance, this RECOMMENDATION will be reviewed by the CCSDS to determine whether it should: 1) remain in effect without change; 2) be changed to reflect the impact of new technologies, new requirements, or new directions; or 3) be retired or cancelled.

CCSDS RECOMMENDATION FOR TELECOMMAND: COMMAND OPERATION PROCEDURES

Foreword

This document, which is a technical Recommendation prepared by the Consultative Committee for Space Data Systems (CCSDS), is intended for use by participating space Agencies in their development of space telecommand systems.

This Recommendation allows the implementing organizations within each Agency to proceed coherently with the development of compatible Standards for the flight and ground systems that are within their cognizance. Agency Standards derived from this Recommendation may implement only a subset of the optional features allowed herein, or may incorporate features not addressed by the Recommendation.

The *Recommendation for Telecommand, Part 2: Data Routing Service* (Reference [3]) defines the standard data structures and data communication procedures within the intermediate telecommand system layers to be used by conventional missions. The Command Operation Procedure forms a subpart of the Data Routing Service, which is described in Reference [3]. This Recommendation contains the definition of the Command Operation Procedure in the form of state tables at the level of detail necessary to allow cross support. It is assumed that the reader is familiar with the terminology and data structures defined in Reference [3].

Through the process of normal evolution, it is expected that expansion, deletion or modification to this document may occur. This Recommendation is therefore subject to CCSDS document management and change control procedures, which are defined in Reference [1].

CCSDS RECOMMENDATION FOR TELECOMMAND: COMMAND OPERATION PROCEDURES

Document control

Document	Title	Date	Status/Remarks
CCSDS 202.1-B-1	Recommendation for Space Data System Standards. Telecommand, Part 2.1: Command Operation Procedures, Issue 1	October 1991	Original Issue

CCSDS RECOMMENDATION FOR TELECOMMAND: COMMAND OPERATION PROCEDURES**Contents**

	Page
Foreword	iii
References	vii
1 Introduction	1-1
1.1 Purpose and Scope	1-1
1.2 Applicability	1-1
1.3 State Table Format	1-2
1.4 Interlayer Interfaces	1-3
2 COP-1	2-1
2.1 Services and Protocols	2-1
2.1.1 Services	2-1
2.1.1.1 Sequence-Controlled Service	2-1
2.1.1.2 Expedited Service (BD Service)	2-3
2.1.2 Protocols	2-4
2.1.2.1 At the Sending End: FOP-1	2-4
2.1.2.2 At the Receiving End: FARM-1	2-4
2.2 Internal Variables	2-5
2.2.1 FOP-1 Variables	2-5
2.2.1.1 State	2-5
2.2.1.2 Stored_Lockout_Flag	2-6
2.2.1.3 Stored_Wait_Flag	2-7
2.2.1.4 Stored_Retransmit_Flag	2-7
2.2.1.5 Transmitter_Frame_Sequence_Number, V(S)	2-7
2.2.1.6 Wait_Queue	2-7
2.2.1.7 To_Be_Retransmitted_Flag	2-7
2.2.1.8 AD_Out_Flag, BC_Out_Flag, and BD_Out_Flag	2-7
2.2.1.9 Sent_Queue	2-8
2.2.1.10 Expected_Acknowledgement_Frame_Sequence_Number [NN(R)]	2-8
2.2.1.11 Timer_Initial_Value (T1_Initial)	2-8
2.2.1.12 Transmission Count Variables	2-9
2.2.1.13 Suspend_State (SS)	2-11
2.2.1.14 FOP_Sliding_Window_Width (K)	2-11
2.2.2 FARM-1 Variables	2-11
2.2.2.1 State	2-12
2.2.2.2 Lockout_Flag	2-12
2.2.2.3 Wait_Flag	2-12
2.2.2.4 Retransmit_Flag	2-12
2.2.2.5 FARM-B_Counter	2-13

CCSDS RECOMMENDATION FOR TELECOMMAND: COMMAND OPERATION PROCEDURES

	Page
2.2.2.6 Receiver_Frame_Sequence_Number V(R)	2-13
2.2.2.7 FARM Sliding Window Variables	2-13
2.2.2.8 FARM_Sliding_Window_Width (W)	2-14
2.2.2.9 FARM_Positive_Window_Width (PW) and FARM_Negative_Window_Width (NW)	2-15
2.2.2.10 Buffer Administration Variables	2-17
2.3 COP-1 Interface to Higher Layer	2-17
2.3.1 Sending End	2-17
2.3.1.1 Sequence-Controlled Service Management Interface	2-18
2.3.1.2 Sequence-Controlled Service FDU Transfer Interface	2-23
2.3.1.3 Expedited Service Interface	2-25
2.3.2 Receiving End	2-26
2.4 COP-1 Interface to Lower Layer	2-27
2.4.1 Sending End	2-27
2.4.1.1 From FOP-1 to Frame Generation	2-27
2.4.1.2 From Frame Generation to FOP-1	2-28
2.4.2 Receiving End	2-28
2.4.2.1 From the Frame Validation Check to FARM-1	2-28
2.4.2.2 From FARM-1 to the Frame Validation Check	2-28
2.5 Actions	2-28
2.5.1 FOP-1	2-28
2.5.2 FARM-1	2-32
Annex A Command Operation Procedures Glossary	A-1
Annex B Command Operation Procedures Interlayer Interfaces	B-1
Figure 1-1 — State Table Format	1-2
Figure 2-1 — COP-1 Variables, Frame and Report Values	2-3
Figure 2-2 — FARM Sliding Window Concept	2-14
Figure 2-3 — FOP-1 State Transitions: Main Protocol	2-41
Figure 2-4 — FOP-1 State Transitions: Initialisation Protocol	2-42
Figure 2-5 — FOP-1 State Transitions	2-43
Figure 2-6 — FARM-1 State Transitions	2-46
Figure B-1 — Interlayer Interfaces	B-2
Table 2-1 — FOP-1 State Table	2-34
Table 2-2 — FARM-1 State Table	2-44

CCSDS RECOMMENDATION FOR TELECOMMAND: COMMAND OPERATION PROCEDURES

References

- [1] “Procedures Manual for the Consultative Committee for Space Data Systems”, CCSDS A 00.0-Y-4.0, Issue 4, Yellow Book, Consultative Committee for Space Data Systems, September 1990 or later issue.
- [2] “Telecommand, Part 1: Channel Service”, Recommendation CCSDS 201.0-B-1, Issue 1, Blue Book, Consultative Committee for Space Data Systems, January 1987 or later issue.
- [3] “Telecommand, Part 2: Data Routing Service”, Recommendation CCSDS 202.0-B-1, Issue 1, Blue Book, Consultative Committee for Space Data Systems, January 1987 or later issue.
- [4] “Telecommand, Part 3: Data Management Service”, Recommendation CCSDS 203.0-B-1, Issue 1, Blue Book, Consultative Committee for Space Data Systems, January 1987 or later issue.
- [5] “Telecommand, Summary of Concept and Service”, CCSDS 200.0-G-6, Issue 6, Green Book, Consultative Committee for Space Data Systems, January 1987 or later issue.

The latest issues of CCSDS documents may be obtained from the CCSDS Secretariat at the address indicated on page i.

CCSDS RECOMMENDATION FOR TELECOMMAND: COMMAND OPERATION PROCEDURES

1 Introduction

1.1 Purpose and Scope

This Recommendation contains the detailed specification of the logic required to carry out Command Operation Procedure-1 (COP-1) of the Transfer Layer.

The *Recommendation for Telecommand, Part 2: Data Routing Service*, (Reference [3]) contains the standard data structures and data communication procedures used by the intermediate telecommand system layers (the Transfer and Segmentation Layers). In particular, it contains a brief description of the Command Operation Procedure (COP) within the Transfer Layer. This Recommendation contains the detailed definition of COP-1 in the form of state tables, along with definitions of the terms used. It is assumed that the reader of this document is familiar with the data structures and terminology of *Part 2*.

In case of conflict between *Part 2* (Reference [3]) and this Recommendation, this Recommendation will take precedence.

1.2 Applicability

This Recommendation serves as a guideline for the development of compatible internal Agency standards in the field of spacecraft commanding. This Recommendation is not retroactive, nor does it commit any Agency to implement the recommended telecommand concepts at any future time. Nevertheless, all Consultative Committee for Space Data Systems (CCSDS) Agencies accept the principle that all future implementations of telecommand that are used in cross-support situations will be based on this Recommendation.

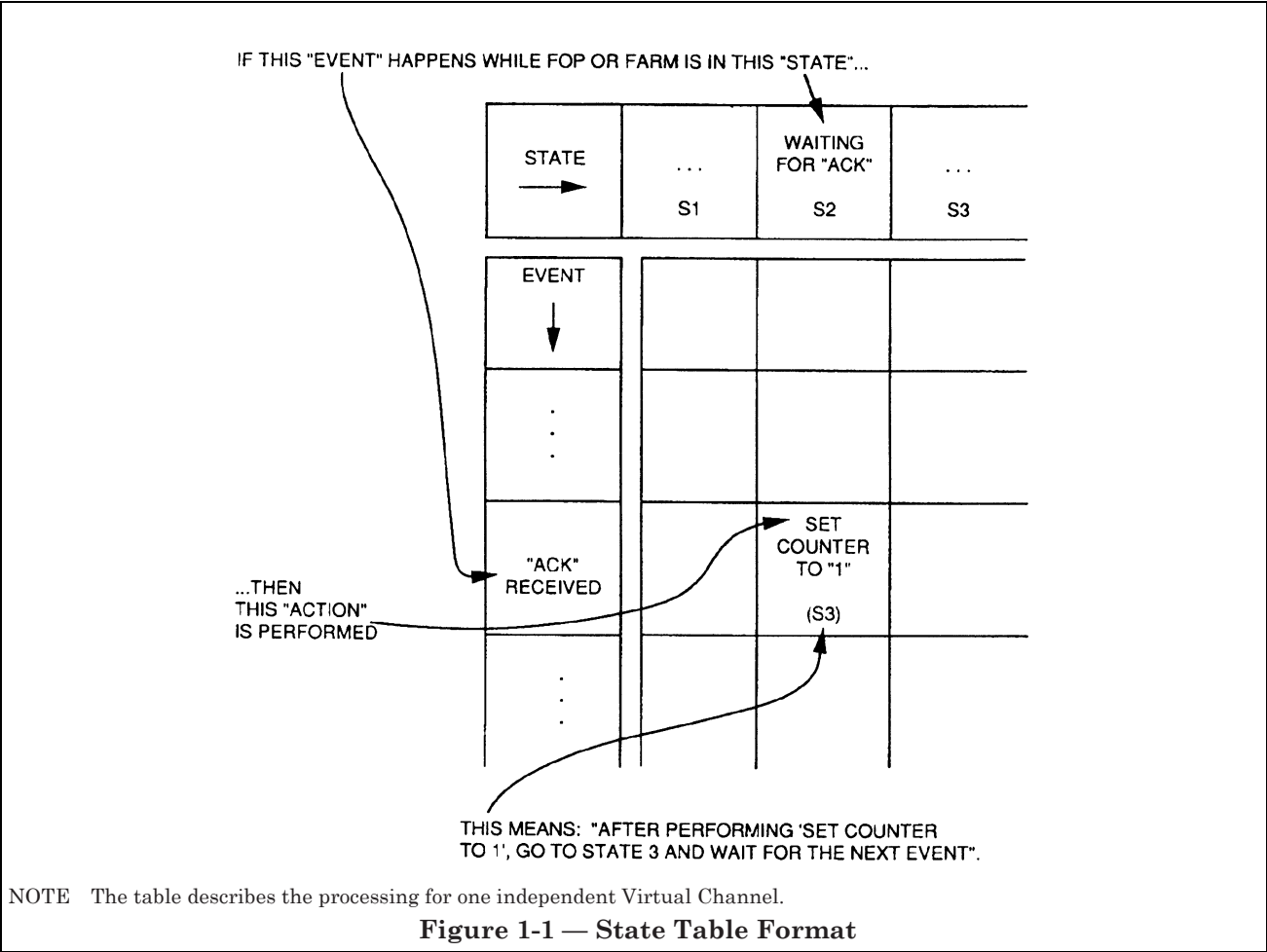
The CCSDS has developed a layered concept for future spacecraft telecommanding, which is summarized in *Telecommand, Summary of Concept and Service* (Reference [5]) and defined in the *Recommendation for Telecommand Part 1: Channel Service* (Reference [2]), *Part 2: Data Routing Service* (Reference [3]), and *Part 3: Data Management Service* (Reference [4]). Standard services are defined within each layer, and Agencies will be encouraged to develop corresponding facilities to provide these services in support of Projects. This Recommendation is applicable only to those Projects that are compatible with the Transfer Layer as defined in *Part 2*.

Where preferred options or mandatory capabilities are clearly indicated herein, the indicated sections of the specification must be implemented when this Recommendation is used as a basis for cross support. Where optional subsets or capabilities are allowed or implied in this specification, implementation of these options or subsets is subject to specific bilateral cross-support agreements between the Agencies involved. The recommendations in this document are to be invoked through the normal standards programs of each member Agency, and are applicable to those missions for which cross support based on capabilities described in these recommendations is anticipated.

CCSDS RECOMMENDATION FOR TELECOMMAND: COMMAND OPERATION PROCEDURES

1.3 State Table Format

This document contains the state tables for the Telecommand Command Operation Procedure (TC COP). For the Frame Operation Procedure (FOP) or Frame Acceptance and Reporting Mechanism (FARM), the state table shows the various “states” (columns) in which the process might be at a given time, and the “events” (rows) which cause “actions” and/or state changes. The action and/or state change appropriate to the occurrence of a particular event, when the processes are in a particular state, is shown at the intersection of the respective row and column. State transitions are indicated by state numbers in parentheses; thus “(S2)” indicates “go to State Number 2”. See Figure 1-1.



CCSDS RECOMMENDATION FOR TELECOMMAND: COMMAND OPERATION PROCEDURES

1.4 Interlayer Interfaces

In order to define the COP-1 services and protocols completely and clearly, it was necessary to define some of the characteristics of the interface between the COP and the Higher and Lower Layers. For example, a decision had to be made as to whether the Higher Layer may deliver only one frame at a time to Frame Operation Procedure-1 (FOP-1) or may deliver a group of frames. A strategy for ensuring accountability of sequence-controlled frames all the way from the sending-end Higher Layer through the spacecraft and back to the Higher Layer had to be established.

It is realized that there are other ways in which the interfaces could be defined. In particular, if two layers are implemented as part of a single system, their interfaces could be simplified. It is the responsibility of the implementers to ensure that all of the requirements for the basic operation of the COP are met.

Additional information about the assumed interlayer interfaces is included in Annex B.

CCSDS RECOMMENDATION FOR TELECOMMAND: COMMAND OPERATION PROCEDURES

2 COP-1

Command Operation Procedure-1 (COP-1) is a closed-loop telecommanding protocol that utilizes sequential (“go-back-n”) retransmission techniques to correct Telecommand (TC) Frames that were rejected by the spacecraft because of error. COP-1 allows Type-A TC Frames to be accepted by the spacecraft only if they are received in strict sequential order and their contents can be immediately passed on to the layer above.

Within COP-1, control of sequentiality is provided by the Frame Acceptance and Reporting Mechanism (FARM), and therefore frame sequence numbering is explicit. The Frame Sequence Number must be present in each Type-A frame. Type-A frames must be transmitted by the FOP with their numbers arranged in strict upcounting order. If one or more frames are missed, retransmission is initiated either in response to a “Retransmit” Flag in the Command Link Control Word (CLCW) or a timeout on the ground. Window mechanisms on the ground and spacecraft prevent a new frame with the same sequence number as that of a missing frame from being transmitted or accepted.

Valid Type-B frames (i.e., “Bypass” frames) will always be accepted.

NOTE In this section, although it may be mentioned that COP-1 handles “frames”, these are actually partial frames made up of a TC Frame Data Unit (FDU) plus the Frame Header data generated by COP-1. The remainder of the Frame Header will be generated by the Lower Layer. The Frame Data Unit consists of the data to be inserted in the Telecommand Transfer Frame Data Field, as defined in Reference [3].

COP-1 is just one of the functions performed within the Transfer Layer. It is the first function performed when an FDU is received by the Transfer Layer on the sending end and the last one performed before the FDU is delivered to the Higher Layer on the receiving end. For purposes of defining the interfaces to COP-1, the function following Frame Operation Procedure-1 (FOP-1) on the sending end will be called “Frame Generation”, and the one preceding Frame Acceptance and Reporting Mechanism-1 (FARM-1) on the receiving end will be called “Frame Validation Check”.

2.1 Services and Protocols**2.1.1 Services**

COP-1 provides two distinct services to the layer above. These services are “Sequence-Controlled Service” and “Expedited Service”.

CCSDS RECOMMENDATION FOR TELECOMMAND: COMMAND OPERATION PROCEDURES

2.1.1.1 *Sequence-Controlled Service (AD Service)*

This service concerns two types of frames:

- “AD” for Telecommand Frame Data Units (TC FDUs), which are frames carrying data from the layer above
- “BC” for the two frames carrying protocol control information for configuring COP-1 (“Unlock” and “Set V(R)”)

In COP-1, the Sequence-Controlled Service is based on an automatic request for retransmission (ARQ) procedure of the “go-back-n” type with sequence-control mechanisms both on the ground and on board the spacecraft and the necessary presence of a standard report returned in the telemetry downlink, the CLCW. The Sequence-Controlled Service is initiated by means of four distinct “Initiate AD Service” Directives, as shown in Table 2-1 (FOP-1 State Table). Two of these directives result in the transmission of one of the two control commands (Type-BC frames). Each of the two control commands causes a well-defined action in FARM-1, which is then reflected in the CLCW. A timer is used to cause retransmission of the control command if the expected response is not received, with a limit on the number of automatic retransmissions allowed before the Higher Layer is notified that there is a problem in initiating the AD Service. The other two directives allow the AD Service to be started without waiting for spacecraft action (although one requires receiving a good CLCW).

Once COP-1 for a particular Virtual Channel has been initialized for an AD Service, TC FDUs are inserted into frames and transmitted on that Virtual Channel in the order in which they are presented to COP-1. The retransmission mechanism ensures with a high probability of success that

- no TC FDU is lost
- no TC FDU is duplicated
- no TC FDU is delivered out of sequence

The AD Service guarantees in-order delivery of TC FDUs on a single Virtual Channel. Because of the possibility of retransmission on only a single Virtual Channel, there is no guarantee that TC FDUs on separate Virtual Channels, each using an AD Service, will be delivered to the Higher Layer in the order initially transmitted.

For the Type-AD frames, the automatic retransmission procedure makes use of several variables, the most notable being the Receiver_Frame_Sequence_Number, V(R); the Transmitter_Frame_Sequence_Number, V(S); the Next Expected Frame Sequence Number contained in the CLCW, N(R); and the Frame Sequence Number in the TC Frame Header, N(S). (See Figure 2-1.) These variables are described in Section 2.2.