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Space data communications

Prepared by the
Standards Approval Board (STAB)
for Space Data Communications

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SPACE DATA COMMUNICATIONS PROCEDURES, STANDARDS, AND SPECIFICATIONS

This document introduces and defines the architecture of the Space Data Communications documentation tree, which forms the PSS-04 branch of the ESA Procedures, Specifications & Standards (PSS) series.

The purpose of the Space Data Communications PSS documents is to ensure the compatibility of spacecraft TT&C subsystems with the relevant ESA infrastructure (i.e. the ESA (ESOC) tracking and data-communication network and the ESA (ESTEC) satellite check-out facilities).

DOCUMENT CHANGE RECORD

Issue number and date	Sections affected	Remarks
Issue 1 March 1991	New document	Complies with Reference [1] for both Level 1 (PSS-04-0) and Level 2 (PSS-04-10 and PSS-04-20)

REFERENCES

- [1] **ESA STANDARDISATION POLICY AND ARCHITECTURE (ESA PSS-00-0)**
Issue 1, Revision 4, 15 September 1989, also available as ESA/ADMIN (89) 14,
16 October 1989.

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1. PURPOSE AND SCOPE

1.1 PURPOSE

This document introduces and defines the architecture of the Space Data Communications documentation tree, which forms the PSS-04 branch of the ESA Procedures, Specifications & Standards (PSS) series.

The purpose of the Space Data Communications PSS documents is to ensure the compatibility of spacecraft TT&C subsystems with the relevant ESA infrastructure (i.e. the ESA (ESOC) tracking and data-communication network and the ESA (ESTEC) satellite check-out facilities).

1.2 SCOPE

This document implements the Space Data Communications branch (PSS-04) as defined in Reference [1], both at Level 1 and at Level 2, that is:

- PSS-04-0 (this document) for Level 1
- PSS-04-10 (Section 3.2 of this document) for Level 2
- PSS-04-20 (Section 3.3 of this document) for Level 2

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2. OBJECTIVES AND MANAGEMENT

2.1 Objectives: an Overview

Space Data Communications are concerned with the following technical areas:

- **Telemetry**, i.e. the acquisition of supervisory and scientific data on board the spacecraft, their transmission from the spacecraft and their acquisition by the ground systems.
- **Telecommand**, i.e. the generation of spacecraft control data by ground systems, their transmission from the ground and their acquisition by the spacecraft subsystems.
- **Tracking and Ranging**, i.e. the localisation of the spacecraft.

These technical areas are traditionally identified by the terms "Telemetry, Tracking and Command" (TT&C). An essential responsibility of the Agency is to define and implement the corresponding infrastructure, so as to provide the required services to the various mission projects at a minimum cost and with maximum operational efficiency. To achieve this, the Agency has set up a Standards Approval Board (STAB) to undertake the preparation of the necessary technical documents.

At the beginning of the 1970's, the STAB produced the ESA Telemetry, Tracking, Command and Data Handling (TTC & DH) Standards. Since that time, the evolution in space mission performance and operational requirements has led to the definition of new services in the area of TT&C. In order to ensure that the next generation of space data communication standards be widely recognized and supported internationally, the task of defining them was entrusted to the Consultative Committee for Space Data Systems (CCSDS) which comprises technical representatives from several space agencies (e.g. NASA, ESA, CNES, BSC, DLR, NASDA, and others).

The CCSDS issues technical "recommendations" for standards which, while still covering the traditional elements of TT&C techniques, are architecturally aligned with the seven-layer "ISO Reference Model for Open Systems Interconnection". Thus, a series of CCSDS Recommendations for Space Data System Standards was issued, from which most of the new Space Data Communications PSS documents are directly derived, as shown in Table 2.1.

2.2 Preparation and Approval

The responsibility for preparing the Space Data Communications PSS documents rests with the Standards Approval Board (STAB) for Space Data Communications.

The STAB determines the need for a new PSS document (or a new issue of an existing one) and reports to the Telematics Supervisory Board (TSB) for agreement to proceed with the preparation of a Standard. As a result of this agreement, a STAB Panel is nominated to prepare the document.

When the STAB Panel has reached full consensus on the final text of a Standard, formal Panel approval is endorsed by the STAB Chairman and the TSB. The Standard is then formally approved by the Inspector General of ESA on behalf of the Director General of ESA.

2.3 Publication and Distribution

Once the Standard is approved by the Inspector General of ESA, ESA Publications Division is responsible for printing the PSS document and organising its proper publication and distribution throughout ESA and European space industry, as well as to other national (or international) space agencies.

CCSDS Recommendation	Related ESA Standard	Equivalent ISO Layer
Radio Frequency and Modulation Systems	Radio Frequency and Modulation Standard	Layer 1 (Physical)
Telemetry Channel Coding	Telemetry Channel Coding Standard	Layer 2 (Data Link)
Packet Telemetry	Packet Telemetry Standard	Layers 2 & 3 (Data Link and Network)
Telecommand (Part 1 and Part 2 essentially)	Packet Telecommand Standard	Layers 2 & 3 (Data Link and Network)
Advanced Orbiting Systems, Networks and Data Links	Advanced Orbiting Systems, Networks and Data Links	Layers 2 & 3 (Data Link and Network)

Table 2.1 **EXAMPLE OF CCSDS-DERIVED ESA SPACE DATA COMMUNICATIONS STANDARDS**

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3. SPACE DATA COMMUNICATIONS DOCUMENT TREE

3.1 ESA STANDARDISATION DOCUMENT TREE

The ESA Standardisation Document Tree is defined in Reference [1], from which the following figures have been extracted:

- Figure 3.1 shows the ESA standardisation architecture (or documentation tree), which is structured into PSS branches and levels, down to Level 1.
- Figure 3.2 shows the PSS-04 branch with the documents defined at Level 1 and Level 2. This document (PSS-04-0) covers both levels.

3.2 SPACE LINK STANDARDS AND PROTOCOLS (PSS-04-10)

The Space Link Standards and Protocols documents are essentially concerned with the data communication techniques relevant to the space link, i.e. where the transmission medium is space.

The documents are all at Level 3, as shown in Figure 3.3. The numbers are allocated as follows:

(a) From PSS-04-100 to PSS-04-149

These numbers are used for the Standards. The number PSS-04-100 is, in principle, not allocated but reserved for future use for the sub-branch. The current allocation, from PSS-04-103 to PSS-04-107, reflects a direct mapping of the reference numbers used for the former TTC & DH Standards of ESA, as shown in the following example:

TTC & DH Reference Number	Space Data Communications Reference Number
TTC-A-03	PSS-04-1 03

Since it is not planned to re-issue the phased-out Standards TTC-A-01 and TTC-A-02 (respectively issued as ESA PSS-45 and ESA PSS-46) in

the new PSS-04 series, the reference numbers PSS-04-101 and PSS-04-102 are left unallocated until further notice.

(b) From PSS-04-150 to PSS-04-199

These numbers are used for the Specifications. The number PSS-04-150 is, in principle, not allocated but reserved for future use for the subbranch. Specifications are deemed to comply with one (or more) Space Data Communications Standard. Their subject is, typically, the definition of an on-board unit (or device) which is critical to the operation of the spacecraft by the ESA ground infrastructure, experience having shown that compliance with the Standards alone is not sufficient to guarantee trouble-free spacecraft operations.

3.3 SPACECRAFT DATA INTERFACES AND PROTOCOLS (PSS-04-20)

The Spacecraft Data Interfaces and Protocols documents are essentially concerned with the data communication techniques relevant to the data systems on board the spacecraft. Typical topics are: data transfer interfaces (from the spacecraft data bus down to the command pulse concept to activate latching devices), spacecraft time management, etc.

The documents are all at Level 3, as shown in Figure 3.4. The numbers are allocated as follows:

(a) From PSS-04-200 to PSS-04-249

These numbers are used for the Standards. The number PSS-04-200 is, in principle, not allocated but reserved for future use for the subbranch. This sub-branch can be considered to be similar to the TTC-B-00 category of the former TTC & DH Standards of ESA.

(b) From PSS-04-250 to PSS-04-299

These numbers are reserved for future Specifications deemed to comply with one or more of the Standards defined in paragraph (a) above. Any reason for selecting a particular subject would be identical to those given in Section 3.2, Paragraph (b). The number PSS-04-250 is, in principle, reserved for future use of the subbranch. Any first, future specification will receive the number PSS-04-251.

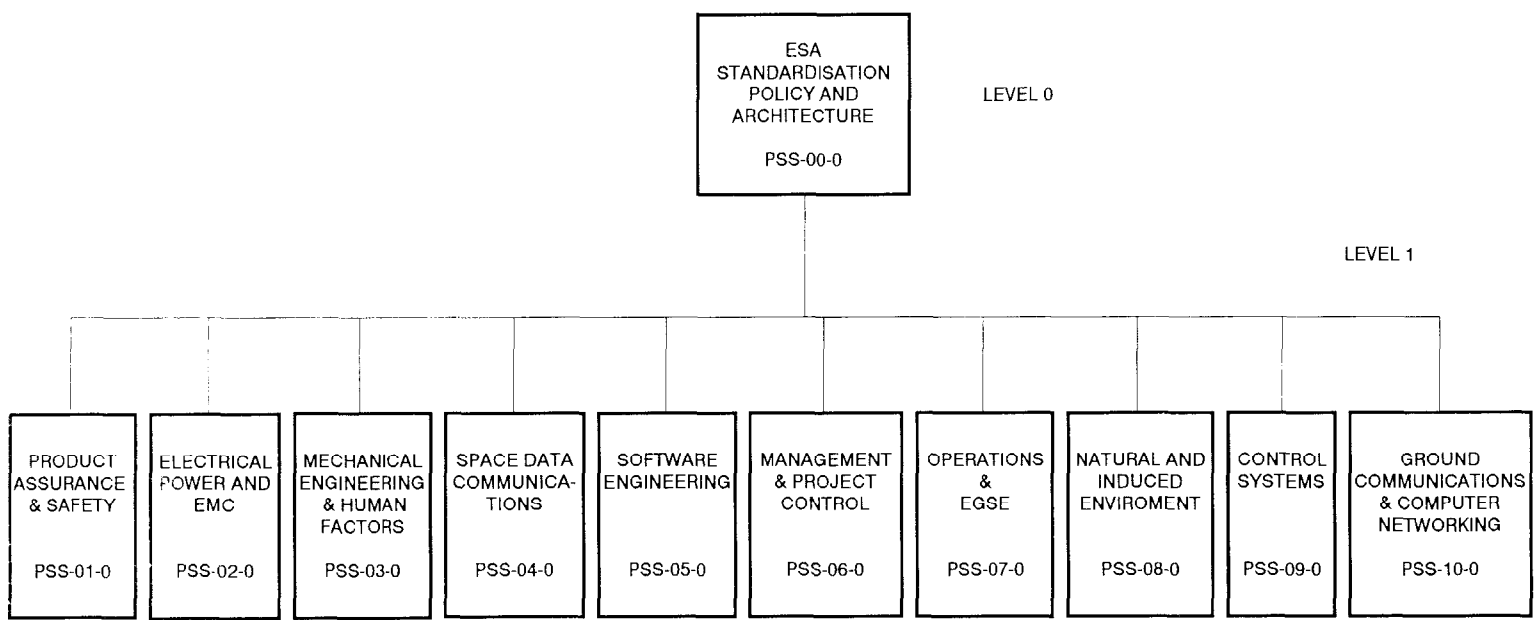


Figure 3.1 ESA STANDARDISATION DOCUMENT TREE

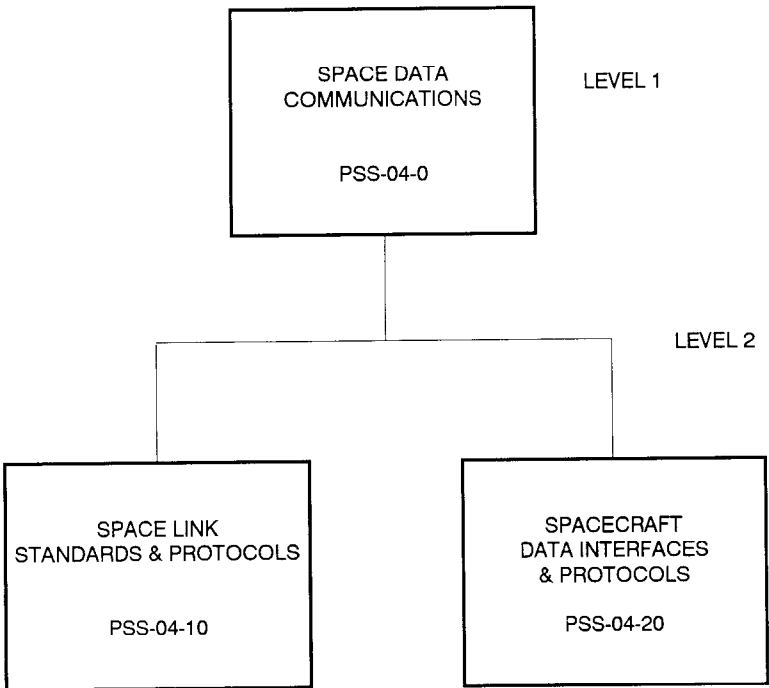


Figure 3.2 SPACE DATA COMMUNICATIONS BRANCH

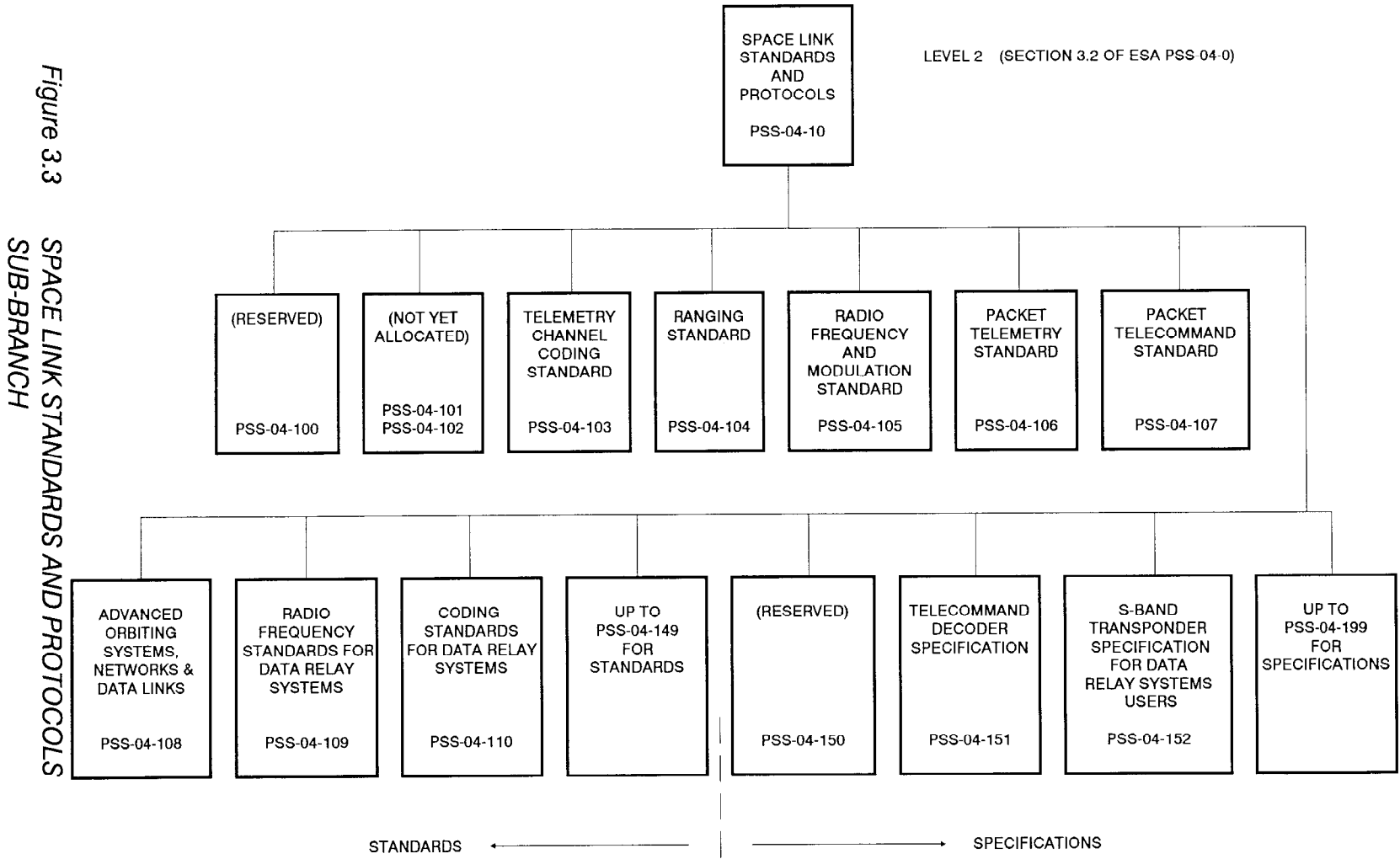


Figure 3.3 SPACE LINK STANDARDS AND PROTOCOLS SUB-BRANCH

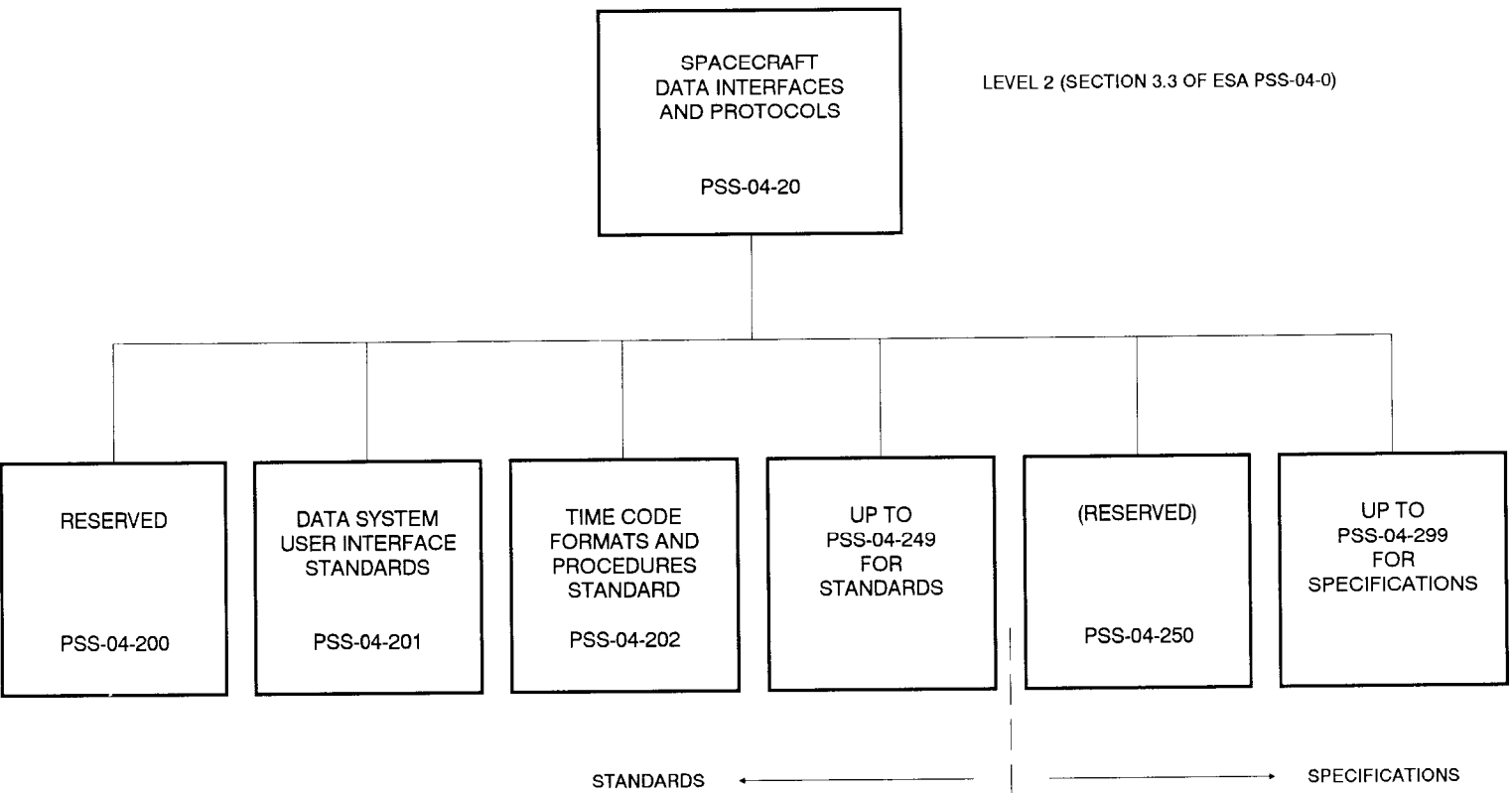


Figure 3.4 SPACECRAFT DATA INTERFACES AND PROTOCOLS SUB-BRANCH

4. APPLICABILITY

In line with the instructions of Reference [1] and following approval of the Inspector General of ESA, the applicability of the Space Data Communications PSS documents to ESA projects is categorised as follows:

4.1 MANDATORY STANDARDS

The Standards belonging to the Space Link Standards and Protocols subbranch (i.e. all documents from ESA PSS-04-100 up to (and including) ESA PSS-04-149) are, in principle, planned to be categorised as **MANDATORY STANDARDS**. However, for each Standard, it is necessary to specify which part of the ESA infrastructure is concerned for mission support, and to which architectural ISO layer it corresponds:

(a) Conventional Mission Support by ESA Ground Network.

In Table 4.1, this mission support type is short-named as "CONVENTIONAL". The table also indicates the ISO layer relevant to each Standard. For instance, the Radio Frequency and Modulation Standard (PSS-04-105) and the Ranging Standard, Volume I, (PSS-04-104) correspond to the ISO Layer 1 (Physical Layer).

(b) Mission Support by ESA Ground Network via the ESA Data Relay Satellite System.

In Table 4.1, this mission support type is indicated as "DRS USERS". A comparison between this type of mission support and the preceding one ("CONVENTIONAL") shows that they differ at the level of the Layer 1 Standards.

(c) Support for Missions Conforming to Advanced Orbiting Systems Standards.

Advanced Orbiting Systems (A.O.S.) Standards are primarily intended to define the support services for manned missions, but may also be used for unmanned missions. These spacecraft must primarily comply with a set of enhanced Layer 2 and 3 Standards specifically developed for advanced orbiting systems within the CCSDS. In Table 4.1, this type of mission support is short-named as "A.O.S.", and the set of Standards

corresponding to it shown to be PSS-04-108 (Advanced Orbiting Systems, Networks and Data Links).

"A.O.S." spacecraft must also comply with several other Standards, as required by their mission operational requirements. This is not shown in Table 4.1, for the sake of clarity, since such spacecraft may require, for example, to be compatible with both "CONVENTIONAL" and "DRS USERS" Layer 1 Standards.

4.2 **RECOMMENDED PRACTICES**

All documents not listed in Table 4.1 are categorised as **RECOMMENDED PRACTICES**, and in particular the Specifications of both PSS-04-100 and PSS-04-200 subbranch, and the Standards of the PSS-04-200 subbranch.

ESA PSS REFERENCE	TITLE OF STANDARD	ISO LAYER	APPLICABLE MISSION SUPPORT TYPE
PSS-04-103	TELEMETRY CHANNEL CODING STANDARD	2	* CONVENTIONAL * DRS USERS
PSS-04-104	RANGING STANDARD VOLUME I: Direct Ground to Spacecraft Ranging	1	* CONVENTIONAL
PSS-04-104	RANGING STANDARD VOLUME II: Ranging via Data Relay Systems	1	* DRS USERS
PSS-04-105	RADIO FREQUENCY AND MODULATION STANDARD	1	* CONVENTIONAL
PSS-04-106	PACKET TELEMETRY STANDARD	2/3	* CONVENTIONAL * DRS USERS
PSS-04-107	PACKET TELECOMMAND STANDARD	2/3	* CONVENTIONAL * DRS USERS
PSS-04-108	ADVANCED ORBITING SYSTEMS, NETWORKS AND DATA LINKS	2/3	* A.O.S.
PSS-04-109	RADIO FREQUENCY STANDARDS FOR DATA RELAY SYSTEMS	1	* DRS USERS

Table 4.1 LIST OF MANDATORY STANDARDS OF THE PSS-04-100 SUB-BRANCH (AT DATE OF ISSUE)

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5. RELATIONSHIP WITH CCSDS

Most of the Space Data Communications PSS documents are directly derived from equivalent CCSDS (*) Recommendations. This is particularly true for the majority of the Mandatory Standards of the PSS-04-100 sub-branch.

ESA Projects must bear in mind that:

- (a) The Space Data Communications PSS documents are those that are applicable in priority to their mission, and in particular the Mandatory Standards.
- (b) CCSDS Recommendations can only be applicable to an ESA Project in the following cases:
 - as a complement to the ESA PSS documents when evaluating and negotiating the cross-support capability of another CCSDS agency's infrastructure;
 - as a substitute for the corresponding ESA Space Data Communications PSS document, when such a document is planned but not yet ready and/or approved.

NOTE (*): CCSDS: Consultative Committee for Space Data Systems

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6. OTHER RELATED DOCUMENTATION

In addition to the related CCSDS Recommendations forming the basis for most of the Space Data Communications PSS documents, it is currently planned to issue, and update as required, a "Catalogue" of developed equipment, devices and software complying with the said PSS documents, both for on-board and ground use. It has been agreed to compile such a "Catalogue" as a CCSDS document, and not only as an ESA one.

Furthermore, there will still be other ESA documentation, solely published by the responsible departments/divisions, which will be directly related to the Space Data Communications PSS documents. This documentation shall be obtained from the following ESA establishments:

(a) At ESOC

- Stations and Communications Engineering Department (SCED)
- Operations Department (OD)
- ESA Computer Department (ECD), for data management matters.

(b) At ESTEC

- Radio Frequency Systems Division (code XR) for on-board radio frequency and ranging systems.
- On-board Data Division (code WD) for on-board telemetry and telecommand links and network protocols and data management.
- Simulation and Electrical Facilities Division (code WG) for satellite checkout (EGSE systems, etc.)

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