

The Packet Utilisation Standard, PUS

1. Background and History

In the late 1980s, CCSDS published firstly its packet telemetry and, subsequently its packet telecommand Recommended Standards (Blue Books) together with accompanying “Concept and Rationale” handbooks (Green Books). These documents subsequently underwent several updates, with the last occurring in 2001:

Packet TM: CCSDS-100.0-G-1 “Telemetry: Summary of Concept and Rationale”
CCSDS-102.0-B-5 “Packet Telemetry”
CCSDS-103.0-B-2 “Packet Telemetry Service Specification”
Packet TC: CCSDS-200.0-G-6 “Telecommand: Summary of Concept and Rationale”
CCSDS-201.0-B-3 “Telecommand: Part 1 Channel Service”
CCSDS-202.0-B-3 “Telecommand: Part 2 Data Routing Service”
CCSDS-202.1-B-2 “Telecommand: Part 2.1 Command Operation Procedures”
CCSDS-203.0-B-2 “Telecommand: Part 3 Data Management Service”

Shortly after the CCSDS standards appeared, the ESA Standards Approval Board (STAB) used them to derive their own – compatible - packet standards:

Packet Telemetry Standard: ESA PSS-04-106
Packet Telecommand Standard ESA PSS-04-107

Whilst these CCSDS and ESA packet standards defined in detail the communication protocols for the transmission of telemetry and telecommand packets between Application Processes on-board and peer Application Processes on the ground, they did not contain any recommendations for how packets should actually be deployed for the monitoring and control of a spacecraft. Moreover, no CCSDS Recommended Standard was planned on this subject; nor indeed was one ever produced.

ESA foresaw a potential problem whereby missions utilising CCSDS packets would implement their own mission-specific solutions, with a consequent proliferation of bespoke on-board packet management systems and supporting ground monitoring and control applications. Therefore, in the early 1990s, the ESA Committee for Operations and EGSE Standards (COES) was charged with the task of developing a standard for how packets should be used, which would satisfy the operational requirements of a broad range of missions. The first ESA Packet Utilisation Standard was produced by COES in 1994 and became the ‘de facto’ standard for all ESA missions thereafter:

Packet Utilisation Standard: ESA PSS-07-101 Issue 1 May 1994

When the responsibility for the production of pan-European Space standards was transferred from ESA to ECSS, a re-issue of the PUS standard was deemed timely. Several ESA and non-ESA missions had applied the standard since its first issue (XMM, Integral, Rosetta, Envisat, ATV, Proba, MSG) and a body of operational experience had

already been acquired. As a consequence, many suggestions had been tabled for extending and improving the PUS. These ranged from:

- a. improvements in the presentation to avoid misunderstandings of interpretation that had arisen, to
- b. extensions to the existing standard to reflect what had been implemented on a mission-specific basis.

The CCSDS packet standards had also evolved in the meantime (e.g. removal of the segmentation option for telemetry packets) and the opportunity was also taken to re-align the PUS with the latest CCSDS standards. After a lengthy public review cycle, the ECSS PUS was issued in 2003:

Telemetry and Telecommand Packet Utilization: ECSS-E-70-41A, January 2003

The evolution of the PUS and its relationships with other ECSS, ESA and CCSDS standards is shown in Figure 1 below.

2. What does the PUS contain?

The PUS defines a set of “standard” monitoring and control **services** expressed in terms of:

- a. the operational concept that determines the requirements;
- b. the service model (i.e. how the on-board Application Process which hosts the service should behave) and,
- c. the structure and semantics of the associated telemetry and telecommand packets.

The standard services defined in the PUS are:

No.	Service Name
1	Telecommand Verification Service
2	Device Command Distribution Service
3	Housekeeping and Diagnostic Data Reporting Service
4	Parameter Statistics Reporting Service
5	Event Reporting Service
6	Memory Management Service
8	Function Management Service
9	Time Management Service
11	On-board Operations Scheduling Service
12	On-board Monitoring Service
13	Large Data Transfer Service
14	Packet Forwarding Control Service
15	On-board Storage and Retrieval Service
17	Test Service
18	On-board Operations Procedure Service
19	Event-Action Service

A space project can choose to implement only those standard PUS services which suit its specific mission characteristics and requirements. Furthermore, it can choose to implement a given service at one of several different levels ranging from very simple to rather complex. Recognizing also that there may be requirements for mission-specific services or mission-specific additions to the standard services, the PUS includes rules and guidelines for how these extensions should be implemented.

3. The next steps

After a further 6+ years of experience with the ECSS PUS and the evolution in the meantime of on-board data management systems and monitoring and control concepts, there are plenty of reasons for an update of the standard:

- a. A dossier has been maintained by the ESA PUS working group of comments, proposals and errors forwarded by PUS users over the years;
- b. Since the beginning of this year, ESA/ESOC has been compiling a further set of comments and proposals from the Operations Teams of flying missions and missions under preparation;
- c. Related CCSDS and ECSS standards have further evolved. In particular:
 - CCSDS has replaced its former packet telemetry and telecommand standards by a “Space Packet Protocol” (SPP) standard which is closely derived from the former AOS packet standards. Unfortunately, the SPP does not retain backwards-compatibility with the CCSDS packet standards, so this represents a major challenge for the PUS which is currently firmly linked to the concepts that underpinned the earlier CCSDS standards¹;
 - CCSDS has embarked on a series of standards for Spacecraft Monitoring and Control (SMC), which overlaps significantly with the PUS domain.

¹ ESA has drawn this inconsistency to the notice of CCSDS and, in principle, an update to the SPP has been agreed to establish such backwards-compatibility. However, at the time of writing, a satisfactory update to the standard has not yet been implemented.

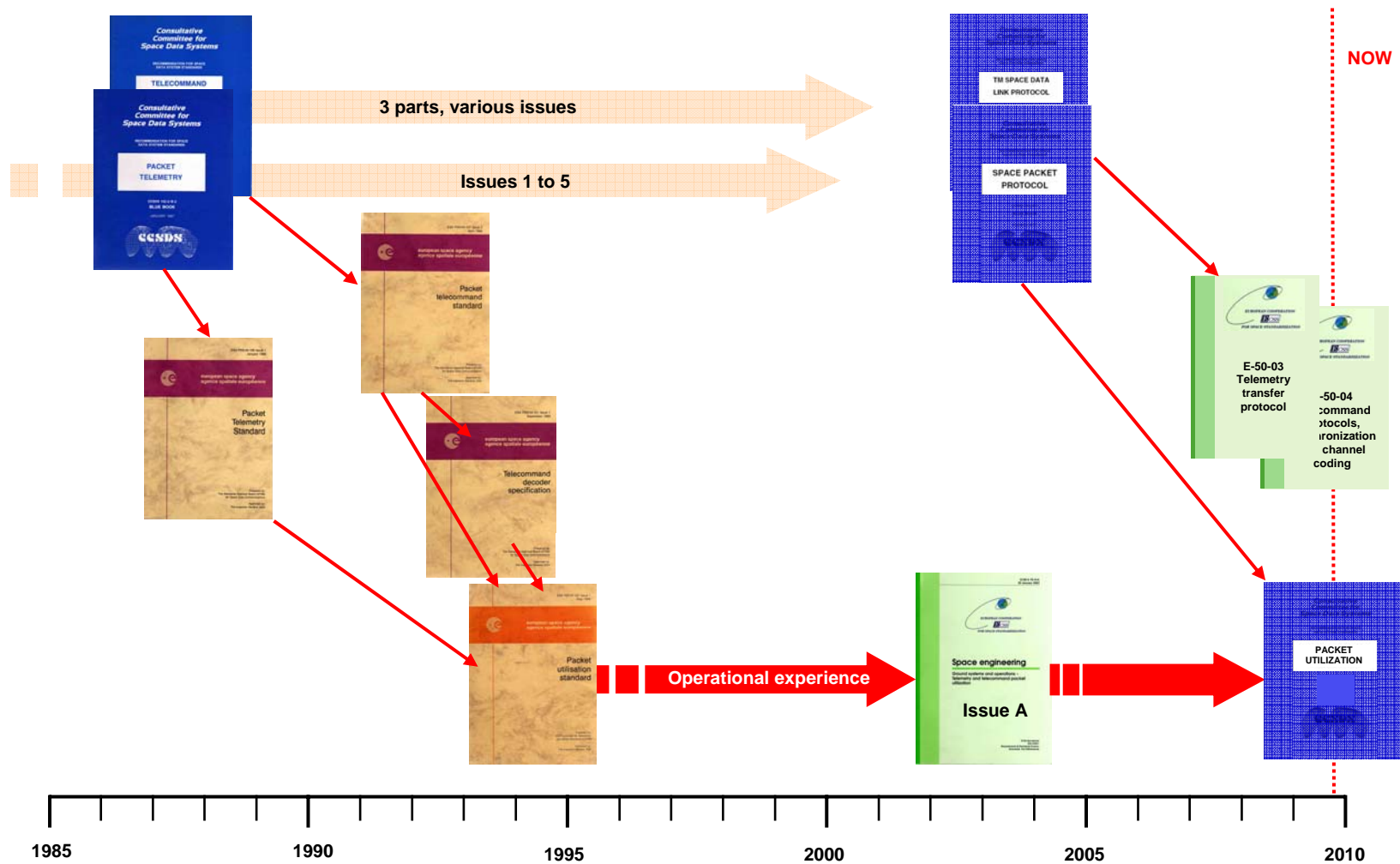


Figure 1 PUS Evolution and relationships with other standards