# Avionics Data, Control and Software Systems
## ADCSS-2013

*Telemetry and Telecommand Packet Utilization*

*The ECSS-E-ST-70-41C*

*October 2013 ECSS WG Draft*

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ESTEC/TEC-SWM
22 October 2013

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# ECSS-E-ST-70-41C WG – Main Purpose

- The Main Purpose of the PUS-A to PUS-C upgrade has been:

  *processing 190 change requests…*

  - to remove the PUS-A deficiencies and inject lessons learned

  - to improve the standard to meet the need for future missions

  - to acknowledge the existence of new ECSS and CCSDS standards and ensure consistency

  - to implement the ECSS drafting rules that apply to any ECSS Standards [e.g. naming each requirement to facilitate tailoring, traceability]

  - *to maintain backward compatibility when possible*

- This new version of the PUS has been developed by the major stakeholders including Space Agencies and Industry, with representatives of both the Space Segments and the Ground Segments

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# ECSS-E-ST-70-41C WG Members

| Organisation | Representatives | |
|---|---|---|
| **ESA** | S. Valera *convenor*<br><br>*M. de Lande Long book captain* | G.P. Calzolari<br><br>M. Schön |
| **ASTRIUM** | R. Gessner<br><br>P. Parmentier | J. Rueting |
| **CNES** | *P. Arberet*<br><br>M.C. Charmeau | J.P. Loubeyre<br><br>N. Pons |
| **DLR** | S. Zimmermann | |
| **EUMETSAT** | F. Croce | |
| **SPACEBEL** | A. Bourdoux | |
| **TAS** | S. Candia<br><br>P. Fourtier | G. Garcia |

# PUS C – A new document structure

1. *Scope*
2. *Normative references*
3. *Terms, definitions and abbreviated terms*
4. Context and background
5. PUS foundation model
6. Service Type Overview
7. Service Type System Specification
8. Space/Ground Interface Requirements
   a. Space packet overview
   b. Packet data field for TM packet
   c. Packet data field for TC packet
   d. Packet Field Code (PTC/PFC)
9. Service Type Interface Specification

## Annexes

A. informative Request type & report type summary
B. normative Command Pulse Distribution Unit
C. informative CRC and ISO checksum
D. informative IEEE and MILBUS real formats

| | |
|---|---|
| **PUS foundation model** | **±10 pages** |
| **ST System Specification** | **± 300 pages** |
| **ST Interface Specification** | **± 150 pages** |
| **ECSS-E-ST-70-41C** | **± 600 pages** |

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# The PUS Foundation Model

The **PUS Foundation Model** defines the model (including vocabulary) that:

- has been used to produce the **"standard service types"**;
- shall be used to produce the **"mission-specific service types"**, i.e.:
  - adding new service types, subservice types, message types, …
  - adding capabilities to the "standard service types";
- shall be used to produce the **"mission services"**, i.e.:
  - creating the required services by:
    - "realising the service types", and
    - inheriting all mandatory subservices and minimum capabilities;
  - selecting, for each service, the additional capabilities, the optional subservices, etc;
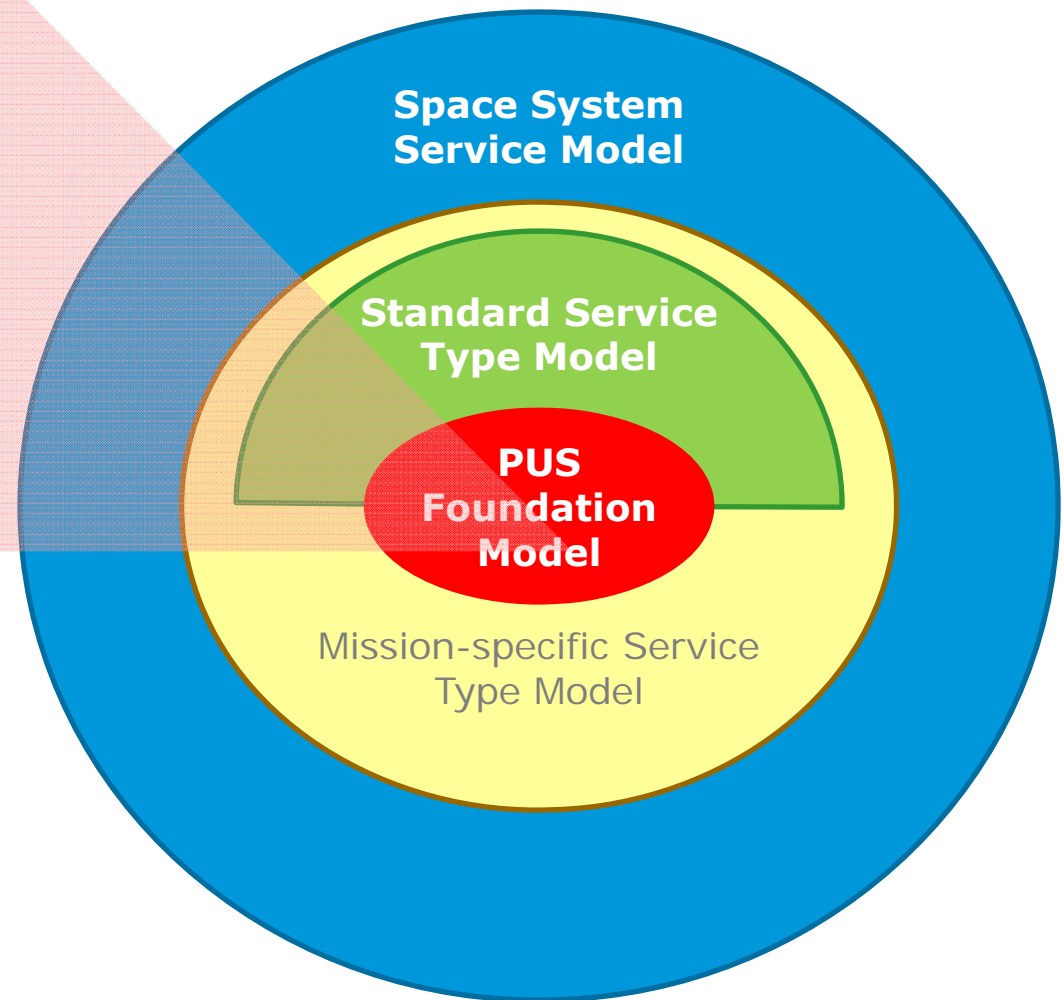  - creating the service specific definitions.

Space System
Service Model

Standard Service
Type Model

PUS
Foundation
Model

Mission-specific Service
Type Model
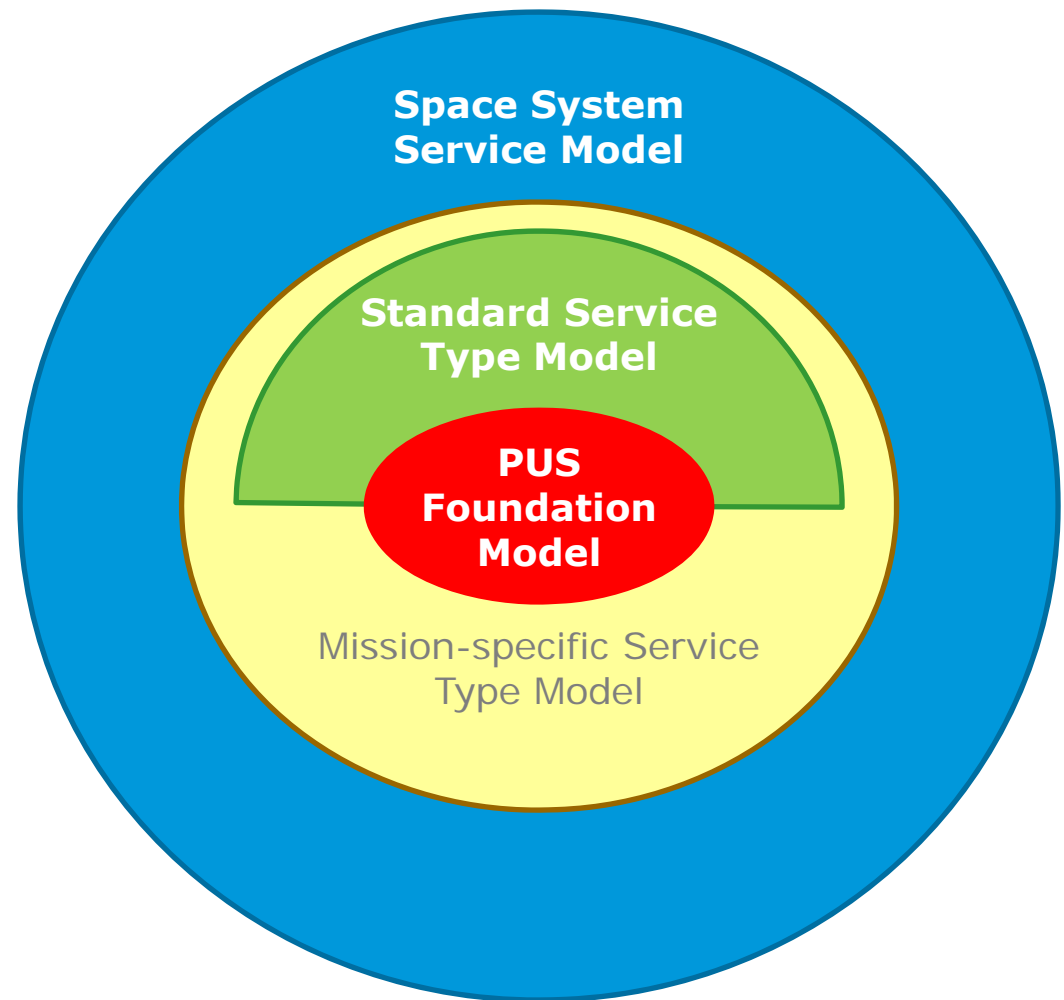
# The Service Type System Requirements

The **ST System Requirements**

addresses the "Semantic" of each service type including:

- the service type concept and related architecture
- the message type concept and related architecture
- the overall service type topology (focusing on message exchange between service users and service providers)

Space System
Service Model

Standard Service
Type Model

PUS
Foundation
Model

Mission-specific Service
Type Model

# The Service Type Interface Requirements
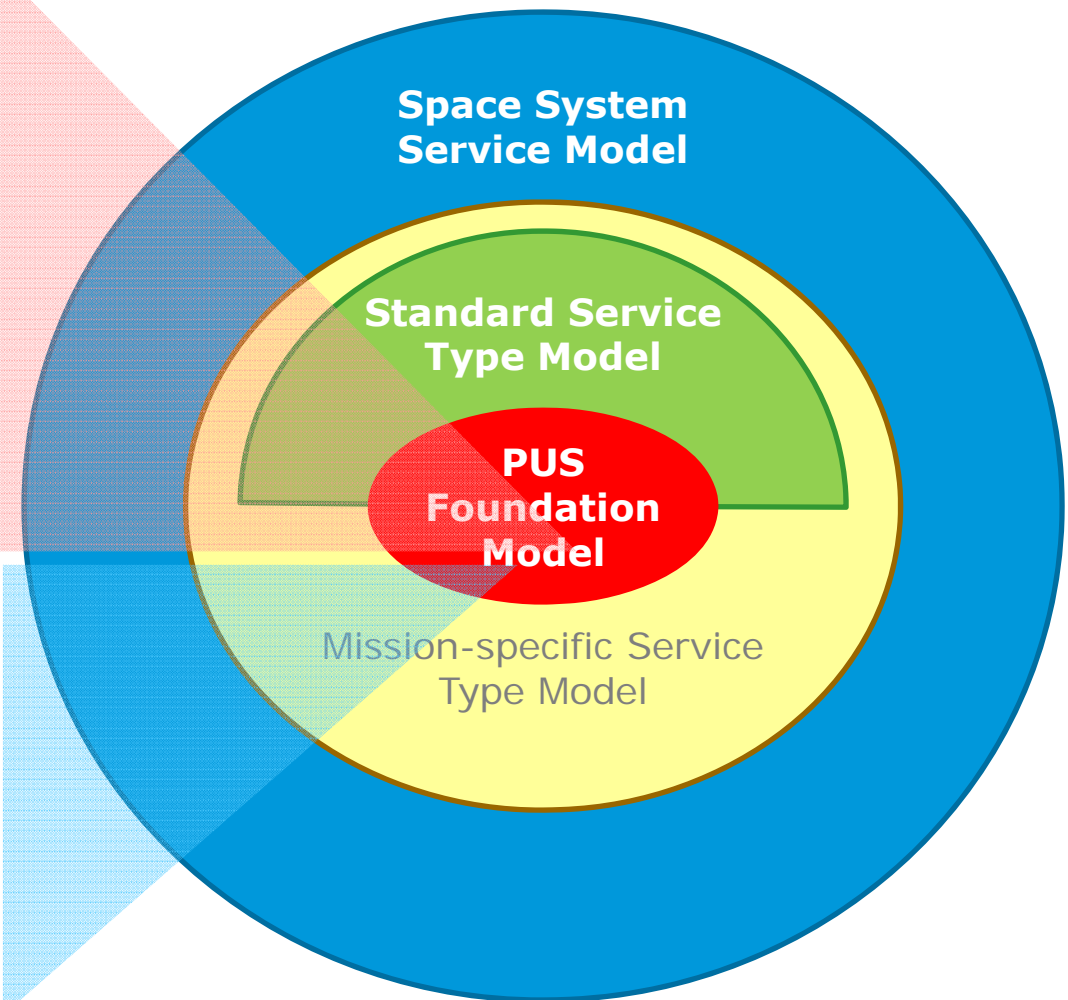
The **ST System Requirements**

addresses the "Semantic" of each service type including:

- the service type concept and related architecture
- the message type concept and related architecture
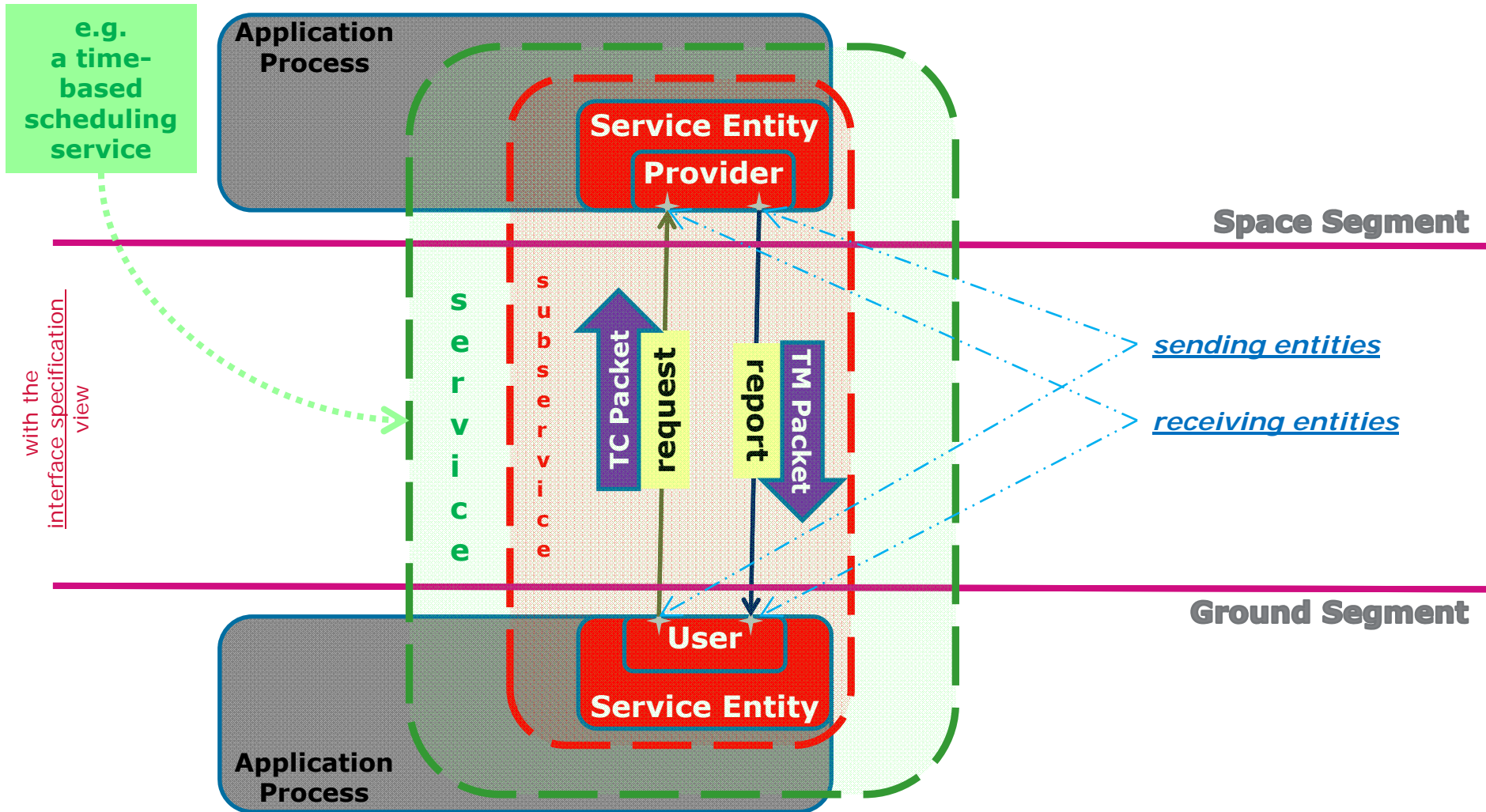- the overall service type topology (focusing on message exchange between service users and service providers)

The **service type interface requirements**

specifies the Ground/Space Link message exchange protocol i.e.:

- how requests are transported within CCSDS SPP & PUS telecommand packets;
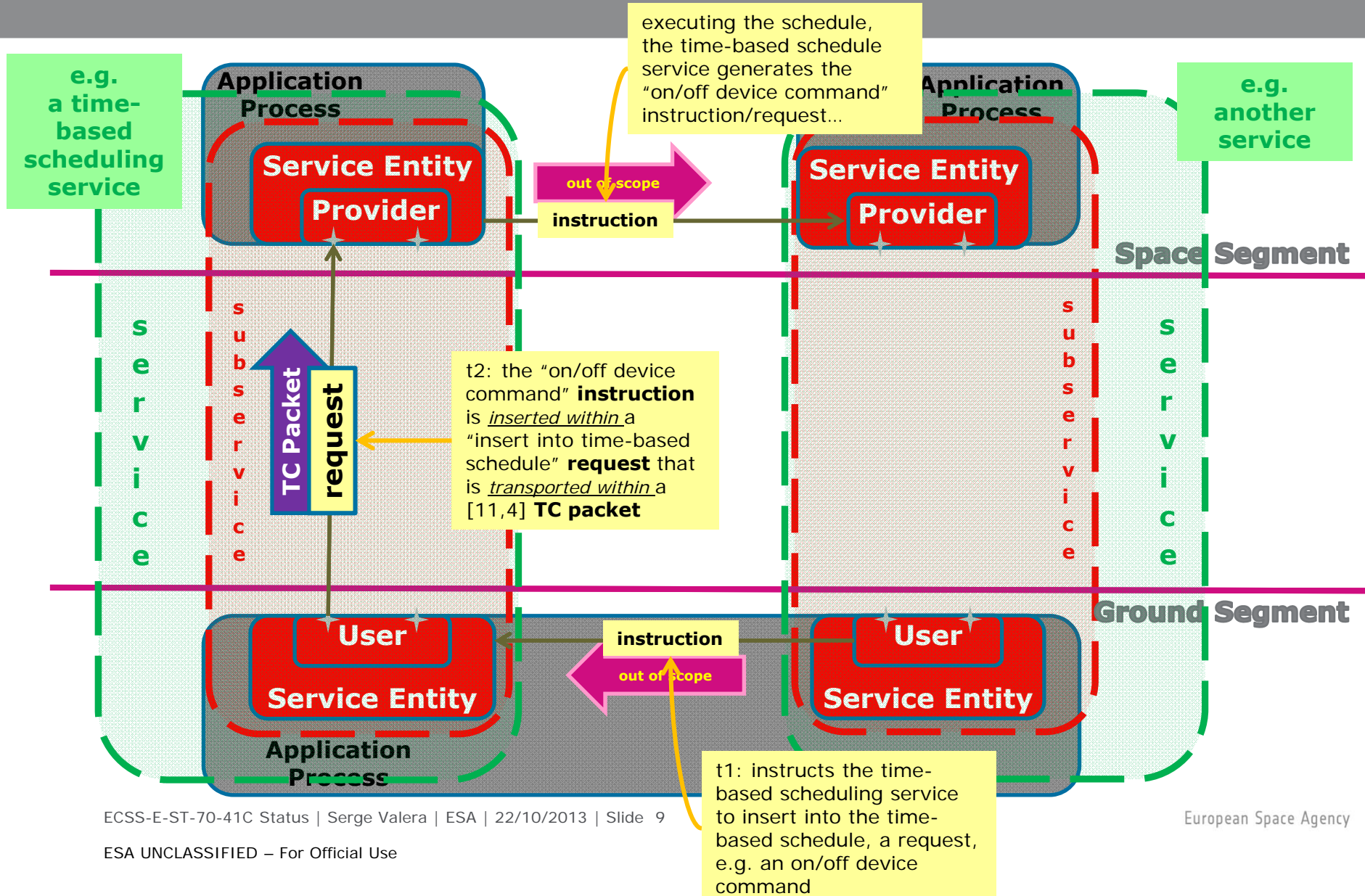- how reports are transported within CCSDS SPP & PUS telemetry packets.

**Space System Service Model**

**Standard Service Type Model**

**PUS Foundation Model**

Mission-specific Service Type Model

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# A <u>system specification</u> view of a Service

**e.g. a time-based scheduling service**

with the <u>interface specification</u> view

**Application Process**

**service**

**subservice**

**Service Entity**

**Provider**

**Space Segment**

TC Packet

**request**

**report**

TM Packet

*sending entities*

*receiving entities*

**Ground Segment**

**User**

**Service Entity**

**Application Process**

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# A time-based scheduling service interacting with other services

executing the schedule, the time-based schedule service generates the "on/off device command" instruction/request...

e.g. a time-based scheduling service

e.g. another service

Application Process

Service Entity
Provider

out of scope

instruction

Application Process

Service Entity
Provider

Space Segment

service

subservice

service

subservice

TC Packet

request

t2: the "on/off device command" **instruction** is _inserted within_ a "insert into time-based schedule" **request** that is _transported within_ a [11,4] **TC packet**

User
Service Entity

instruction

out of scope

User
Service Entity

Ground Segment

Application Process

t1: instructs the time-based scheduling service to insert into the time-based schedule, a request, e.g. an on/off device command

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# A specification view of a request

PUS system requirements only address the *what*, i.e. the information from a semantic viewpoint

**Request type [x, y]**    RT instruction

RX provides multiple instruction slots = TRUE

instruction 1 of type [x, y]    instruction 2 of type [x, y]    ...    instruction N of type [x, y]

**Request of type [x, y]**

instruction slot 1    instruction slot 2    ...    instruction slot N

packet primary header (48 bits) | packet data field

Figure 10-1 The space packet structure

Figure 10-5 Packet secondary header for telecommand packets

Figure 10-6 User data field for telecommand packets

Figure 11-1 Distribute on/off device commands

**PUS interface requirements address the how, the data representation of the information**

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# A specification view of a <u>report</u>

**PUS system requirements only address the *what*, i.e. the information from a semantic viewpoint**

**Report type [x, y]**    **RT notification**

RT provides multiple instruction slots = TRUE

**notification 1 of type [x, y]**    **notification 2 of type [x, y]** ...    **notification N of type [x, y]**

**Report of type [x, y]**

**notification slot 1**    **notification slot 2**    ...    **notification slot N**

Figure 10-1 The space packet structure

Figure 10-3 Packet secondary header for telemetry packets

Figure 10-4 User data field for telemetry packets

Figure 11-4 Register dump report

**PUS interface requirements address the how, the data representation of the information**

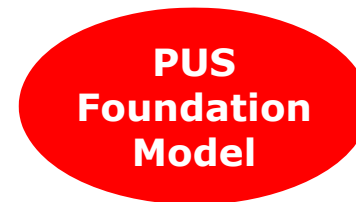| TYPE | Realisation |
|---|---|
| service type (ST) | service |
| subservice type | subservice<br>application process |
| ST minimum capability<br>ST additional capability | capability |
| ST transaction<br>• of request type<br>• of indication type | |
| instruction type | instruction |
| request type (RX)<br>• RX instruction slot | request |
| notification type | notification |
| report type (RT)<br>• RT notification slot | report |
| ... | ... |

**System Requirements related**

**PUS Foundation Model**
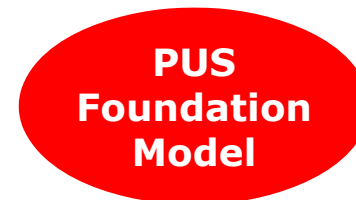
# The PUS Foundation Model **System Specification** concepts, 2

| TYPE | Realisation |
|---|---|
| **message type** | **message** |
| • **request type** | • **request** |
| • **report type** | • **report** |
|    • **request verification RT** |    • **acceptance report**<br>   • **start of execution**<br>   • **progress of execution**<br>   • **completion of execution** |
|    • **response RT** |    • **response** |
|    • **indication RT** |    • **indication** |
| **...** | **...** |

*System Requirements related*

**PUS Foundation Model**

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# The PUS Foundation Model **Interface Specification** concepts

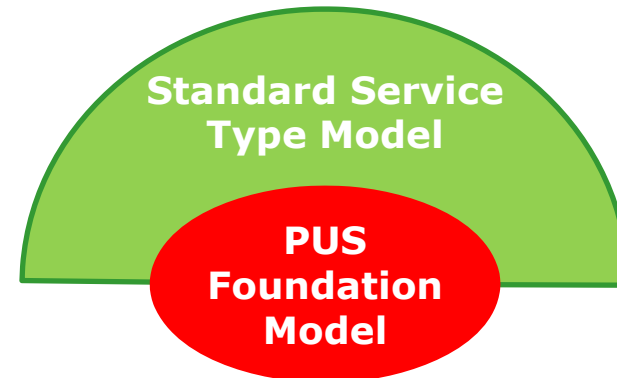| TYPE | Realisation |
|---|---|
| CCSDS packet type<br>PUS packet type | CCSDS packet header<br>PUS packet secondary header |
| telecommand packet type | telecommand packet transporting a request |
| telemetry packet type | telemetry packet transporting a report |
| packet field code<br>• type code (PTC)<br>• format code (PFC) | |
| ... | ... |

Interface Requirements related

**PUS Foundation Model**

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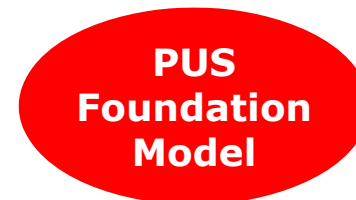
# The Standard Service Type Model, 1

## Standard Service Types

| | | |
|---|---|---|
| ST 1 | **request verification** | **2** |
| ST 2 | **device access** | √ |
| ST 3 | **HK, diagnostic and TM mode** | ... |
| ST 4 | **parameter statistics** | √ |
| ST 5 | **event reporting** | √ |
| ST 6 | **memory management** | √ |
| ST 8 | **function management** | √ |
| ST 9 | **time management** | ... |
| ST 11 | **time-based scheduling** | √ |
| ST 12 | **on-board monitoring** | √ |
| ST 13 | **large packet transfer** | **2** |
| ST 14 | **real-time forwarding control** | √ |
| ST 15 | **on-board storage and retrieval** | ... |
| ST 17 | **test** | √ |
| ... | | |

**Standard Service Type Model**

**PUS Foundation Model**

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# ST2 – Device access

| Standard Service Types | |
|---|---|
| ST 1 | **request verification** | |
| ST 2 | **device access** | √ |
| ST 3 | **HK, diagnostic and TM mode** | |
| ST 4 | **parameter statistics** | |
| ST 5 | **event reporting** | |
| ST 6 | **memory management** | |
| ST 8 | **function management** | |
| ST 9 | **time management** | |
| ST 11 | **time-based scheduling** | |
| ST 12 | **on-board monitoring** | |
| ST 13 | **large packet transfer** | |
| ST 14 | **real-time forwarding control** | |
| ST 15 | **on-board storage and retrieval** | |
| ST 17 | **test** | |
| ... | | |

## +/- ready

New capabilities proposed for:

- register contents acquisition
- CPDU commands distributed by (on-board) software
- low-level commands for device configuration and actuation
- low-level commands for data acquisition

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# ST3 – HK, diagnostic and TM Mode

| Standard Service Types | | |
|---|---|---|
| ST 1 | request verification | |
| ST 2 | device access | |
| ST 3 | HK, diagnostic and TM mode | ... |
| ST 4 | parameter statistics | |
| ST 5 | event reporting | |
| ST 6 | memory management | |
| ST 8 | function management | |
| ST 9 | time management | |
| ST 11 | time-based scheduling | |
| ST 12 | on-board monitoring | |
| ST 13 | large packet transfer | |
| ST 14 | real-time forwarding control | |
| ST 15 | on-board storage and retrieval | |
| ST 17 | test | |
| ... | | |

## under construction

Preliminary draft only is available.

A new subservice is proposed:

• the TM mode subservice that provides the capability to operate on dedicated sets of HK or diagnostic packets, i.e. reducing the number of requests needed to modify e.g. the current TM plan.

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# ST6 – memory management

| Standard Service Types | |
|---|---|
| ST 1 | **request verification** | |
| ST 2 | **device access** | |
| ST 3 | **HK, diagnostic and TM mode** | |
| ST 4 | **parameter statistics** | |
| ST 5 | **event reporting** | |
| ST 6 | **memory management** | √ |
| ST 8 | **function management** | |
| ST 9 | **time management** | |
| ST 11 | **time-based scheduling** | |
| ST 12 | **on-board monitoring** | |
| ST 13 | **large packet transfer** | |
| ST 14 | **real-time forwarding control** | |
| ST 15 | **on-board storage and retrieval** | |
| ST 17 | **test** | |
| ... | | |

## +/- ready

The memory management service defines 4 subservices:

- the raw data memory management subservice

- the structured data memory management subservice (for memories containing e.g. files, on-board control procedures)

- the common memory management subservice (common to raw and structured data memories)

- the memory configuration subservice that manage memories as wholes independently of their content and specific addressing scheme (e.g. enabling/disabling scrubbing, write protecting memories)

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# ST11 – time-based scheduling

| Standard Service Types | |
|---|---|
| ST 1 | **request verification** | |
| ST 2 | **device access** | |
| ST 3 | **HK, diagnostic and TM mode** | |
| ST 4 | **parameter statistics** | |
| ST 5 | **event reporting** | |
| ST 6 | **memory management** | |
| ST 8 | **function management** | |
| ST 9 | **time management** | |
| ST 11 | **time-based scheduling** | √ |
| ST 12 | **on-board monitoring** | |
| ST 13 | **large packet transfer** | |
| ST 14 | **real-time forwarding control** | |
| ST 15 | **on-board storage and retrieval** | |
| ST 17 | **test** | |
| ... | | |

**+/- ready**

The A version of this Service has been completely re-assessed resulting in 3 proposed new service types, i.e.

- ST11: the time-based scheduling
- ST21: the telecommand sequencing
- ST22: the orbit-based scheduling

--------------------------------------------------

The time-based scheduling service provides the capability to command on-board application processes using requests pre-loaded on-board the satellite and released at their due time.

It supports the concept of sub-schedules.

This service is an *extension of the ground monitoring and control* [As such, the application processes that execute the requests released by the telecommand sequencing service directly send the telecommand verification reports, if any, to the ground.]

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# The Standard Service Type Model, 2

| Standard Service Types | | |
|---|---|---|
| ... | | |
| ST 18 | **on-board control procedure** | √ |
| ST 19 | **event – action** | √ |
| ST 20 | **parameter management** | √ |
| ST 21 | **telecommand sequencing** | √ |
| ST 22 | **position-based scheduling** | √ |
| ST 23 | **file management** | √ |

**Standard Service Type Model**

**PUS Foundation Model**

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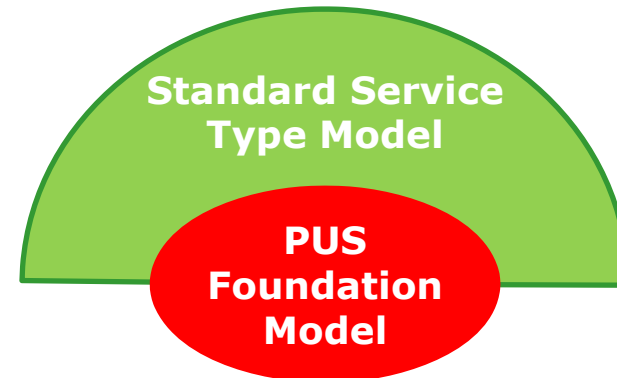
# ST20 – parameter management

| Standard Service Types | | |
|---|---|---|
| ... | | |
| ST 18 | **on-board control procedure** | |
| ST 19 | **event – action** | |
| ST 20 | **parameter management** | √ |
| ST 21 | **telecommand sequencing** | |
| ST 22 | **position-based scheduling** | |
| ST 23 | **file management** | |

## +/- ready

The parameter management service relates to the management of on-board parameters, providing the capability:

- to read their current values, and

- to set new values.

In the context of this service, the parameter definition consists of:

- the mapped on-board memory address,

- the parameter type code (PTC), and

- the parameter format code (PFC).

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# ST21 – telecommand sequencing

## +/- ready

| Standard Service Types | | |
|---|---|---|
| ... | | |
| ST 18 | **on-board control procedure** | |
| ST 19 | **event – action** | |
| ST 20 | **parameter management** | |
| ST 21 | **telecommand sequencing** | √ |
| ST 22 | **position-based scheduling** | |
| ST 23 | **file management** | |

The telecommand sequencing service provides the capability to release, one by one, the telecommands contained in an on-board sequence of telecommands.

Within a telecommand sequence, the delay between the release of a telecommand and the release of the next telecommand can be specified.

Several telecommand sequences can be running in parallel.

The service provides the capability to load a telecommand sequence from a file stored on-board or directly from ground.

This service is an *extension of the ground monitoring and control*.

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# ST22 – position-based scheduling

**+/- ready**

| Standard Service Types | |
|---|---|
| ... | |
| ST 18 | **on-board control procedure** | |
| ST 19 | **event – action** | |
| ST 20 | **parameter management** | |
| ST 21 | **telecommand sequencing** | |
| ST 22 | **position-based scheduling** | √ |
| ST 23 | **file management** | |

The (orbit) position-based scheduling service provides the capability to command on-board application processes using requests pre-loaded on-board the satellite and released when the Spacecraft reaches the associated position on the orbit.

This service does not specify how the orbit positions are determined, i.e. this is done when tailoring the service to the mission.

It supports the concept of sub-schedules.

This service is an *extension of the ground monitoring and control*.

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# ST23 – file management

**Standard Service Types**

| | | |
|---|---|---|
| ... | | |
| ST 18 | **on-board control procedure** | |
| ST 19 | **event – action** | |
| ST 20 | **parameter management** | |
| ST 21 | **telecommand sequencing** | |
| ST 22 | **position-based scheduling** | |
| ST 23 | **file management** | √ |

## +/- ready

The file management service provides the capability to manage on-board file systems and files.

File systems can either be:

- flat, where directory structures are not supported, or
- structured, where files are stored within directories.

Two subservices are defined for the file management service:

- The file handling subservice provides an interface to the on-board file handling system and includes requests for file management actions such as deleting a file, copying a file, creating a directory.

- The remote file copy subservice copies files, in either direction, between an on-board file system and a remote file system (e.g. on the ground). *This implies that the subservice provides a limited interface to a dedicated file transfer layer that can uplink and downlink files using, for example, the CCSDS CFDP protocol.*

The file management service is not concerned with the contents of the files that it manages.

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# ECSS-E-ST-70-41C WG - Previsions

- *The last announced plan August 2013 announced end of October 2013 for the WG delivery of the draft for Public review. Additional WG effort is required to finalise the draft.*

- on 13th November 2013, the current draft will be presented to the ECSS Technical Authority, asking for <u>an additional 2 to 3 months to finalise it</u>.

- If that new plan realises, still to be discussed with ECSS, the **Public Review**:
    - **could be initiated in Jan./Feb. 2014**
    - **could last 6 to 8 weeks**
    **During that review, the WG recommends focusing on the ECSS-E-ST-70-41C system specification**

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**Any questions?**

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