# Introduction

## Purpose and Scope

The purpose of this document, prepared by ESOC, is to identify the functional requirements on the Solar Orbiter spacecraft, including the payload, necessary for the conduct of all mission operations. In addition, this document defines all requirements related to the major deliverable items needed at the Operations Control Centre for the preparation and execution of the mission operations.

# Applicable Documents

AD1 Telemetry and Telecommand Packet Utilisation Standard. ECSS-E-70-41A. 30/01/2003

AD4 Solar Orbiter Statement of Work. SOL-EST-SOW-1718. 01/03/2011

# Reference Documents

RD1 Solar Orbiter Space to Ground Interface Control Document (SGICD). SO-ESC-IF-05002

RD8 Solar Orbiter TM/TC and Packet Structure ICD. SOL-S-ASTR-TN-0079

# Terms, Definitions and Abbreviations

APID Application ID

EQM Engineering Qualification Model (of spacecraft)

HK Housekeeping

IF Interface

OBT Onboard Time

PFM Proto Flight Model (of spacecraft)

TBD To Be Defined

TBC To Be Confirmed

TC Telecommand

TM Telemetry

UTC Universal Time Coordinated

# General Description

## Product Perspective

## General Capabilities

## General Constraints

## Operational Environment

## Assumptions Dependencies

# Specific Requirements

## General Requirements

## Capabilities Requirements

## System Interface Requirements

### Telemetry

|  |  |
| --- | --- |
| **Name** | **TM-4** |
| **Description** | Telemetry shall be provided to allow adequate and unambiguous verification of acceptance, progress (where applicable) and execution of all telecommands sent from any source (sent from Ground for immediate, delayed or time-tagged execution, and sent from onboard applications). |
| **Validation Method** | Testing |

The level of verification will be specified by the command acknowledgement field.

## Adaptation Missionization Requirements

## Computer Resource Requirements

## Security Requirements

## Safety Requirements

### Failure Detection Isolation and Recovery (FDIR)

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| --- | --- |
| **Name** | **FDIR-14** |
| **Description** | Failure detection algorithms shall avoid continuous production of the same anomaly report packet, if the same failure is detected within a number of monitoring cycles which is to be defined for each failure case. |
| **Validation Method** | Testing |

## Reliability Availability Requirements

## Quality Requirements

## Design Requirements

## Software Operations Requirements

## Software Maintenance Requirements

## System Software Observability Requirements

# Verification Validation Integration Requirements

## Verification Validation Process Requirements

## Validation Approach

## Validation Requirements

## Verification Requirements

### Service 1: Telecommand Verification

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| --- | --- |
| **Name** | **TCV-1** |
| **Description** | Telecommand packets shall be validated by the destination application process at the moment of acceptance via checksum verification. No check of the packet sequence counter shall be made. |
| **Validation Method** | Testing |

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| --- | --- |
| **Name** | **TCV-2** |
| **Description** | A telemetry packet for successful command acceptance shall be generated by the receiving application for every telecommand properly received and containing valid data. |
| **Validation Method** | Testing |

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| --- | --- |
| **Name** | **TCV-3** |
| **Description** | A telemetry packet for unsuccessful command acceptance shall be generated by the receiving application for every telecommand not properly received or containing invalid data. This telemetry packet shall indicate the reason for not acceptance of the related telecommand. |
| **Validation Method** | Testing |

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| --- | --- |
| **Name** | **TCV-4** |
| **Description** | A telemetry packet for successful command execution shall be generated by the receiving application for every telecommand properly executed. |
| **Validation Method** | Testing |

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| --- | --- |
| **Name** | **TCV-5** |
| **Description** | A telemetry packet for unsuccessful command execution shall be generated by the receiving application for every telecommand failing to execute. This telemetry packet shall indicate the reason for the failed execution of the related telecommand. |
| **Validation Method** | Testing |

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| --- | --- |
| **Name** | **TCV-6** |
| **Description** | The level of verification required in Service 1 telemetry (execution and/or acceptance) shall be controlled by each telecommand. |
| **Validation Method** | Testing |

The level of verification will be specified by the command acknowledgement field.

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| **Name** | **TCV-7** |
| **Description** | Telecommand verification packets shall indicate the first 4 Bytes of the telecommand (APID + packet sequence control). |
| **Validation Method** | Testing |

### Service 3: Housekeeping And Diagnostic Data Reporting

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| **Name** | **PERP-1** |
| **Description** | Essential and sufficient housekeeping data to characterize the current status of the spacecraft (and its payloads) and to indicate whether there is an anomalous condition that requires Ground intervention shall be generated. |
| **Validation Method** | Testing |

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| **Name** | **PERP-2** |
| **Description** | The Structure ID of the housekeeping (or diagnostic) packet shall be the first field in the packet source data after the packet data field header. |
| **Validation Method** | Testing |

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| **Name** | **PERP-3** |
| **Description** | It shall be possible to allow the definition of special diagnostic telemetry packets which support over-sampling of selected parameters for troubleshooting purposes. The onboard system shall ensure that a minimum sampling interval consistent with the measurement of the transient phenomenon will be possible for all housekeeping parameters. |
| **Validation Method** | Testing |

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| **Name** | **PERP-7** |
| **Description** | It shall be possible to specify the frequency of generation of a specified housekeeping (or diagnostic) telemetry packet via telecommand. |
| **Validation Method** | Testing |

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| **Name** | **PERP-12** |
| **Description** | It shall be possible to enable/disable by telecommand the generation of an existing housekeeping (or diagnostic) packet (and for more than one packet as part of the same command). |
| **Validation Method** | Testing |

### Service 5: Event Reporting

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| **Name** | **EVRP-1** |
| **Description** | Event based reporting shall be supported by means of dedicated report telemetry packets (progress or anomaly reports). For anomaly reports, 3 levels of criticality shall be distinguished:   * Low criticality (warning, no recovery action required) * Medium criticality (requiring Ground recovery action) * High criticality (requiring onboard action) |
| **Validation Method** | Testing |

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| **Name** | **EVRP-2** |
| **Description** | The Structure ID of the event packet (called Event ID) shall be the first field in the packet source data after the packet data field header. |
| **Validation Method** | Testing |

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| **Name** | **EVRP-3** |
| **Description** | All onboard events of operational significance, including notification of all onboard autonomous actions, shall be reported in a complete and unambiguous manner using event reports packets. |
| **Validation Method** | Testing |

Events of operational significance cover, amongst other:

* reporting of failures and/or anomalies detected onboard
* reporting of autonomous onboard actions
* reporting of normal progress of operations/activities, e.g. detection of events, which are not anomalous (such as payload events)
* reaching of predefined steps in an operation etc.

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| **Name** | **EVRP-4** |
| **Description** | Anomaly reports shall contain a unique identification of the anomaly, its time of detection and a record of the input data to the anomaly detection function. |
| **Validation Method** | Testing |

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| **Name** | **EVRP-5** |
| **Description** | Event packets data field (event parameters including Event ID) shall be limited to 40 bytes. |
| **Validation Method** | Testing |

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| **Name** | **EVRP-6** |
| **Description** | The design of the reporting mechanism shall be such to avoid excessive use of the downlink bandwidth (and of the onboard storage capacity), i.e. anomaly reports shall be generated only once per anomaly occurrence, even if the detection cycle repeats itself, nominal events shall be generated for major steps in a process. |
| **Validation Method** | Testing |

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| **Name** | **EVRP-7** |
| **Description** | The reasons for the generation of an event report packet shall be uniquely identified by APID, packet type and subtype and event ID. |
| **Validation Method** | Testing |

Parameters shall only be used to provide supporting or auxiliary information.

### Service 17: Connection Test

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| **Name** | **FTS-1** |
| **Description** | An "are you alive" function shall be provided for testing the end-to-end connection between Ground and any onboard intelligent user. |
| **Validation Method** | Testing |

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| **Name** | **FTS-2** |
| **Description** | An "are you alive" function shall be provided for testing |
| **Validation Method** | Testing |

# System Models