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TECHNICAL NOTE

Instrument Operations Definition Guidelines

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Reference	**SOL-ESC-TN-10034**
Issue/Revision	**1.0**
Date of Issue	**24/05/2016**
Status	**Issued**

European Space Agency
Agence spatiale européenne

APPROVAL

Title Instrument Operations Definition Guidelines	
Issue Number 1	**Revision Number** 0
Author SOL FCT	**Date** 24/05/2016
Approved By	**Date of Approval**
Ignacio Tanco	Digitally signed by Ignacio Tanco DN: cn=Ignacio Tanco, o=ESA, ou=HSO-OPS, email=ignacio.tanco@esa.int, c=DE Date: 2016.06.07 16:52:28 +02'00'

CHANGE LOG

Reason for change	Issue Nr.	Revision Number	Date
First Issue	1	0	June 2016

CHANGE RECORD

Issue Number 1	**Revision Number** 0		
Reason for change	**Date**	**Pages**	**Paragraph(s)**
First Issue	1	0	June 2016

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1 INTRODUCTION

1.1 Purpose and Scope

This Technical Note is aimed at the Solar Orbiter Instrument Teams, and in particular at the members in charge of the definition of Instrument Operations. It seeks to provide a clear and concise set of guidelines to help with the definition of the inputs for nominal flight procedures as required in [AD-1]. These guidelines do not apply to contingency recovery procedures.

1.2 Reference Documents

[RD-1] SOL-ESC-TN-10015, Solar Orbiter Operations Implementation Concept, Issue 1.0
[RD-2] SOL-ESC-PL-10001, Solar Orbiter FOP Preparation Plan, Issue 1.0
[RD-3] SOL-ESC-IA-50002, Science Operations Implementation Agreement, Issue 1.1
[RD-4] SOL-SGS-ICD-0003, IOR ICD, Issue 0.6
[RD-5] SOL-SGS-ICD-0007, TM corridors ICD, Issue 0.6

1.3 Applicable Documents

[AD-1] SOL.EST.RCD.0050, Solar Orbiter EID-A, Issue 5.0
[AD-2] ECSS-E-ST-40C Tailoring for Ground Segment Systems, QMS-EIMO-GUID-CKL-9500-OPS, Issue 1.0
[AD-3] ECSS-E-ST-80C Tailoring for Ground Segment Systems, QMS-EIMO-GUID-CKL-9501-OPS, Issue 1.0
[AD-4] SOL FOP Production Plan, SOC-ESC-PL-10001, Issue1,Rev.0
[AD-5] Planning Files Interface Control Document, MDS-MCS-SW-ICD-1001-OPS-GD, Issue 3.0
[AD-6] MOIS-MATIS Templates ICD, ESO-ID-RHEA-0002, Issue 1.2 Draft
[AD-7] SOL Instrument FOP Procedure Input ICD, SOL-ESC-IF-10002, Issue 2.0
[AD-8] Atrium OBCP Product Language Specification, ASG7.SRD.11208.ASTR, Issue 1.0

2 OPERATIONS BASIC PRINCIPLES

As summarized in [AD-1], and described in more detail in [RD-1], Solar Orbiter will be an ‘off-line’ mission, which means that, with the exception of LEOP and NECP operations, all telecommands required to carry out routine operations will be loaded in advance to the Spacecraft, and executed out of visibility. All telemetry generated on-board likewise will be stored on-board for later retrieval.

Evaluation of the success or failure to carry out the previously loaded operations will be performed by the Flight Control Team (FCT) as a routine off-line activity.

Instrument operation procedures will be defined by the Instrument Teams in their respective Instrument User Manuals (IUM) and coded by the FCT as part of the Flight Operations Plan (FOP) preparation. The FOPPP [RD-2] describes in detail the guidelines to be followed by the FCT in the creation of flight procedures in the ESOC system, including naming convention for both procedures and their children sequences. Instrument teams will build their operations requests using these sequence names, which the FCT will make available once they are created.

Flight procedures, both for Instrument and for Spacecraft platform operations, define a) the commanding required to perform a specific action, b) the associated telemetry checks required to evaluate its success criteria, and c) the constraints that apply to initiate the execution of the procedure. The set of telecommands defined in each flight procedure shall be extracted by the FCT into one or more Telecommand Sequences and imported into the Operational Database. Only previously validated telecommand sequences will be used for flight operations, as described in the SOIA [RD-3].

As such, <u>telecommand sequences are the smallest atomic operation that can be invoked at the level of SOC/MOC for mission planning and constraint checking</u>. It is therefore fundamental that telecommand sequences (and thus also flight procedures) are defined with the needs of mission planning in mind. It is by the combination of different low-level telecommand sequences that all complex operations can be planned and checked.

The consequence of the above is that individual telecommand sequences shall be mapped to specific planning mode transitions and constraint checks, without the need to parse the value of the parameters contained in each sequence.

Instrument teams will provide the SOC with their operations inputs in the form of IORs, essentially a container for sequence calls, which SOC then will check and convert to PORs – essentially the same, but for use by the MOC. Both IOR and POR are expected to be self-contained in terms of operations, i.e. they will start from a ‘default state’ and finish in the same or equivalent “default state”. As a consequence, for recovery a dedicated “bring instrument to default state” CRP may be needed.

Finally, Mission Planning will rely on carrying out a series of checks on the timeline of telecommand sequences proposed for execution against a set of planning rules. In case of violation of any rule, the offending sequence, and therefore the offending activity, will be taken out of the plan. The aim is to avoid replanning of system or platform conditions as a result of a planning rule violation.

Note that Mission Planning concerns by definition only routine operations. In case of instrument anomalies, the contingency recovery procedures used to recover from them are **exempt of adhering to these guidelines**.

3 GUIDELINES FOR PROCEDURE/SEQUENCE DEFINITION

3.1 General guidelines

1) **Procedures shall not contain logical branching:** As the MTL does not support conditional execution, each procedure may contain one or more telecommand sequences, but these must always be defined in a stepwise manner, without jumps or branching.
2) **Procedures shall indicate the relative timing of all telecommands,** note that the IOR ICD [RD-4] includes a description of the time jitter for telecommand execution.
3) **Procedures must define the TM checks necessary to verify telecommand execution success**. These TM checks however may not constitute conditional checks to choose the execution of the next step (see point #1 above).
4) **Use of sequence parameters shall be minimized:** Procedures, and their associated telecommand sequences, may define telecommand parameters whose value is not fixed, but rather defined at the time of invocation. The use of this facility however shall be reduced to the minimum possible, as it introduces a degree of variability which hinders constraint modelling and checking at planning level.
5) **Procedures shall not involve loops:** procedures are single operational instances which execute at discrete points in time. Multiple executions require multiple invocations, rather than defining a repeating loop.
6) **Procedures and sequences with specific, atomic goals are preferable** to generalised procedures which may achieve many variations of an operational task.
7) **Separate procedures/sequences shall be used for materially different operational tasks**, either in their execution constraints or resource usage.
8) **The overall number of sequences per procedure shall be minimised**. As a goal, a procedure should contain one sequence, although complex procedures may contain several.

3.2 Sequence split criteria

As explained above, separate telecommand sequences are needed to identify changes in mission planning items. The following list contains criteria to be used when defining telecommand sequences inside procedures, which could lead to a split of an operation into separate sequences.

A) **EMC-noise state:** Even though the EMC signature will only be characterised later, separating sequences along sensible lines will help to accommodate characterisation results.
B) **Power demand:** It is sensible to separate sequences that mark transitions in power demand levels, as well as those that go from a stable power demand to a variable one (for EMC reasons).
C) **TM production rate:** HK TM production rates are expected to be fairly stable, but any changes in TM production rates, particularly for Low-Latency TM and Science TM, are expected to be identified via dedicated sequences.
D) **Duration:** Sequences with long internal delays (i.e. more than a few minutes) shall be avoided. As an example, in the need of thermal relaxation times after a mode transition before the instrument can be used for science acquisition, the mode transition and start of science acquisition shall be specified as separate sequences.
E) **Safety constraints:** transitions in applicability of operational safety constraints (e.g. sensitivity to thruster firings) shall be identified by specific sequences.
F) **Science constraints:** Any transition in the constraints for science operations (e.g. attitude stability, EMC quietness, imagery acquisition, etc) shall be easily identified by specific sequences.

3.3 Operations Enveloping

It is not expected that the instruments generate separate sequences for every operational task with a minute impact on the level of resources. It is considered acceptable to maintain a single sequence to trigger various instrument state changes which are similar in resource usage, applicable constraints, etc, and then simply ‘envelope’ at planning level the resource/constraint modelling with the worst case of the set.

This approach avoids excessive granularity in operations definition, but it is a compromise in terms of efficiency, as the worst case (i.e. most restrictive) will be used for science planning.

3.4 Science data production and flushing

Only data written onto the Spacewire link is of interest at planning level. The use on instrument-internal science storage memory, for those instrument that have it, is considered transparent to planning, and SOC/MOC will not model it.
However, when such internal-storage instruments do release science onto the Spacewire via a commanded flush, SOC require that the volume of each of these flushes can be determined from each sequence that commands one. It is acceptable that this volume is a parameter of the sequence.
Instruments that produce Science TM straight onto Spacewire can use a limited set of sequence parameters to pass on the values of resource-affecting variables like cadence, compression rate, etc. as long as the nature of the observation is preserved (see points 4 and 6 in Sect. 3.1).
It is noted though that due to the autonomous character of some of the instrument modes and the unpredictable nature of the sun's behaviour, science TM production is hard to model accurately. Therefore, as described in the TM corridors ICD [RD-5], any modelling of science data volume as part of the planning process – thereby relying sequence calls to estimate science data production – is to be done for indicative purposes only. Ultimately the instrument teams are responsible to stay within their assigned TM corridors.