



esac

European Space Astronomy Centre
P.O. Box 78
28691 Villanueva de la Cañada
Madrid
Spain
T +34 91 8131 100
F +34 91 8131 139
www.esa.int

DOCUMENT

Solar Orbiter Instrument Operation Request Interface Control Document (IOR ICD)

Prepared by	Christopher Watson
Reference	SOL-SGS-ICD-0003
Issue	1
Revision	<u>1.3</u>
Date of Issue	<u>28/06/2021</u>
Status	Issue
Document Type	ICD

Distribution



APPROVAL

Title	
Issue 1	Revision <u>1.3</u>
Author Chris Watson	Date <u>28/06/2021</u>
Approved by	Date
SOC Development Manager	
EPD PI	
EUI PI	
MAG PI	
METIS PI	
PHI PI	
RPW PI	
SOLO-HI PI	
SPICE PI	
STIX PI	
SWA PI	

CHANGE LOG

Reason for change	Issue	Revision	Date
Minor VSTP clarifications	1	1.3	June 2021
Correct i-VSTP reservations sequence list	1	1.2	May 2021
Update for RSCW-4 dress-rehearsal (no schema change)	1	1.1	April 2021
Update in preparation for E2E-1	1	1	March 2019
First issue for signature Changes detailed in change log	1	0	March 2017
Changes detailed in change record	0	7	Jan 2017
Refined VSTP IORs Added VSTP_max TCs attribute +1 command count for each VSTP window Updated schema for VSTP_max_TC Updated timing on VSTP IOR delivery Do not represent a re-entry point Added SOC slot usage to section 7 Removed references to STP periods spanning an RSW - Baseline is now that STP periods are always a week, even within RSWs Updated Schema for ICD version Added Open issues section and “backup” LTP plans	0	6	Jan 2016
AdG comments	0	5	July 2015
Added Acronyms list AdG comments AW comments Updates to schema	0	4	July 2015
Added VSTP IORs elements and descriptions Added filenaming Inserted ICDVersion attribute (JM comment) CV (EUI) comments Observation ID replaces unique ID Typos, XML profile example clean up Added first draft of schema	0	3	July 2015
Comments from JL, IT, BS Comments from AdG	0	2	Aug 2014
First draft	0	1	July 2014



CHANGE RECORD

<u>Issue 1</u>	<u>Revision 1.3</u>		
<u>Reason for change</u>	<u>Date</u>	<u>Pages</u>	<u>Paragraph(s)</u>
<u>Successful VSTP CRR => send no revision</u>			<u>2.3. 3.9</u>
<u>Resolve minor inconsistency between the schema and the ICD text wrt VSTP_slot_count usage in VSTP IORs</u>			<u>4.1.2</u>

Table of contents:

1	INTRODUCTION.....	6
1.1	IOR context	6
1.2	Reference Documents	7
1.3	Acronyms.....	8
2	DELIVERY ASPECTS	9
2.1	Delivery mechanism.....	9
2.2	Delivery timing and time-span.....	9
2.2.1	NMP and EMP	9
2.2.2	Cruise Phase.....	10
2.3	Filename.....	10
3	SPECIAL FEATURES OF VSTP IORS.....	12
3.1	Time-span and relationship to STP.....	12
3.2	VSTP IORS are resource neutral.....	13
3.3	VSTP IORS are non-critical.....	14
3.4	VSTP allowed sequence calls will be whitelisted	14
3.5	VSTP commanding is only allowed within RSWs.....	14
3.6	Reserving the VSTP slot at STP.....	14
3.7	Declared number of commands per slot.....	15
3.8	Earliest and latest VSTP positions inside an IOR.....	15
3.9	Revision of VSTP IORS (i.e. upissue with incremented version)	16
4	DETAILED FORMAT.....	18
4.1	Command Request File Format	18
4.1.1	header.....	18
4.1.2	Header2.....	19
4.1.3	Occurrence List.....	21
4.1.4	Observation ID.....	25
4.1.5	Unique ID.....	27
4.2	Constraints on the IOR content not explicit from the structure.....	27
4.3	Command Request Response Format.....	27
5	MODELLING SEQUENCES	28
5.1	General comments on modelling sequences for resource usage.....	28
5.2	SOLO-HI use of IOR resources	28
5.2.1	SOLO-HI modelling sequences.....	28
5.3	SPICE modelling sequences	29
6	IOR GRANULARITY AND TIMELINE-REENTRY	31
6.1	IORs per STP period	31
6.2	150 TCs/day constraint in practise.....	31
6.3	Timeline Reentry.....	32
6.4	Empty IORs are prohibited.....	32
6.4.1	Remote-sensing instruments outside of the specific RS operating windows defined in the EFECS	33
6.4.2	Simple case avoiding empty IORs.....	33
6.4.3	More complex case avoiding empty IORs.....	33
7	TIME-TAGGING AND MTL LOADING.....	34
7.1	MTL-load levelling	34
7.1.1	Aside on clock drift	34
7.1.2	Leap-seconds	35
8	SCHEMA.....	37
8.1	Notes on inconsistencies wrt MOC CRF format	37
9	OPEN ISSUES	38
9.1	Handling “backup” LTP plans	38

1 INTRODUCTION

This document defines the mission planning interface between Instrument Teams and the Solar Orbiter SOC, by which the planned operations for each instrument are submitted for routine operations. The files passing across this interface are called “**Instrument Operational Requests**” or **IORs**. This commanding interface is active in Cruise Phase, NMP and EMP (i.e. after NECP).

The format of the ICD is derived from the Solar Orbiter PLID [RD-1], which is in turn a tailoring of the generic ESOC infrastructure mission planning document “Planning Files Interface Control Document” [RD-2].

This ICD is not strictly a “tailoring” of [RD-1] because formally the PI-SOC interface lies outside the scope of the PLID. However it is sensible to maintain these interface formats as common as possible. It is acknowledged that there are fields within this ICD that are redundant when viewed solely within the scope/context of the IOR. This is a consequence of maintaining consistency with the generic ICDs.

1.1 IOR context

Outside of NECP and dedicated special operations and/or contingency recoveries, the instrument operations for Solar Orbiter are integrated into a single consistent plan at SOC and then forwarded to the OGS. This occurs in Short-Term Planning (STP) cycles¹.

In these phases instrument teams plan their operations

- According to the scientific goals of the specific period, types of pointing target (for RSWs) and data quotas as decided by the SWT and as elaborated in i) the Science Activity Plan, and then ii) the SOOPs at a greater level of detail.
- According to the windows and constraints communicated in the planning skeleton file (i.e. the E-FECS), and resource allocations communicated by corresponding files.

The instrument teams submit their planned instrument commanding to the SOC in an **IOR**. For commonality reasons this interface retains the same general format as the PDOR interface with OGS, but implements a restricted subset of functionality².

At the SOC the plans are integrated together and checked for consistency and resource constraints (example: power consumption, predicted SSMM usage). Problems at this stage are resolved, normally by discussion with the Instrument Team and submission of a revised IOR.

¹ The LTP process is different, being driven more by coordination than by detailed commanding products.

² Some elements of the PDOR interface are necessarily excluded. For example all IOR commanding is directed to the MTL.

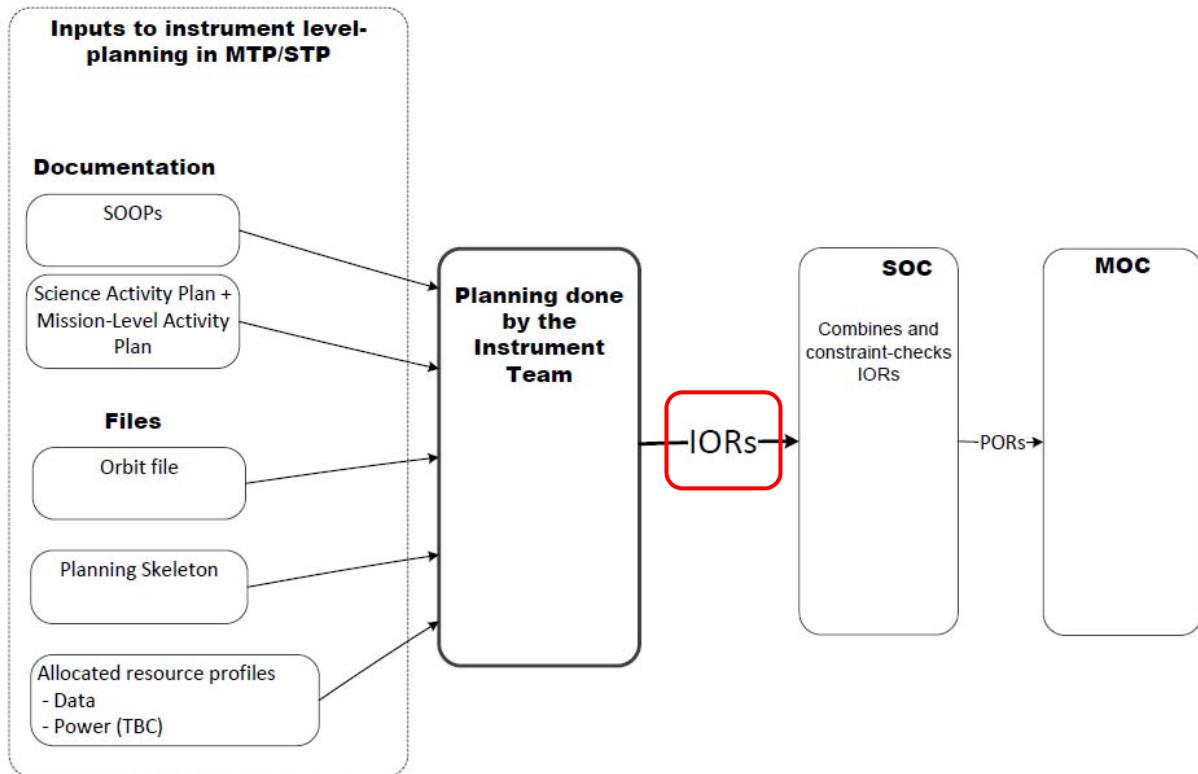


Figure 1, IOR interface in context

Within NMP and EMP phases the scope of the planning cycles the IOR is used as follows:

Planning cycle	Use of IOR
LTP	No IOR. LTP is performed without this level of detail of specific instrument commanding inputs.
STP	The STP IORs are processed into telecommands that are uploaded to the spacecraft.
VSTP	VSTP IORs are used to add commands within specific windows identified in the STP IOR. This is foreseen only for commanding where there is a tight space->ground->space loop needed.

1.2 Reference Documents

- [RD-1] “Solar Orbiter Planning Interface Control Document (PLID)”, Luca Michienzi (ESOC), SOL-ESC-IF-05010, v1_2, Sept 2017
- [RD-2] “Planning Files Interface Control Document”, Arek Kowalczyk (ESOC), MDS-MCS-SW-ICD-1001-OPS-GD, v4_4, Nov 2016



[RD-3] “Solar Orbiter SOC<->Instrument Teams File transfer ICD”, Emilio Salazar, SOL-SGS-ICD-0009, v1_1, May 2018

[RD-4] “Planning Files and Event File ICD”, MDS-MCS-SW-ICD-1001-OPS-GD, Holger Dreihahn et al., V4_4, 30 Nov 2016

1.3 Acronyms

CP	Cruise Phase
CRR	Command Request Response
E-FECS	Enhanced Flight Events and Communication Skeleton <i>Also called planning skeleton. This is a SOC-extended version of the FECS that comes from MOC which details the spacecraft events</i>
EMP	Extended Mission Phase
HK	Housekeeping telemetry
IERS	International Earth Rotation and reference system Service
IOR	Instrument Operational Request
IS	In-Situ
LLD	Low-Latency Data <i>That “thin-slice” of science data that can always be downlinked promptly to ground</i>
LTP	Long-Term Planning
MiB	“MibiBytes” <i>Non-SI unit of storage. 1 MiB = 2²⁰ = 1048576 Bytes For info: single sector of SSMM is 1 MiB, and total available SSMM volume (2 modules) is 62 GiB</i>
MIB	Mission Information Database <i>The database defining the TM TC structures, used for example by SCOS-2000 at MOC.</i>
MOC	Mission Operations Centre. <i>For Solar Orbiter this is ESOC in Darmstadt.</i>
MTL	Mission TimeLine <i>The onboard time-tagged queue from which nominal operations execute</i>
MTP	Medium-Term Planning
NMP	Nominal Mission Phase
RS	Remote Sensing
RSCW	Remote-Sensing Checkout Window <i>The checkout windows for RS-instruments in cruise phase</i>
SAP	Science Activity Plan <i>The top-level science plan of how solar orbiter will utilise the time within CP, NMP, EMP to fulfil its science goals</i>
SOC	Science Operations Centre <i>For Solar Orbiter this is ESAC near Madrid</i>
SpW	SpaceWire
SSMM	Solid State Mass Memory
STP	Short-Term Planning
TAC	Turn-Around Calibration <i>Complements LLD as prompt science link to ground. Because a “fatter slice” of science can come through this (compared to LLD) it is normally OFF, and only enabled for specific activities that need it (those where there is a mandatory tight space->ground->space loop needed), and then only when the downlink can support it.</i>
TMC	TeleMetry Corridor
TMC-M	TMC-Measured <i>TMC plus Measured data of actual write rates seen at the SSMM</i>
VSTP	Very Short Term Planning

2 DELIVERY ASPECTS

2.1 Delivery mechanism

The IORs shall be delivered to SOC via the file-transfer mechanism detailed in [RD-03]. Deliveries of **sets** of STP IORs shall be zipped together according to the instructions of [RD-03]. Delivery of VSTP IORs is single IOR at a time.

SOC will confirm the reception of each IORs with a CRR file delivered via the same file-transfer approach used for the IOR submission. The CRR file will contain the results of a set of sanity checks conducted on the submitted IORs, and will contain error messages in the case that any of the sanity checks fail. The checks may not be instantaneous, but the CRR should be provided inside of 5 minutes of IOR submission.

2.2 Delivery timing and time-span

2.2.1 NMP and EMP

STP IORs are delivered in a batch to cover a time-range of typically 1 week.

Each time-range of execution is defined in the EF ECS but typically begins on a Monday at 00:00Z and extends to the equivalent start point of the next time-range. Instrument-teams shall ensure that all commanding delivered for a given planning cycle shall lie exclusively inside the relevant time-range. This constraint applies both at the level of:

- The sequence call times contained in the IOR
- The individual command times that result once the sequences are expanded to commands

Additionally instrument-teams shall ensure

- The time-range constraints shall be met also once the sub-second time-shifting of section 7 is taken into account. Practically-speaking this can be easily achieved by ensuring that the final 1 second of the time-range is clear of all commanding.

The STP IOR files shall typically be delivered to SOC on the Tuesday 10 days prior to this Saturday. This gives time to process the IORs and iterate if necessary with Instrument Teams prior to delivery to MOC at 4 days prior. Very often it is necessary to modify this baseline timing to account for holidays, reacting to MIB deliveries, or unusual pass schedules. As such the actual deadlines associated to individual STP cycles are maintained on the SOC public confluence pages under the appropriate “STP-xxx to yyy Schedule” pages.



Within the identified VSTP-IOR supported periods, VSTP files shall be delivered to SOC at least TBC³ hours **prior to the start of the pass which completes prior to start of the reserved slot at STP⁴**. Pass times are visible in the E-FECS “planning skeleton” file.

2.2.2 Cruise Phase

In principle the Cruise Phase mission planning works in a similar way as NMP/EMP.

2.3 Filename

Previous issues of this ICD attempted to maintain commonality with the Solar Orbiter Metadata standard. However the meta data standard has not been designed with planning products in mind. Further there are legacy filenaming approaches at MOC which are different. Therefore in this issue the filenaming approach is revised.

The MTP cycle, and therefore MTP IORs, have been descoped. This is the historical reason for the apparently redundancy of STP signifiers in the IOR filename.

For the STP IORs the file-name is:

`IOR_S_S[mission-STP-number]F[IOR-number]_[instrument]_V[version].SOL`

Where

`[mission-STP-number]` is the three digit number of the STP cycle **within** the mission, starting from 1

`[IOR-number]` is the two digit number of the IOR file **within** the STP, starting from 1

`[instrument]` is the source, being a mnemonic for one of the instrument teams. Baseline mnemonics are the four character IDs (used also deeper in the XML).

SEPD	EPD
SEUI	EUI
SMAG	MAG
SMET	METIS
SPHI	PHI
SRPW	RPW
SSPI	SPICE
SSHI	SOLO-HI
SSTX	STIX
SSWA	SWA

`[version]` supports two options. The first is a one character the version of the file, starting from 1. It start from 1 again for each new instance of an IOR having different preceding fields. The second is the same except two characters starting from 01. The latter option has been introduced because in certain STP cycles we have come close to the one-character limit. The SOC system currently supports both usages in parallel, so instrument teams can migrate to the new usage in their preferred pace.

³ 36 hours TBC.

⁴ Within VSTP, the timing is tight enough that the position of the individual passes becomes important. Furthermore uplink of operations within the same pass that they are executed is excluded. Thus instrument teams are encouraged to place VSTP slots immediately following a pass, where turn-around time is critical.



Alphabetical characters may be used within the version-field to identify IORs created as part of a ground test activity.

For the VSTP IORs the filename is:

IOR_V_S[mission-STP-number]X[vstp-slot-number]_[instrument]_V[version].SOL

The [vstp-slot-number] which is two digit decimal number, nn, starting from 01 **at each new STP-cycle**, and incrementing by one with each reserved VSTP slot. The VSTP slot number is therefore a reference within each STP.

VSTP slots have to be declared or “reserved” in the content of the STP. As well as reserving a time-span free of STP commanding, this STP IOR slot declaration is also identifying the slot-number – this is required to match the slot-number in the subsequent VSTP filename that provides commands for the reserved time-range. This means that if a reserved slot is not ultimately used, then the slot numbers within the submitted VSTP IORs will not be contiguous (there will be a gap).

[version] is a fixed prefix “V” followed by a single digit decimal number, starting from 1, which increments each time a new IOR for the VSTP slot in question has to be issued. There is no link at filename-level between this and the STP IOR version. Alphabetical characters may be used within the version-field to identify IORs created as part of a ground test activity.

N.B. this field is maintained for consistency with other IOR filenames (albeit single character only). However given that the VSTP cycle occurs very late, and is not guaranteed to reach the spacecraft (e.g. non-critical commanding only) then any iteration on delivered VSTP IORs is very likely to mean that the commanding is not ready in time. Reaching a 9th version of a VSTP IOR is in practise impossible. See section 3.9 for a special constraint on VSTP versions and CRRs.

The SOC CRR files will follow the same filename strategy as IORs and IORGs, but the suffix SOL will be replaced with CRR. The IORG_*.CRR returns a zip of the CRRs in the same way that the IORG brought a zip of IORs. Inside the zip, each IOR_*.CRR responds to each IOR_*.SOL within the IORG.

There is one special-case filename that may occur inside the zip, being IDEM_IORG_*.CRR. This occurs only if the delivery is rejected at the level of the entire zip, e.g. if the zip is corrupt and cannot be opened. The IDEM prefix is introduced as a way to refer to the container name without a naming collision.



3 SPECIAL FEATURES OF VSTP IORS

3.1 Time-span and relationship to STP

In certain respects VSTP IORS are treated very differently to other IORS, as described here.

The STP delivery of IORS fully covers a short period (typically 1 week, identified by STP_BOUND events in the EFECs).

STP deliveries have IOR file granularity that respects section 6, such that

- There is an IOR boundary at each STP planning period boundary
- IOR boundaries reflect “safe restart points” in terms of planning

The VSTP IORS don't replace STP commanding, but insert additional commanding. There is no modification nor deletion of the existing STP commanding. The addition/insertion is only allowed within empty slots already identified/reserved at STP⁵. Each VSTP IOR corresponds to a specific reserved slot. The reserved slots must be free from STP commanding (a small margin either side of the reserved slot must also be free to cover the timing issues of section 7.1.1, value TBC but probably 1 second). Only (maximum) two VSTP slot reservations are allowed within any single **STP IOR file**.

VSTP usage is only supported for RSWs (and agreed precursors/RSW_EXT periods) in NMP/EMP.

⁵ In other words, besides the sequence calls of the STP IOR, these IORS also have to identify where (in time) subsequent VSTP commanding will/may be inserted. These identified periods are the “empty slots”.

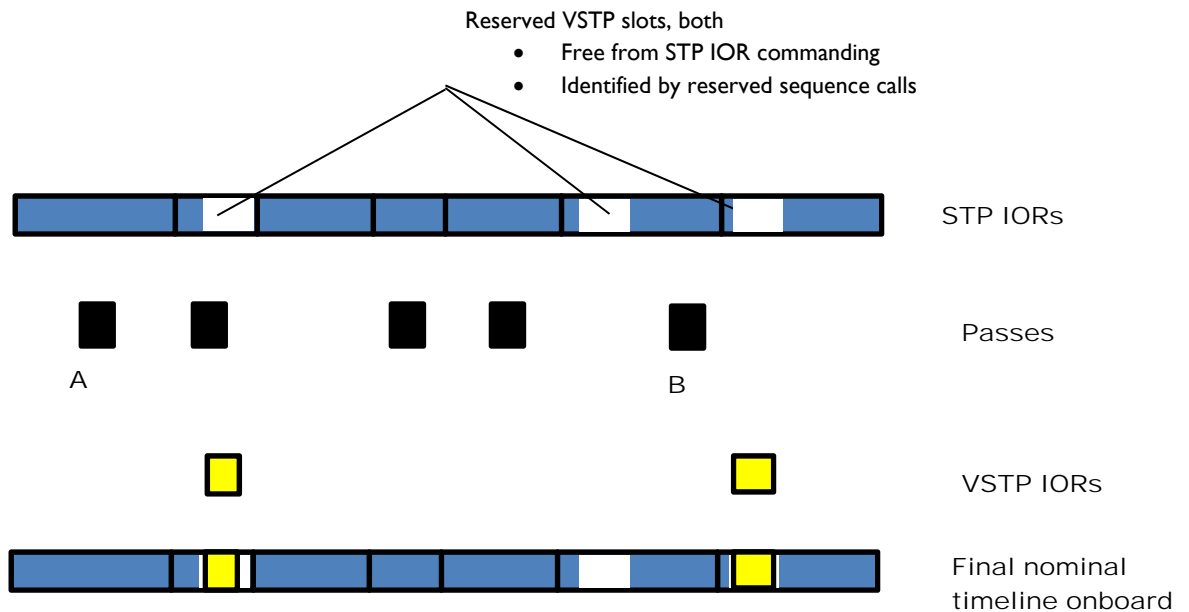


Figure 2, VSTP IOR relationship to STP IOR

It is not mandatory that a reserved slot is actually used. Also the VSTP commanding does not need to **fill** the reserved time, as long as all its commanding lies inside the range.

In section 2 the timing of VSTP deliveries was discussed. Because of the tight timing of the VSTP cycle, the timing of passes has to be taken account when determining delivery deadlines. Furthermore it is not allowed to assume that a VSTP IOR can be uploaded inside the same pass within which it also executes (if indeed it executes during a pass). Thus in the diagram above the first and third VSTP IORs shown, would nominally be uploaded in the passes A and B respectively. Instruments wanting to minimise the turn-around time of VSTP IORs are therefore recommended to schedule their VSTP slots shortly after a pass.

3.2 VSTP IORs are resource neutral

The VSTP cycle is too short to allow resource checking on the incoming VSTP IORs. Therefore the VSTP IORs are required to be resource-neutral commanding only. Resource neutral includes:

- No changes to power consumption profiles wrt previous planning cycles
- No changes to EMC-noisy activities wrt previous planning cycles
- No changes to data production wrt to the prediction derived from the previous cycles

In order to ensure that VSTP is only used for resource neutral activities, the SOC will (in discussion with the instrument teams) write and maintain a document detailing the identified and agreed sequences that are allowed be called within VSTP. This list is expected to be restricted to those sequences bound to tight-loop calibration updates (i.e. small subset of

overall instrument sequences). The planning software will only forward to MOC VSTP IORs consistent with this list.

3.3 VSTP IORs are non-critical

There must be no criticality if the commanding is not sent. Because of the tight-loop of VSTP commanding the forwarding schedule and uplink to the spacecraft is success-orientated, and could easily fail in the event of e.g. station failure. VSTP commanding is therefore best-effort, and not guaranteed. It is unsuitable for e.g. safety related activities.

3.4 VSTP allowed sequence calls will be whitelisted

In order to allow to enforce the previous points, each instrument will establish in discussion with SOC and MOC a whitelist of instrument sequences that meet the resource-neutral and non-critical criteria and that **are** foreseen to be used for i-VSTP.

3.5 VSTP commanding is only allowed within RSWs

Both remote sensing and in-situ instruments may make use of the VSTP capability, but only within RSWs.

3.6 Reserving the VSTP slot at STP

Each slot is reserved by inserting two special sequence calls in the STP IOR. One sequence call identifies the start of a reservation and the second identifies the end of a reservation.

Sequence name	Purpose
<i>“Starting the reservation” calls</i>	
ADMF740A	SPICE VSTP reservation start
ADMF740C	SWA VSTP reservation start
ADMF740E	EUI VSTP reservation start
ADMF740G	PHI VSTP reservation start
ADMF740I	MAG VSTP reservation start
ADMF740K	RPW VSTP reservation start
ADMF740M	EPD VSTP reservation start
ADMF740P	SOLO-HI VSTP reservation start
ADMF740R	STIX VSTP reservation start
ADMF740T	METIS VSTP reservation start
<i>“Ending the reservation” calls</i>	
ADMF740B	SPICE VSTP reservation end
ADMF740D	SWA VSTP reservation end
ADMF740F	EUI VSTP reservation end
ADMF740H	PHI VSTP reservation end
ADMF740J	MAG VSTP reservation end
ADMF740L	RPW VSTP reservation end

ADMF740N	EPD VSTP reservation end
ADMF740Q	SOLO-HI VSTP reservation end
ADMF740S	STIX VSTP reservation end
ADMF740U	METIS VSTP reservation end

Table 1, list of reserved sequence calls for VSTP reservation

These sequences are defined by MOC but are configured such that the relevant instrument team is allowed to call them. They will contain no formal parameters. All normal rules concerning sequence calls apply to these calls as well.

Each of these calls contributes one TC to the allowed 150 per day.

The one special feature is that the first sequence carries additional meta data (as XML attributes) describing the reservation.

3.7 Declared number of commands per slot

Instruments have an EID-A requirement to respect 150 TCs/ day.

When a VSTP slot is declared in the IOR at STP, the syntax includes a maximum number of TCs that will/can be inserted later.

- This allows SOC to check that the sum of normal and VSTP commanding still meets this constraint.

Additionally each VSTP slot reservation adds two implicit commands as described above.

Later any VSTP IORs delivered will be checked that they do not exceed the VSTP_max_TC parameter declared at STP.

3.8 Earliest and latest VSTP positions inside an IOR

VSTP windows must be fully contained inside the STP IOR in which they occur. I.e. they cannot span a normal IOR boundary.

The reservation calls occupy a second each, so the window really available for VSTP execution times starts one second later and ends one second earlier than the corresponding reservation calls. This window defines both the limit of execution times that can come in the subsequent VSTP IOR and the metadata values that shall be attached to the first call. As shown in Figure 3 the reservation start call can occur **at** the start of the validity range, but the must occur 1 second (or more) before the end of the validity range. This makes rules for the reservation call placement with the rules for “normal” telecommands.

This limit of execution times applies to the child **telecommands** that will be expanded from the VSTP sequences, not simply the parent sequence execution times.

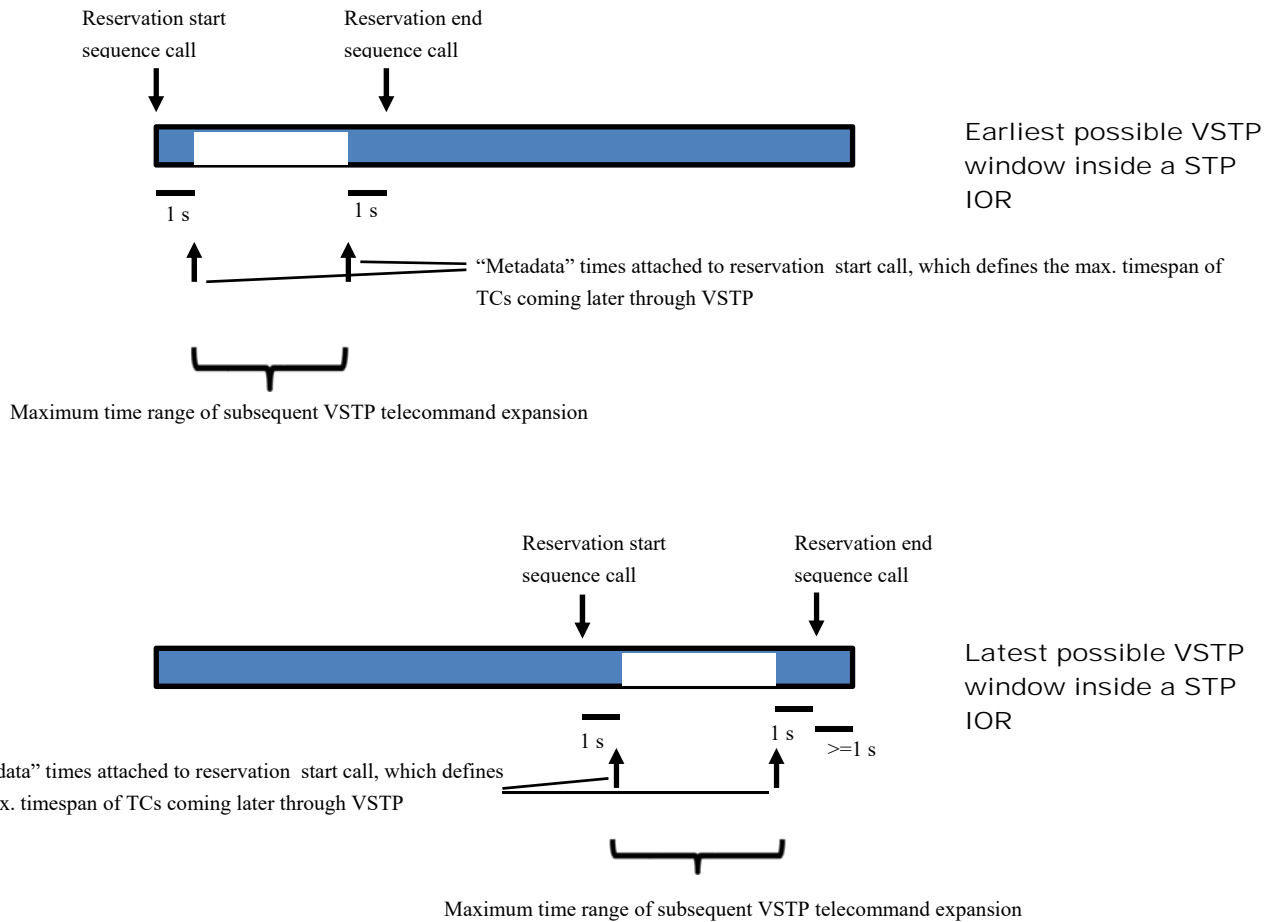


Figure 3, Positioning of VSTP window inside an STP IOR

Only two VSTP reservations are allowed within a given IOR.

3.9 Revision of VSTP IORs (i.e. upissue with incremented version)

VSTP IORs are subject to a special constraint wrt CRRs and sending of revised content.

Related to the tight turn-around for VSTP, MOC systems can not accept upissued instrument VSTP commanding products. This means that if an error is found in a VSTP IOR at SOC then it may be possible to revise the IOR to fix the problem⁶, but if no problem is detected at SOC then it is no longer possible to revise the IOR (because it will have been automatically processed and forwarded to MOC).

⁶ SOC is not a 24/7 environment so, depending on timing, it may be that there is no human support to this fixing.



As such, a successful SOC CRR response (one with no errors) to a VSTP IOR shall be understood as “send no further revision” message.

4 DETAILED FORMAT

Each IOR file is an XML file with structure as defined in the following subsections.

Within the tables the following abbreviations are used:

E/A Element/Attribute

Need

M Mandatory

O Optional

Q Qualified, the need for the field depends on other elements, as described

4.1 Command Request File Format

Top level elements are <planningData>, which contains child <commandRequests>, which in turn contains children <header> and <occurrenceList> as described below.

4.1.1 header

The <header> element contains

Field	E/A	Type	Description	Need
type	A	string	Enumerates the filetype. For IORs this shall be set to “ IOR ” ⁷	M
formatVersion	A	integer	“1”	M
genTime	E	string	File generation time in format YYYY-DDDThh:mm:ssZ <i>Subseconds are not supported in the IOR</i>	M
validityRange	E	complex	See below	M

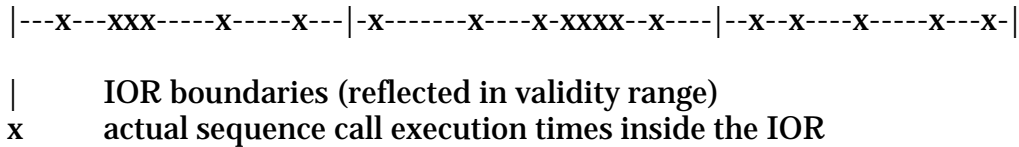
The validity range complex element contains the following:

Field	E/A	Type	Description	Need
startTime	E	string	YYYY-DDDThh:mm:ssZ <i>Subseconds are not supported in the IOR</i>	M
stopTime	E	string	YYYY-DDDThh:mm:ssZ <i>Subseconds are not supported in the IOR</i>	M
type	A	string	Type in which time is specified, value fixed to “absoluteTime”.	M

⁷ N.b. this is not an allowed enumeration within the [PLID]. As mentioned before the IOR ICD is not strictly a tailoring of the PLID.



The validity range identifies the period of time that the IOR file covers. In other words it defines the IOR file boundaries. This is not the same thing as execution times of the individual sequence calls within. See ASCII diagram below representing STP IORs.



The end of one STP validity period to be contiguous with the start of the next (except for periods e.g. outside of RSWs where RS-instruments are not actively operating). There shall be IOR boundaries that align with the once-weekly STP_BOUND event, and with the start/end of each ~six month LTP planning period. Other IOR boundaries are up to the instrument teams to set. All IOR boundaries identify “safe restart points”, see section 6.

See also section 6.4 for a prohibition against empty IORs.

For VSTP IORs, the validity range shall match the starttime, endtime of the iVSTP element making the reservation in the corresponding STP IOR.

Sequence call timing shall be such that the subsequent expansion to child telecommands remains inside the validity range. In other words one cannot call a sequence that lasts one minute, less than sixty seconds from an IOR boundary.

4.1.2 Header2

The <header2> element does not exist in the legacy CRF format. Its purpose is to group all non-standard/non-legacy header data in a single place. This includes items from the filename, which are duplicated explicitly as metadata in this header, and have the same meaning as detailed in section 2.3.

The <header2> element contains:

Field	E / A	Type	Description	Need
ICDVersion	A	string	This field allows direct comparison of the version of this ICD that the XML (or indeed the schema) is created against “v0_8” ⁸	M
VSTP_slot_count	A	integer	A count of the number of VSTP slot reservations embedded in the IOR file.	<u>M in STP</u> <u>O in VSTP</u>

⁸ This is an added attribute for the IOR, not present in the generic CRF definition. At the current time the schema enforces this value by making the attribute both “required” and “fixed”

			This is meaningful only in STP IORs. In VSTP IORs it <u>can be absent; if not absent it shall be set to zero; in any case it is not used.</u>	
planningCycle	A	string	“S” or “V” as from IOR filename	M
missionSTP	A	integer	of form xxx As from IOR filename	M
IORorSlotNumberInSTP	A	integer	If planningCycle is “S” then this field is the number of the S IOR inside of the STP. Otherwise (VSTP) it is the number of the reserved VSTP slot inside the STP. of form xx as from IOR filename.	M
instrument	A	string	SEPD EPD SEUI EUI SMAG MAG SMET METIS SPHI PHI SRPW RPW SSPI SPICE SSHI SOLO-HI SSTX STIX SSWA SWA as from IOR filename.	M
IORVersion	A	string	One character [version] as from IOR filename. (Note that the V prefix of the filename is omitted)	M
MIBVersion	A	string	Full line content of vdf.dat file, five fields plus tab separators	M
TMCVersion	A	string	Two character [version] alphanumeric from the applicable TMC filename.	M
EFECSTVersion	A	string	Two character [version] alphanumeric from the applicable EFECST filename.	M

Note that currently the “instrument” metadata from the filename is included here, even though it can be redundant with the “source” of later sequence calls. This is to cover a possible use of IORs where in-situ instruments with very low commanding rates might submit IOR files without a single sequence call.

4.1.3 Occurrence List

Within the IOR the standard occurrence is a sequence call. The sequences called are defined in the instrument MIB.

Also within the occurrence list it is possible to include VSTP slot windows.

First an <occurrenceList> is defined.

Content of <occurrenceList>:

Field	E / A	Type	Description	Need
count	A	integer	A count of the number of sequence calls contained in the occurrence list	M
creationTime	A	string	The creation time of the occurrence list in absolute time format YYYY-DDDThh:mm:ssZ	M
author	A	string	Used to identify the user that created the IOR. For the internal use of the instrument-team.	M
sequence	E	complex	Sequence calls	O

And each sequence-call <sequence> occurrence contains the following:

Field	E / A	Type	Description	Need
name	A	string	The name of the sequence. This must match exactly the 8 character CSF_NAME of the sequence in the MIB	M
observationID	E	string	LTP observation ID (See section 4.1.4 ⁹)	M
uniqueID	E	string	MOC unique ID (see section 4.1.5)	M
source	E	string	Indicates the Instrument Team “SEPD” EPD “SEUI” EUI “SMAG” MAG “SMET” METIS “SPHI” PHI “SRPW” RPW “SSPI” SPICE “SSHI” SOLO-HI “SSTX” STIX	M

⁹ To be noted that this ID reference is not available onboard (it is not part of the CCSDS TC structure that is uplinked).

			“SSWA” SWA	
destination	E	string	“R” meaning routine	M
executionTime	E	complex	See below	M
parameterList	E	complex	See below. Mandatory if the sequence call requires parameters.	Q

For the case in STP where the sequence <name> is the special sequence for the start of a VSTP reservation the following child element must be added to the <sequence>.

Field	E / A	Type	Description	Need
iVSTP	E	simple	A container for metadata associated to a VSTP reservation	Q Use only if the parent <name> is the special sequence for start of a VSTP reservation

Where <iVSTP> is present, it contains the following attributes:

Field	E / A	Type	Description	Need
starttime	A	string	in absolute time format YYYY-DDDThh:mm:ssZ This is the earliest execution time that the subsequent VSTP IOR will be allowed to use. There must be at least one second margin between this time and the execution time of the reservation start call	M
endtime	A	string	in absolute time format YYYY-DDDThh:mm:ssZ This is the latest execution time that the telecommand expansion of the subsequent VSTP IOR will be allowed to use. There must be at least one second margin between this time and the execution time of the reservation end call.	M
VSTP_max_TCs	A	Integer	Defines the maximum number of telecommands that will be inserted within the slot, via VSTP commanding. This allows to check	M

			the 150 TCs/day constraint prior to the delivery of VSTP IORs ¹⁰ .	
slotInSTP	A	Integer	Is the positional count of the VSTP slot in the STP. This is used to link to the latter VSTP IOR that will (may) arrive to fill this slot. The value here has to correspond to the [vstp-slot-number] component of the later VSTP IOR filename	

VSTP slot windows can only be present in STP IORs. They reserve a slot for later use in VSTP. The time range indicated by the slot must be free of other IOR called commanding.

The <executionTime> complex element is composed of the following:

Field	E / A	Type	Description	Need
actionTime	E	string	Absolute time at which the sequence is requested to be begun onboard. YYYY-DDDThh:mm:ssZ <i>Subseconds are not supported in the IOR</i> <i>See also section 7</i>	M

The <parameterList> complex element is composed of the following:

Field	E / A	Type	Description	Need
count	A	integer	A count of the number of parameters to be specified for the sequence call.	M
parameter	E	Complex	One element for each formal parameter of the sequence in question. These shall be ordered in the same order as the formal	M

¹⁰ I.e. the allowed number of normal (non VSTP) commands per day allowed will be reduced from 150, by the sum of all <VSTP_max_TCs> parameters within that day. The number of normal commands implied by the IOR will be determined by using MIB information for the number of TCs present within each sequence call.

			parameters of this sequence in the MIB (i.e. according to the CSP_FPNUM ¹¹¹²)	
--	--	--	---	--

The <parameter> complex element is composed of the following:

Field	E / A	Type	Description	Need
name	A	string	This field must exactly match the MIB CSP_FPNAME	M
position	A	integer	Defines the position of the formal parameter within the called sequence. Since formal parameters are already required to be ordered (above) the position values of (formal) parameters inside a given sequence call always follow the natural number sequence 1, 2, 3, The position removes any ambiguity in case a given sequence has multiple instances of a given parameter. The first parameter shall have position 1.	M
unit	A	string	For engineering parameters: if the unit is given in the MIB database then the same unit must be specified here, and if the unit is not present in the database then it must also be absent from the IOR file. n.b. MIB restrictions limit the unit to no more than 4 characters	Q
value	E	complex	Defines the value of the formal parameter. This field is made mandatory for Solar Orbiter ¹³ . The format to be used to specify the parameter value shall comply with the	M

¹¹ The official definition of the formal parameter ordering inside sequences comes from the instrument procedures embedded in the MOC Flight Operations Plan (FOP), and equivalently in the corresponding system MIB created at MOC (if distributed). In terms of the system MIB, the position reflects the CSP_FPNUM. Typically this ordering simply reflects the order in which the formal parameters appear in the procedure/sequence.

¹² Other CRF-based interfaces that are not IORs (e.g. PDORs) may allow access to both sequences and **telecommands** as occurrences. Here, in the case of direct telecommand parameter access (rather than via sequence formal parameter access as in the IOR) the position instead reflects the order of the parameters inside the TC structure (i.e. ordered according to MIB CDF_BIT value).

¹³ [RD-2] permits that this field be left blank, if the MIB defines a default value associated to the sequence/command parameter, with which to populate the value. This approach is considered unhelpful in that it leads to IORs that are not fully-explicit, therefore the option to refer to MIB defaults is removed for Solar Orbiter.

			parameter type for raw values, and with the calibration type for engineering values. See below for associated attributes	
description	E	string	Comment field	O

Attributes of the <value> complex element are:

representation	A	string	This field specifies whether the value is supplied in the native format of the parameter, or in a calibrated form. <ul style="list-style-type: none"> “Raw”: The value is supplied in uncalibrated form, i.e. no decalibration is needed to encode the parameter into the uplink. N.b. Raw parameters are not necessarily unsigned int. It depends on native format of the parameter defined via the MIB CPC_PTC and CPC_PFC. “Engineering”. The value is supplied in a calibrated form, which assumes decalibration prior to encoding on the uplink. Depending on the type of parameter calibration (e.g. textual or numeric) the engineering value can be different formats. 	Q
radix	A	string	The radix must be specified for all Raw parameters. It must be omitted for all engineering parameters. For unsigned integer raw parameters it can take one of the following <ul style="list-style-type: none"> “Decimal” “Hexadecimal” “Octal” For all other raw parameter types it must be “Decimal”	Q

4.1.4 Observation ID

The following rules shall be followed for the definition of the Observation ID.

- Each observation ID shall be limited to 26 characters



- The first 4 characters shall identify the source (same as for the subsequent field¹⁴)
- In cases where multiple Observation IDs apply, they are separated within the string by a semicolon (;)

The SOC proposal for this field is that the ID reflects the “Observation ID” assigned at LTP. I.e. The SOOP planning performed at LTP will identify periods of operation linked to science goals. These periods will be assigned IDs. The instrument teams would ensure that their IOR sequence calls relating to each SOOP would contain the appropriate ID¹⁵.

The ObservationID is typically assigned by the software that supports LTP (SOOP Kitchen). The format for the ObservationID is

AAAA_PPvV_SSS_III_OOOO_JJJ

where the components of this string are:

AAAA: 4-character instrument ID (Section 2.3)

PPvV: 4-character string indicating the LTP plan ID; this refers to the Long-Term Planning period in question (e.g. LTP 12). An example would be “120A”.

SSS: 3-digit alphanumeric SOOP Type code: this represents the SOOP archetype, and is uniquely mapped to it. *E.g.*, IDF might always refer to “I_DEFAULT” **.

III: 3-digit (base-58) SOOP Instance, an enumerator of the occurrence of this SOOP Type within the scope of this planning period. It is not necessarily enumerated chronologically within the plan.

OOOO: 4-character (base-58) Observation Type, with scope per instrument. This is uniquely mapped to each instrument’s observation (*e.g.*, SPICE’s SPICE_MOVIE30 mode is always mapped to “Upq4”).

JJJ: 3-digit (base-58) Observation Instance, an enumeration of the occurrence of this observation, with scope per planning period. Again, this is not necessarily enumerated chronologically.

The source of this information is the Long-Term Planning process whose output is distributed to the instrument teams by GFTS. The format for the machine-readable JSON output describing each instrument’s plan, including the ObservationID for each observation, is documented in [TBW].

There may be cases in which the instrument team needs to insert an observation which is linked to a SOOP, but was not originally foreseen at LTP. In this case, the LTP software will not already have defined an ObservationID. However, an appropriate ID can be reconstructed, respecting the same SOOP-Type and Observation-Type codes, and assigning a base-58 number for JJJ such that the first character is “z”: *i.e.*, “z11” for the first unforeseen instance of each observation type within that SOOP, *etc.*

¹⁴ This redundancy of source information is necessary to allow the planning system to search on a single field.

¹⁵ Exact form of the SOOP ID is TBC. Potentially some parts of the field may remain free for instrument-team usage.



The concept for this ID is that it identifies a self-contained scientific “observation” or meaningful macro-level unit of science acquisition¹⁶. It is accepted that this definition is vague and the details of how an ID spans operations will vary instrument to instrument. Often it will be that a group of consecutive sequences share the same ID because they work together to achieve a particular operation.

As alluded to above, an observation may be related to more than one SOOP. In such cases, the ObservationID will contain multiple 26-character substrings, delimited by a semicolon.

4.1.5 Unique ID

The Unique ID is a 20 character string which is unique to each called sequence instance. The first four characters follow the [instrument] mnemonic of the Header2, and the other 16 characters are free providing they guarantee uniqueness.

The Unique ID appears in the XML-format of the Telecommand History data provided by MOC. This provides one means for instrument teams to find the commanding status (once the commands have been dispatched to the Spacecraft)¹⁷. Note that the unique IDs are not uplinked and are therefore not available onboard¹⁸.

4.2 Constraints on the IOR content not explicit from the structure

Sequence calls are required to be ordered in time-order within the IOR.

No new sequence call can be made before all child commands of the previous call have completed. This is checked within SOC mission-planning based on known duration of sequences.

4.3 Command Request Response Format

The format of the SOC command request response is close to the CRR format used by MOC. Differences are:

- formatVersion is omitted
- databaseVersion is made optional
- line is made optional (some errors we generate don't correspond to a particular line number).

There is a schema for the SOC CRR attached to this document in SOC-Public Confluence.

¹⁶ I.e. not necessarily, or not usually, unique per sequence.

¹⁷ Of course for the Solar Orbiter mission only very minor time-shifting of IOR timings occur within the planning stream so equally the executionTime provides a key to search for specific operations

¹⁸ Although nothing stops command parameters communicating an “observation ID” to the instrument to use onboard. Instruments that have foreseen functionality like this may find it useful to match the IOR unique ID to their onboard ID.

5 MODELLING SEQUENCES

Modelling sequences are sequences present in certain instruments' IORs that are not sequences recognisable to MOC but have some special purpose.

5.1 General comments on modelling sequences for resource usage

In common with ESA planetary mission planning approach, spacecraft resource usage will be checked at MOC/SOC. These resources include

- Data production onto Spacewire
- Power
- EMC quietness

For Solar Orbiter, the baseline approach is to perform these checks by processing the IORs submitted by the instrument teams, using a SOC model of the instrument behaviour derived from IUMs and discussion.

For certain instruments this parsing of the IOR to deduce approximate resources may be impossible. Therefore, on a **case-by-case basis**, and in agreement with MOC and SOC, instruments may be permitted to submit their own resource estimate(s), as a substitute for the independently computed resource estimate, as a component of the IOR. Where such is agreed it is recorded below.

5.2 SOLO-HI use of IOR resources

SOLO-HI operations run from a schedule within the instrument, elements of the schedule being loaded as an instrument-level file transfer. This creates two problems

- resource usage implicit in the IOR is completely opaque
- the MTL execution times are not directly connected to the resource usage times, being the time the schedule file is transferred to the instrument across Spacewire, not the time that the schedule will execute.

Therefore it is agreed to support SOLO-HI resource definitions as follows:

5.2.1 SOLO-HI modelling sequences

SOLO-HI will insert calls to a “fake” (or “modelling”) sequence, invented to carry resource information as parameters. The sequence shall be called at the start of each IOR, and at each point in time when **any** of the resources change. Resources are

- Worst-case 5-min-average power
- HK rate
- Low-latency rate
- Bulk science rate
- EMC status

These “modelling sequences” are interleaved amongst the genuine sequences achieving the file load to SOLO-HI. However the timing of the modelling sequences reflects the actual timing of the resource changes and is therefore not directly linked to the adjacent file load content. It is

SOLO-HI responsibility to ensure that IORs are delivered with correct modelling sequences, even when e.g. resource changes arise from content-changes within different IOR files.

These modelling sequences will be interpreted by SOC and

- Used internally for SOC modelling
- Converted to ESOC “resource profiles” for subsequently inclusion in the PORs transferred from SOC->MOC. (The modelling sequences themselves are removed from the PORs).

Note that exceptionally modelling sequences **are** allowed to overlap with, and occupy identical UTC second slots with MIB sequences. Also modelling sequences do not count towards the 150 commands per day (not contributing commands).

Example:

```
<occurrenceList count="9" creationTime="2016-280T12:00:00Z" author="Anik De Groof" vstp_slot_count="0">
  <sequence name="HI_RESRC"> <!--Fake sequence 'SoloHI resources with parameters'-->
    <observationID>SSHI00000000001</observationID>
    <insertOrDeleteFlag>Insert</insertOrDeleteFlag>
    <source>SSHI</source>
    <destination>R</destination>
    <executionTime>
      <actionTime>2022-001T00:00:00Z</actionTime>
    </executionTime>
    <parameterList count="5">
      <parameter name="SHI_PWR" position="1" unit="W">
        <value representation="Engineering">9</value>
        <description>SoloHI worst-case 5-min-avg power</description>
      </parameter>
      <parameter name="SHI_HK" position="2" unit="b/s">
        <value representation="Engineering">0</value>
        <description>SoloHI HK datarate</description>
      </parameter>
      <parameter name="SHI_LL" position="3" unit="b/s">
        <value representation="Engineering">0</value>
        <description>SoloHI LL datarate</description>
      </parameter>
      <parameter name="SHI_SCI" position="4" unit="b/s">
        <value representation="Engineering">0</value>
        <description>SoloHI Science datarate</description>
      </parameter>
      <parameter name="SHI EMC" position="5" >
        <value representation="Engineering">1</value>
        <description>SoloHI EMC Noise Level</description>
      </parameter>
    </parameterList>
  </sequence>
```

5.3 SPICE modelling sequences

SPICE has four modelling sequences defined to request that the SPICE CE decontamination heater provided by the spacecraft is turned ON or OFF. Conversion of these requests to real sequence calls occurs at SOC and is expected to come online during LTP-04.

The modelling sequences are:

- SCEDH_ON to request the Spice nominal CE Decontamination Heater ON
- SCEDHOFF to request the Spice nominal CE Decontamination Heater OFF



- SOUDH_ON to request the Spice nominal OU Decontamination Heater ON
- SOUDHOFF to request the Spice nominal OU Decontamination Heater OFF

CE example:

```

<occurrenceList count="2" creationTime="2021-082T22:00:00Z"
author="DaveAtSOC">

  <sequence name="SCEDHOFF">
    <!--SPICE Switch off nominal CE decontamination heater -->
    <observationID>SSPI_031A_000_000_LZHg_113</observationID>
    <uniqueID>SSPIIORS000000005809</uniqueID>
    <source>SSPI</source>
    <destination>R</destination>
    <executionTime>
      <actionTime>2022-007T01:00:01Z</actionTime>
    </executionTime>
    <parameterList count="0"/>
  </sequence>

  <sequence name="SCEDH_ON">
    <!--SPICE Switch on nominal CE decontamination heater -->
    <observationID>SSPI_031A_000_000_HPFr_111</observationID>
    <uniqueID>SSPIIORS000000005926</uniqueID>
    <source>SSPI</source>
    <destination>R</destination>
    <executionTime>
      <actionTime>2022-007T02:00:00Z</actionTime>
    </executionTime>
    <parameterList count="0"/>
  </sequence>

</occurrenceList>

```

6 IOR GRANULARITY AND TIMELINE-REENTRY

6.1 IORs per STP period

The minimum allowed number of separate IOR files per STP, within an active period is one (noting the prohibition of empty IORs, and the recommendation wrt re-entry points, both below).

The maximum number of separate IOR files per STP is fourteen, corresponding to an average of two IORs per day.

6.2 150 TCs/day constraint in practise

The EID-A establishes a limit of 150 TCs/day from ground/MTL¹⁹. A part of this constraint arises from how full the MTL can be at any time. The MTL will be “topped up” in units of entire IORs. Thus, the 150 TCs/day constraint has to be interpreted as the maximum number of commands per IOR.

Then because the constraint isn’t solely MTL-fill-driven, and to avoid encouraging unhelpful workarounds²⁰, we have to retain the constraint in its original form as well.

Therefore we have two parallel constraints that apply to IOR command numbers:

A. No more than 150 TCs per IOR

B. No more than 150 TCs per day per instrument

E.g. **if** one chooses the maximum allowed granule-size of an IOR, spanning from one STP boundary to the next (7 days) then the restriction is **150 TCs per seven days**. Or in other words, only the simple form in the EID-A (second bullet) applies **providing** the IOR granularity is daily.

For the practical implementation of check B, the period of one day is taken to be midnight-to-midnight in UTC.

In both cases the 150 includes TCs arising from reserved i-VSTP slots (section 3.6).

For check A this is simple to include because the entire slot is required to reside inside a single IOR, so there is no ambiguity about which IOR the iVSTP TCs count towards.

For check B there can be an ambiguity if the slot spans a midnight. We adopt the convention that all iVSTP TCs are counted at the instant of the “starttime” metadata of the reservation (i.e. all TCs are counted at the earliest time in the slot that the first iVSTP command could later occur).

SOC will determine no. of TCs arising from each sequence call in the IOR by consulting the applicable MIB sequence tables.

¹⁹ I.e. does not include service-20 TCs for inter-instrument communication, nor TCs operating in an automatic way (e.g. event-action) that bypass the MTL.

²⁰ Like creating multiple fine-granularity IORs solely for the purpose of exceeding 150 TCs/day

6.3 Timeline Reentry

During a contingency condition on an instrument, commands to the instrument may be lost. Some instruments will have complex commanding in the MTL, where current commands assume the successful execution of preceding commands. In these cases the point of re-entry into the running MTL for an instrument that was in contingency cannot be performed arbitrarily, and has to be done at a suitable point.

- i. For instruments requiring control of the re-entry into MTL, the granularity of the IOR shall be used to convey this information. I.e. the start of a new individual IOR file is used to indicate a usable re-entry point. It is recommended that **at least** one such point occurs each day of nominal operations to reduce delays in restarting an instrument's science operations. Where this approach is used, the first IOR file of a planning period must also be a legitimate re-entry point. This is the one-point in each STP planning period where the positioning of a re-entry point is time-constrained. The link between IOR granularity and timeline re-entry applies only to STP IORs. In other words the positioning of the VSTP IOR windows have no meaning wrt to timeline re-entry.
 - a. In the past it was proposed that each individual IOR would also be fully self-consistent, meaning it would contain zero reliance on commands from a previous IOR and that post-contingency re-entry into the MTL could be done at MOC without any understanding of the forthcoming operations and required instrument state. This constraint can now be relaxed for those instruments where it was problematic, BUT with the caveat that those instruments will now be expected to support MOC in understanding the "bridging" commanding needed to come from the normal recovery state into the expected
 - i. This support may have consequences for the on-call availability of instrument team staff, or conversely instrument recovery may be delayed if the team is unavailable
 - ii. It may be necessary for the instrument team to provide bridging commanding directly to MOC in the form of a PDOR (see MOC documentation)
 - ii. For instruments that don't require any control of the re-entry into the MTL, a granularity of one individual IOR file every 24 hours is proposed.

It is assumed that instruments will make clear in their User Manuals (and specifically their contingency recovery procedures) whether their re-entry into the MTL needs to be controlled in this way or not.

6.4 Empty IORs are prohibited

It is not allowed to send an IOR that contains no sequence calls (an "empty IOR").

6.4.1 Remote-sensing instruments outside of the specific RS operating windows defined in the EF ECS

Remote-sensing instruments are not allowed to command outside of those periods specifically identified as RS operating periods in the LTP and recorded via the EF ECS keywords. Those RS operating periods being defined by:

- Time from an RSW_START to an RSW_END, and
- Time within the appropriate RSW_EXT_[name] window

Outside of these periods no RS-instrument IORs are sent.

Early warning of potential change:

Because of the RS synoptic campaigns aka SPROUTs etc. it could be that this constraint is abandoned in future (but not expected before LTP-5 at the earliest). In this case, both the RSW and RSW_EXT_[name] windows would still be retained because it is expected that the character of RSWs will remain distinct from synoptic periods, and that certain restrictions would continue to apply. For example more stringent rules wrt the EMC windows could apply during synoptics. Also that iVSTP will only be supported in RSWs.

6.4.2 Simple case avoiding empty IORs

Recall that, apart from the STP boundaries, instrument teams control where they place IOR boundaries. Thus in most cases empty IORs can be avoided just by expanding the validity periods of the non-empty IORs.

For example if an instrument chooses to typically break the IORs every 24 hours, with seven IORs in a typical STP, and if one particular 24 hour period would contain no sequence calls, then we expect that the instrument team will change one of the IORs to cover 48 hours instead and deliver instead six IORs in this STP.

6.4.3 More complex case avoiding empty IORs

Since the STP boundaries are fixed, there can be cases that cannot be covered by the preceding approach. E.g.

- If an IS instrument doesn't call any sequences for a whole STP period
- If there is an unfortunate collision of STP boundaries, RSW periods and desired RS-instrument non-commanding

In these cases we expect no IOR to be sent, and we accept that the validity periods of the surrounding IORs that *are* sent are not contiguous over the problematic period. At SOC we would expect to be informed to about particular no-IOR occurrences via some informal mechanism outside of this ICD.

7 TIME-TAGGING AND MTL LOADING

7.1 MTL-load levelling

The spacecraft MTL has a limit on the number of TCs that can exist within a single execution slot in the MTL²¹. In order to avoid that any MTL overload situation can occur in-flight, the following approach is adopted.

- The sequences calls shall be time-tagged only in whole seconds
- The sequences called in the IORs contain command delta-times in the database only in whole number of seconds²²
- The SOC shall apply a specific time-offset (<1 second) to each instrument's timestamps to spread the commands of the various instruments. See Table 2.

Time offset applied at SOC	Instrument
0 (no offset)	EPD, MAG
+0.125 sec	EUI
+0.250 sec	METIS, SOC-1
+0.375 sec	PHI
+0.500 sec	RPW, SWA
+0.625 sec	SOLO-HI
+0.750 sec	SPICE, SOC-2
+0.875 sec	STIX

Table 2, allocation of time-offsets applied at SOC

Consequences of this approach:

- The actual execution time of an operation will not exactly match the UTC given in the IOR (but with offset less than 1 second)
- In general instruments cannot arrange to execute a particular MTL-commanded operation at exactly the same instant²³.

SOC-1 and SOC-2 slots are for SOC commanding. One known set of SOC-inserted commanding is for SSMM and Downlink control. Other sets are possible – e.g. commands to “glue” i-VSTP commanding into the existing MTL, heatshield door operations.

7.1.1 *Aside on clock drift*

A fine detail worthy of note in this context:-

²¹ Max 5 TCs within a given execution slot. Slots occur every 0.125 seconds.

²² This means that the optional millisecond sub-field within CSS_EXETIME of the MIB shall be set to “000” or not used.

²³ The mechanism used by certain IS instruments to synchronise acquisitions according to a modulo operation applied on the raw OBT (as seen at the instrument) is not MTL-commanded, and is not affected by this constraint.

The execution slots in the IOR exist in “UTC ticks”. The onboard execution slots exist in “OBT ticks”. The mapping between these time systems is performed transparently within the MOC. Inevitably this means that besides the deterministic time offset described above, there can be up to a +/-0.0625 sec offset in the actual execution time of a command introduced in the mapping from UTC ticks to OBT ticks. Normally speaking this UTC->OBT offset is consistent and 1:1, but occasionally the onboard clock will have drifted such that it is approximately half-way between UTC ticks. As the clock drifts across this midpoint there can be a point in time where the mapping “flicks” from e.g round-up to round-down, and in this instant the mapping is not 1:1.

This is not foreseen to be a problem.

- This was the reason in Table 2 to separate the execution slots which contain two instruments such that they are not adjacent. This minimises the max. TC load that can occur (arising from IOR commanding) instantaneously in this special case to 3 TCs in a single slot.
- The ordering of TCs per instrument is still preserved, even in this special case, thanks to the restrictions on 1 second commanding. The actual delta time between two TCs nominally separated by 1 sec could (rarely) drop to 0.875 sec (or equivalently increase to 1.125 sec) due to this effect.

7.1.2 Leap-seconds

Occasionally leap-seconds will be announced by the IERS.

Because

- Legacy systems at SOC/MOC are unaware of leap-seconds in planning
- Leap-second decisions will not be known at the time of LTP planning
- There is no geometrical need for 1 sec absolute time accuracy in commanding²⁴
- Safety constraints on commanding intervals are almost always of the form “not less than”

the handling of leap-seconds within mission-planning is excluded.

For commanding/ IORs:

- No IOR shall ever contain a time of the form YYYY-DDDT23:59:**60**, even in the case that a leap second exists at this time ²⁵
- The conversion of UTC to OBT is performed at the time of uplink (and some days of commanding are held onboard at any time as protection against missed-pass) thus:
 - The insertion of leap-second for TC relates to **time-of-uplink**, rather than **time-of-execution**²⁶

²⁴ Example: 1 second offset at perihelion is equivalent to a third of an arcsecond error on pointing.

²⁵ The “60” possibility for the seconds field has been removed from the schema

²⁶ Note that nominally time correlation on **telemetry** behaves differently, inserting the leap-second at the correct time. Thus for instrument teams precisely tracking TC execution in terms of TM events/acknowledgements there can be a 1 sec offset apparent between the formal leap-second occurrence and the time that the leap-second becomes reflected in TC. This is on top of the offset/jitter effects mentioned earlier in this section.



- For any instrument planning that **ignores** leap-seconds this manifests as an additional one second worth of command interval delay that will appear between subsequent sequence calls. This additional second will occur ~a day to some days after the IERS leap-second, typically at the boundary between individual IOR files.
- For any instrument team planning that internally **includes** leap-seconds, there is **additionally** the disappearance of 1 sec worth of expected commanding interval at the IERS leap-second (i.e. in terms of the **time-separation** between two sequence calls). Instruments planning in this way shall protect themselves against impact of this possibility²⁷.

²⁷ E.g. for commanding intervals that have a minimum separation, applying intervals in the IOR that are at least 1 second larger than the minimum allowable. This could be done either in general or e.g. specifically close to 00:00:00 of every 1 Jan and 1 July.

8 SCHEMA

See accompanying .xsd file.

8.1 Notes on inconsistencies wrt MOC CRF format

As noted in the introduction, the IOR ICD is largely consistent with the MOC CRF format.

Ignoring

- Transparent removal of unneeded elements
- Restrictions on field values
- Changes of optional->mandatory

this subsection is highlighting the few deliberate differences.

These are:

- An "observationID" is defined in addition to the "uniqueID" in the CRF
- There is no VSTP metadata associated to the reserved VSTP reservation sequence calls in the CRF.
- There is no <header2> in the CRF

9 OPEN ISSUES

9.1 Handling “backup” LTP plans

Sometimes the science goals of a particular RSW may depend critically on the availability of a suitable solar feature that cannot be guaranteed in advance.

The proposed approach to handle these cases is to have two plans at LTP. Firstly a prime plan based on the availability of the hoped-for feature, secondly a back-up plan that can run reliably regardless of the actual solar conditions encountered.

N.b. to prevent an explosion of permutations, only **one RSW** of a given six-month planning period would be allowed to have this dependency. The plans would be identical up to the critical RSW (and perhaps precursor), and would then diverge thereafter.

Both plans would be completed in the LTP planning, dual E-FECs and TMCs would be delivered to the instrument teams. During the execution of the plan, it is assumed that the availability of the requisite feature can be decided by the SOOP coordinator with ~2 weeks lead time²⁸, such that only a single chain of STP plans have to be considered.

It is assumed that planning periods having this dependency are rare, since it implies significant additional planning work by both SOC and Instrument Teams

This approach implies the ability to manage parallel prime and backup TMCs, E-FECs. The filenaming convention herein needs to be expanded to support this.

²⁸ This is not implying additional precursor activities. It is assumed that Earth-based assets (and perhaps Solar Orbiter low-latency data from earlier RSWs) is sufficient to decide the availability of a suitable feature.