RPW Operations Centre (ROC)
Project overview

X.Bonnin

Outlines

1. ROC main objectives
2. Organization and responsibilities
3. Constraints and dependencies
4. Overall design

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ROC main objectives

The ROC supervises the RPW ground segment. It gathers the functions usually supported by the operations and data processing centres for the RPW instruments.

- Implement an operational centre to support the RPW ground segment activities
- Ensure the instrument operations and health monitoring during the Solar Orbiter mission
- Ensure the instrument data processing, including the production of full calibrated science data
- Archive relevant science data to the Solar Orbiter data archive
- Be the single point of contact with ESA concerning the ground segment activities
- Support ESA in the definition and preparation of the mission operations planning
- Support RPW instrument team in the AIT/AIV and ground calibration activities.

The ROC is located at the "Laboratoire d'Etudes Spatiales et d'Instrumentation en Astrophysique" (LESIA) at Meudon (France), which is also the RPW PI-ship laboratory.

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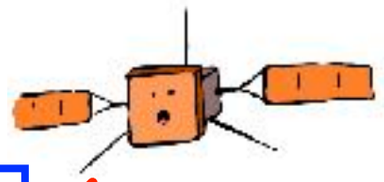
Solar Orbiter ground segment Organization



US PIs

HIS/SWA

SoloHI

(Single point of contact between each PI team and the SOC)

Science Operations Centre (SOC)

ESAC

SWA

EUI
PHI
RPW *(ROC)*
METIS
MAG
STIX
EPD
SPICE

European PIs

Non-Routine, Engineering, Anomalies

Science Ground Segment (SGS)

ESTRACK

TM

TC

Mission Operations Centre (MOC)

ESOC

Operations Ground Segment (OGS)

(PSP)

Science Community

RPW ground segment organization

RPW Ground Segment

TNR-HFR
M.Maksimovic
L.Matteini
QN.Nguyen
A.Vecchio
LESIA

LFR
T.Chust
R.Piberne
B.Katra
LPP

TDS
J.Soucek
D.Pisa
IAP

SCM
M.Kretzschmar
J.-Y.Brochot
G.C.Chenaï
LPC2E

BIAS unit
A.Vaivads
Y.Khotyaintsev
E.Johansson
IRF-U

Sub-system ground segment teams

System
S.Chaintreuil

MEB
M.Dekkali

Flight software
P.Plasson
LR.Malac-Allain

RPW E-GSE
D.Dias
K.Boughedada

RPW AIT/AIV
J.Parisot
S.Thjis

MEB GSE
L.Gueguen

Instrument support teams (LESIA)

ROC

RPW AIT/AIV
E.Guilhem
J.Sanisidro

RPW System
Eric Lorfevre

Instrument support team (CNES)

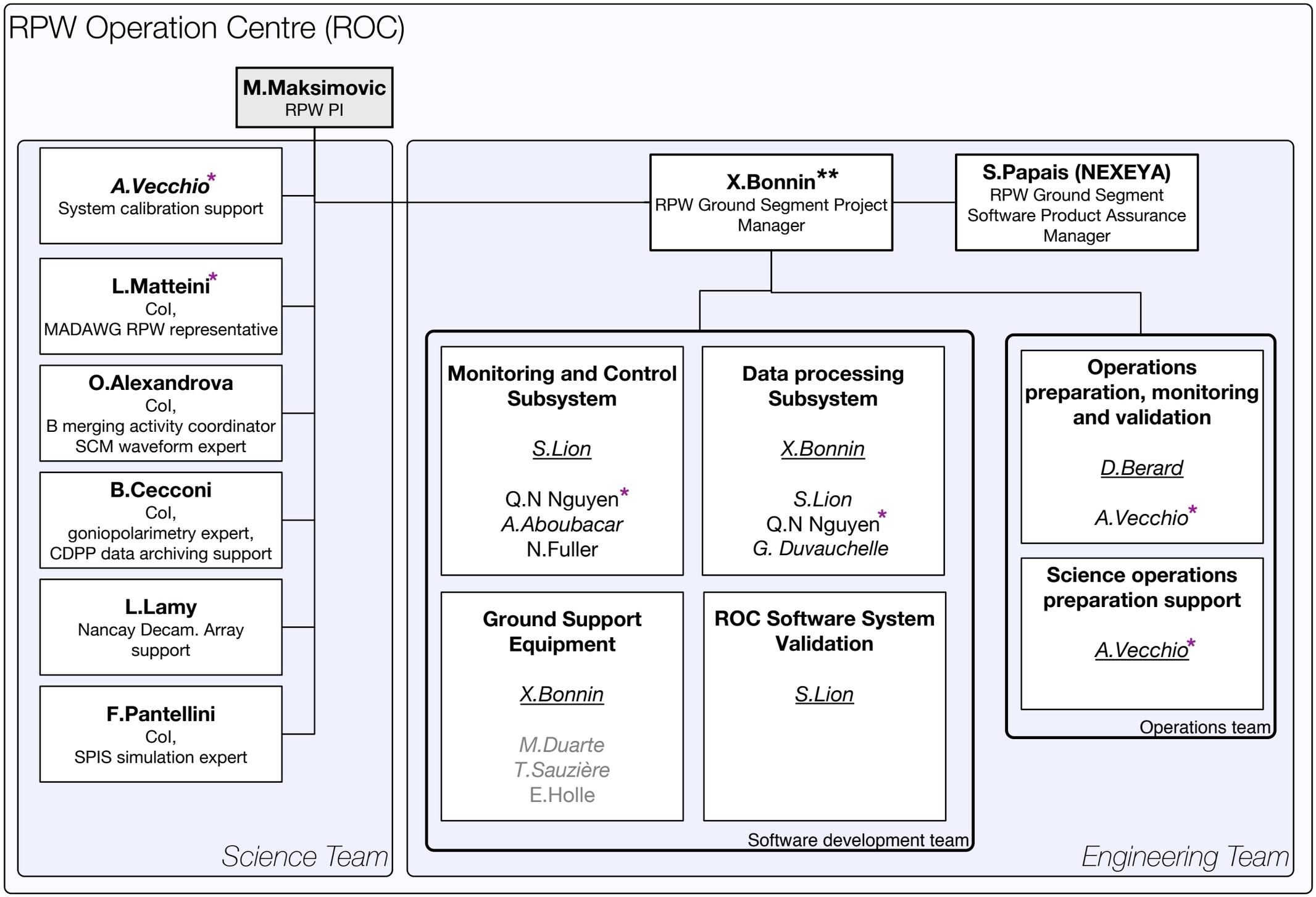
RPW Command Control
J.-M. Travert

Ground segment development support
D.Raulin

ROC Quality Assurance
S.Steere

Ground segment support team (CNES)

ROC organization (LESIA)



*** Also involved in TNR-HFR**

*** Since 2017/08/28 (after Y.de Conchy)*

MOC overall responsibilities

The MOC is a part of the OGS, responsible for all mission operations planning, execution, monitoring and control activities. It will, in particular, in charge of the following tasks relavant for the science operations:

- Overall mission planning
- Provision of instrument TM raw data via the Data Dissemination System (DDS) in a timely manner
- Performing anomaly (out of limit) checks on a set of payload parameters
- Notifying payload anomalies to the SOC/PIs

Non-routine, engineering and anomalies payload are directly managed between the MOC and Instrument Teams (IT). It concerns more particularly all of the operations before the Cruise Phase (CP).

SOC overall responsibilities

The SOC is responsible for supporting the planning of science operations and the coordination of the science operations plans of the IT to generate a conflict-free science operational timeline. Especially:

- The Instrument Operations Requests (IOR) generated by the IT will be collected at the SOC, and merged in a single Payload Operations Requests (POR) to be submitted to the MOC on a periodic basis.

- The SOC will provide to the IT all the necessary inputs to support the science operations planning activities

- The SOC will produce the ancillary data received from the MOC and ancillary data products that will be provided to the IT in support of the science operations planning process as well as interpretation of instrument data

- The SOC will construct a Solar Orbiter data archive, which includes, among others, all value-added science data generated by the IT

- The SOC will pre-process a reduced set of science TM, promptly downlinked with low latency (LL), in support to the science operations planning. The LL data processing pipeline will include IT-provided software to analyse instrument TM.

Science routine operations are managed between the SOC and Instrument Teams (IT). It concerns more particularly all of the operations after the Near Earth Commissioning Phase (NECP).

ROC responsibilities as an operations centre (1/2)

- Agree on a long-term science activity plan and define the scientific priority of scientific goals
- Support the definition of the science operations
- Provide inputs for the definition and implementation of the science operations planning
- Prepare and deliver to the MOC the flight procedures for RPW, to be included in the Flight Operations Plan (FOP)
- Prepare and deliver to the MOC, a RPW instrument state model (ISM)

ROC responsibilities as an operations centre (2/2)

- Plan the RPW science operations, in agreements of the mission science operations planning and constraints (TM data rate and power consumption)
- Prepare and submit to the SOC the instrument operations requests (IOR), and control the uplinked TCs.
- In case of non-routine operations, prepare and submit to the MOC, Payload/Memory Direct Operations (PDOR/MDOR), and control the uplinked TCs
- Ensure the monitoring of instrument. (MOC will just perform a primary control of relevant HK, according to the RPW user manual instructions)
- Optimized the science performance of the instrument on-board
- Ensure the selection, monitor the downlink and process the Selected Burst Mode (SBM1/SBM2) data
- Maintain the instrument flight software
- Supervise investigations in case of anomalies
- Participate to the preparation of the commissioning phase. In particular, plan the RPW operations specific to the commissioning phase, and ensure the validation of the science performance

ROC responsibilities as a data processing centre

- Deliver to the SOC an operational Low Latency data pipeline for RPW (prior to the launch)
- Support the definition of the Solar Orbiter science data products (prior to the launch)
- Support the definition and implementation of the Solar Orbiter data archive (prior to the launch)
- Retrieve from the MOC DDS, analyse and store the RPW TM raw data, and related data products (TM/TC reports)
- Retrieve from the SOC GFTS and store the Solar Orbiter ancillary data (SPICE kernels and CDF-digest), as well as the science operations inputs (E-FECS, TMC)
- Generate and validate higher processing level data products, including full calibrated science data files and derived products (summary plots)
- Promptly distribute all the RPW data to the RPW Lead CoI teams, as well as Solar Orbiter IT and SOC/MOC.
- After the end of the proprietary period (3 months), distribute relevant science data to the Solar Orbiter data archive. Additionally, RPW science data will also be available from the Centre de Données de Physique des Plasmas (CDPP) in Toulouse

RPW ground segment support teams responsibilities

TDS/LFR/THR/SCM/Bias sub-system Lead CoI teams

- Ensure the calibration of their sub-system
- Support the ROC in the definition of the science data products for RPW
- Deliver to the ROC, operational software dedicated to the production of calibrated data files
- Support the validation of the science data products
- Support the preparation of the instrument operations
- Provide expertise support in case of anomalies

RPW instrument support teams responsibilities

Instrument/flight software teams

- Provide expertise support in the preparation of the operations
- Provide expertise support in case of anomaly investigation
- Support the ROC in the maintenance/patching of the flight software

AIT/AIV and GSE teams (LESIA)

- Make available AIT/AIV and GSE facilities in support to the flight procedures (i.e., TC sequences) preparation activities
- Make available AIT/AIV and GSE facilities in case of anomaly investigation

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Constraints and dependencies

- ROC activities planning is constrained by the following milestones at RPW and Solar Orbiter levels:
  - EM2/PFM system ground calibration campaigns driven by the CNES AIT/AIV team
  - RPW LLVM delivery schedule
  - SOC/MOC Instrument Team (IT) interface validation tests
  - System Validation Test (SVT) campaign
  - System Operation Validation (SOV) campaign
  - In-flight operations schedule, including LEOP/NECP operations (prepared with CNES)
- Reviews
  - No formal review of the instrument ground segments by ESA
  - Key points planned during the development of the ROC

(See details in the project management/development/operations plan presentation)

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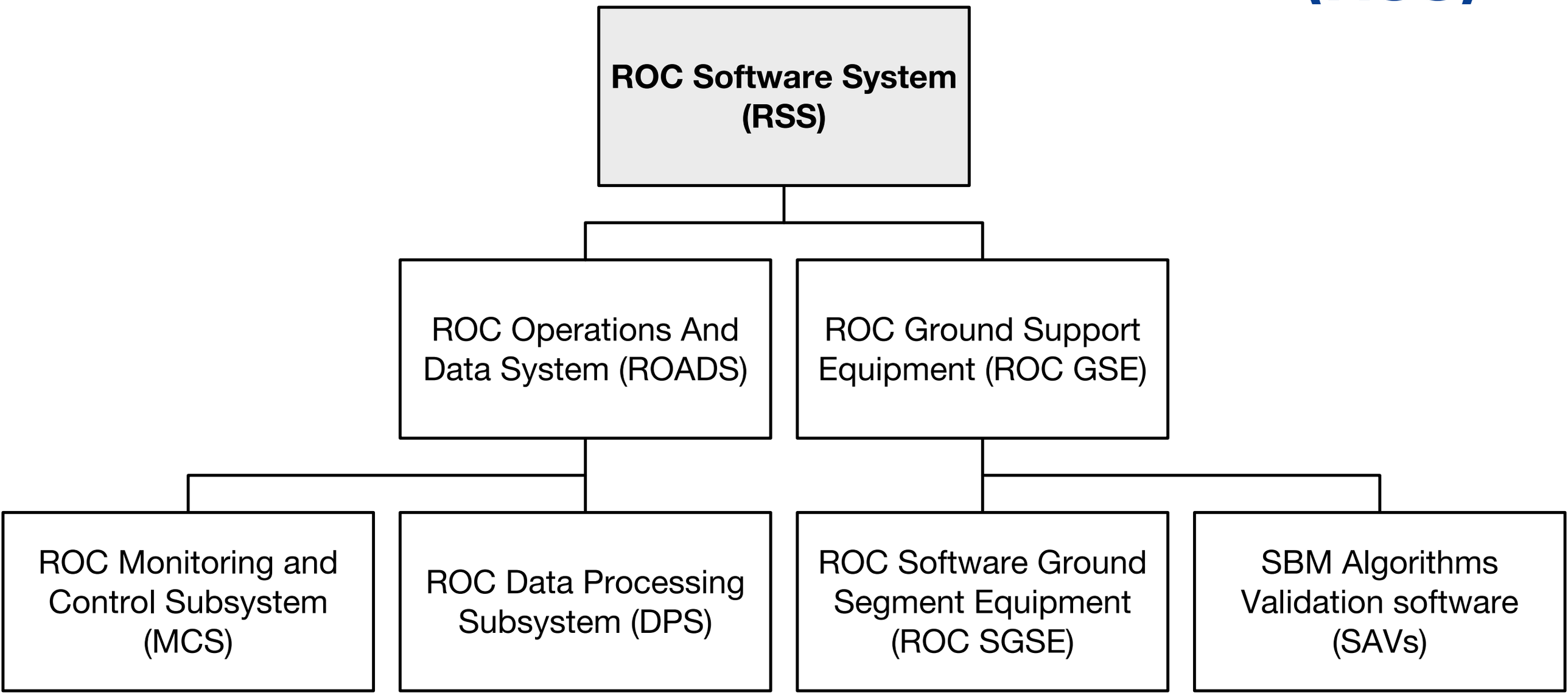
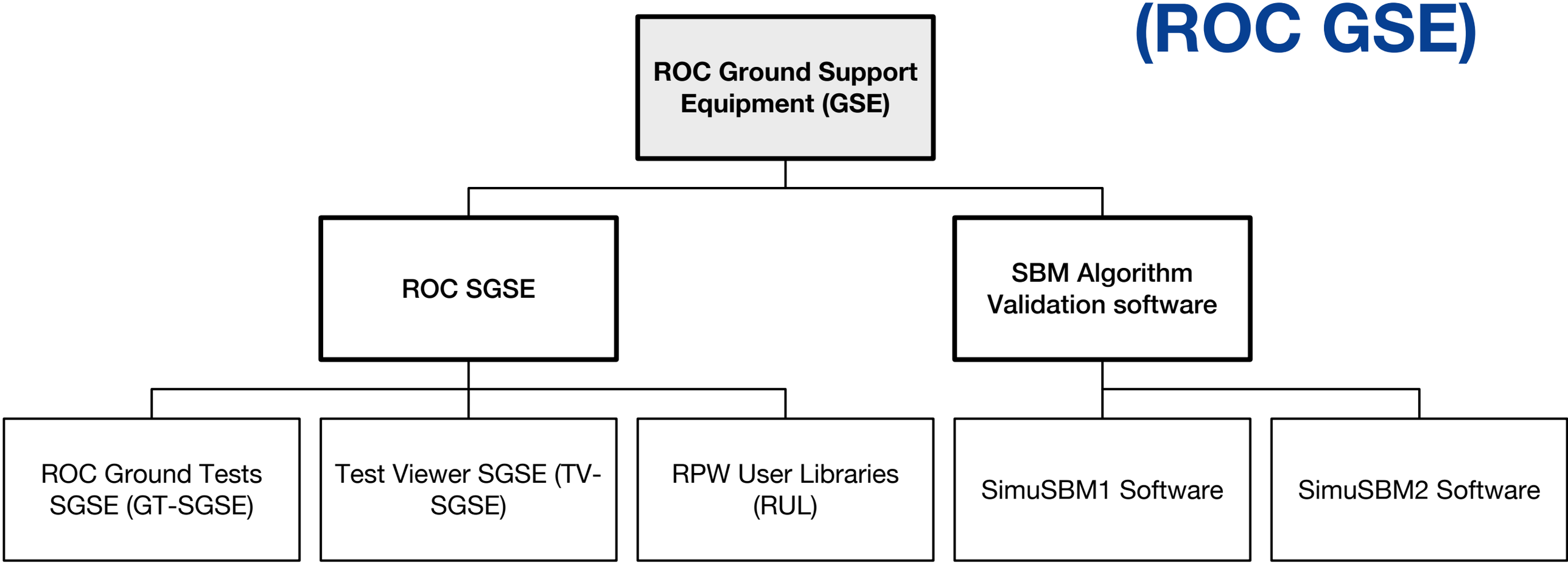
ROC Software System (RSS)



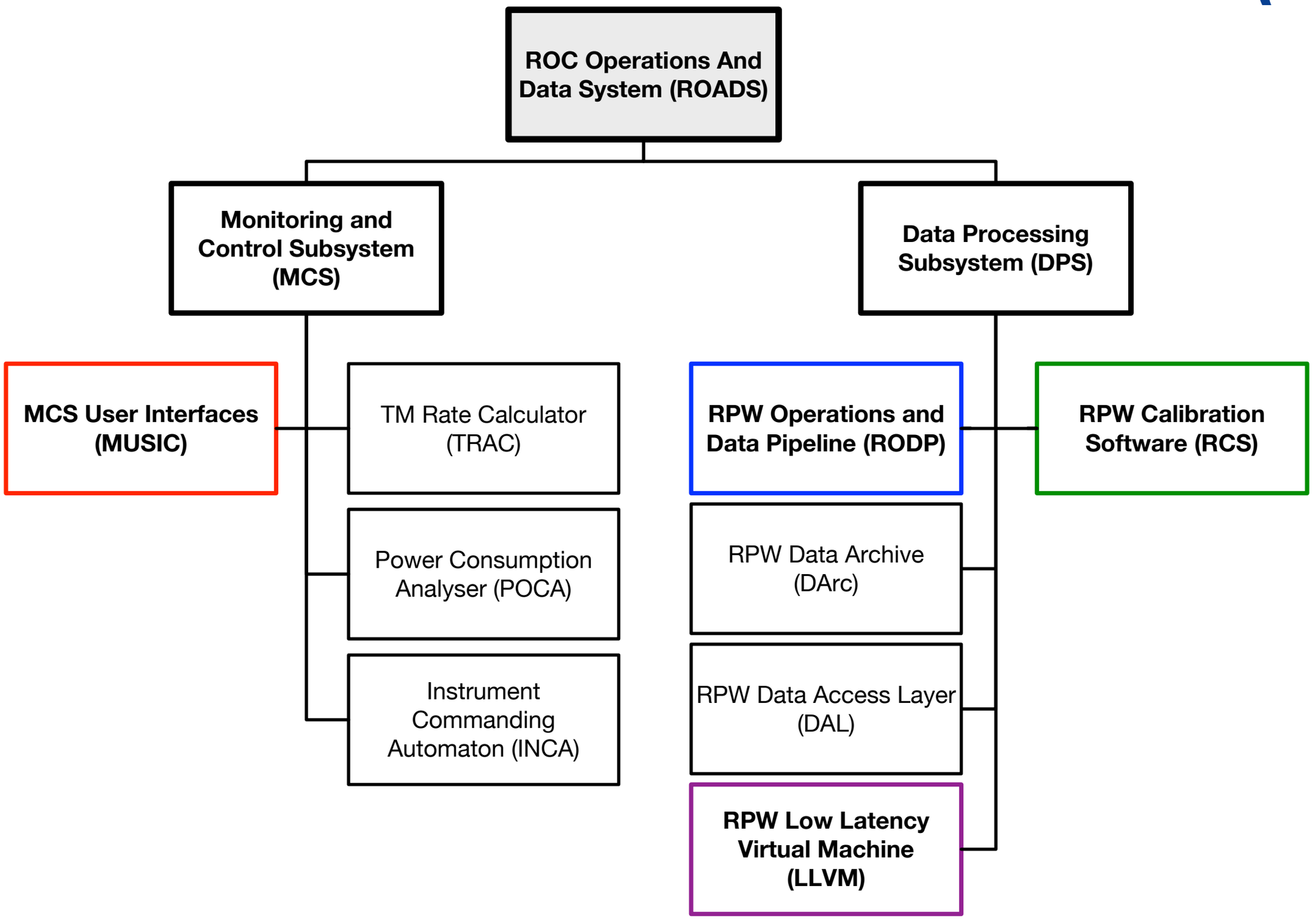
ROC Ground Support Equipment (ROC GSE)



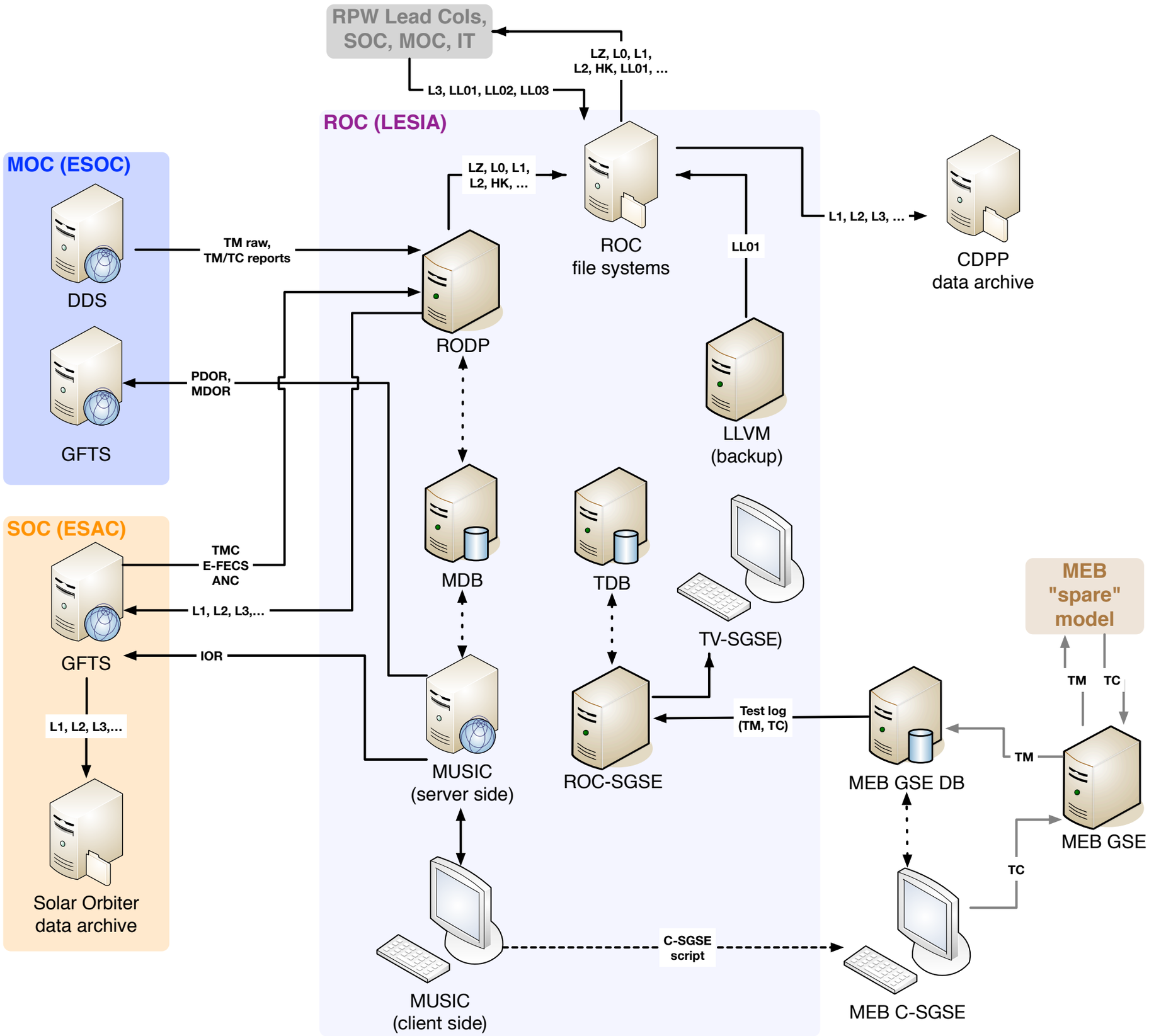
- SAVs: Tools in support to the RPW DPU SBM1/SBM2 algo. validation on-ground and in-flight.

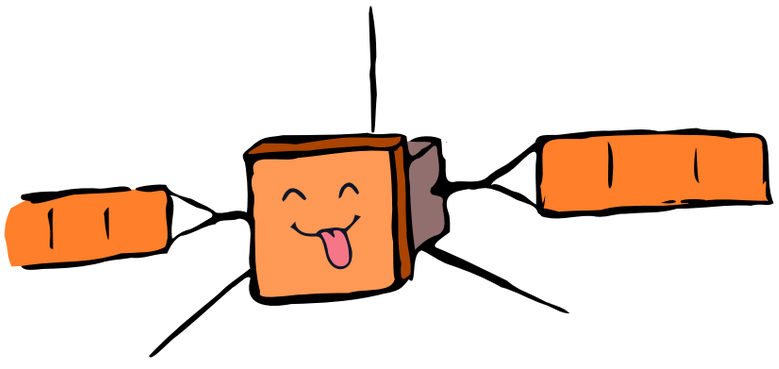
- ROC-SGSE: Tools in support to ground EM2/PFM calibrations campaigns. Also used during the mission to analyse RPW "spare-like" model data on-ground.

ROC Operations And Data System (ROADS)

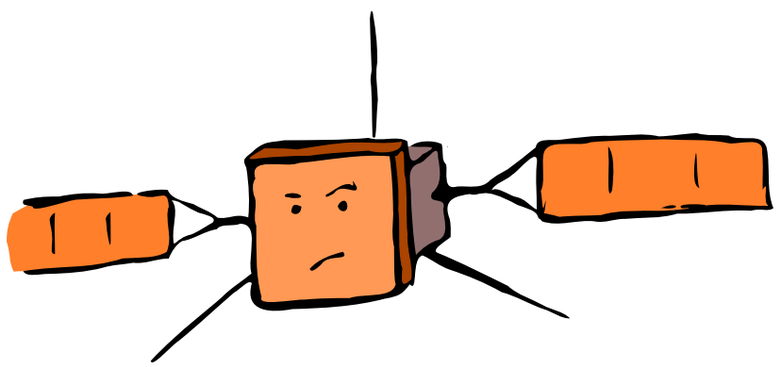


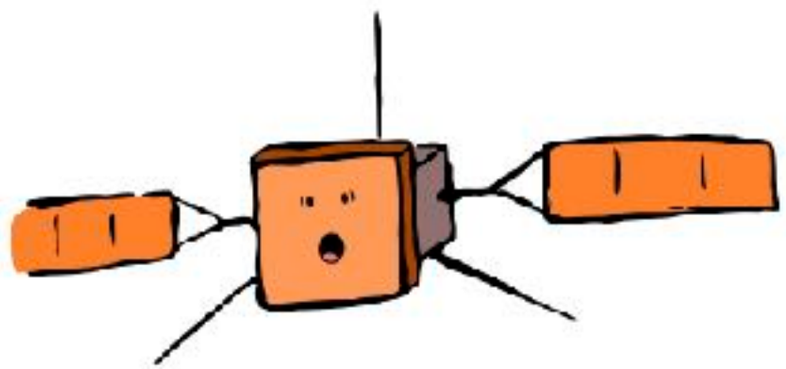
RSS overall design

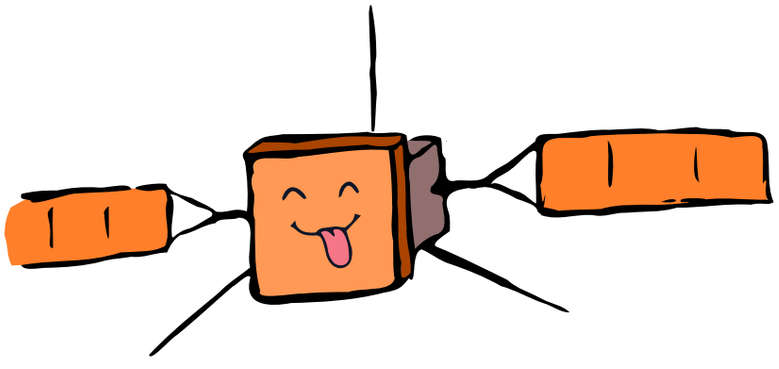




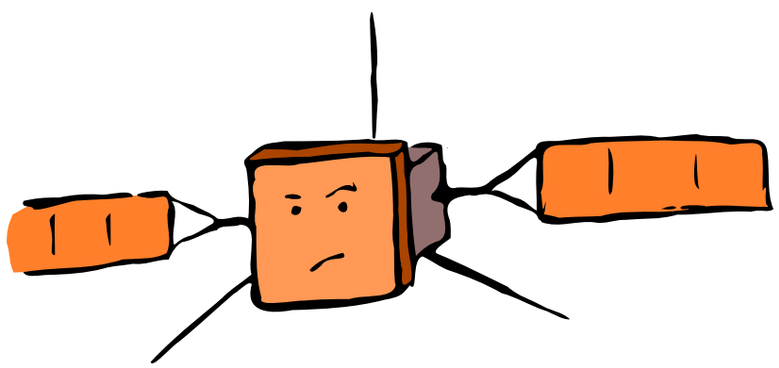
To be continued…

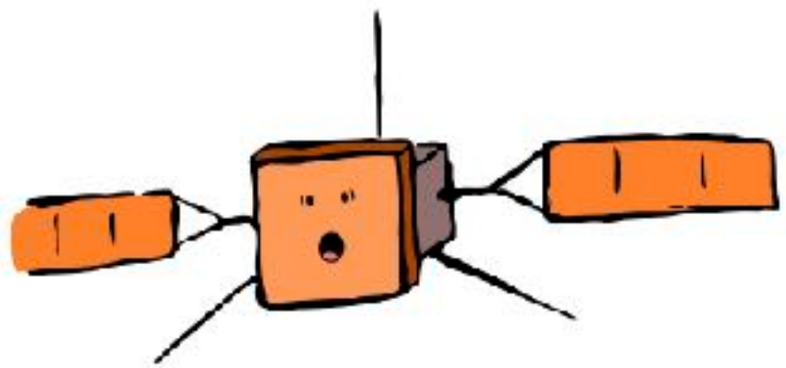




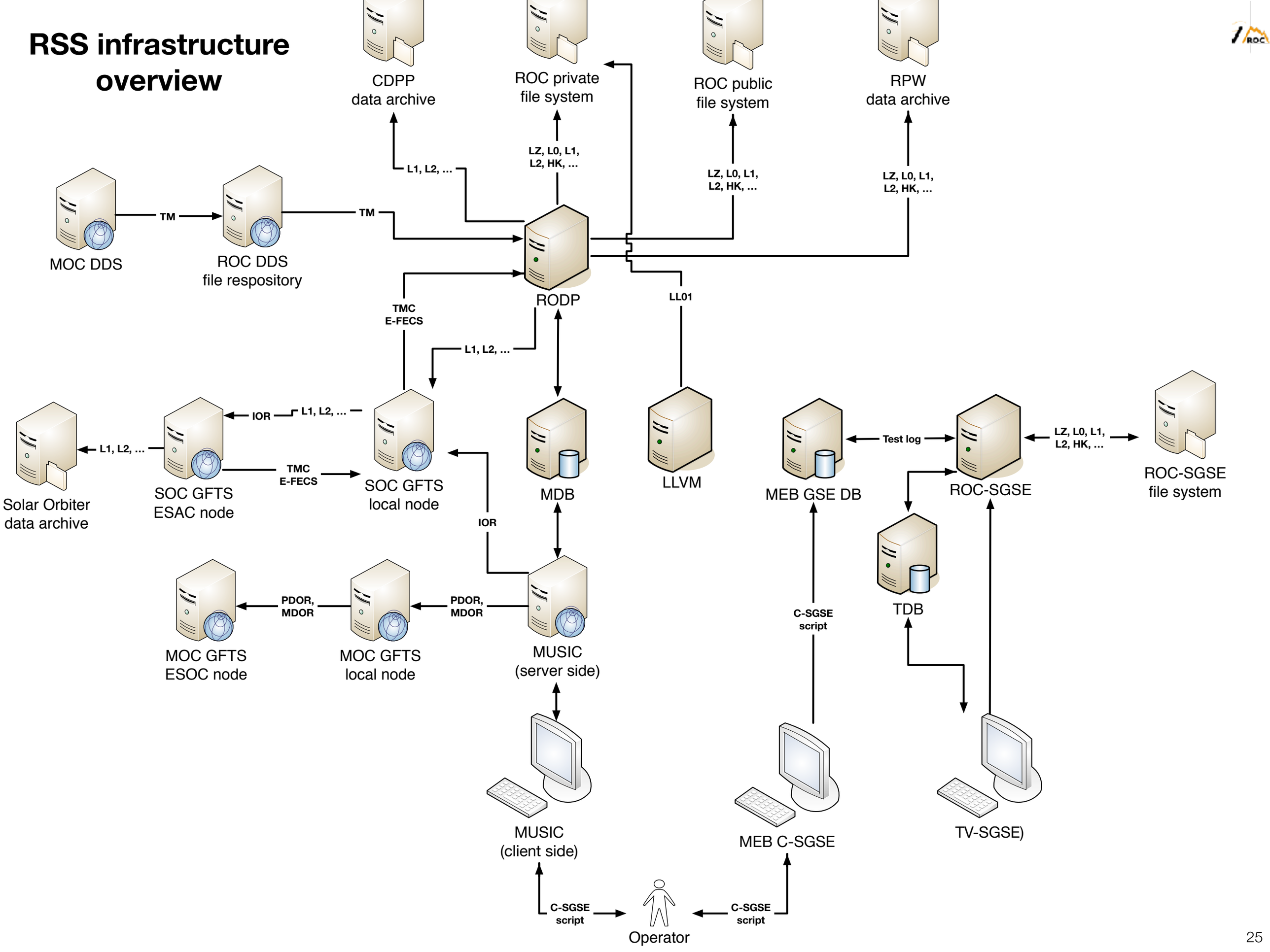


Bonus!





RSS infrastructure overview



Procédures (contenant les séquences de TC)

One file
One Procedure
N Sequences
N Steps
N Statements

Stmt_nr	Step_nr	Stmt_type	Stmt_id	Blk_flag	Time_tag	info		Param_val_int_tm	Param_val_tm	Proforma	Packet	Manual_Dispatch
1	1	CMT				Purpose of the procedure: configuration of TDS, LFR, TNR-HFR for NORMAL MODE						
2	1	CMT				Purpose of step 1 is the configuration of TDS						
3	1	CMT				FIRST TC	TC_TDS_LOAD_NORMAL_PAR"					
4	1	CMD	ZIW00098		00:00:00	Send TDS_LOAD_NORMAL_PAR						Y
5	1	PKT	YIW00190			RPW TM Packet with parameters details (Using PKT Params sheet)	TM_TDS_TC_ACC_SUCCESS					
6	1	PKT	YIW00206			RPW TM Packet with parameters details (Using PKT Params sheet)	TM_TDS_TC_EXE_SUCCESS					
7	2	CMT				Purpose of step 2 is the configuration of LFR						
8	2	CMT				SECOND TC (executing 1 sec after FIRST TC)	TC_LFR_LOAD_NORMAL_PAR					
9	2	CMD	ZIW00078		00:00:01	Send LFR_LOAD_NORMAL_PAR						Y
10	2	PKT	YIW00123			RPW TM Packet with parameters details (Using PKT Params sheet)	TM_LFR_TC_ACC_SUCCESS					
11	2	PKT	YIW00139			RPW TM Packet with parameters details (Using PKT Params sheet)	TM_LFR_TC_EXE_SUCCESS					
12	3	CMT				Purpose of step 3 is the configuration of THR						
13	3	CMT				THIRD TC (executing 1 sec after SECOND TC)	TC_THR_LOAD_NORMAL_PAR_1					
14	3	CMD	ZIW00112		00:00:01	Send THR_LOAD_NORMAL_PAR_1						Y
15	3	PKT	YIW00240			RPW TM Packet with parameters details (Using PKT Params sheet)	TM_THR_TC_ACC_SUCCESS					
16	3	PKT	YIW00248			RPW TM Packet with parameters details (Using PKT Params sheet)	TM_THR_TC_EXE_SUCCESS					

From IW-FCP-030.xls

Science Activity Plan (SAP)

Science Activity Plan

The Science Activity Plan (SAP) describes in a structured way all scientific activities to be carried out by the instruments throughout the cruise and nominal phases in order to fulfill the Science Requirements of the mission.

Top-level science objectives

↓

Detailed science objectives

↓

Specific Science Activities

↓

Science Orbits

Science Operations Planning Cycles

- *Mission-level Planning*
  - *Science Working Team (SWT) defines top-level science activities for the entire mission (Science Activity Plan, SAP), as well as detailed science goals for each orbit.*
- *Long-Term Planning (LTP)*
  - *Covers 6 months, planned ≥ 6 months before execution (~ 1 orbit; fixes ground stations allocation)*
  - *Given input from SWT, the Science Operations Working Group (SOWG) defines a coherent mission-level observing plan for a given orbit. They will be assisted by the SOC, which will provide detailed information on the resources available.*
- *Medium-Term Planning (MTP)*
  - *Covers 6 months, fixed 4 weeks before execution (defines top-level science operations per orbit: fixes S/C resources, instrument modes, default pointing)*
- *Short-Term Planning (STP)*
  - *Covers 1 week, planned ~1 week before execution (generates detailed schedules of commands for S/C and payload; last opportunity to modify instrument ops. modes)*
- *Very-Short-Term Planning (VSTP)*
  - *For subset of remote-sensing windows only: update S/C fine pointing to track features on solar disk*
  - *Opportunity for fine-pointing updates: once per 24h, time between pointing definition and execution ≤ 3 days*

How to build a SAP

How to build a mission-long SAP?

SolO's (sub)objectives

SOOPs

SOOP A

SOOP B

SOOP C

SOOP D

Step 1

Step 2
Strategy

EPD normal+burst
EUI/HRI AR mode
MAG Normal
Metis GLOBAL
PHI/HRT NOM 0
RPW normal+burst
…

10 instruments, many modes

- EPD
  - EPD Normal Mode
- EUI
  - EUI/FSI Synoptic mode (S)
  - EUI/FSI reference synoptic mode (R)
  - EUI/FSI Global eruptive event mode (G)
  - EUI/HRI Coronal hole mode (C)
  - EUI/HRI Quiet Sun mode (Q)
  - EUI/HRI Active Region mode (A)
  - EUI Beacon mode
  - EUI/HRI Eruptive Event mode (E)
  - EUI/HRI Discovery mode (D)
- MAG
  - MAG Burst Mode
  - MAG Normal Mode
- METIS
  - METIS standard modes
  - METIS special modes
  - METIS observing mode characteristics
- PHI
- RPW
- SoloHI
- SPICE
- STIX
- SWA

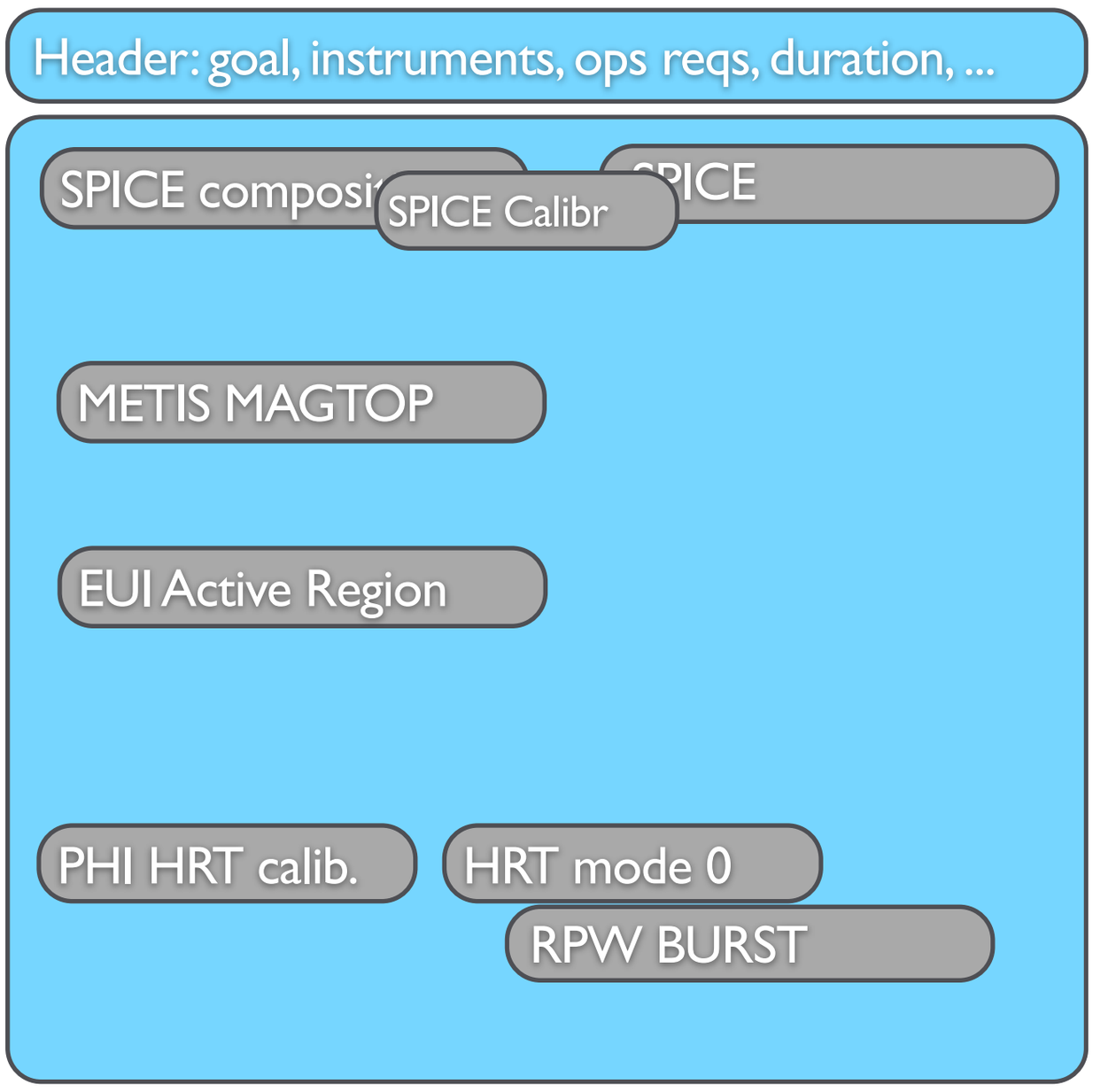
10 years mission timeline

To be checked against mission constraints

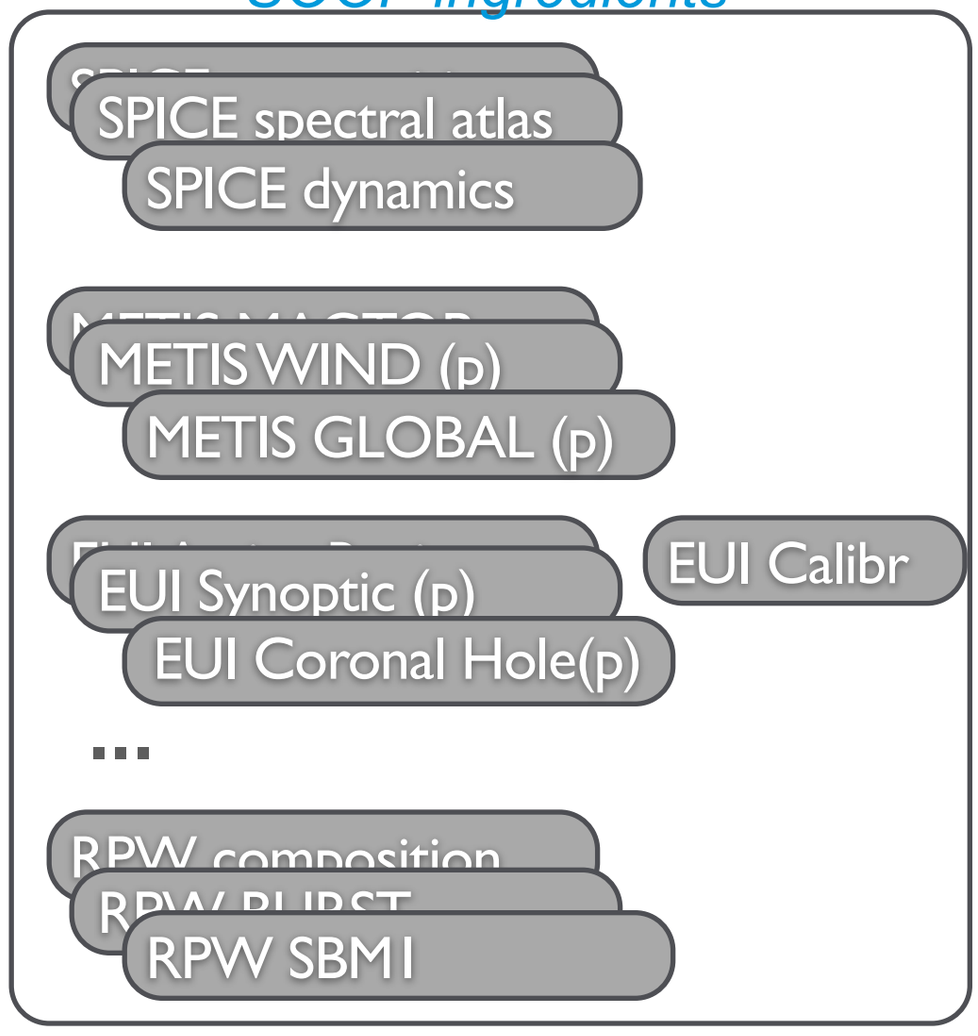
Step 3
Simulation

LTP & SOOP concept

- SOOP = collection of instrument operations that belong together, i.e serve a common science goal *(or calibration goal during manoeuvre)*



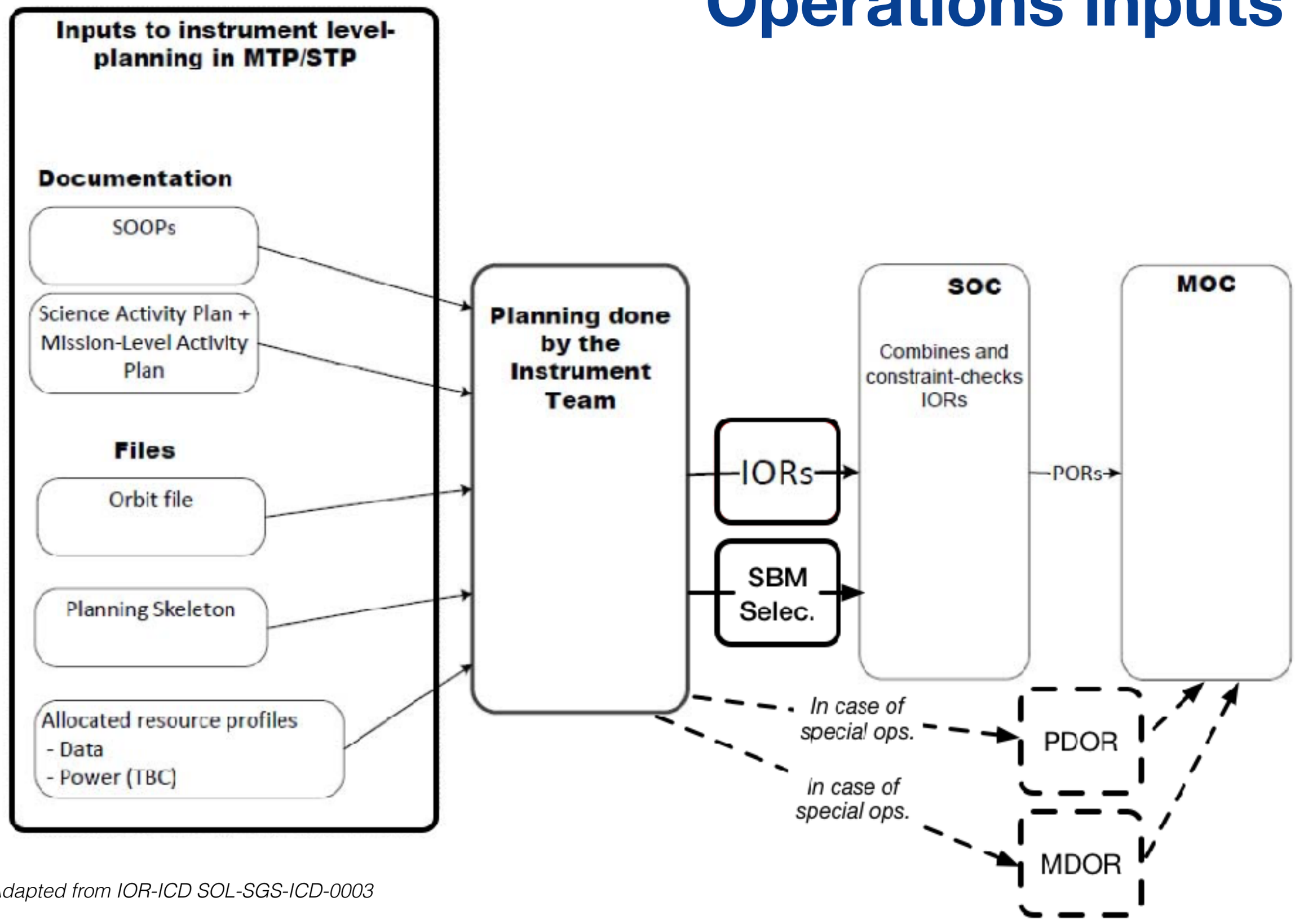
Library of science & aux. modes
'SOOP ingredients'



+ Metadata: **average** power, TM **rate**, conflicts & dependencies

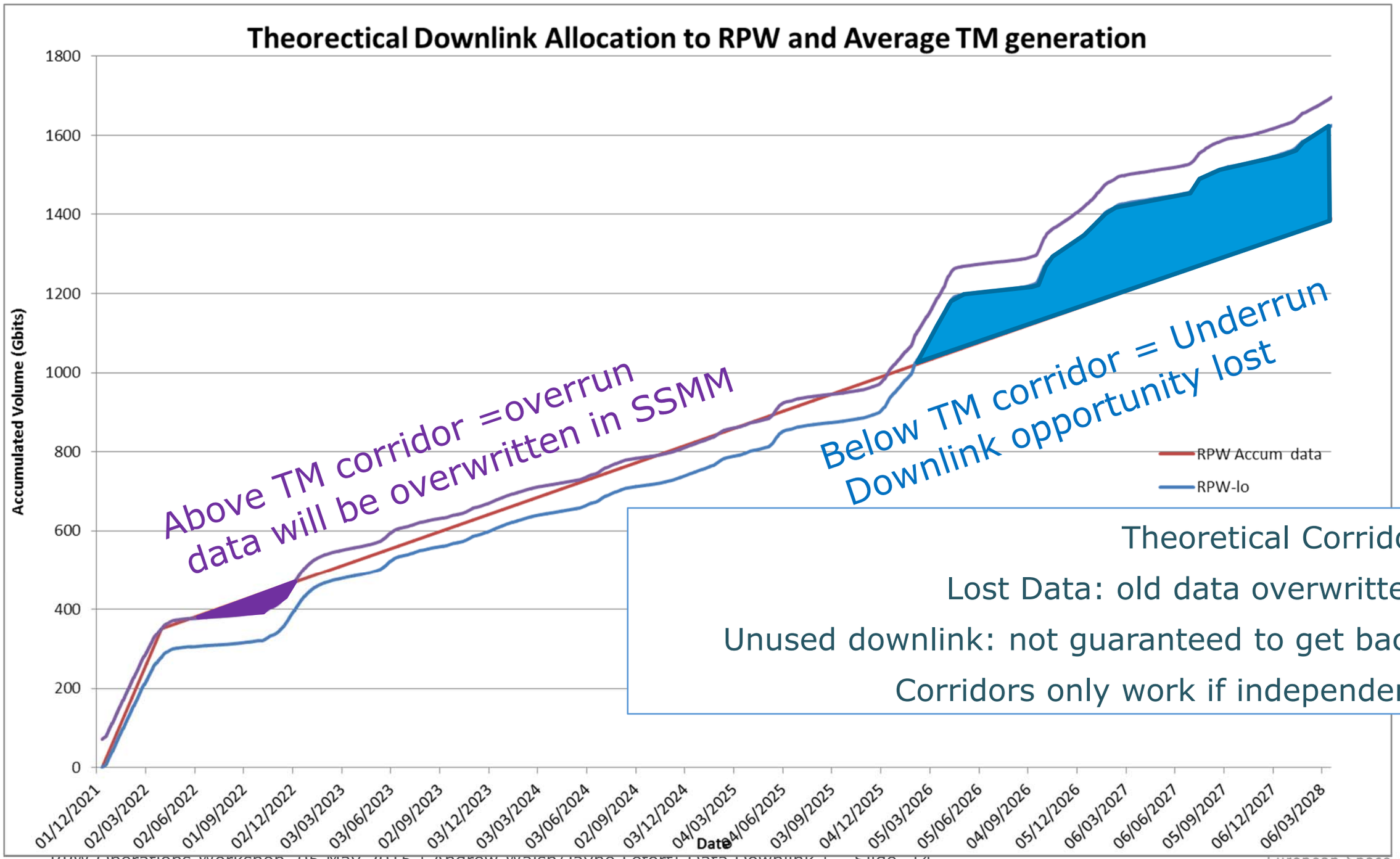
- High-level ops, no time-stamping, durations (~resources) can be tweaked

Operations inputs



Adapted from IOR-ICD SOL-SGS-ICD-0003

Downlink & Storage limitations



RPW Calibration Software (RCS)

RCS name	Function	Team in charge	Programming Languages
THR data CALiBrAtion SoftwaRe (THR_CALBAR)	Produce TNR-HFR L2/L2S calibrated science data files in the CDF format	TNR-HFR team (LESIA, Meudon)	IDL
TDS data CALiBrAtion Software (TDS_CALBA)	Produce TDS L1R/L2/L2S calibrated science data files in the CDF format. L2/L2S only concern the non-waveform (WF) data products.	TDS team (IAP, Pragues)	IDL
LFR data CALibration UniT (LFR_CALBUT)	Produce LFR L1R/L2/L2S calibrated science data files in the CDF format. L2/L2S only concern the non-WF data products.	LFR team (LPP, Palaiseau)	Python
SCMCAL	Produce TDS/LFR L2/L2S magnetic WF calibrated data files in the CDF format	SCM team (LPC2E, Orléans)	IDL
BIas CAlibration Software (BICAS)	Produce TDS/LFR L2/L2S electrical WF calibrated data files in the CDF format. The BICAS is a part of the IRFU_MATLAB package.	Bias team (IRF, Uppsala)	Matlab