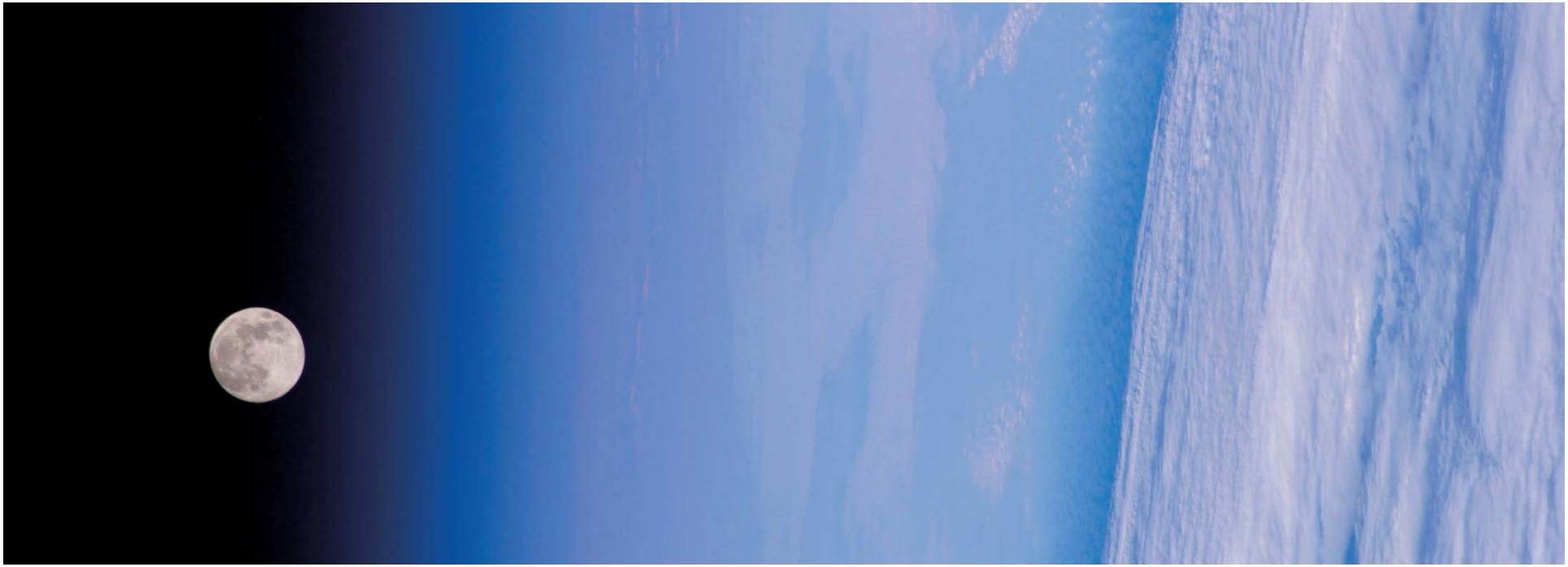
CoRA-SAGE ADCSS, 15/10/2018



CoRA Smart AOCS&GNC Elements (SAGE)

Lorenzo Tarabini Castellani

Aerospace

www.aerospace.sener

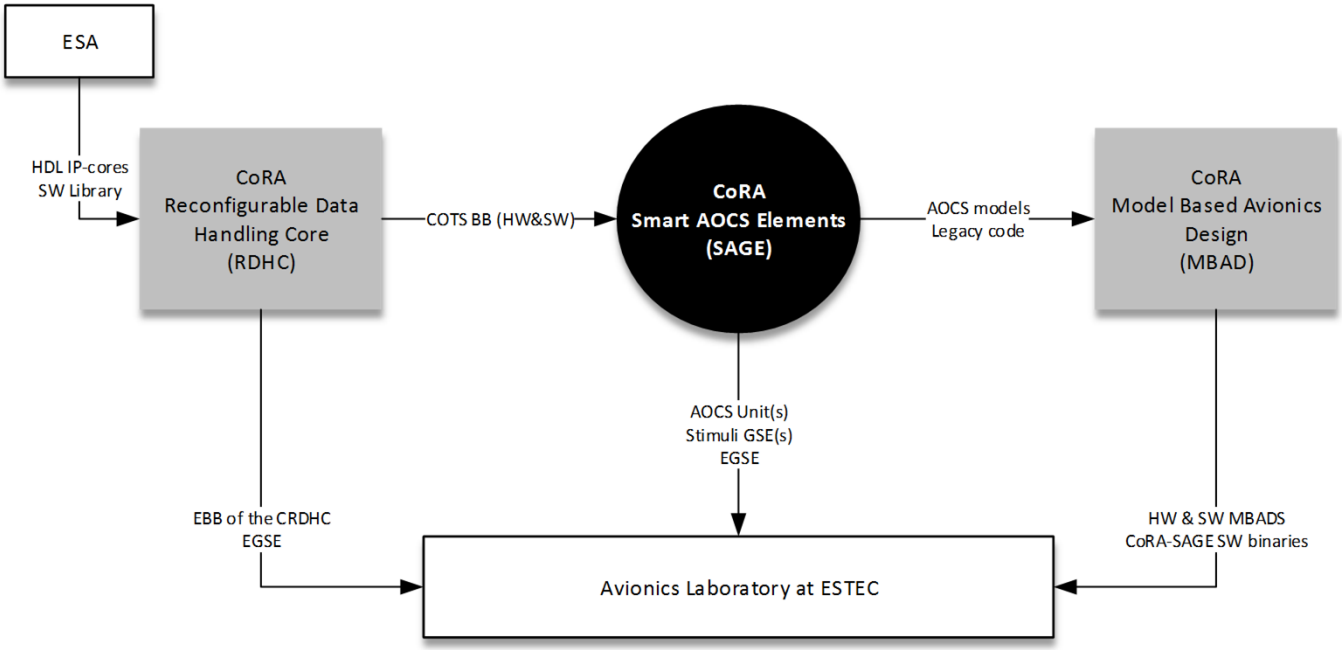
Index

Objectives

CoRA-SAGE Objectives 1/3

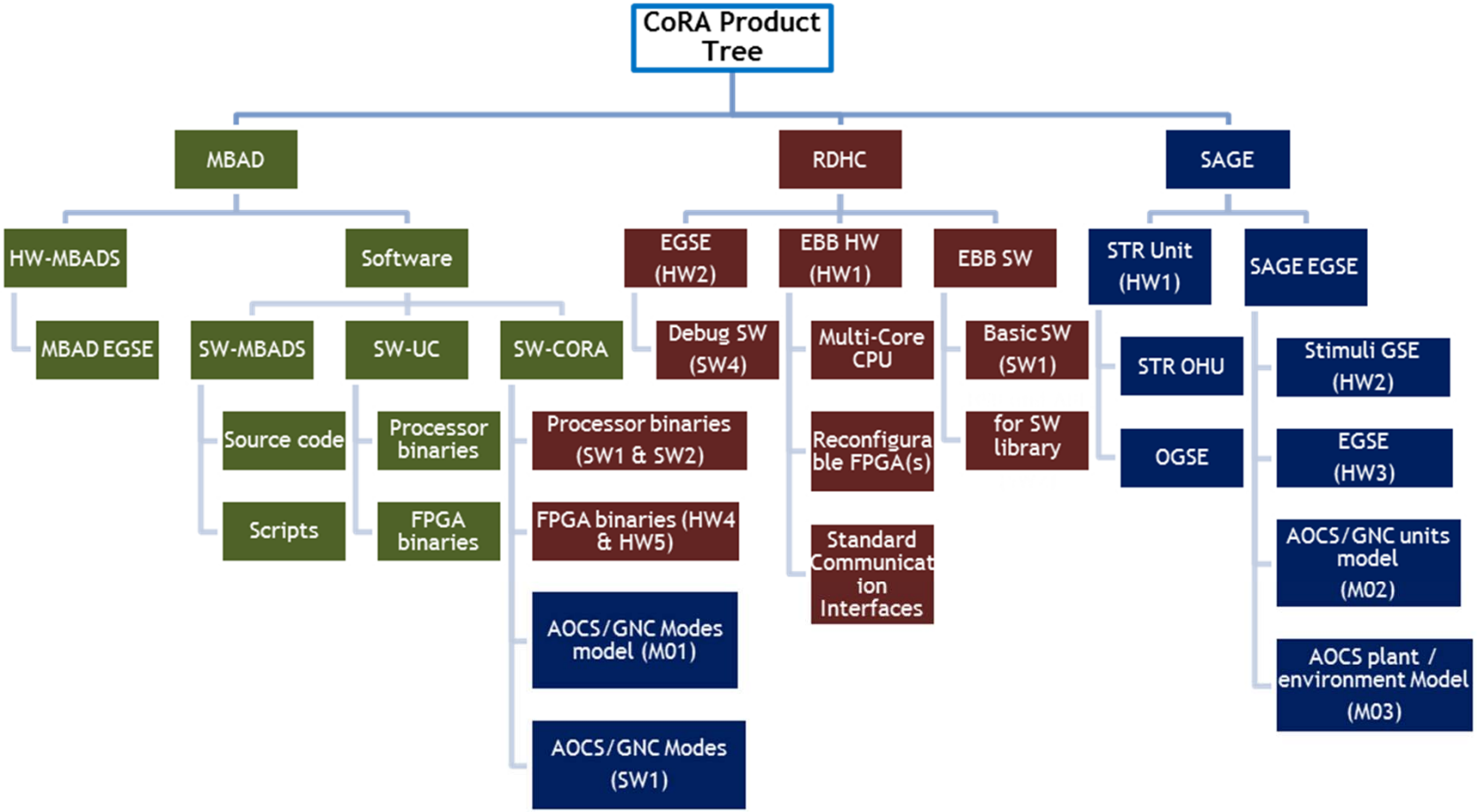
Objectives

- CoRA Smart AOCS&GNC Elements (SAGE) is a multidisciplinary activity aimed to implement AOCS & GNC functional chains with reliable sensors and actuators in a compact and reconfigurable way fitting in the overall avionics architecture called CoRA and developed in parallel with the MBAD and RDHC activities.



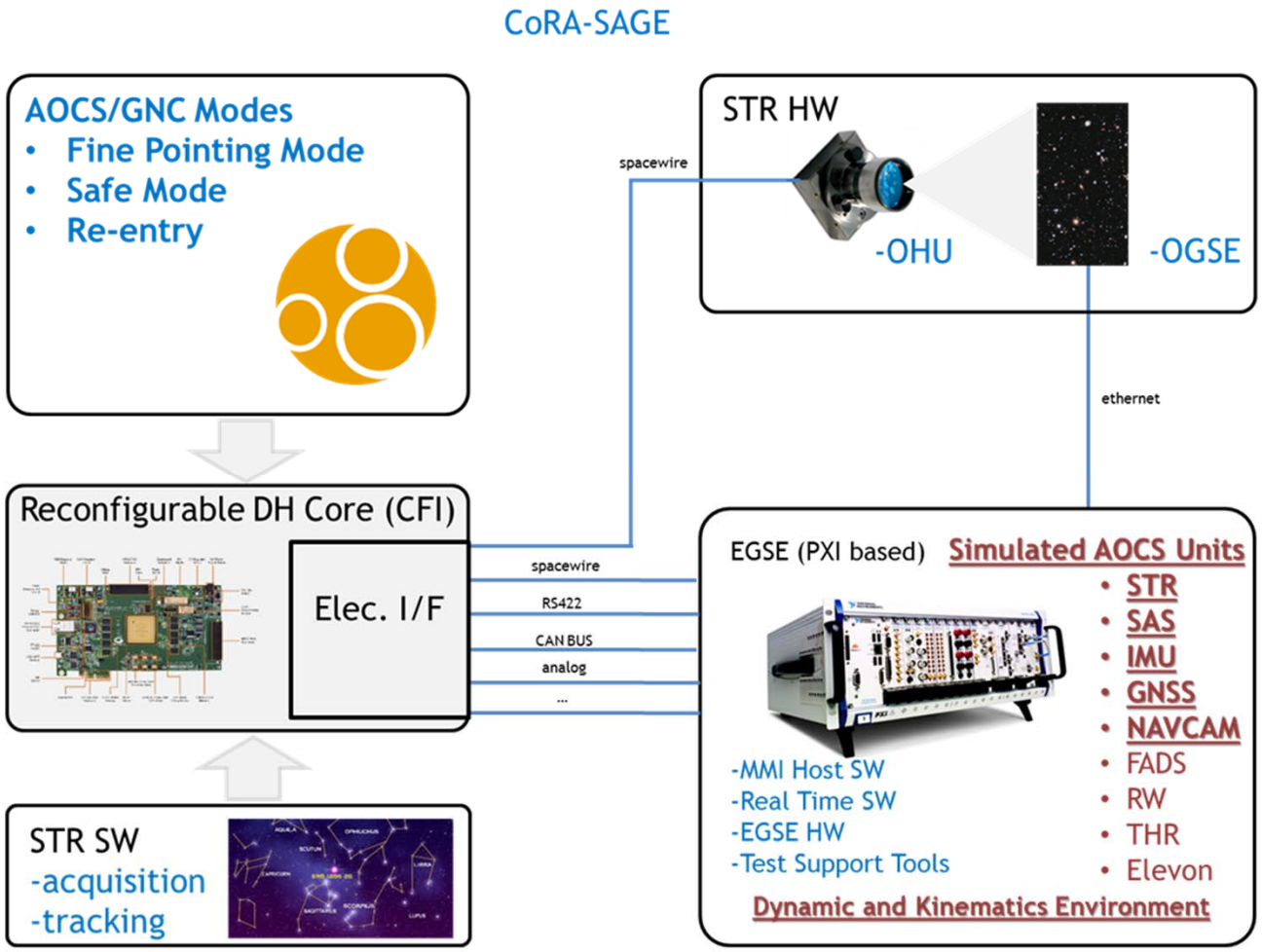
CoRA-SAGE Objectives 2/3

Product Tree besides the parallel CoRA activities



CoRA-SAGE Objectives 3/3

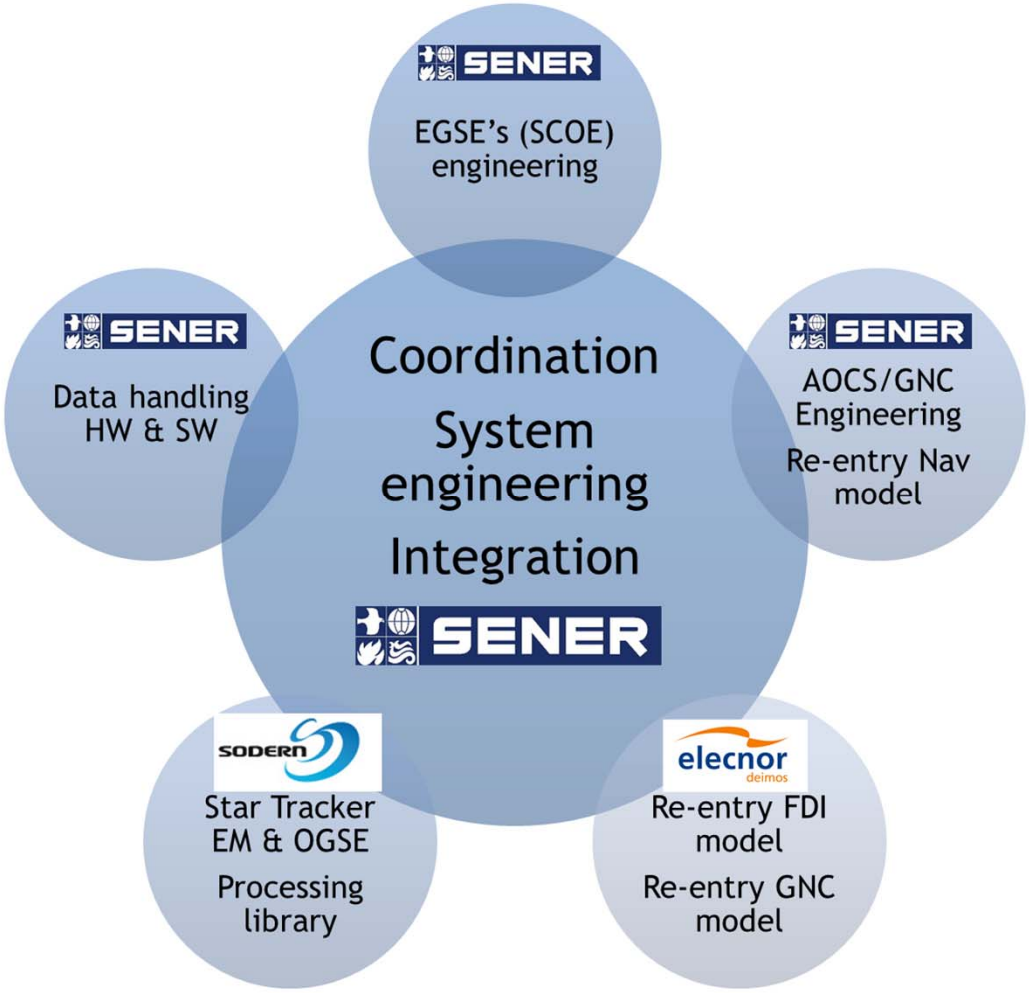
CoRA-SAGE environment overview



Consortium

CoRA-SAGE Technical Baseline

Consortium



Baseline Mission

Baseline Mission

Space Rider is a reusable orbital vehicle designed to fly up to 6 times to carry out Earth Observation, Microgravity, Telescope and Rendez-Vous missions. Space Rider will be launched by Vega from Kourou. Space Rider will be composed by an Orbital Servicing Module (OSM) and by a Re-Entry Module (RM). OSM will separate before the re entry.

The nominal mission data are

- Mission duration: 2 Months
- Mass (OSM+RM): 4100kg
- Orbit altitude: 400 Km
- Orbit Inclination: 5º
- Attitudes: Nadir & Inertial

AOCS/GNC Modes

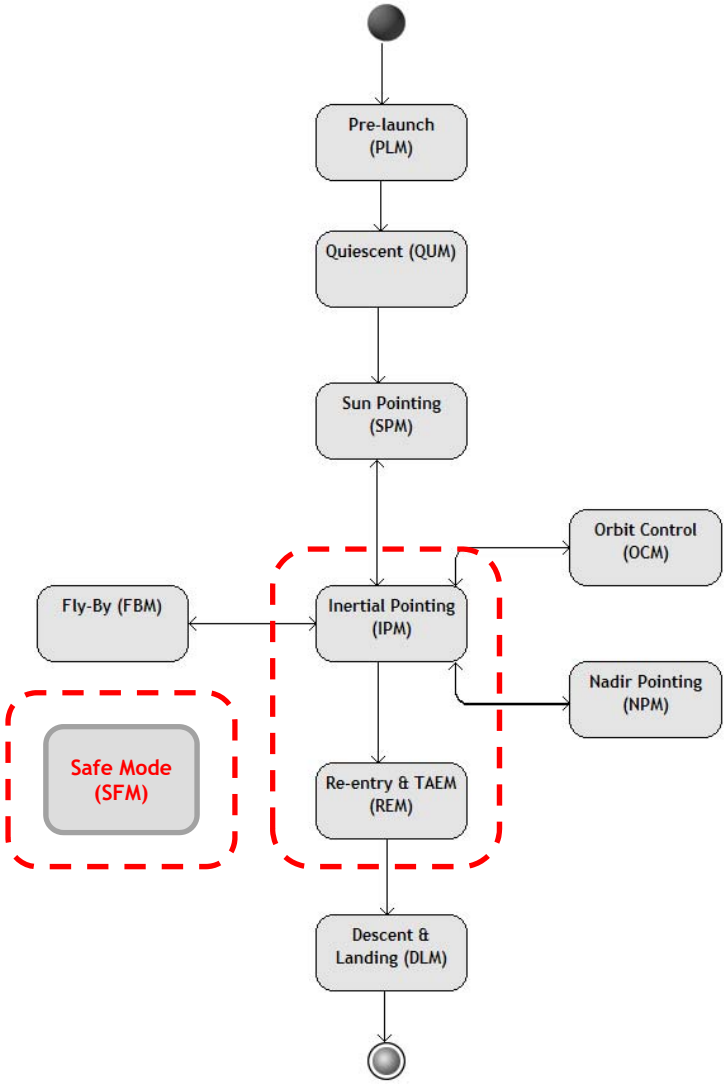
AOCS/GNC Modes (1/2)

In the frame of the CORA-SAGE activity, the following AOCS/GNC modes will be used as reference AOCS/GNC software:

- Inertial Pointing Mode (IPM)
- Re-Entry & TAEM (REM)
- Safe Mode (SFM)

This mode selection allows to cover very different needs and requires a large set of AOCS/GNC units including:

- Star Trackers
- GNSS
- INS
- Sun Sensors
- Gyroscopes
- Fluid Air Data System
- Reaction Wheels
- Thrusters
- Entry Elevons



AOCS/GNC Modes (2/2)

AOCS/GNC Modes development is carried out in Matlab and then implemented in taste.

GNC Develop. (Matlab/ Simulink) → GNC Conversion to Fixed Point (Matlab Simulink) → GNC Autocode to C (Matlab Simulink) → Interface with OBSW (taste) → Embedding into final target (taste)

AOCS/GNC Modes – SAFE MODE

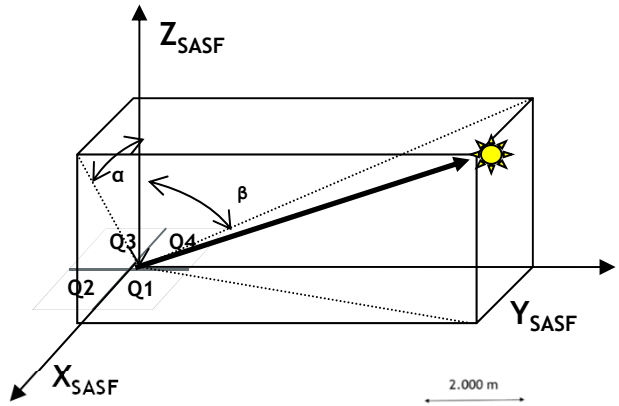
AOCS/GNC Modes - Safe Mode (1/4)

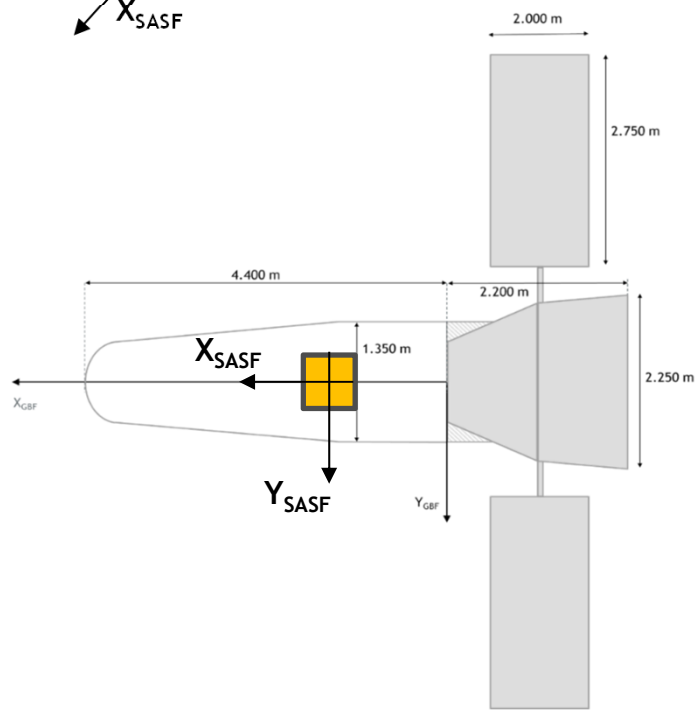
- **SFM overview:**

- Objective:
  - ❑ Point the sun with the solar arrays in a fixed position.

- Requirements:
  - ❑ Use redundant sensors: SAS and GYR.
  - ❑ Use RCS as actuator.
  - ❑ Robust GNC algorithm.
  - ❑ APE < 15º.
  - ❑ Angular rate < 8º/s.

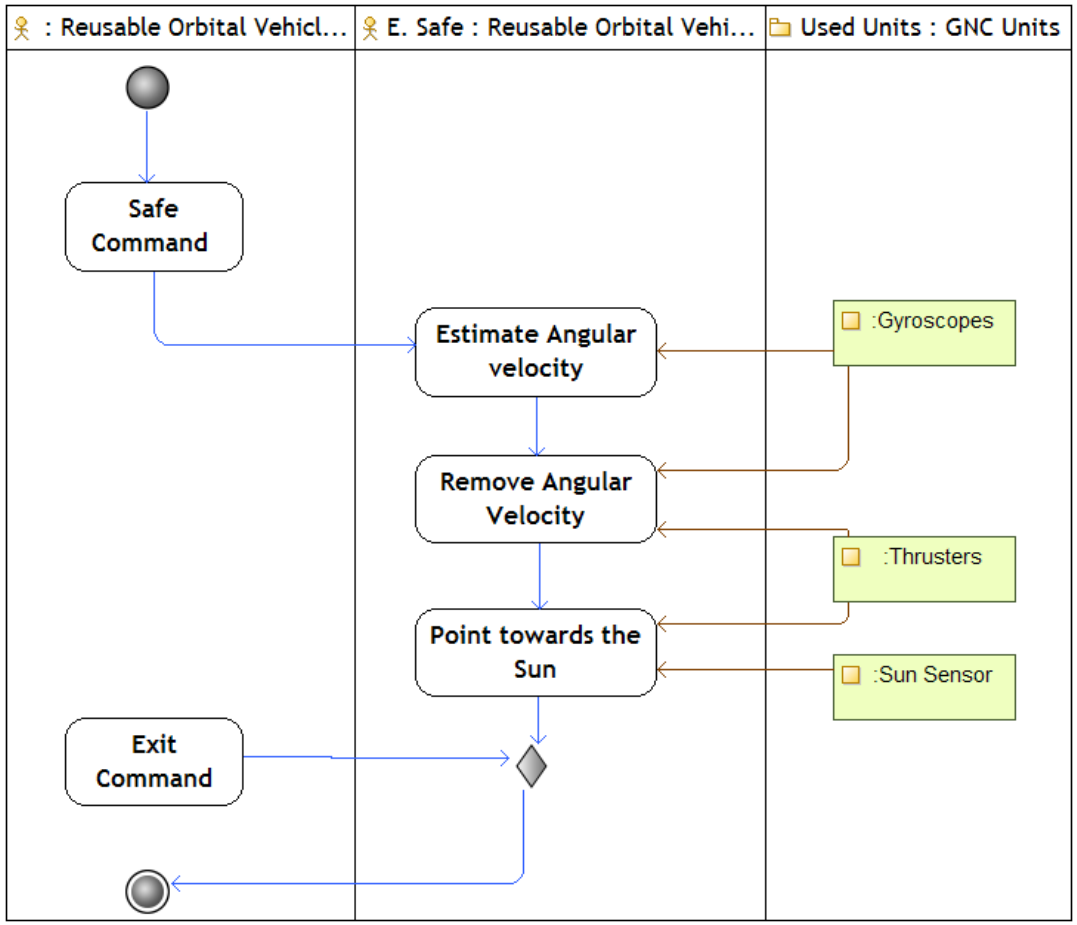
- Space Rider Configuration:
  - ❑ Solar panels perpendicular to Z_{CGB}.
  - ❑ SAS boresight axis is parallel to Z_{CGB}.





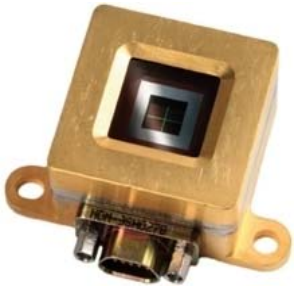
AOCS/GNC Modes - Safe Mode (2/4)

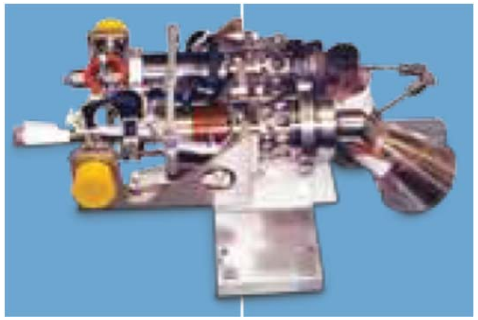
SFM is carried out in orbit according to the following Activity Diagram.

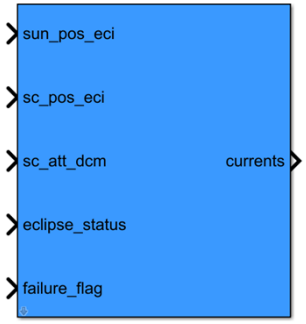


AOCS/GNC Modes - Safe Mode (3/4)

- **AOCS/GNC Units:**
  - SAS x1 (redundant units not included in the design)
  - IMU x1
  - RCS : 6 Thrusters of 220N
  - Modelling: heritage of SENER validated models.

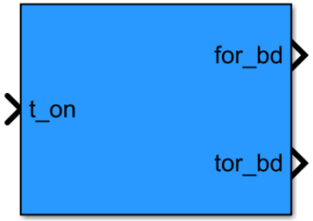






SAS

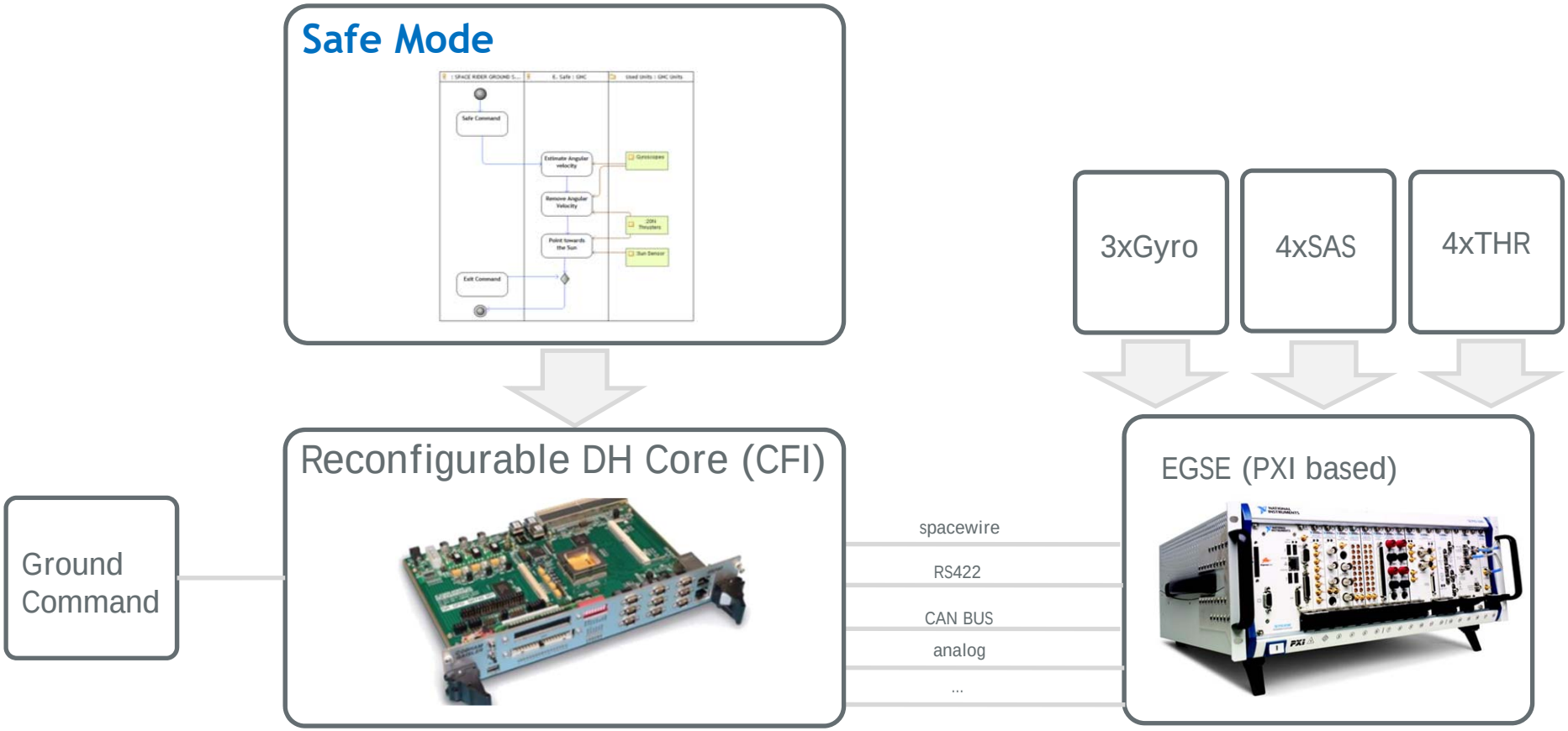
Gyroscope



RCS

AOCS/GNC Modes - Safe Mode (4/4)

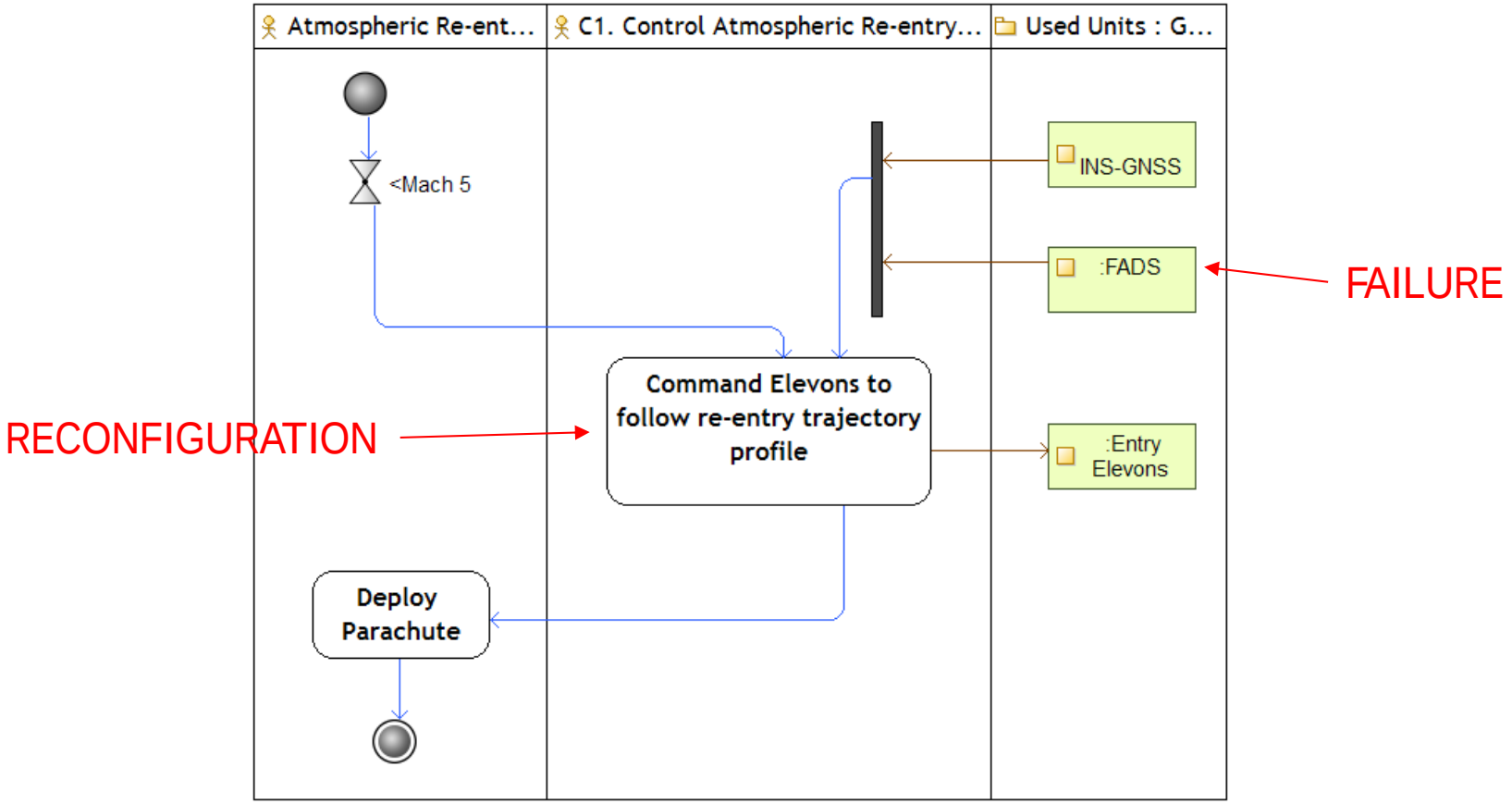
SFM is implemented in CORA as follows:



AOCS/GNC Modes – Re-Entry & TAEM

AOCS/GNC Modes - Re-Entry & TAEM

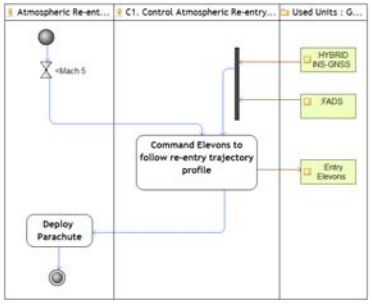
REM starts when Mach <5 and ends at parachute deployment. This mode includes the autonomous FDIR.



AOCS/GNC Modes - Re-Entry & TAEM (cont.)

REM is implemented in CORA as follows:

Re-Entry Mode + FDIR



Reconfigurable DH Core (CFI)

spacewire

RS422

CAN BUS

analog

...

2xGNSS

2xINS

1xFADS

EGSE (PXI based)

2x Elevon

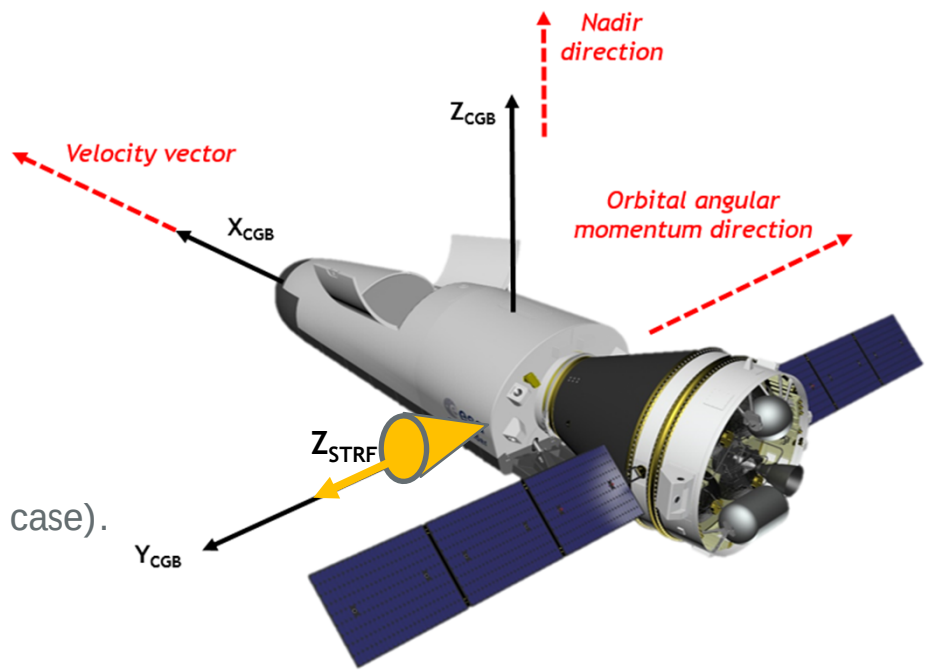
AOCS/GNC Modes - Fine Pointing Mode (1/5)

- **FPM overview:**

  - Objective:
    - ❑ Points the cargo bay to Nadir:
      - ➢ Earth Observation.
      - ➢ Micro-gravity experiments (aerodynamic drag is minimized for this attitude).

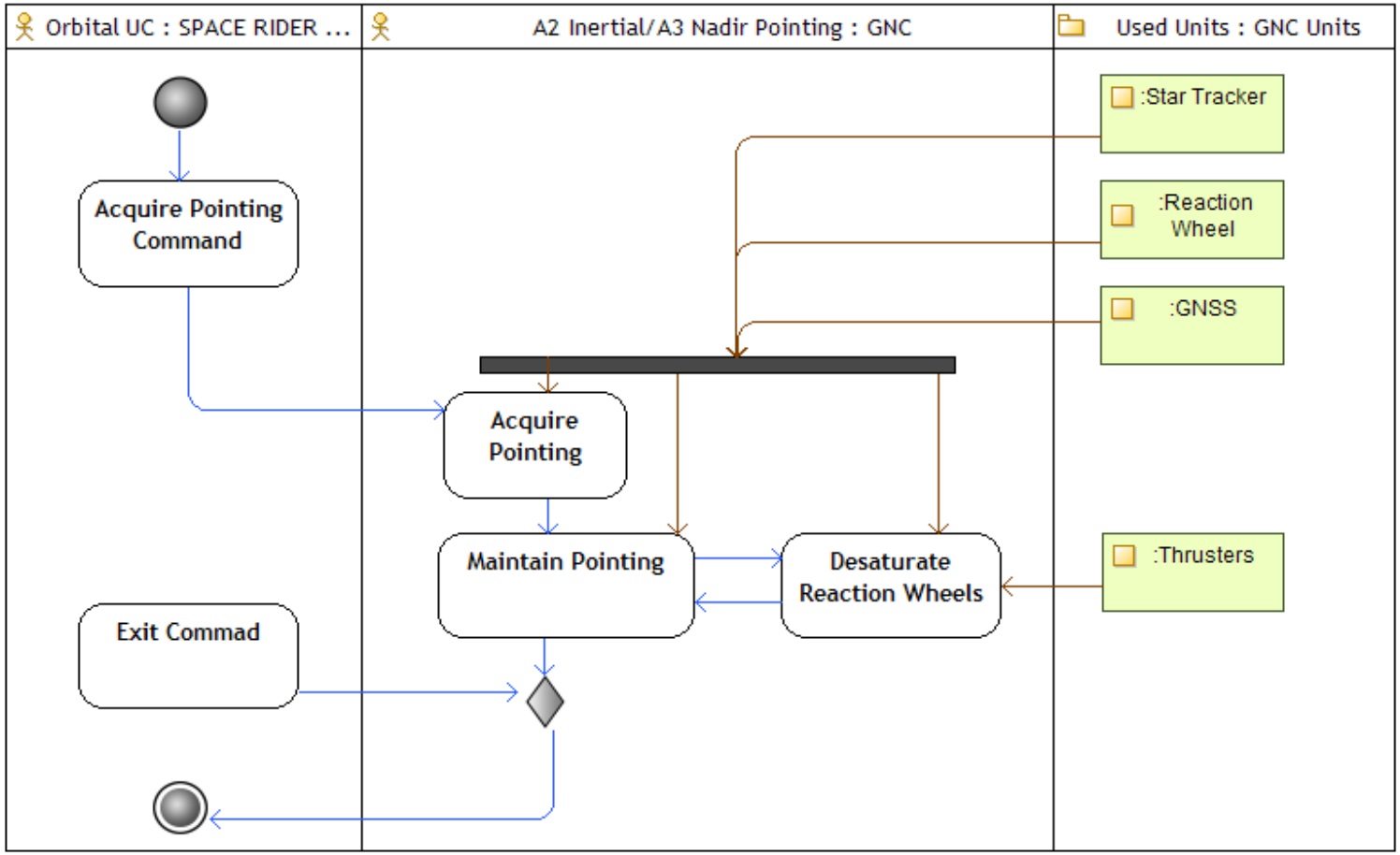
  - Requirements:
    - ❑ Use primary sensors:
      - ➢ STR in Attitude Tracking Mode.
      - ➢ GPS in Attitude Tracking Mode.
    - ❑ Use RWs as actuators.
    - ❑ APE < 0.5º.
    - ❑ Angular rate < 5º/s

  - Space Rider Configuration:
    - ❑ Solar panels perpendicular to X_{CGB} (worst case).
    - ❑ STR boresight axis matches with + Y_{CGB}.
      Sun is out STR FoV with this lay-out.
    - ❑ RWs are not saturated.



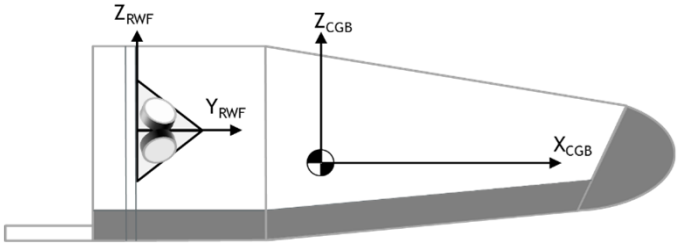
AOCS/GNC Modes - Fine Pointing Mode (2/5)

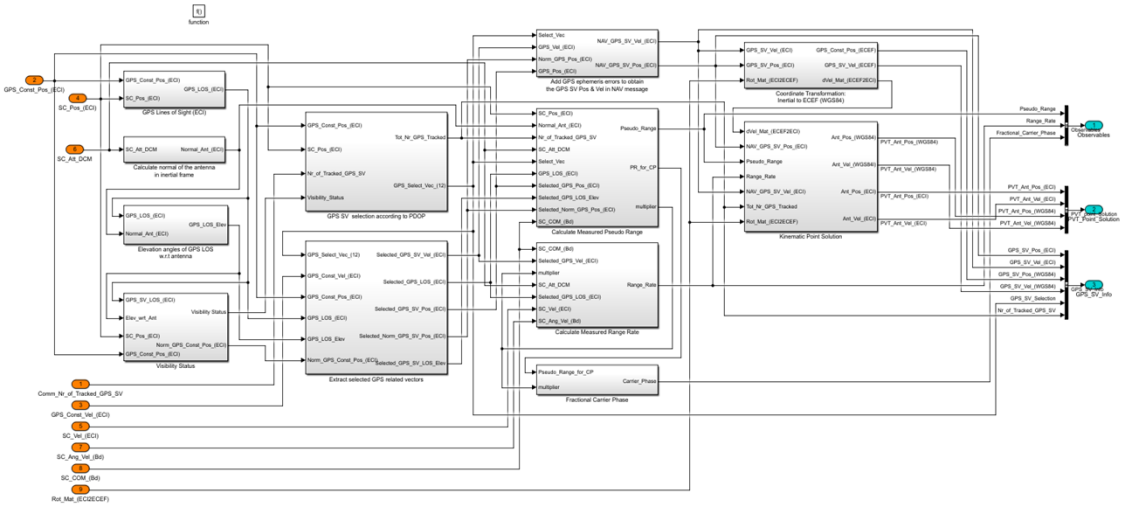
FPM is carried out in orbit according to the following Activity Diagram

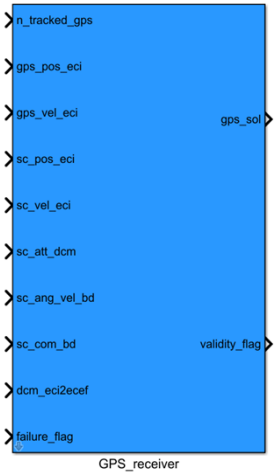


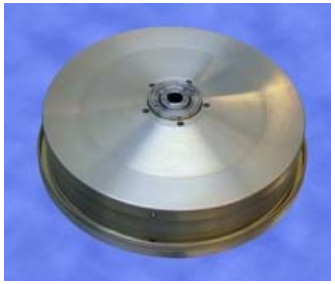
AOCS/GNC Modes - Fine Pointing Mode (3/5)

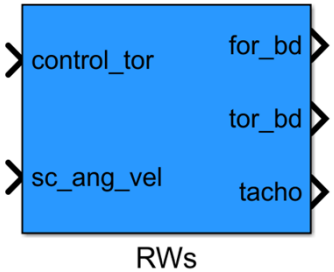
- **AOCS/GNC Units:**
  - STR x1
  - GPS atenna x1
  - RWs : 4 wheels in pyramidal configuration.
  - Modelling: heritage of SENER validated models.







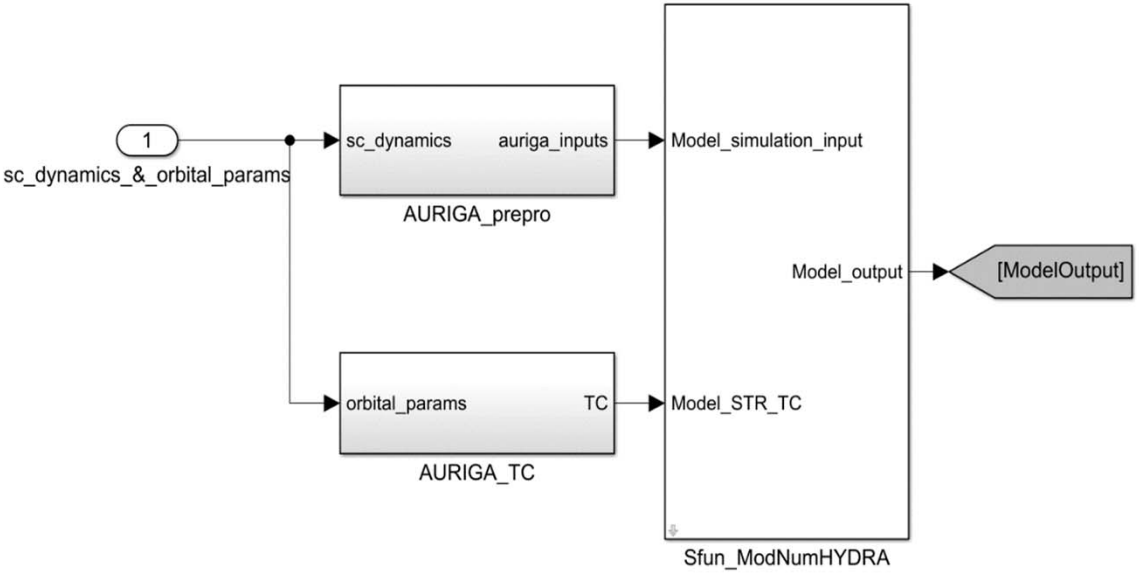


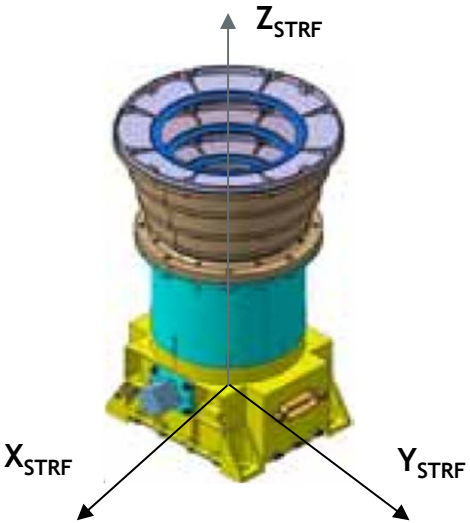


AOCS/GNC Modes - Fine Pointing Mode (4/5)

- **AOCS/GNC Units – AURIGA STR:**

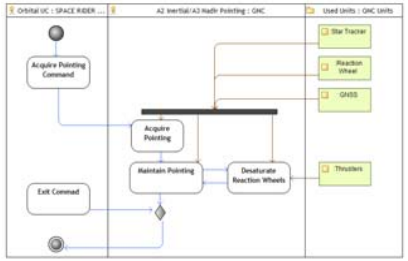
- STR x1
- AURIGA Simulink model provided by Sodern.
- Performances of the attitude tracking mode of the STR.





AOCS/GNC Modes - Fine Pointing Mode (5/5)

Fine Pointing Mode



STR HW

-OHU

-OGSE

spacewire

ethernet

Reconfigurable DH Core (CFI)

Ground Command

spacewire

RS422

CAN BUS

analog

...

EGSE (PXI based)

STR SW

acq & tracking

1xGNSS

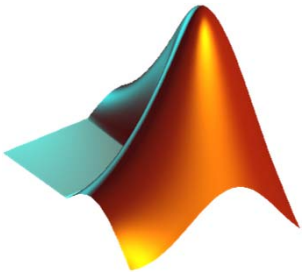
4xRW

4xTHR

Validation Approach

Validation Approach (1/3)

- Close loop tests in Matlab/Simulink:



Performances → Monte Carlo

Functionalities → Single Test

- Open loop tests in TASTE:

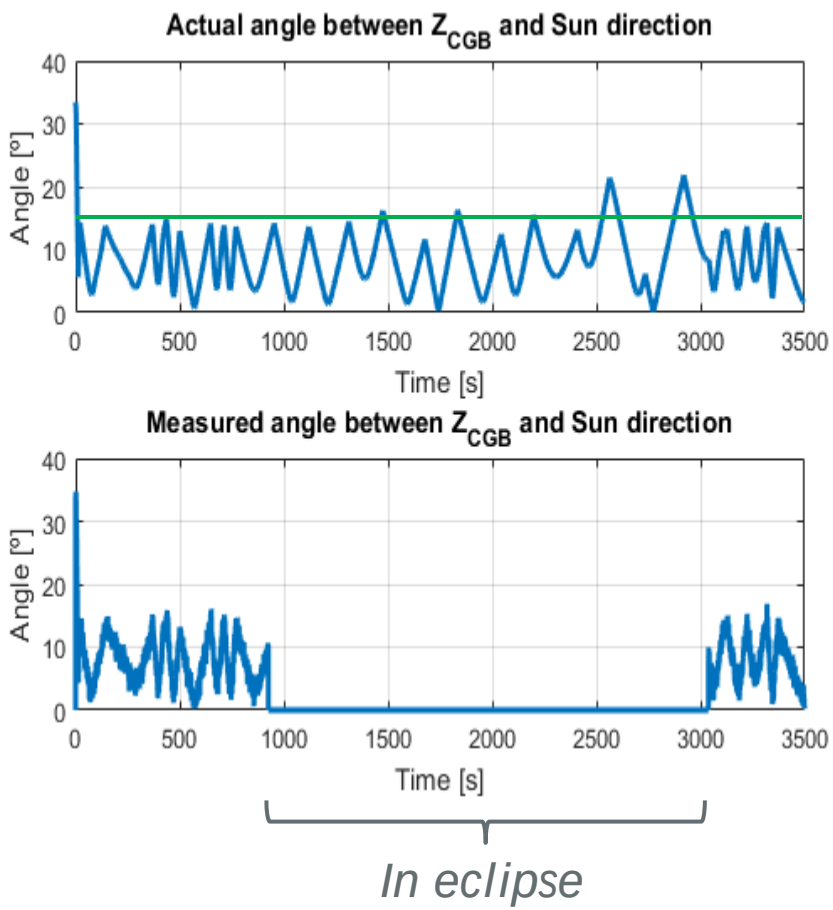
taste
The Assert Set of Tools for Engineering

Software Generation → Single Test

- ❑ Varying bias error of employed sensors between shoots.
- ❑ In order to consolidate design parameter selection.
- ❑ Demonstrate performance and capabilities.
- ❑ Validate software generation and deployment in TASTE

Validation Approach (2/3)

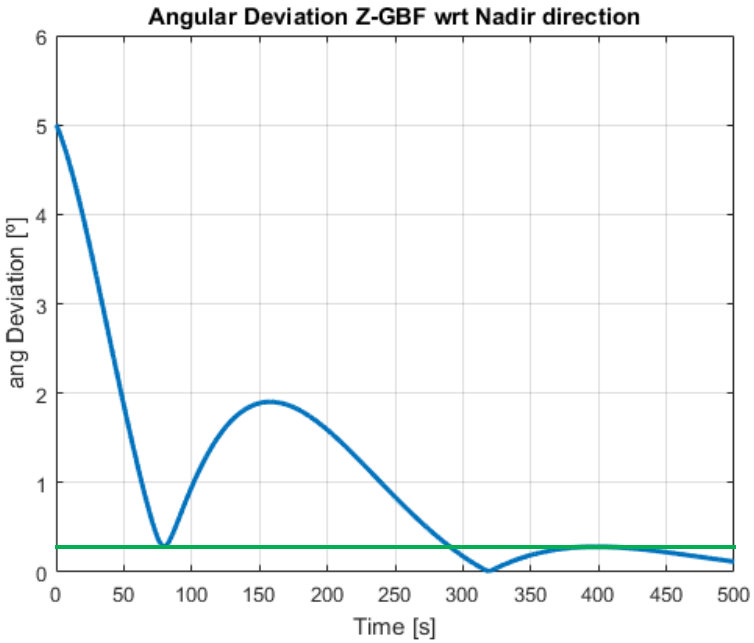
- **SFM Preliminary Results:**



- Initially, the angular deviation is about 35º.
- After 20 seconds the +-15º band is entered and maintained.
- During eclipse the angular deviation increases (error angles are computed from gyro measurements). Only small degradation of GNC performances is observed.
- Performance:
  - ❑ Attitude pointing error < 15º when SAS is illuminated.
  - ❑ Peaks during gyro-based attitude control of 8º over nominal limits.

Validation Approach (3/3)

- **Preliminary Results:**

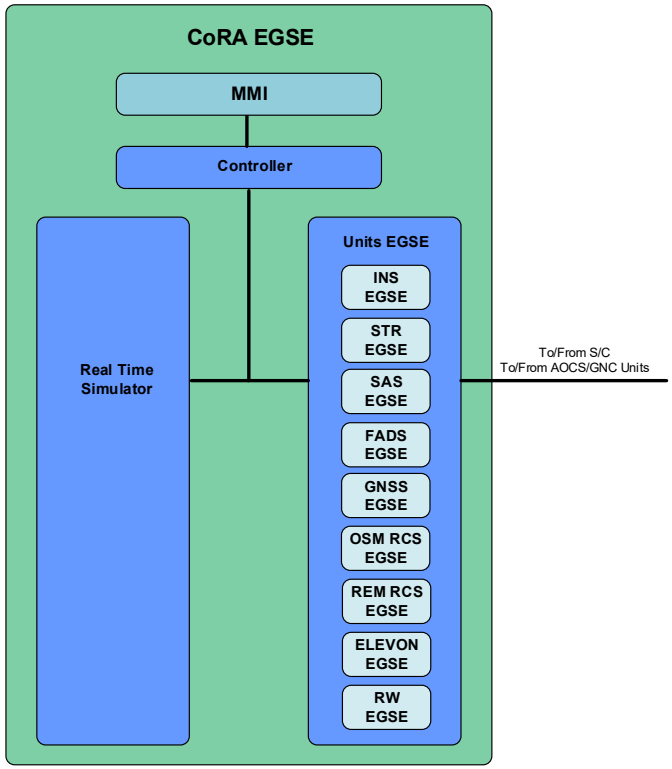


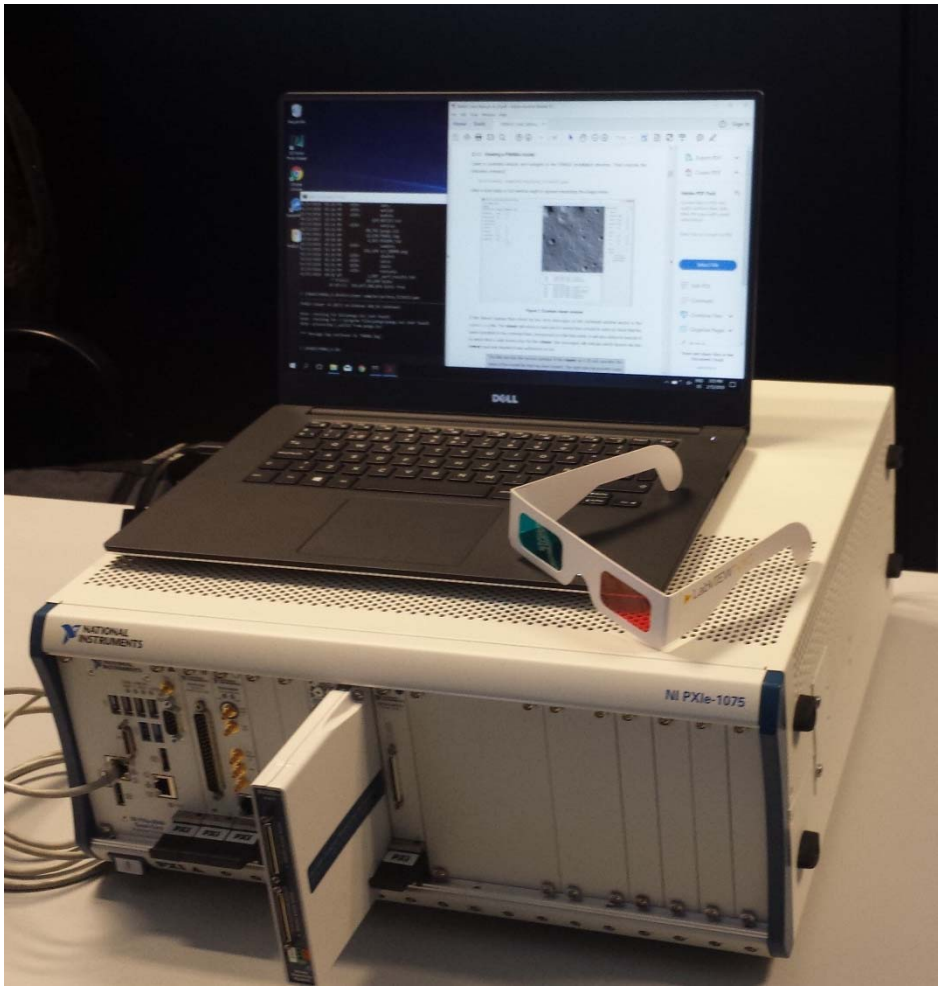
- Initially, the angular deviation is 5º.
- Implemented GNC points Z_{CGB} to nadir.
- Performance:
  - ❑ Attitude pointing error < 0.2º after about t=300s

CoRA EGSE

CoRA EGSE (1/3)

Components:
- MMI.
- Controller.
- Real Time Simulator.
- Units EGSE





CoRA EGSE (2/3)

From this Tab the user has access to:

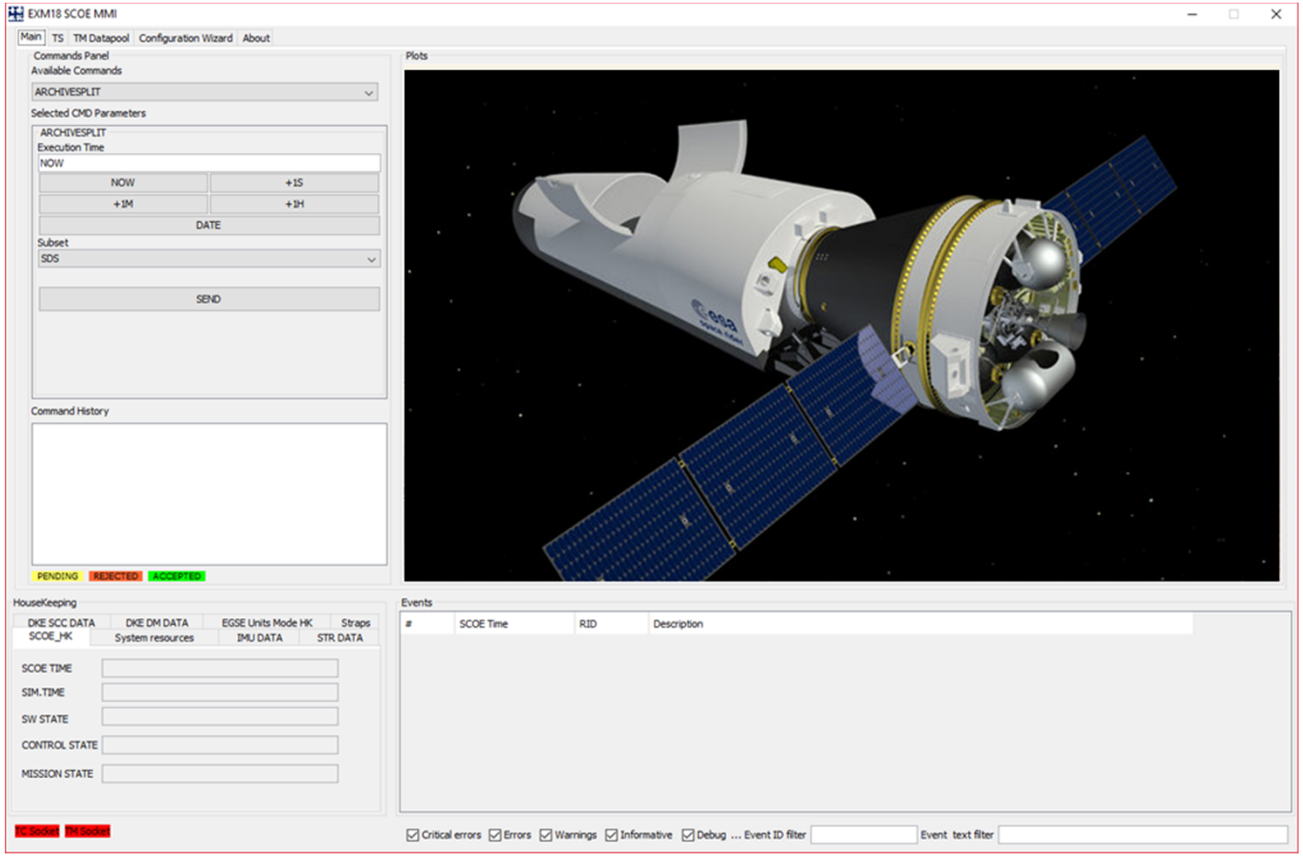
- The **Commands panel,** where the desired command can be selected, its arguments populated and pressing the send button it will be transferred to the SCOE to be executed.

- The **command history panel**, where the sent commands are stored, having a color code which defines the status. Red : command rejected, Yellow : Acceptance pending, Green: command accepted.

- **Housekeeping panel,** where all the cyclic data indicating the status of RTSW housekeeping variables and EGSE units is displayed.

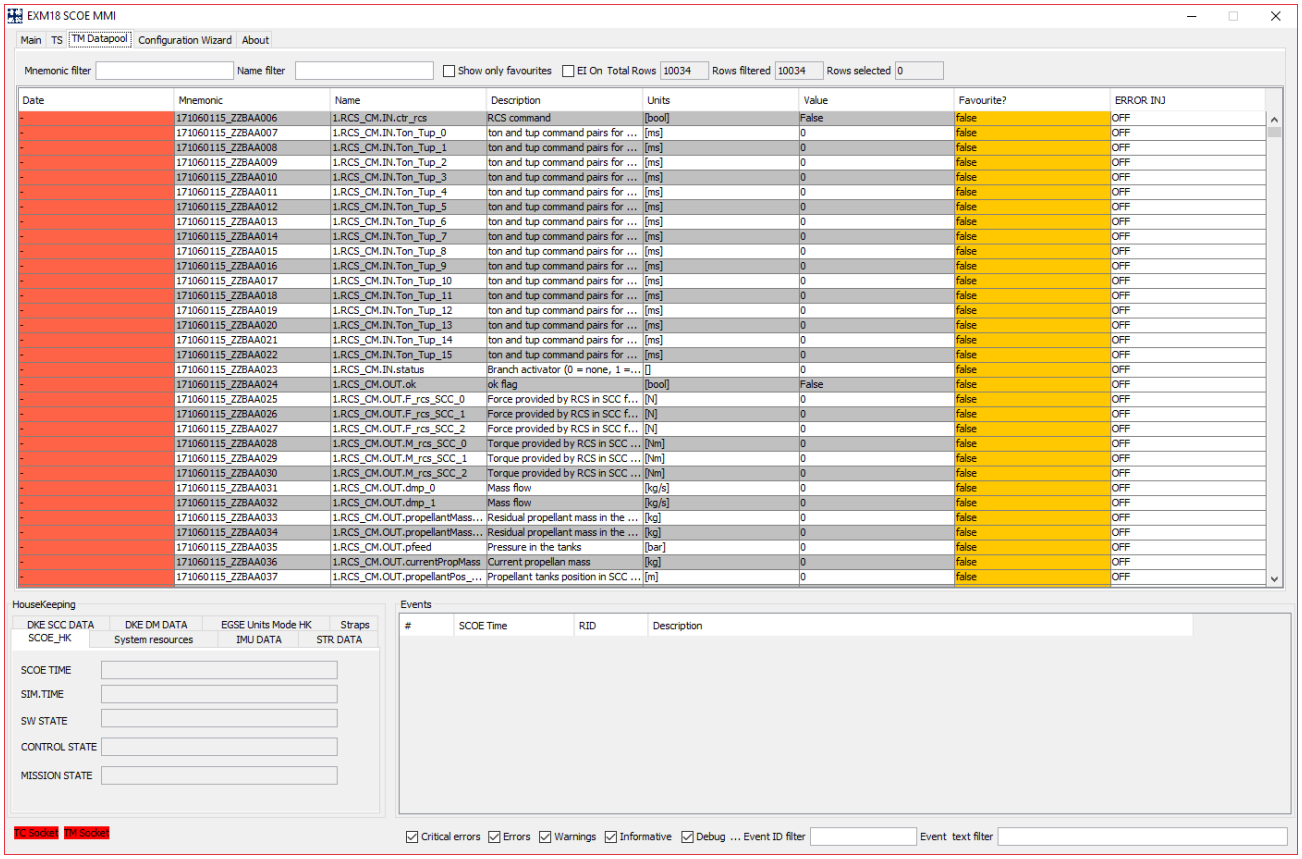
- **Events Panel**, where the log of the SCOE is displayed graphically.

- **Plot Desktop:** Where plots can be added for detailed visualization.



CoRA EGSE (3/3)

The variables of datapool corresponding to the mathematical models and TMTC/OPERATIONAL units are displayed.



Date	Mnemonic	Name	Description	Units	Value	Favourite?	ERROR INJ
-	171060115_ZZBAA006	1.RCS_CM.IN.ctr_rcs	RCS command	[bool]	False	false	OFF
-	171060115_ZZBAA007	1.RCS_CM.IN.Ton_Tup_0	ton and tup command pairs for ...	[ms]	0	false	OFF
-	171060115_ZZBAA008	1.RCS_CM.IN.Ton_Tup_1	ton and tup command pairs for ...	[ms]	0	false	OFF
-	171060115_ZZBAA009	1.RCS_CM.IN.Ton_Tup_2	ton and tup command pairs for ...	[ms]	0	false	OFF
-	171060115_ZZBAA010	1.RCS_CM.IN.Ton_Tup_3	ton and tup command pairs for ...	[ms]	0	false	OFF
-	171060115_ZZBAA011	1.RCS_CM.IN.Ton_Tup_4	ton and tup command pairs for ...	[ms]	0	false	OFF
-	171060115_ZZBAA012	1.RCS_CM.IN.Ton_Tup_5	ton and tup command pairs for ...	[ms]	0	false	OFF
-	171060115_ZZBAA013	1.RCS_CM.IN.Ton_Tup_6	ton and tup command pairs for ...	[ms]	0	false	OFF
-	171060115_ZZBAA014	1.RCS_CM.IN.Ton_Tup_7	ton and tup command pairs for ...	[ms]	0	false	OFF
-	171060115_ZZBAA015	1.RCS_CM.IN.Ton_Tup_8	ton and tup command pairs for ...	[ms]	0	false	OFF
-	171060115_ZZBAA016	1.RCS_CM.IN.Ton_Tup_9	ton and tup command pairs for ...	[ms]	0	false	OFF
-	171060115_ZZBAA017	1.RCS_CM.IN.Ton_Tup_10	ton and tup command pairs for ...	[ms]	0	false	OFF
-	171060115_ZZBAA018	1.RCS_CM.IN.Ton_Tup_11	ton and tup command pairs for ...	[ms]	0	false	OFF
-	171060115_ZZBAA019	1.RCS_CM.IN.Ton_Tup_12	ton and tup command pairs for ...	[ms]	0	false	OFF
-	171060115_ZZBAA020	1.RCS_CM.IN.Ton_Tup_13	ton and tup command pairs for ...	[ms]	0	false	OFF
-	171060115_ZZBAA021	1.RCS_CM.IN.Ton_Tup_14	ton and tup command pairs for ...	[ms]	0	false	OFF
-	171060115_ZZBAA022	1.RCS_CM.IN.Ton_Tup_15	ton and tup command pairs for ...	[ms]	0	false	OFF
-	171060115_ZZBAA023	1.RCS_CM.IN.status	Branch activator (0 = none, 1 =...	[]	0	false	OFF
-	171060115_ZZBAA024	1.RCS_CM.OUT.ok	ok flag	[bool]	False	false	OFF
-	171060115_ZZBAA025	1.RCS_CM.OUT.F_rcs_SCC_0	Force provided by RCS in SCC f...	[N]	0	false	OFF
-	171060115_ZZBAA026	1.RCS_CM.OUT.F_rcs_SCC_1	Force provided by RCS in SCC f...	[N]	0	false	OFF
-	171060115_ZZBAA027	1.RCS_CM.OUT.F_rcs_SCC_2	Force provided by RCS in SCC f...	[N]	0	false	OFF
-	171060115_ZZBAA028	1.RCS_CM.OUT.M_rcs_SCC_0	Torque provided by RCS in SCC ...	[Nm]	0	false	OFF
-	171060115_ZZBAA029	1.RCS_CM.OUT.M_rcs_SCC_1	Torque provided by RCS in SCC ...	[Nm]	0	false	OFF
-	171060115_ZZBAA030	1.RCS_CM.OUT.M_rcs_SCC_2	Torque provided by RCS in SCC ...	[Nm]	0	false	OFF
-	171060115_ZZBAA031	1.RCS_CM.OUT.dmp_0	Mass flow	[kg/s]	0	false	OFF
-	171060115_ZZBAA032	1.RCS_CM.OUT.dmp_1	Mass flow	[kg/s]	0	false	OFF
-	171060115_ZZBAA033	1.RCS_CM.OUT.propellantMass...	Residual propellant mass in the ...	[kg]	0	false	OFF
-	171060115_ZZBAA034	1.RCS_CM.OUT.propellantMass...	Residual propellant mass in the ...	[kg]	0	false	OFF
-	171060115_ZZBAA035	1.RCS_CM.OUT.pfeed	Pressure in the tanks	[bar]	0	false	OFF
-	171060115_ZZBAA036	1.RCS_CM.OUT.currentPropMass	Current propellan mass	[kg]	0	false	OFF
-	171060115_ZZBAA037	1.RCS_CM.OUT.propellantPos_...	Propellant tanks position in SCC ...	[m]	0	false	OFF

Conclusions

Conclusions

This presentation contains an overview of the CoRA SAGE activity.

It presents:

- The SAGE Objectives
- The role of the consortium formed by SENER, SODERN and DEIMOS
- The Space Rider Baseline Mission.
- The selected AOCS/GNC Modes and in particular:
  - Safe Mode (SFM).
  - Re-Entry and TAEM Mode (REM).
  - Fine Pointing Mode (FPM).
- The AOCS/GNC Validation Approach
- And finally the CoRA EGSE that will be delivered to ESTEC.

La manera de ver el futuro

1956-2016

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