MICROSCOPE OPERATIONS

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November 16th, 2015
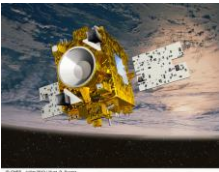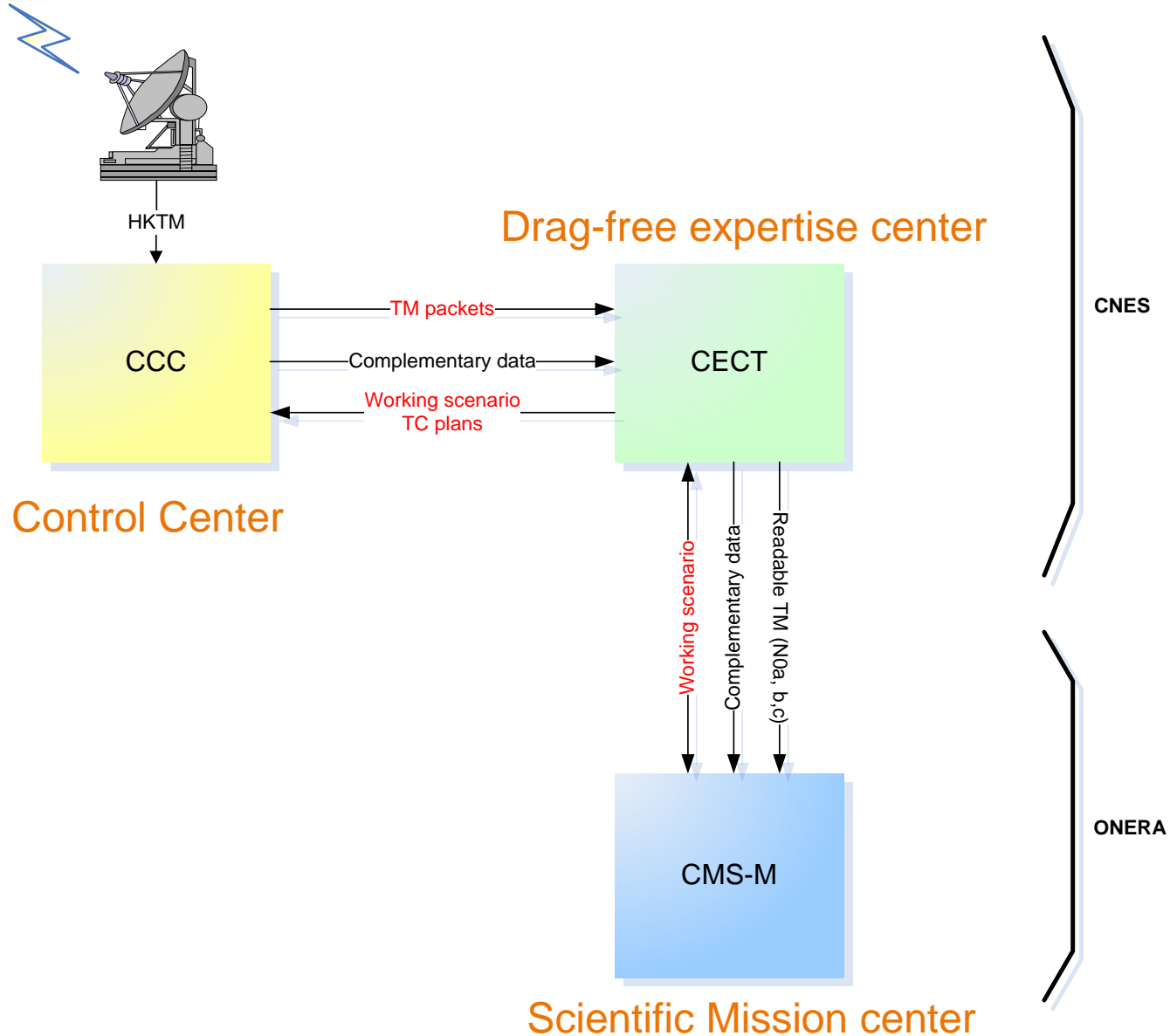
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Introduction: the ground segment

HKTM

Drag-free expertise center

CCC

CECT

TM packets

Complementary data

Working scenario
TC plans

Control Center

Working scenario

Complementary data

Readable TM (N0a, b,c)

CNES

ONERA

CMS-M

Scientific Mission center

Introduction: the ground segment

3 main entities composing the ground segment

✦ Command and Control Center **CCC**
  » Almost generic CNES MYRIADE CCC
  » Connected to CNES ground stations network
  » Platform handling (programming and monitoring)
  » AACS handling outside mission modes

✦ Drag free expertise center **CECT**
  » Specific center for MICROSCOPE
  » Output N0 mission data (TM, orbit and attitude determination)
  » Mission programming implementation (T-SAGE and AACS)
  » Monitoring of the status and performance for T-SAGE environment (drag-free, propulsion, thermal…)

✦ Scientific mission center for Microscope **CMSM**
  » Payload and mission monitoring
  » Mission programming definition
  » Scientific processing (N1 data for calibration, N2 for EP evaluation)
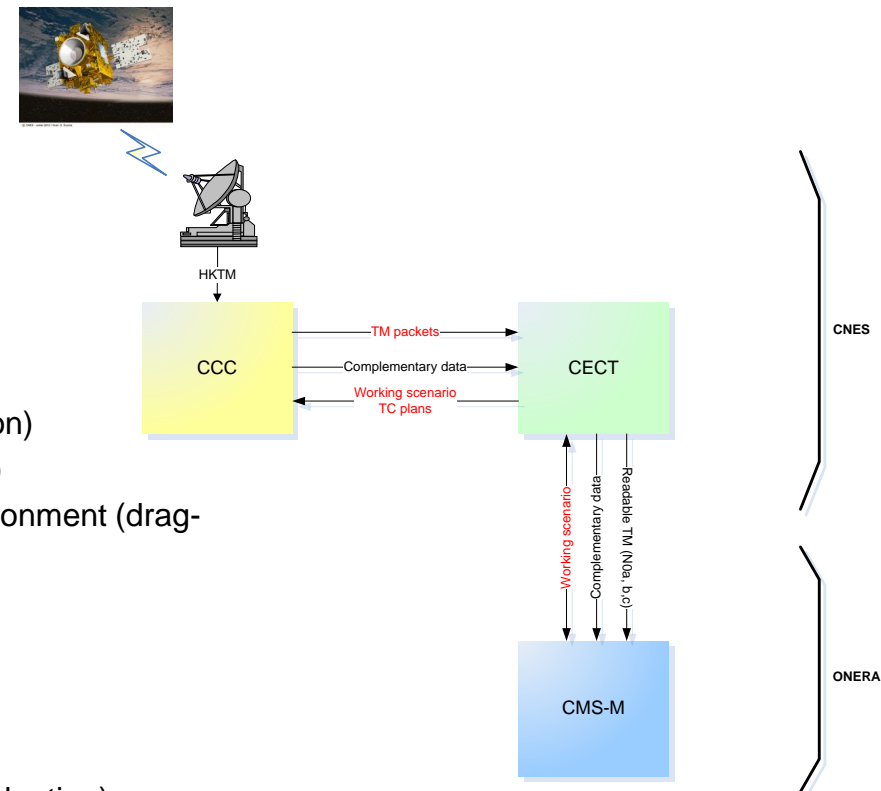
Introduction: back to the future…

● MICROSCOPE was successfully launched on the 09th of August 2015

● It evolves on a sun synchronous orbit at 707km altitude
   (1 orbit lengths 1h40min)

● 2 months were necessary for the commissioning of the complex spacecraft and overall system

● 1 month was dedicated to preliminary tests

● We are now on the 16th of November 2015, mission is running…
What happened last week onboard and around MICROSCOPE?

Operational chronogram

Let's enter into the operational chronogram…

Each day:

- ✦ **Everyday activities**
- ✦ **Specific activities**

Monday the 09th of November, 2015

Monday activities

✦Scenario update (CMSM, based on SWG inputs)

» Will serve as input for the Tuesday GPOM meeting and scenario approval

» List of sessions executed / to be performed
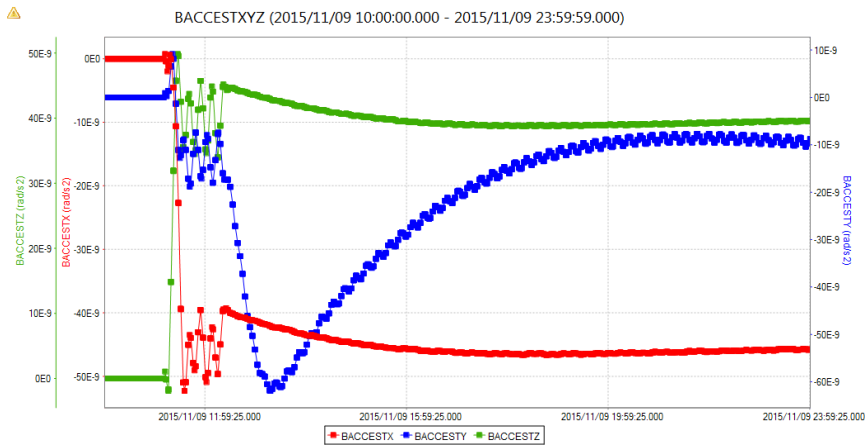(calibration, EP tests in inertial/spinning mode…)

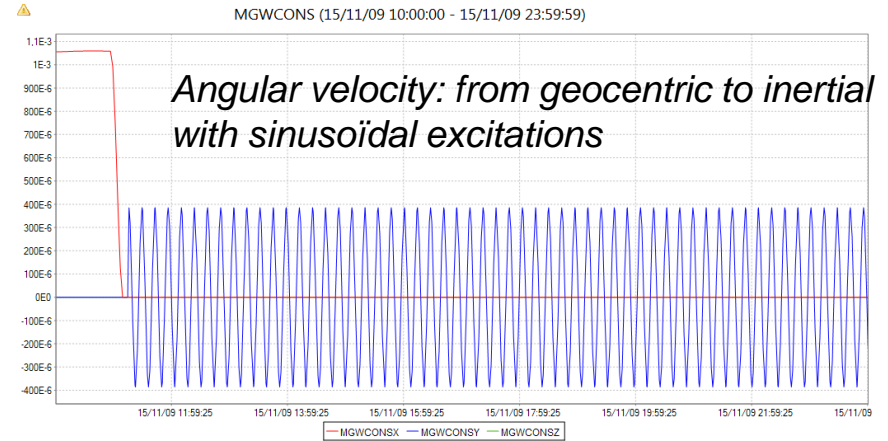Scenario MICROSCOPE : mic_cmsm_scenarioTravail (: 2427)

Everyday activities

✦Onboard activities (automatic execution, 2 weeks autonomy)

» Transition at 13:12:11 to CAL_deltaY, *10 orbits session to assess mass off-centring*

Angular velocity: from geocentric to inertial with sinusoïdal excitations

Attitude estimator convergence (angular biases)

8 thrusters commands (max 300μN)

Monday the 09th of November, 2015
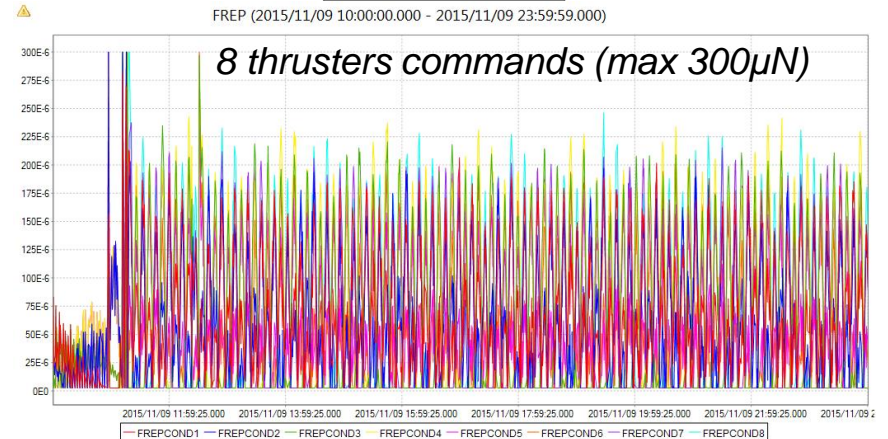
Everyday activities

✦Pass planning, ground stations management

» ~8 passes per day with CCC – ground station – spacecraft connection

» Automatic telemetry retrieval, 260Mbytes/day

» Use of resources shared with other CNES missions

(optimization of ground stations reservation)
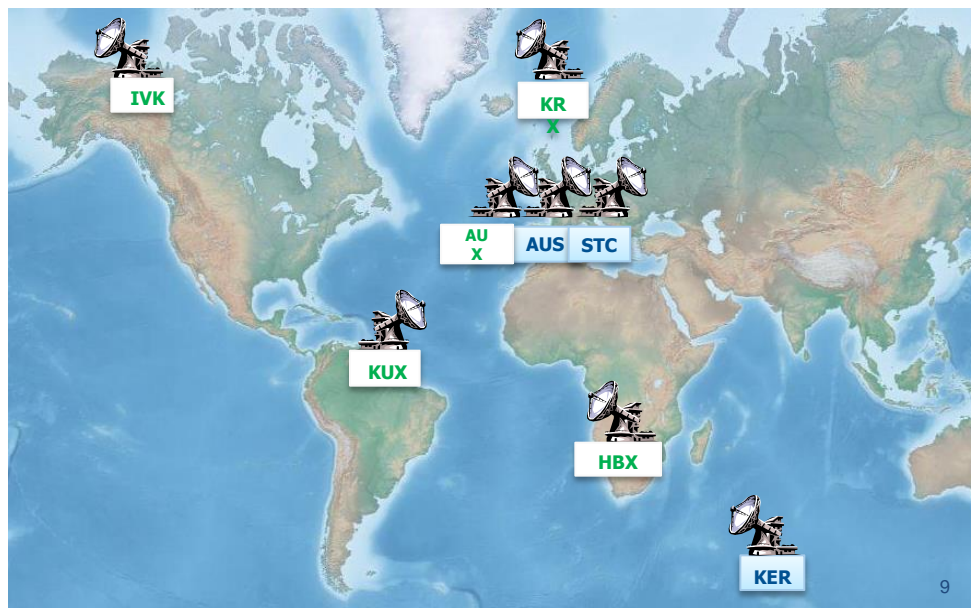
Station	AOS time	Duration
MIC-IVK	01:17:00	11'42
MIC-HBK	03:33:42	09'43
MIC-AUS	04:54:58	08'21
MIC-AUS	06:32:09	11'33
MIC-KRX	11:16:33	09'05
MIC-AUS	16:03:24	09'23
MIC-AUS	17:40:04	11'27
MIC-IVK	22:47:42	09'49

Monday the 09th of November, 2015

Everyday activities

✦ Monitoring: automatic alarms & warning reviewed in working hours

» CCC: after each pass, monitors platform parameters

» CECT: after each pass, monitors drag-free parameters w.r.t. scenario

» CMSM: every day, monitors payload parameters w.r.t. scenario

✦ Operational orbit determination (CCC): update of orbital events (for ground stations designation, collision monitoring…)

based on GPS + Doppler measurement

✦ N0b daily packaging of TM by CECT for CMSM

» All the TM is extracted from binary downloaded data, raw values are transferred into a physical and readable format to CMSM

» Operational orbit determination and prediction is added

Tuesday the 10th of November, 2015

Everyday activities

◆ Onboard activities (automatic): transition to CAL_tetacZIS1grav, *40 orbits session to assess misalignments*

Angular biases estimator (depends on the drag-free point)

Angular velocity: end of sinusoïdal attitude excitation, back to inertial

Start of TSAGE mass sinusoïdal excitation (12µm)

8 thrusters commands (max 300µN)

Tuesday, the 10th of November, 2015
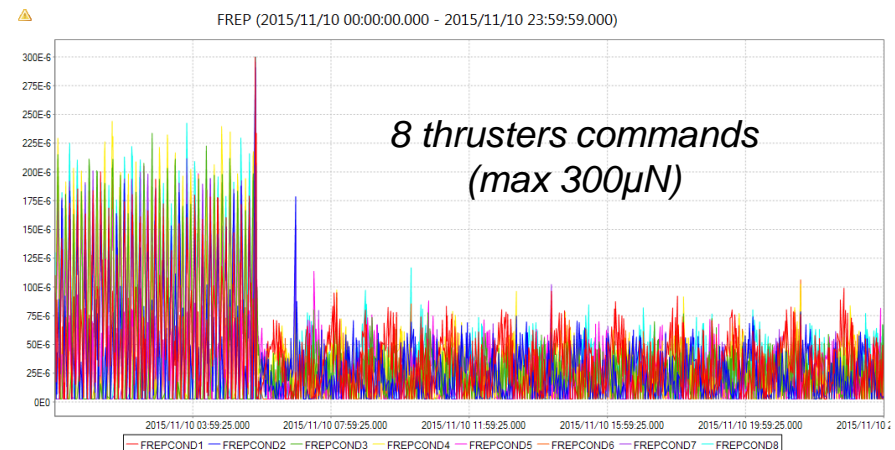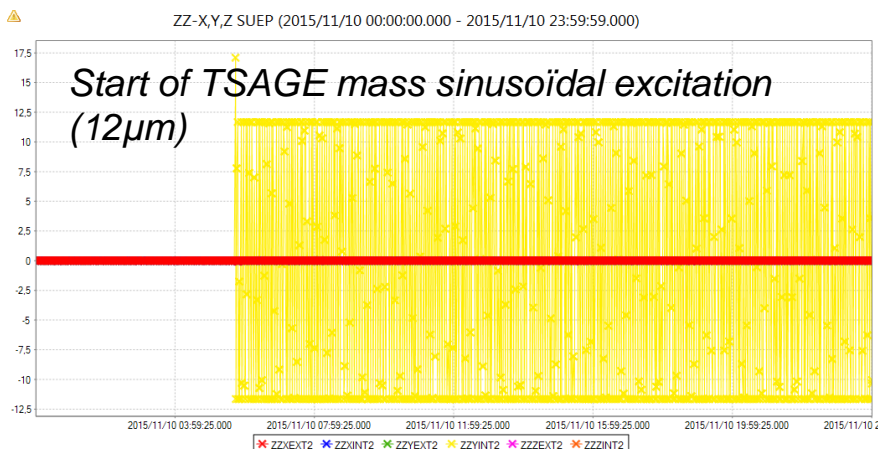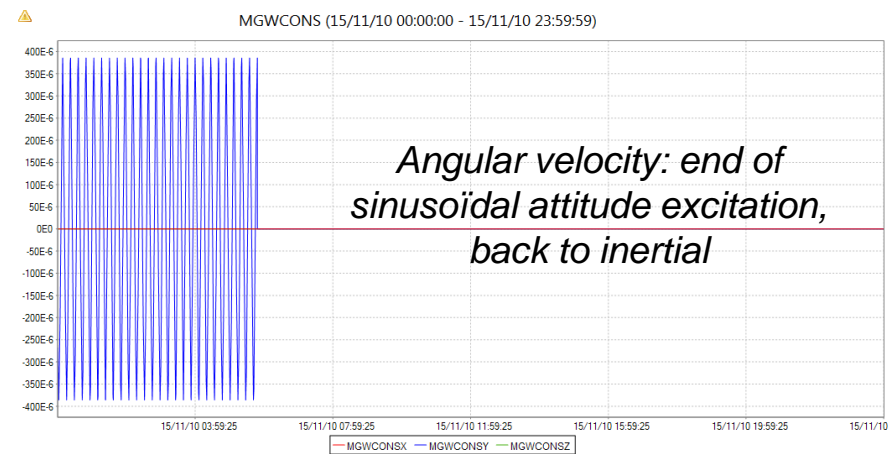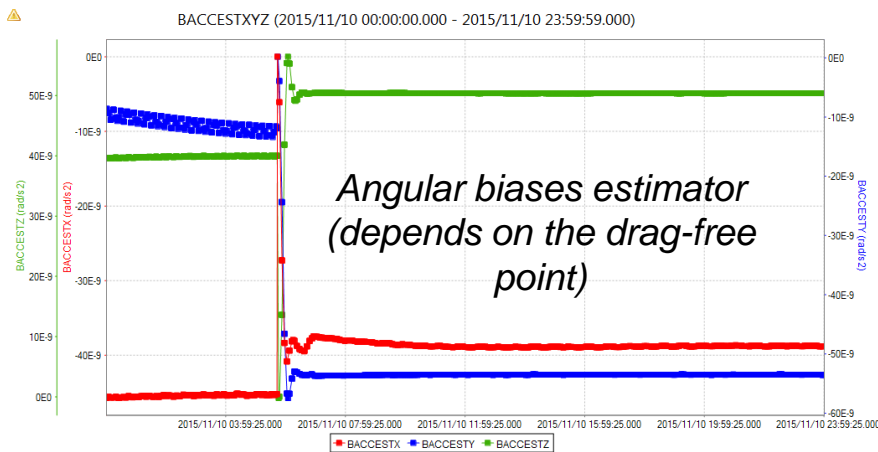
Everyday activities

✦ TM retrieval, Monitoring, orbit determination, N0b… as usual

Tuesday activities

✦ GEX expertise group weekly meeting (CECT, morning)

» Expertise tools products analyses, for N0c packaging (session by session)

● ORAMIC: fine attitude determination (accelero-stellar hybridation)

● GAZMIC: propulsion and gas consumption expertise

● ZOOMIC: fine orbit determination (GPS and Doppler measurements)

» Expertise of the previous alarms

● *e.g. check that singular events on the linear acceleration is "normal", due to µ-debris impacts*

ACCLIN (2015/11/10 00:00:00.000 - 2015/11/10 23:59:59.000)

Tuesday, the 10th of November, 2015
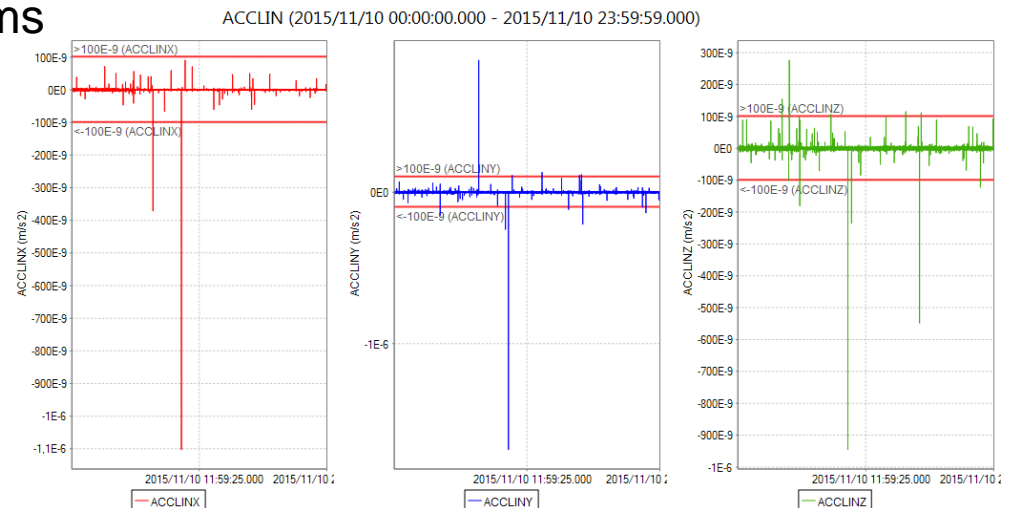
Tuesday activities

✦ GPOM weekly meeting (CCC+CECT+CMSM, afternoon)

» Review of the previous week mission operations

» Validation and acceptation of the N0c products
  ● Uploaded to CMSM for N1,N2 data processing
  ● Previous week telemetry, session by session with fine attitude and orbit determination

» Consolidation, validation and approval of the mission scenario for the next 2 weeks

✦ CECT mission programming:

» Based on the mission scenario and a library of pre-qualified (simulation) sessions forms

» AACS and payload telecommands computed by CECT to ensure correct transition from one session to the following

» Attitude guidance is computed by CCC in accordance with CECT outputs

Operational chronogram

Wednesday the 11th of November, 2015

Wednesday, the 11th of November, 2015

Everyday activities

- Onboard activities: CAL_tetacZIS1grav in progress
- TM retrieval, Monitoring, orbit determination, N0b… as usual

Wednesday activities

- Nothing scheduled on Wednesdays, backup for the programming
- Remark: 11th of November was a day off, CCC, CECT, CMSM closed
  - » Autonomy of the system: everything works, but no data analysis
  - » CCC alert if transition to safe mode or collision risk (spacecraft safety)

FREP (2015/11/11 00:00:00.000 - 2015/11/11 23:59:59.000)
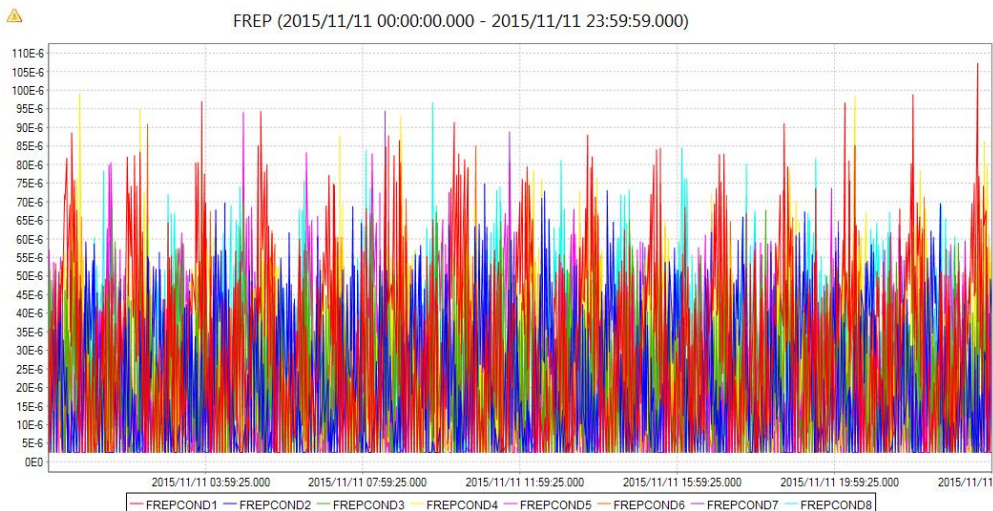
Thrusters commands, nothing to declare…

Operational chronogram

Thursday the 12th of November, 2015

Thursday, the 12th of November, 2015

Everyday activities

✦ Onboard activities: CAL_tetacZIS1grav always in progress…

✦ TM retrieval, Monitoring, orbit determination, N0b… as usual

Thursday activities

✦ Early morning: platform (Rx/Tx) and guidance programming (CCC)

✦ Morning GCO: operational coordination meeting (CCC+CECT)

» Review of the past ground segment and platform operations

» Acceptance of the coming ground segment and platform operations

✦ Afternoon: upload all the telecommands plans → ensures 14 days of onboard autonomy *(AACS + payload from CECT ; platform + guidance from CCC)*

Operational chronogram

Friday the 13th of November, 2015

Friday, the 13th of November, 2015

Everyday activities

- ✦Onboard activities: transition to CAL_tetacYIS1grav, another calibration session to assess misalignements
- ✦TM retrieval, Monitoring, orbit determination, N0b… as usual

Friday activities

- ✦Nothing scheduled on Fridays

Saturday and Sunday, the 14th-15th of November, 2015

Everyday activities

✦ TM retrieval, Monitoring, orbit determination, N0b… as usual but
- » Warning & alarms review performed by operators the next Monday
- » CCC alert if transition to safe mode or collision risk (spacecraft safety)

✦ Onboard activities: Moon avoidance…
- » Every 28 days the Moon enters into the star tracker field of view
- » Switch to coarse mode is necessary: mission in pause for a few days
- » Automatically handled via the mission scenario and all the associated mechanisms

◆Onboard activities: Moon avoidance…

Etats SCAA SAGE (2015/11/15 08:00:00.000 - 2015/11/16 09:00:00.000)

TSAGE back to Full Range Mode

SC back to coarse mode
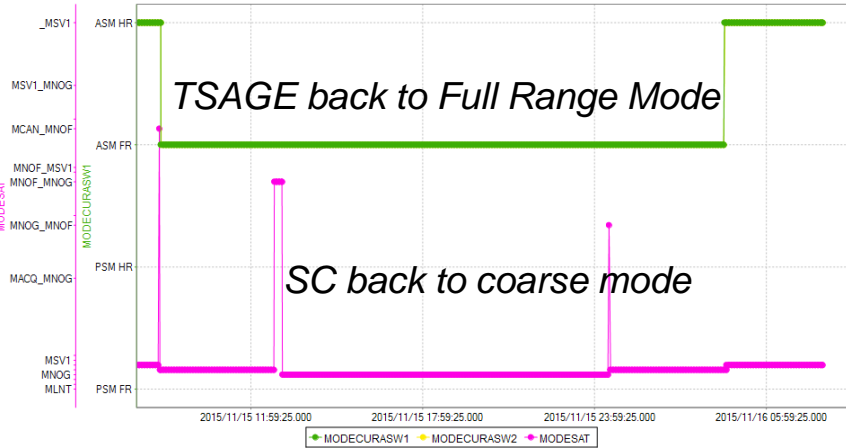
MGWCONS (15/11/15 08:50:00 - 15/11/16 09:00:00)

Attitude guidance: transition to spinning mode
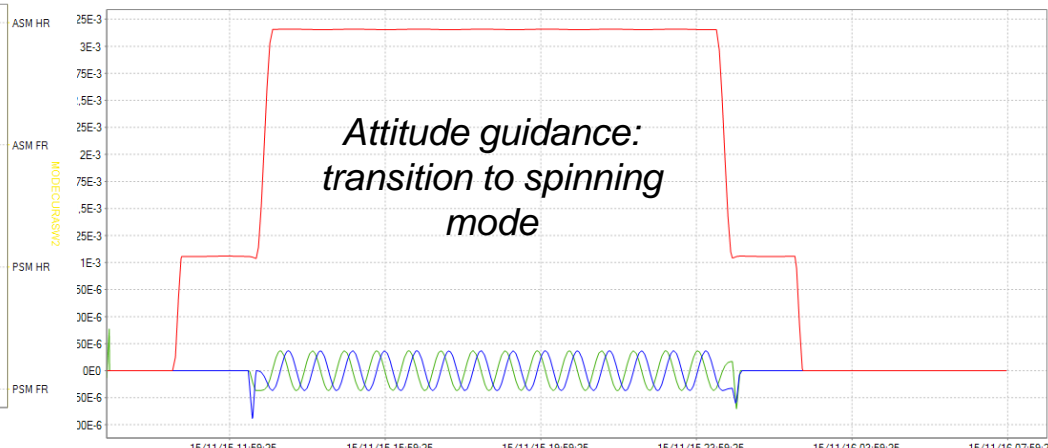
FREP (2015/11/15 08:50:00.000 - 2015/11/16 09:00:00.000)

Thrusters command to set SC in coarse mode (spinning attitude), then switch off propulsion to control with magneto-torquers
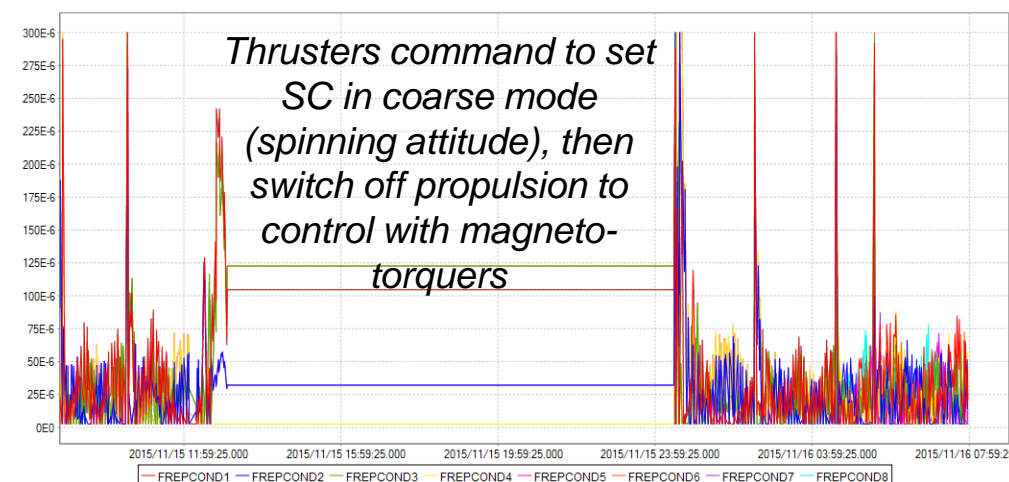
Then one more week of operations is done, good job…

Conclusion

✦Operational activities have been presented (daily, weekly)

✦Operational centers, meetings

CCC		**CECT**		**CMS**

GCO **GPOM**

Operational coordination
1h / week

CCC Ops
Platform & Ground Segment

CECT Ops
*Mission &
Drag-free monitoring*

CMS Ops
*Mission &
Payload monitoring*

Implementation, processing and 1st analysis
Daily

GEX
*Payload environment
expertise*

SPG
*Payload,
Performance & Science*

Processing and analysis, expertise
Weekly + on request

SWG

Mission performance and scenario supervision
Scientific exploitation
Monthly + when required

Conclusion

- What you've seen will soon be reality
- Asynchronous and/or continuous data analysis is also performed by experts in CECT and CMSM
- It was "real data" in live from the running QO-11 test:
  - ✦ operational qualification for the routine operations
  - ✦ 15 days test, with real time operations
- It relies on a very representative simulator:
  - ✦ BVSS: real time simulator including an OnBoard Computer and all its interfaces with the simulated equipment
  - ✦ SUSON: TSAGE simulator including an EM of the payload electronic, running at 1kHz in closed loop with the BVSS

Conclusion

Status of the system qualification:

- All the subsystems have been individually validated (2013-2014)
- Compatibility tests between all the subsystems have been achieved (autumn 2014)
- Functional tests with all the subsystems connected have been achieved to verify the overall system requirements (2014-2015)
- We are now performing the operational qualification: verify the operational organization and flight procedures in representative conditions (nov. 2015 – march 2016)

- Remaining major tests:
  - » Commissioning phase validation ("compressed to" 15 days, in December)
  - » LEOP validation (Launch and Early Operations, 2 days, 3 tests in Jan, Feb, March)