



# Experiment scenarii description

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**FFIORD Seminar – March 7th, 2012**

# Summary

## ■ Nominal mission

- ♦ Scenarii definition
- ♦ Timeline

## ■ Extended mission

- ♦ Scenarii definition
- ♦ Timeline



## ■ FFIORD Mission summary:

- ♦ 12 days: GNC closed loop with RF navigation
- ♦ 43 days: GNC open loop → FFRF sensor and RF navigation full validation
- ♦  $dV = 6 \text{ m/s}$

	Trajectory definition	Trajectory control	Objective
<b>Passenger experiment</b>	PRISMA	PRISMA	FFRF sensor and RF navigation functional validation
<b>Open loop primary experiment</b>	PRISMA	PRISMA	FFRF sensor and RF navigation functional validation and performance assessment , preliminary validation of guidance / control functions
<b>Closed loop primary experiment</b>	FFIORD	FFIORD	GNC FFIORD validation based on RF navigation estimation and long duration experiment



# FFIORD Nominal Mission Timeline

FFRF SENSOR CHECKOUT	1 day 21/06/2010	Basic health check via TM/TC exchange (no RF signal)
FFRF SENSOR VALIDATION	12 days 30/08/2010	FFRF sensor commissioning and basic characterization
FFRF INIT	3 days 15/09/2010	FFRF sensor characterization and calibration, functional tests and performance evaluation
FFRF ENVELOPE	10 days 07/10/2010	FFRF sensor characterization on a wide domain. RF multipath calibration. FFIORD GNC pre-validation in open loop.
FFRF GNC1 Part 1	4 days 28/10/2010	Sequential commissioning in CL of all FFIORD GNC “core” part functionalities
FFRF PASSENGER NEAR	13 days 24/01/2010	FFRF sensor characterization at very close distances (down to 3 m)
FFRF GNC1 Part 2	2 days 12/02/2011	Sequential commissioning of all FFIORD GNC functionalities
FFRF PASSENGER FAR	2 days 15/02/2011	FFRF sensor characterization at very long distances (up to 31 km)
FFRF GNC2	2 days 24/02/2011	Repetition of GNC1 with different conditions
FFRF GNC3	4 days 10/03/2011	Long term formation flying operations



Passenger  
experiments

FFRF SENSOR CHECKOUT	1 day 21/06/2010
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FFRF GNC3	4 days 10/03/2011



# PASSENGER

## ■ CHECKOUT 1 day

- ♦ Check equipment power, temperature, mode transition and basic TM (no RF signal)

## ■ SENSOR VALIDATION 12 days

- ♦ **FFRF commissioning**
  - functional behaviour, signal acquisition in LP/HP, Data handling over FFRF ISL , TM emission and ground retrieval TC acceptance and execution, NPU configuration
- ♦ **Clock bias and timing services (synchronization)**
- ♦ **FFRF performance on distance and LoS measurements**
- ♦ **NAV commissioning and performance**
- ♦ **Antenna handover**

## ■ PASSENGER NEAR 13 days

- ♦ **Test functional behaviour and performance of FFRF subsystem in eclipse period at short distance from 360m to 3m**
  - Half of the experiment run during eclipses period with periodical OFF/ON of the Target FFRF sensor.
  - 2nd half was run outside of the eclipse period with continuous working of the FFRF sensor.
  - The RF navigation was activated during the 2nd half of the experiment.

## ■ PASSENGER FAR 2 days

- ♦ **Test functional behaviour and performance of FFRF subsystem above 10km and up to 30 km**

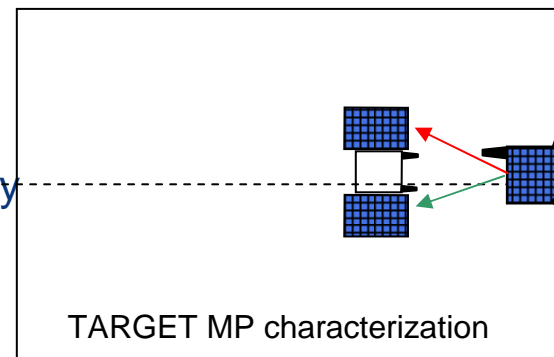


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FFRF GNC3	4 days 10/03/2011



## ■ Objectives

- ♦ Validate FFRF subsystem satisfactory behavior
- ♦ Characterize performance : IAR, distance and LoS accuracy
- ♦ Calibrations (FFRF end-to-end biases, multipath errors)



## ■ Tests

- ♦ Acquisition time **x150**
  - low / high power, various LoS and distances (25m → 10 km), w / wo aid
- ♦ Acquisition / tracking thresholds **x2**
  - distance where loss / acquisition of signal occurs
- ♦ Antenna handover (Target rotation) in different configurations
- ♦ IAR **x60**
  - Rotation aided IAR-LoS / Distance IAR
- ♦ Multipath characterization **x1**
  - multipath error / build correction tables
- ♦ Performance **x72**
  - Assess LoS and distance accuracy in fine mode / coarse mode
  - Calibrate end-to-end bias
- ♦ Ionosphere impact **x6**
  - Assess presence of ionospheric bias / ionospheric variation over an orbit w / wo drift





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# FFIORD GNC1

## Objectives:

- Sequential commissioning of all GNC functionalities
- First round of formation flying and rendezvous experiments
  - ➔ Constitutes the "core" part of the FFRF based CL operations

## Part 1: 28/10/2010 to 01/11/2010

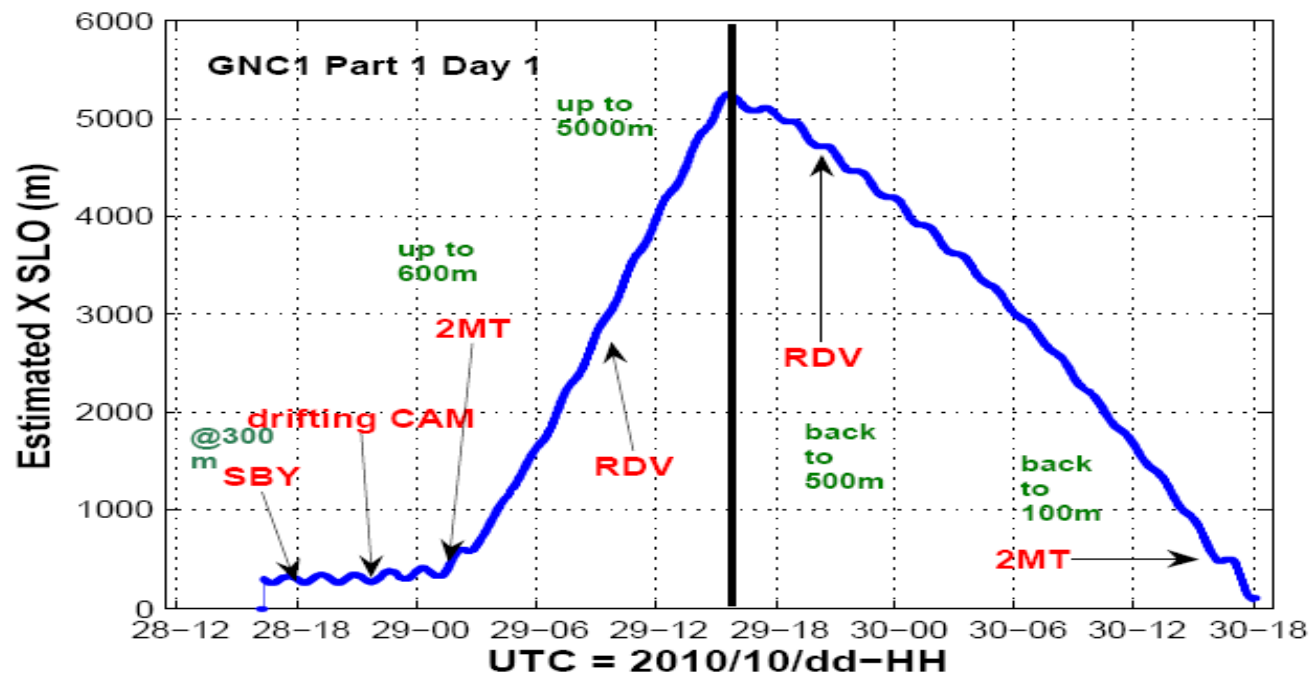
### Day 1 – C/L commissioning

SBY, CAM, 2MT, Inverse RDV

### Day 2 – Towards close range

RDV, 2MT

➔ *1st full rotation aided IAR and initialization of the RF filter without any GPS based aiding data*



**SBY:** Stand-by function

**CAM:** Collision avoidance

**2MT:** 2-Maneuvers transfer

**RDV:** Rendezvous

## Day 3 – Close range activities

PROX, CAM

## Day 4 – 1st rotation aided IAR

RDV, 2MT, SBY

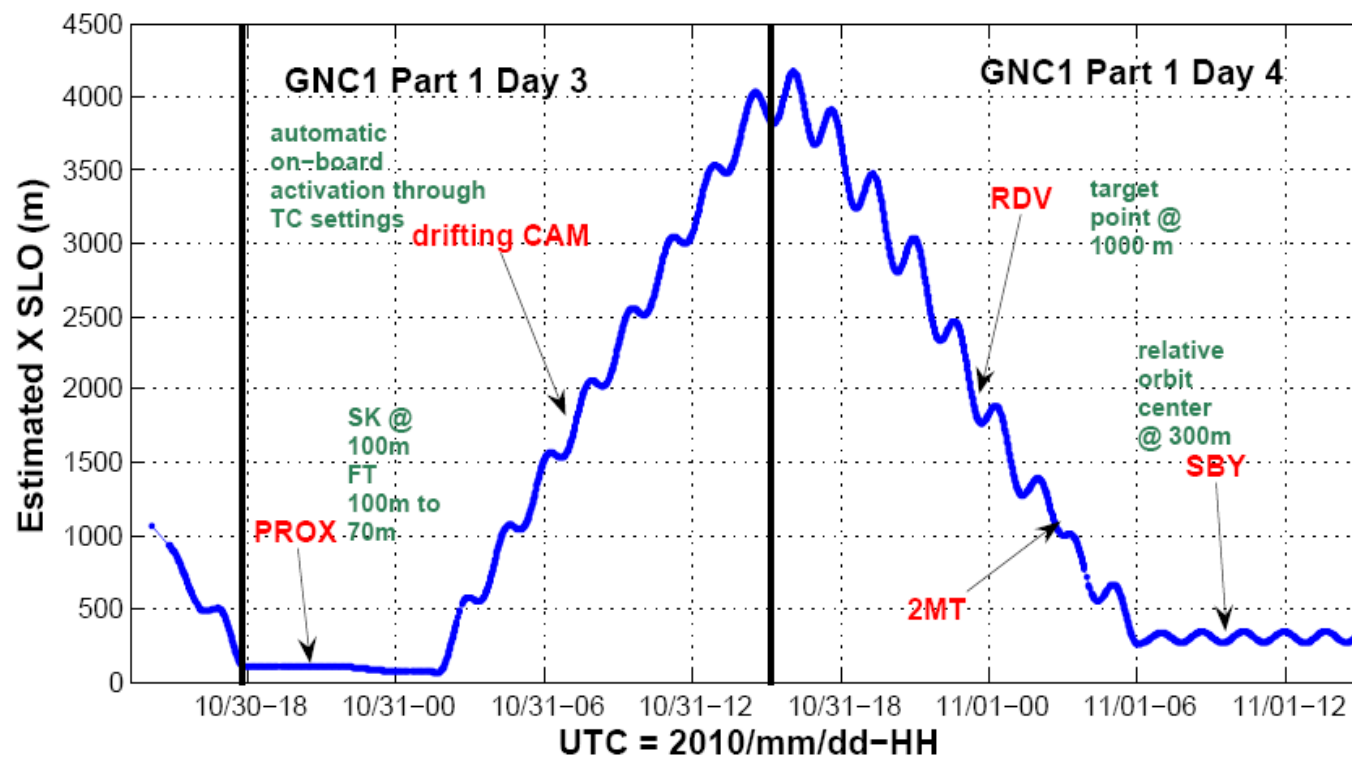
**PROX:** Proximity operations

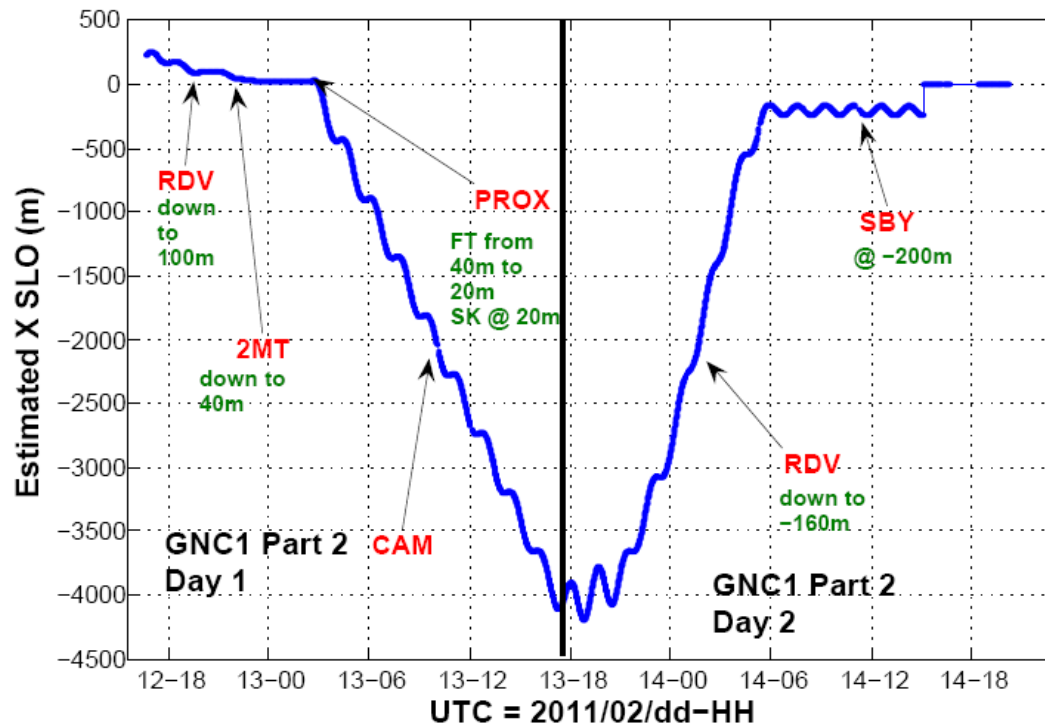
**SBY:** Stand-by function

**CAM:** Collision avoidance

**2MT:** 2-Maneuvers transfer

**RDV:** Rendezvous





## Part 2: 12/02/2011 to 14/02/2011

### Day 1 – Getting closer than Part 1!

RDV, 2MT, PROX : down to 20m with reorientations of the formation, CAM

→ RF navigation reset with full FFRF IAR process

### Day 2 – RDV from the other direction

RDV, SBY

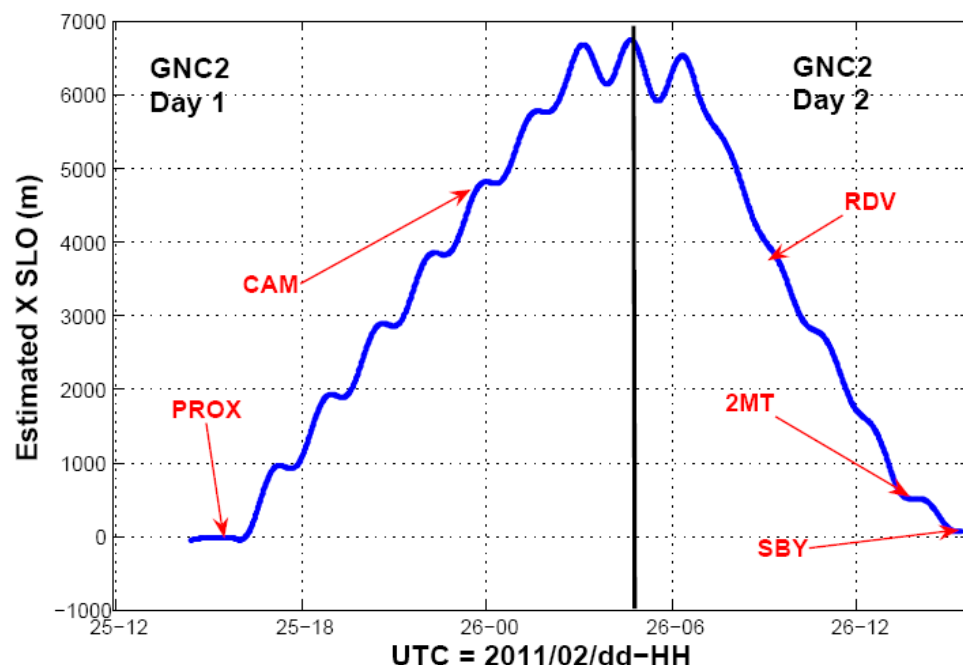
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# FFIORD GNC2

## Objectives:

Repetition under different conditions of the various activities already performed during GNC1



## 25/02/2011 to 26/02/2011

### Day 1 – Getting closer than GNC1!

PROX from 40m to 15m distance  
 2MT to circumvent Target  
 PROX on the other side of Target  
 CAM circumventing Target, with a drifting trajectory  
 Reset RF navigation function with full FFRF IAR process (1st time)

### Day 2 – First retreat to SBY!

RDV from 6.5 km down to 500 m distance  
 2MT to reach 100m  
 SBY Autonomous retreat to the closest standby orbit (simulating an anomaly) and optimal orbit maintained during 7 orbits



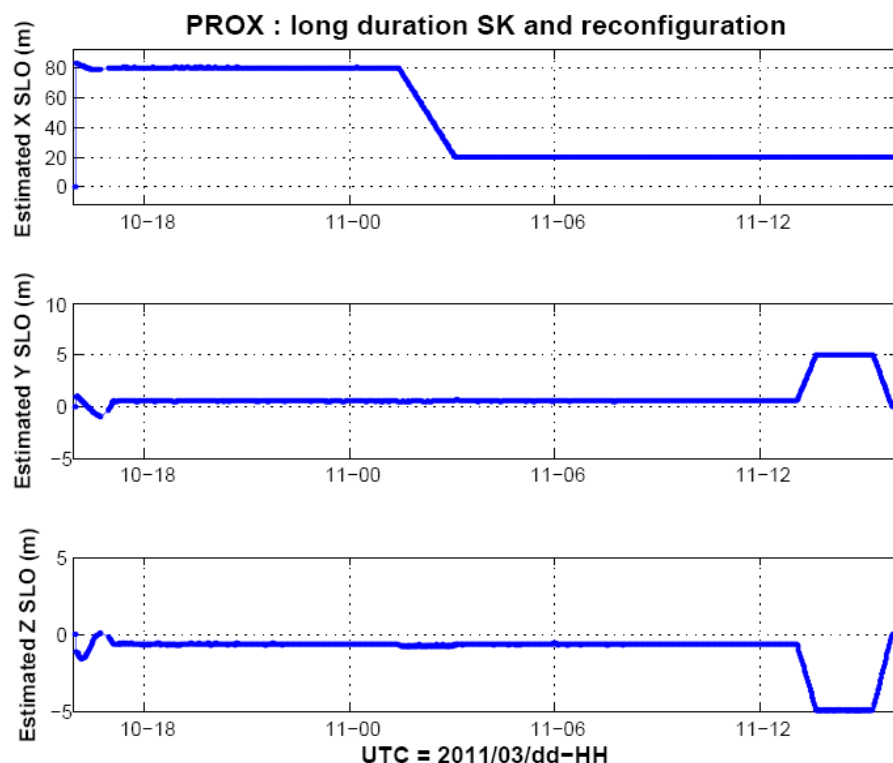
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# FFIORD GNC3

## Objectives:

- last repetition of activities already performed during GNC1 and GNC2
- long term performance assessment (SBY, PROX, CAM)
- demonstration of formation reorientation with big amplitude
- multiple hops 2MT



**10/03/2011**

## Day 1 – 24h PROX !

PROX during 24h on Vbar axis at 80m then at 20m  
Part of the control with sub-pulse resolution (thrust accuracy increase)

5m out of plane / radial maneuvers at the end of the day

→ *Demonstration of formation reorientation with big amplitude.*





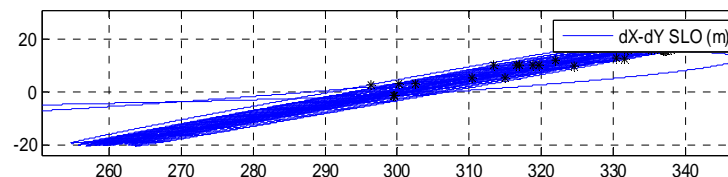
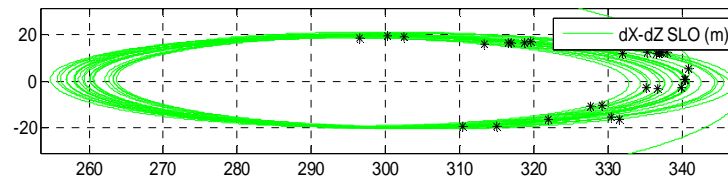
# FFIORD GNC3

**11/03/2011 to 13/03/2011**

**Day 2/3 – 36h long SBY !**

SBY orbit during 1.5 day at 300 m

→ *Representative of programmed “idle phase of formation flying mission” (low cost control and stable configuration)*



**Day 3/4 – The last one...**

2MT to approach Tango

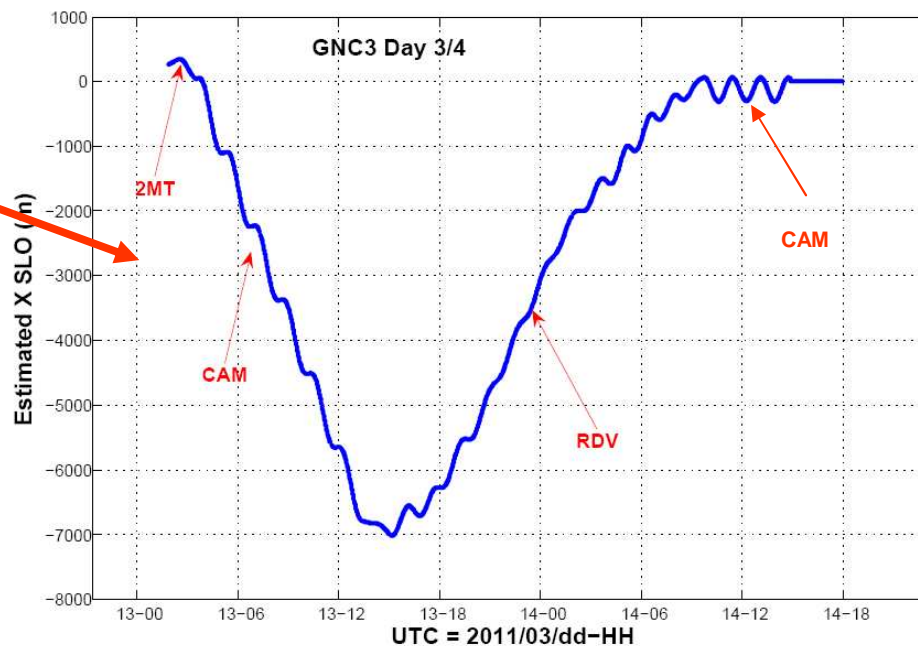
CAM and free flying drift up to 7km

drift used to perform FFRF multipath calibration at low elevation angles

RDV to come back to 2km

multiple hops 2MT to approach Tango at 30m

CAM to set Mango on a safe relative orbit circumventing Tango



## Extended Mission scenari

- **FFIORD Extended Mission summary: 23 consecutive days**
  - ♦ *5 days*: FFRF-VBS metrology hand-over
  - ♦ *6 days*: Vision based Rendezvous
  - ♦ *12 days* : Star tracker characterization (microscope preparation)
  - ♦  $dV = 4.8 \text{ m/s}$
  
- **Prisma based control (FFIORD trajectory definition):**
  - ♦ Transition between experiments (separation for rendezvous)
  - ♦ Microscope activities (intensive attitude maneuvers)
  - ♦ FFRF characterization activities
  
- **FFIORD based control experiment :**
  - ♦ Vision based rendezvous
  - ♦ Proximity operations with metrology transition



Week 1	6860_NavCRVBS_Recette	10/10/2011	21:41:43
	6880_AFFdrift_4km	11/10/2011	15:59:34
	6881_ATTMVR_1	11/10/2011	16:00:00
	6882_ATTMVR_2	12/10/2011	16:00:00
	6870_NavFRVBS_Recette	13/10/2011	15:57:32
	6883_ATTMVR_3	14/10/2011	15:16:33
Week 2	6863_PROX_VBSnav_CNES	17/10/2011	07:48:48
	6891_AFFdrift2_4km	18/10/2011	06:00:00
	6884_ATTMVR_4	18/10/2011	06:00:00
	6885_ATTMVR_5	19/10/2011	06:00:00
	6873_RDV_VBSnav_4km	20/10/2011	05:57:58
	6873_RDV_VBSnav_4km	21/10/2011	05:57:58
Week 3	6864_PROX_VBSnav_OHB	24/10/2011	04:28:58
	6890_AFFdrift_10km	25/10/2011	06:00:00
	6887_ATTMVR_7	25/10/2011	06:00:00
	6888_ATTMVR_8	26/10/2011	06:00:00
	6874_RDV_VBSnav_10km	27/10/2011	05:57:58
	6889_ATTMVR_9	28/10/2011	06:00:00

Week 4	6863_PROX_VBSnav_CNES	31/10/2011	03:14:18
	6892_AFFdrift2_10km	01/11/2011	06:00:00
	6950_ATTMVR_10	01/11/2011	06:00:00
	6951_ATTMVR_11	02/11/2011	06:00:00
	6875_RDV_VBSnav2_10km	03/11/2011	05:57:58
	6886_ATTMVR_6	04/11/2011	04:00:00
Week 5	6866_SBY_VBSnav_CNES	07/11/2011	02:40:58
	6952_ATTMVR_12	08/11/2011	06:00:00
	6953_ATTMVR_13	09/11/2011	06:00:00

