OVERVIEW OF SVOM SYSTEM

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On behalf of SVOM system team

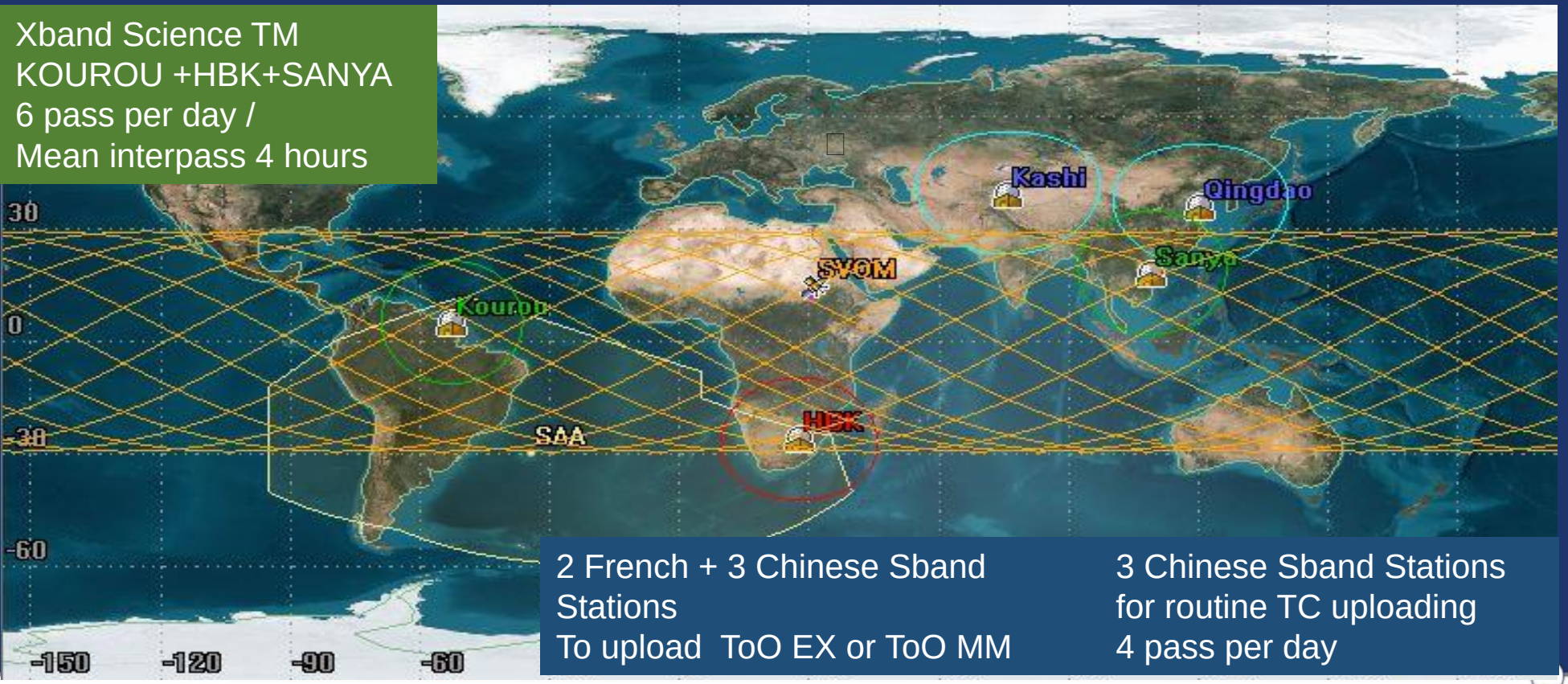
Orbit and Attitude

SVOM Orbit

Orbit	Reference Orbit
Altitude	600~650 km
Eccentricity	0 ±0.003
inclination	29° ±0.2°
T (600 km)	97 min

One manoeuver per year for orbit keeping

Xband Science TM
KOUROU +HBK+SANYA
6 pass per day /
Mean interpass 4 hours



2 French + 3 Chinese Sband Stations
To upload ToO EX or ToO MM

3 Chinese Sband Stations for routine TC uploading
4 pass per day

VHF network (GRB and ToO MM data)

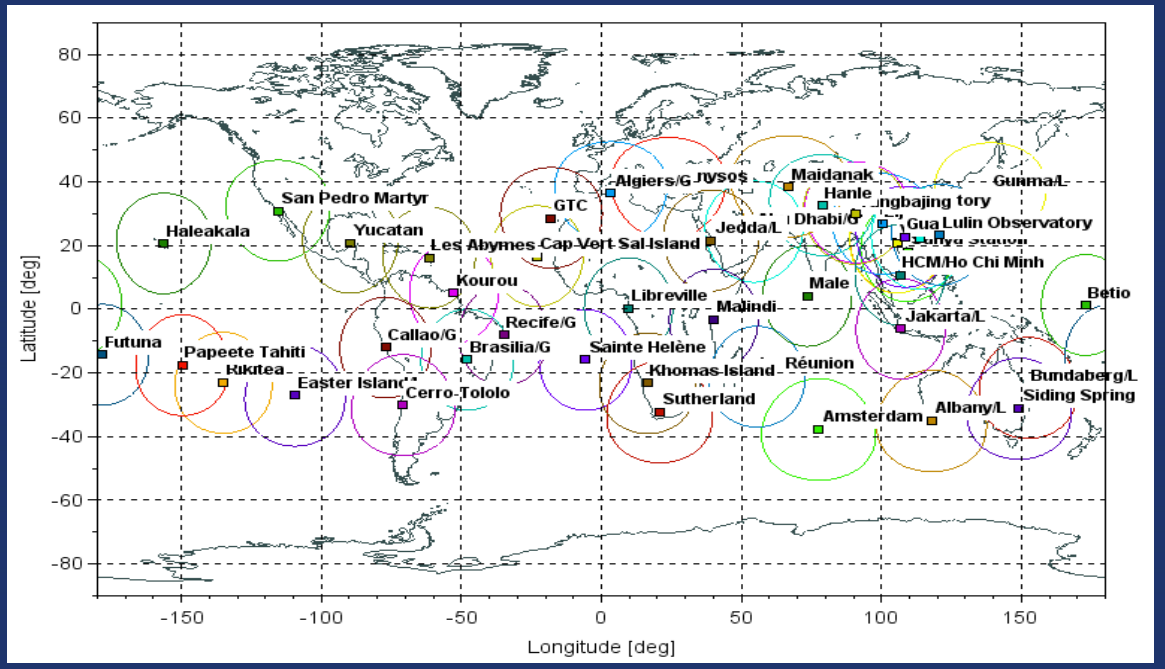
The VHF networks is composed of 45 stations :

- 20 hosting sites provided by SVOM collaboration (Observatory, University)
- 25 hosting sites provided by institutional network (DORIS, REGINA, ARIANE …)

The VHF network is used to dowload GRB alert message in less than 30s for 60% of the case – used also for GRB data and ToO MM data

Phase B network Coverage Optimization in progress

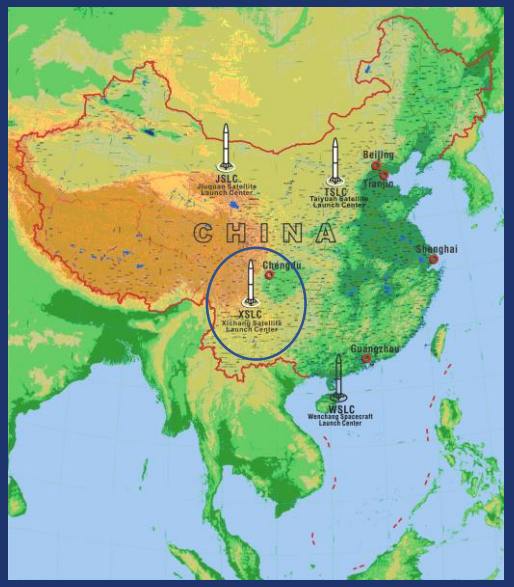
Contract with hosting sites in preparation



45 stations network leading to 75 % coverage

Could be used for Einstein PROBE

Launch and Lifetime



- LAUNCH 2021 Dec - LM-2C from Xichang Launch Pad
- Life time : 3 years nominal + 2 years for extended mission

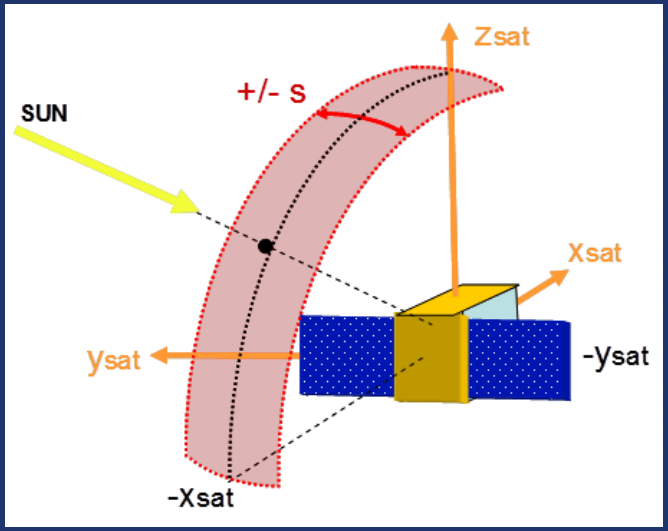
2022 → 2026 … 5 main OPS phases

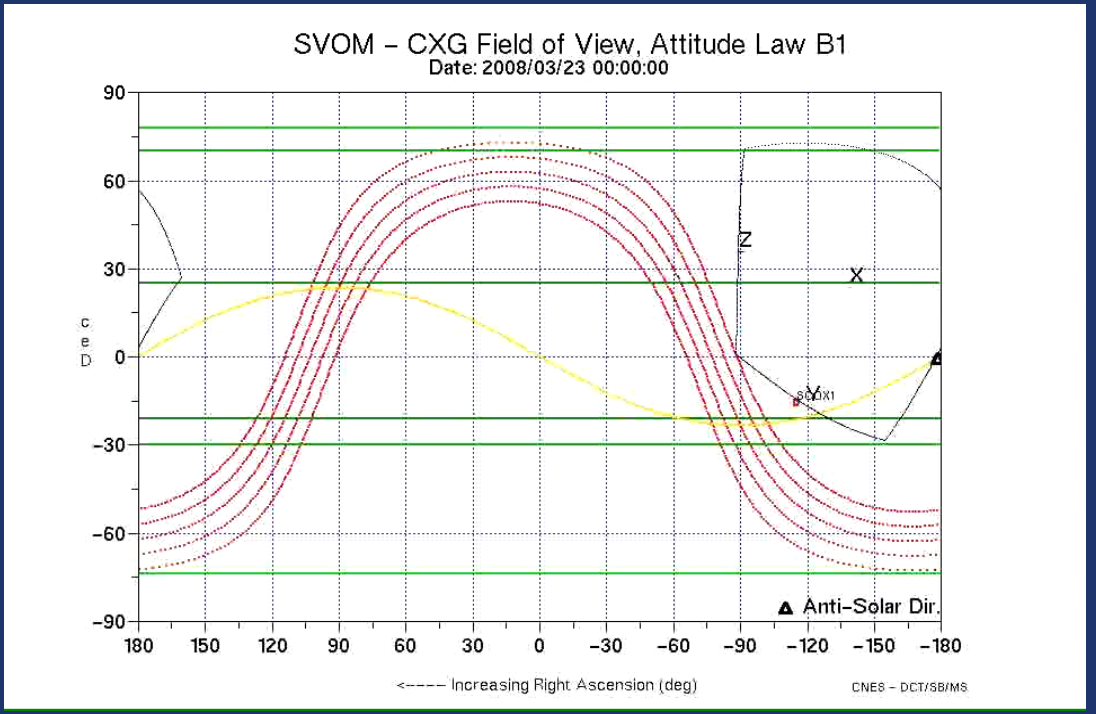
LEOP	20 days	Launch and Early Orbit Phase up to nominal pointing mode with Instrument power on in standby mode
LEOP KP		
Commissionning phase	2 months	Platform verification then progressive tuning of the mission parameters, first calibrations
CRR		
Verification phase	5 months	Validation of the science product and performances
Verification workshop		
Operational phase	2.8 years	
Extended operational phase	2 years	
End of life /de-orbiting		

Orbit and attitude law

Attitude law (so called B1 law) designed to optimize the GRB pointing **by the SL** and **by the ground telescopes**

- Galactic Equator Sco-X1and will be out of ECLAIRs field view.
- Compliant with constraints vs instrument avoidance angle and thermal constraints
- Optimizes the GRB follow up by ground telescopes





→ Lead to earth in instrument FOV during « day part » of the orbit

Observing program

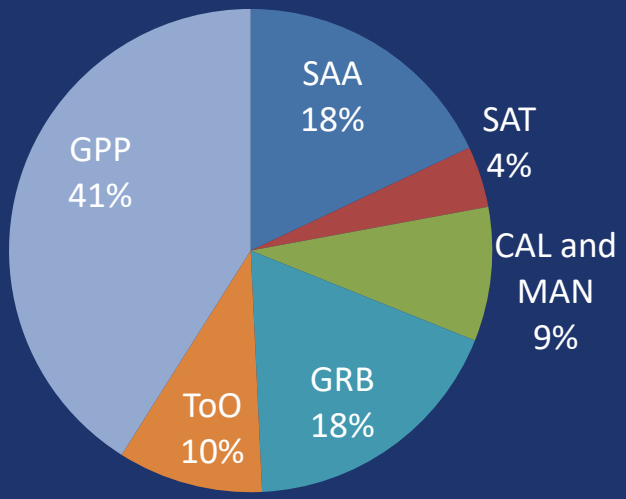
Observing program

Core Program observations		
GRB initial observation	Autonomous pointing	1 to 2 per week (14 orbits)
GRB Revisits	Request from ground by ToO NOM process	80% of the GRB
Transient source observations from ECLAIRs catalog		
CAT (cat source above a threshold)	On board Autonomous mechanism if pointed	1 per month (14 orbits)
Target of Opportunity Observations		
ToO-NOM (Astronomical Events)	Programmed in less than 48h	1 to 5 per day (1 orbit)
ToO-EX (Major Events)	Programmed in less than 12h	1 per month (14 orbits)
ToO-MM (tiling)	Programmed in less than 12h	1 per month - goal 1 per week
General Program Observations		
Pre-planned target and Survey	Programmed for one week	10° from B1 law (85% to 50%) from 1 to 14 orbits

System Scenario for mission analysis

Observing program evolution

Nominal mission
TOTAL time per year



Progressive evolution

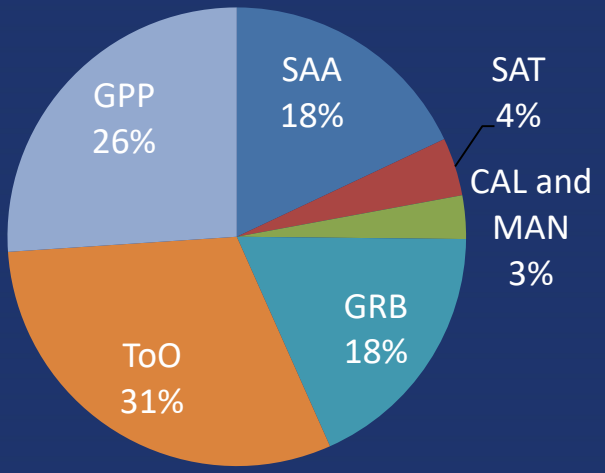
The **TOTAL TIME** :

USEFUL TIME

1. Core Program
2. ToO Program
3. General Program

4. Calibrations
5. South Atlantic Anomaly(SAA)
6. Satellite failure
7. PF maintenance and Orbit Manoeuvers

Extended mission
TOTAL Time per year



During the nominal mission (first 3 years), the goal is to **optimize the CORE program** (GRB pointing and GRB follow-up by the ground)
→ **Only 1 ToO per day and GP pointing near B1 law (>10° for 85%)**

During the extended mission (last 2 years), the goal is **to increase ToO science** and **to improve General Program accessibility**. This leads to relax B1 law constraint for satellite pointing (decreasing the GRB follow-up by the ground) → **up to 5 ToO per day**

Priority management

Priority management is performed on board

A higher priority obs interrupts a lower priority one

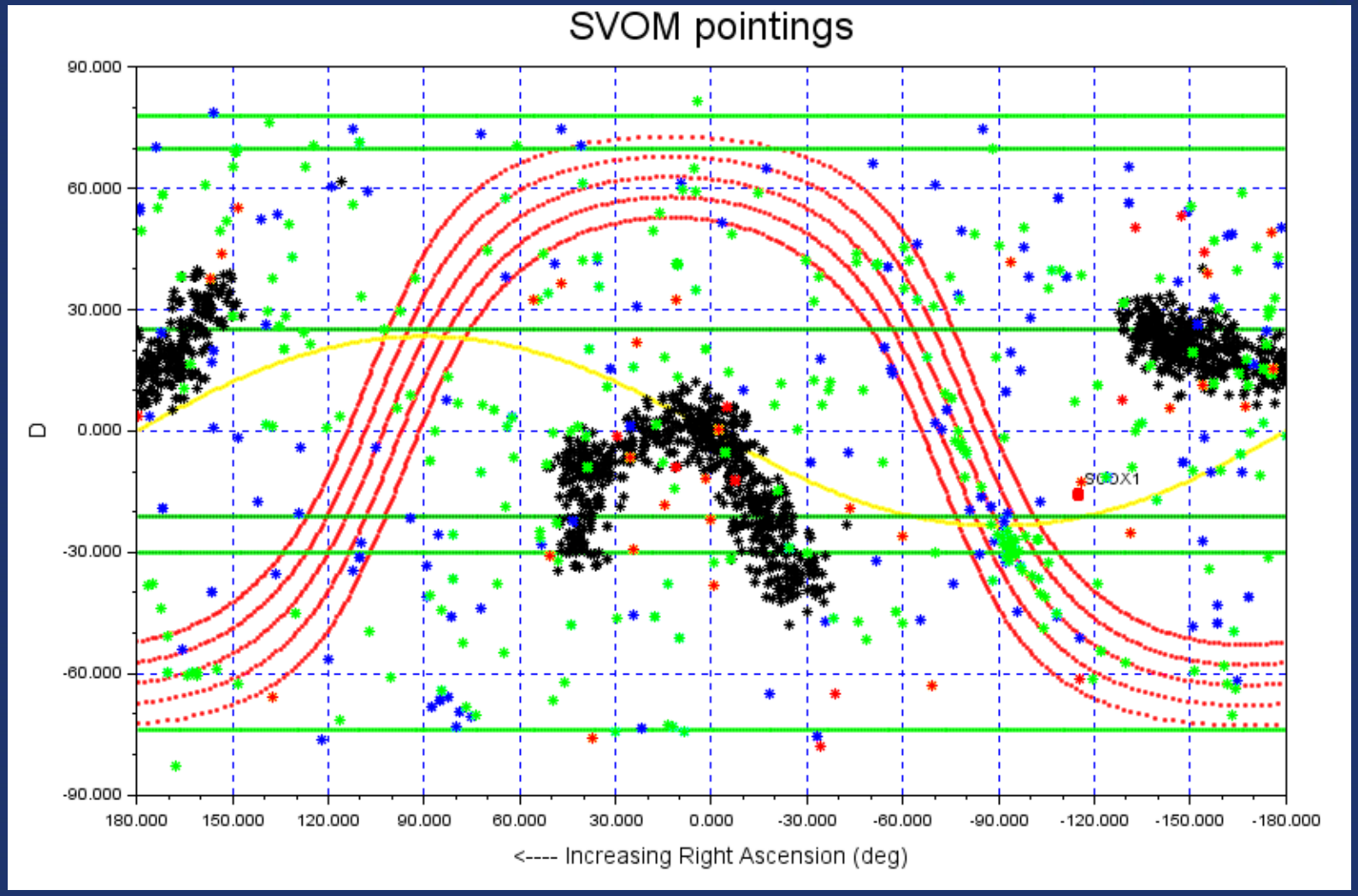
Highest priority level

1. ToO MM or ToO EX – a new one interrupts the current one (the ground can choose to interrupt or not the current observation by a new request)
2. GRB or CAT – a new GRB sequence can interrupt a current one only after 15 minutes (early loc sequence)
3. ToO NoM
4. General Program PPT

Lowest priority level

SATELLITE CONTRAINTS
1 pointing per orbit max for each program excepted for ToO MM with 3 tiles allowed per orbit in a 5x5 ° square

Nominal mission scenario (1 year / around 2000 pointing)



Dark dots are GP pointings < 10° from B1 (85%)

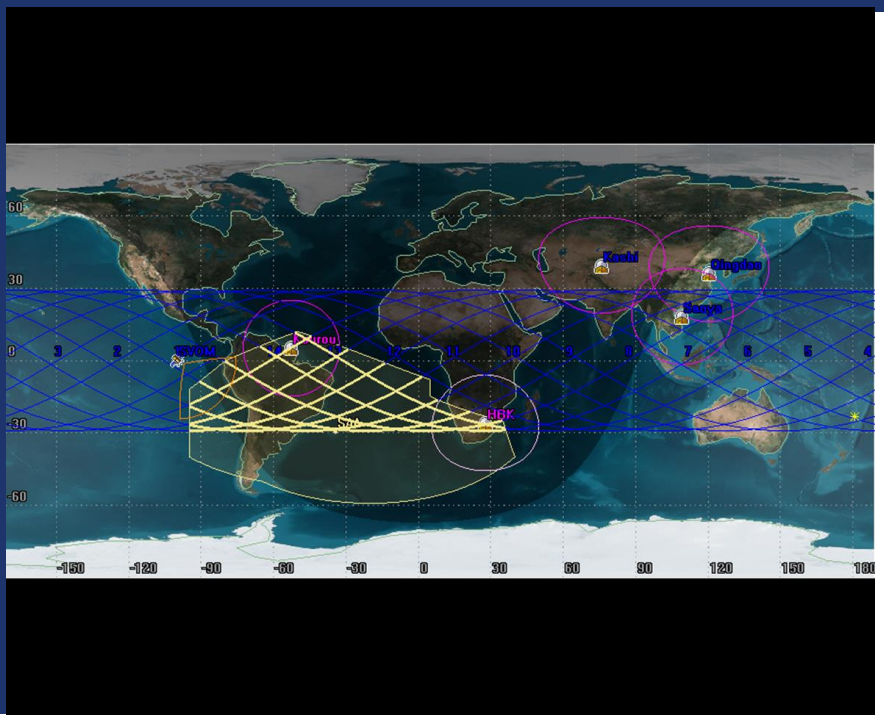
Blue dots are GP pointings > 10° from B1 (15%)

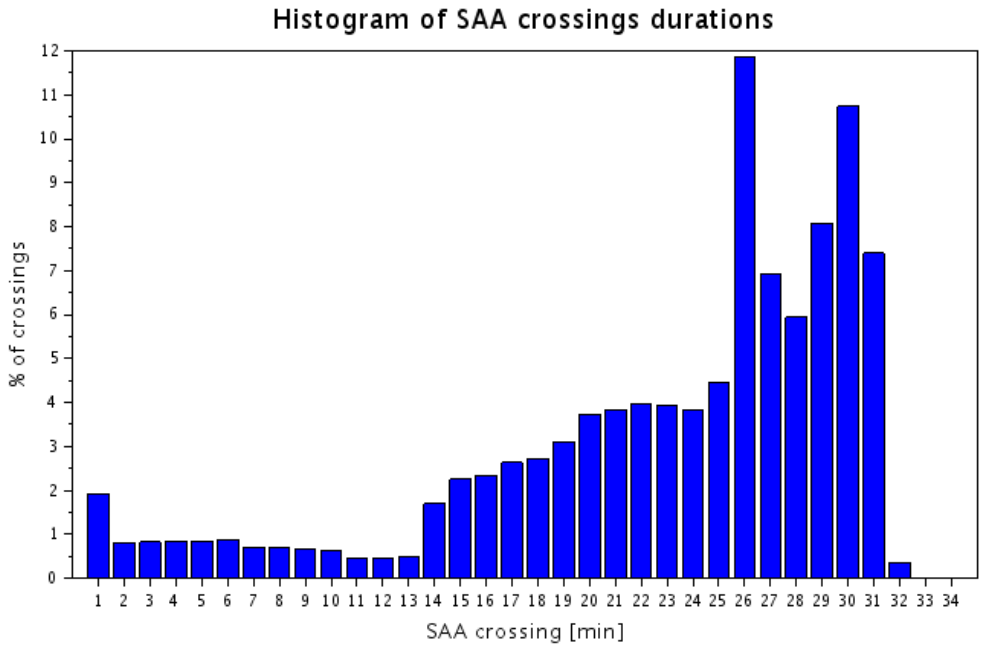
Green dots are ToO pointings (1 per day)

Red dots are pointed GRB (around 60 GRB)

Observing contraints due to the orbit and the satellite attitude

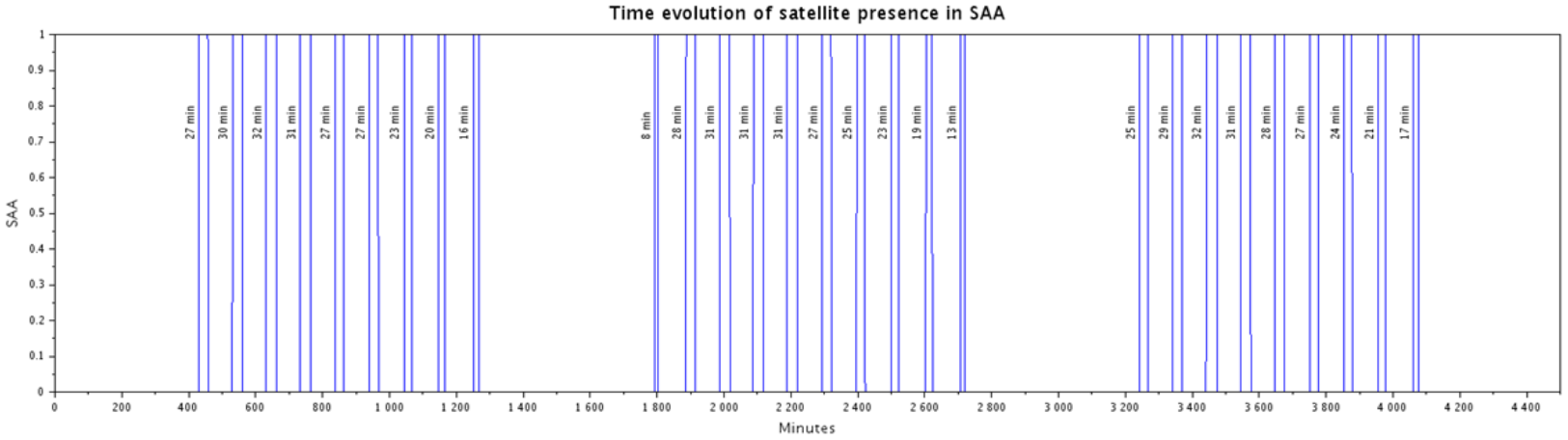
Observing constraints due to SAA





10 pass per day

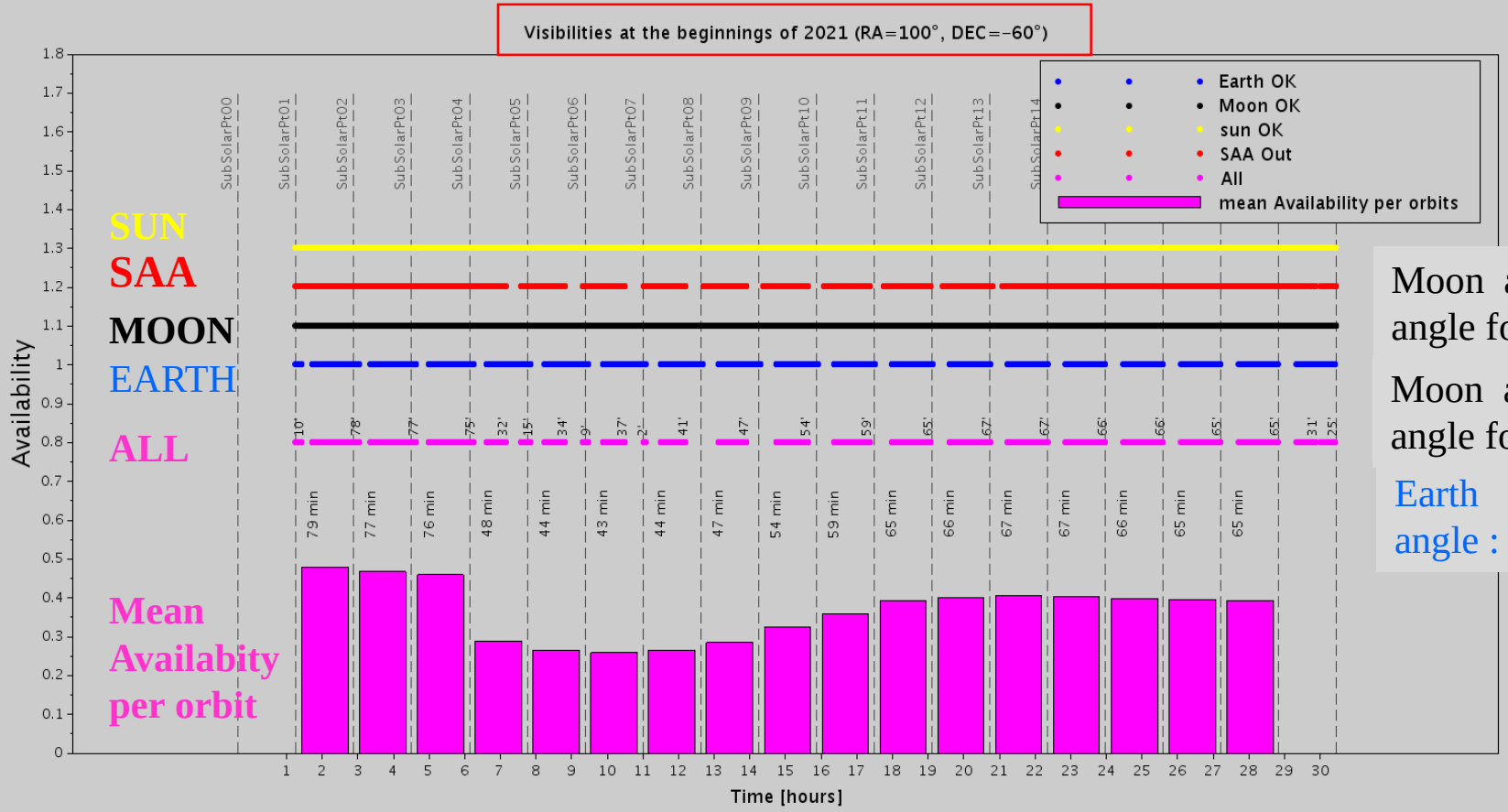
30 min for long pass



Useful time variability over one day

Useful time per orbit depends on SAA and Earth occultation duration

High elevation pointing



Moon avoidance angle for VT: 20°

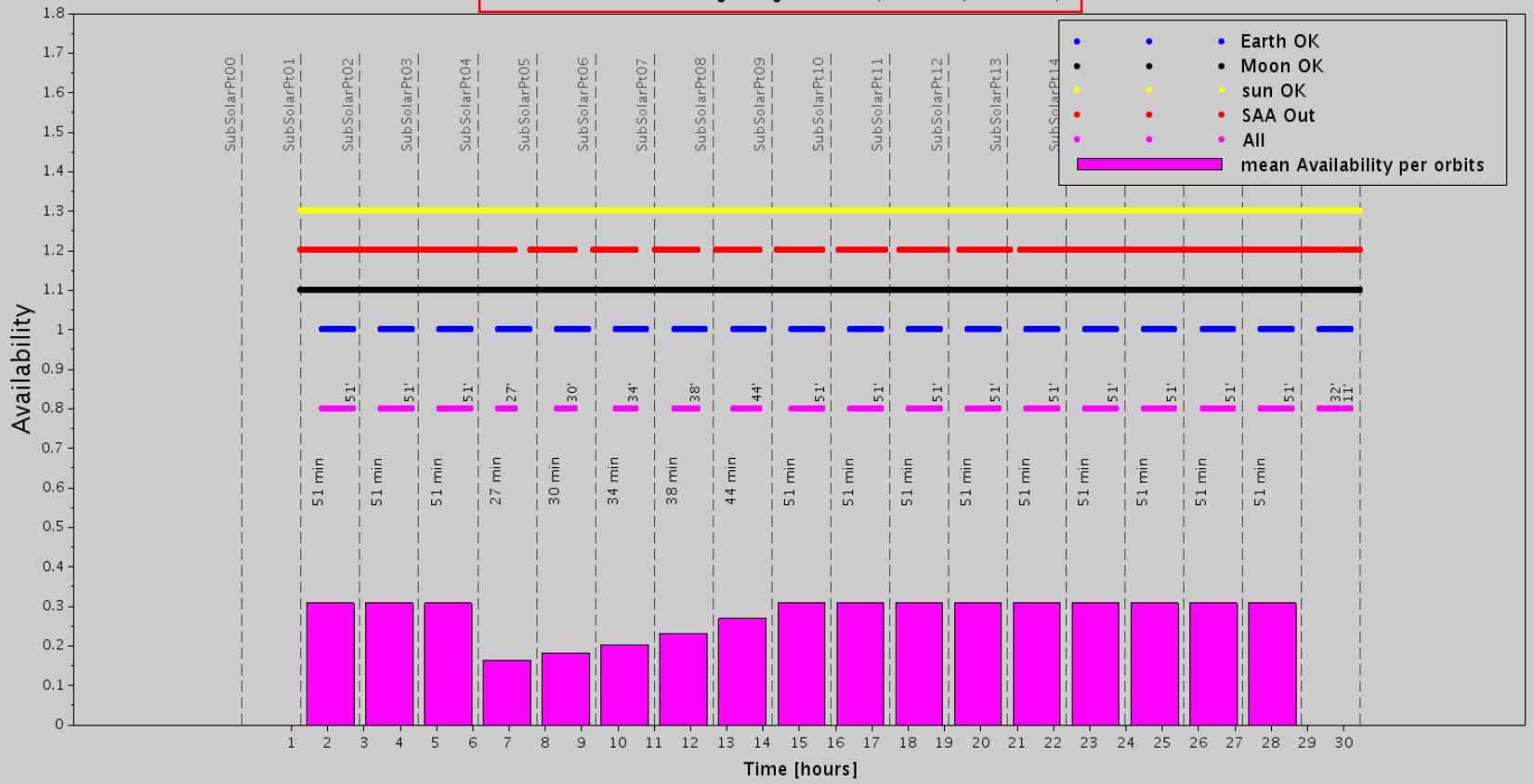
Moon avoidance angle for VT: 10°

Earth avoidance angle : 20°

For one day Mean Availabity per orbit between 43 min to 79 min for DEC = - 60°

Useful time variability over one day

Pointing in the orbit plane



For one day Mean Availabity per orbit between 27 min to 51 min for DEC = 30°

This variability must be taken into account by the mission planning process to compute the duration of the pointing vs usefull time requested by the scientists (see J.Jaubert ‘s presentation)

Mission programming

Mission scheduling on ground

Every year for GP

- Call for OBS for GP over 1 year
- Selection of a list of Pre_planned target with priority and survey obs

Every WEEK for GP

- A GP Work Plan (WP) includes 7 days of observation from Sunday to Sunday
- TC plan is uploaded each Friday (2 days of backup before the start of the WP)
- A Mission planning process is implemented to complete the observations not performed due to ToO or GRB obs (refer to GP mission plannig presentation)

Every day for ToO NOM

- ToO Work Plan from 1 day to 3 days (Week End)
- TC plan upload on working days (5/7)

At any time, on request → ToO MM and ToO EX

- ToO Work Plan for 1 observation
- TC plan upload as soon as possible with French S band station support

ToO MM programing constraints

- The system is design to program 1 ToO_MM per month at the beginning of the mission with a goal of **1 per week** (TBC) in less than **12 hours** (goal)
- ToO-MM observation is split into several orbits (between **1 and 14**)
- The maximum number of the tiles observed in one orbit is **3 tiles baseline / 5 / tiles goal (TBC)** **with a tile duration** greater than **10 minutes**
- The tiles are programmed in one orbit shall be inscribed within a **5°x5°** (TBC) square MAXIMUM
- **The tiles are programmed** **outside SAA and outside earth occultation** periods
- **VT attitude chart** **are sent** after each tile **to the ground** by using the VHF network (TBC)
- **MXT photons** are sent to the ground by using the VHF network during the ToO-MM OBS
- ToO MM observation shall **not be interrupted by a new GRB observations**.

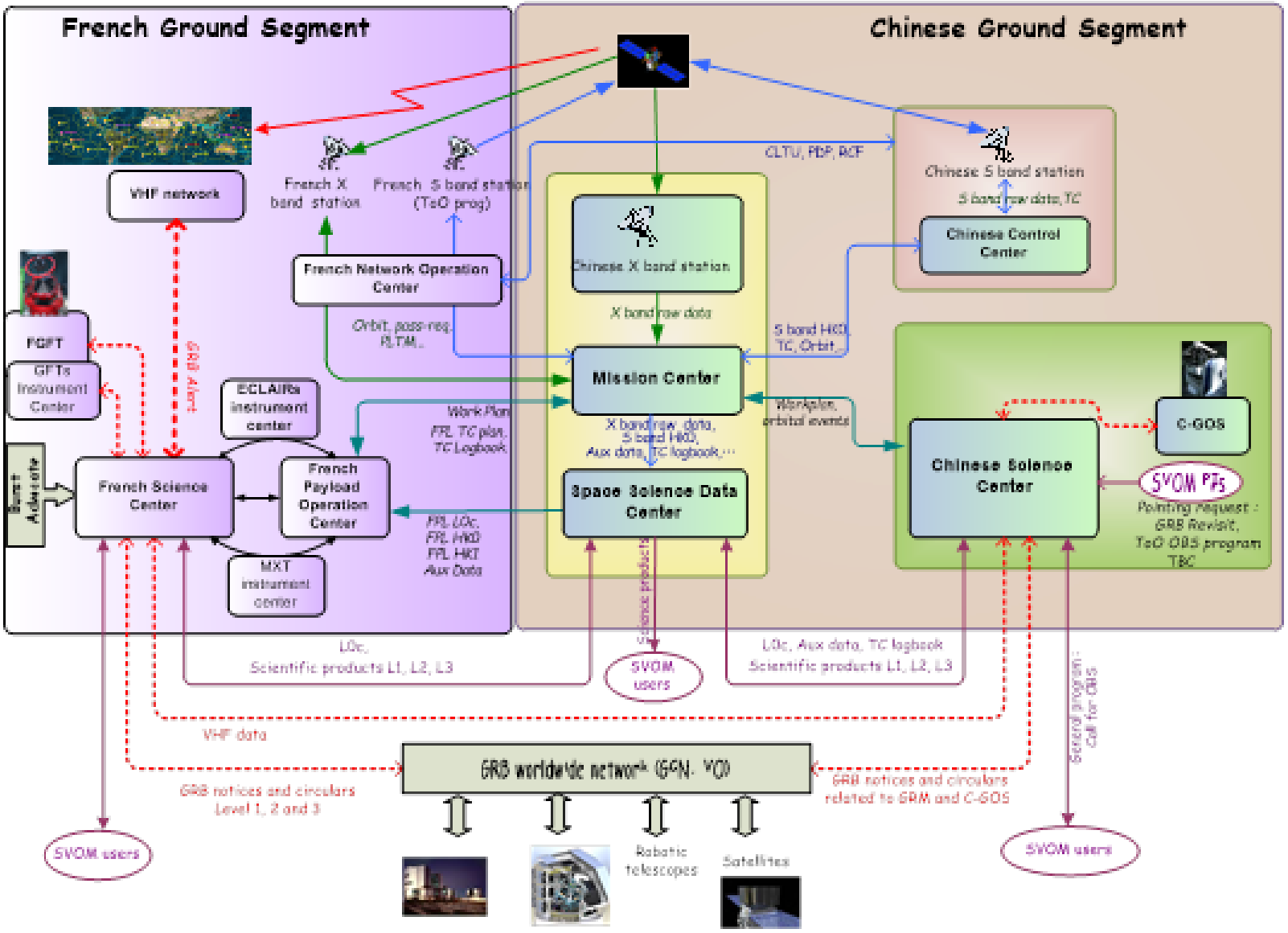
The slew to point the GRB is inhibited on board during the whole duration of the ToO EX/MM observation but the alert L1 message and data shall be downloaded by VHF

Timeline for ToO MM programming

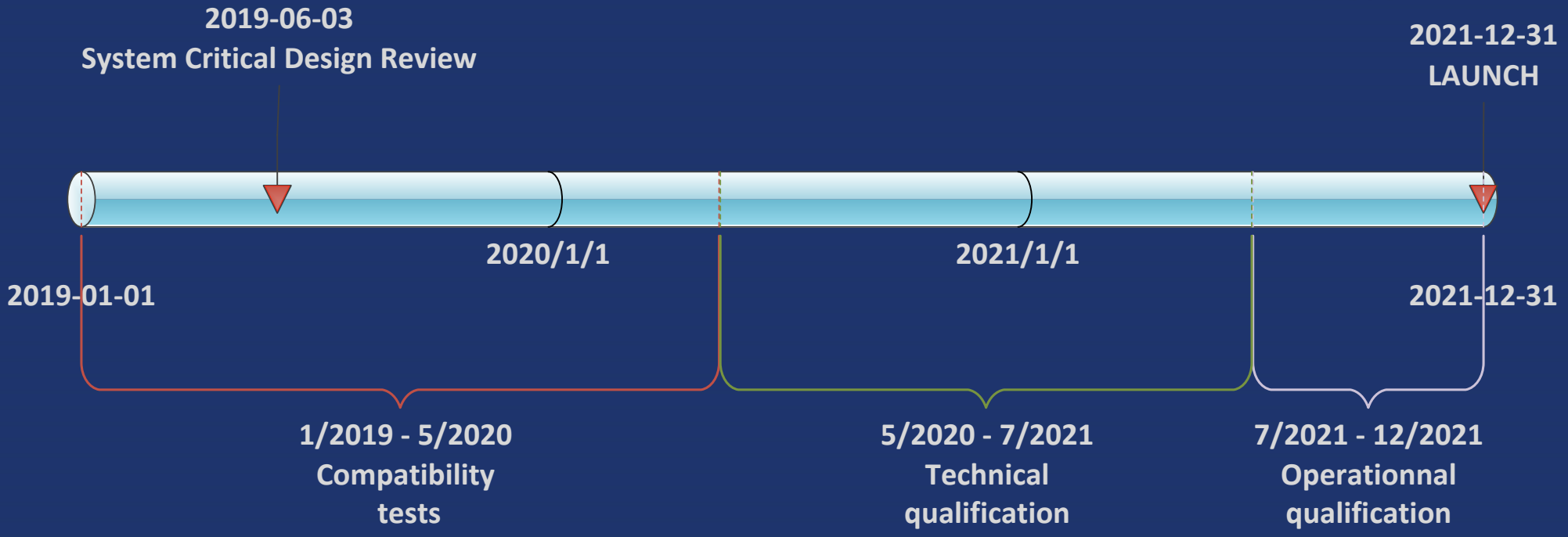
Time	*Science process*	*Operational process*	*example of a mean case*
T_GW trigger	GW Trigger received by FSC		12:00
	GW validation by FSC If OK (science + SVOM accessibility)		00:30
T_ToO MM alert	**FSC WARN mission center (phone call)**		**12:30**
	FSC starts the tiling process	Iteration between MC/CCC/NOC (1 hour) to select the Sband pass for TC uplink	
	FSC refines the tiling scenario during 12h (TBC)and update the current scenario		
T-ToO MM alert +1h		Sband Pass identification for TC upload from CCC	**13:30**
T_Sband pass minus 5:30 hours (near 80% or the cases)			**14:30**
OPS Process : Baseline 05:30 To be discussed	Request can be cancelled up to the end of the TC genration	WP elaboration with Current scenario at T-Sband pass -5:30	01:00
		OCG	00:30
		TC generation	*02:30*
		Upload	00:30
		margins before visi	01:00
T_Sband pass		**TC upload**	**20:00**
		Delay between ToO MM alert and the start of the observation	07:30

System Next Steps

System Architecture



System Activities in C/D Phases



Interface compatibility verification

- S band satellite tranceiver and ground station
- X band satellite emiter and ground station
- VHF band satellite emiter and VHF ground station
- All ground interface between all centers

Main tests

- Satellite End to end test with the the TC plan generated by the ground segment
- Ground alert real time loop (GRB and ToO EX/MM)
- Nominal mission scenario (1 Week)
- Science products with simulated data

Operability tests

- To train the operational teams with the final operational procedures

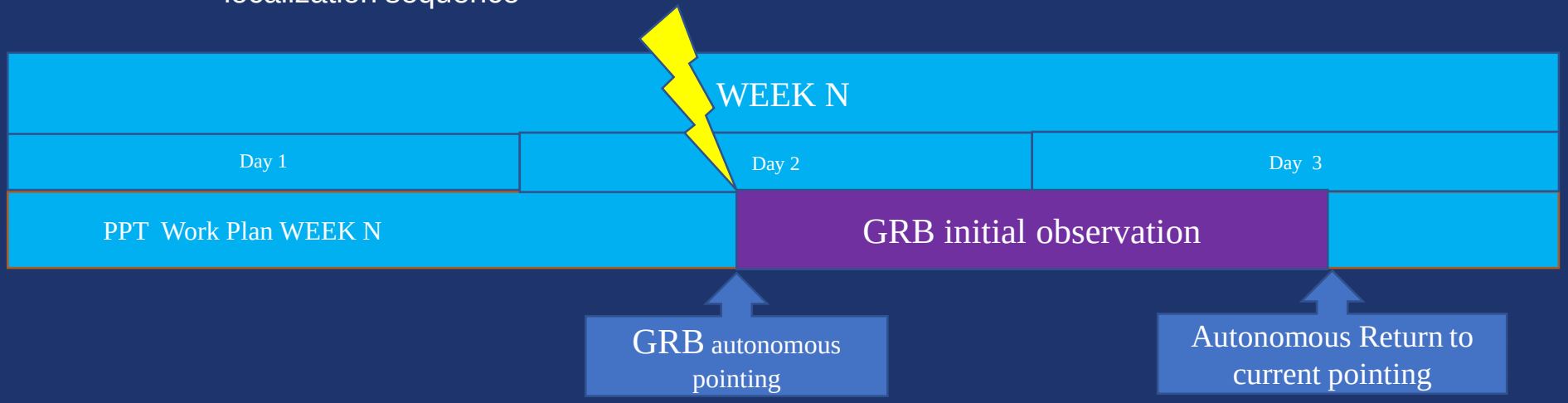
Back Up Slides

GRB/CAT Autonomous management on board

GRB/CAT sequence :

Detection by ECLAIRs (alert L1) – error box +/- 13 arcmin (MRR-CP3)
Alert L1 is sent by VHF in less than 30s for 65% of the GRB (MRR-CP9)
GRB is pointed autonomously by the satellite in less than 5 min (MRR-CP6) for 14 orbits

- MXTLOC SEQUENCE → +/- 2 acmin on board (MRR-CP7)
- VT LOC SEQUENCE → +/- 1 arc sec on ground (MRR CP8)
- Pointing adjustment with MXT position after the first orbit (autonomous on board)
- Solar panel adjustment 15 minutes TBC after the slew to keep high stability during the early localization sequence



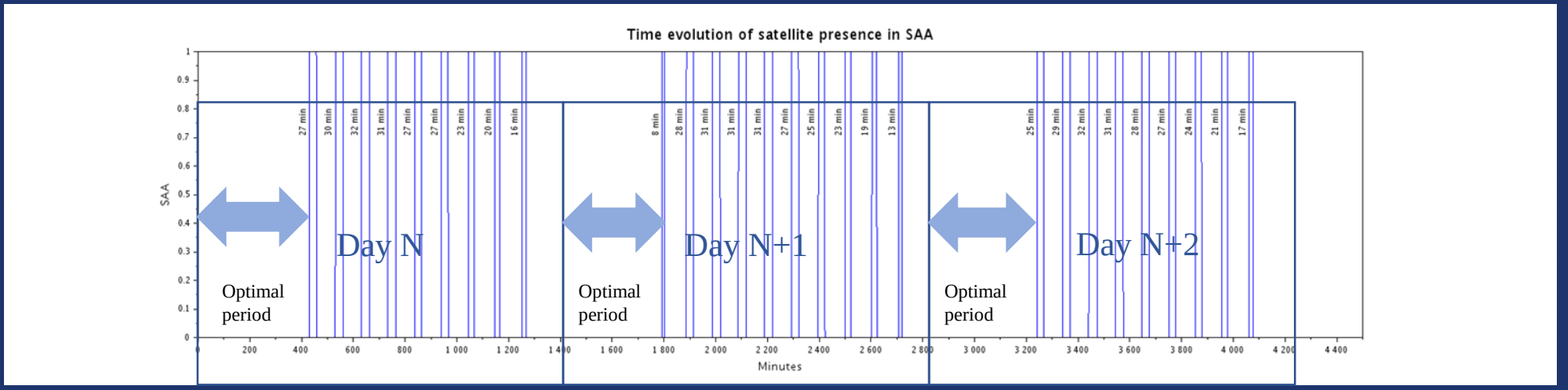
Autonomous Return to Current pointing = the pointing already planned by the ground at the return time
GRB Revisit by ToO NOM mechanism

ToO NOM programming constraints

ToO list with priority is always available at Science Centers to avoid a loop between scientist and operational team. This list is processed once a day from Monday to Friday (5/7) by MC to generate the work plan and the associated TC plan

- if the operational constraints are not met, the ToO with the next highest priority is programmed
- This list allows to program on the Friday the ToO observations to be performed the week end

The programming process for ToO NOM shall minimize the SAA duration during the programming period (24 hours)



Science Center / Scenario N

Tile 1 (α1,δ1),d1, p1

Tile 2 (α2,δ2),d2,p2

Tile 3 (α3,δ3),d3,p3

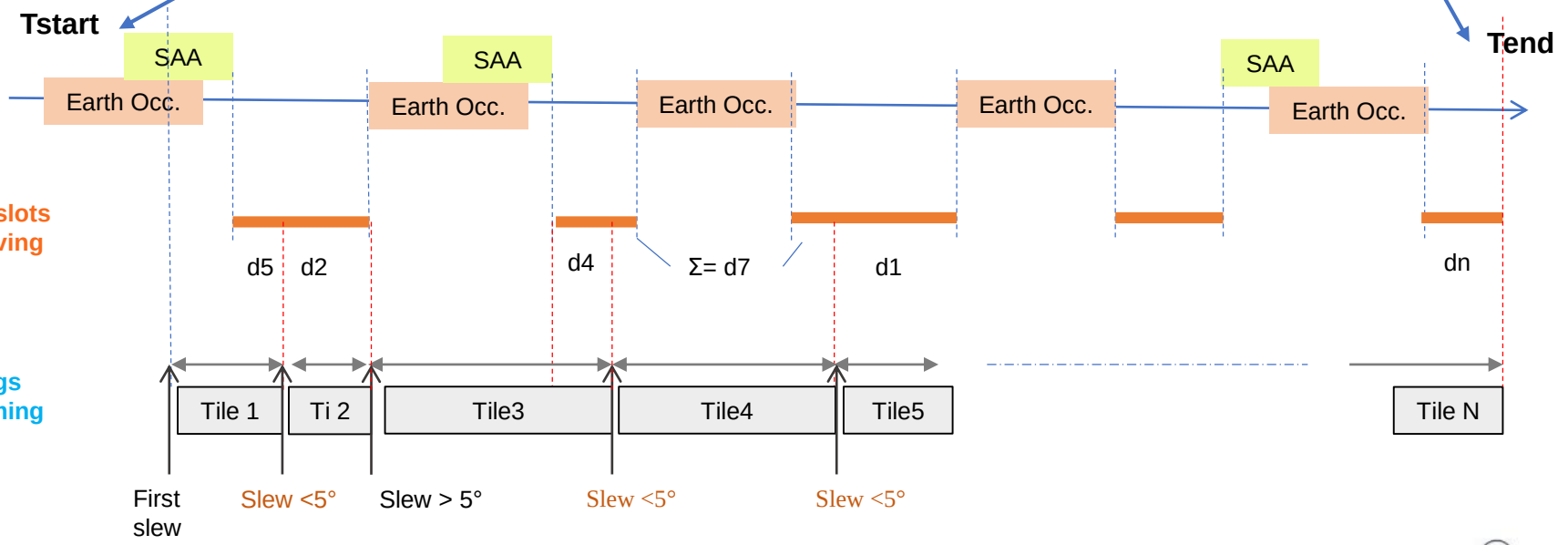
Tile N (αn,δn),dn,pn

ToO MM alert trigger

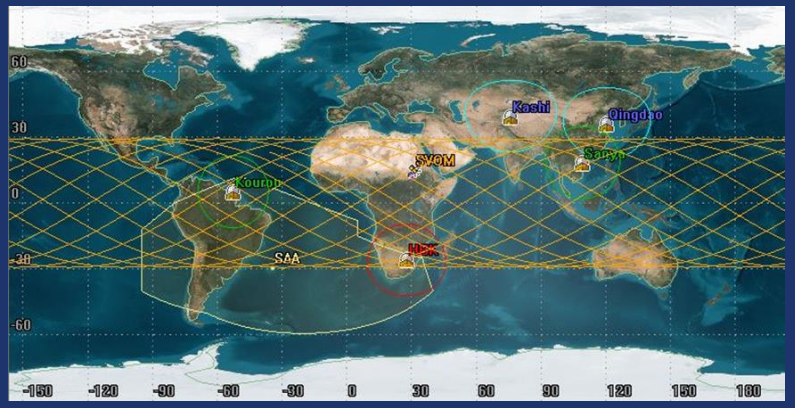
Mission Center

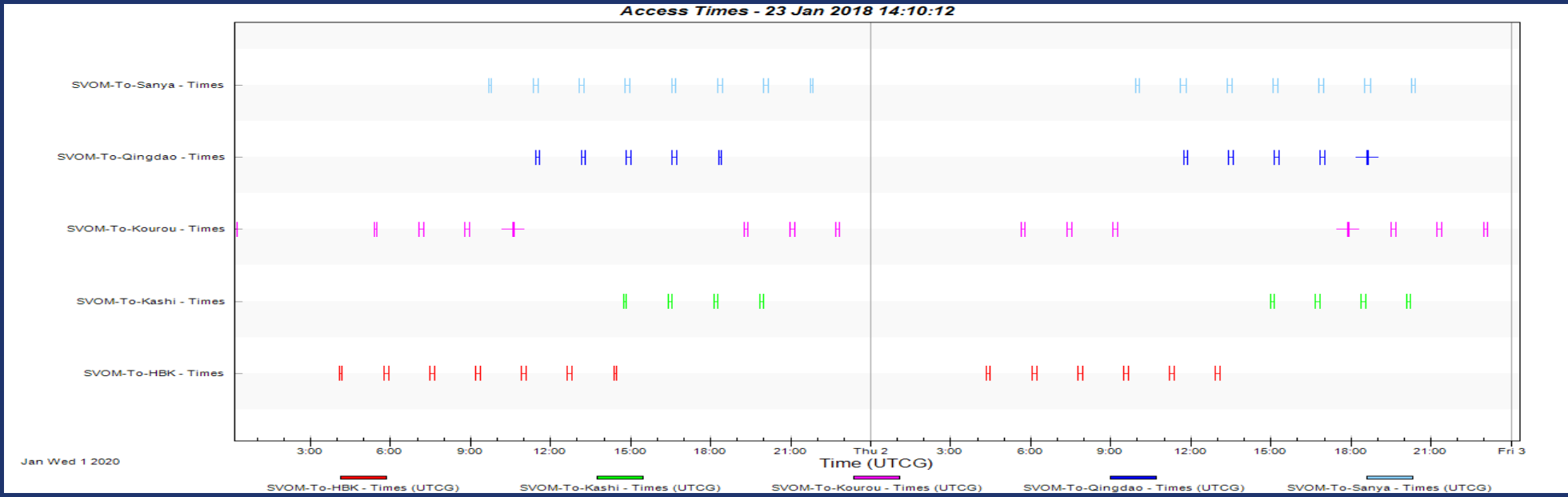
S-band 1 | S-band 2 | **Tstart** | S-band 3 | **Tend** | S-band 4

Tiling sequence after S-band 2

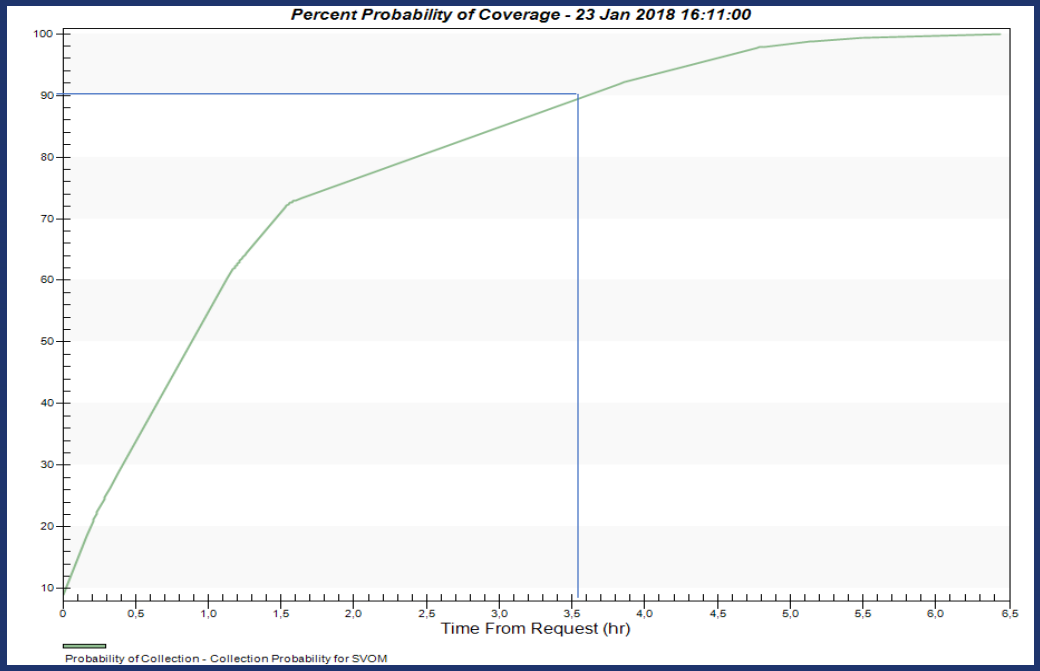


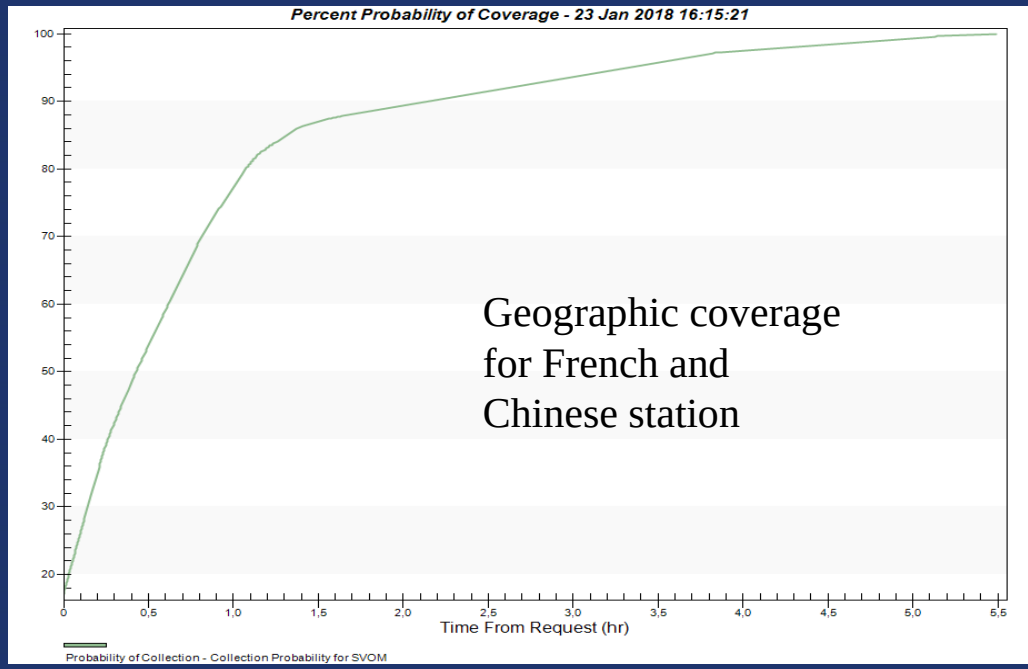
S band pass repartition





Sband geographic coverage and availability





Geographic coverage for French and Chinese station

Around 80% of the French Stations passes could be available for SVOM satellite (simulation from Network Operation Center in CNES for 2020)

- Total pass number per day : 17,6
- Pass with conflicts per day : 3,5
- Pass available : 14,1

For French stations 70% of passes in less than 4 hours

No data for Chinese availability vs geographic coverage - A lot of satellite are managed by CLTC and S band station are very busy – No status at this time

Data latency allocations and timeline

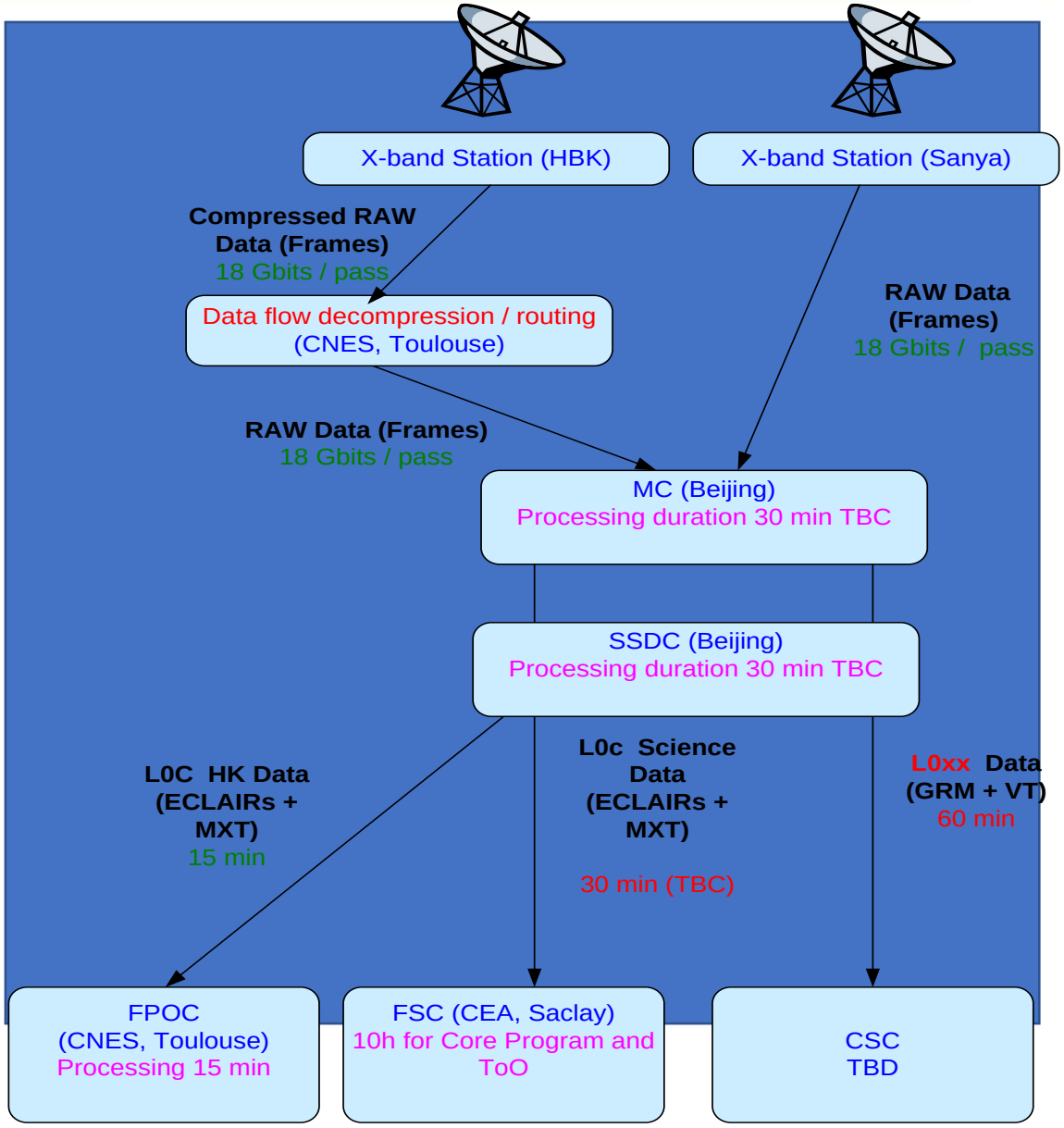
Product availability allocations

Data latency 24h For Core program

Data latency 24 h For ToO

Data latency 72h for transient

Data latency 30 days For General program



Max delay betwen 2 visi 10h (90%)

End of pass

2 hours (TBC)

Raw data available at MC

1 hour (TBC)

L0c data available at SSDC

1 hour (TBC)

Tests in progress to improve the data rate