ESA telemetry support for Einstein Probe

ESA Einstein Probe team
7th joint CAS-ESA-MPE-CNES workshop on EP

24-26/04/2024

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Requirements for ESA support

- Ground Stations for X-band downlink (payload data) in 8.092-8.332 GHz band

- 102.7 Mbps data rate

- At least one pass per orbit whenever no coverage from Sanya station available

- Only passes with duration > 3 min to be considered

- Priority of scheduled stations:
  Sanya -> ESA provided stations

- Latency (GS received to Mission Control) <30 min (goal: <10 min)

- Nominal GS support start date: Q1 2024

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ESA Ground architecture and Interfaces with CAS
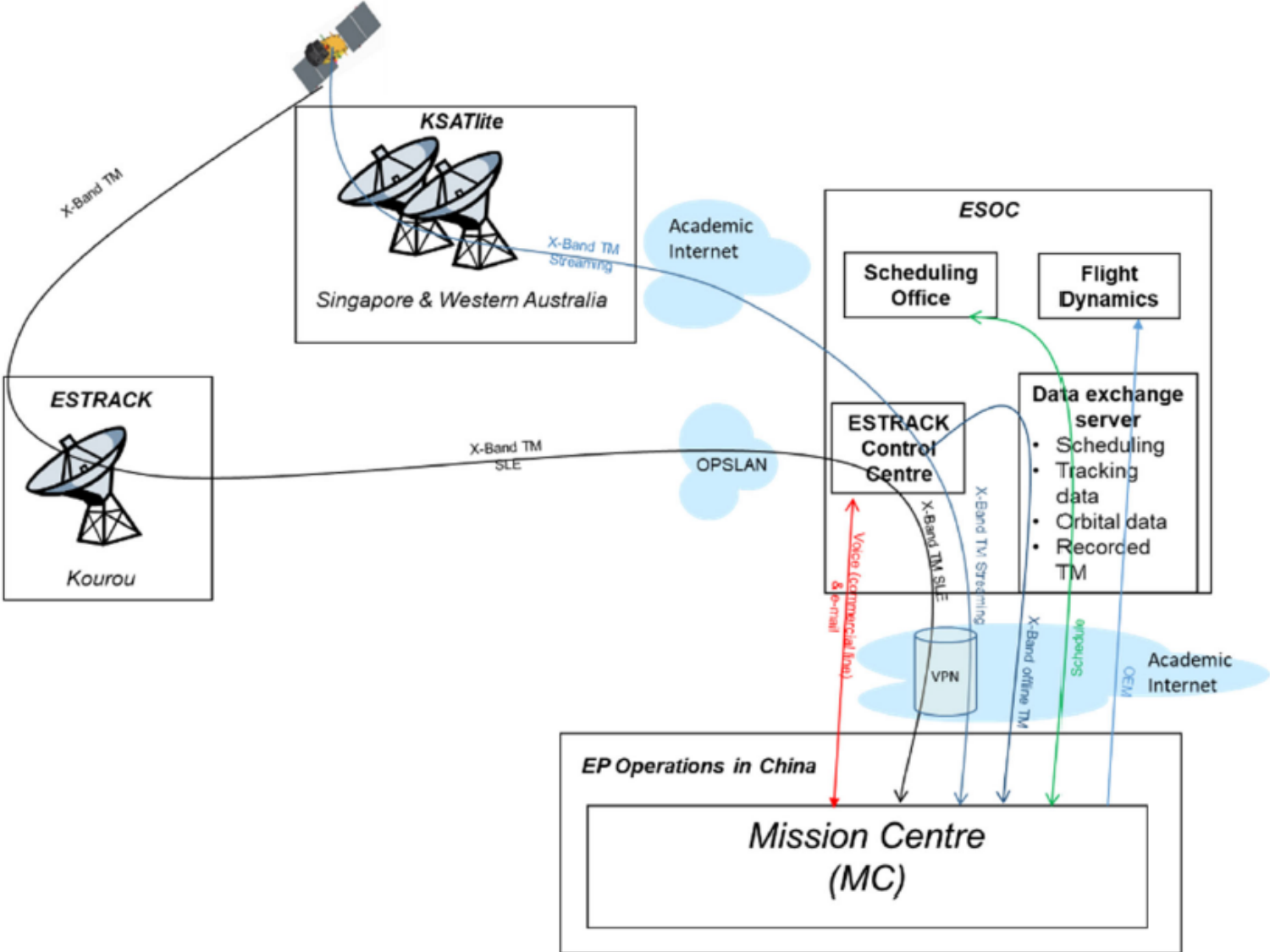
Ground Stations and RF performance

- ● Nominal

- ● May be added later/backup, if needed

Kourou (KRU-1) is part of ESTRACK and it is owned by ESA

The other stations are from KSAT under ESA contract ("augmented stations")

	Kourou	Singapore	Western Australia
Longitude	52 deg 48' 16.79" W	1° 23'47.93"N	29.010417 °S
Latitude	5 deg 15' 05.18" N	103°50'03.62" E	115.341708 °E
Altitude[m]	-14.6709	12	242
Antenna Diameter [m]	15	5	5
X-Band G/T [dB/K]	41	27.68	28.28

Visibility pattern

About half day is covered by Sanya, the rest needs to be covered by ESA stations (~8 passes/day)

Ground System development activities - highlights
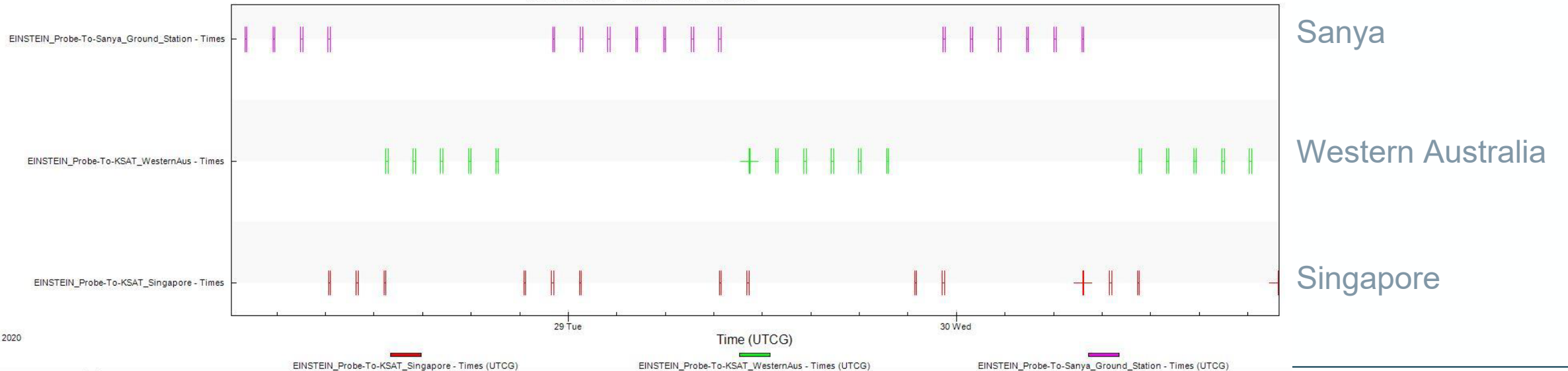
- June 2021: GS supplier selection through competitive tender

- July 2021: successful RF Compatibility Test at ESOC facility with transmitter EM provided by CAS

- August 2023: Ground-to-Ground ICD finalised (issue 1.4)

- December 2023: KSAT antennas installed and licensed

- December 2023-March 2024: Definition and setup of comms infrastructure including a complete separation from KSAT and CAS and 3 data delivery methods (SLE, stream, sftp)

- January-March 2024: in flight testing and debugging of GS support

Typical Sequence of Operations

1. CAS sends OEM data every day

2. ESOC FD fully automated

    - Converts OEMs in STDMs and TLE for the ground stations

    - Converts OEM in station events predictions forwarded to ESOC scheduling office

3. ESOC Scheduling Office schedules Einstein Probe passes with priority of stations: Sanya -> Kourou -> Western Australia -> Singapore

    - Pass plan is provided to CAS and passes are scheduled with the different stations

4. CAS reviews pass plan and commands Einstein Probe spacecraft transponder ON for the scheduled passes

5. Ground stations fully automated configure for the passes and wait for a signal from Einstein Probe Satellite

6. Einstein Probe satellite autonomously switches on the transponder during the pass to transfer science data to ground. During the pass the science operations are continued by Einstein Probe satellite.

7. KSAT stations start streaming of the data to ESOC at data reception on the ground stations.

8. ESOC starts streaming of the data to CAS upon reception of the stream in ESOC.

9. KSAT stations record the received data in a file on sftp. ESOC collects the files when they are available and makes the files available for CAS for download via sftp.

System Performance to date

Nominal support started in mid March

        11.03.2024 start of nominal support from Kourou,

        19.03.2024 start of nominal support from Western Australian and Singapore station

1 pass/orbit achieved

5-6 passes each day from ESA provided stations

1 failed pass in 30 days – issue was fixed before the next scheduled pass

Latency from KSAT stations (streaming through academic internet) <30 min and approaching 10 min

Latency from Kourou to be improved by increasing connectivity bandwidth (planned in week 17) to allow 150 Mbps

Data quality of delivered data is good for all stations.

Scheduling is working as expected.

Flight dynamics is working as expected.

Next Steps

Kourou bandwidth increase in week 17 – will allow latency requirement compliance.

Overall EP Project Management will be transferred to ESAC (ESA Science Operations Centre) at end of May 2024 – no change for GS support

At the end of the nominal lifetime of 3 yrs, if mission extension is wished by CAS, the ESA EP project will have to request internally the budget for extending the GS support. This is standard practice and generally no issue, but it needs to be prepared ~1 year in advance.

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Thanks

Many thanks to CAS EP Ground System team for the nice cooperation !

Many thanks to Melanie Flentge (the ESOC project manager for EP) !

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