Introduction of CFOSAT Orbit and Platform Current Status

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ZOOM

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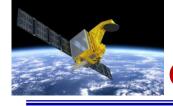# Orbit Basic Situation

– **Since launch till 2020.12.31, CFOSAT made the following orbit maneuver:**

  – **Early phase maneuver to reach the frozen SSO, from 10.31 to 11.02, 2018;**

  – **Routine orbit keeping maneuver to maintain the ground track within a range of ±20km, on 01.04, 04.18, 08.29, 12.06, 2019, 04.02, 07.17, 09.03, 12.03, 2020, about once every 3 months;**

  – **Collision avoidance maneuver, rised the altitude on 07.22, and dropped back on 07.29, 2020.**

– **The fuel cost for orbit ground track keeping each time is less than 0.1kg. And the fuel left onboard right now is around 18.6kg.**
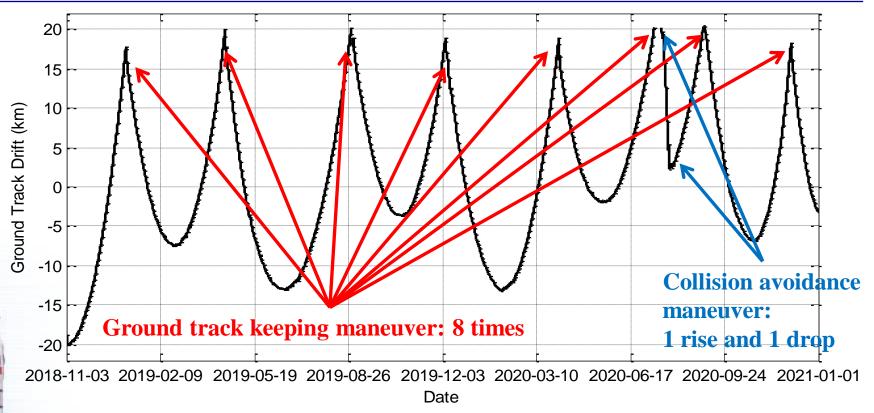
Orbit Maneuver List

No	Remark	Date
1	Thrustor calibration	2018.10.31
2	1st Dual pulse to generate frozen orbit	2018.11.01
3		2018.11.01
4	2nd Dual pulse to generate frozen orbit	2018.11.02
5		2018.11.02
6	1st Orbit ground track keeping	2019.01.04
7	2nd Orbit ground track keeping	2019.04.18
8	3rd Orbit ground track keeping	2019.08.29
9	4th Orbit ground track keeping	2019.12.06
10	5th Orbit ground track keeping	2020.04.02
11	6th Orbit ground track keeping	2020.07.17
12	Collision avoidance maneuver (Rising altitude)	2020.07.22
13	Collision avoidance maneuver (Dropping altitude)	2020.07.29
14	7th Orbit ground track keeping	2020.09.03
15	8th Orbit ground track keeping	2020.12.03

Reach frozen SSO

Orbit ground track keeping

Collision avoidance maneuver

Ground Track Keeping

Ground track keeping maneuver: 8 times
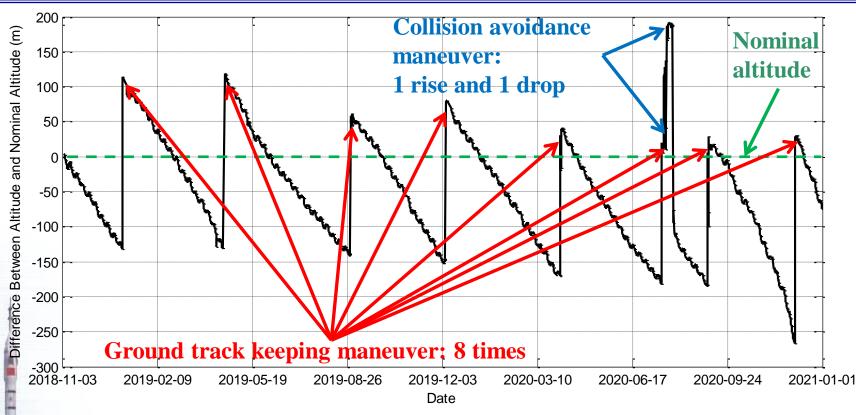
Collision avoidance maneuver:
1 rise and 1 drop

- The **ground track** was kept within the range of ±20km.
- It means that the ground strips of adjacent orbits have **enough overlap margin** to **prevent** remote sensing observation **gap**.
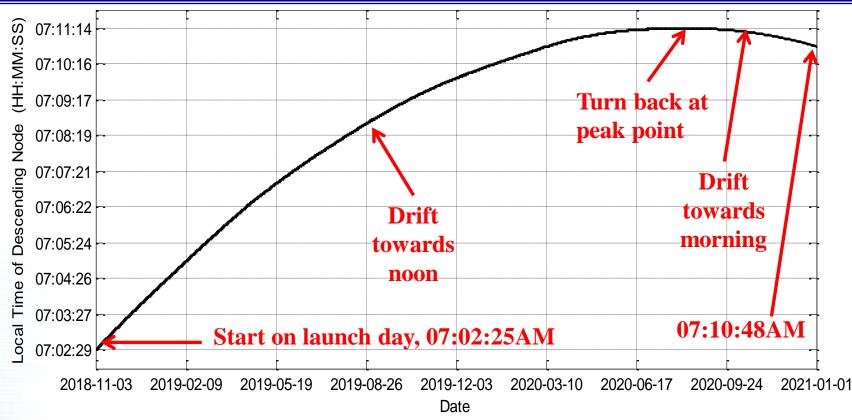
Orbit Altitude Changing

- The orbit **altitude difference** was kept within the range of **+150m to -300m** through orbit maneuver for ground track keeping.
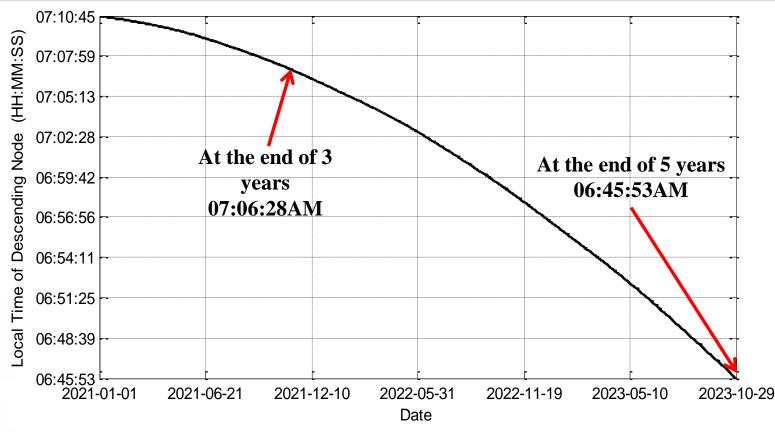- It means that the **distance** between satellite and ocean surface keeps stable for SWIM & SCAT signal echo.

The chart shows: Local Time of Descending Node (HH:MM:SS) plotted against Date.

Y-axis values: 07:11:14, 07:10:16, 07:09:17, 07:08:19, 07:07:21, 07:06:22, 07:05:24, 07:04:26, 07:03:27, 07:02:29

X-axis values: 2018-11-03, 2019-02-09, 2019-05-19, 2019-08-26, 2019-12-03, 2020-03-10, 2020-06-17, 2020-09-24, 2021-01-01

Turn back at peak point

Drift towards noon

Drift towards morning

Start on launch day, 07:02:25AM

07:10:48AM

- The **LTDN** (Local Time Descending Node) is drifting.
- It started from **07:02:25AM** on **2018.10.29** (the launch day), keeps drifting towards noon, then after reaching the peak point, it turns back towards morning, and reached **07:10:48AM** on **2020.12.31**.
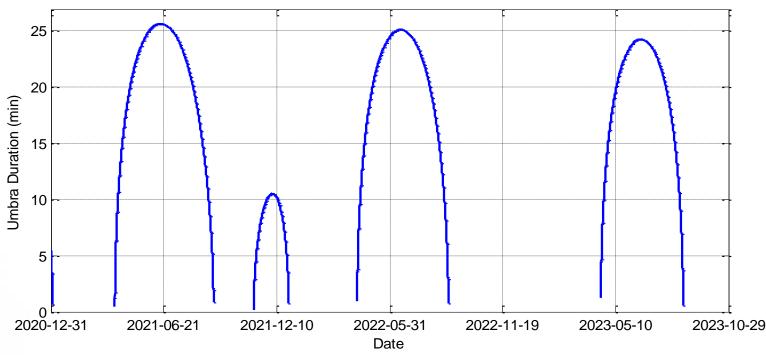- Right now it is still drifting towards morning.

- **This is the estimation curve of LTDN in the future.**
- **At the end of 3 years (2021.10.29), it's estimated to reach 07:06:28AM**
- **At the end of 5 years (2023.10.29), it's estimated to reach 06:45:53AM**
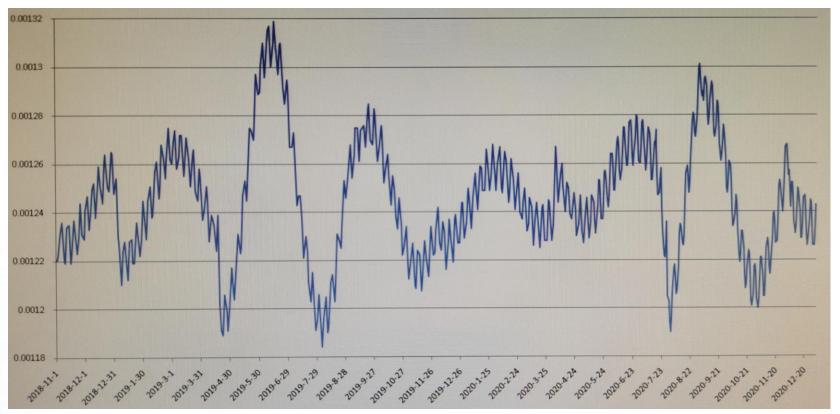
Umbra Duration Estimation

- **This is the estimation curve of umbra duration in the future.**
- **The orbit umbra phase is estimated to appear twice each year, the longer one in summer, the shorter one in winter;**
- **The longest umbra will appear in each orbit for more than 4 months, and more than 1500s(25mins) per orbit.**
- **However, due to the drift of LTDN, there will be no winter umbra phase since 2022.**
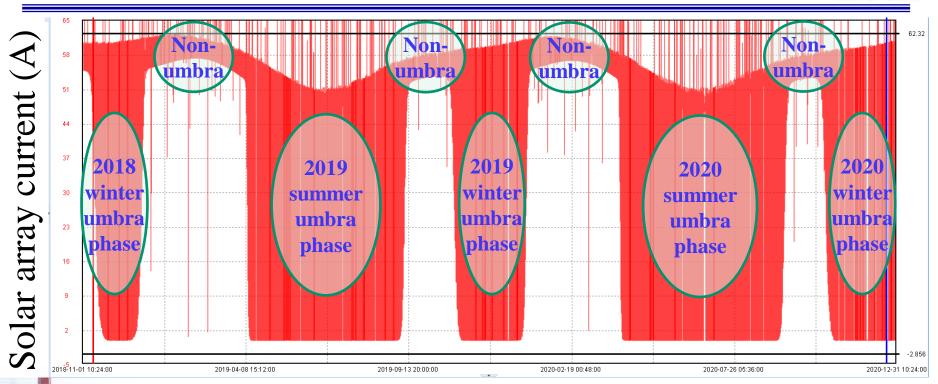
Orbit Eccentricity

- To keep the frozen orbit characteristics, the orbit eccentricity is designed as 0.00123.
- In the last 2 years, the orbit eccentricity value runs very stable between 0.00132 and 0.00118.
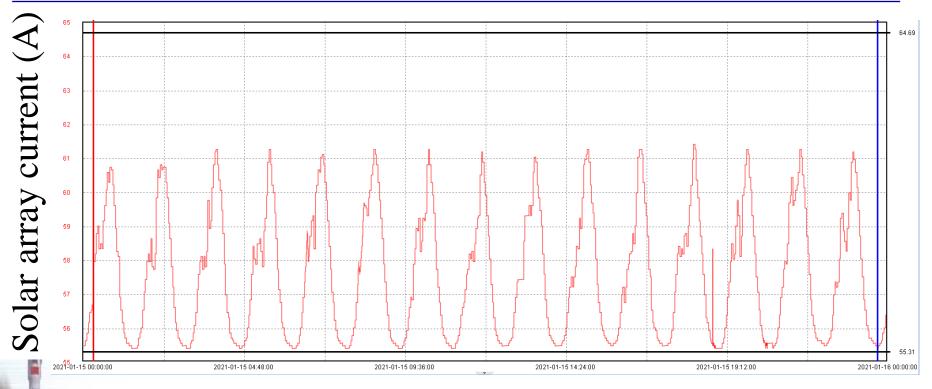
- ◆ This is the curve of solar array current since launch day.
- ◆ Part of time, CFOSAT flies in the 95mins non-umbra orbit.
- ◆ And since the launch day till now, it has gone through 2 orbit umbra phases each year.
  - ➢ Winter umbra phase, from Nov to Jan, the longest duration is about 15mins per orbit;
  - ➢ Summer umbra phase, from Apr to Sep, the longest duration is about 25mins per orbit;
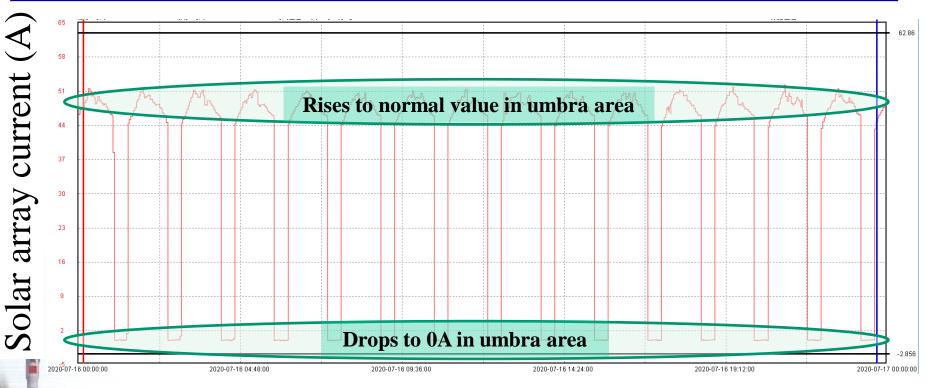
Power Supply – Solar array current(2)

◆ This is the curve of solar array current in 24 hours on 2021.01.15, in the middle of orbit non-umbra phase. It is clear to see the 15 orbit circles per day.

◆ The solar array current keeps stable, only varies between 55A and 62A.

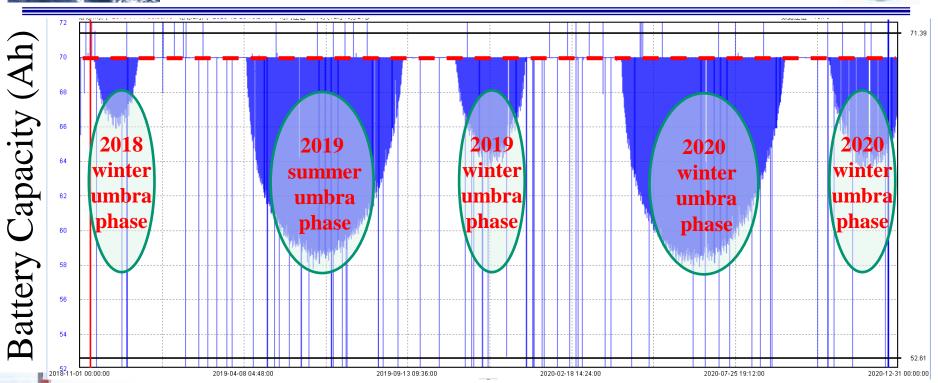This is the curve of solar array current in 24 hours on 2020.07.16, in the middle of summer umbra phase. It is also clear to see the 15 orbit circles per day.

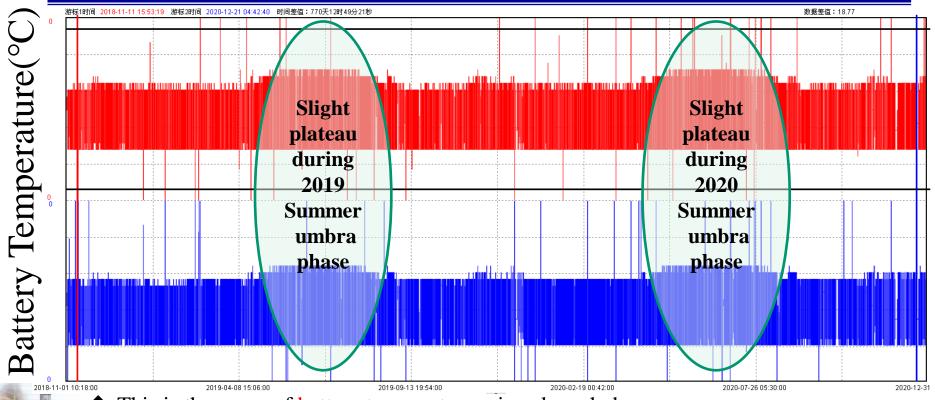In one orbit, the solar array current drops to 0A in umbra area, and rises to normal value (>50A) in sunshine area.

Battery Capacity (Ah) (y-axis)

- 2018 winter umbra phase
- 2019 summer umbra phase
- 2019 winter umbra phase
- 2020 winter umbra phase
- 2020 winter umbra phase

◆ This is the curve of battery capacity since launch day.

◆ The full battery capacity is 70Ah (the red dash line).

◆ It discharges during umbra and charges during sunshine.

◆ In winter umbra phase, it discharges less; in summer umbra phase, it discharges more.

◆ The lowest capacity is about 58.2Ah, so the maximum DOD (depth of discharge) is (70-58.2)/70=16.85%, much better than battery specification (<30%), meaning that it will benefit a lot for the battery in-orbit long life.
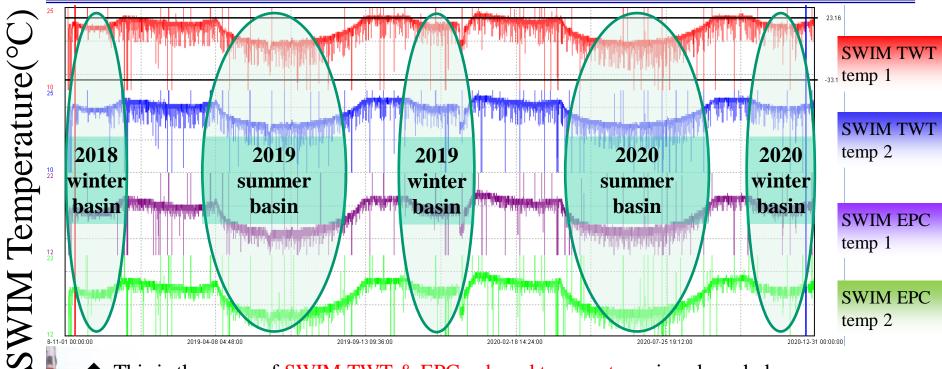
◆ This is the curve of battery temperatures since launch day.

◆ The battery temperatures are maintained within 1℃~7℃, with very slight plateau during summer umbra phase, because deep discharging activity in umbra causes battery temperature rising.

◆ The stable control of battery in low temperature status also benefits for the battery in-orbit long life.

SWIM Temperature(°C)

	SWIM TWT temp 1
	SWIM TWT temp 2
	SWIM EPC temp 1
	SWIM EPC temp 2

2018 winter basin

2019 summer basin

2019 winter basin

2020 summer basin

2020 winter basin

23.16

-33.1

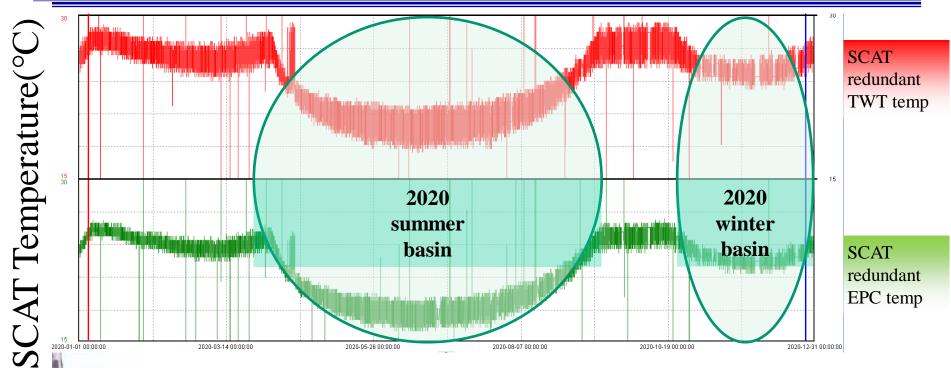8-11-01 00:00:00   2019-04-08 04:48:00   2019-09-13 09:36:00   2020-02-18 14:24:00   2020-07-25 19:12:00   2020-12-31 00:00:00

◆ This is the curve of SWIM TWT & EPC onboard temperature since launch day.
  ✓ TWT temperature varies between 10°C and 25°C;
  ✓ EPC temperature varies between 12°C and 22°C;
◆ All the temperatures are within normal range, indicates that there is no critical degeneration of onboard thermal control subsystem since launch.
◆ It is clear to see that, there are two basins in the curves each year, which indicates the impact from orbit umbra phase. Because if there is orbit umbra appearing, the onboard temperature will drop.

Onboard Temperature: SCAT

- ◆ SCAT was switched from nominal part to redundant part on 2019.12.30. So SCAT curve was plotted starting since 2020.01.01.
- ◆ This is the curve of SCAT TWT & EPC onboard temperature since launch day.
  - ✓ TWT temperature varies between 16℃ and 30℃;
  - ✓ EPC temperature varies between 16℃ and 26℃;
- ◆ All the temperatures are within normal range.
- ◆ Similar as SWIM, there are two basins in the curves each year, during orbit umbra phase.

- CLTC (China Satellite Launch and TT&C General) is the facility being in charge of CFOSAT ground TT&C operation.

- It arranged 4 TT&C visibility for CFOSAT each day, 2 in the morning for descending orbit, 2 in the evening for ascending orbit;

- The routine mission TCs for SWIM and DTS are uploaded on each Tuesday and Friday. Usually SCAT doesn't need any routine mission TC.

- Since launch till 2020.12.31, CLTC has sent 5709 telecommands, including:

  - In orbit test mission TC
  - Routine mission TC
  - Orbit element injection TC
  - Ground track keeping orbit maneuver TC
  - Collision avoidance orbit maneuver TC
  - Anomaly handle TC
  - Other TC

Conclusion

– **In the last 26 months after launch, CFOSAT orbit meets requirement. Orbit ground track keeping maneuver was performed successfully each time. Tare enough here onboard fuel margin;**

– **The battery DOD and temperature are maintained within normal range, which benefit a lot for long life time;**

– **The onboard equipment temperatures are maintained within normal range with enough margin, which means onboard thermal control function works well without big degeneration.**

– **The satellite is under health condition for the rest of 3 years life time, and 5 years extended life time.**

Future Risk of Platform and Orbit

- As we said in the previous pages, there will be no winter umbra since 2022;

- It mean that, there is a potential risk that satellite may go through higher onboard temperature each winter since 2022;

- DFH will keep on monitoring the onboard temperature status at that time, and take essential activity if needed.

- However, since there is sufficient margin to the thermal border, this risk has nothing to be worried about actually.

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