Plan-A Comments…on Jupiter Option Presented Yesterday.

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Scenario A_Ballsitic-2:
Actual Flight Sequence for 39deg, 1AU

DEPARTURE DATE = 2015 11 16 12
6-ELM(O+W)= 0.522430d+09 0.716807d+00 0.412549d+01
0.538077d+02 0.538723d+02 0.000000d+00
AND EPOCH=2015 11 16 13 10 46

1 13 15 2017 12 16 12 0 0 0 9.467
6-ELM(O+W)= 0.480394d+09 0.691216d+00 0.303261d+02
0.394643d+02 0.350523d+02 0.000000d+00
AND EPOCH=2020 10 29 14 7 25 SW Alt.= 3208524 km

2 15 13 2020 11 1 10 17 52 0 7.261
6-ELM(O+W)= 0.237473d+09 0.375005d+00 0.347301d+02
0.394643d+02 0.421404d+02 0.358872d+03
AND EPOCH=2020 11 1 10 17 52 SW Alt.= 546 km

3 13 13 2022 11 1 7 53 52 0 20.007
6-ELM(O+W)= 0.149599d+09 0.166995d-01 0.389541d+02
0.388792d+02 0.103333d+03 0.297263d+03
2022 11 1 7 53 52

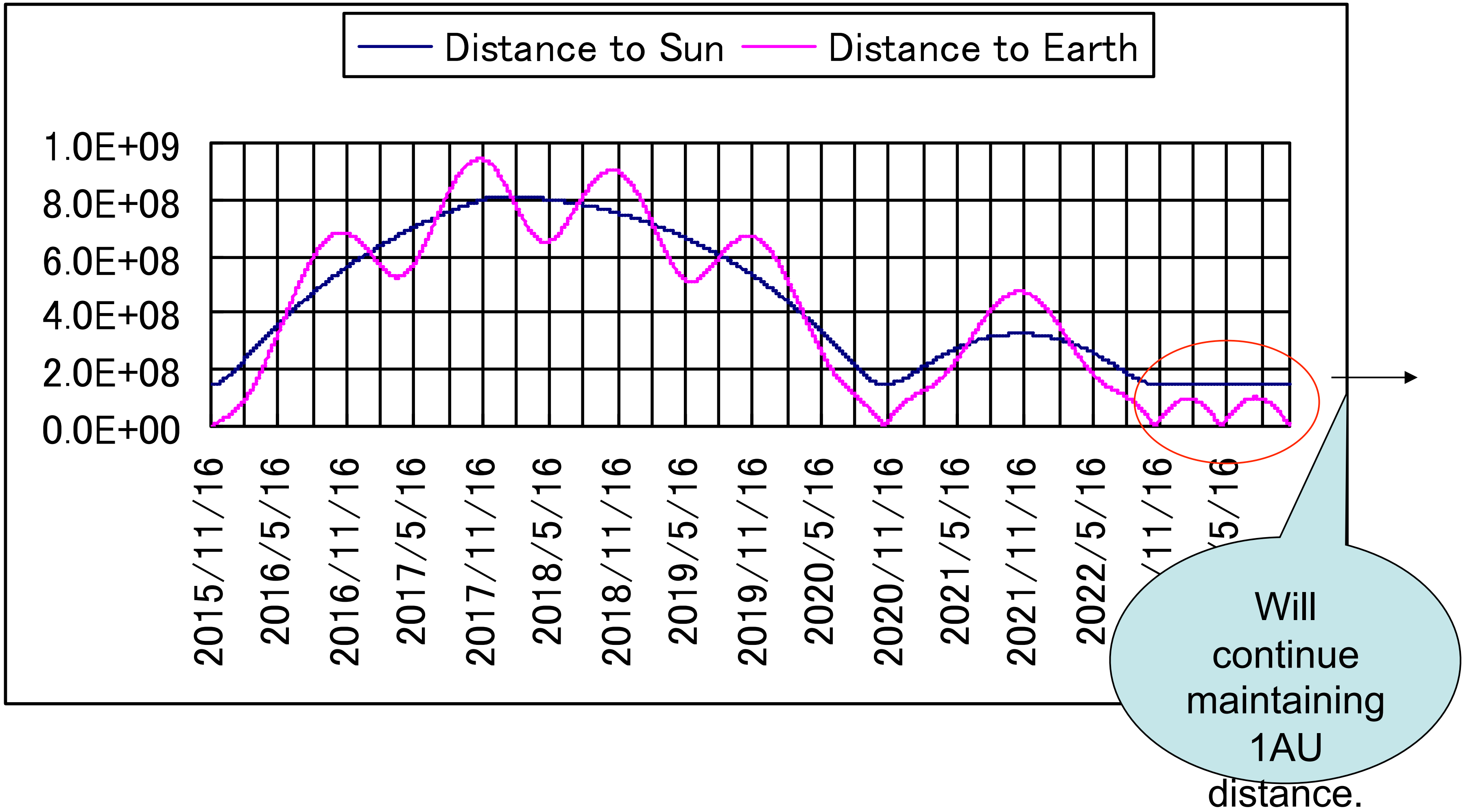
4 Final ORBIT.

- 30deg, 5.5 (1.5) AU in 2 years,
- 35 deg, 2.2 (1.4) AU in 5 years,
- 39deg, 1.0 (1.0) AU in 7 years,

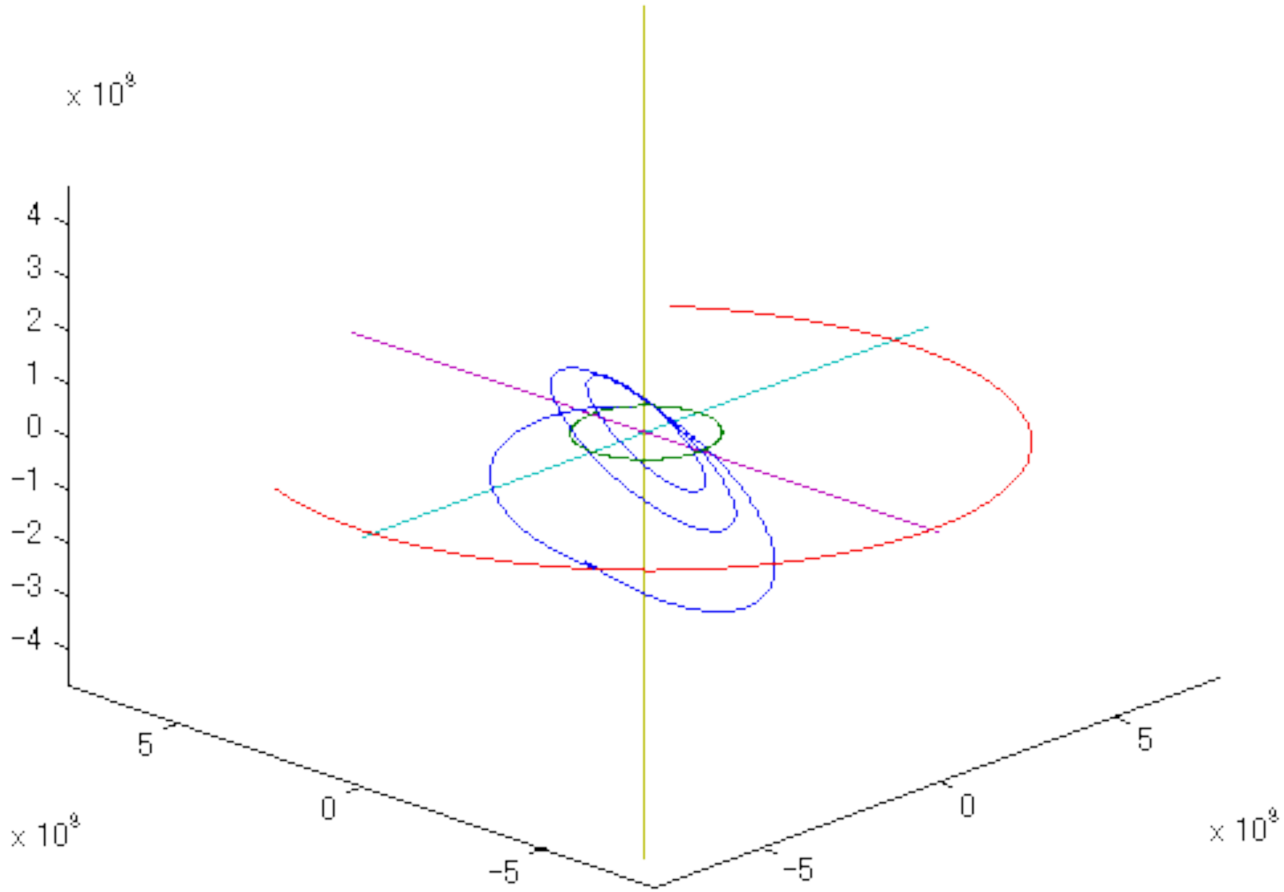
With **NO** scheduled Delta-V.

Sci Obs possible all the time.

Scenario A_Ballsitic-2:
Distance to Sun and Earth for 39deg, 1AU

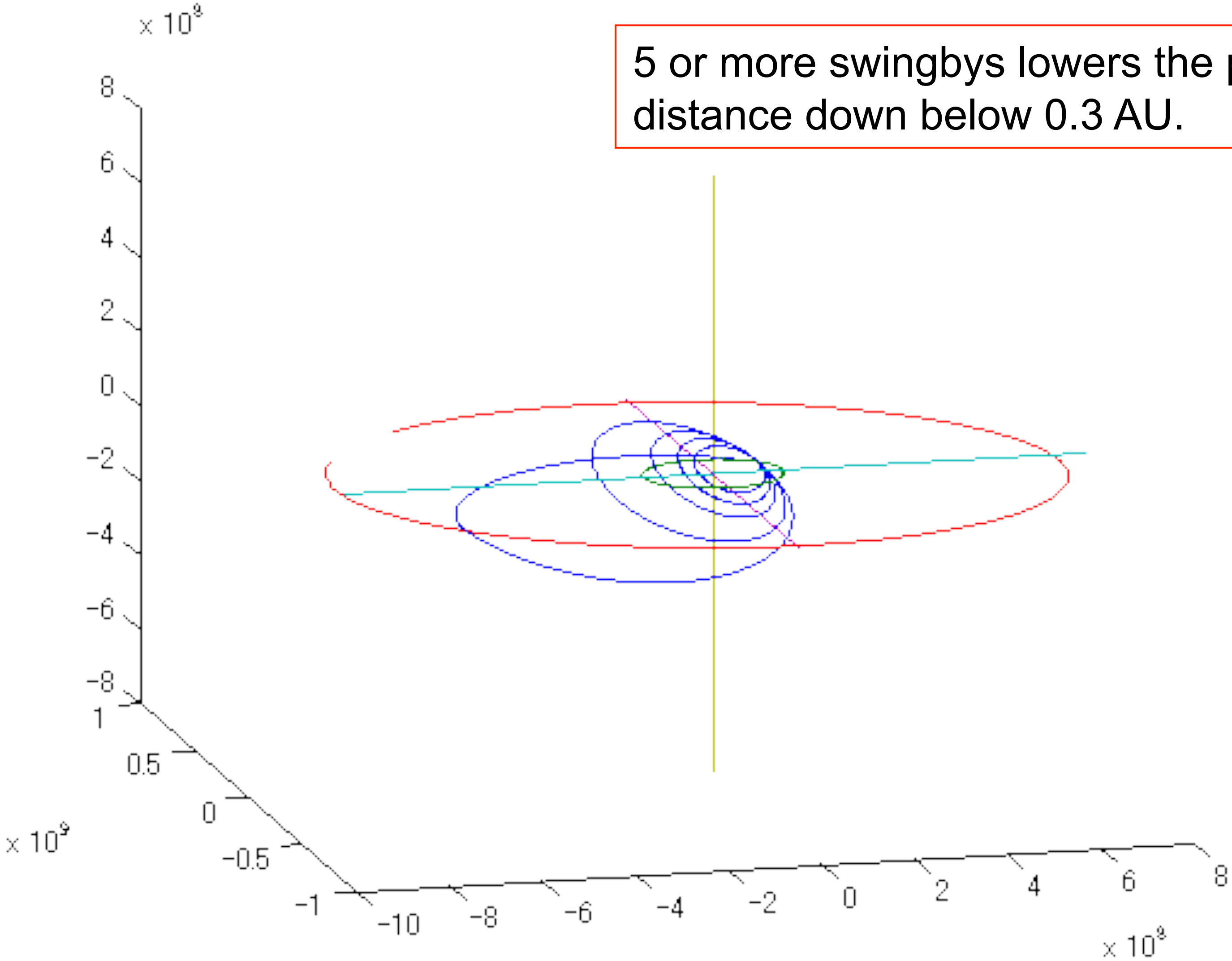


Strategy A-Ballistic-2



Strategy A-Ballistic-2+

5 or more swingbys lowers the perihelion distance down below 0.3 AU.



Mass Breakdown (with Options)

	Hinode	Hayabusa	Solar Probe+	SOLAR-C Plan-A ballistic	Remarks
Communication	9	21	32	50	<- Similar to Solar Probe+
					with large HGA
TTC	15	7.5	included above	15	<- Same as Hinode
AOCS(GNC)	82	43	43	82	<- Same as Hinode
Power System	55	16	119	55	<- Same as Hinode
Solar Array Panel	51	45	included above	200	<- 8kW Array @ 1AU
Propulsion	38	41	21	37	
Electric Propulsion		58			
Ignition/Fire Control	8	8	0	8	
Structure	129	70	59	130	<- Similar to Hinode
Thermal Control	26	9	16	50	<-Assumed
Harness, Mechanical I/F	68	31	19	68	<- Similar to Hinode
Mission P/L	288	33	55	300	<- Lightened & Updated from Hinode
Miscelaneous			69	125	<- Optional Jupiter Orbiter
			Thermal Protection		
Fuel	130	132	53	33	<- 100m/sec Bi-prop Delta-V
Total (kg)	899	514.5	486	1153	
P/L Ratio	**0.32**	**0.06**	**0.11**	**0.37**	**<- 10% Planetary s/c**

This another concept may be launched via H-IIB with 4S fairing.

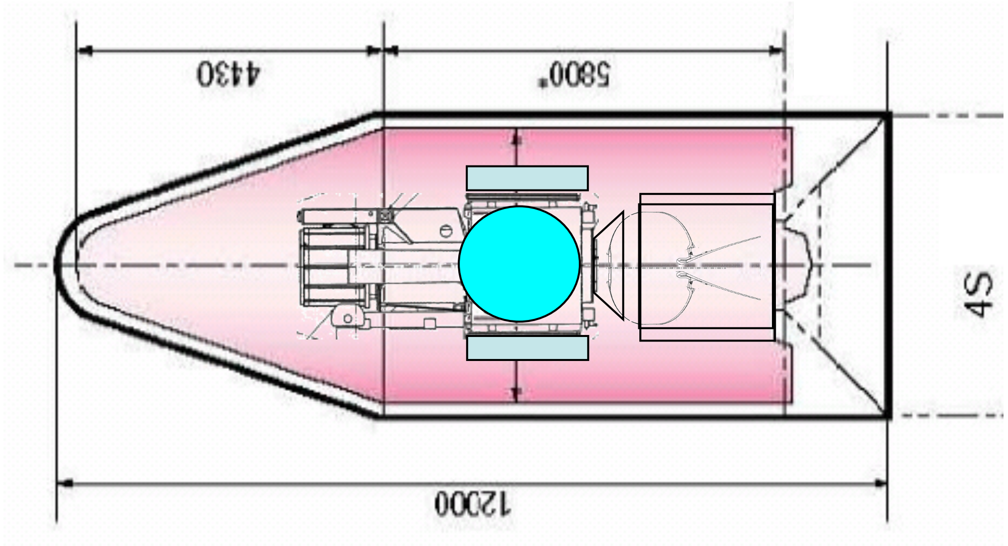
Why negative via Solar Sail ? (1)

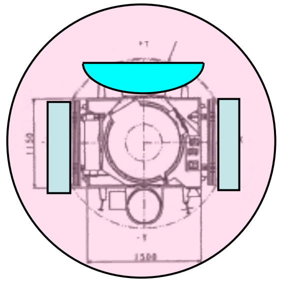
- JAXA is very much keen on Solar Sail. But it is on Solar Power Sail that is a Hybrid Propulsion.
- Pure sail propulsion is perfect, if cruise period is enough long.
- For instance, if 50% mass can be poured for propulsion, high Isp electric propulsion replaces Sail Membrane + Mechanism.
- Solar Power Sail generates Power driving Ultra High Isp Electric Propulsion. It has better benefit. So, JAXA is for Solar Power Sail instead of Pure Sail.

Why negative via Solar Sail ? (2)

- Pure Photon Sail is effective in Smaller Spacecraft owing to Lower Ballistic Coefficient.
- About the Application to larger spacecraft, it is less advantageous over either of Electric Propulsion or Hybrid Solar Power Sail Propulsion. Besides, High resolution Telescopic observation does not fit for the spacecraft that always changes its attitude.
- Still deploying 20k square meters sail is a key. JAXA's hybrid propulsion concept reduces sail area drastically down to 2k square meters for 600kg spacecraft and makes the credibility more high.

4S Fairing Compatibility

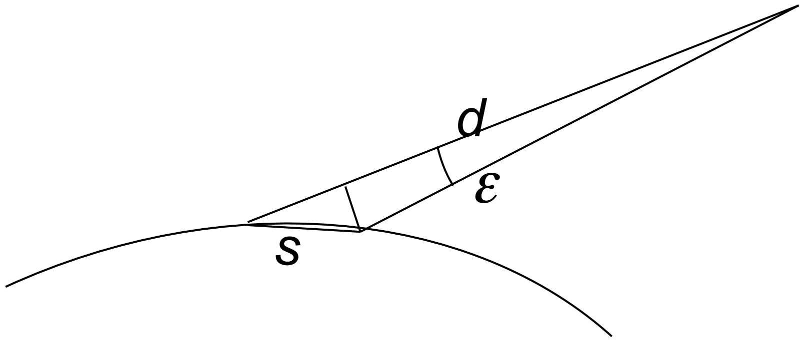




Even with a HGA and enlarged Solar Array Panels, it fits for 4S fairing of H-IIA.

Spatial Resolution Index

- For Polar Region Observation:



$$d\varepsilon = s\sin\theta$$

$$\frac{\varepsilon}{s} = \frac{\sin\theta}{d} = Resolution\ Index$$

Resolution Index at 1 AU, if normally faces, corresponds to $6x10^{-9}$.

When 1000x1000 pixels for 0.5degx0.5deg FOV, $e=10^{-5}$ radian, and it results in 1,500 km/pixel resolution.

Parameters …..(1)

- There are three major parameters that affect the mission scenario.

1. Resolution (Index) to be as high as possible.

$$\frac{\sin\theta}{d} = Resolution\ Index$$

2. Heat Flux to be below Specification.

$$f = \frac{k}{d^2}$$

3. Observation Period in High Latitude. In other words, angular velocity to be below a threshold.

$$n = \frac{A}{d^2}$$

Parameters .....(2)

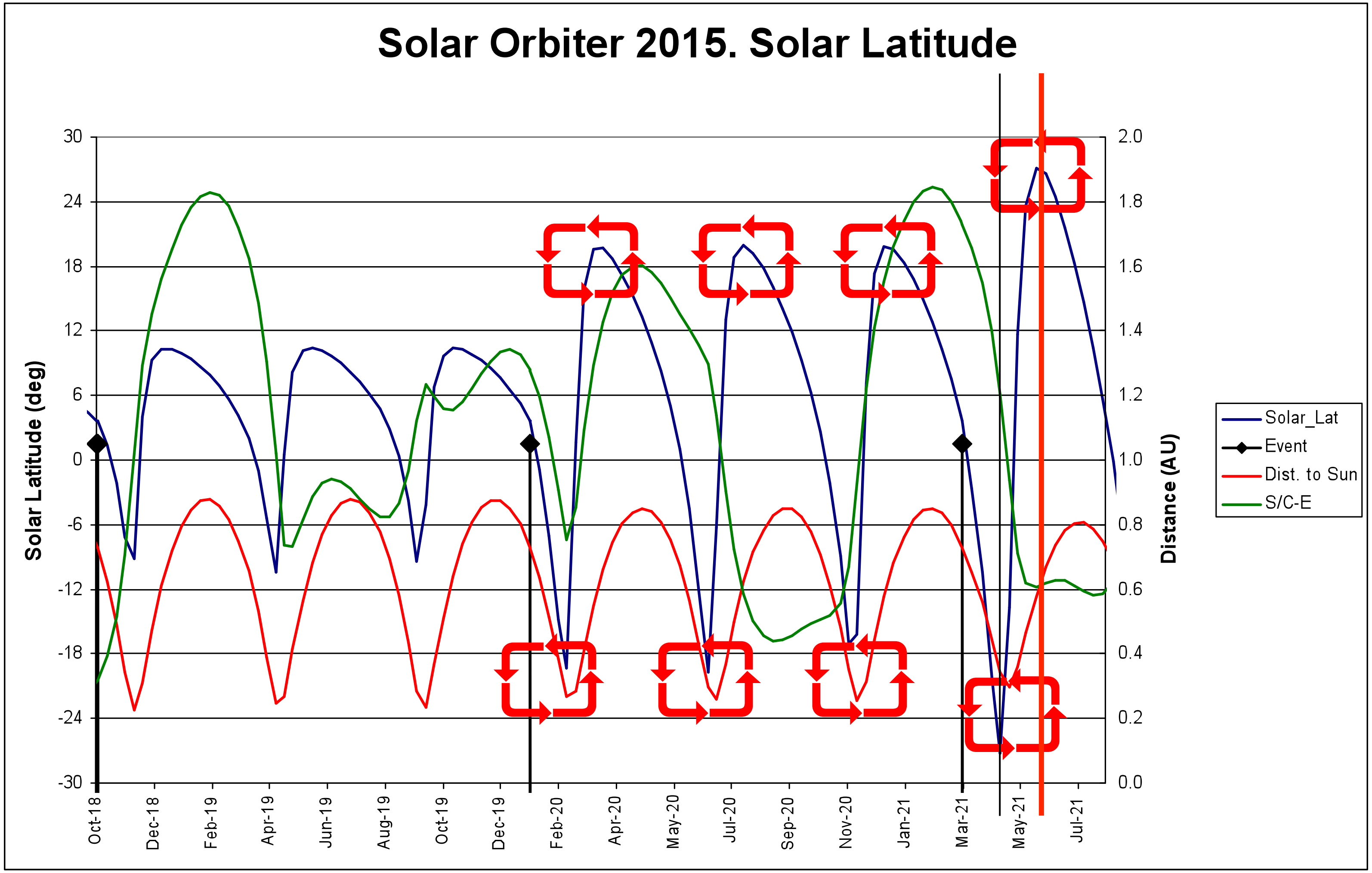
Constraint on both Heat Flux and Observation Period is common, and they restrict simply the distance to the Sun.

Enhancing Resolution (Index) apparently seen by both reducing the distance to the Sun and making inclination higher.

However, this may not be true in view of Heat Flux and Observation points of views.

So, we should be modest as to the distance to the Sun, and have to try to make the inclination higher.

Solar Orbiter Mission Phase

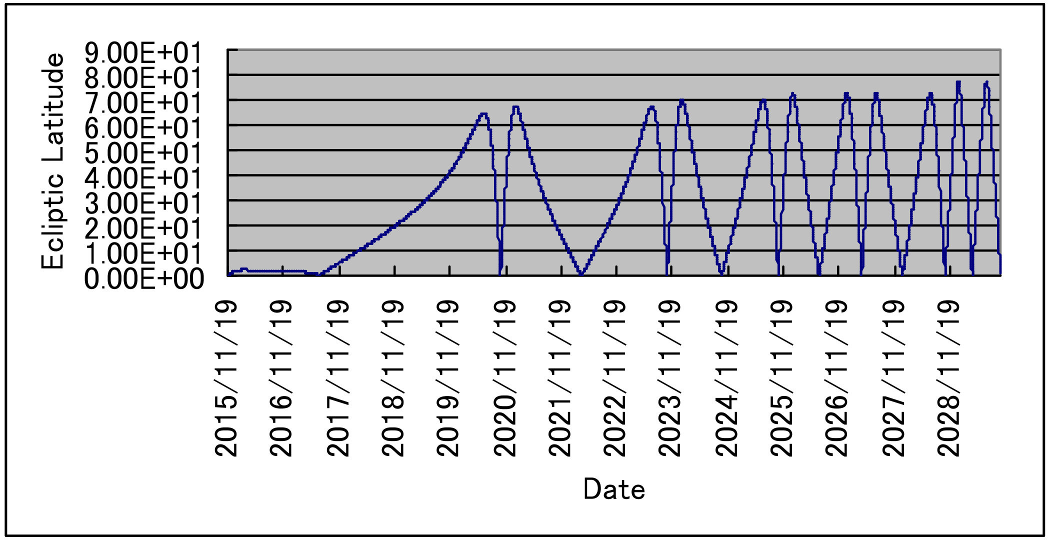


0.25AU, 24 deg in 6 years in Solar Orbiter Scenario.

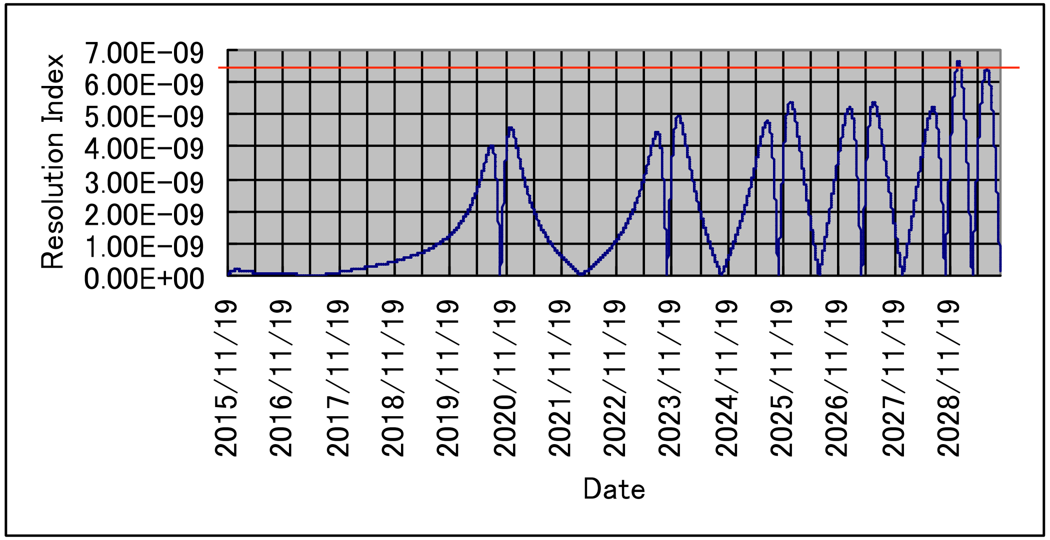
0.6AU when 26 degrees = 4.9x 10^{-9} as Resolution Index.

0.35AU when -25 degrees = 8x 10^{-9} as Resolution Index.

A_Ballistic-1

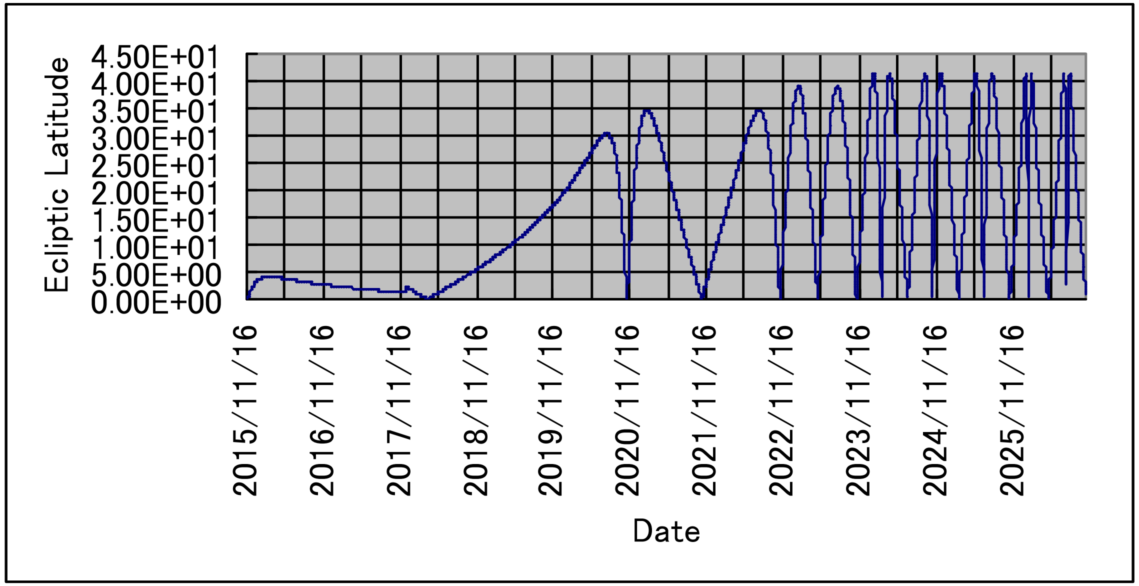


Well maintains high inclination.

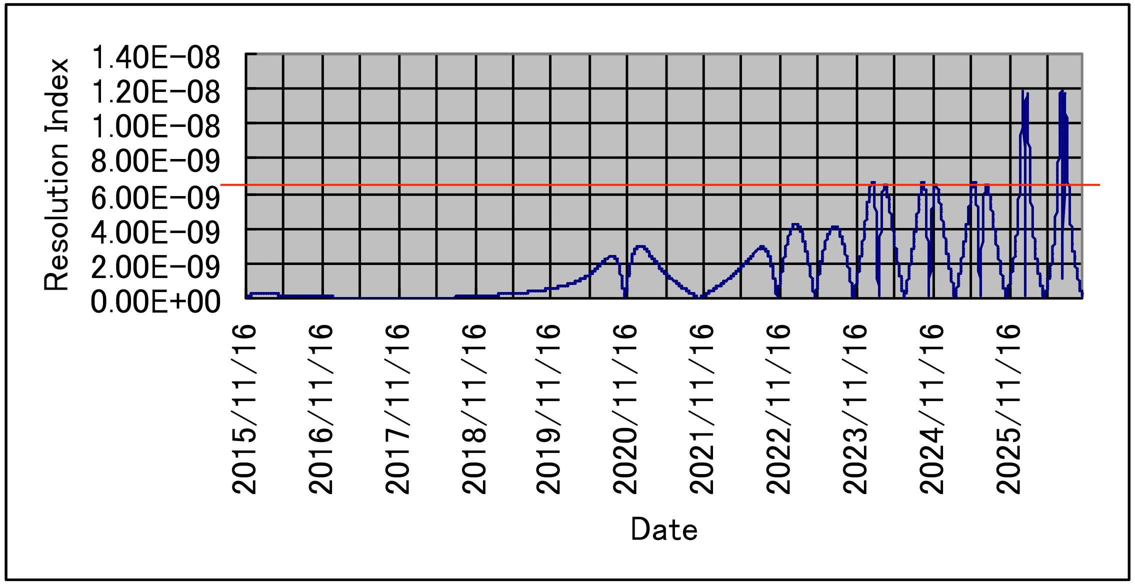


Resolution Index reaches 6×10^{-9} (1/km)

A_Ballistic-2+



Well maintains high inclination.



Resolution Index reaches 12×10^{-9} (1/km)

This is owing to shortened distance to Sun.

Communication Sys on Solar Probe+

The Ka-band (32-GHz) high-power transmitters are 40-W RF output power traveling wave tube amplifiers (TWTAs). The TWTAs are ~50% efficient (DC power of 80 W) and build on heritage from TWTAs on the Kepler (35 W at 32 GHz) and LRO (40 W at 26 GHz) missions. The Xband transmitters are 13-W TWTAs that are heritage from the New Horizons mission and are ~40% efficient (32 W of primary DC power).

The two RF transponders are based on the advanced digital receiver flown on the New Horizons mission and on digital and Ka-band hardware developed for NASA on the CoNNeCT program. The transponders each require only 4 W of primary power in receive-only mode, 8.7 W in receive/X-band transmit mode, 9.7 W in receive/Ka-band transmit mode, or 14.1 W in receive/X- and Ka-band transmit mode.

The output from either of the X-band TWTAs may be steered to any of the antennas through a network of single-pole-double-throw (SPDT) and transfer (XFER) switches, which are themselves configured for redundant operation.

Similarly, the Ka-band TWTAs are switched to the HGA. Hybrid couplers are used with each of the X-band and Ka-band TWTA pairs to increase downlink system reliability.

Communication System Assumes Similar Configuration to Solar Probe+

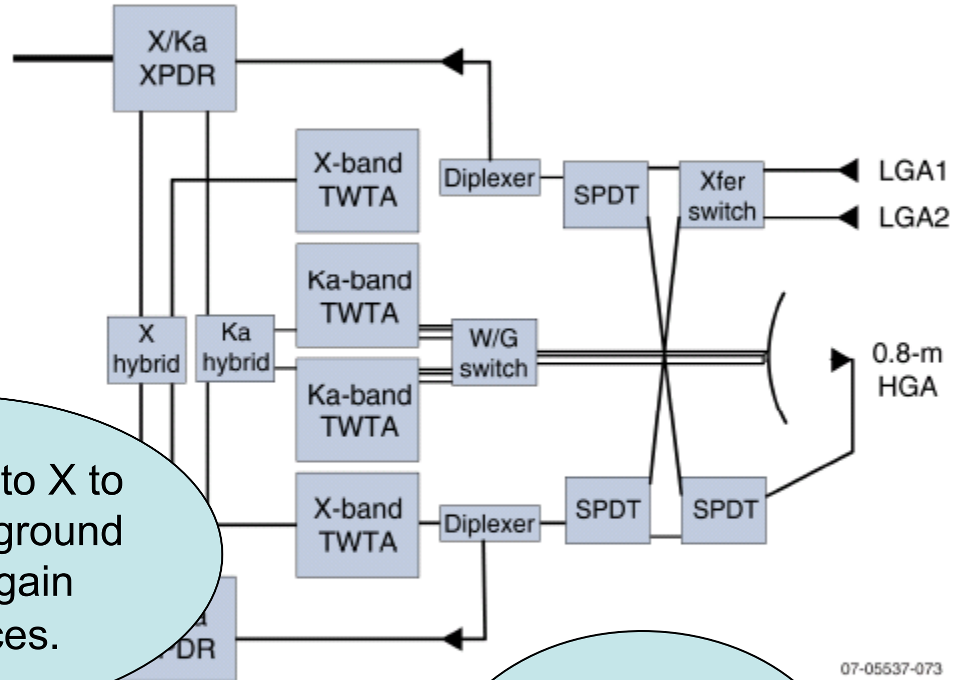
Table 3.10-2. Maximum telemetry rates vs. Earth range.

Downlink Rates vs. Earth Range			
Earth–Spacecraft Distance (AU)	Estimated Maximum Telemetry Rate: 0.8-m HGA, X-band to 34 m, 13- W TWTA	0.8-m HGA, Ka-band to 34 m, 40-W TWTA	LGA, X-band to 70 m, 13-W TWTA
0.5	92 kb/s	932 kb/s	167 bps
1	23 kb/s	233 kb/s	42 bps
1.5	10 kb/s	104 kb/s	10 bps
1.8	7 kb/s	72 kb/s	6 bps

Table 3.10-3. Maximum comm... rates ... range.

Uplink Rates vs. Earth ...		
Earth–Spacecraft Distance (AU)	Estima... Com... 34-m to 0.8-m HGA, X-band	
0.5	>10 kb/s	[illegible]
1	>10 kb/s	97 bps
1.5	>10 kb/s	43 bps
1.8	>10 kb/s	30 bps

Simply due to X to Ka s/c and ground antenna gain differences.



...igure 3.10-1. Solar Probe+ telec...

We, JAXA needs big efforts to improve the capability.

Hayabusa & PLANETC of JAXA:
With 20W X-down, with 1.6m HGA and 64m UDSC antenna: 8kbps ... num.
This is converted to:
With 40W, with 0.8 HGA and 34m USC/JAXA antenna: approximately 1kbps at 2AU, 1.2kbps at 1.8AU. JAXA current communication level is 4 times worse than Solar Probe+.