PARIS Ocean Altimeter

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Acknowledgment:

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Objective

The PARIS Ocean Altimeter is the payload of the PARIS In-Orbit Demonstrator

PARIS IoD objective →

To explore the use of GNSS reflected signals for scientific applications:

- Number of GNSS satellites will be above 150 and for decades (important in climatology)

- Focus of PARIS IoD is mesoscale ocean altimetry (most stringent application foreseen)

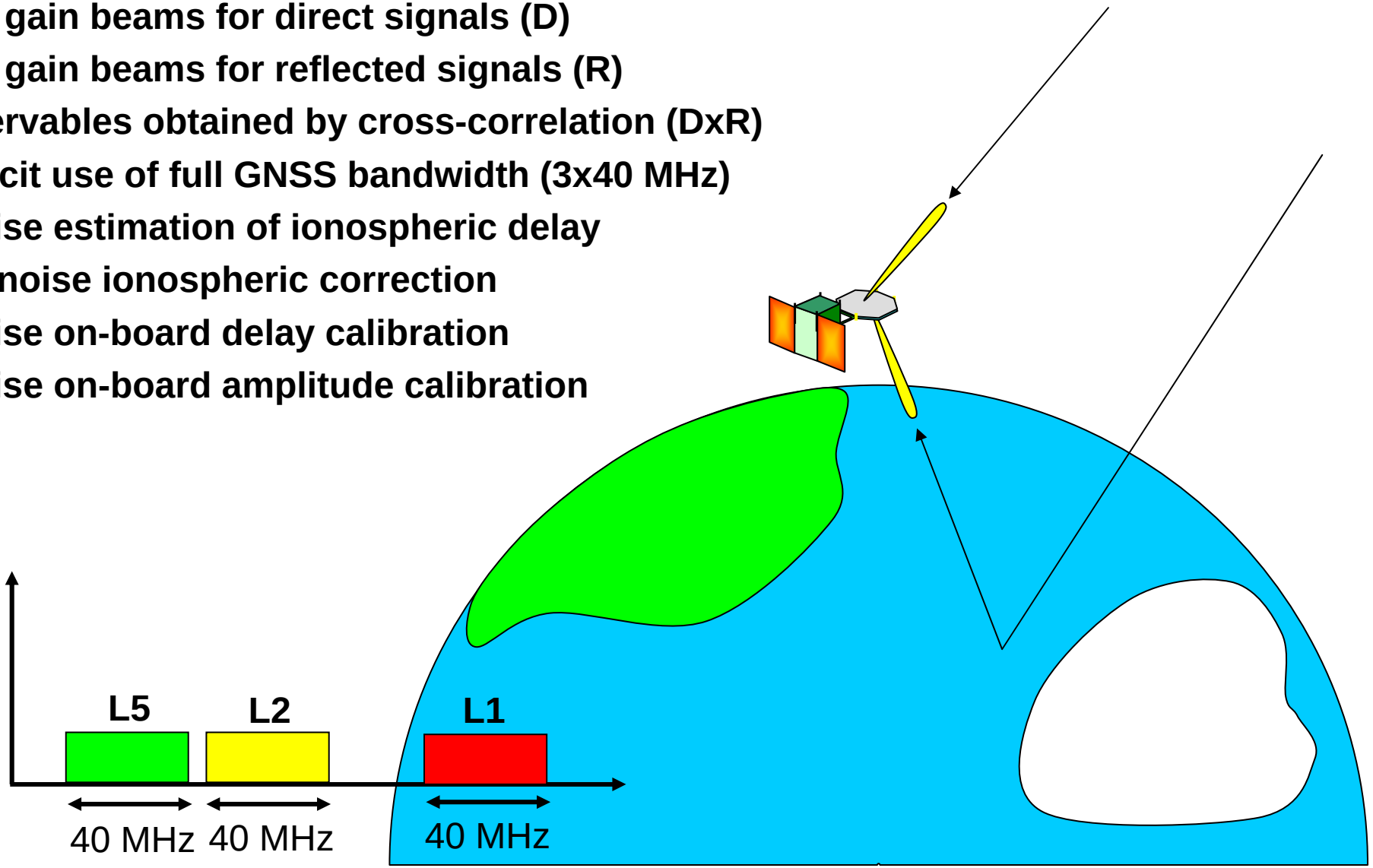
- The demonstration of mesoscale ocean altimetry could lead into a follow-on mission

Mission Summary

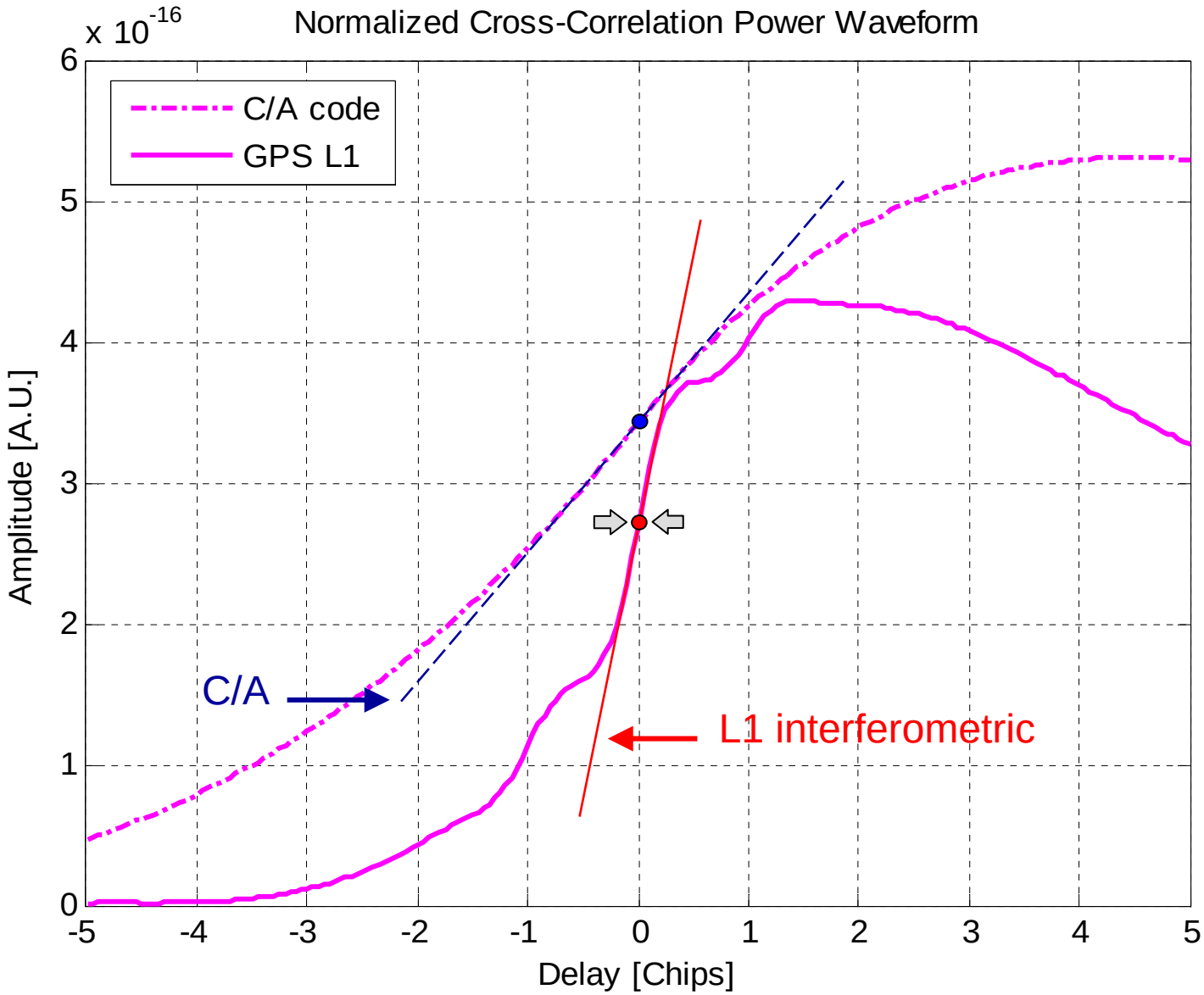
Instrument	PARIS Altimeter	
Instrument Principle	GNSS reflectometry	
Main Scientific Product	Mesoscale Ocean Altimetry	
Secondary Scientific Product	Polar Ice Thickness	
Scientific by-products	Ionospheric total electron content Wind speed over ocean Wind direction over ocean Significant Wave Height Mean Square Slope of ocean surface Sea Ice Extent	
Exploratory Scientific Products	Ocean Currents Swell Waves Ice Age Forestry Biomass Soil Moisture	
Particular Application	Tsunami detection	
	In-orbit Demonstrator	**Operational Mission**
Orbit	Polar Sun Synchronous	Polar Sun Synchronous
Orbital Height	600 km	1500 km
Swath	650 km	1500 km
Revisit Time	4 days	2 days
Spatial Resolution	100 km	< 100 km
Antenna Diameter / Gain	0.9 m / 19 dB	2.4 m / 30 dB
Number of Beams	4	16
Frequencies	GPS L1+L5 Galileo E1+E5 (option)	All 3 bands of GPS, GLONASS, GALILEO, BEIDOU
Total Altimetry Accuracy (1σ)	< 20 cm (~15 cm at nadir)	< 7.5 cm (~5 cm at nadir)
Platform	TET	PROTEUS-like
Launcher Configuration	Piggyback	Main passenger

PARIS IoD – Concept

- High gain beams for direct signals (D)
- High gain beams for reflected signals (R)
- Observables obtained by cross-correlation (DxR)
- Implicit use of full GNSS bandwidth (3x40 MHz)
- Precise estimation of ionospheric delay
- Low noise ionospheric correction
- Precise on-board delay calibration
- Precise on-board amplitude calibration



Interferometric Processing



10-fold improvement demonstrated

from a bridge in quasi-specular conditions

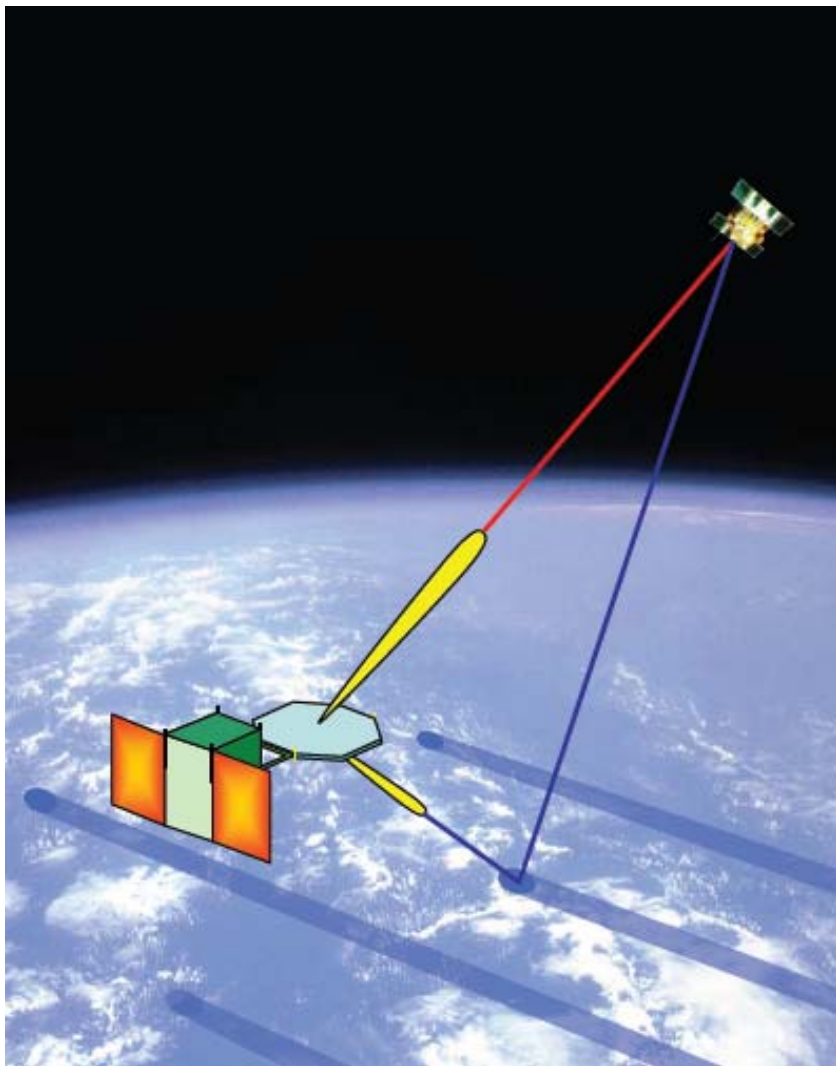
Next step: aircraft experiment in diffused conditions

(a 3-fold precision improvement expected, at least)

Specular Pointing

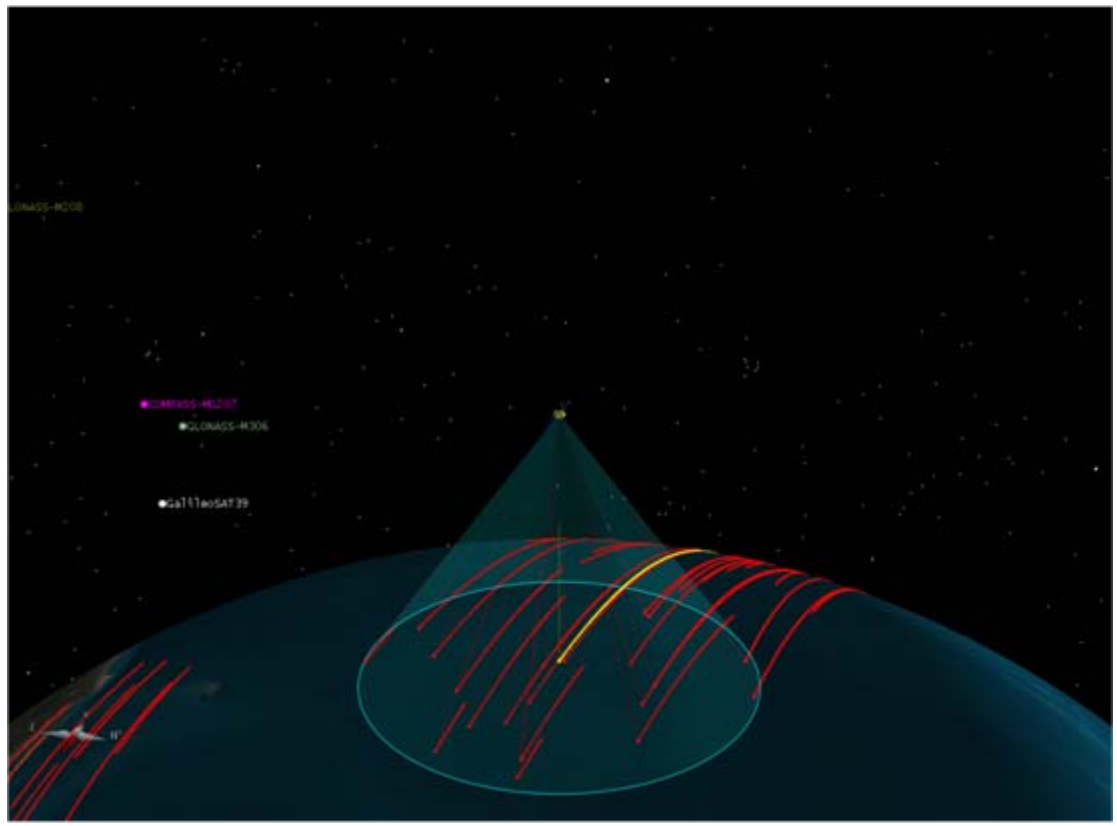
PARIS IoD

4 specular points (GPS + GALILEO)



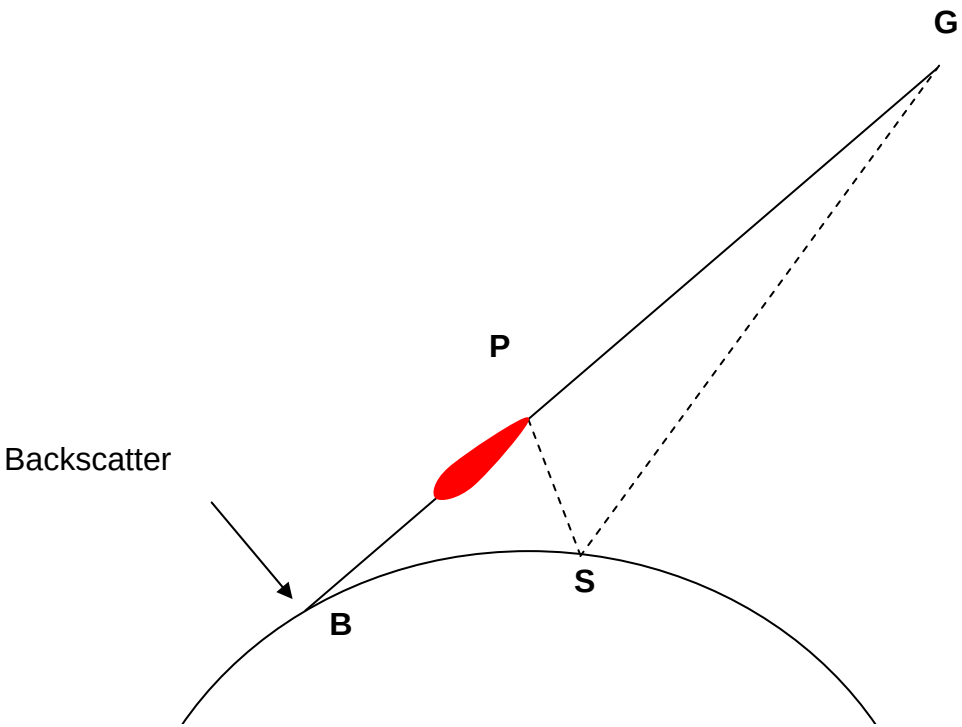
Operational mission

20 specular points
GPS + GALILEO + GLONASS + BEIDOU + INSS

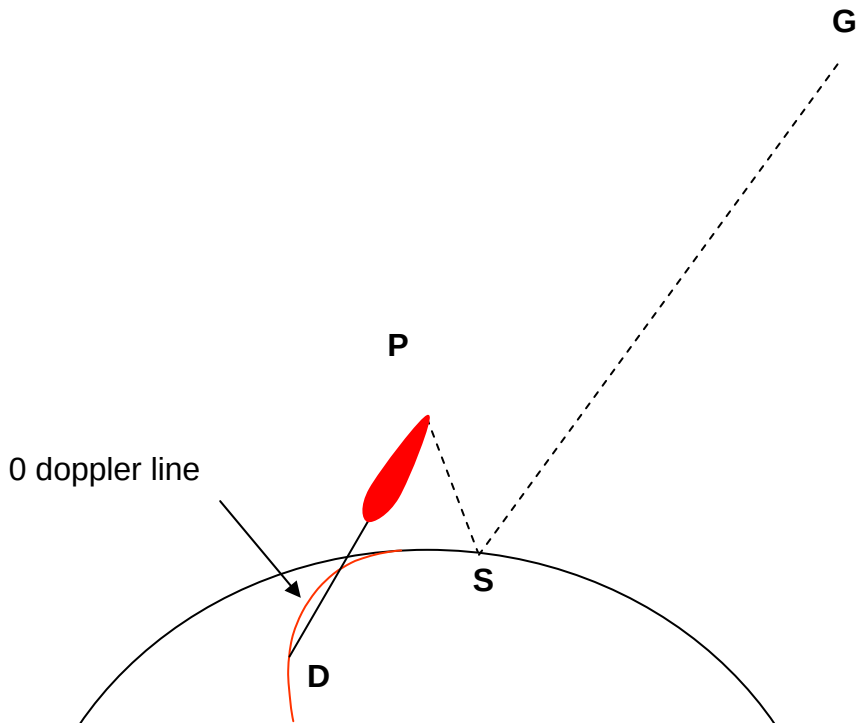


Non-specular Pointing

- Exploring new applications: SWH, ocean surface currents, swell (and rogue) waves …



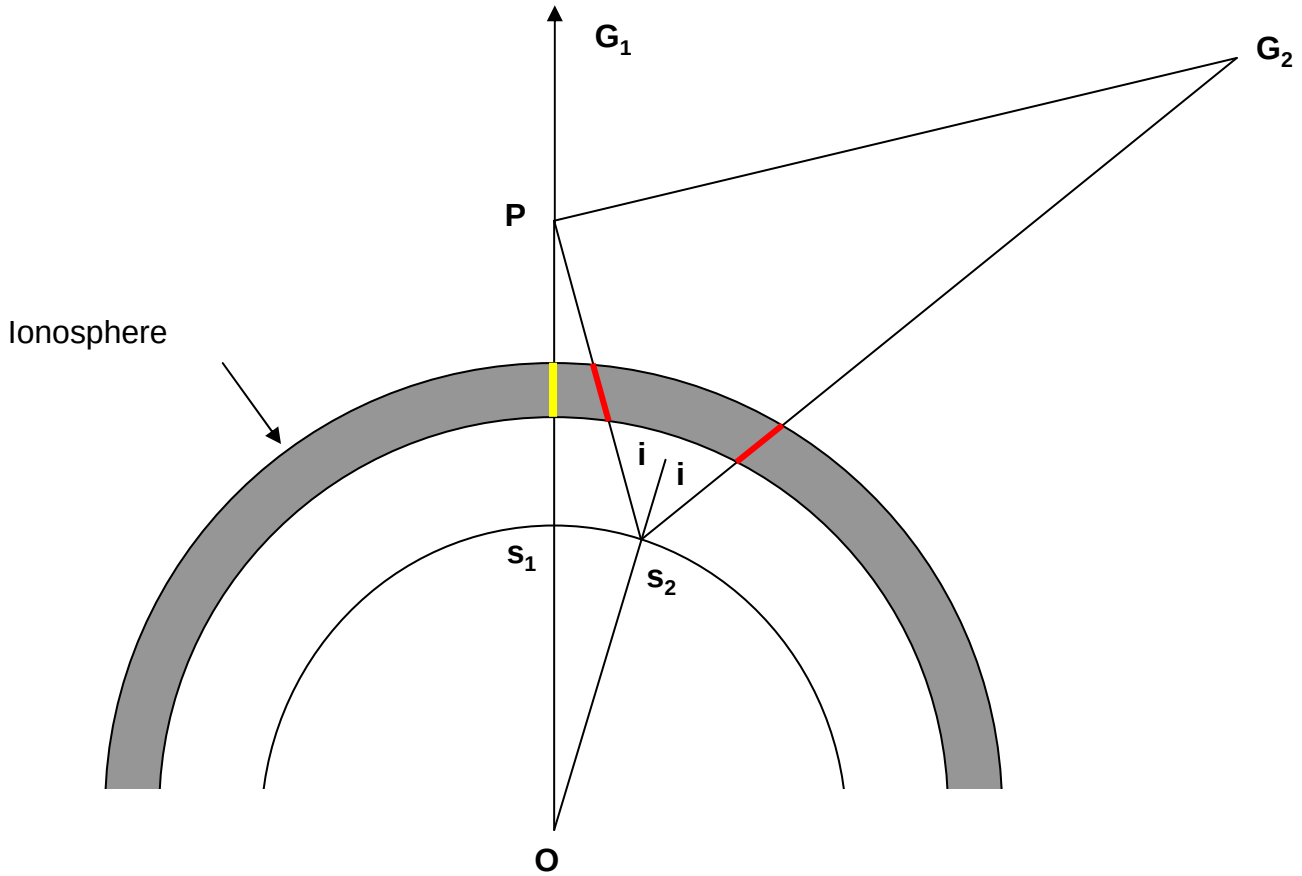
(a) Backscatter



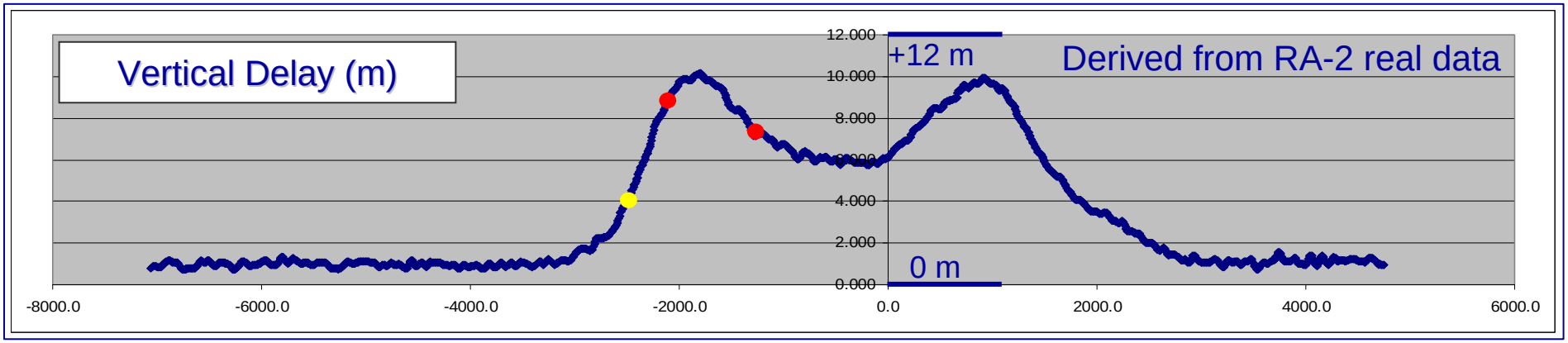
(b) 0-doppler line

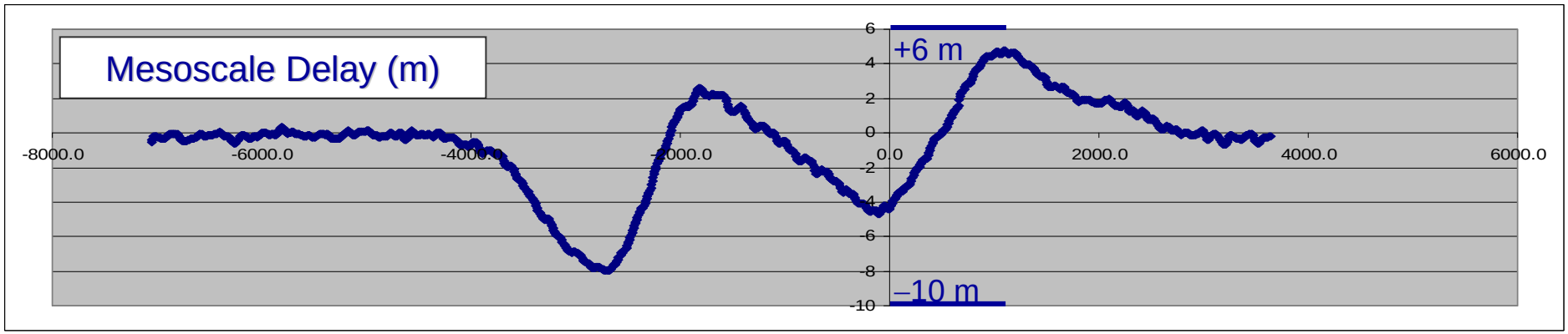
Ionospheric Correction I

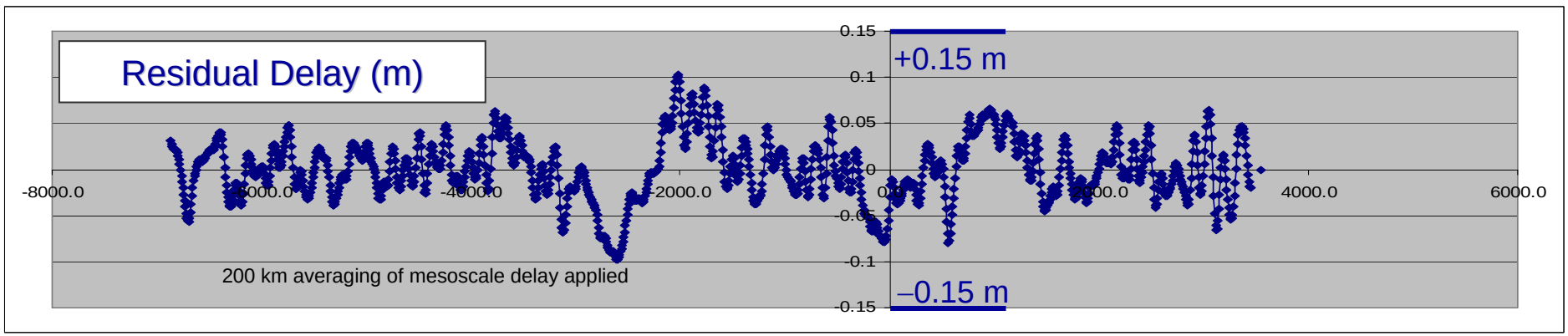
- One of the main goals of this demonstrator is to show that the large ionospheric delay at L-band can be corrected accurately from orbit to keep the required altimetric performance



Ionospheric Correction II

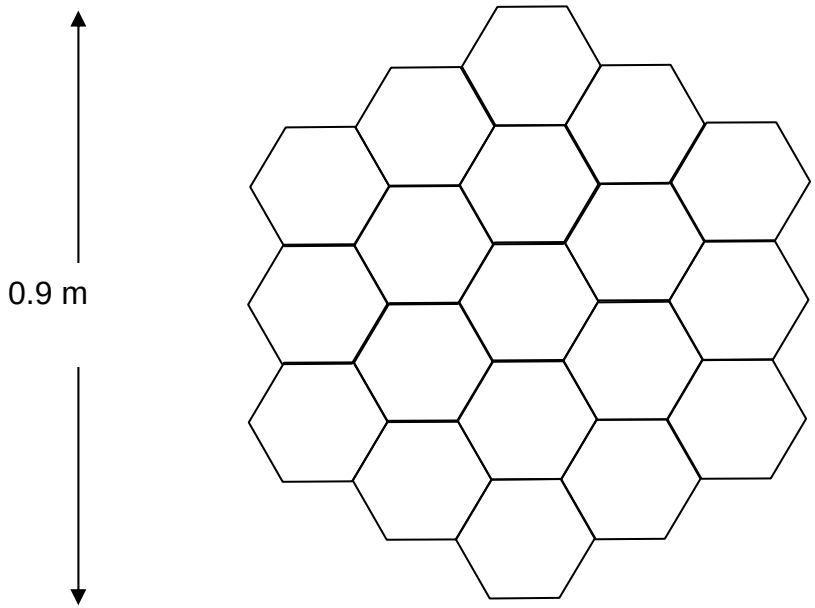


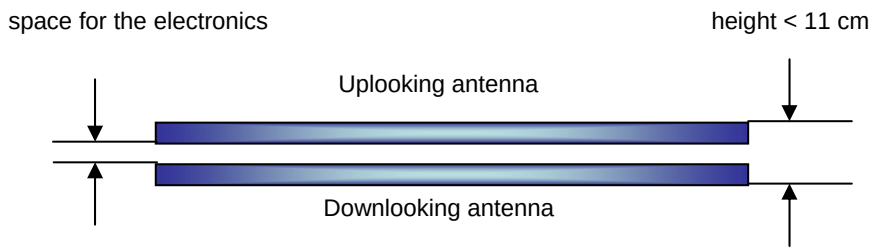




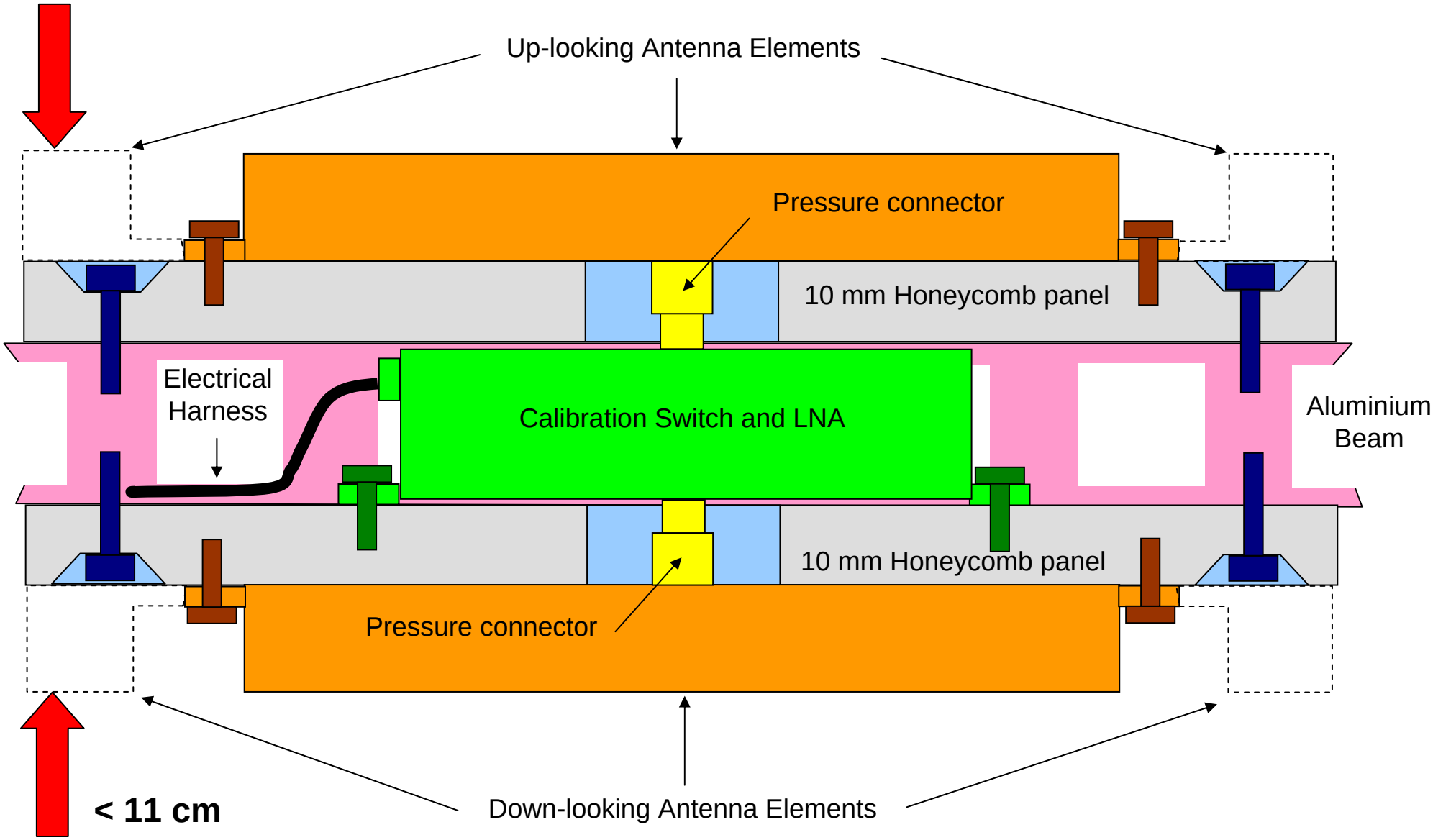
PARIS Ocean Altimeter – Antenna

- Double phased-array with 19 elements on each side
- Dual frequency: GPS L1 and L5 (Galileo E1 and E5)

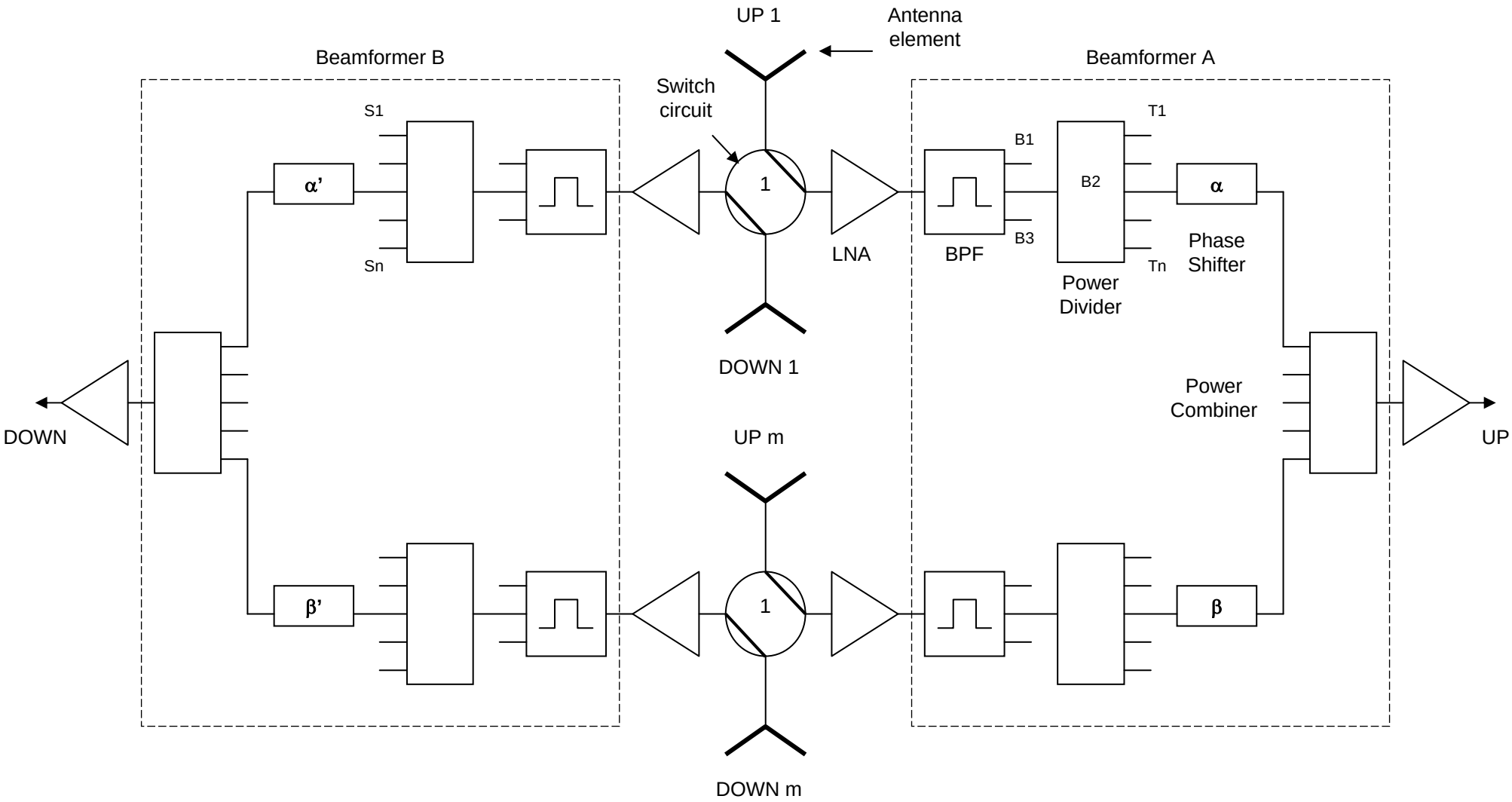




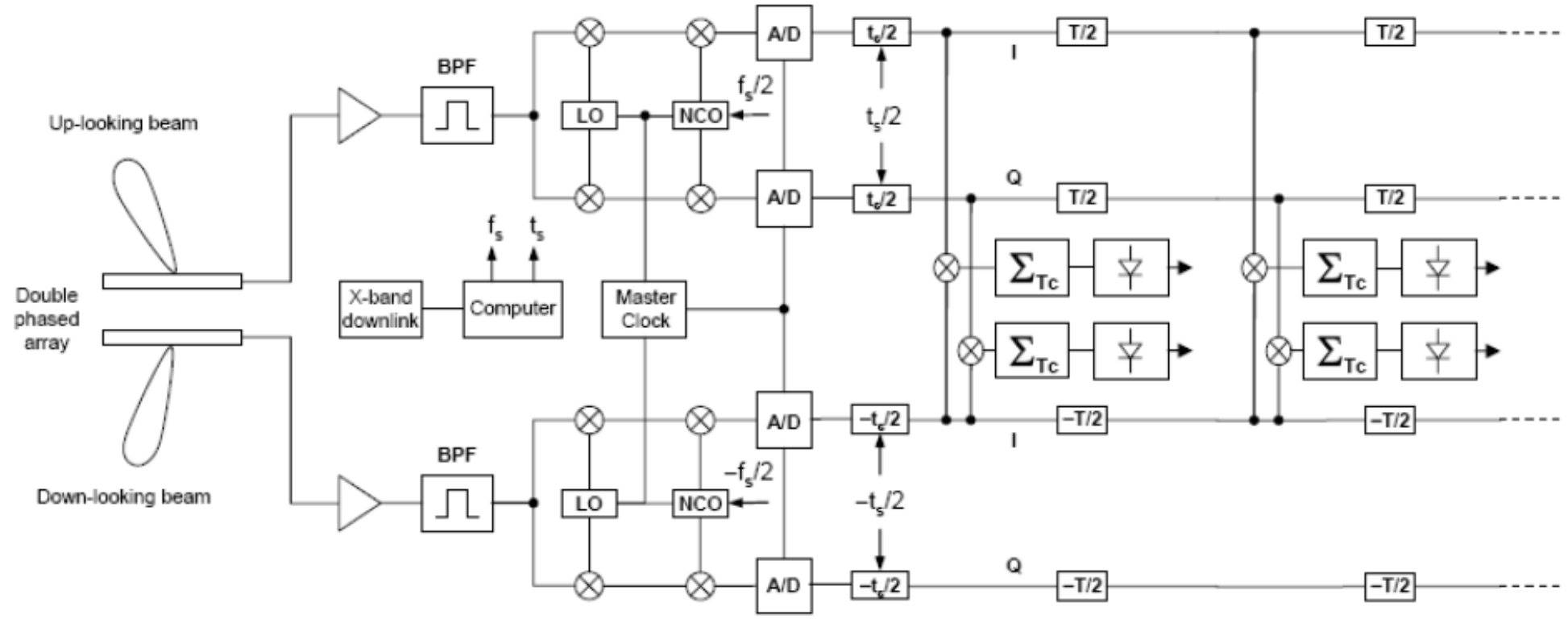
Antenna Element Pairing Up Concept

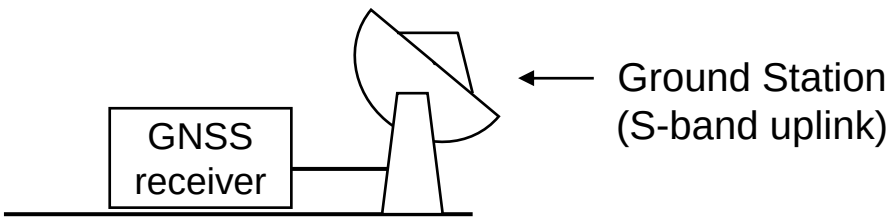


PARIS Ocean Altimeter – Beamformers



PARIS Ocean Altimeter – Block Diagram





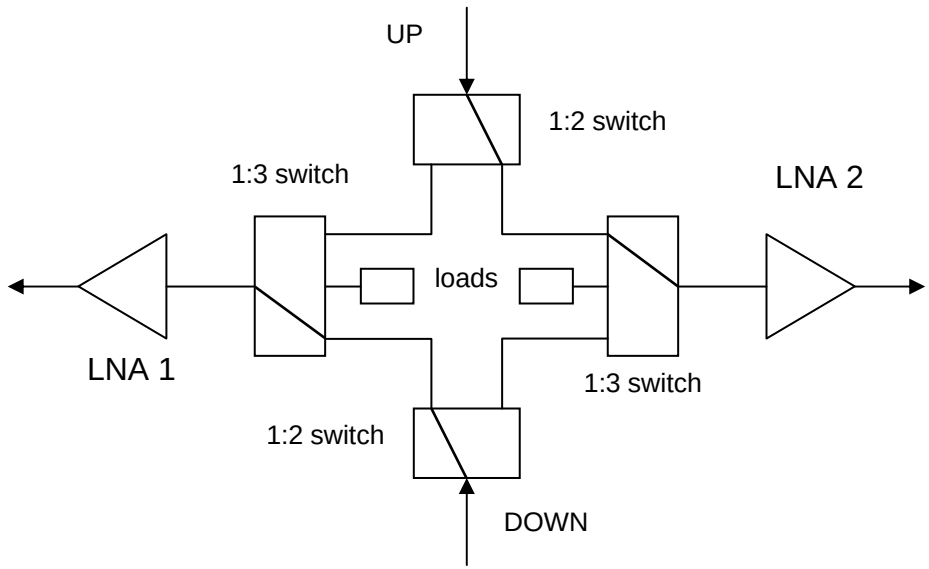
Delay and Amplitude Calibration

- Accurate delay and amplitude calibration are essential for the scientific exploitation of the GNSS signals

- Delay calibration is proposed by the swapping technique, for example

- Amplitude calibration is based on radiometer techniques, using the cold sky and a matched load

- The calibration box in-between the paired up-down elements performs the required switching of the inputs



Preliminary Mass Budget

	Number/Remark	Mass/element (kg)	TOTAL (kg)
Antenna Frame			**30.04762**
Radiator	38	0.15	5.70
CAL/LNA module	19	0.37	7.03
O/E module	19	0.10	1.90
Structure	1	8.00	8.00
Mechanisms	2	3.50	7.00
Optical harness	38 OF cables	0.01	0.42
Electrical Harness	0 RF cables	0.00	0.00
BFN			**5.20**
RF module	1	4.00	4.00
O/E module	1	1.20	1.20
DCM	1	5.00	**5.00**
ICCU	1	4.50	**4.50**
Electrical Harness	1	2.00	**2.00**
Xband			**2.00**
X Band TX	1	1.50	**1.50**
X Band Antenna	1	0.50	**0.50**
TOTAL			**48.75**

TET Capability 47 kg

Preliminary Power Budget

Satellite Component	Power Budget
Solar generator	provides about 210 W
Bus Electronics	power consumption about 50 W
Payload Supply System	power consumption about 20 W
Nominal Budget for Payload	**140 W**

Payload Average Power Consumption < 100 W

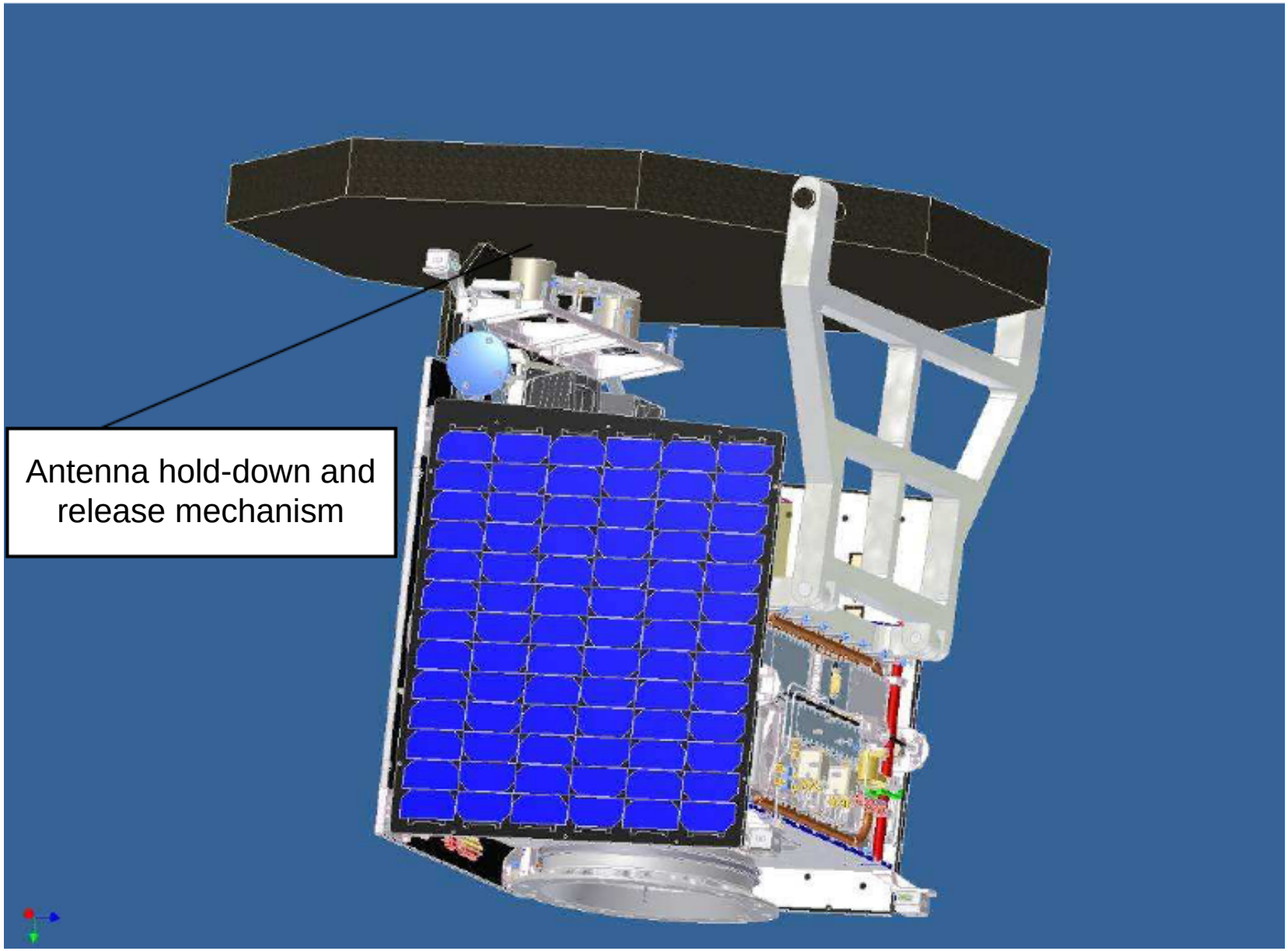
Preliminary Mass and Power Budgets Summary

PARIS IoD preliminary mass and power budgets

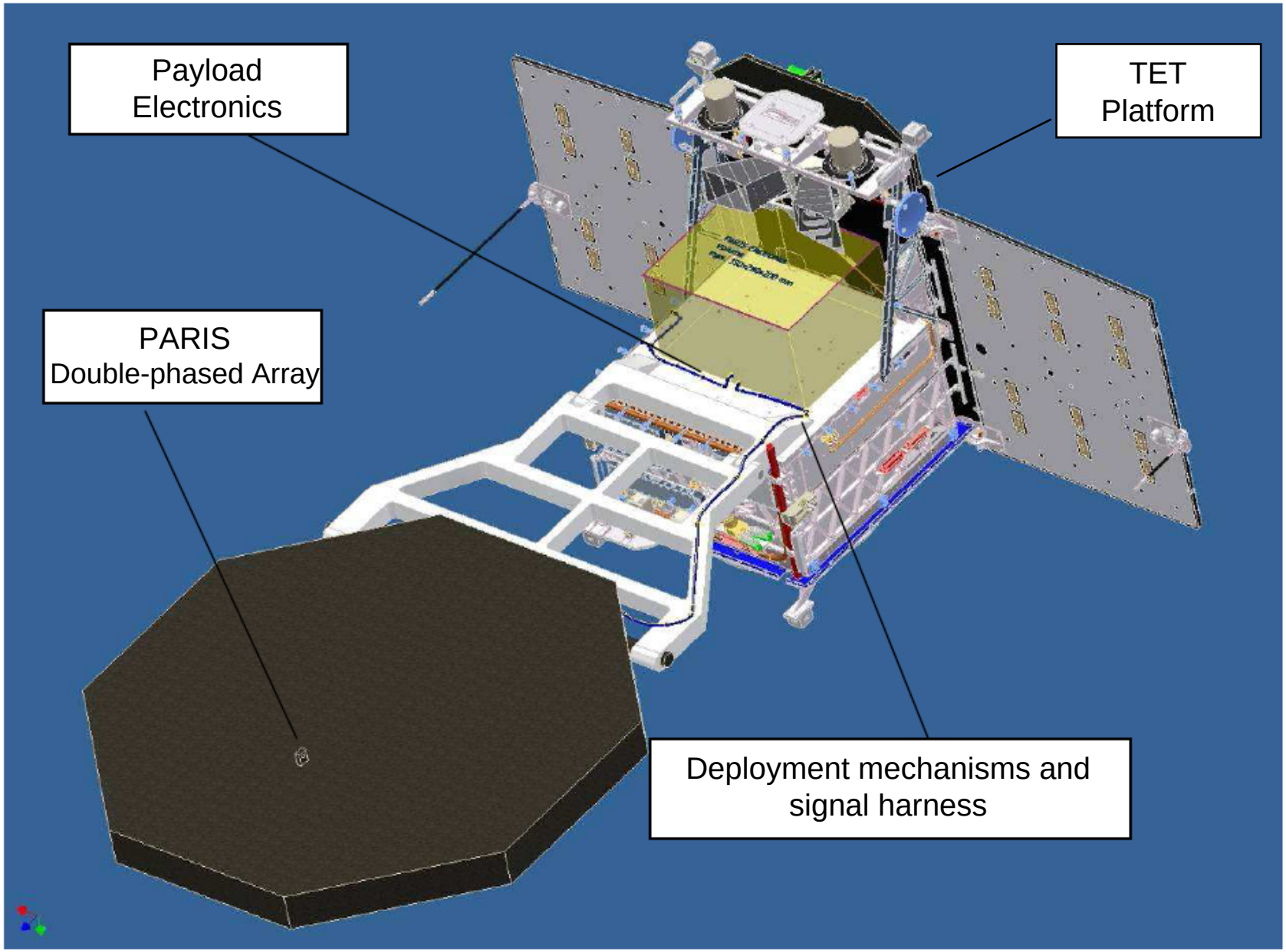
are compatible

with the TET platform

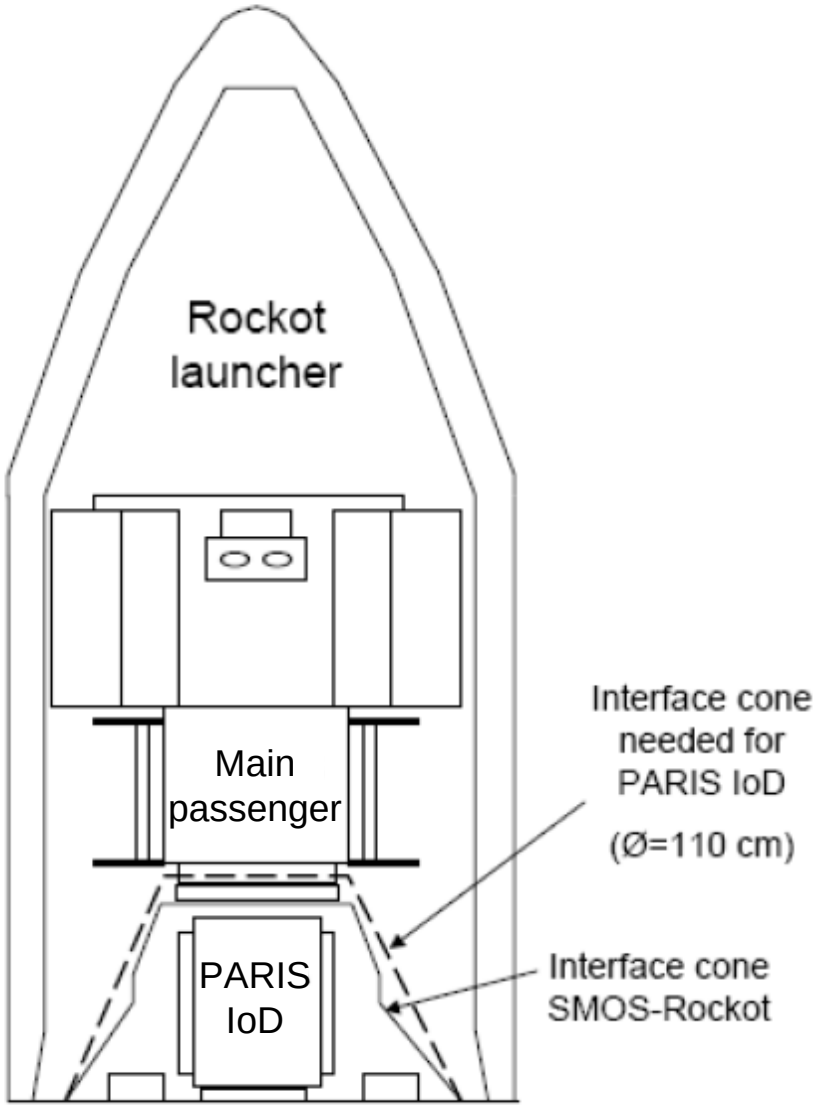
Payload Accommodation – Stowed Configuration



Payload Accommodation on TET Platform



PARIS IoD Launch Scenario



PARIS IoD Overall Planning