

**Nicholas Camussy**

# **The ATV Programme "Jules Verne"**



**Ein Vortrag organisiert vom VDI  
in Kooperation mit DGLR und RAeS**

**16.02.2009**

**Hochschule für Angewandte Wissenschaften Hamburg**

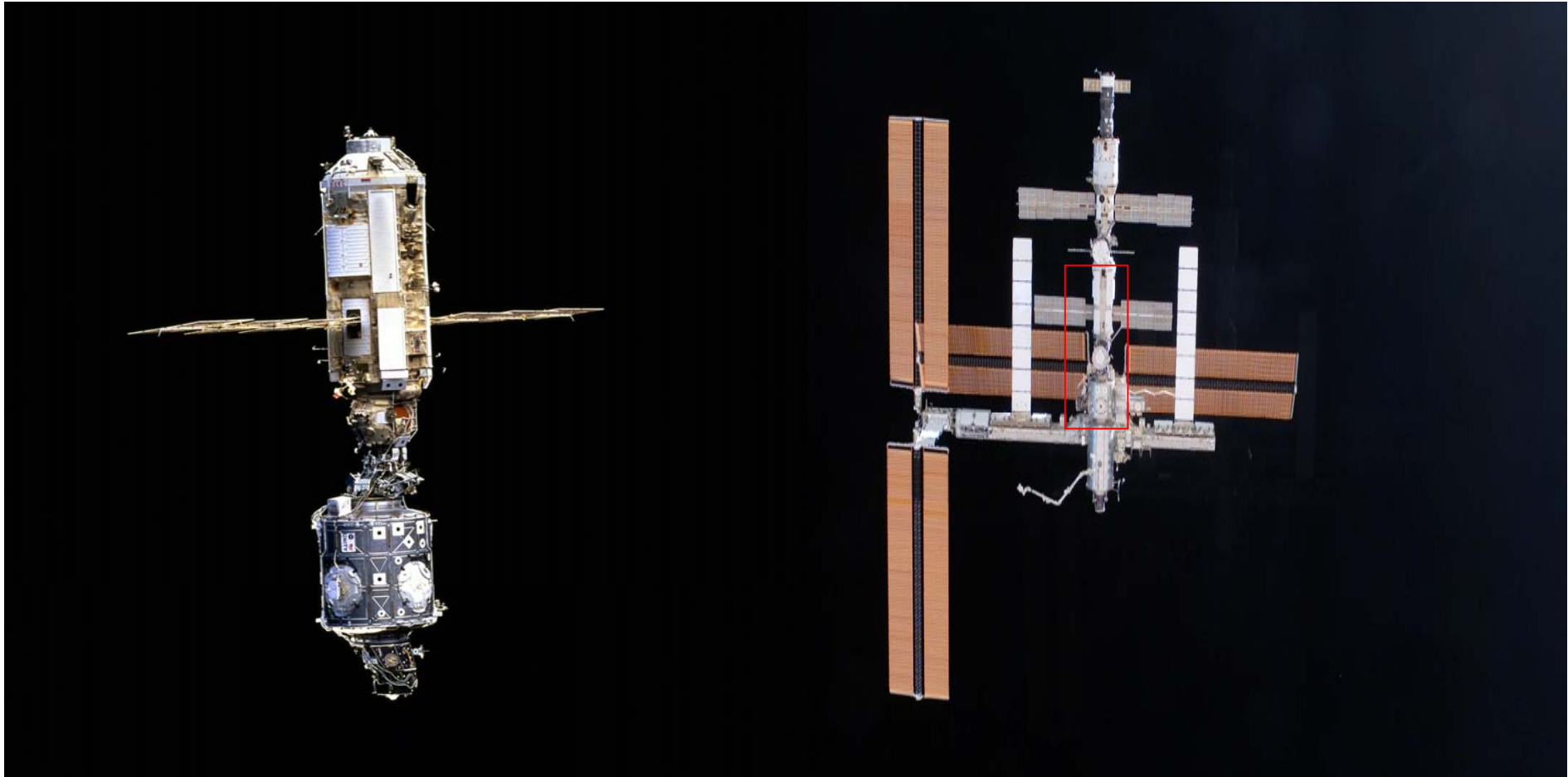
Download: <http://hamburg.dglr.de>

## ATV...what's that ?



- ATV: Automated Transfer Vehicle
- European Resupply spaceship to the International Space Station (ISS)
- First prototype / flight model dubbed Jules Verne. Mission successfully performed in 2008
  - Follow-up mission (Johannes Kepler) in 2010
- Developed by EADS ASTRIUM for the European Space Agency (ESA)
  - Development phase including Jules Verne's mission
  - Production phase for additional 4 to 6 vehicles including mission

# International Space Station (ISS)



Unity and Svezda – 09.1998

ISS – 09.2006

## Mission started in Kourou (French Guiana)



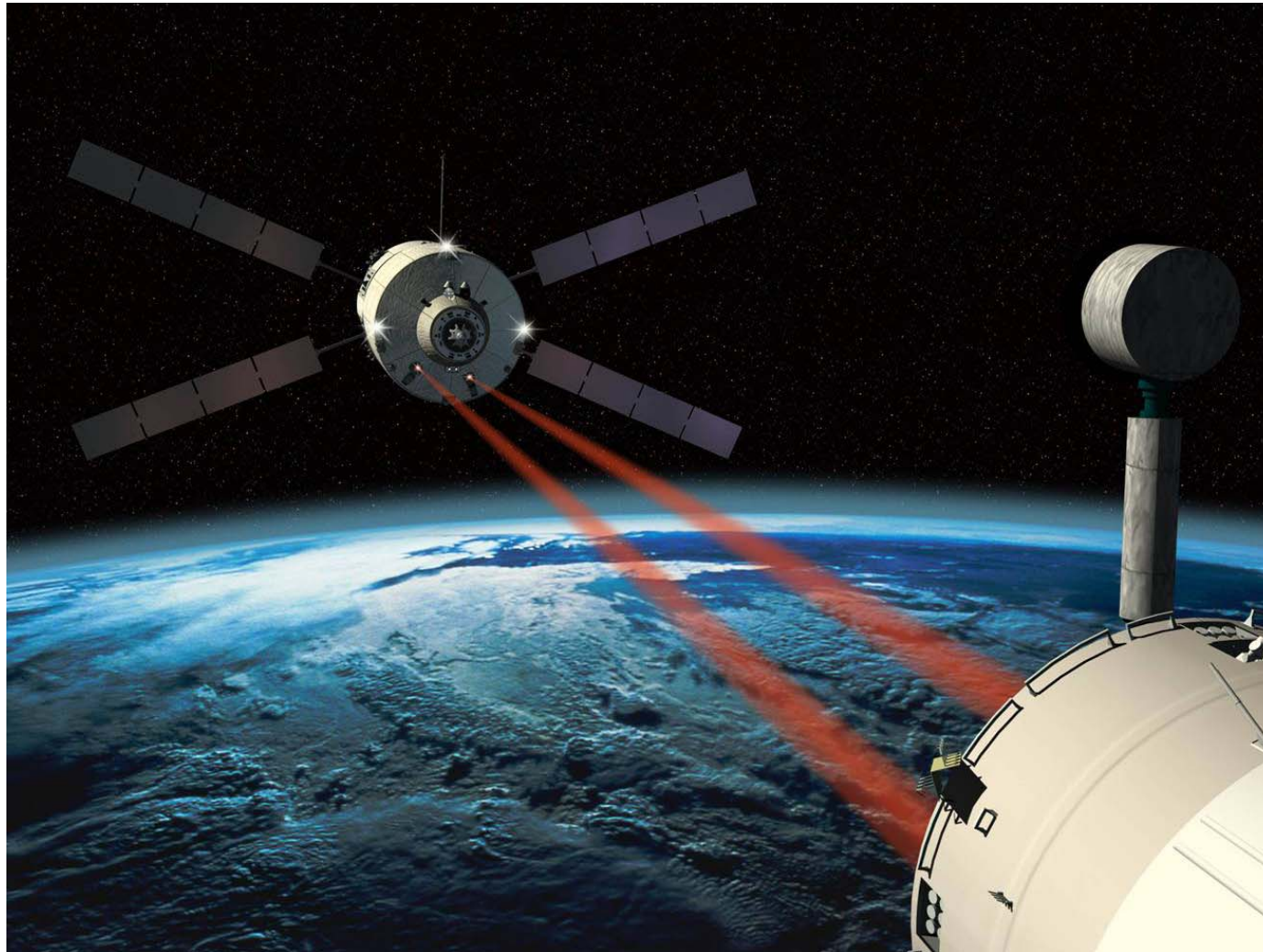
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## Automated approach to the ISS...



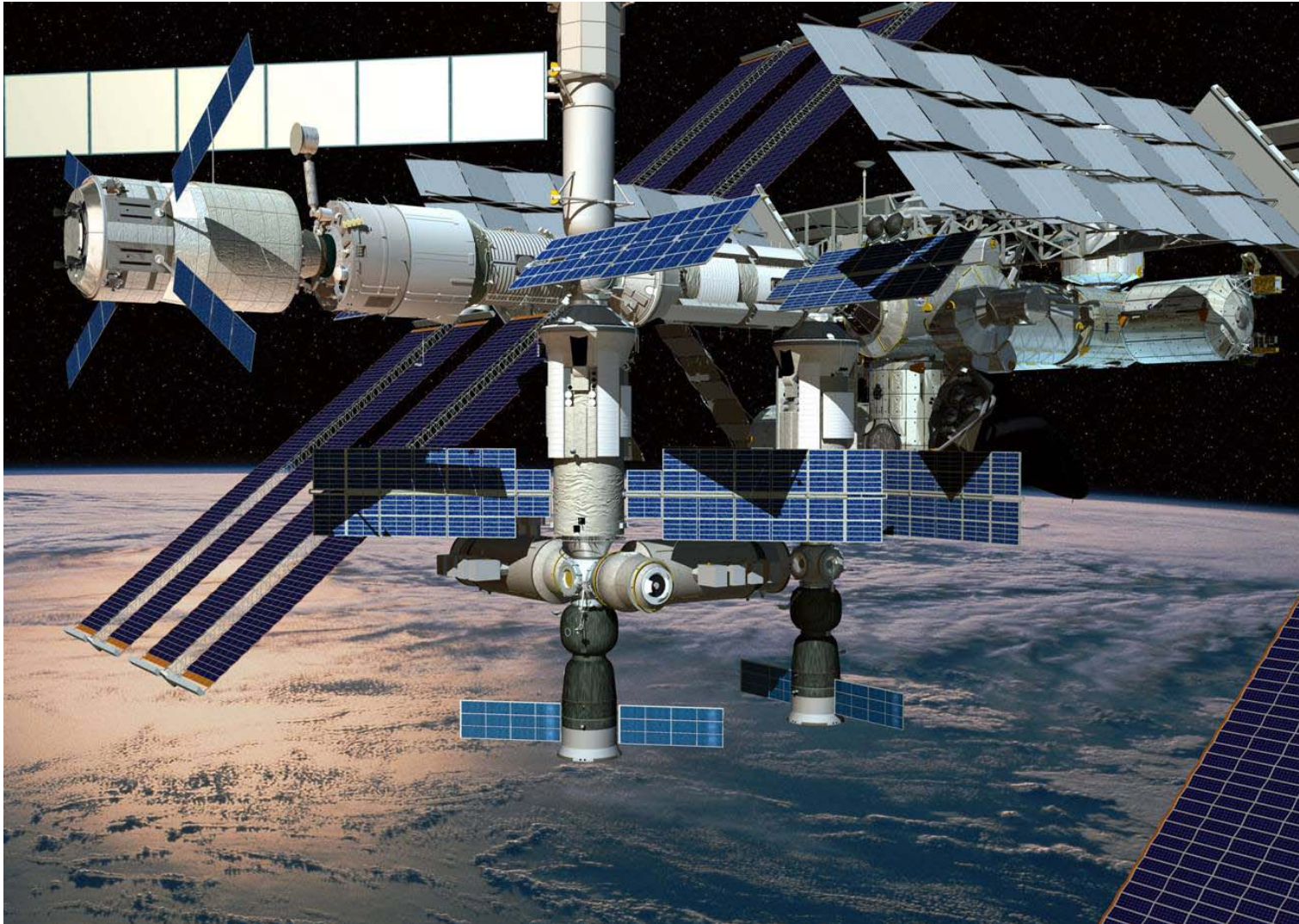
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Another few meters to go....



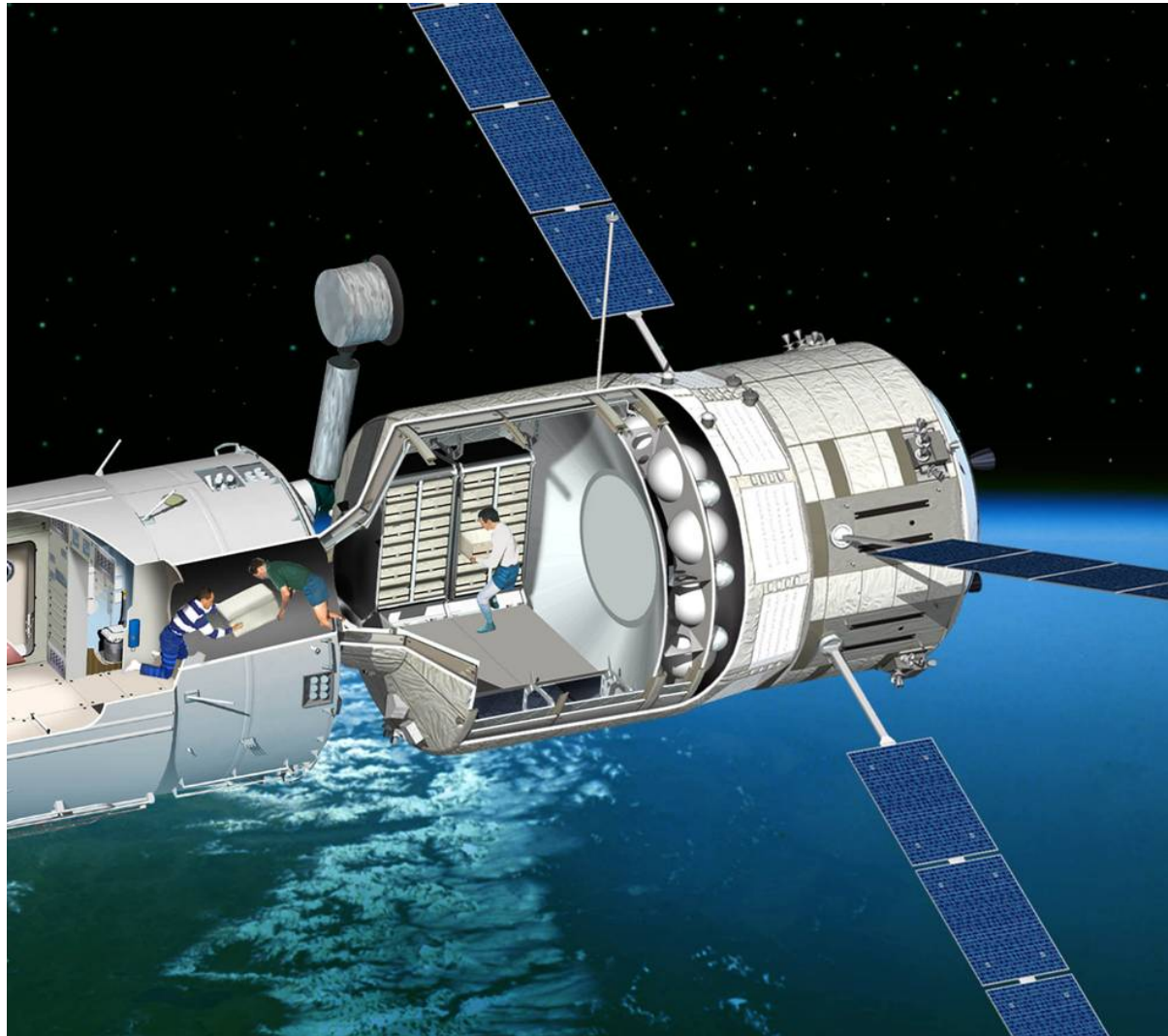
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## Solidly docked to the ISS...



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# Inhabited ATV in space



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# Tug / pusher for the ISS



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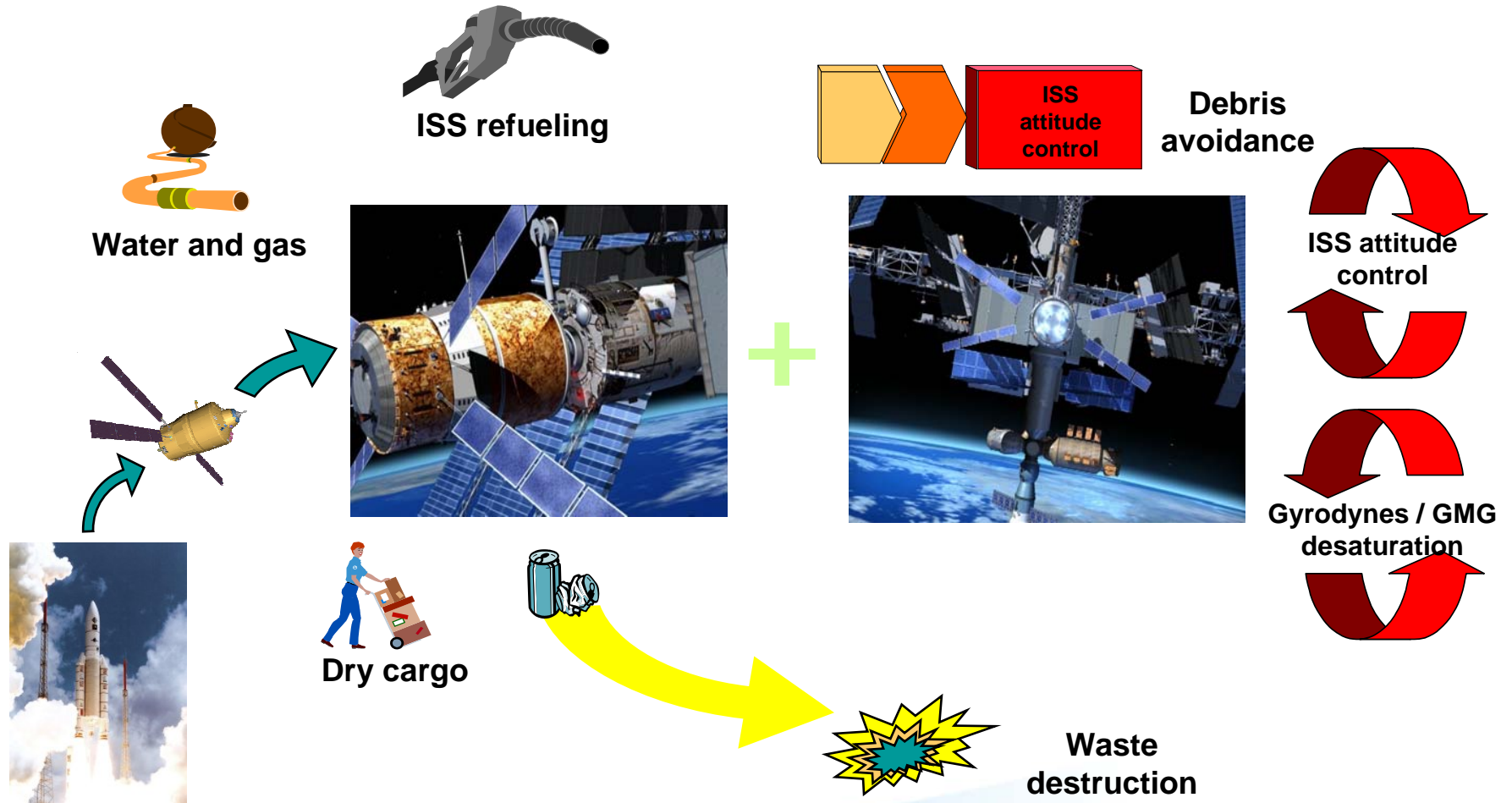


# Fatal splash down in the upper atmosphere

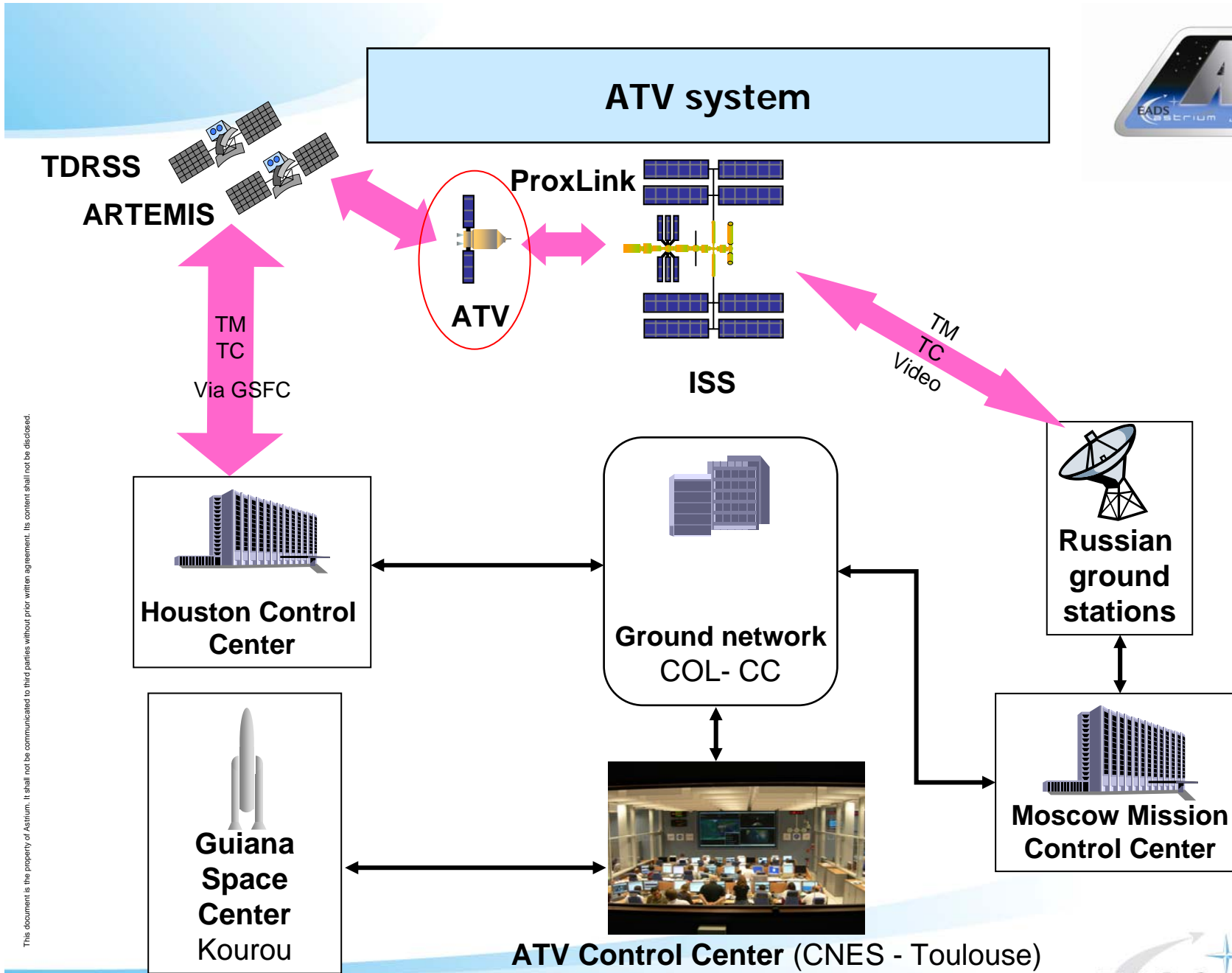


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# ATV missions



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## ASTRIUM is ATV prime contractor



- Program management (relationships with ESA and numerous industrial subcontractors)
- System engineering
- On-board software development and tests
- Integration and tests of the spaceship
- Launch campaign in Kourou
- Development of the system operational reference
- Users manuals, vehicle and mission control procedures

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# ATV Jules Verne characteristics



10,3 m



**Mass at lift off: 19 357 kg**

**Dry mass : 9 784 kg**

**Cargo delivered to ISS : 4600 kg**

**(water, oxygen, fuel, dry cargo)**

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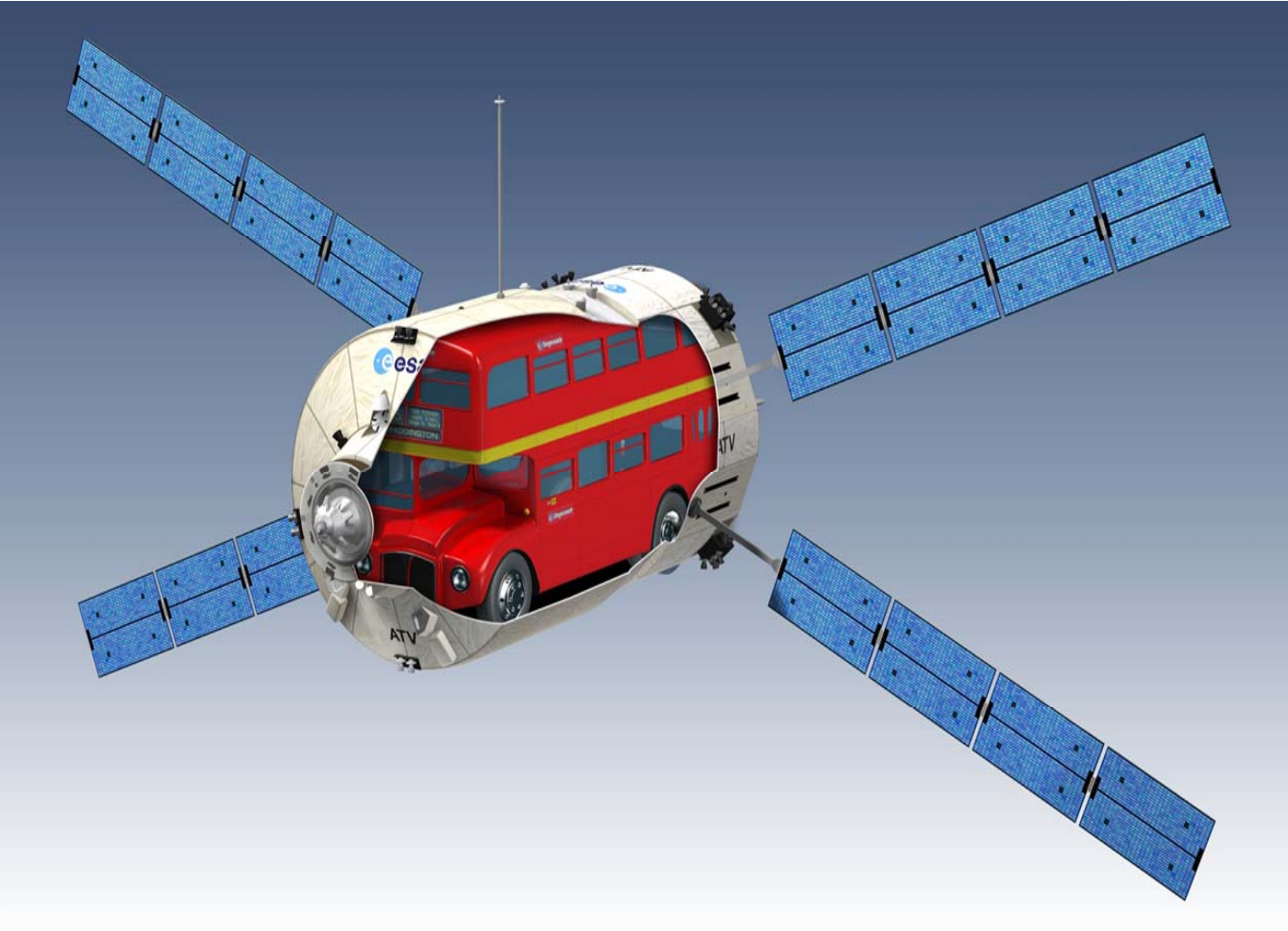
All the space you need

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4,5 m



# Space bus !



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# Family story !



ATV



Apollo



Progress

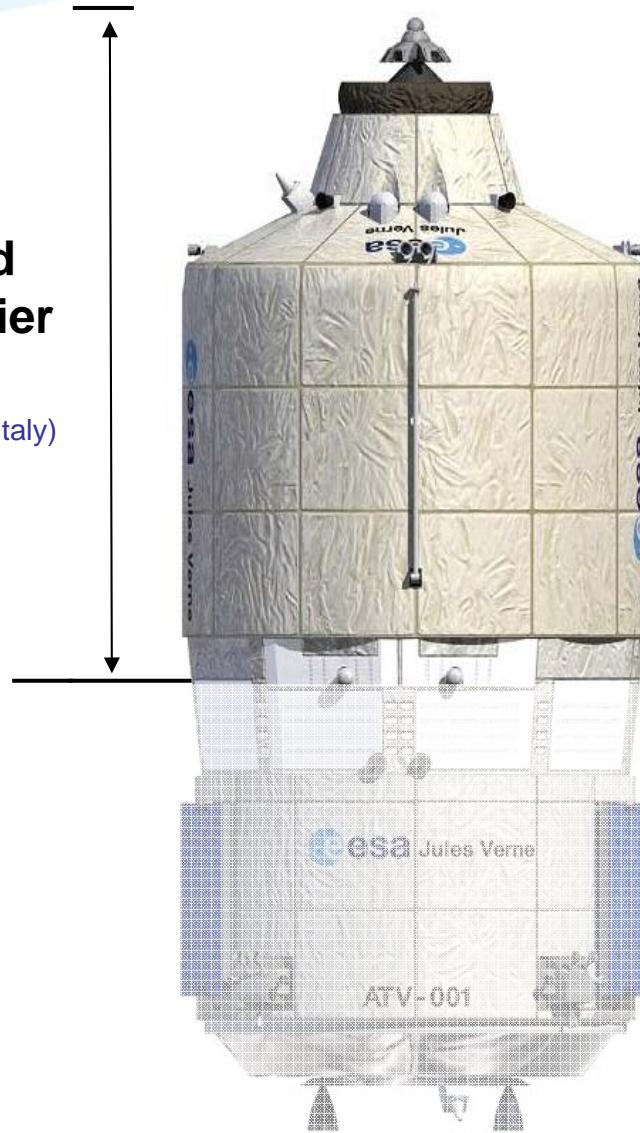
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## Integrated Cargo Carrier

Thales Alenia Space (Italy)



Russian Docking system  
(RSC Energya – Russia)

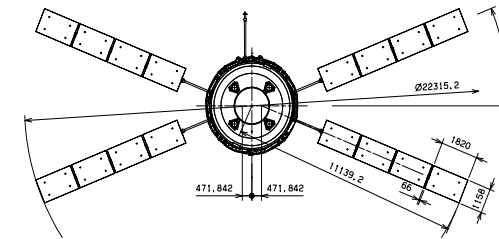
Pressurised  
module (46 m<sup>3</sup>)

Non pressurised module

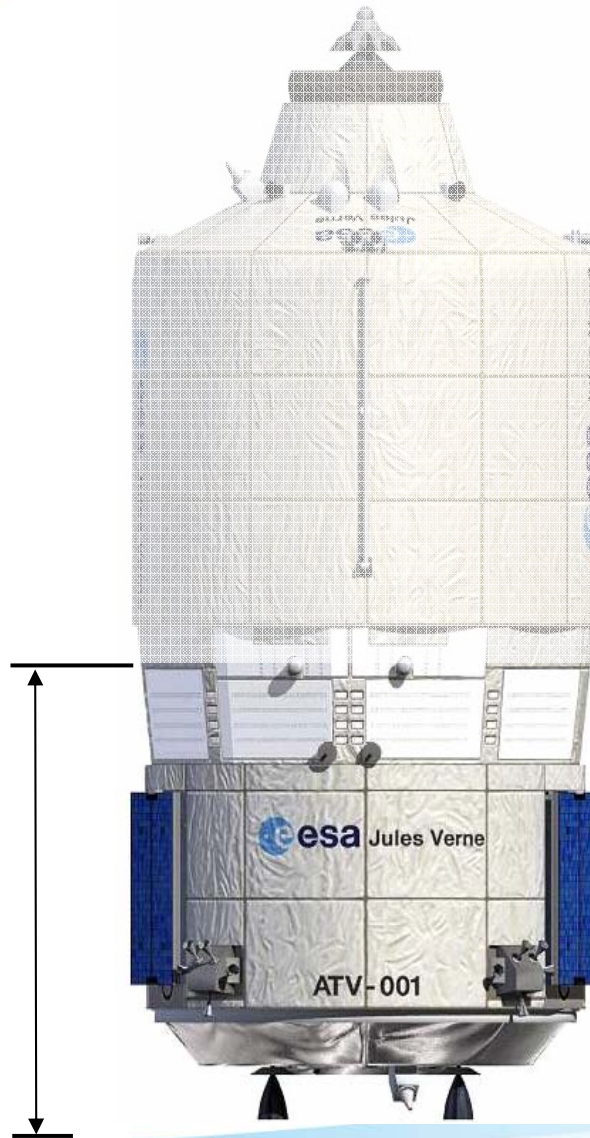
Dry cargo: 1150 kg

Water: 270 kg  
Oxygen: 21 kg  
Fuels: 856 kg

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# Spacecraft



Avionics bay (ASTRIUM)

Propulsion bay (ASTRIUM)

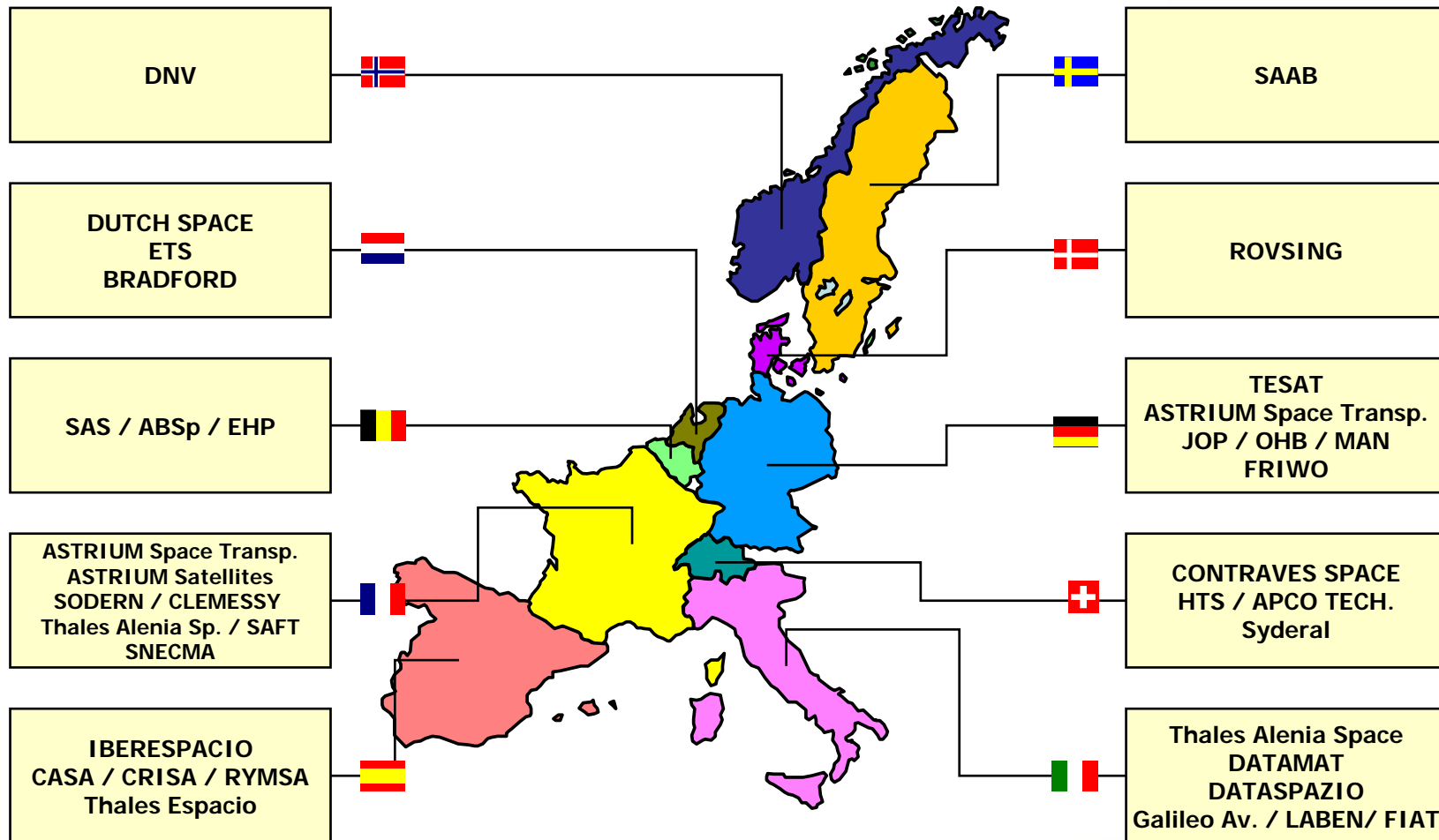
- 28 engines 220 N
- 4 engines 490 N
- Fuels (MMH and MON): 5 858 kg (mission and reboost)

Solar panels (4 wings – Dutch Space )

- 22 meter wingspan
- 4,8 kW beginning of life

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# A true European system !



Major subcontractor in Russia (RSC-E): Docking and refuelling subsystems

Subcontractors in the US: Perkin Elmer, Aerojet, Vacco...

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## Structural model (ESTEC September 2002)



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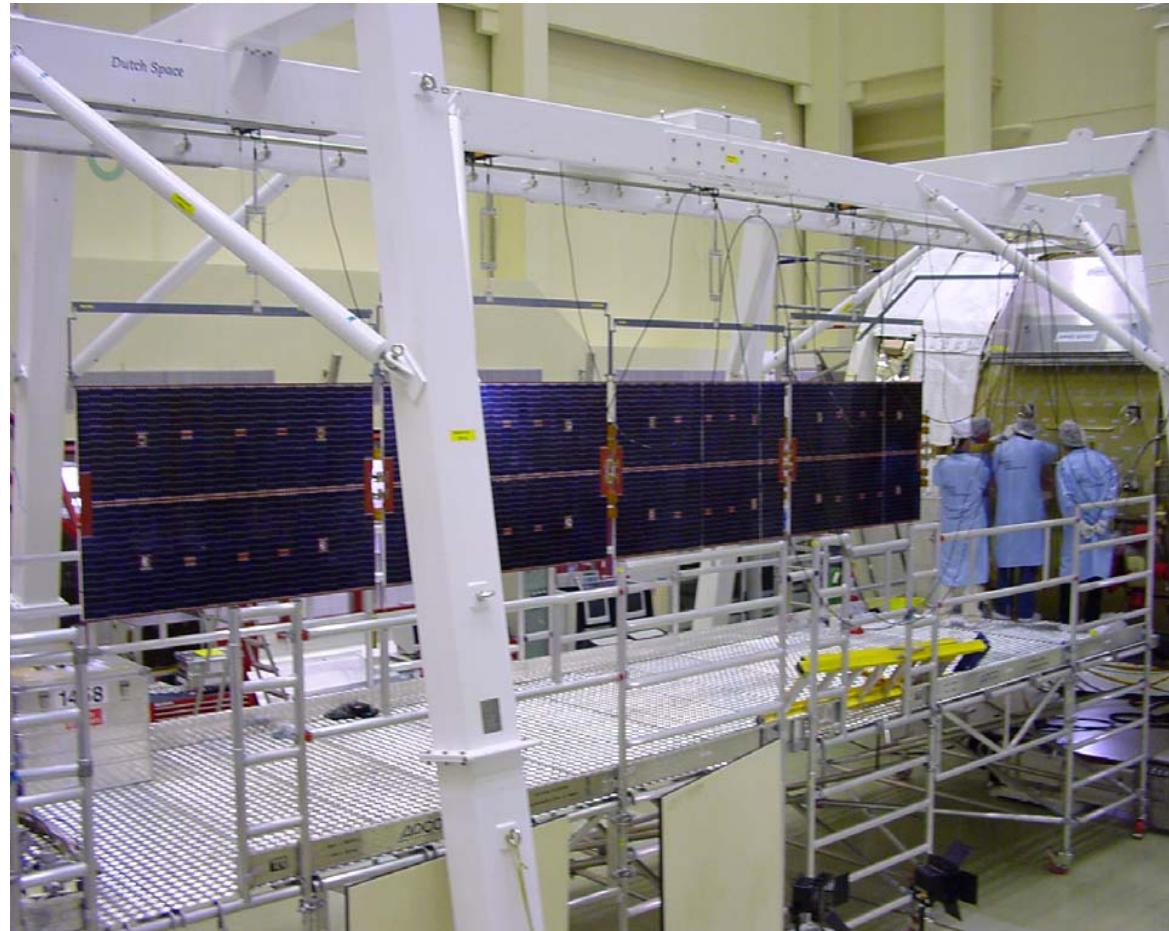
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## Jules Verne EMC tests (ESTEC 2004)

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## Jules Verne – Solar wings deployment tests (ESTEC 2005)

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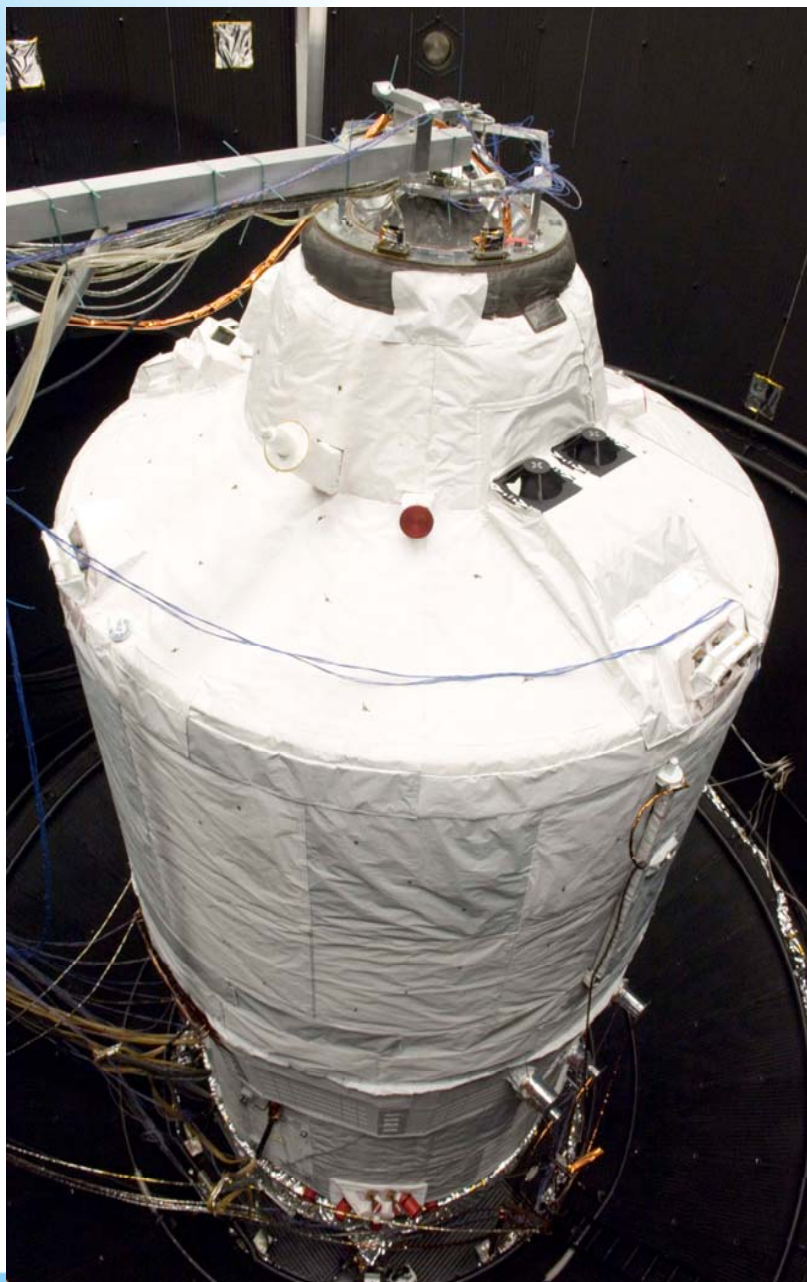
## Jules Verne Acoustic tests (ESTEC June 2006)



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## Jules Verne Thermal vacuum tests (ESTEC December 2006)

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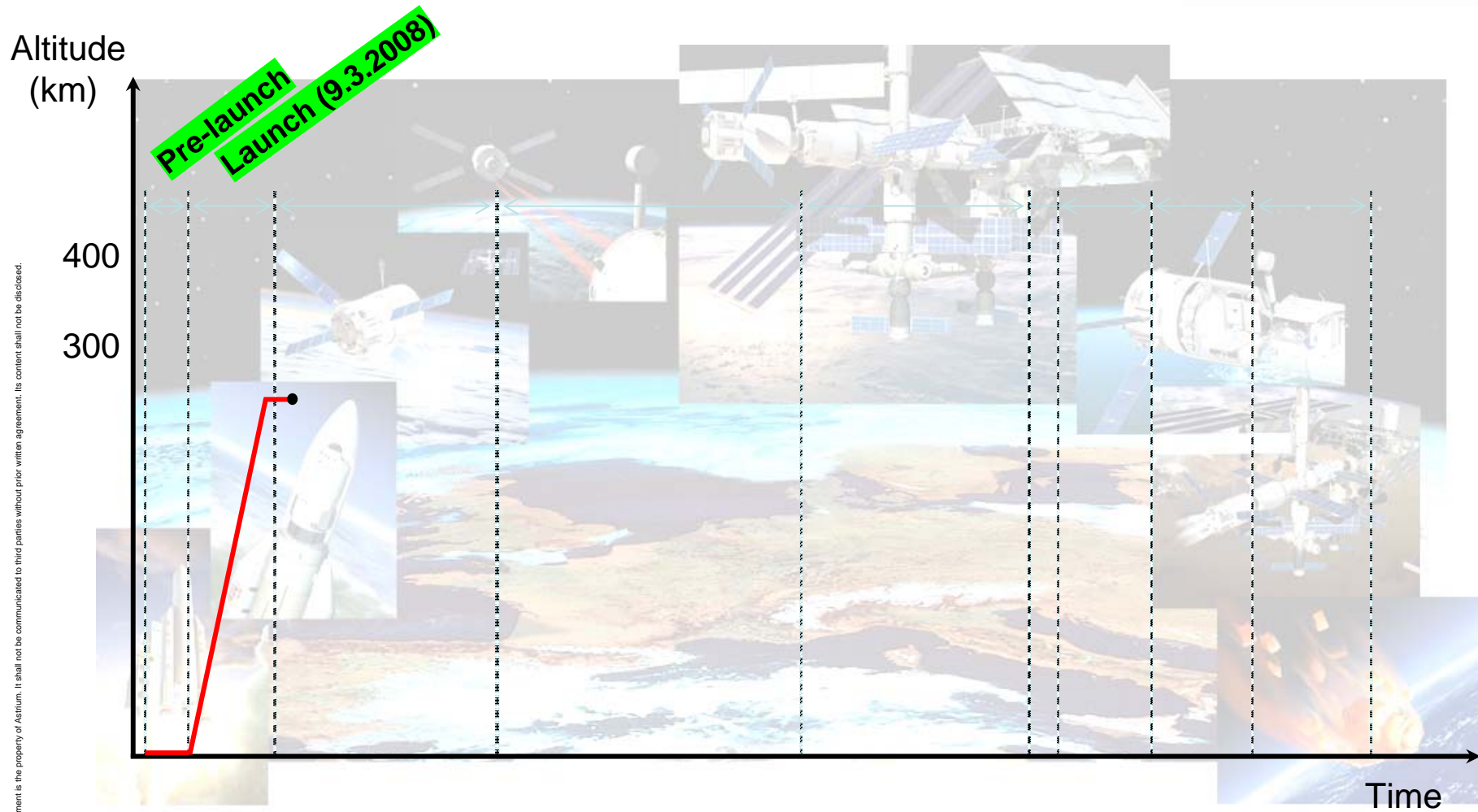
## Functional qualification tests

Les Mureaux  
2006 - 2007



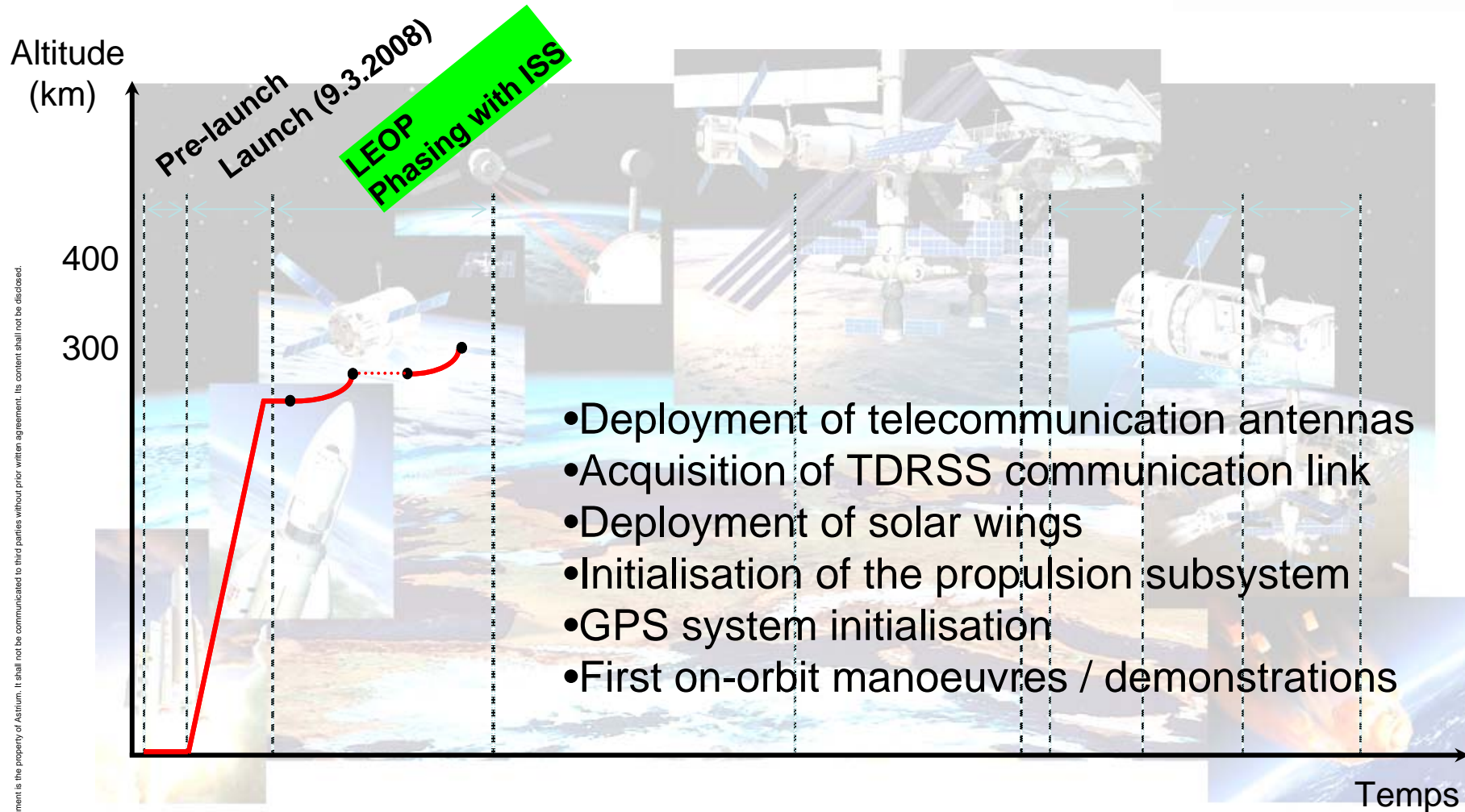
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# Mission profile



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## Low earth orbit ops (LEOP)



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## Prepare to docking (1)



- The ISS is inhabited (3 astronauts on-board as of today) ...and ATV had to demonstrate safety of operations before docking
- 14 March 2008: Demonstration of contingency procedures
  - ATV loitering far behind the ISS
  - Triggering of a Collision Avoidance Manoeuvre (CAM)
  - Fully automated sequence
  - Escape from the ISS managed by a contingency system (dedicated computer and engines....)
  - Survival mode (zero fault tolerance) and exit from survival
  - Manoeuvre successfully executed on first run and without anomalies
- 15 to 19 March 2008: Transfer to parking orbit

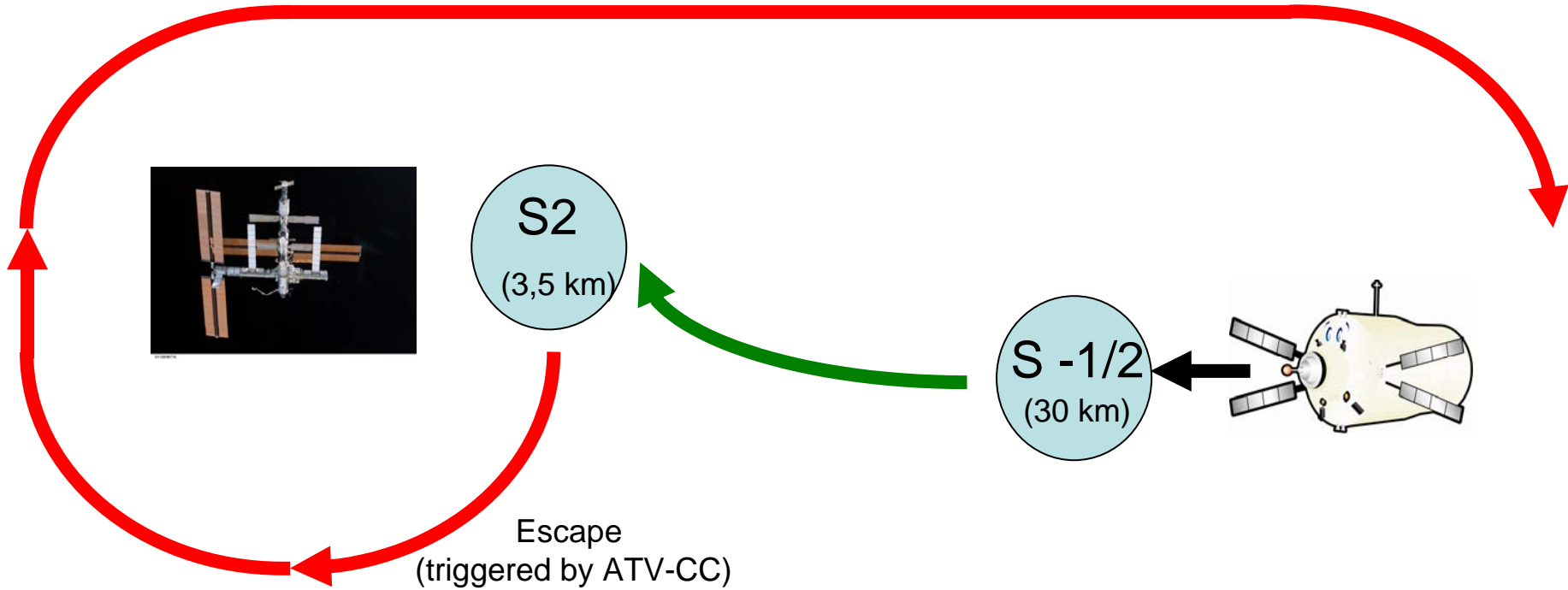
## Prepare to docking (2)



- **20 to 28 March 2008**
  - ATV loitering far behind the ISS
  - Waiting for the US space shuttle to dedock from ISS (no simultaneous ops)
  
- **29 March 2008: “Demo Day 1”**
  - Approaching the ISS at 3,5 km
  - Relative GPS navigation between ATV and ISS (world premiere)
  - Direct communication link between ATV and ISS
  - Manoeuvre completed by issuing an « Escape » command
  
- **31 March 2008: “Demo Day 2”**
  - Approaching the ISS at 11 km
  - Use of the optical rendez-vous sensors (world premiere)
  - Vehicle controlled by the ISS crew and the ATV control centre
  
- **Ready for docking !**

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# Demonstration day 1 (29.3.08)



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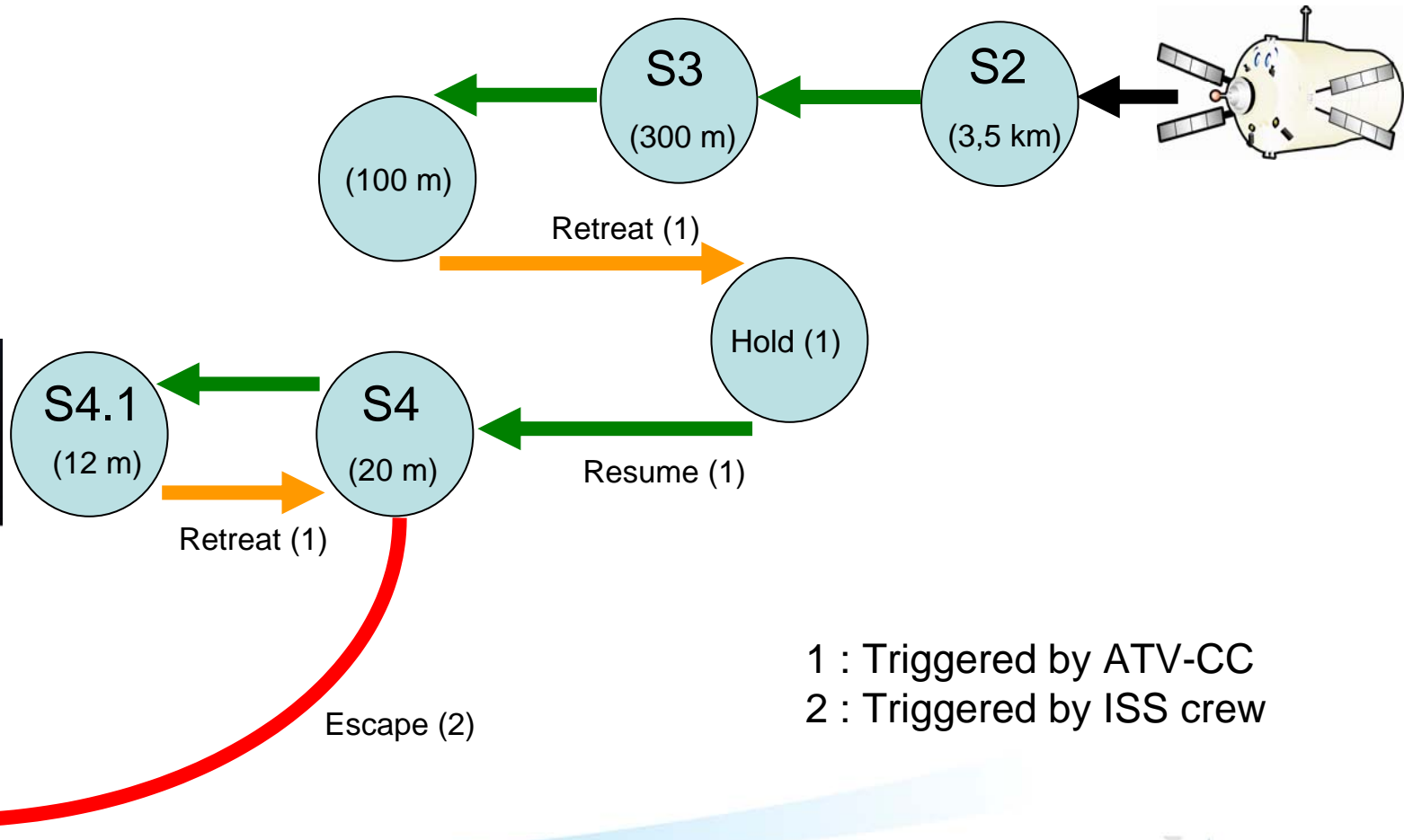
# Demonstration day 2 (31.3.2008)



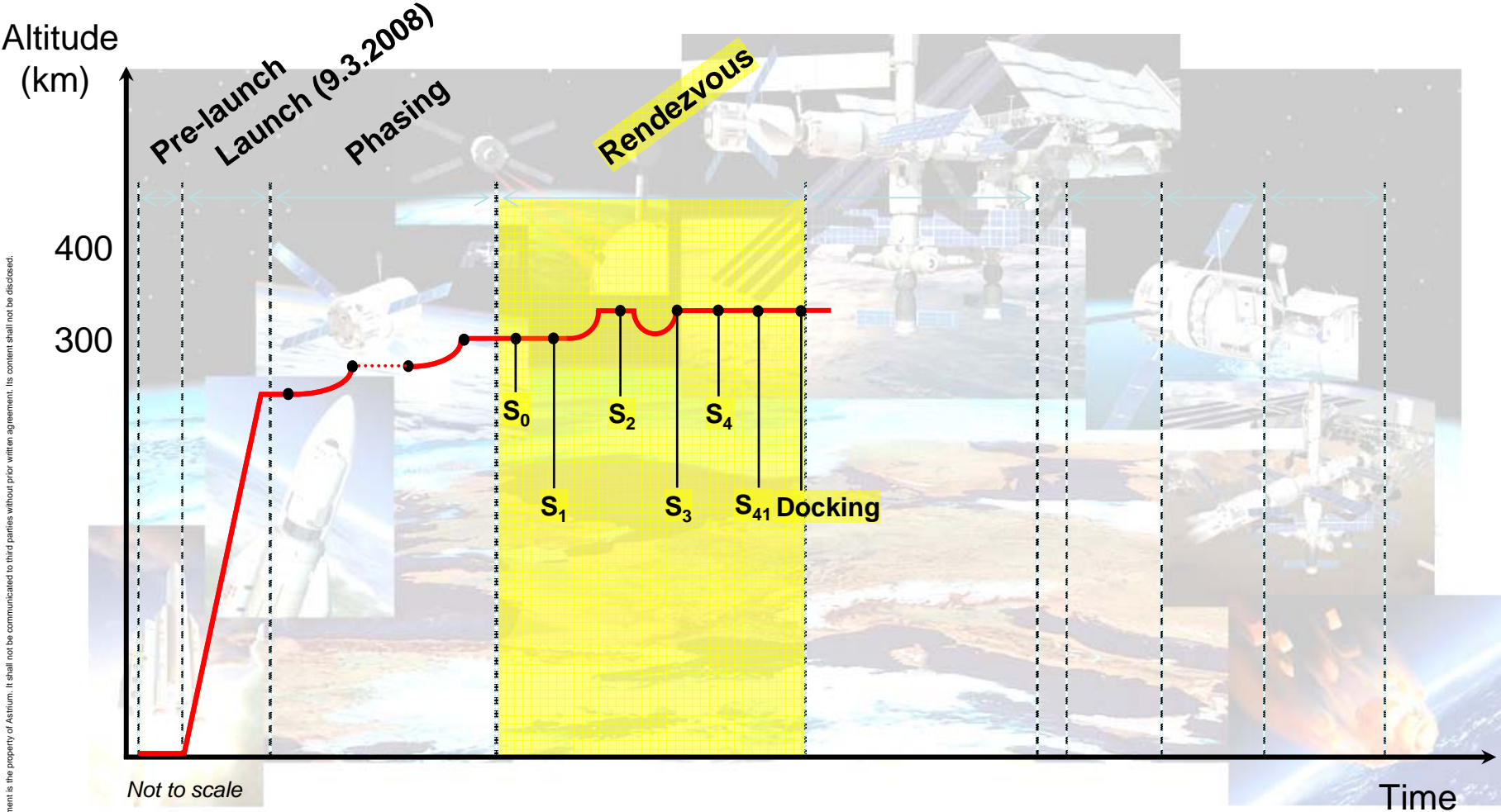
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# Mission scenario



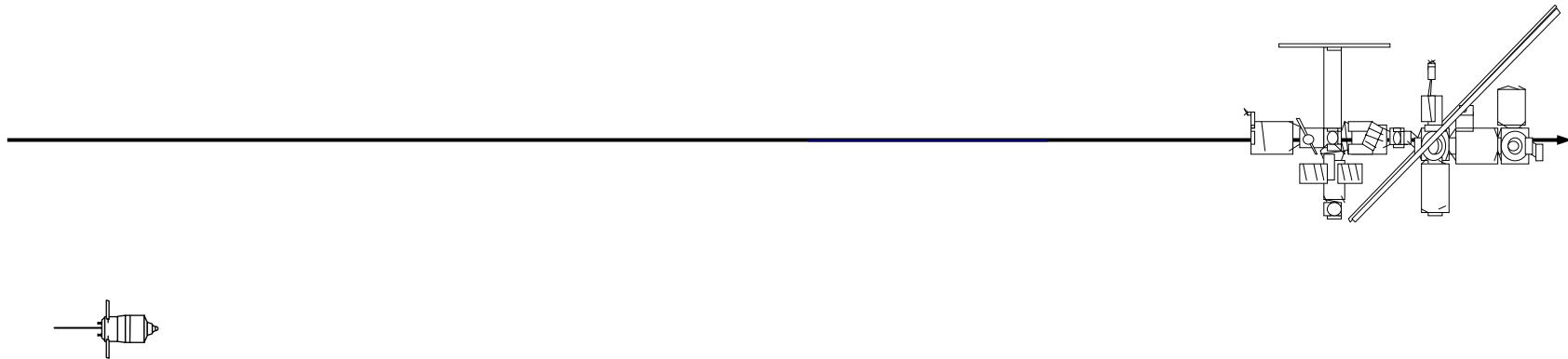
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# Rendez-vous and docking



## Absolute GPS navigation



Long range

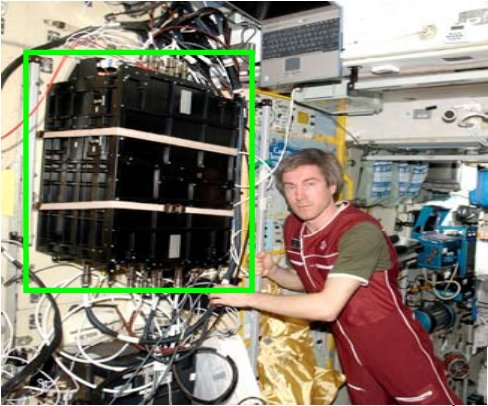
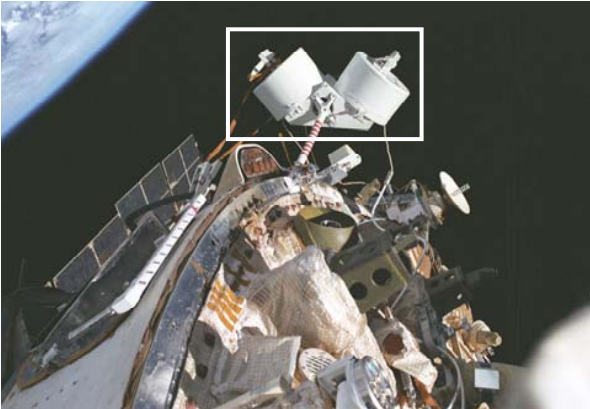
# Rendez-vous and docking



## Hyper frequency link with the ISS

Absolute GPS

Relative GPS



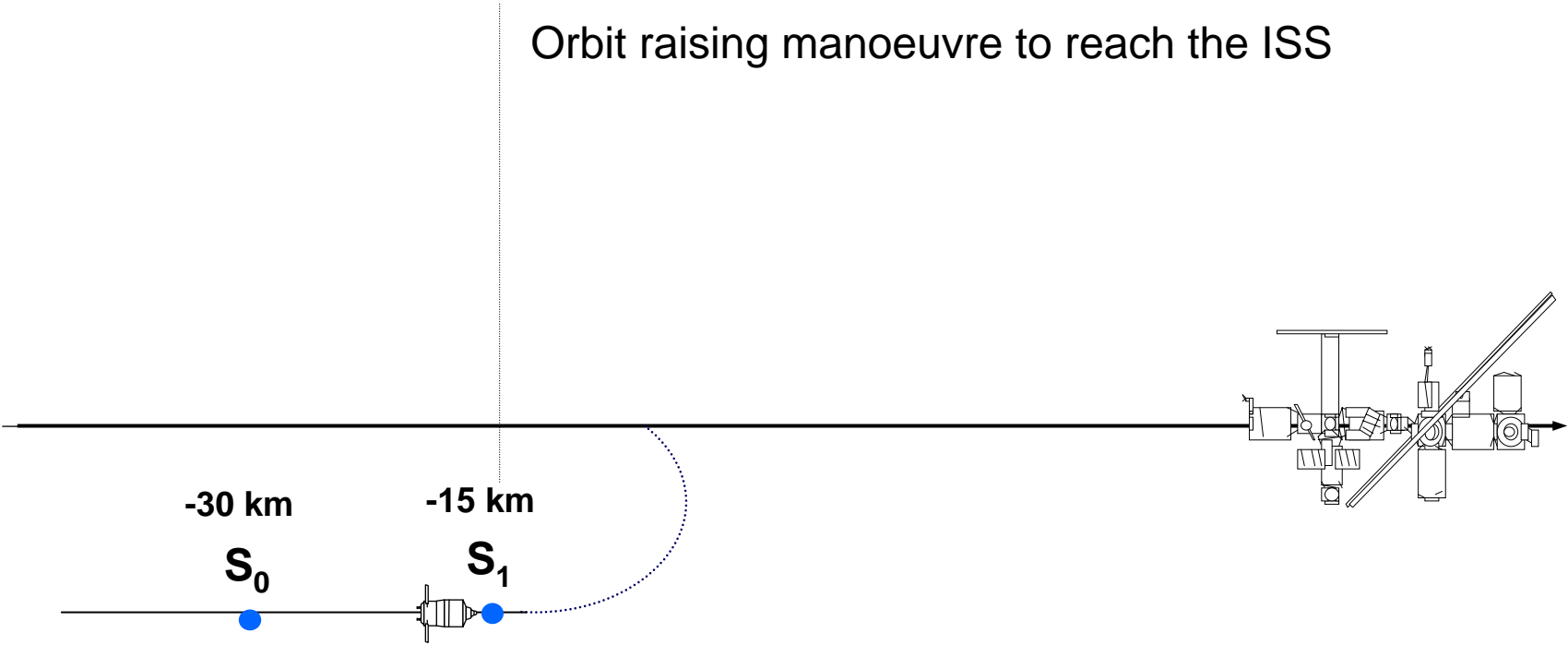
Long range

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# Rendez-vous and docking



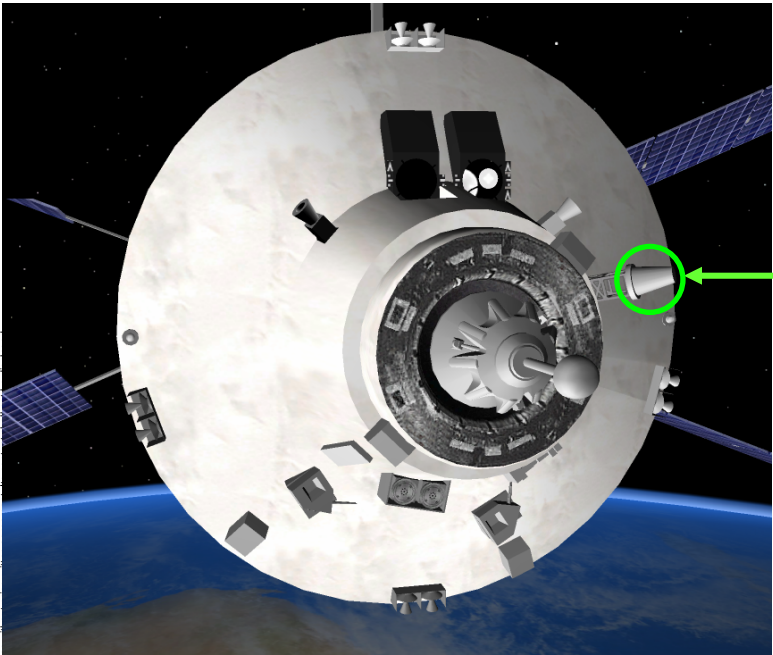
Orbit raising manoeuvre to reach the ISS



Long range

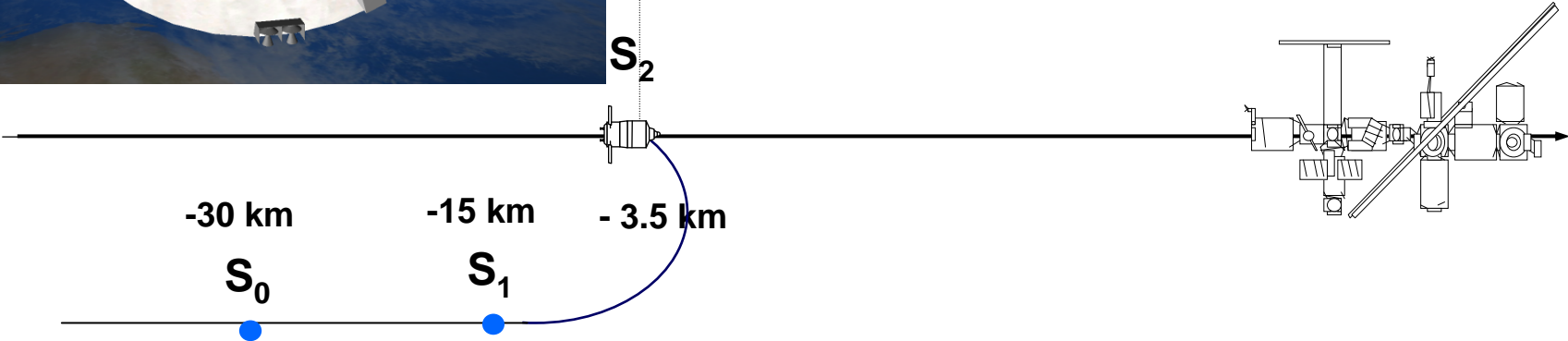
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# Rendez-vous and docking



## Activation KURS and ranging cues

KURS transponder (second transponder on ATV rear side)

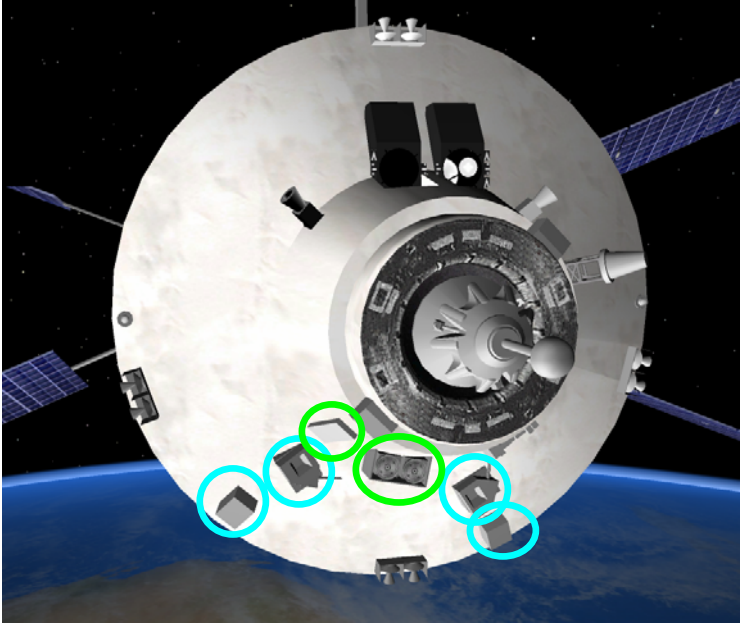


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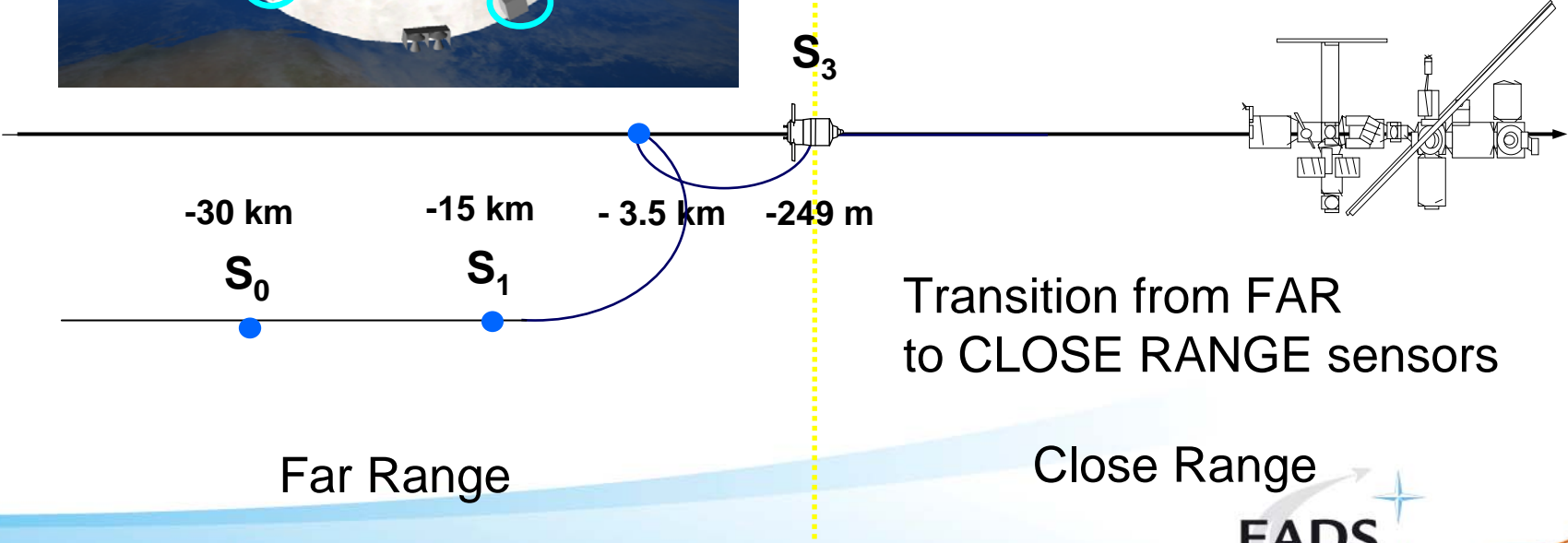
Long range



# Rendez-vous and docking



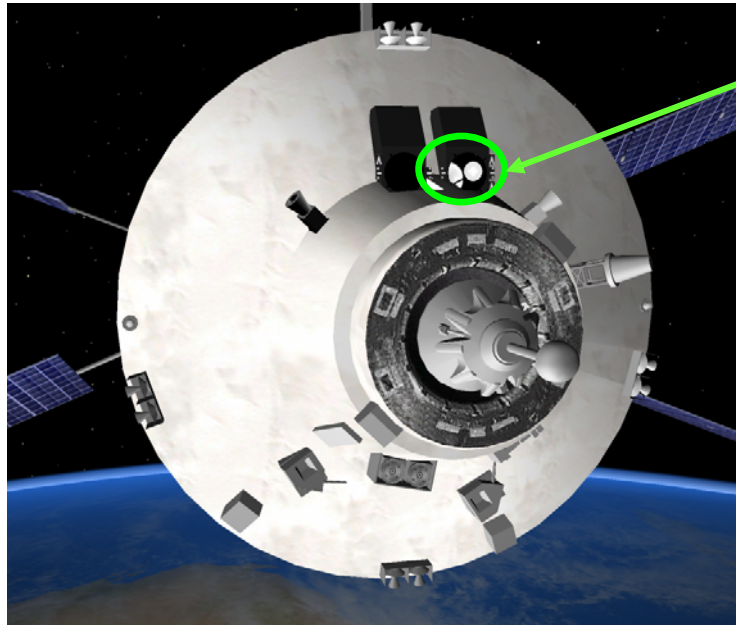
Videometers    Telegoniometers



Transition from FAR to CLOSE RANGE sensors

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# Rendez-vous and docking

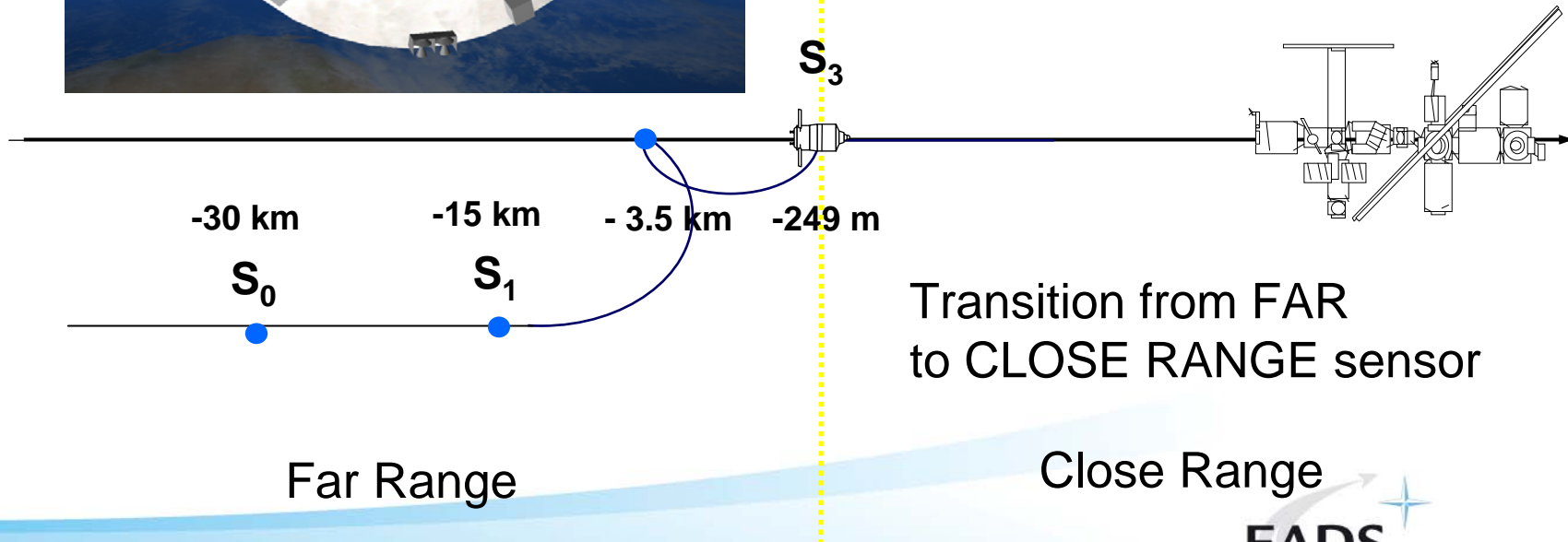


Visual Video Target

and

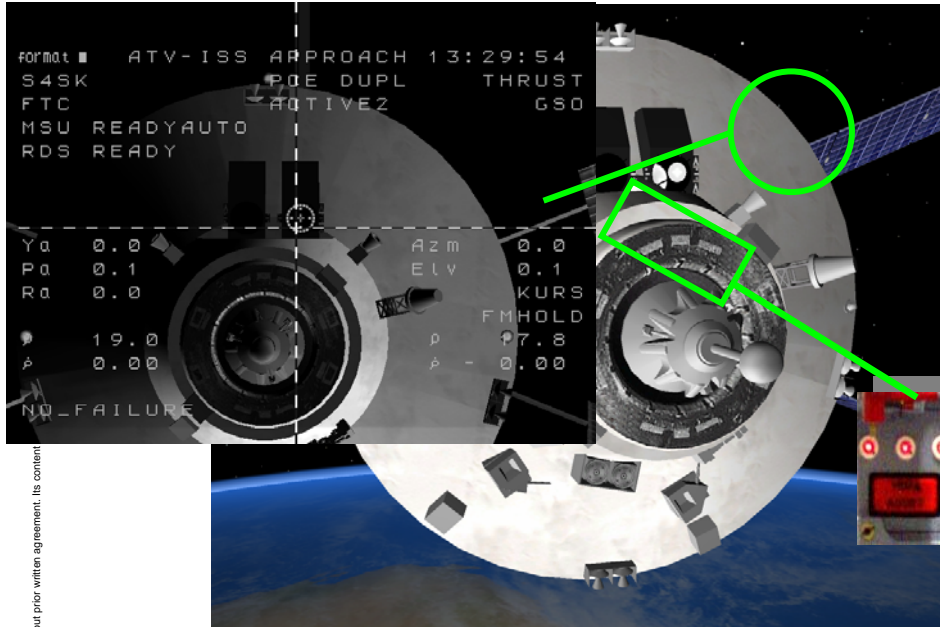
Russian cameras system

Monitoring by crew



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# Rendez-vous and docking

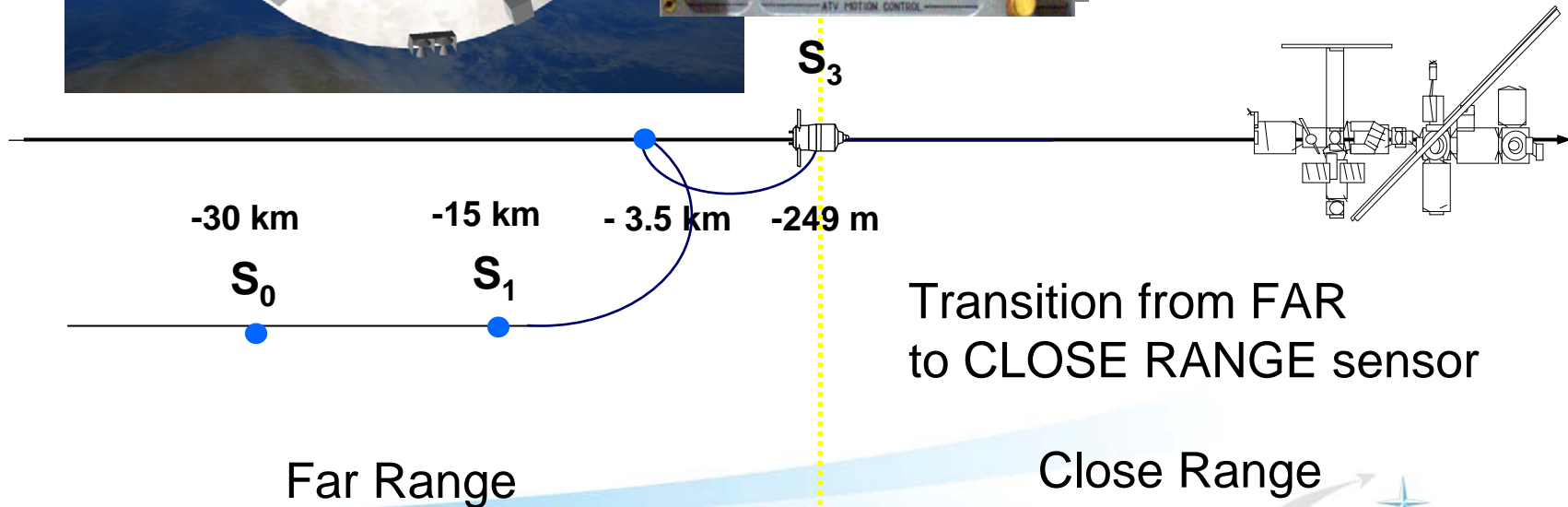


Visual Video Target

and

Russian cameras system

Monitoring by crew

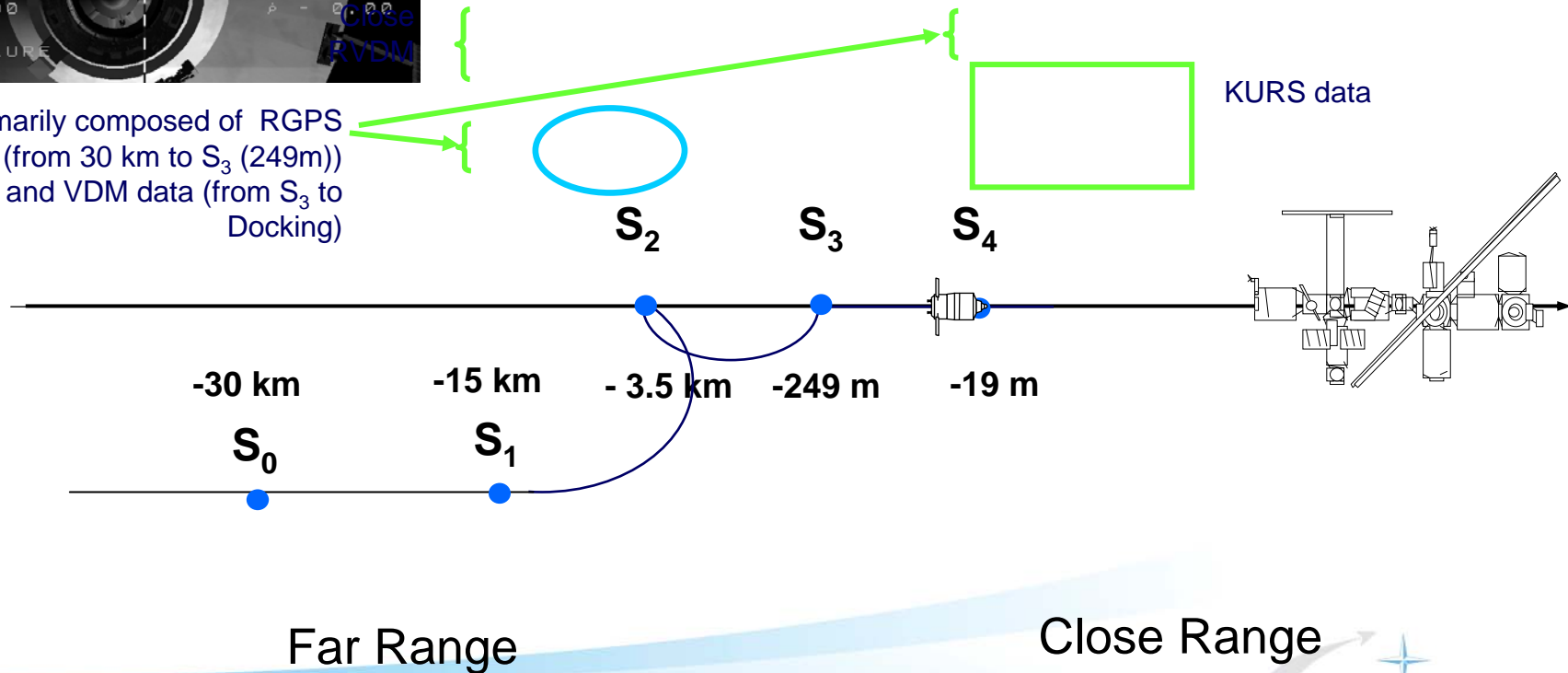


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# Rendez-vous and docking



Primarily composed of RGPS data (from 30 km to S<sub>3</sub> (249m)) and VDM data (from S<sub>3</sub> to Docking)

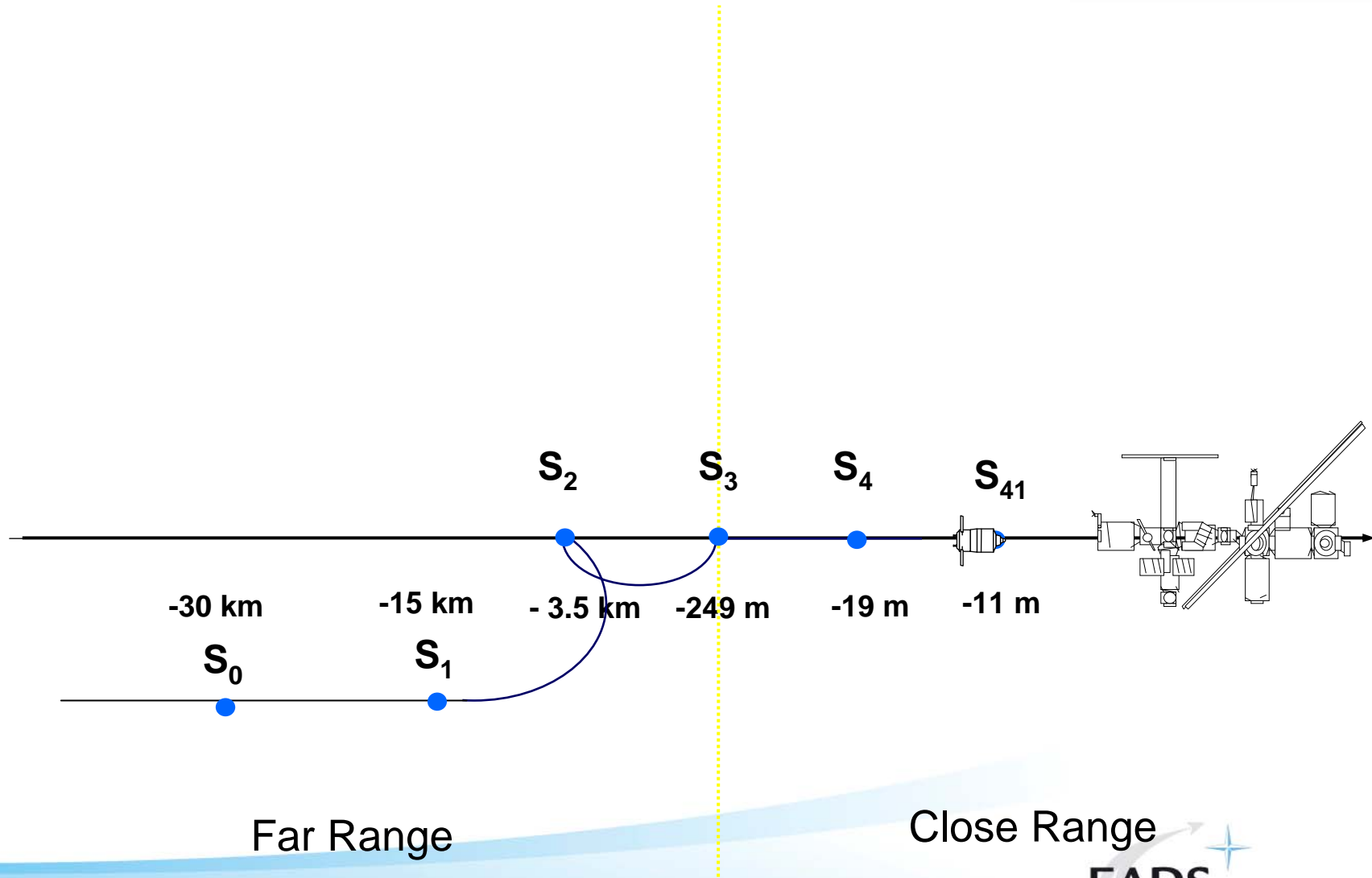


Far Range

Close Range

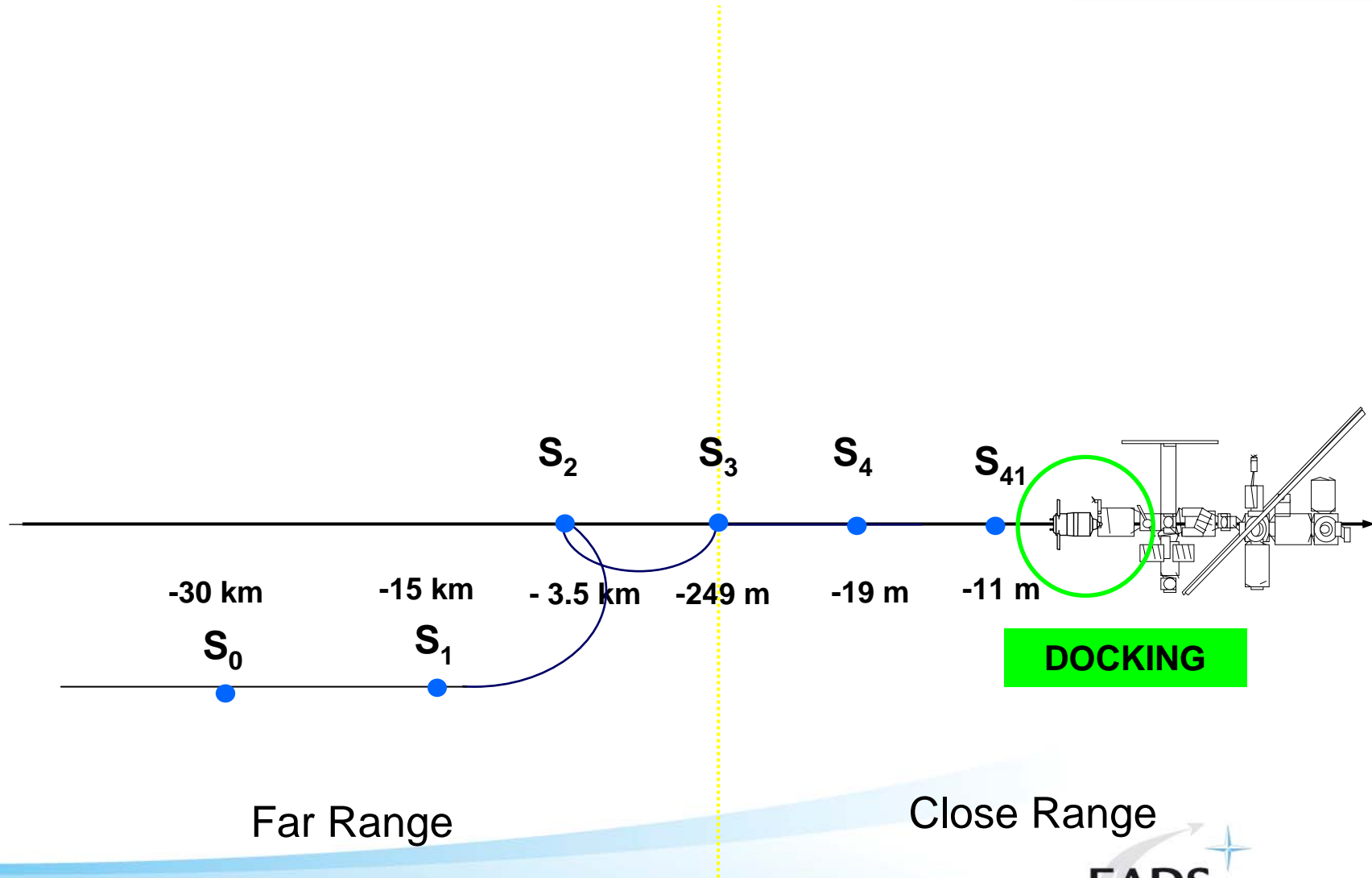


# Rendez-vous and docking phase



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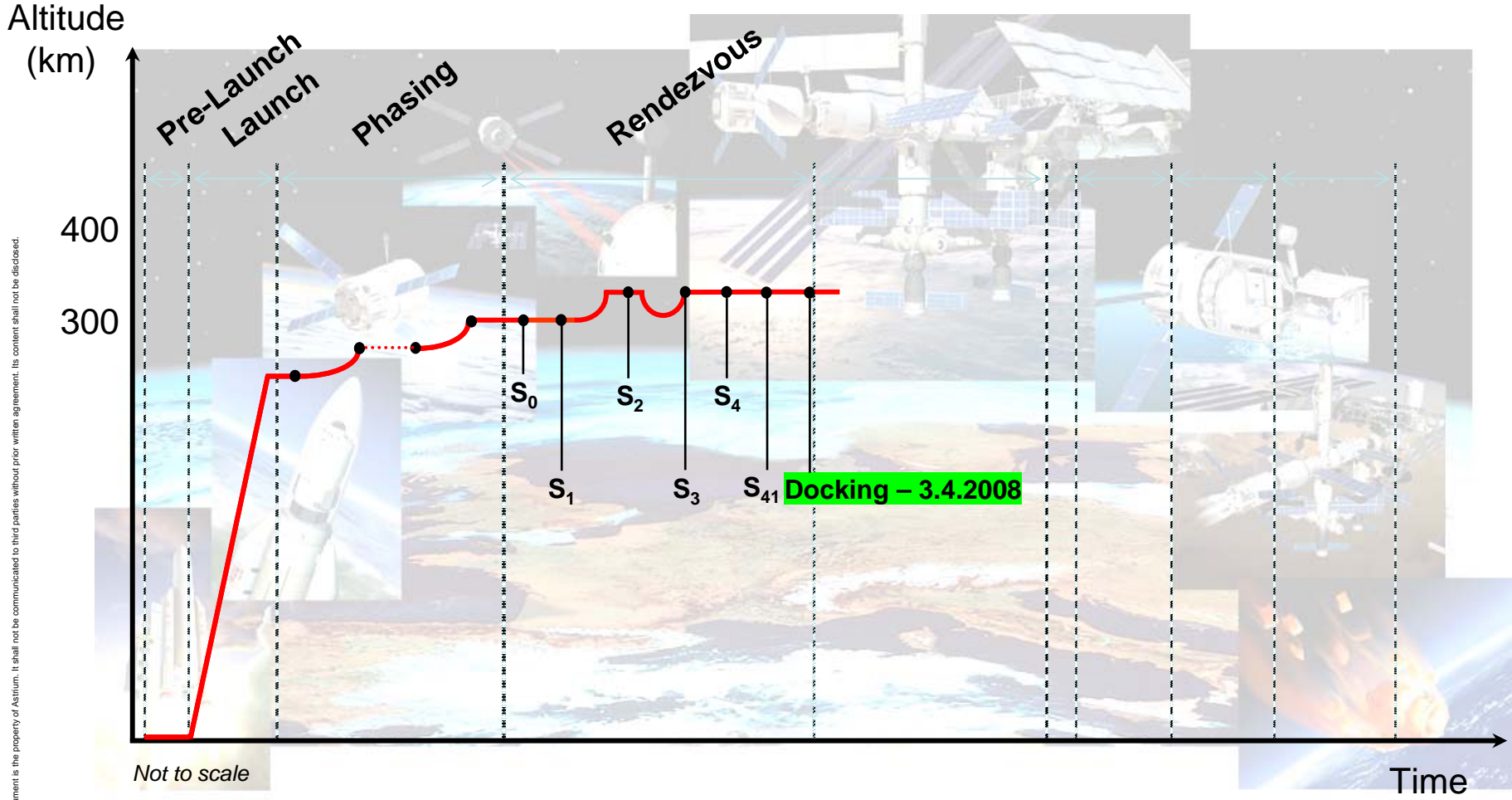
# Rendez-vous and docking phase



Far Range

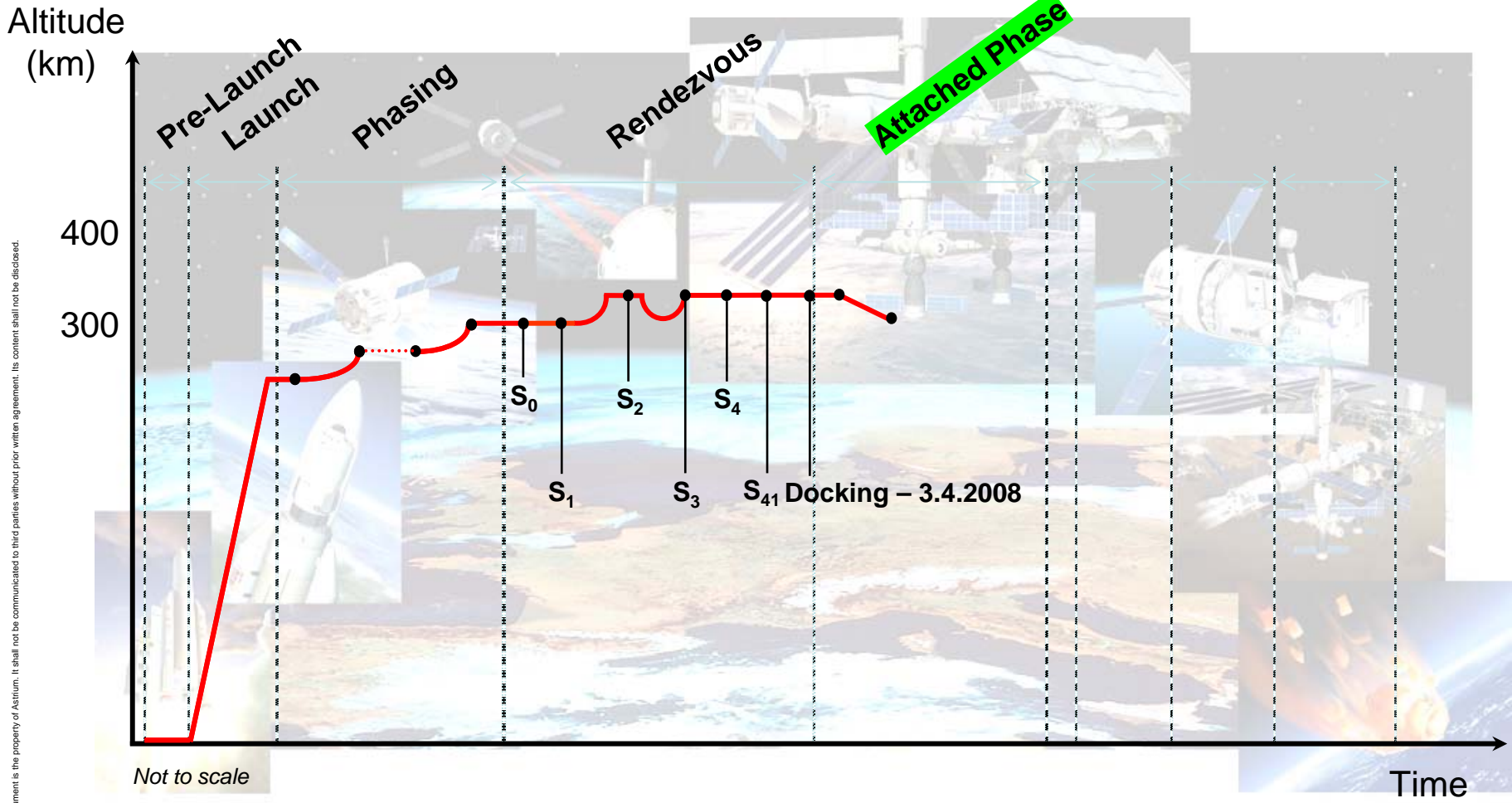
Close Range

# Mission profile



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# Mission profile



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Not to scale

## On-orbit ops



- **Payload transfer**
  - Water, gas, ISS refuelling propellants
  - Dry cargo
  - ATV loaded with wastes
  
- **Propulsive support to ISS**
  - Reboost
  - Attitude and orbit control (debris avoidance manoeuvre / DAM)
  
- **Rest place for the astronauts !**
  
- **All operations performed as planned, no anomalies**

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# ISS reboost by ATV



25 avril

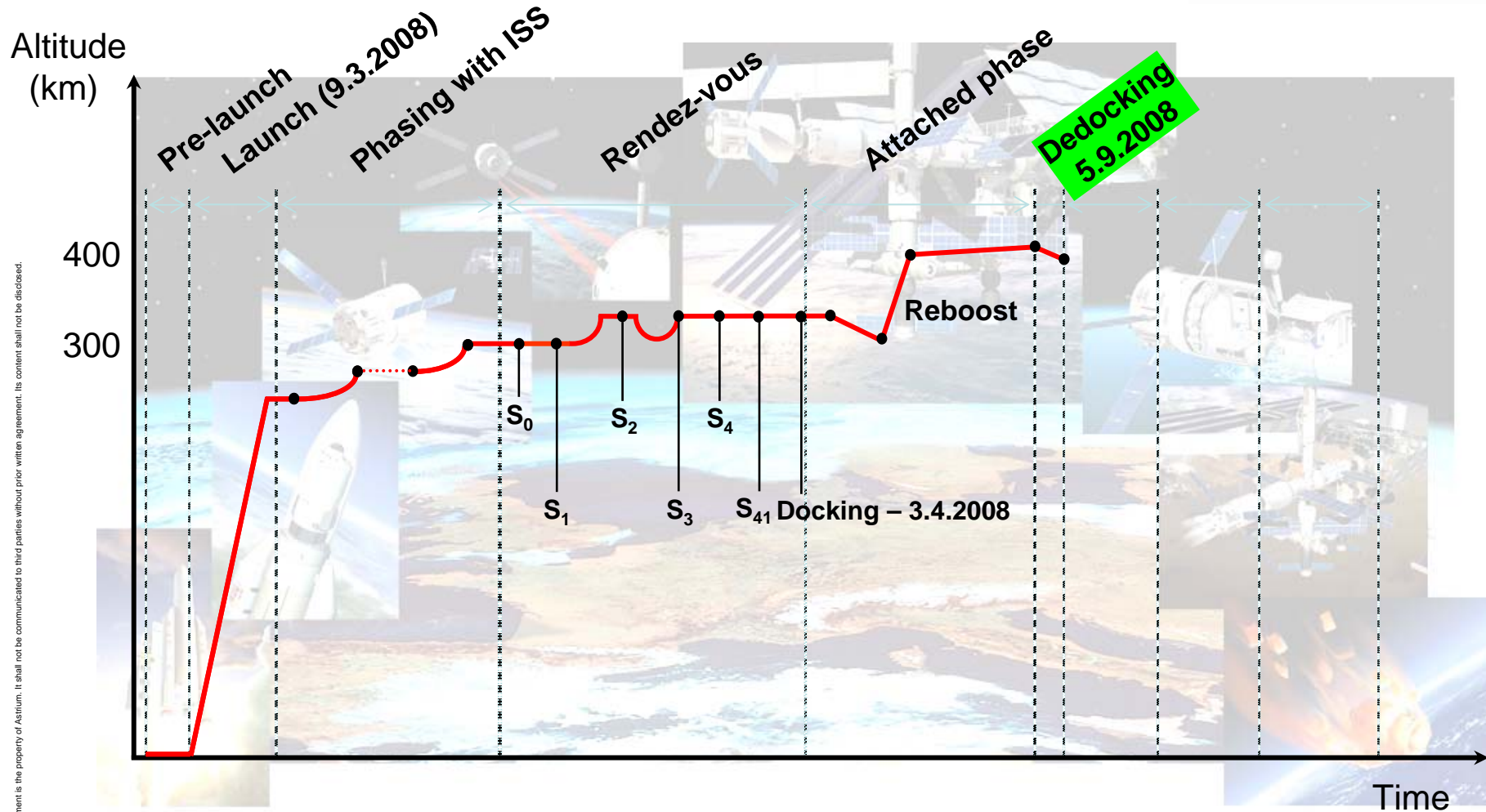
12 juin

08 juillet

06 août

07 août

# Dedocking



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# Deorbitation and reentry



Altitude (km)

400  
300

Pre-launch  
Launch (9.3.2008)

Phasing with ISS

Rendezvous

Attached phase

Dedocking (5.9.2008)

Deorbitation (29.9.2008)

Reentry (29.9.2008)

Reboost

S<sub>0</sub> S<sub>1</sub> S<sub>2</sub> S<sub>3</sub> S<sub>4</sub> S<sub>41</sub> Docking

Time

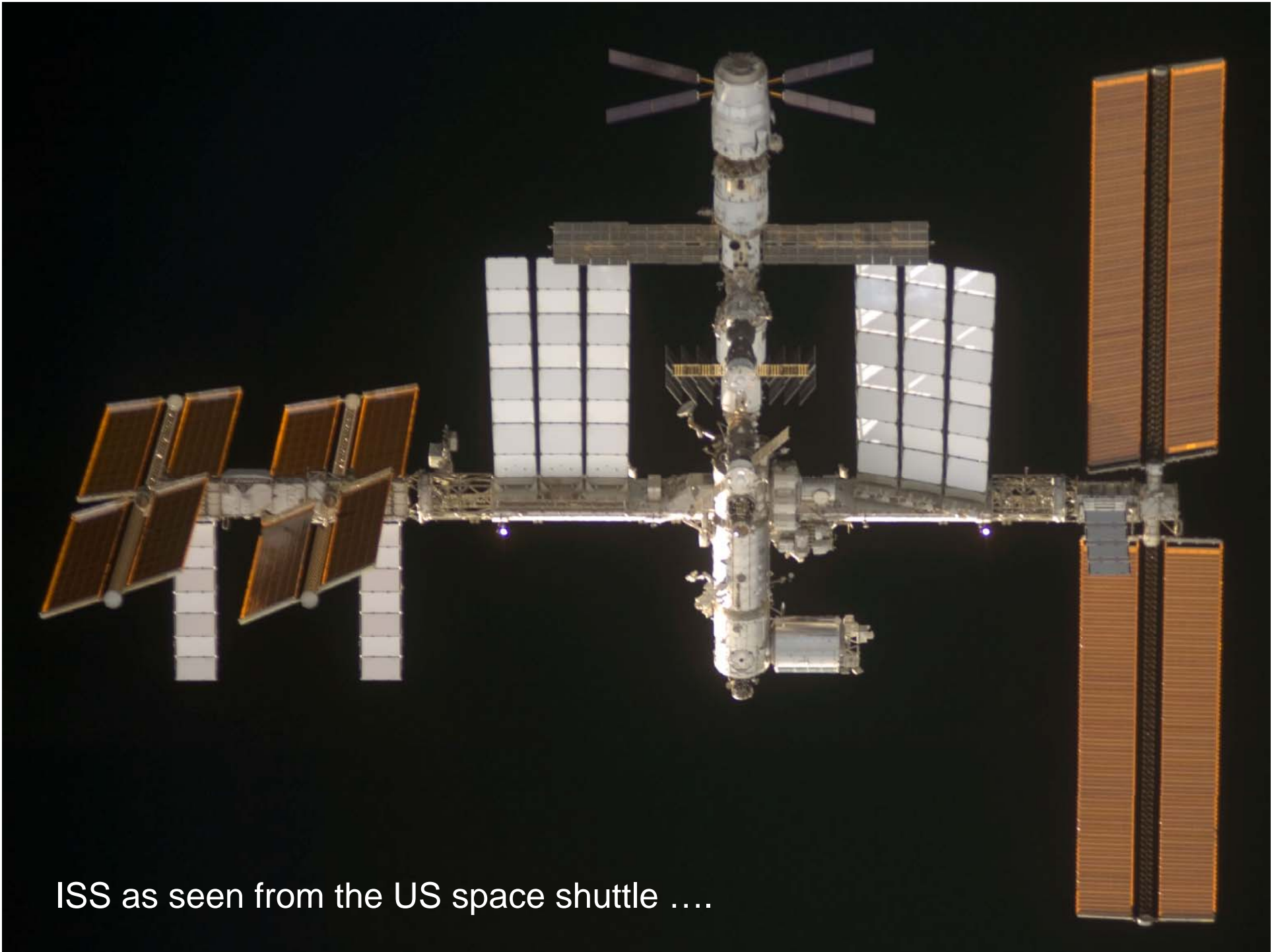
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## What's next ...?



- Successful mission from launch until reentry
  - By far, most complex space mission performed in Europe
  - No failure of any equipment or subsystem
  - No upload of software patch necessary
  - Several « world premieres » performed during this inaugural flight
- Extraordinary human adventure for European teams in permanent interface with counterparts in the US and in Russia
- Extraordinaire competencies developed in Europe, paving the way for further evolutions
  - Non destructive reentry (download of samples from the ISS)
  - Manned flights
  - Planetary exploration



ISS as seen from the US space shuttle ....