Launch Opportunities with VEGA and advanced space propulsion concepts

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The European Family of Launchers: Today

Three launchers qualified and in service

ARIANE 5
HEAVY

Main applications: telecommunications, navigation, scientific Missions, Earth observation

- GTO >10 MT
- LEO 20 MT
- SSO >10 MT
- **79** successes in a row since 2002

SOYUZ
MEDIUM

Main applications: navigation, scientific missions, Earth observation, telecommunications

- LEO 4.8 MT
- MEO 1.6 MT
- SSO 4.4 MT
- **42** successful missions

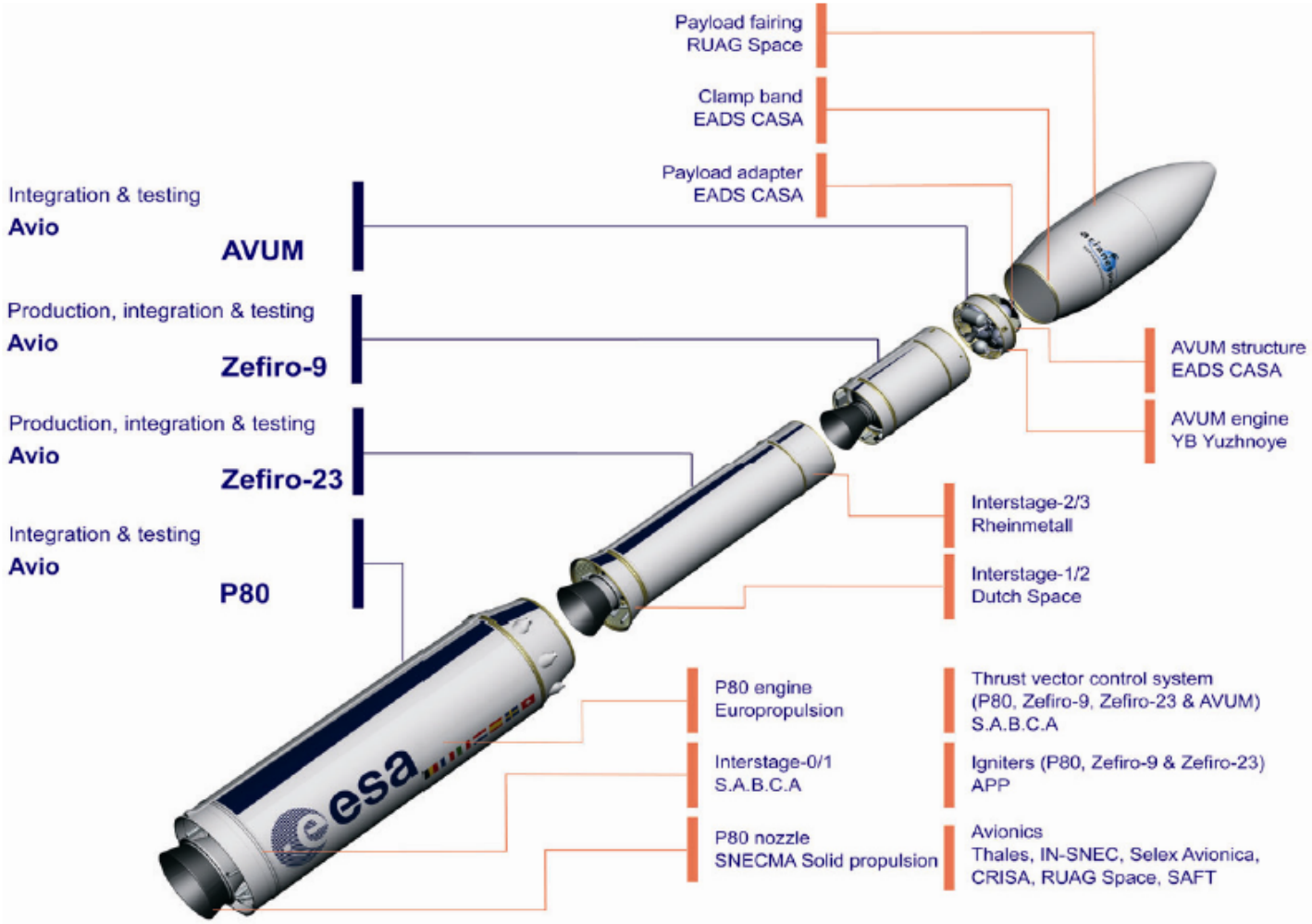
VEGA
LIGHT

Main applications: Scientific missions, Earth Observation

The versatile light-weight launch system

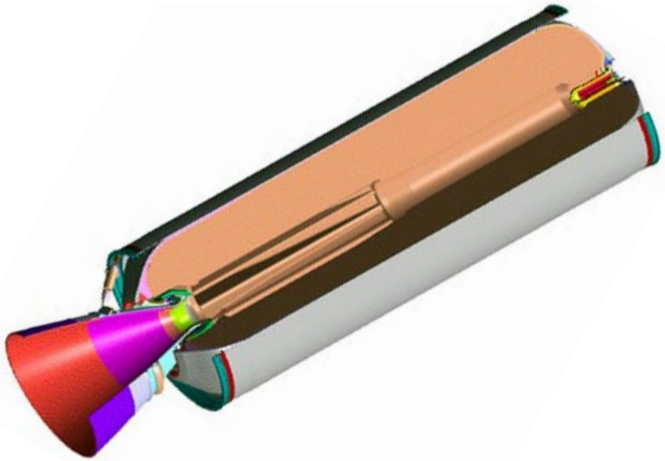
- LEO 2.5 MT
- SSO 1.3 MT
- **11** successful missions out of 11 including Maiden flight in 2012

VEGA Launcher Configuration

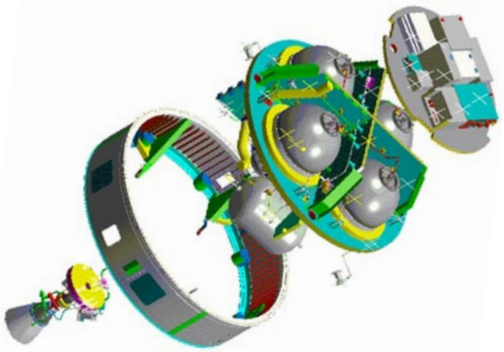


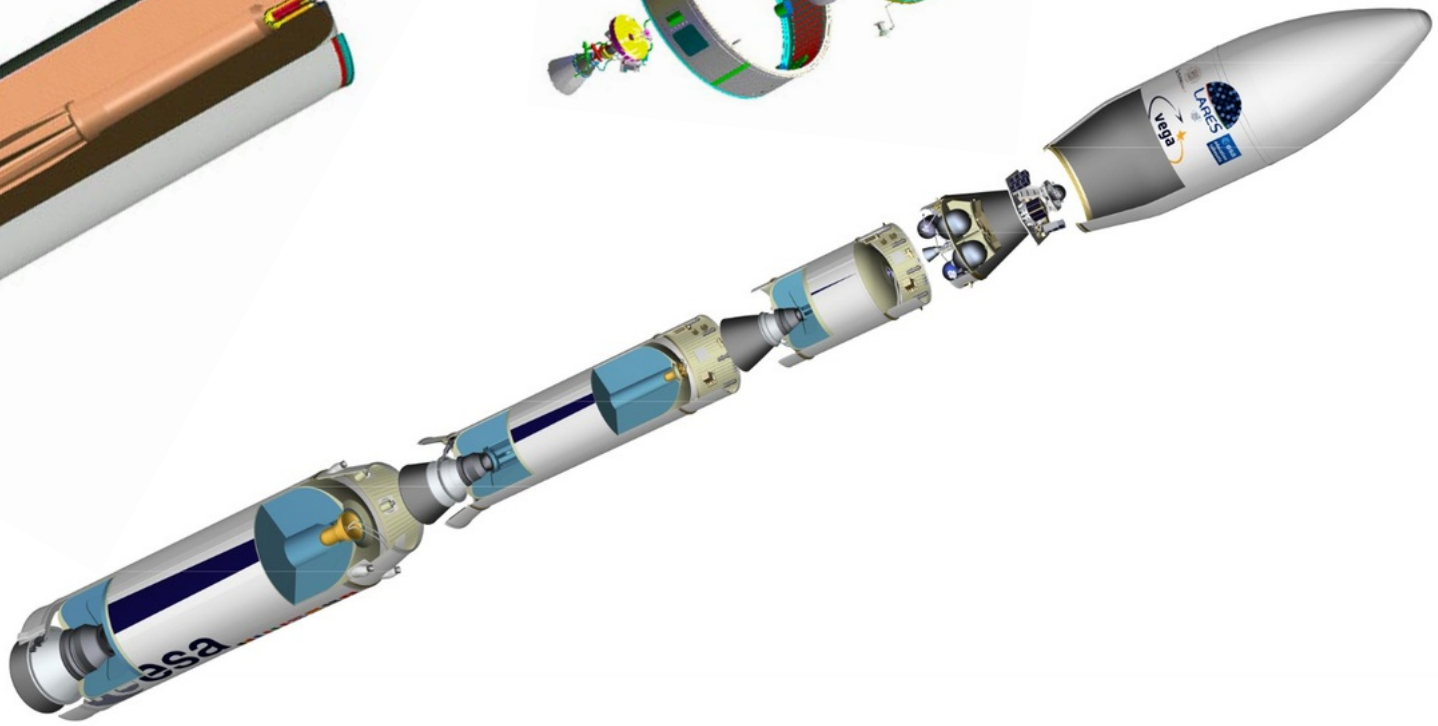
VEGA propulsion systems

Solid rocket motor

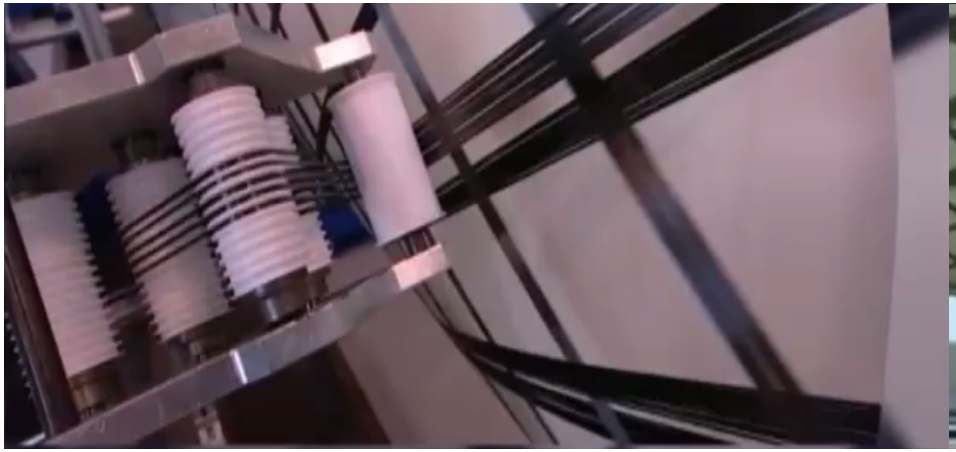


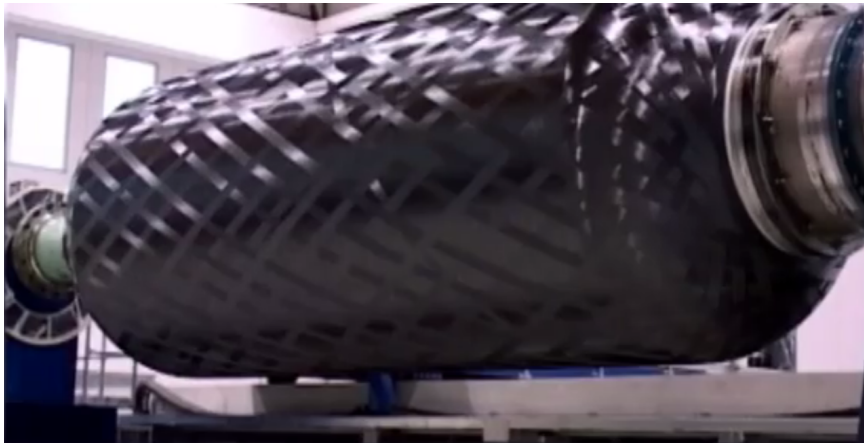
AVUM





Solid Rocket Motor – Case Production





Carbon/epoxy wound case:

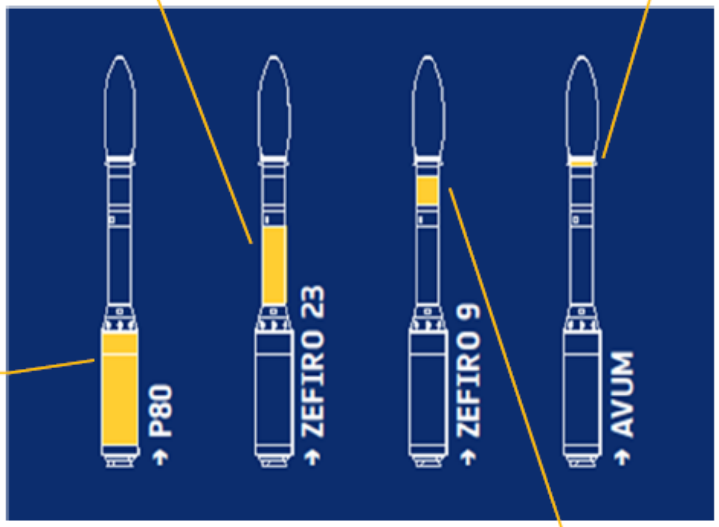
- 3 m diameter for P80
- 2 m diameter for Z23 / Z9
- Cases manufactured in AVIO facilities (Colleferro)

Some figures…

Second stage (Zefiro 23)	
Height	7.5 m
Diameter	1.9 m
Propellant mass	23.9 tons
Thrust (max)	1200 kN
Σ nozzle	25
Burn time	71.6 s

First Stage (P80)	
Height	10.5 m
Diameter	3 m
Propellant mass	88 tons
Thrust (max)	3040 kN
Σ nozzle	16
Burn time	107 s

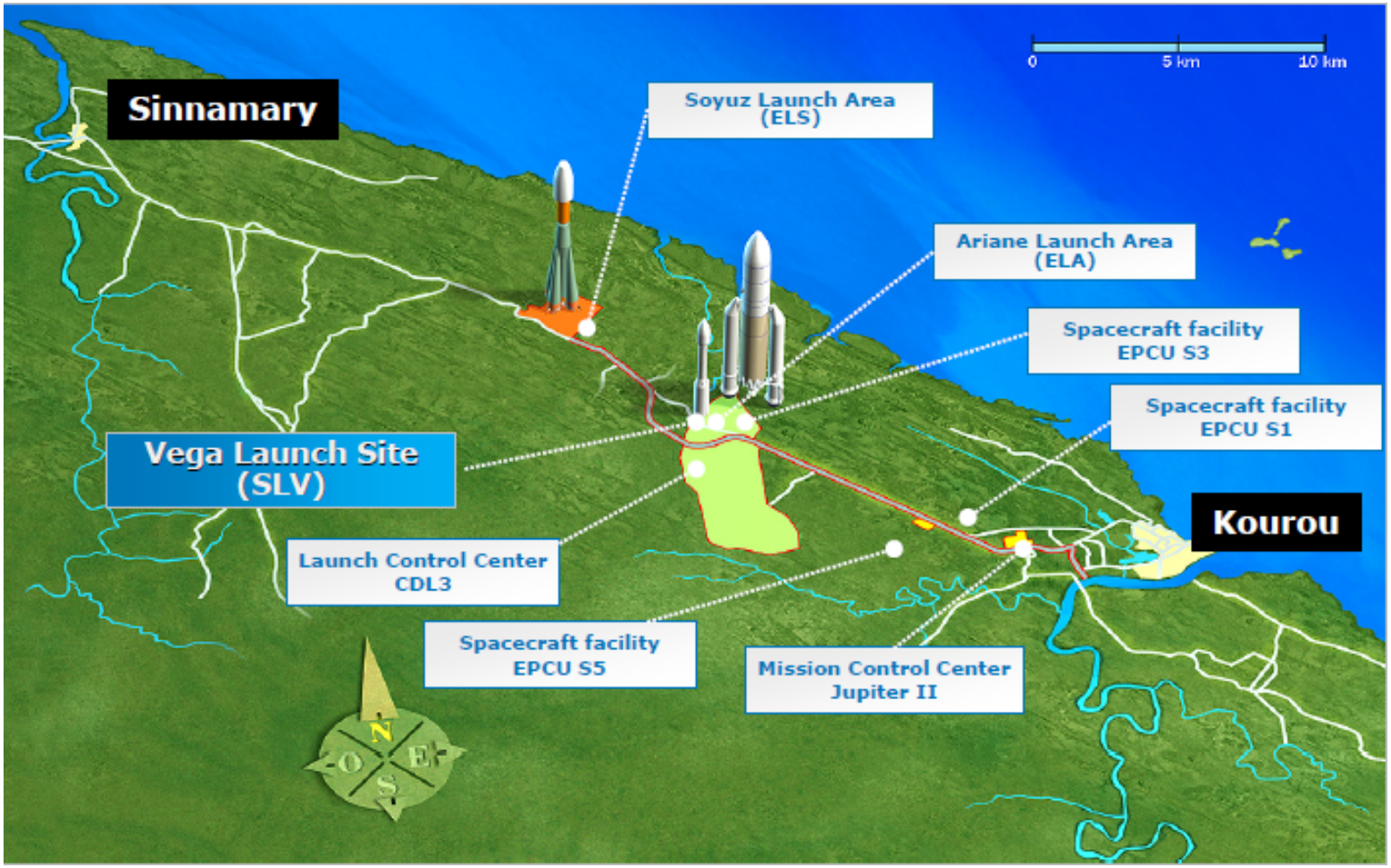
• **139 tons** at lift-off, **30 m** height



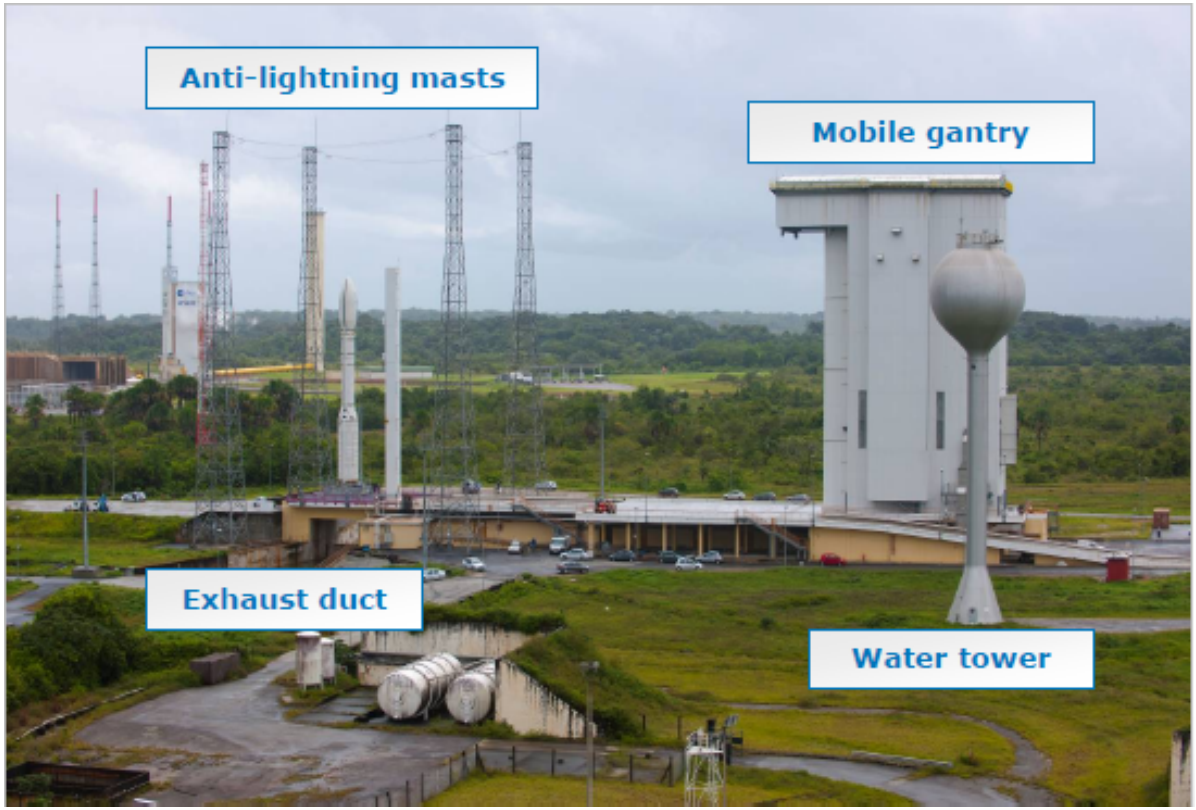
Fourth Stage: AVUM	
Overall height	1.74 m
Diameter	1.9 m
Propellant mass	550 kg
Max engine thrust	2450 N

Third Stage (Zefiro 9)	
Height	3.85 m
Diameter	1.9 m
Propellant mass	10.5 tons
Thrust (max)	313 kN
Σ nozzle	72.5
Burn time	117 s

French Guyana Space Centre



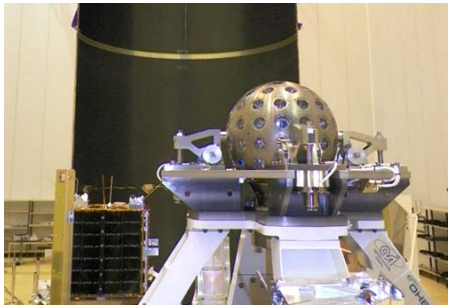
VEGA Launch Zone

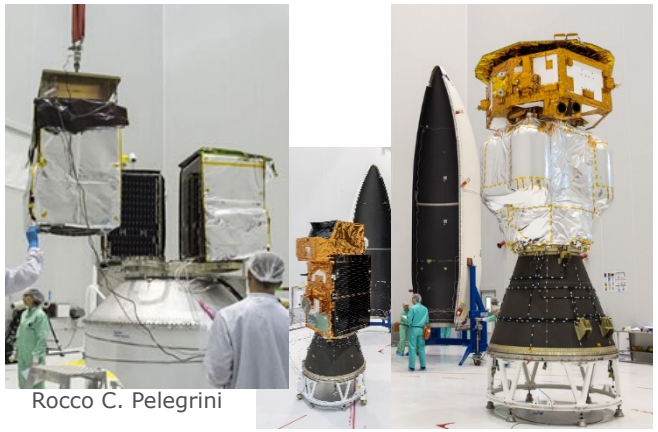


Launch System Control Centre (CDL3)

VEGA Launches

1. VV01: LARES @ 1450 km, i= 69.5°
2. VV02: Proba-V and VNREADSt-1@ SS0 (820 km)
3. VV03: KazEOSat-1 @ SS0 (820 km)
4. VV04: IXV @ suborbital (apogee: 416 km). 5.4°
5. VV05: Sentinel 2A @ SS0 (787 km)
6. VV06: Lisa Pathfinder @ SEL-1
7. VV07: 4 Skysat & Perusat @ SSO (500 km & 675 km)
8. VV08: GÖKTÜRK-1 @ SSO (700 km)
9. VV09: Sentinel 2B @ SSO (786 km)
10. VV10: OPTSAT-3000 & VENμS @ SSO (450 km & 720 km)
11. VV11: Mohammed IV-A @ SSO (620 km)
12. VV12: ADM-Aeolus @ SSO (400 km)





European launcher family

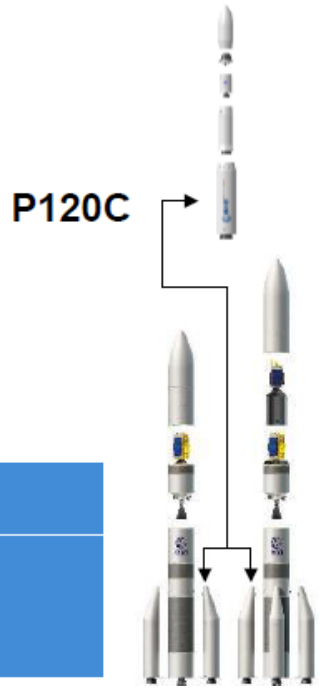
The family of launchers operated from CSG is providing an independent European access to space for most institutional and commercial missions.

Performance	10.5 tons in GTO	1.5 tons in LEO	2.3 tons in LEO	11 tons in GTO	3.0 tons in LEO

The European Family of Launchers: Tomorrow

VEGA-C and ARIANE 6: Competitiveness, performance, modularity

P120C: Common element between the two launchers: 35 SRM/year



ESA and ELV for Vega-C

Aug. 12, 2015
Contract awards

ESA and **ArianeGroup** for the Ariane 6 launch system

ESA and **CNES** for the Ariane 6 launch pad

Ariane 62

Ariane 64

VEGA-C

objective:
2019

Higher performance to meet market expectations

ARIANE 6

objective:
2020

Designed to satisfy market requirements, with simplified program governance to meet our government and commercial customers' expectations

VEGA C Configuration

EU components and Recurring & operations cost reduction

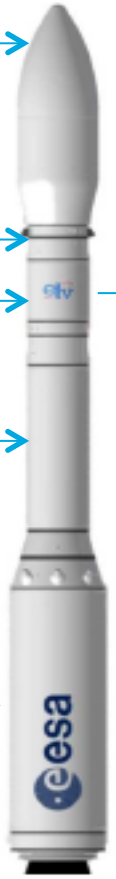
PLF – Ø2.6 m

AVUM – Ø1.9 m
2.45 kN thrust

Z9: Ø1.9m
150 kN thrust

Z23 – Ø1.9 m
1200 kN thrust

P80 – Ø3 m
3050 kN thrust



Enlarged PLF – Ø3.3 m

AVUM+ +150 Kg Fu/Ox
(485 Fu + 243 Ox)
2.45 - 5 kN thrust

Z40 – Ø2.36 m
1200 kN

Common to Ariane 6
P120C – Ø3.4 m
>4000 kN thrust

VEGA-E gives the opportunity to set-up a building blocks launchers family serving the complete LEO payloads class at better competitive prices, using existing or under development propulsive stages (P80, P120C, Z23, Z40, Z9, AVUM, VUS).

VEGA E *'heavy'*

- Single heavy LEO sat;
- Multi-payload LEO small/medium with orbital plane change;
- Deployment of large constellation's;
- Constellation sats replacement;
- Growth potential in higher altitude orbits;

VEGA E *'light+'*

- Typical VEGA payloads at reduced cost

VEGA E *'light'*

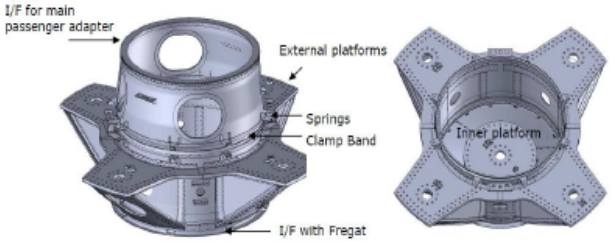
- Single small LEO sats;
- Deployment of LEO smallsats constellations.

Small Satellites Approach

QUALIFIED

SOYUZ

ASAP-S (Arianespace System for Auxiliary Payloads for Soyuz)

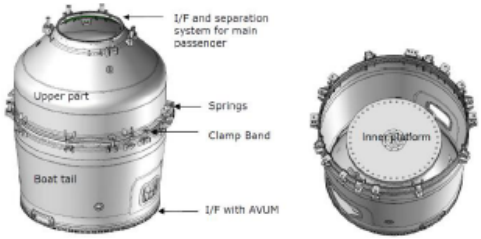


4 external positions :
4 microsat

1 central position:
1 mini satellite or
up to 3 micro satellites

VEGA

VESPA (VEga Secondary Payload Adapter)

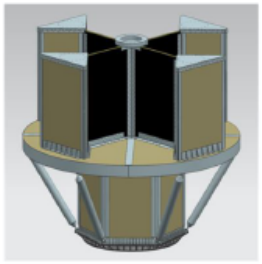


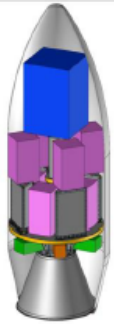
Internal position:
1 mini satellite or
2 micro satellites

UNDER DEVELOPMENT

VEGA & VEGA - C

SSMS (Small Satellite Mission Service)





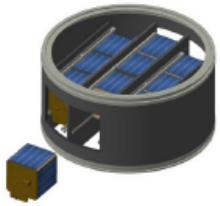
Top position :
1 minisat

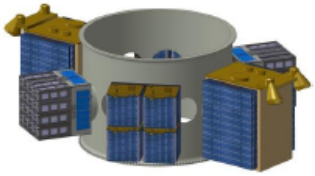
Deck 1, 2:
Up to 8 microsat

Base module:
6 nanosat or
6 cubesat deployers

ARIANE 6

MLS (Microsat LaunchShare)



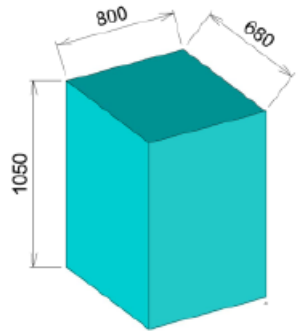


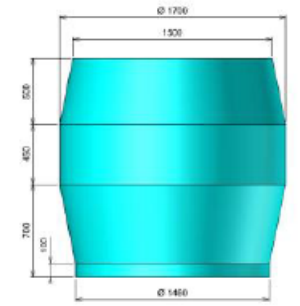
Deployer for
10 XXU satellites

6 positions:
- Light Sat < 250kg
- Plates with 27U+
- CubeSat deployers

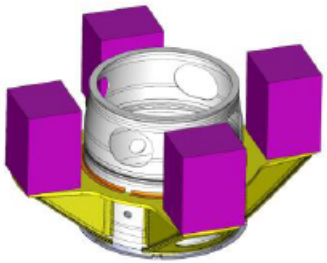
Usable Volume for small satellites (S/C and its adaptor)

ASAP-S & VESPA





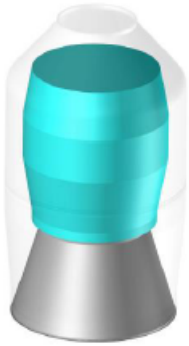
ASAP-S



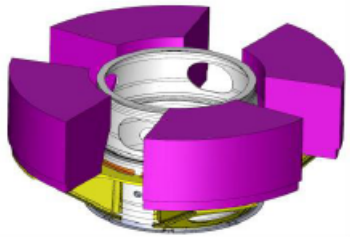
ASAP-S

VESPA

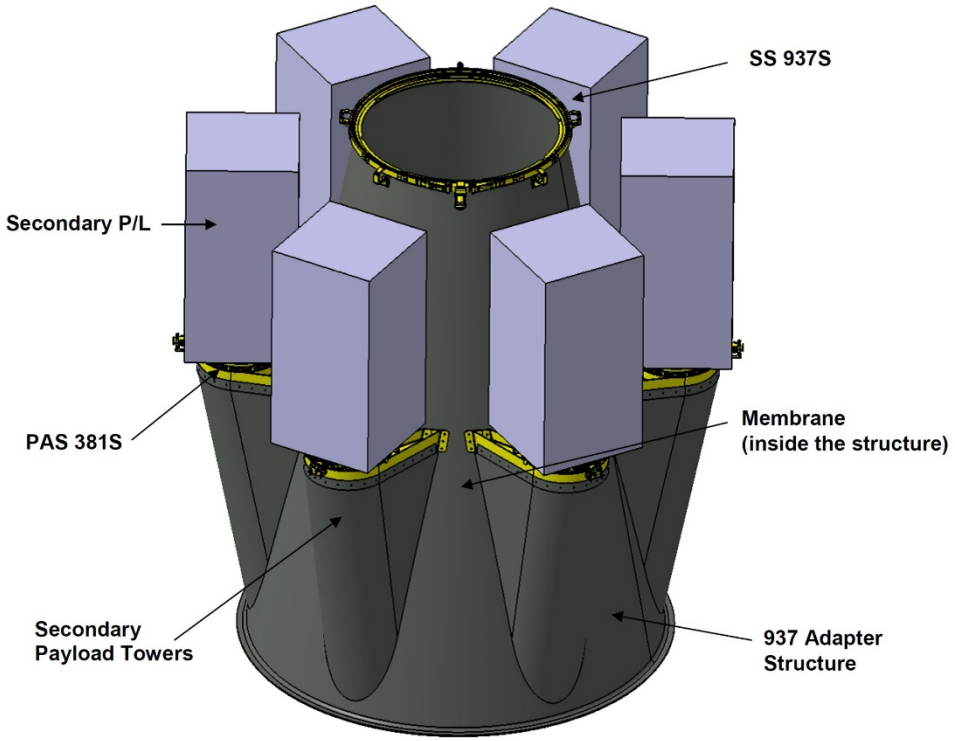
VESPA



ASAP-S extended



VEGA-C: VAMPIRE Overview



The Vampire+ system accommodates these functions by the following features:

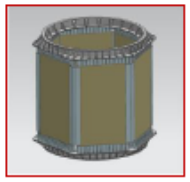
- Adapter structure assembly (937 or 1194 versions)
- Clamp band assembly (937S or 1194VS)
- Separation spring set
- Harness
- Optionally: Secondary P/L Towers.
- Optionally:Payload adapter system 381S (6x)

SSMS Modularity

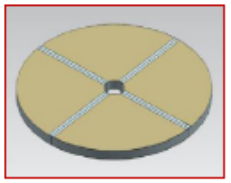
By combining the different SSMS dispenser modules, a VEGA launcher will be able to orbit into LEOa number of satellites from some units up to several dozens, depending on their mass and dimensions.

SET OF MODULES

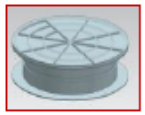
HEXAGON



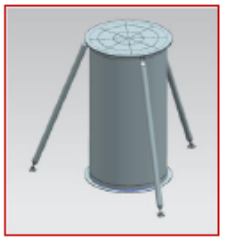
MAIN DECK



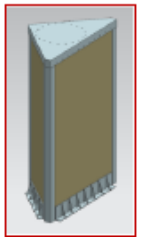
SPACERS



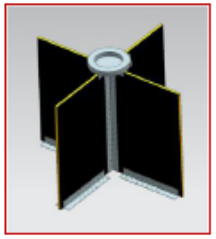
CENTRAL



TOWERS

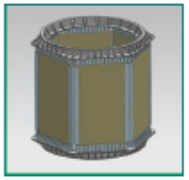


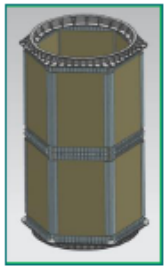
SHEAR WEBS

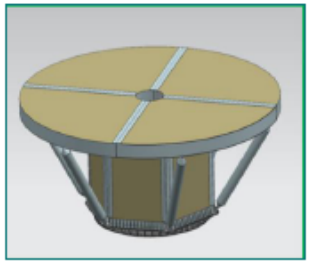


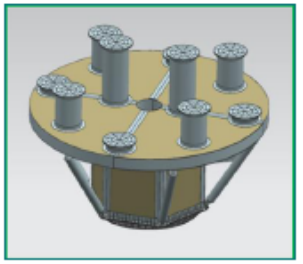
By combining **different modules**, several SSMS **dispenser configuration** are obtained

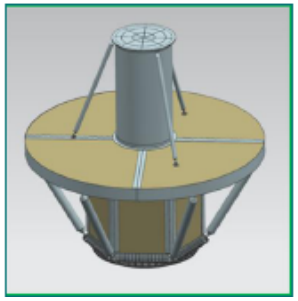
DISPENSER CONFIGURATIONS

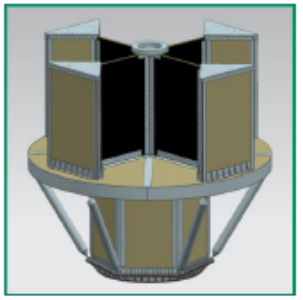












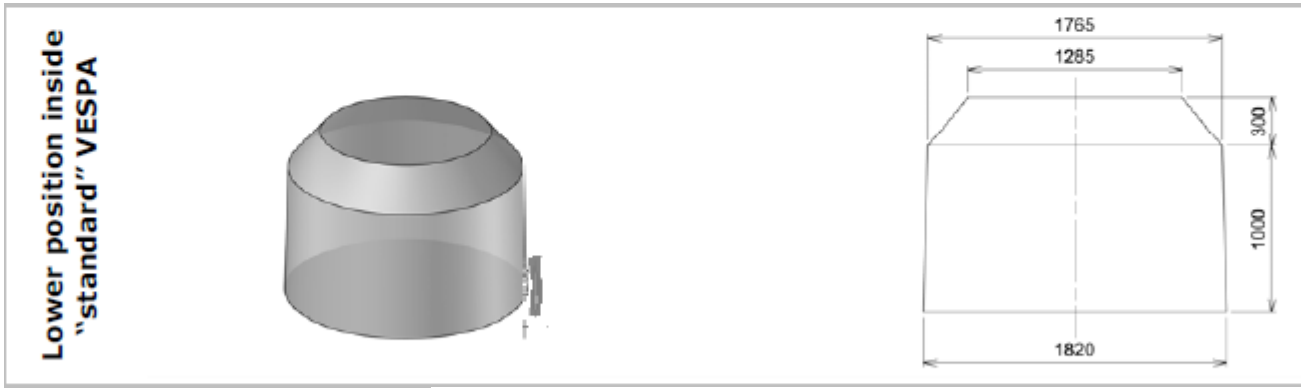
Usable Volume for small satellites

SSMS SMALL SPACECRAFT MISSION SERVICE

SSMS PoC Flight

Mini satellite	Micro satellite				Nano satellite		Cubesat deployer
							
H 1800 mm 1200 x 1200 mm	H 1200 mm 800 x 800 mm	H 1200 mm 800 x 800 mm	H 1100 mm 700 x 600 mm	H 1100 mm 700 x 600 mm	H 600 mm 400 x 300 mm	H 600 mm 400 x 300 mm	H 530 mm 320 x 280 mm

Available mass and volume envelopes



VESPA Lower Position Envelope

600 kg maximum

Stretched version: 1.8 m heighth

SSMS slots available envelopes

#	Class	Mass range (Kg)	Standard Envelope Volume (mm)	Standard position
1	Mini Satellite	400 – 200	H1800 x L1200 x W1200	Top position
2	Micro Satellite	200 – 60	H1200 x L800 x W800	Top position or Deck#2 position (FLEXI-3 configuration)
			H1100 x L700 x W600	Deck #1 position (FLEXI-4 configuration) or Deck#2 position (FLEXI-4 configuration)
3	Nano Satellite	60 – 25	H600 x L400 x W300	Deck#1 position (FLEXI-4 configuration) or Base module position
4	Cubesats Deployer	25 – 1	H530 x L320 x W280 (doors open)	Base module position

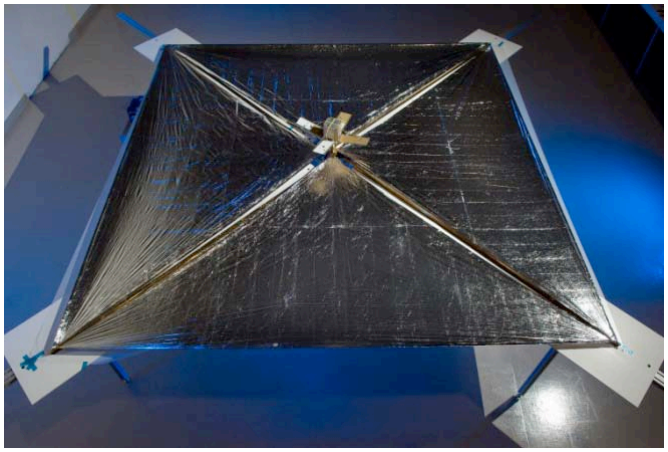
Available mass and volume envelopes

	Large (mm)	Width (mm)	Height (mm)	Mass (kg)	OK/NOK
SSMS Main	1200	1200	1800	400	OK
VESPA LOW	1820	1820	1300	600	OK
VESPA+ LOW	1820	1820	1800	600	OK
VESPA UP	3960	3960	4211 4711	1000	OK

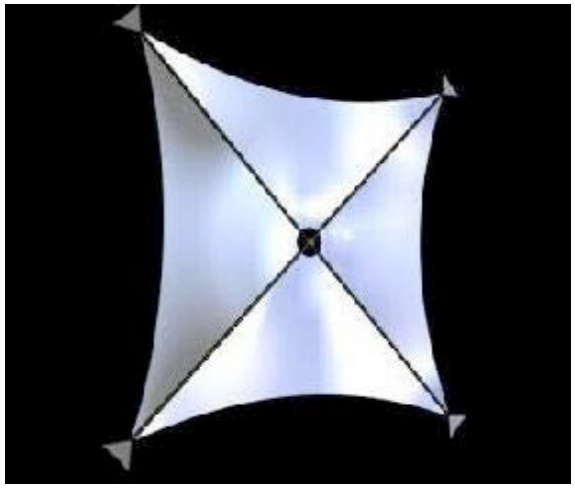
Advanced Space Propulsion: Solar Sail

Solar Sail: Basic Concepts

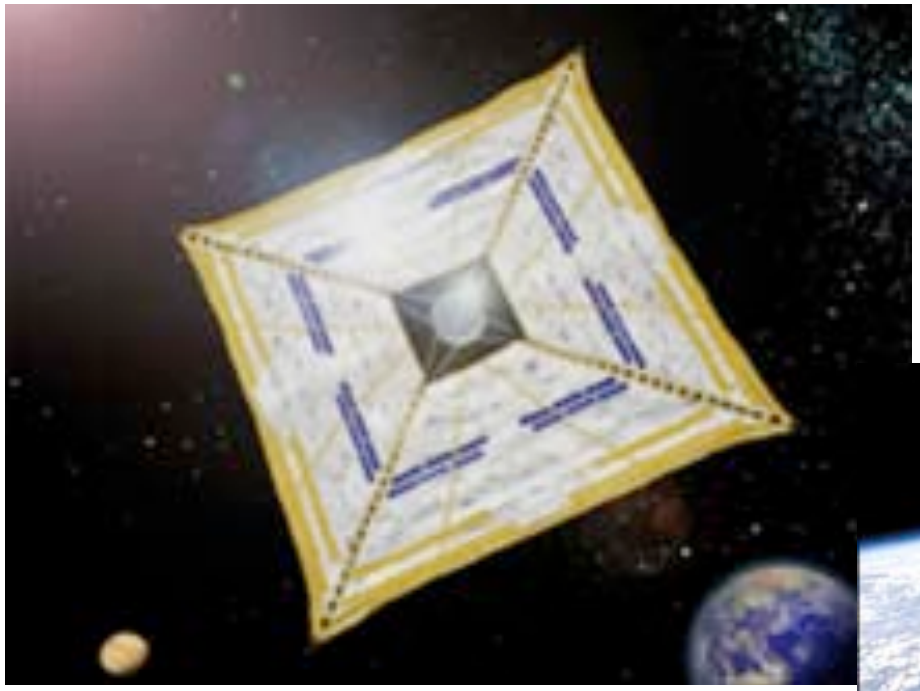
The reflective membrane is a layered structure composed of a plastic support (typically Kapton or CP1) on which a reflecting material (Aluminum) is deposited. To obtain low sail loads the plastic support has a thickness of a few microns (2.5-7.5), while the thickness of the reflecting material is about 100 nm.



A basic sub-system is the control of the sail's orientation to modulate the thrust vector. For such control the classical methods, such as the rotation of the sail system, micro-rockets, or small sails at the edges of their own sail, are unlikely to be effective for large sails; in fact, the moment of inertia of a square sail varies with the fourth power of its side. As a result, a light and fast / stable control subsystem is a major objective in the design of future missions to large sails.



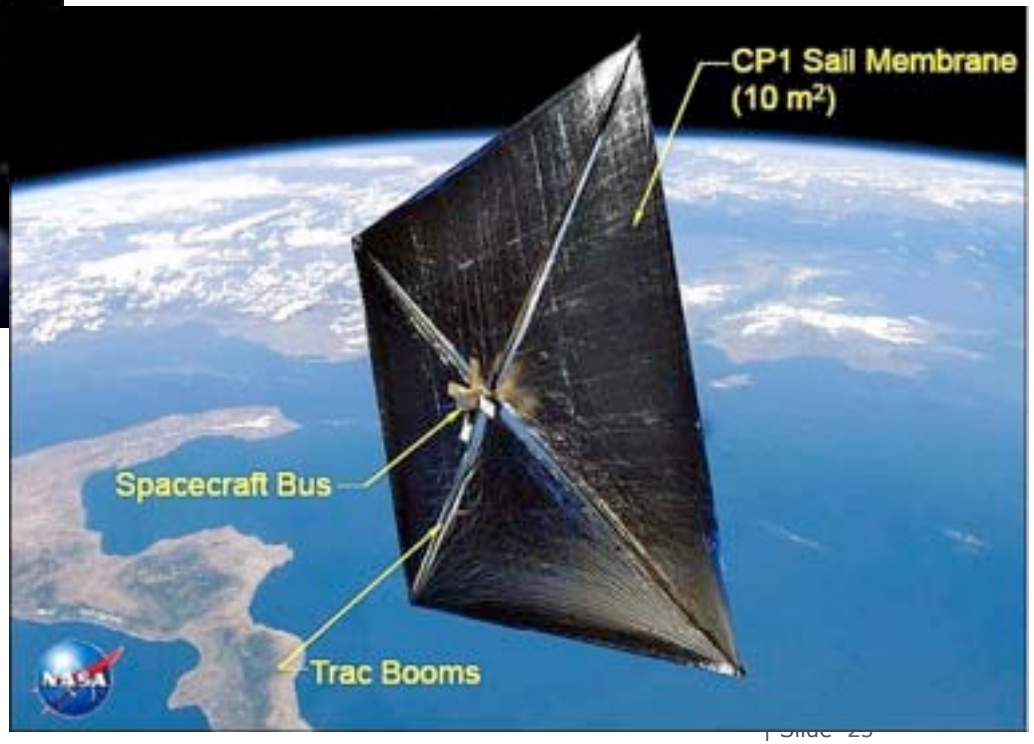
Solar Sail: Mission realized



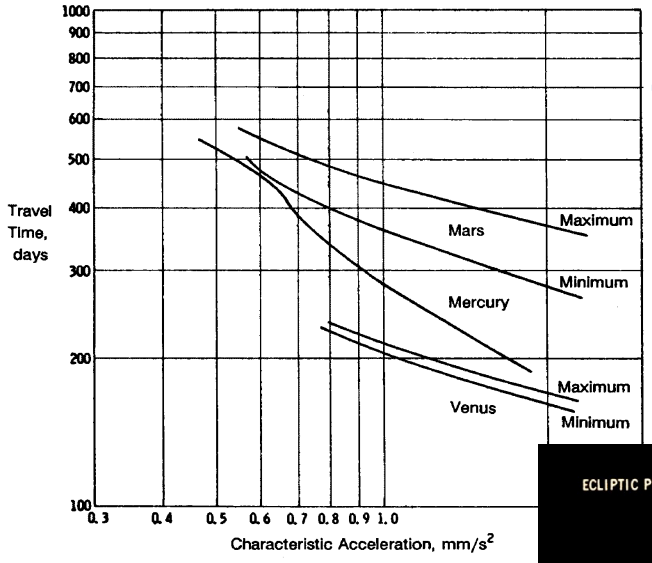
IKAROS (2010)

Solar Photon Sailing

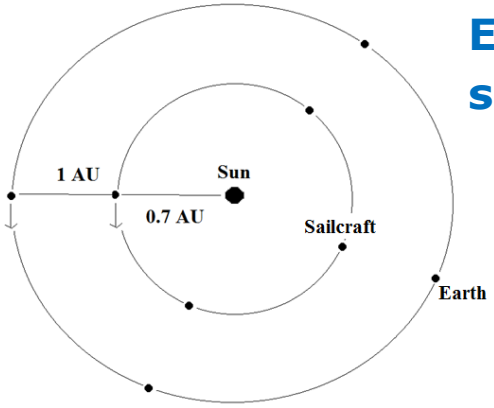
NanoSail-D2 (2011)



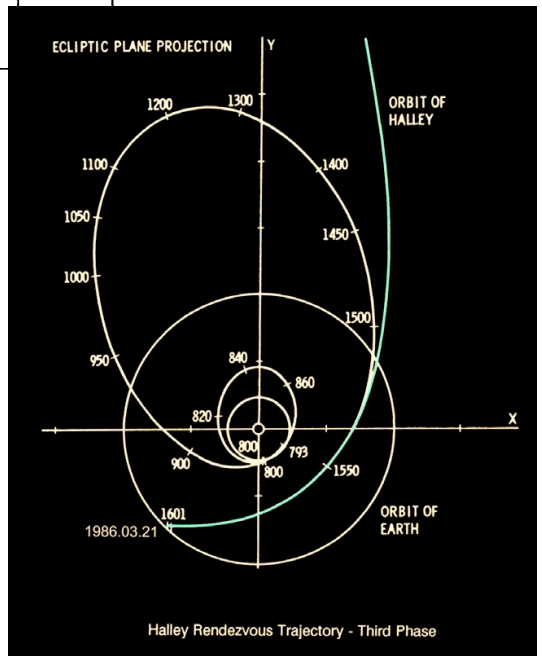
Missions enabled by solar sails



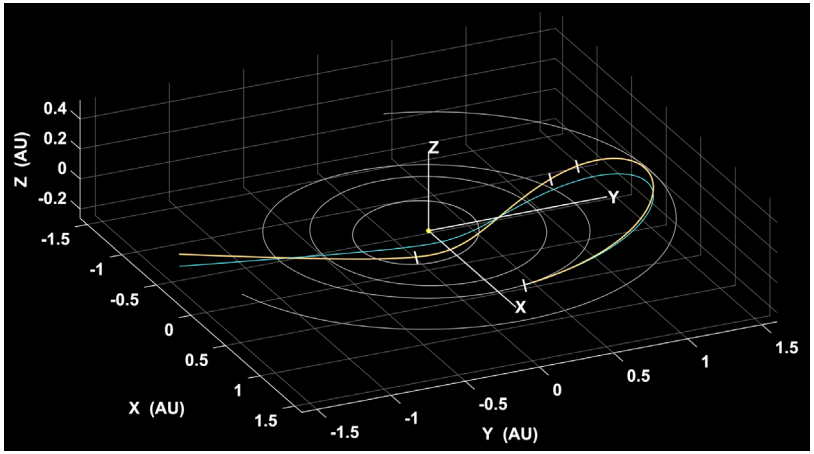
Interplanetary Transfers



Early warning sailcraft



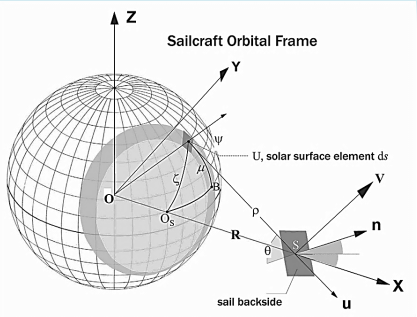
Rendezvous with bodies in a retrograde eliosynchronous orbit

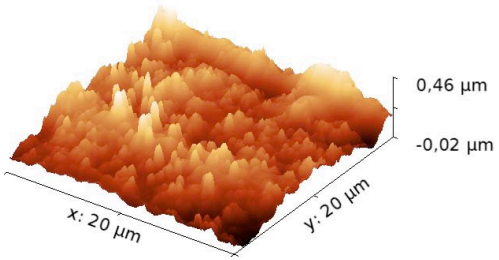


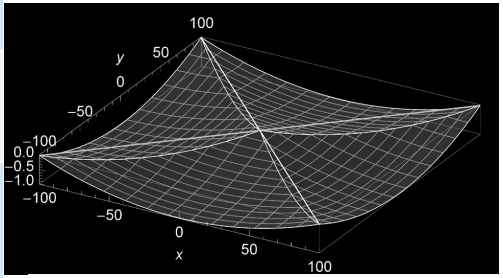
Escape from Solar System

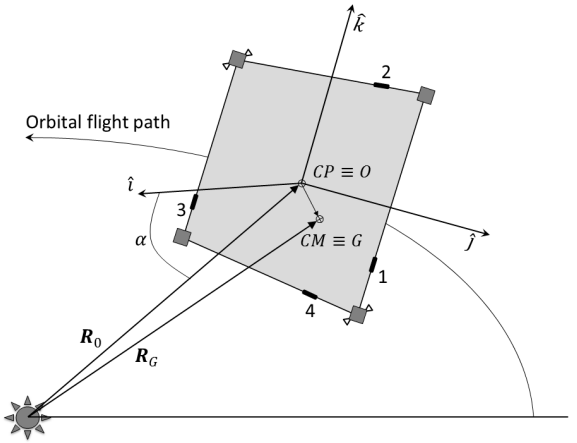
Solar Sails: Proposed Activities

Tasks
Mission Analysis (trajectory and attitude)
Sensor for Early Warning and Antenna
Photonic Materials (for ACS)
Membrane characterization
Basic Optical Measures
Mechanical Measures
Tubular Booms (Composite materials)
Flat Booms Shape-memory

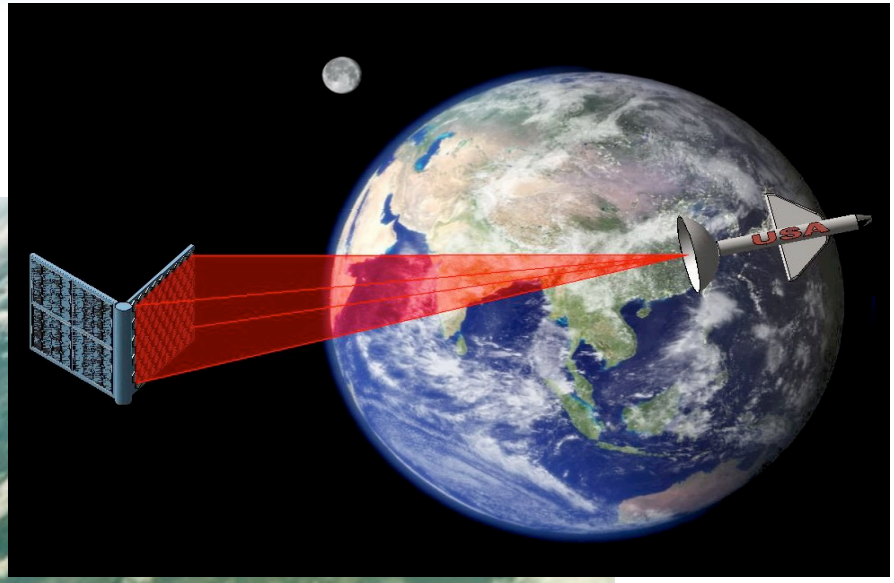


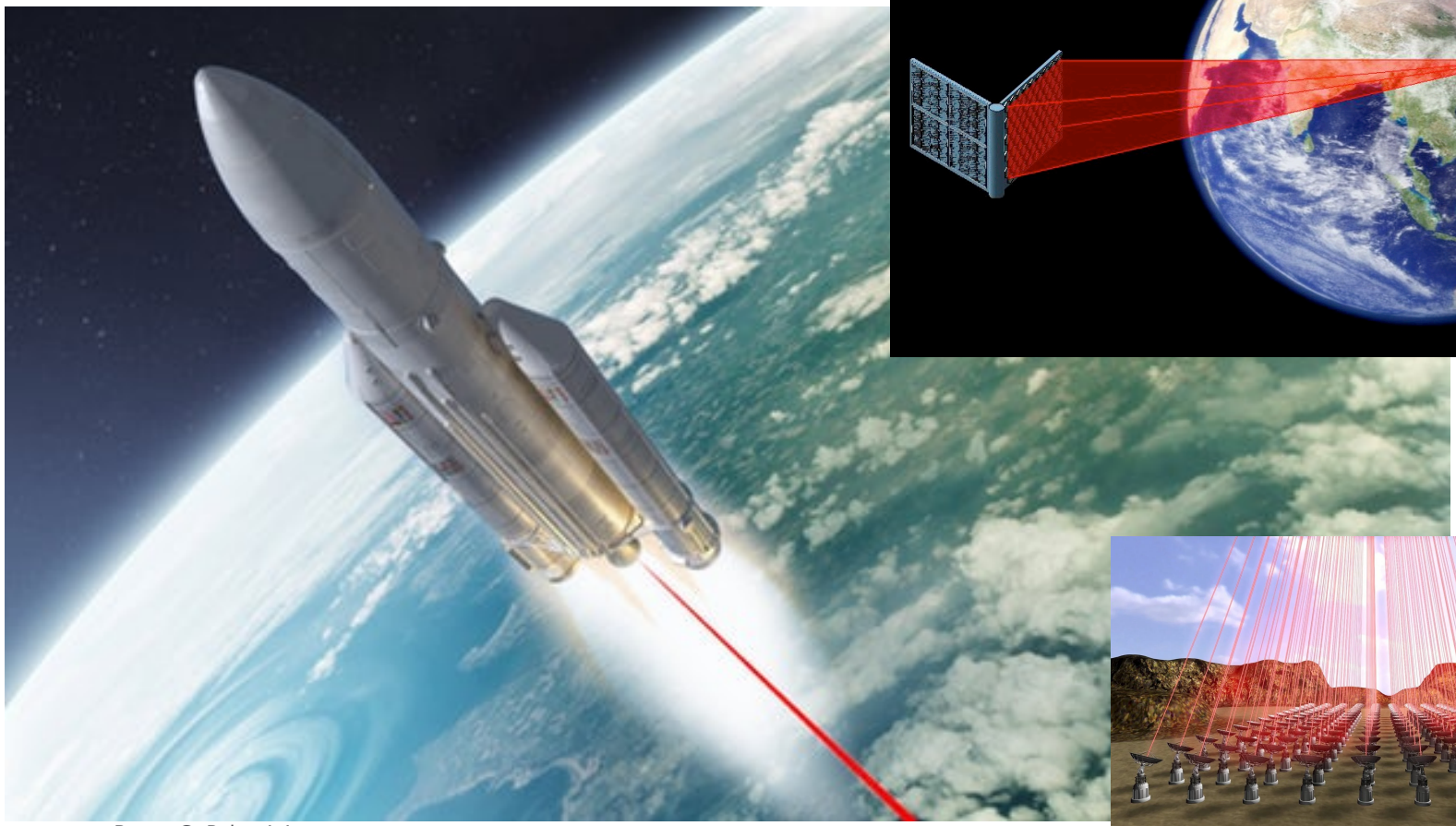




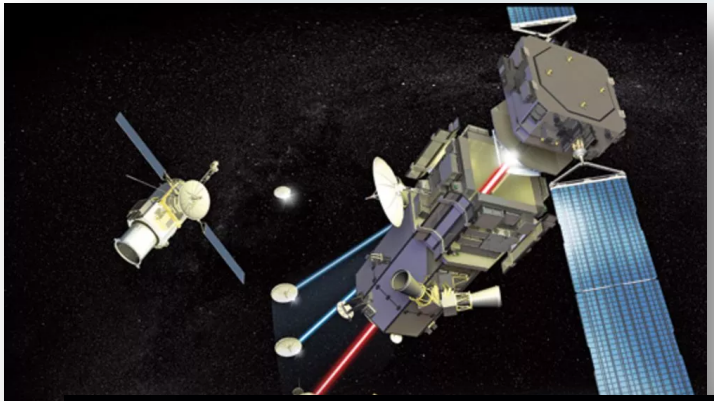


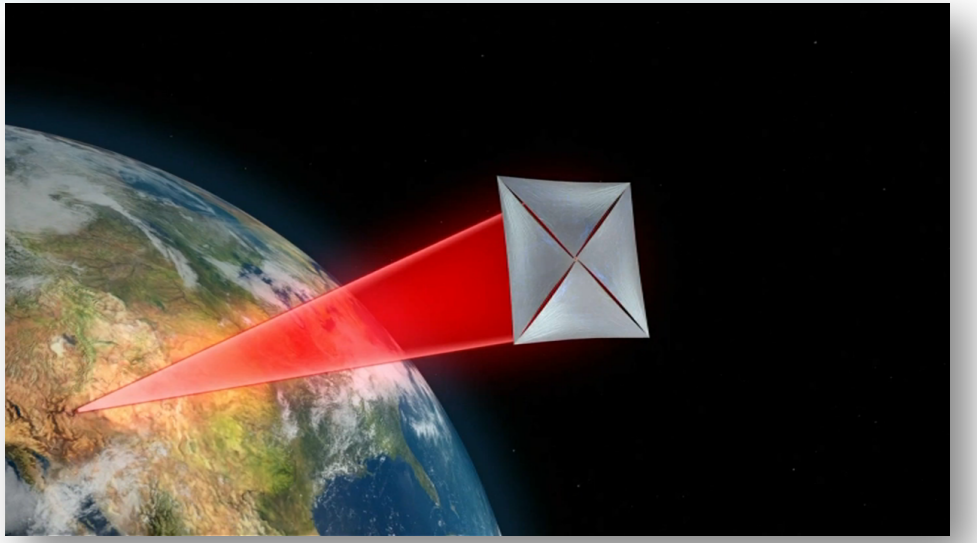
Laser propulsion

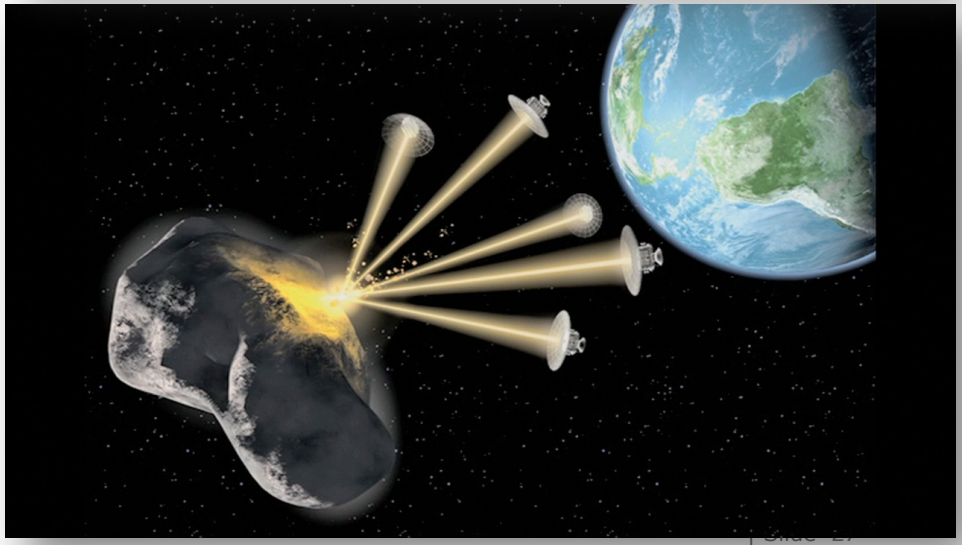




Missions enabled







ASI Research activities

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THANK YOU