RETALT

RETro propulsion Assisted Landing Technologies

DLR

KEY TECHNOLOGIES FOR RETRO PROPULSIVE VERTICAL DESCENT AND LANDING - RETALT –

AN OVERVIEW

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Gabriele De Zaiacomo – *DEIMOS Space*
Jan Vos – *CFS Engineering*
Christoph Thies, Matthew Jevons – *MT Aerospace*
João Carvalho, Sofia Paixão – *Amorim Cork Composites*

June 21st 2022

THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION FRAMEWORK PROGRAMME UNDER GRANT AGREEMENT NO 821890

HORIZON 2020
European Union funding for Research & Innovation

The Name

RETALT

RETro propulsion Assisted Landing Technologie

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Overview

- Funded by the EU in the frame of Horizon 2020
- Lead by DLR
- Carried out by 6 Partners:

  DLR · Almatech · Amorim Cork Composites
  CFS Engineering · Deimos Space · MT Aerospace

- Started 6th of March 2019 – Ends in August 2022

3.5	6	4	3
YEARS	PARTNERS	COUNTRIES	MILLIONS (BUDGET)

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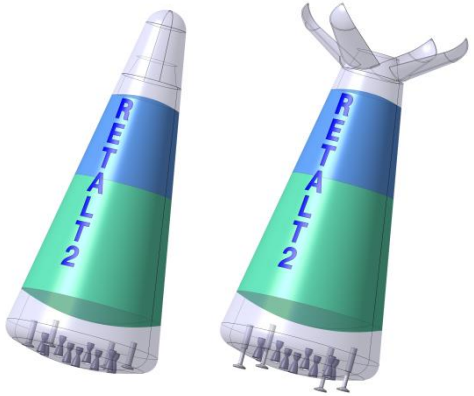
Main Objectives

- To investigate the launch system reusability of

- Operational launch vehicle
  Vertical Take-off Vertical Landing (**VTVL**) Two Stage To Orbit (**TSTO**)
  (inspired by Falcon 9)
  - **RETALT1**

- Future launch vehicle (technology test bed)
  Vertical Take-off Vertical Landing (**VTVL**) Single Stage To Orbit (**SSTO**)
  (inspired by DC-X)
  - **RETALT2**



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Key Technologies

- Aerodynamics and Aerothermodynamics
  - Aerodynamic Database (AEDB)
  - Aerothermodynamic Database (ATDB)

- GNC concept

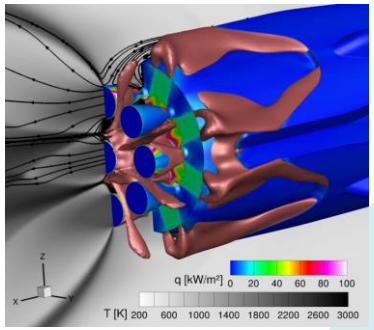
- Structures and Mechanisms
  - Tested demonstrator of deployment mechanisms and structure
    - of aerodynamic control surfaces (Scale approx. 1/5)
    - of landing legs (Scale approx. 1/5)

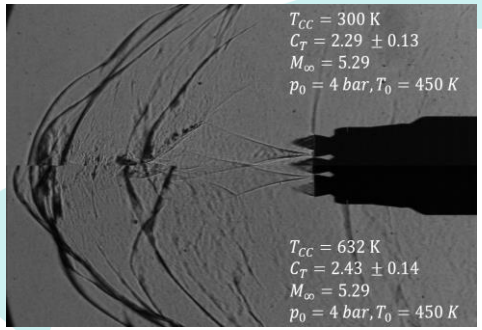
- TPS for base plane and critical structural parts
  - TPS with new mounting technique (trowelable) tested in arc-heated facility (L2K)

Partners

DLR

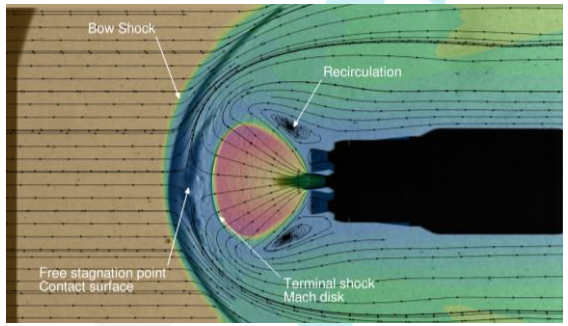
- Coordination and Management
- Reference Configurations
- Aerodynamics and Aerothermodynamics:
  - CFD in Göttingen
  - Wind Tunnel Tests in Cologne
  - AEDB, ATDB

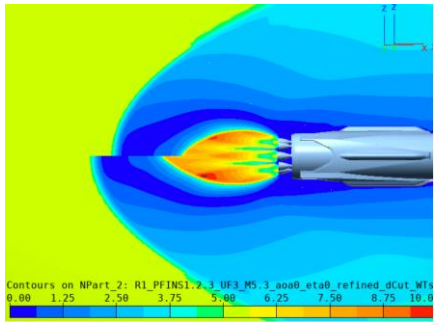




CFS Engineering
Computational Fluids & Structures Engineering

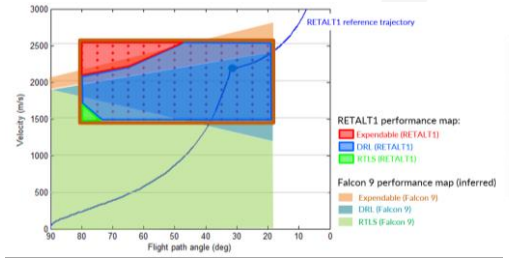
- CFD for aerodynamic loads
- Control surface efficiency
- Extrapolation to flight
- AEDB, ATDB
- Dissemination

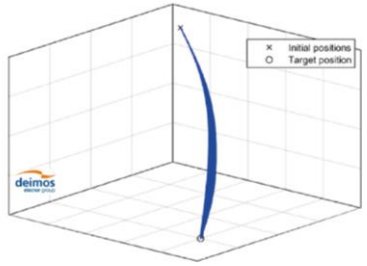


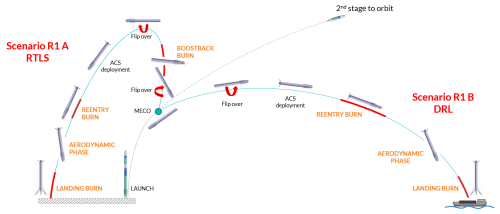


deimos

- Mission analysis
- Flying Qualities Analyses
- GNC Concept and Control laws
- Definition of landing loads







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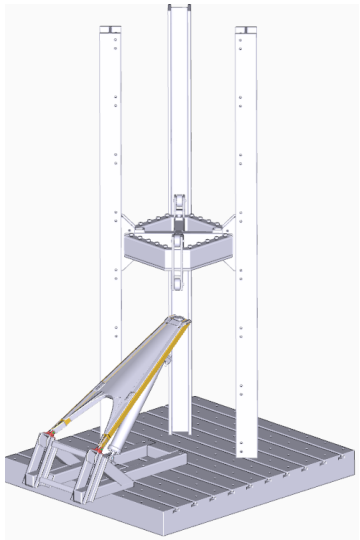
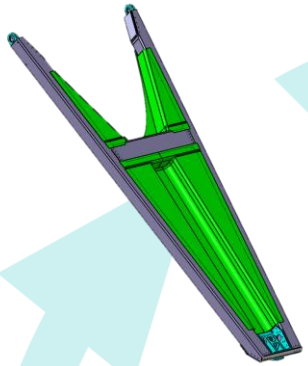
Partners

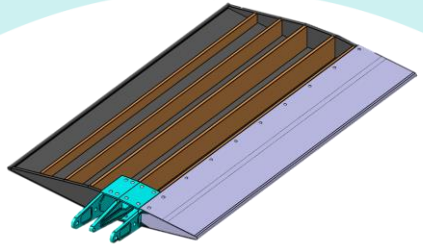
DLR

MT AEROSPACE
An OHB Company

- Structural concept and design
- Design and Manufacturing of landing leg and control surface demonstrators
- Hardware for aerothermodynamic wind tunnel tests

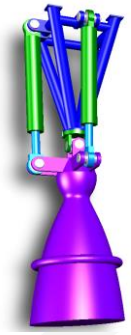


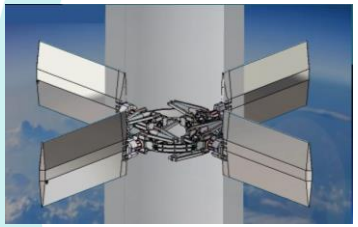


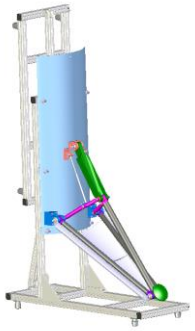


almatech

- Thrust Vector Control (TVC)
- Mechanisms:
  - Landing legs
  - Aerodynamic control surfaces







AMORIM CORK COMPOSITES

- Thermal Protection System:
  - Cork based thermal protection of critical structural components
  - Development of trowelable technique

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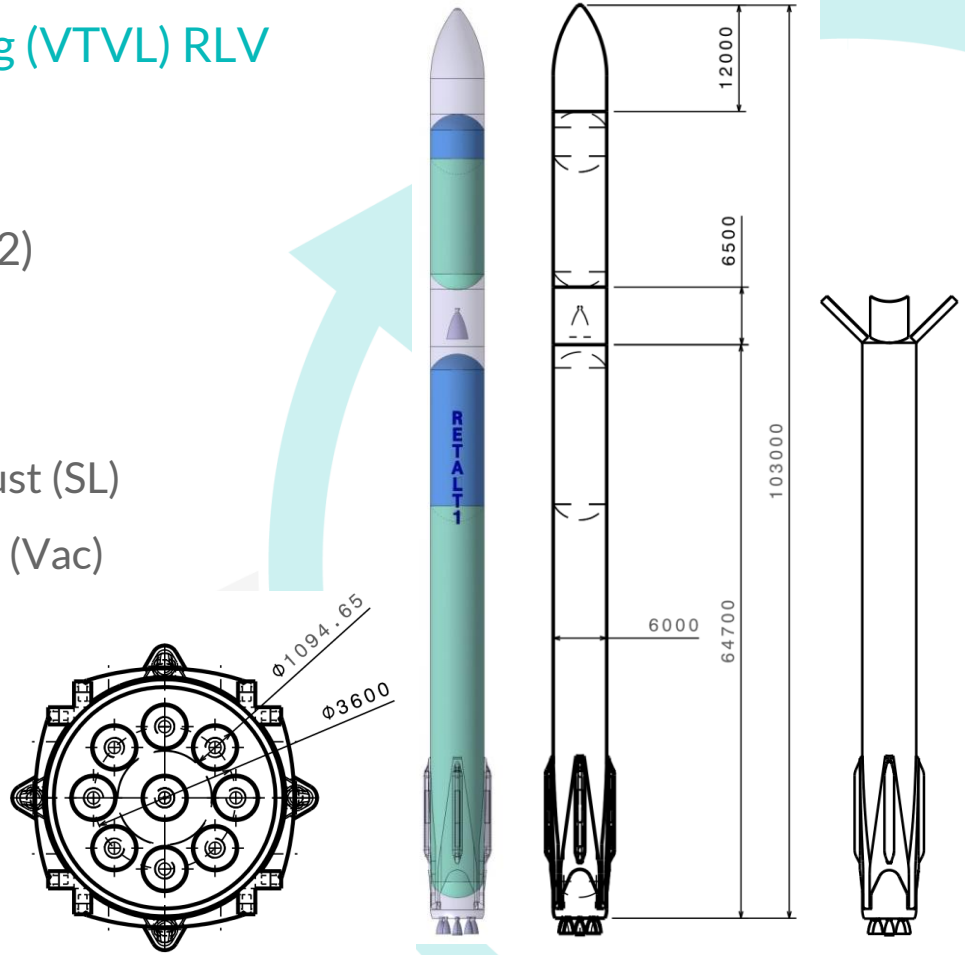
RETALT

RETALT1

- Two Stage To Orbit (TSTO) Vertical Take-off Vertical Landing (VTVL) RLV
- Payload capacity: 14t to Geostationary Transfer Orbit (GTO)

  - LOX/LH2 Gas Generator (GG) engines (similar to the Vulcain 2)
  - Stage 1: 9 engines
  - Stage 2: 1 engine (similar to first stage engine)
  - Stage 1 engines adapted to sea level conditions - 1179 kN Thrust (SL)
  - Stage 2 engine adapted to vacuum conditions - 1364 kN thrust (Vac)
  - Height: 103 m
  - Diameter: 6 m
  - Take-off Mass: 899 t
  - Retro propulsion and the novel aerodynamic control surfaces (interstage segment)



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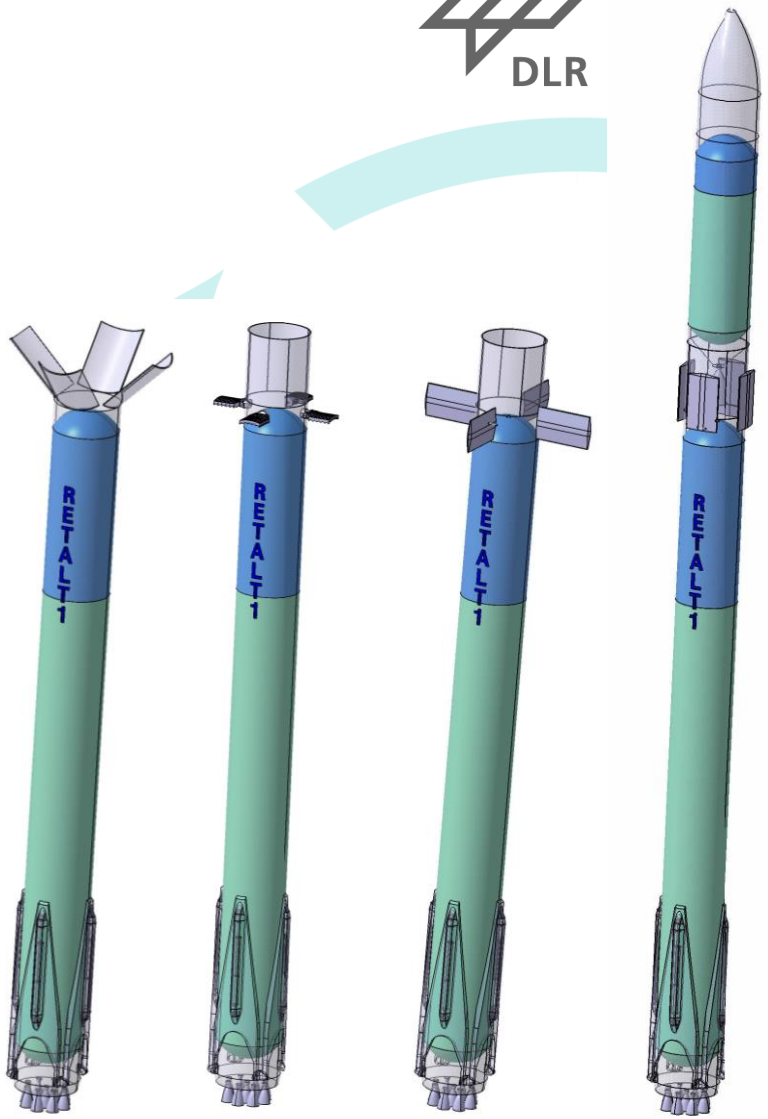
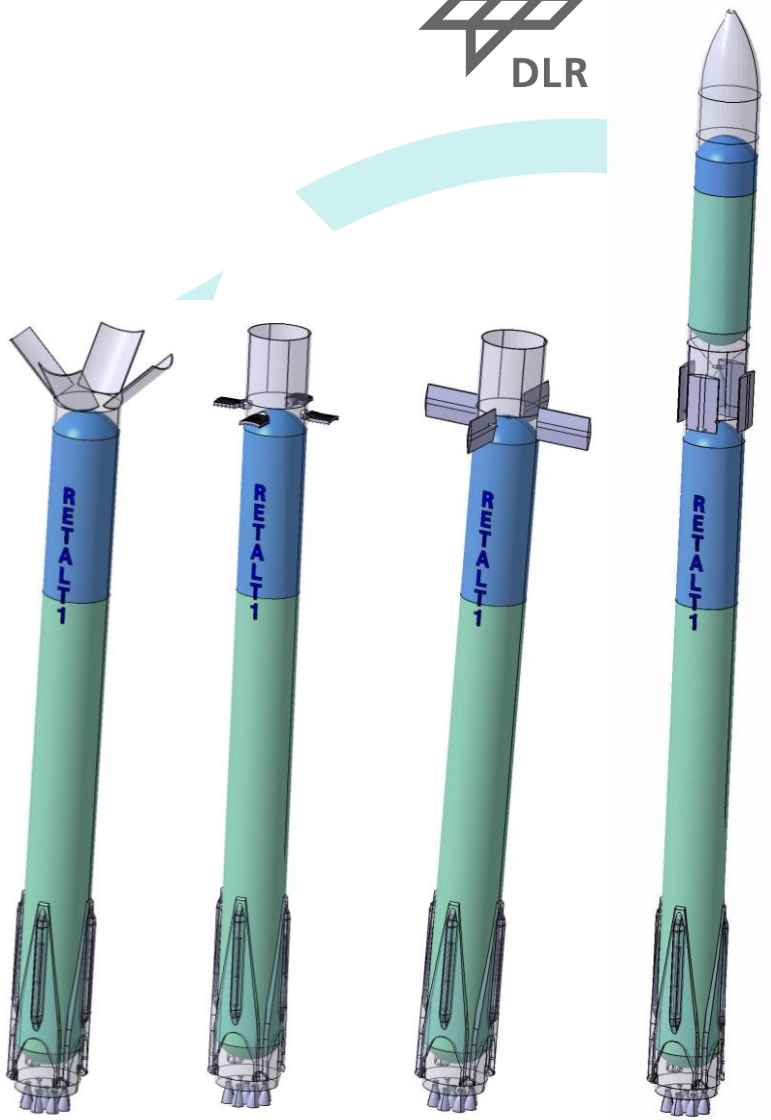


RETALT1

Stage Characteristics	1st Stage	2nd Stage	Fairing	Total
Number of Engines	9	1.0	-	10.0
Reusability	+	+/-	-	+/-
Height [m]	71.2	19.8	12.0	103.0
Diameter [m]	6.00	6.00		6.00
Mass full (GLOW) [t] (incl. Payload)	680.8	204.2	2.5	899.0
Stage Rate	75.7%	24.3%		
Structure Coefficient	8.7%	8.3%		
Mass structure [t]	59.3	16.7		75.9
Propellant mass (incl. descent porpellant) [t]	621.5	187.5		809.0
Descent propellant [t]	50.0	0		50.0
Propellant reserve and residuals mass [t]	7.500	2.500		10.0
Engines	RETALT1-LHLOX-E15-FS	RETALT1-LHLOX-E70-FS		
Engine Cycle	Gasgenerator	Gasgenerator		
Oxidator/Propellant	LOX/LH2	LOX/LH2		
Expansion Ratio	15	70		
Specific Impuls SL [s]	372.2	294.4		
Specific Impuls Vac [s]	401.6	431.9		
Thrust SL [kN]	9x1179 = 10614	1x930 = 930		
Thrust Vac [kN]	9x1273 = 11453	1x1364 = 1364		



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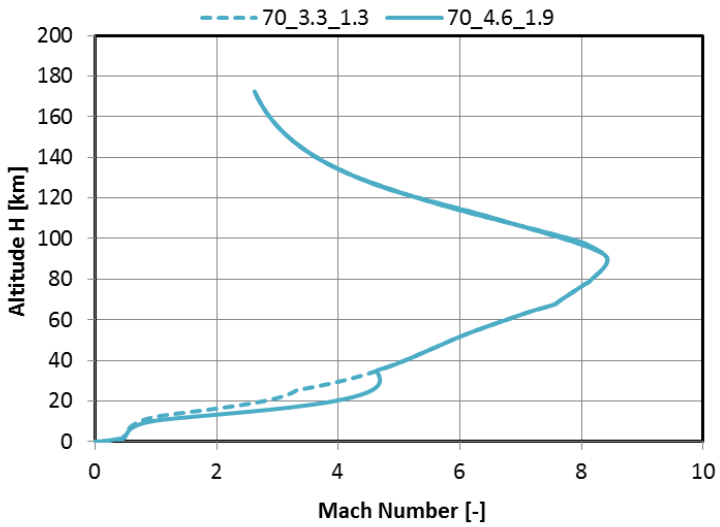
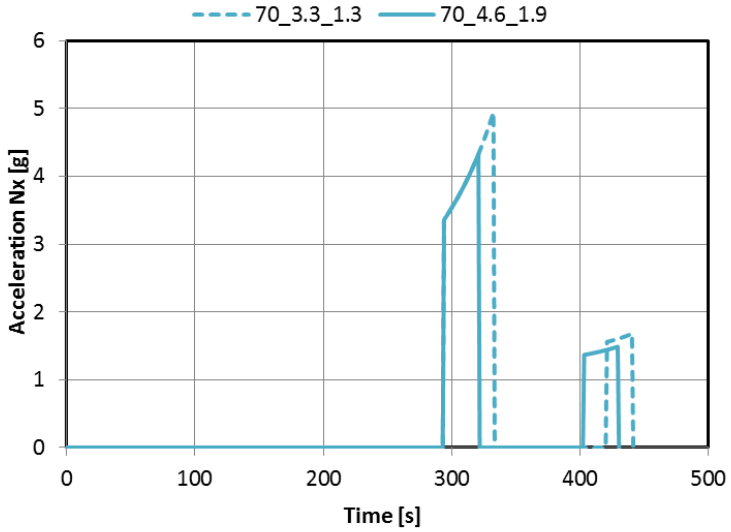
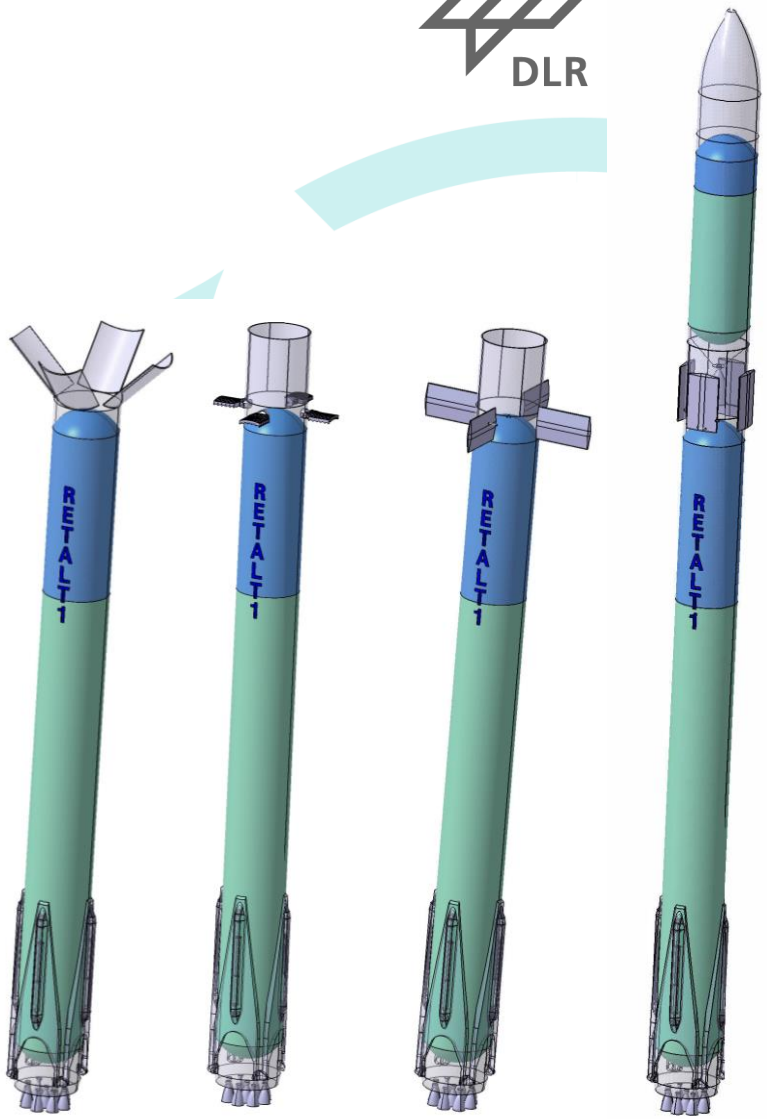




	Start of first breaking maneuver Altitude [km]	End of first breaking maneuver Mach [-]	propellant consumed [t]
Trajectory 70_4.6_1.9	70	4.6	~35.7
Trajectory 70_3.3_1.3	70	3.3	~44.8

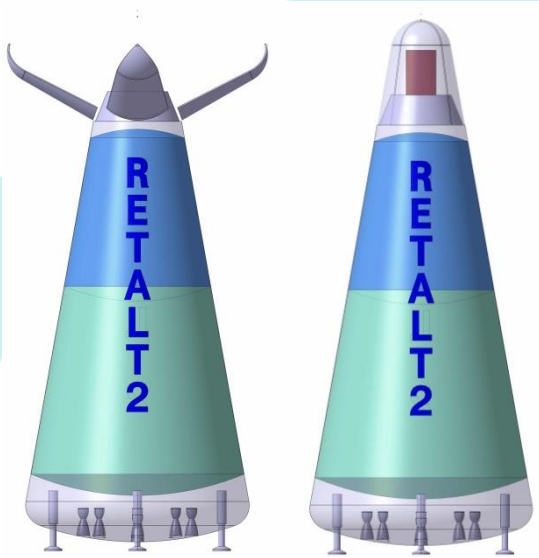


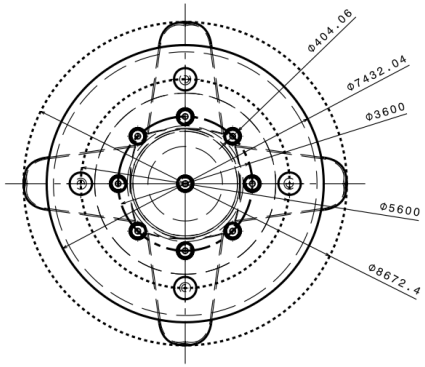
Marwege, A.; Gülhan, A.; Klevanski, J.; Riehmer, J.; Kirchheck, D.; Karl, S.; Bonetti, D.; Vos, J.; Jevons, M.; Krammer, A.; Carvalho, J.: „**Retro Propulsion Assisted Landing Technologies (RETALT): Current Status and Outlook of the EU Funded Project on Reusable Launch Vehicles**“, 70th International Astronautical Congress (**IAC**), Washington D.C., United States, 21-25 October **2019**.

RETALT2

- Single Stage to Orbit (SSTO) Vertical Take-off Vertical Landing (VTVL) RLV
- Payload capacity: 0.5t to Low Earth Orbit (LEO)

  - LOX/LH2 engine (similar to Vinci) adapted to sea level conditions
  - 9 identical engines - 370 kN thrust (Vac)
  - More academically: „technology test bed“
  - Retro propulsion + novel aerodynamic control surfaces (fairing section)
  - Aerodynamic braking: capsule-like shape + fairing segments
  - Nozzle exits flush with base plane of the vehicle
  - Heigth: 17.6 m
  - Diameter: 7.4 m
  - Take-off Mass: 79.4 t





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Comparison of RETALT1 and RETALT2

RETALT2

500 kg to LEO

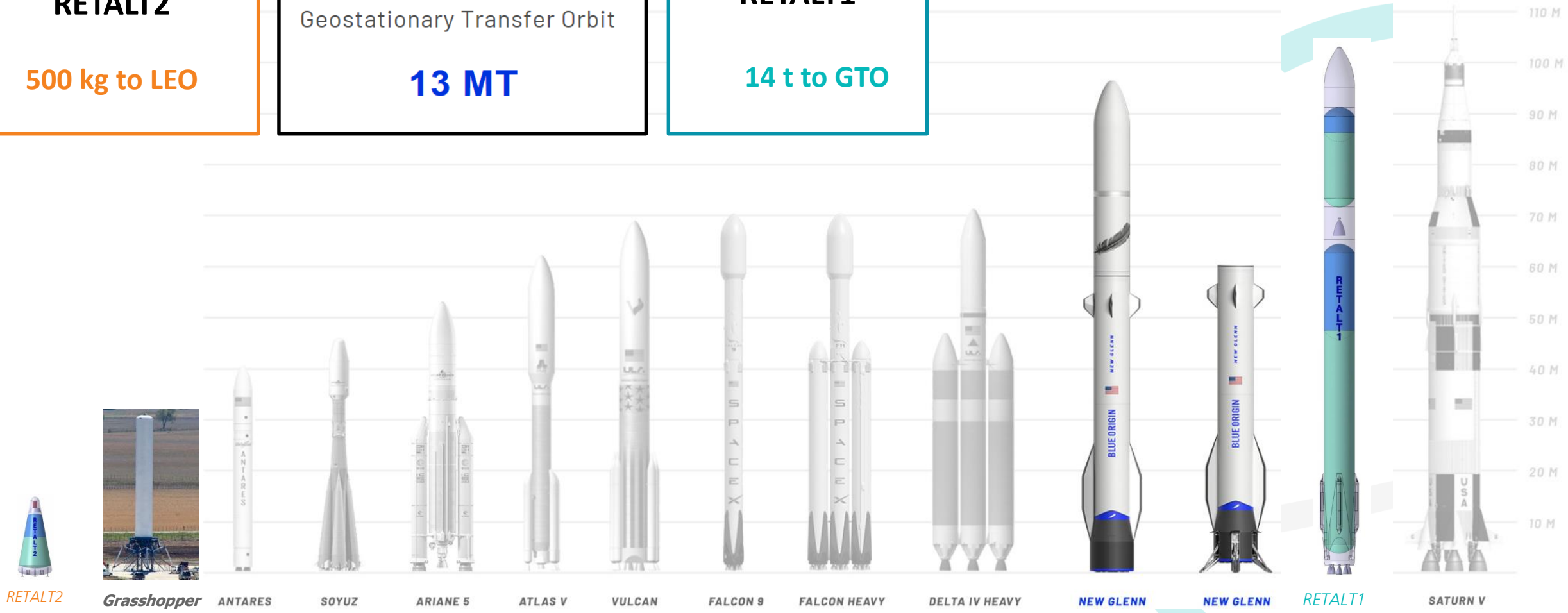
Blue Origin New Glenn:

Geostationary Transfer Orbit

13 MT

RETALT1

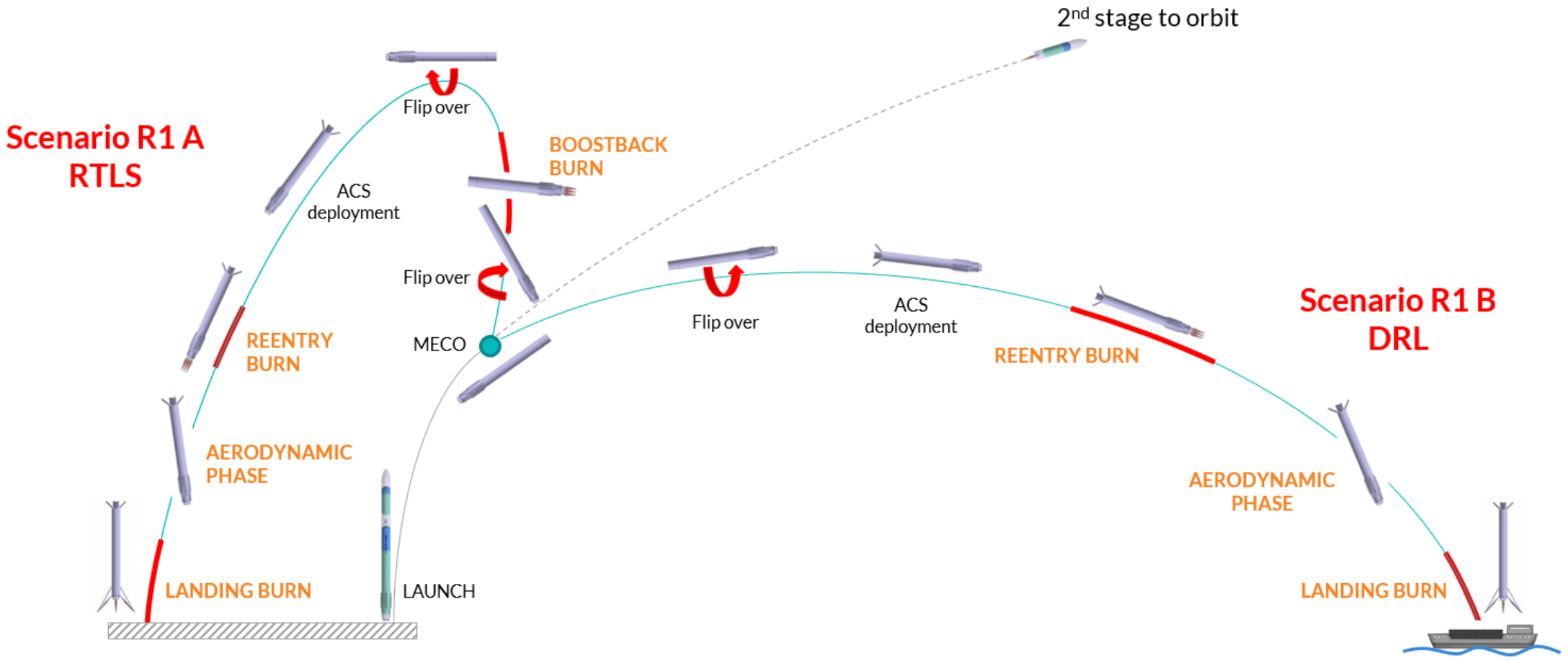
14 t to GTO



**Grasshopper from: Flickr of Steve Jurvetson, acessed 16.05.2022
https://www.flickr.com/photos/jurvetson/7971310054/

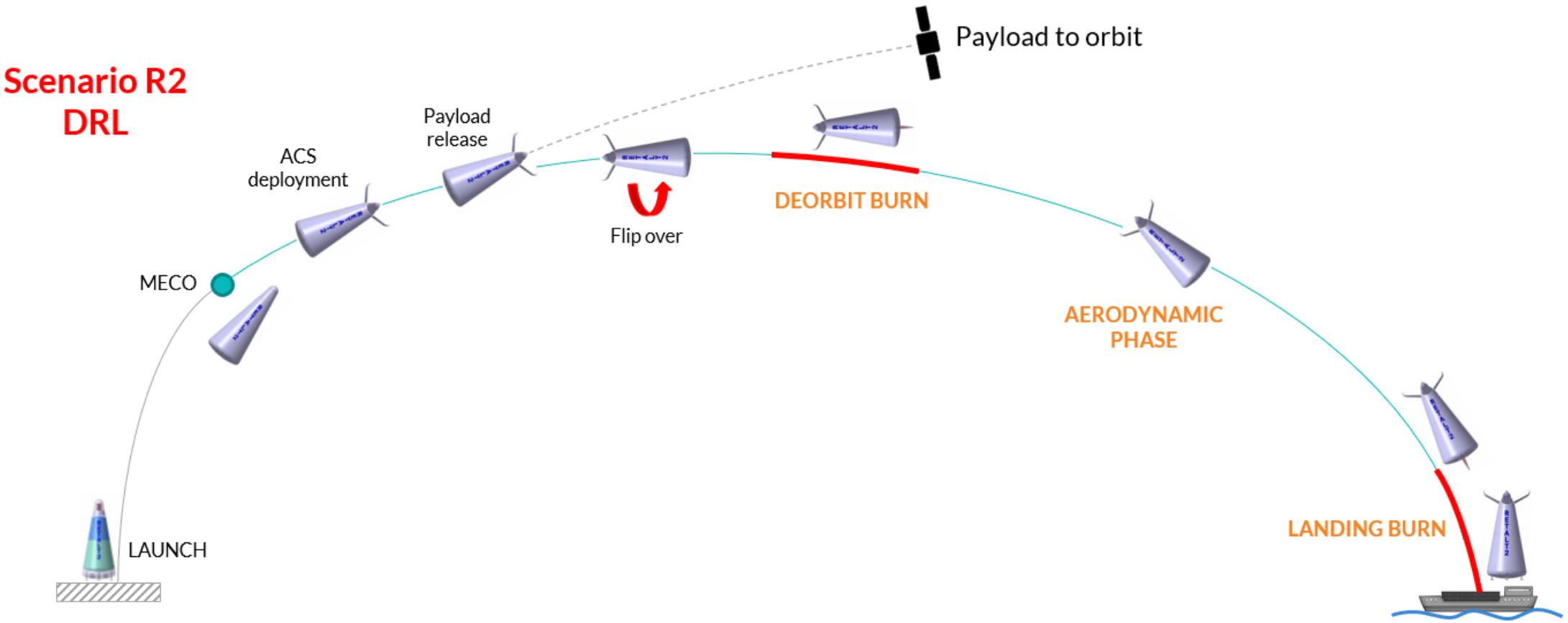
*Comparison taken from Blue Origin

RETALT1 return mission concept



* Graphic by DEIMOS

RETALT2 return mission concept



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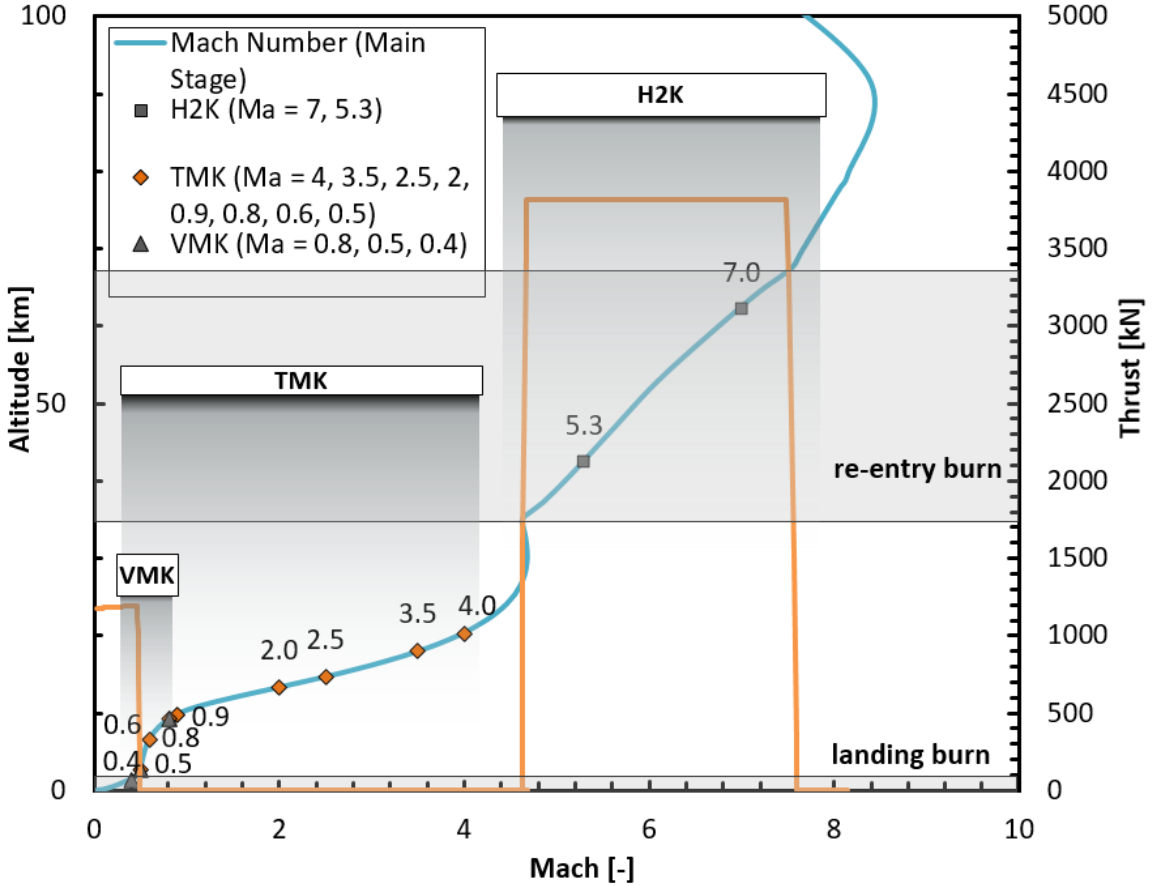
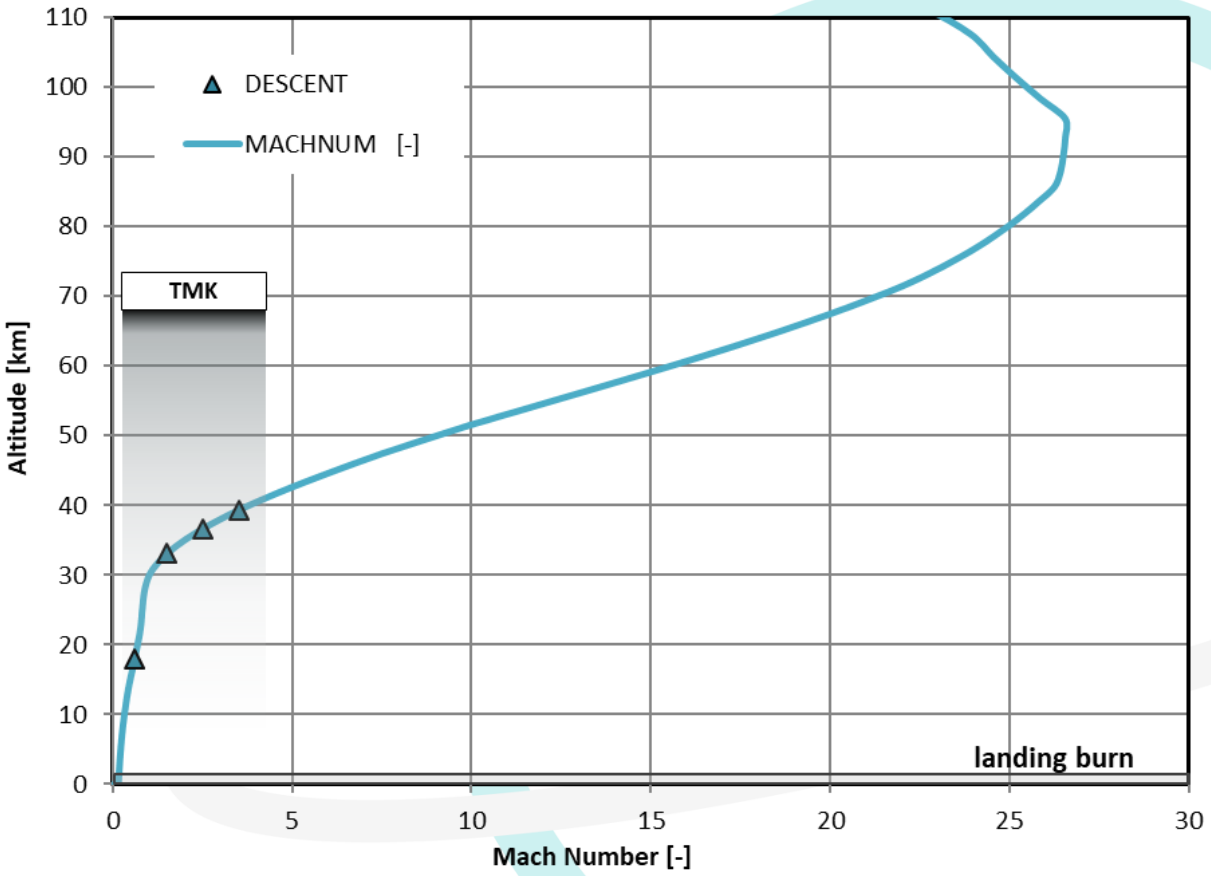
Trajectories

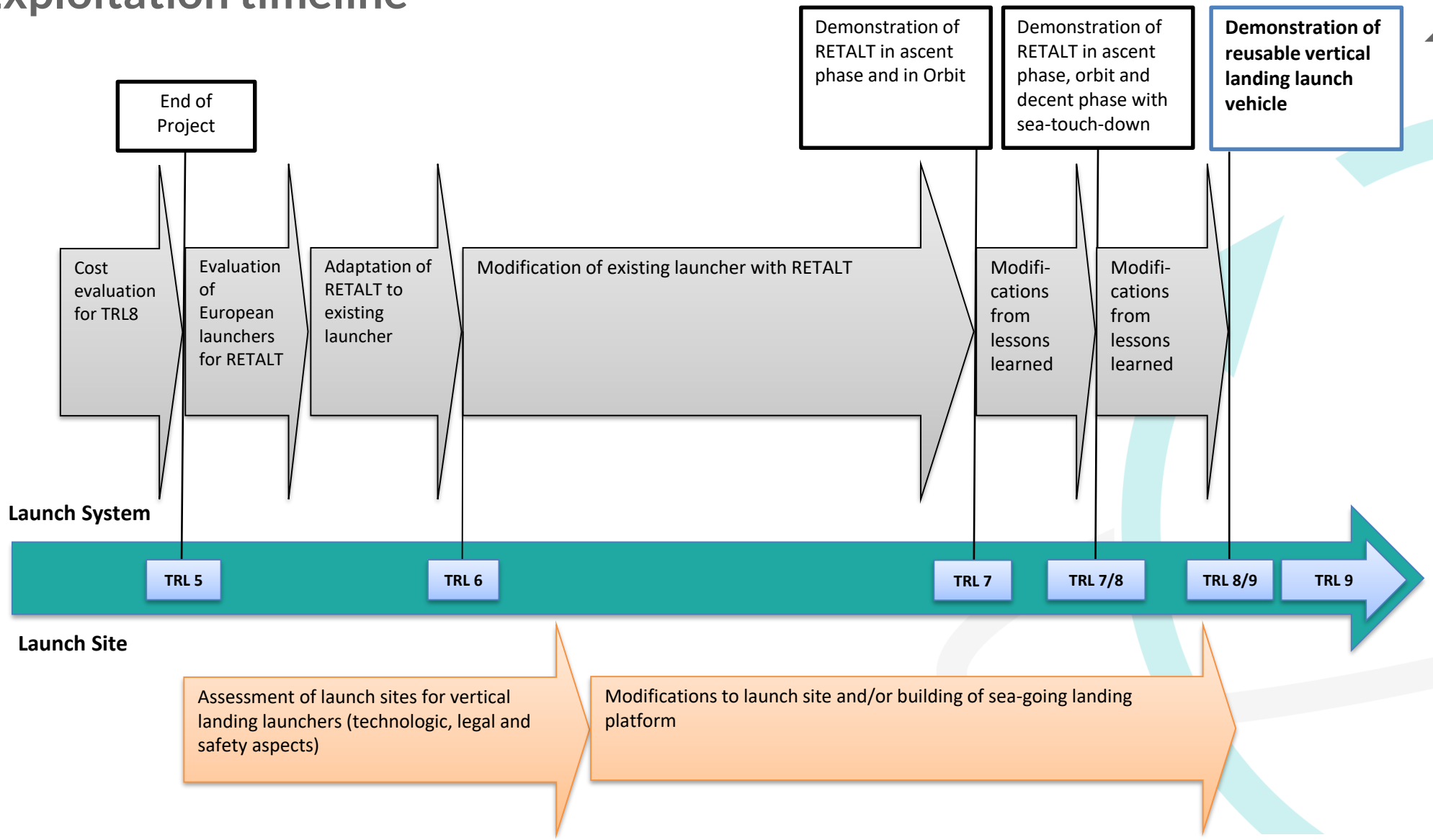


RETALT1



RETALT2

Exploitation timeline



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Conclusion

- Strong multidisciplinary European project team
- Investigation in key technologies for vertical landing with retro propulsion
  - aerodynamics · aerothermodynamics · flight dynamics and GNC · structures · mechanisms · TVC · TPS
- Successful load tests of a landing leg demonstrator
  - Demonstrator exhibited at booth
- Wind Tunnel tests for the complete flight envelope (subsonic, transonic, hypersonic)
  - Models exhibited at booth
- Extensive CFD studies and rebuilding of Wind Tunnel tests and extrapolation to flight
- Studies of several aerodynamic control surfaces and demonstrator built
  - Demonstrator exhibited at booth
- Mission analysis and GNC concept in several loops
- Development of new cork based trowelable TPS material and performance validated in tests in arc-heated facility
  - Samples exhibited at booth
- Dissemination at FAR and in CEAS Journal
- Large potential for exploitation of results and rapid implementation of technologies

Deutsches Zentrum für Luft- und Raumfahrt

almatech

AMORIM
CORK COMPOSITES

CFS Engineering
Computational Fluids & Structures Engineering

deimos
elecnor group

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HORIZON 2020
European Union funding for Research & Innovation

RETALT
RETro propulsion Assisted Landing Technologies

THANK YOU!

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