Primo:
An Ultra-light Launch Vehicle For Nano & Microsatellites

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LEAF SPACE
Simplifying access to space

The microsatellite problem

Requirements	
PL mass	50 kg
Nominal orbit	700 km polar
Launch rate	20 lc/year
Stage number	2
Propulsion tech.	Hybrid

Flight constraints	
Max longitudinal acceleration	65 m/s^2
Max dynamic pressure	35 kPa
Take Off T/W	1.4

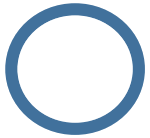
- Low development, production, operations and disposal costs
- Low production, operations and disposal environmental impact

Requirements

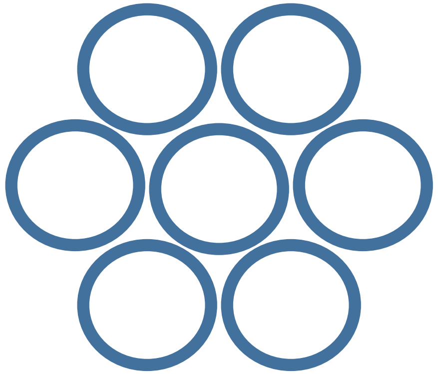
ΔV contributions	Value [km/s]
Orbital Velocity (200 km)	7.79
Hohm. Trans. 200-700 km	0.28
Gravity loss	1.3
Drag loss	0.2
Steering losses	0.05
Performance margin (1%)	0.1
Total	9.72

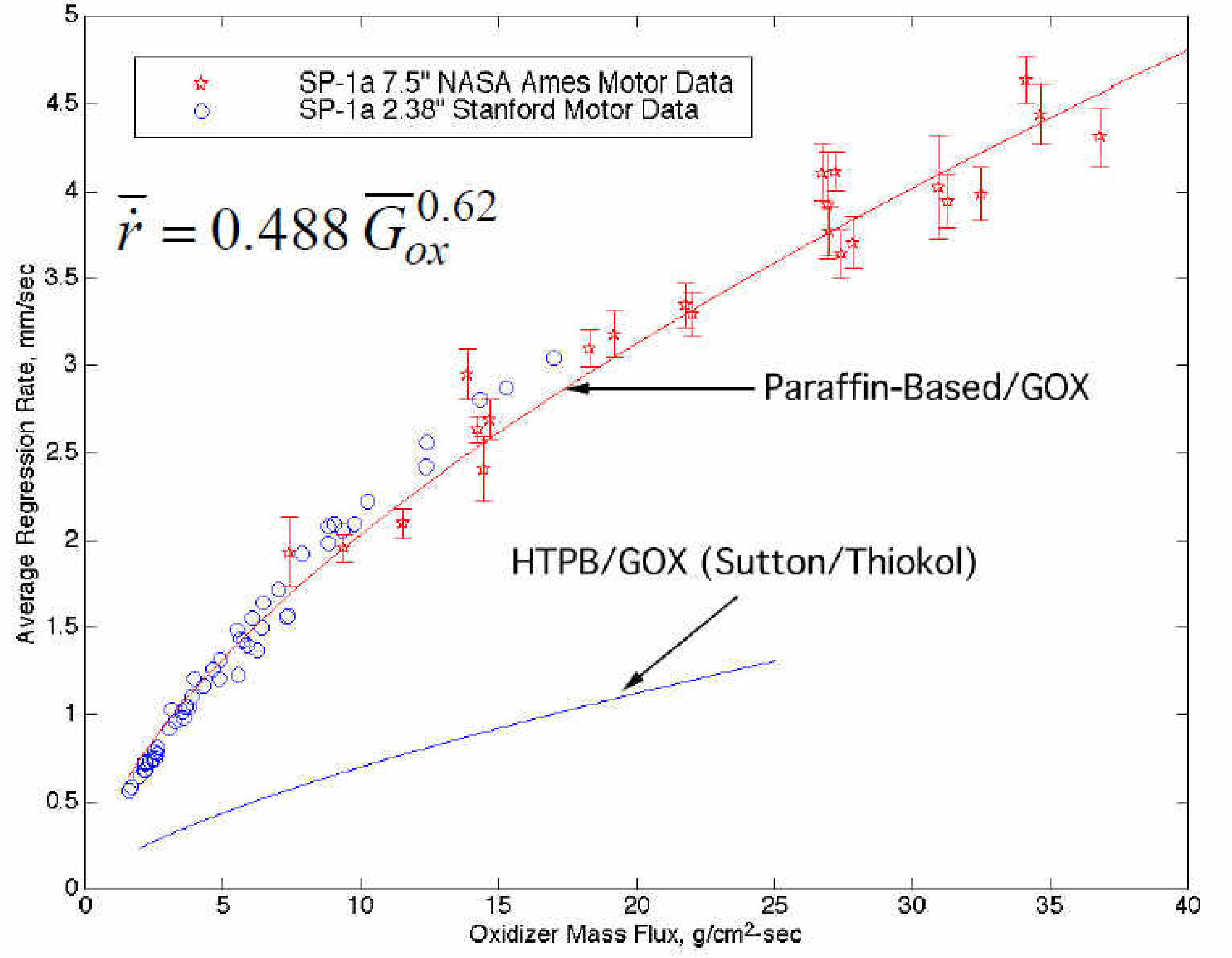
ΔV-Budget

Second Stage: Single



First Stage: EptaWeb





Engines configuration

Feature	ρ	T_b	€/kg	Ox power	Self-p	Storable	Ignition	Isp	Cat	TNT	Avail.
LOX	1141	90.19	< 0.2	1	No	No	Yes	370	No	0	High
N_2O	744	P dep.	< 5	0.36	Yes part.	Yes	Yes	320	Yes	Nd	Medium
H_2O_2	1440	423	< 1.7	0.94	No	Yes	No	320	Yes	1	Low

1st stage Isp	270 s
2nd stage Isp	310 s

Liquid oxidizers

1st stage structural mass fraction	0.1
2nd stage structural mass fraction	0.1

1st stage ΔV	4.025 km/s
2nd stage ΔV	5.695 km/s

Mass & ΔV fraction

GLOW	6360 kg
1st stage initial mass (w/o PL)	5530 kg
1st stage propellant mass	4975 kg
1st stage structural mass	555 kg
2nd stage initial mass (w/o PL)	790 kg
2nd stage propellant mass	710 kg
2nd stage structural mass	80 kg
OF ratio	2.7

Mass budget

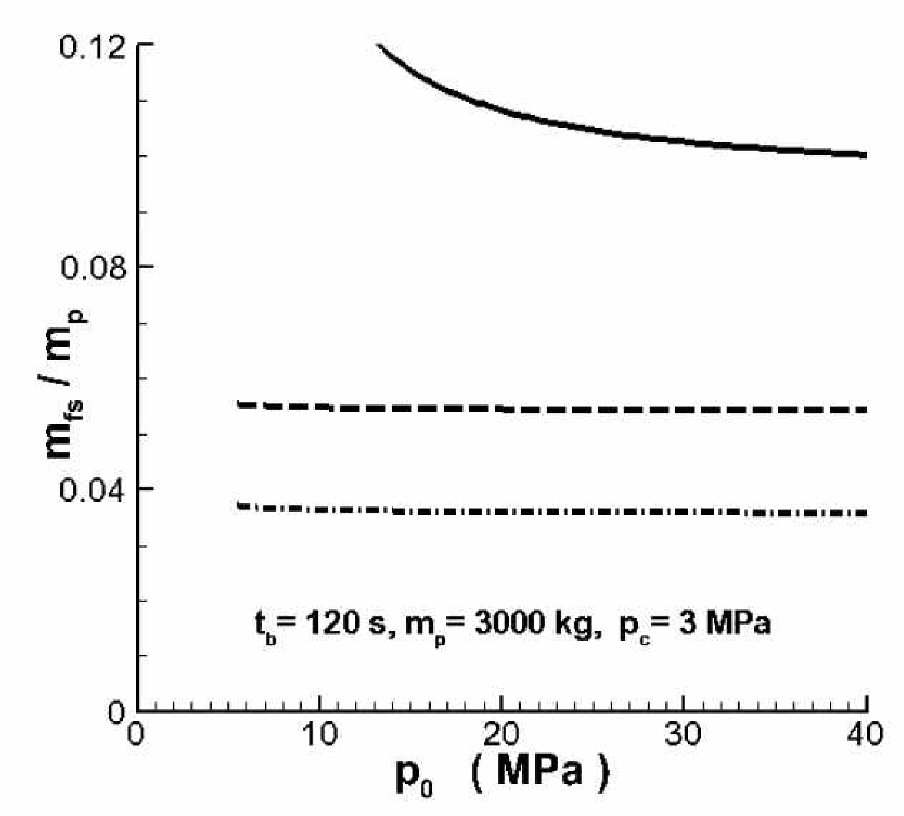
1st stage total initial thrust	87.5 kN
1st stage total initial thrust	12.5 kN
2nd stage initial thrust	12.5 kN
1st stage total final thrust	87.5 kN
2nd stage final thrust	8.35 kN
Motor throttability	40%

Thrust

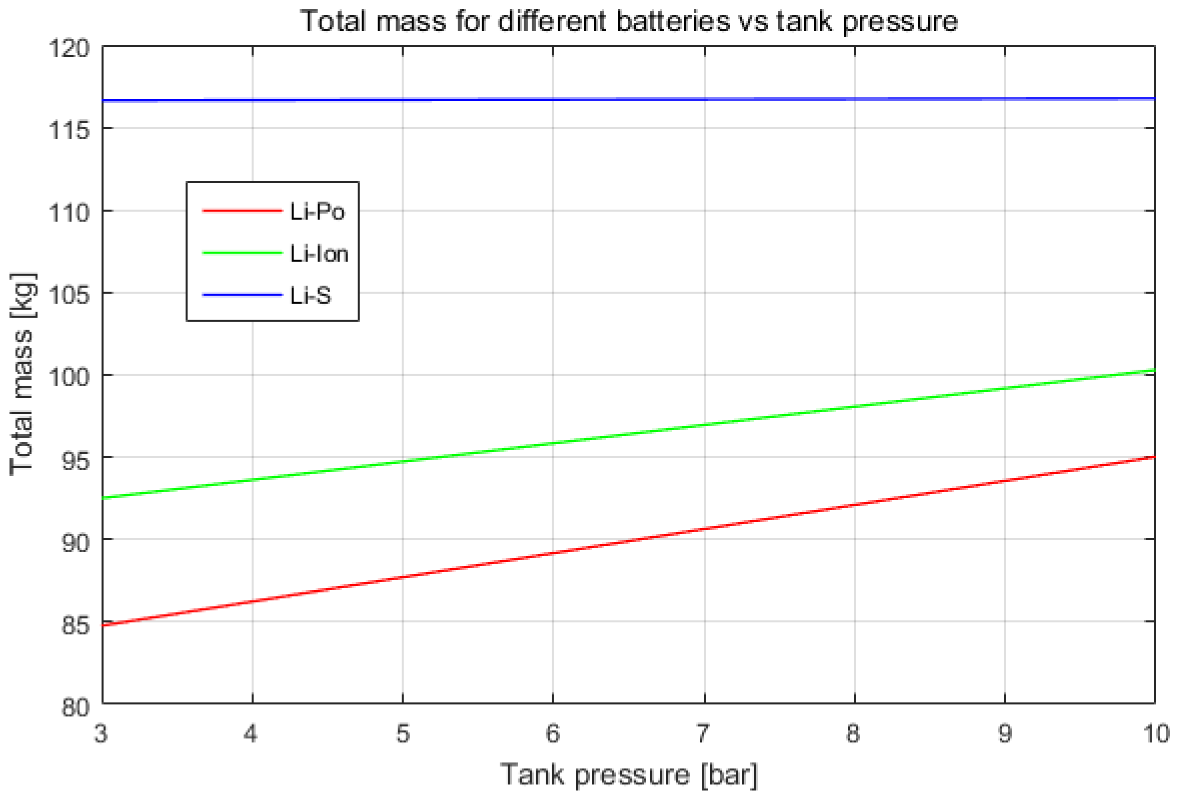
Fuel grain mass	190 kg
1st stage burning time	184 s
2nd stage burning time	211 s
Oxidizer mass flow rate	2.9 kg/s
Combustion chamber length	1.6 m
Combustion chamber diameter	0.4 m

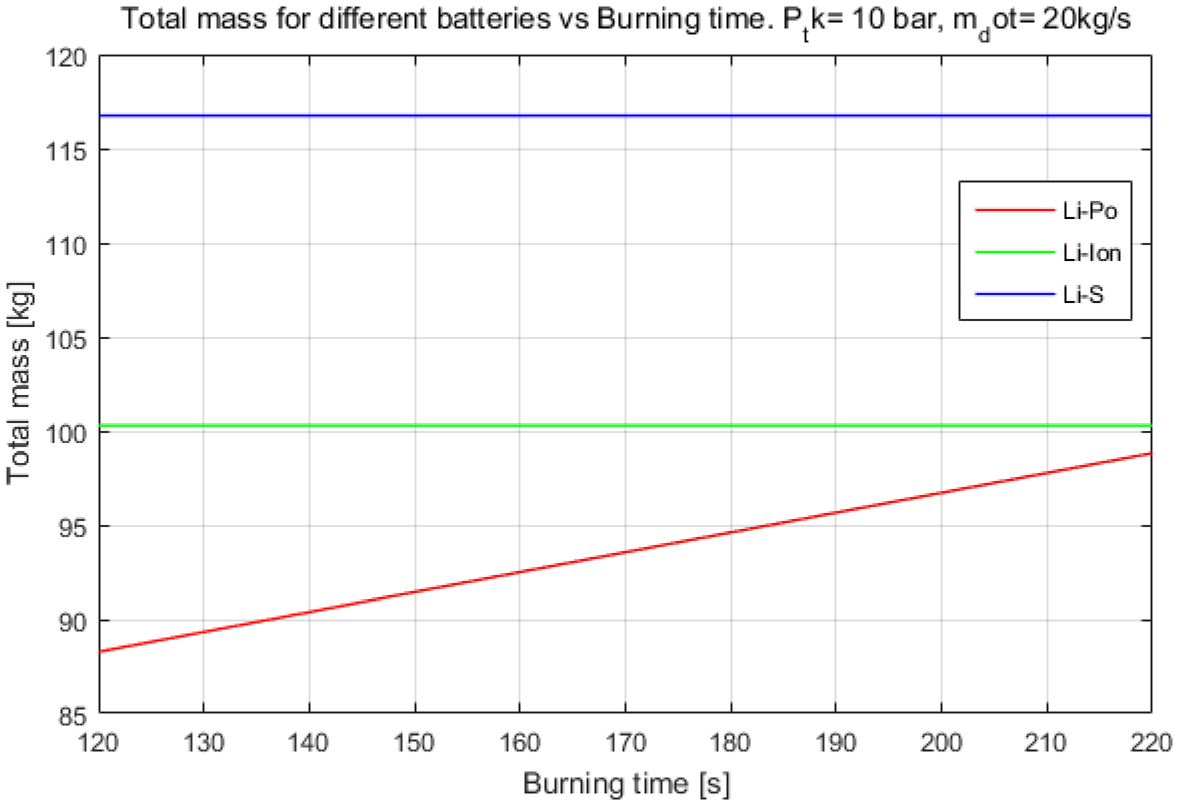
Harlock motor

Pressure-feed	• Higher tank mass • Pressurant needed (tanks, pipeline…) • Low control capability
Turbo-pump	• Liquid fuel needed (tanks, pipeline…) • Higher oxidizer mass • Low control capability • High development time and cost
Electric-pump	• Lower tank mass • High control capability • Low development time and cost

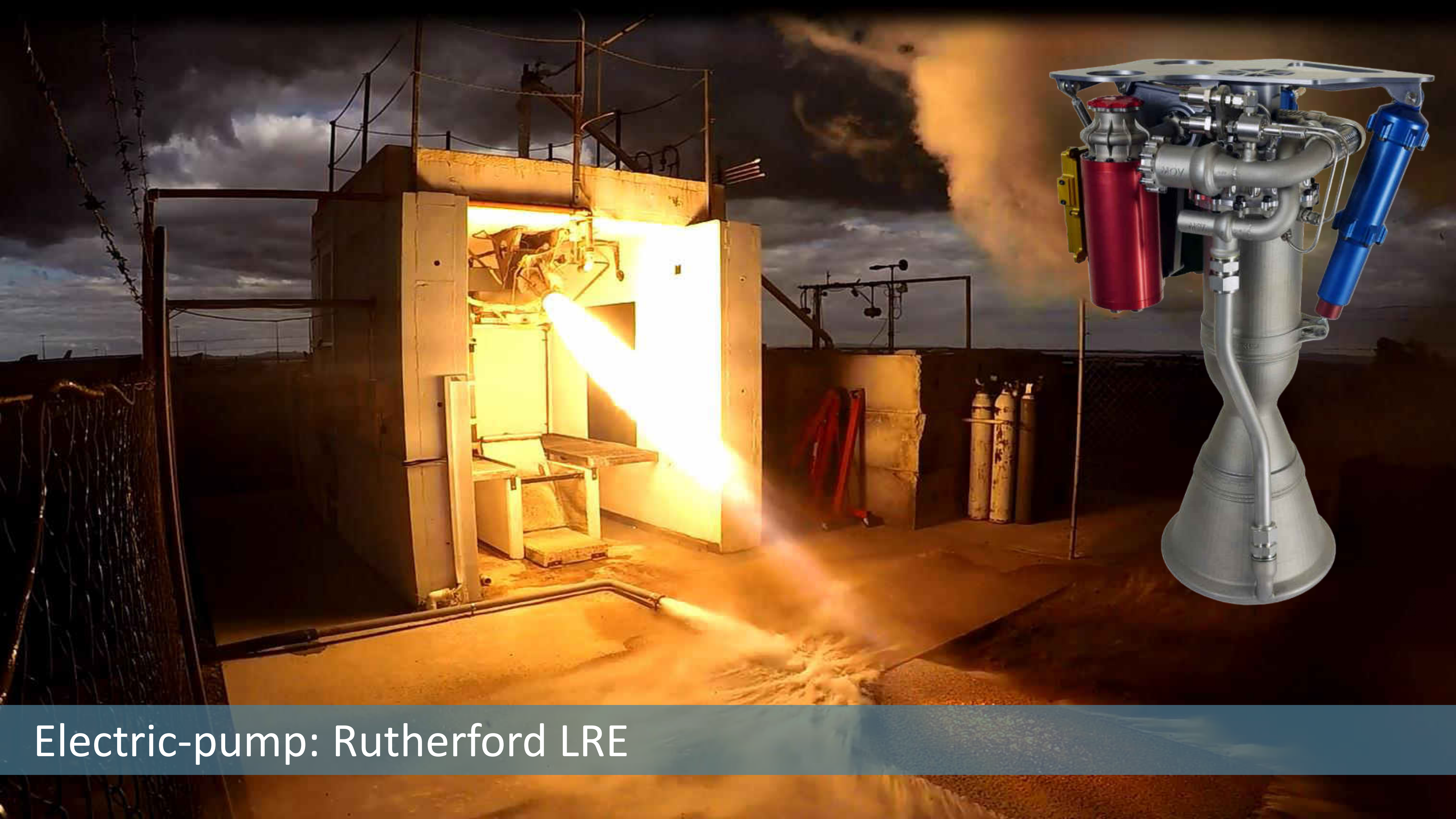


Feed system





Electric-pump



Electric-pump: Rutherford LRE

Cryo-composite tanks

Fairing	10 kg
PL adapter	2 – 10 kg
Avionics & cabling	10 kg
PW system	2 kg
Pressurization system	2 kg
Tank	20 kg

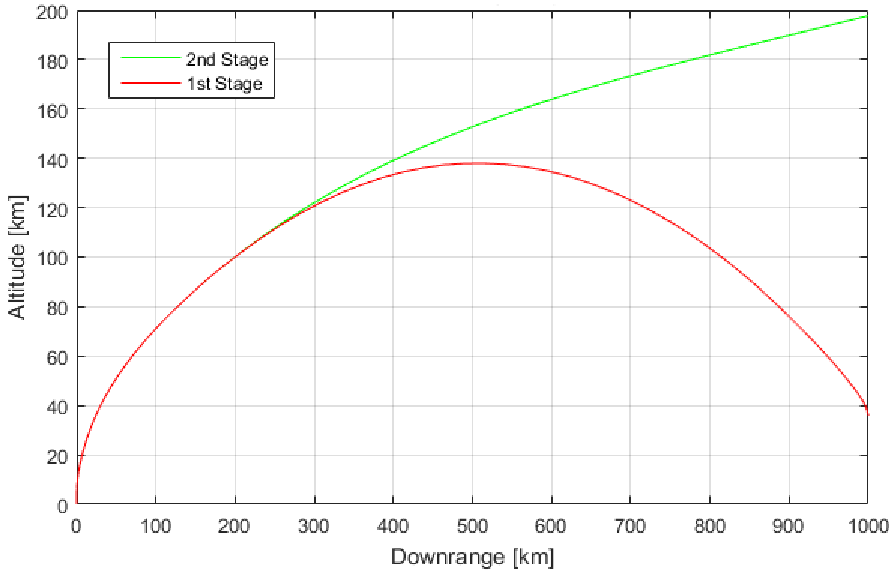
Electric-pump	6 kg
Feed-line	5 kg
Motor	15 kg
TVC	2 kg
Misc.	6 kg
Total inert mass	80 kg

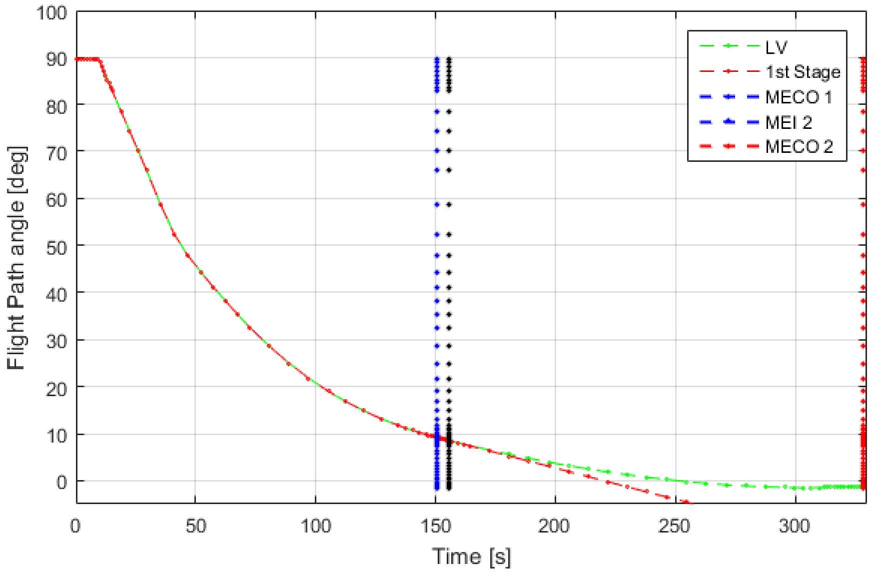
Mass breakdown: 2nd stage

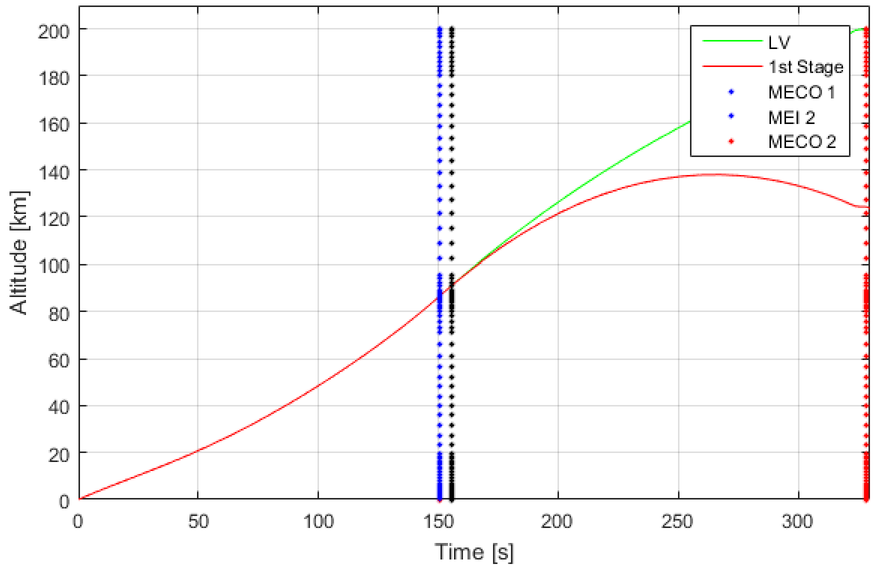
Interstage & separation sys.	30 kg
PL/stage recovery sys.	30 kg
PW system	10 kg
Avionics & cabling	20 kg
Pressurization system	10 kg
Tank	120 kg

Electric-pump	40 kg
Feed-line	40 kg
Motors	105 kg
TVC	30 kg
Misc.	135 kg
Total inert mass	555 kg

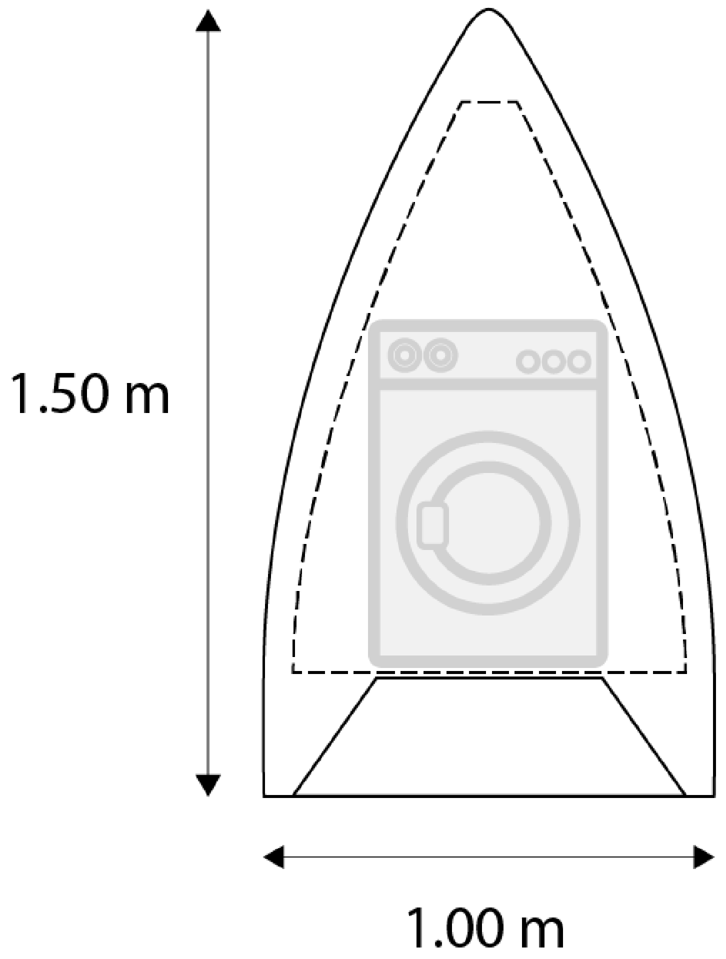
Mass breakdown: 1st stage

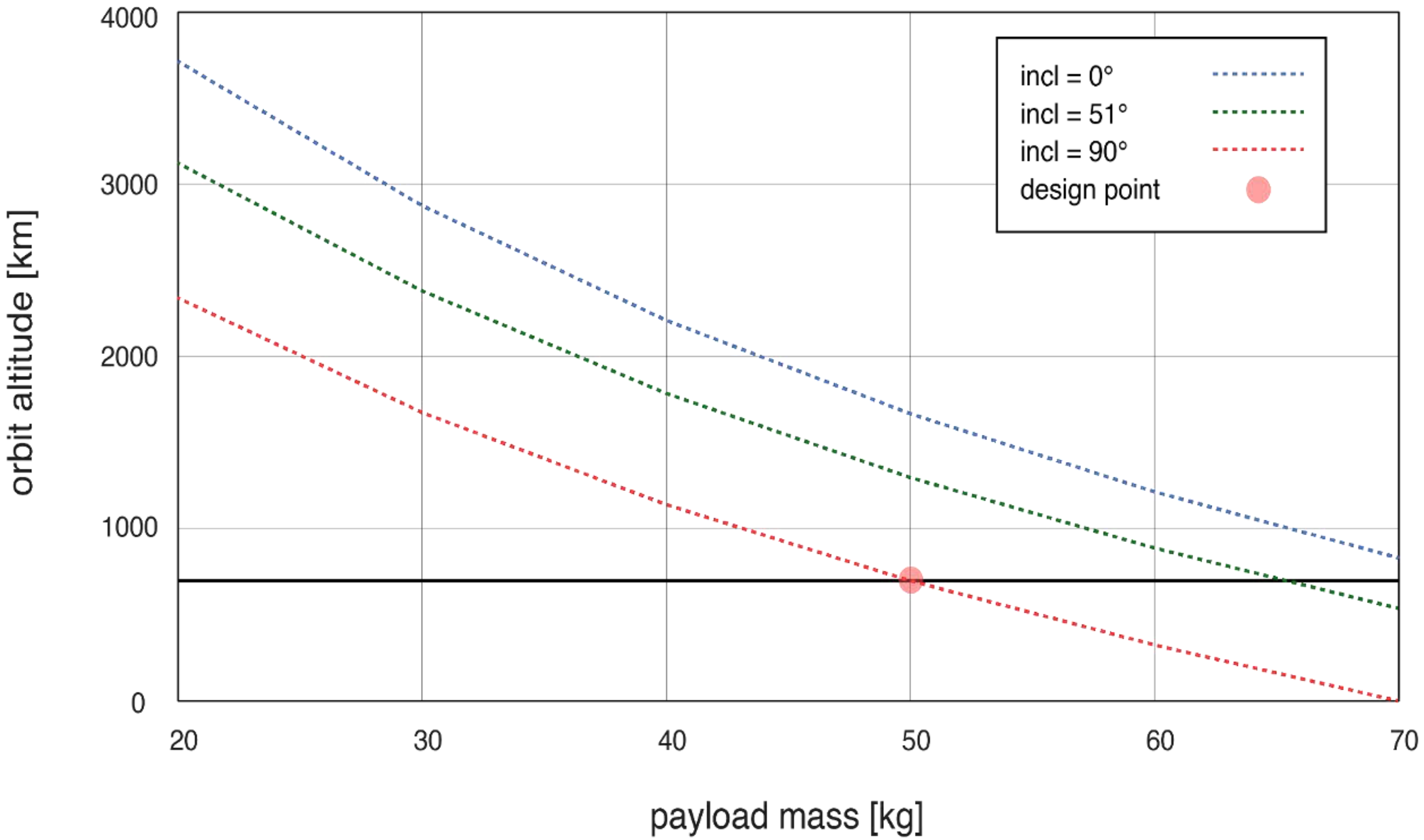




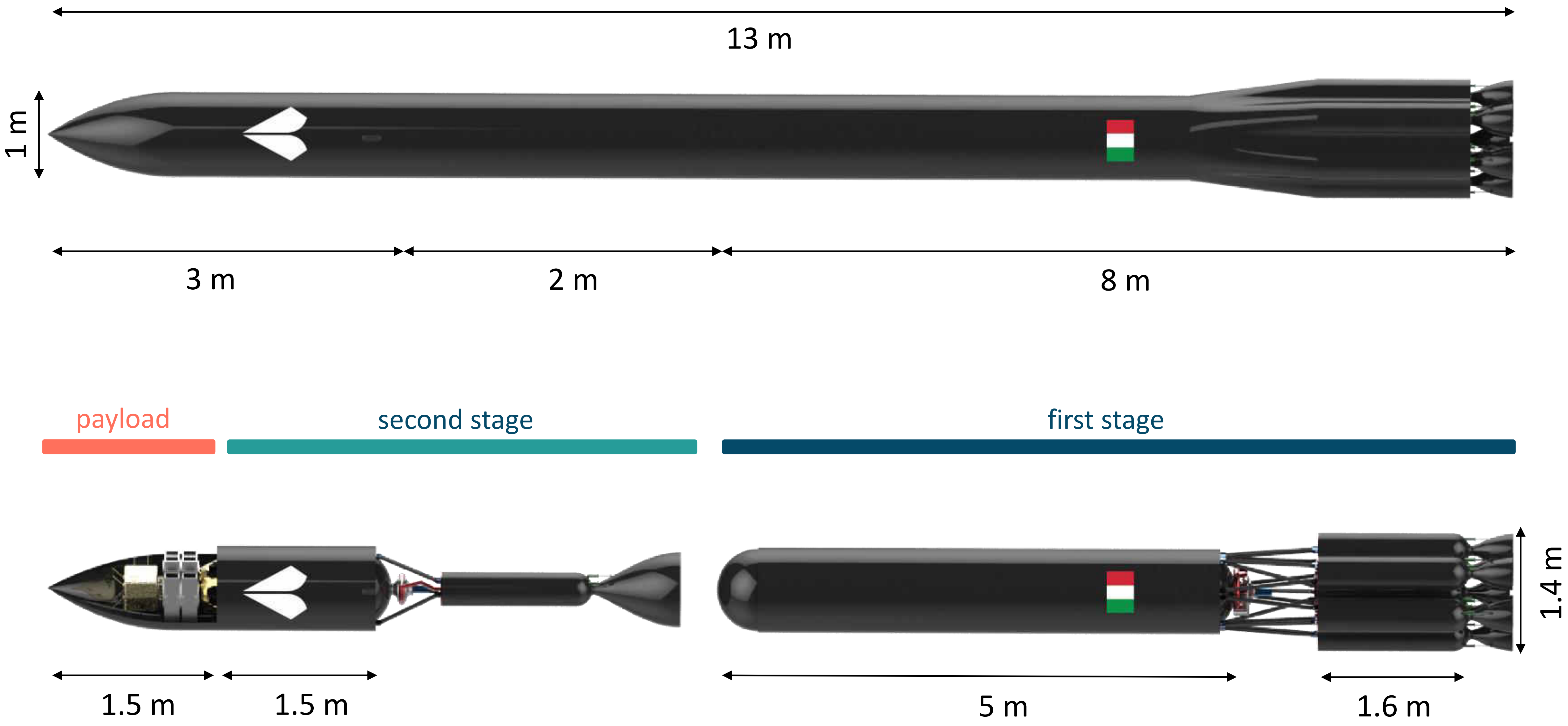


Flight simulation


1.50 m
1.00 m


orbit altitude [km]
4000
3000
2000
1000
0
20
30
40
50
60
70
payload mass [kg]
incl = 0°
incl = 51°
incl = 90°
design point

Payload



Primo configuration

1.3 m
Max diameter

13 m
Height

6.4 T
GLOW

87.5 kN
Lift-Off Thrust

20
Launches per year

2 M€
Price

Overview

- Mass & power budget iterations
- Accurate study on cryo-composite tanks
- Accurate study on ablative composites CC
- Accurate study on TVC and control systems
- 6 DOF flight simulator
- Trajectory optimizer

Future work

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THANK YOU

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