



**AO/1-7557/13/NL/SC
THE ROMANIAN INDUSTRY INCENTIVE SCHEME**

Title of the project : *Study – concept, to achieve a Small Orbital Launcher through zonal cooperation - SOL*

Acronym SOL

Partnership

Prime Contractor **National Company ROMARM SA ,**

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Subcontractor 2 **National Institute for Aerospace Research "Elie**

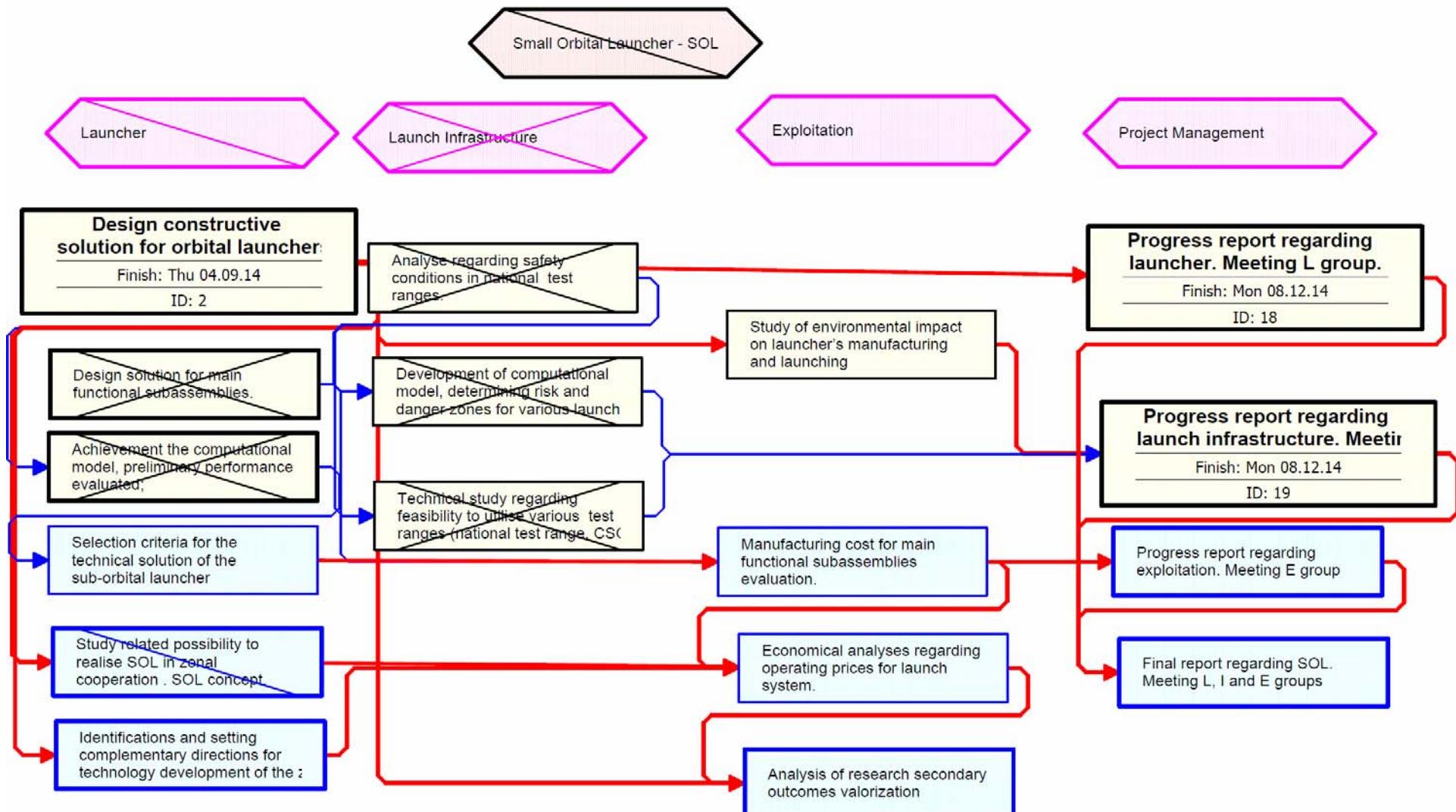
Carafoli" - INCAS-SA , responsible Popa Eduard , e-mail:eduard@incas.ro

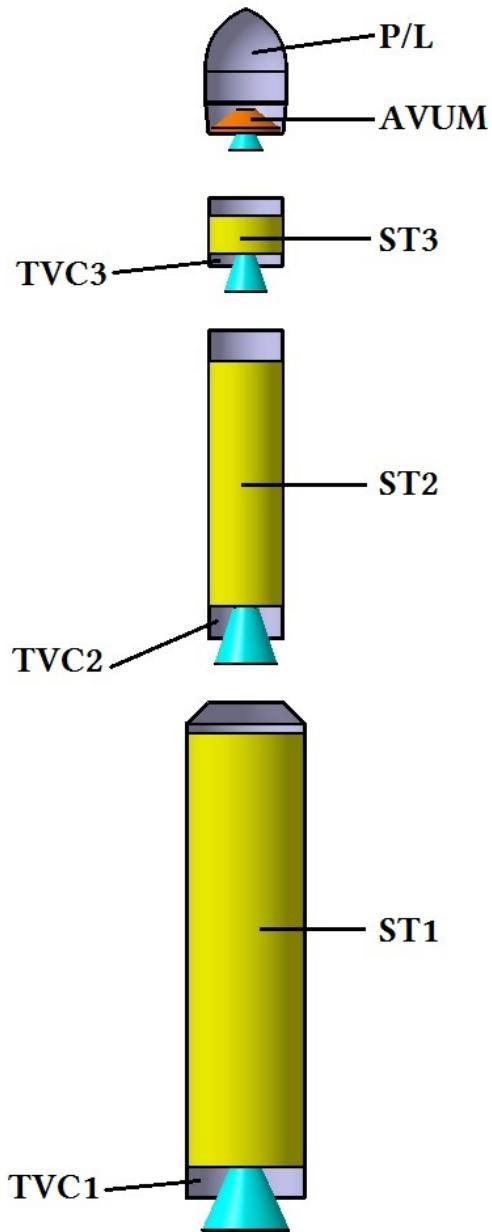
Short description of the project

SOL is an pilot-project consisting in analysis of possibility to achieve a small orbital launcher in zonal cooperation - SOL.

In order to approach SOL project, two major steps must be cover. The first step will be a technical one: to define launcher and his functional subsystems able to inject in equatorail or polar or inclined orbite, at the altitude between 200 km and 1000 km, a satellite of 100 kg mass . The second major step will be an economical one when we need to define benefits and costs of project and how can we support them. As technical approaches we focus on three objectives: launcher, infrastructure and exploitation.

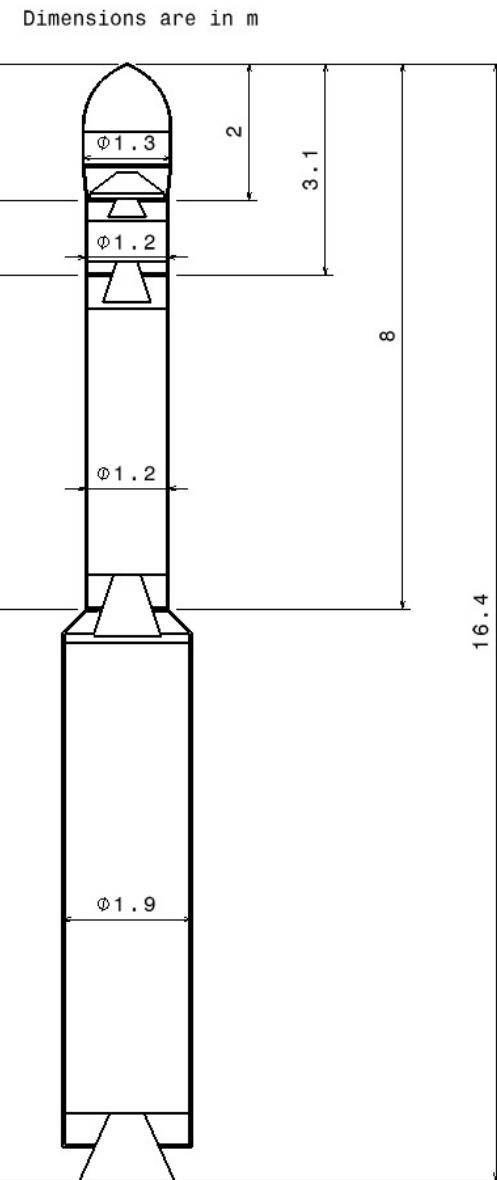
SOL – Stage of Project Activities





Launcher

1. **P/L Payload ;**
2. **AVUM -Attitude and Vernier Upper Module;**
3. **ST- Stage;**
4. **TVC - Thrust Vector Control;**



Communality

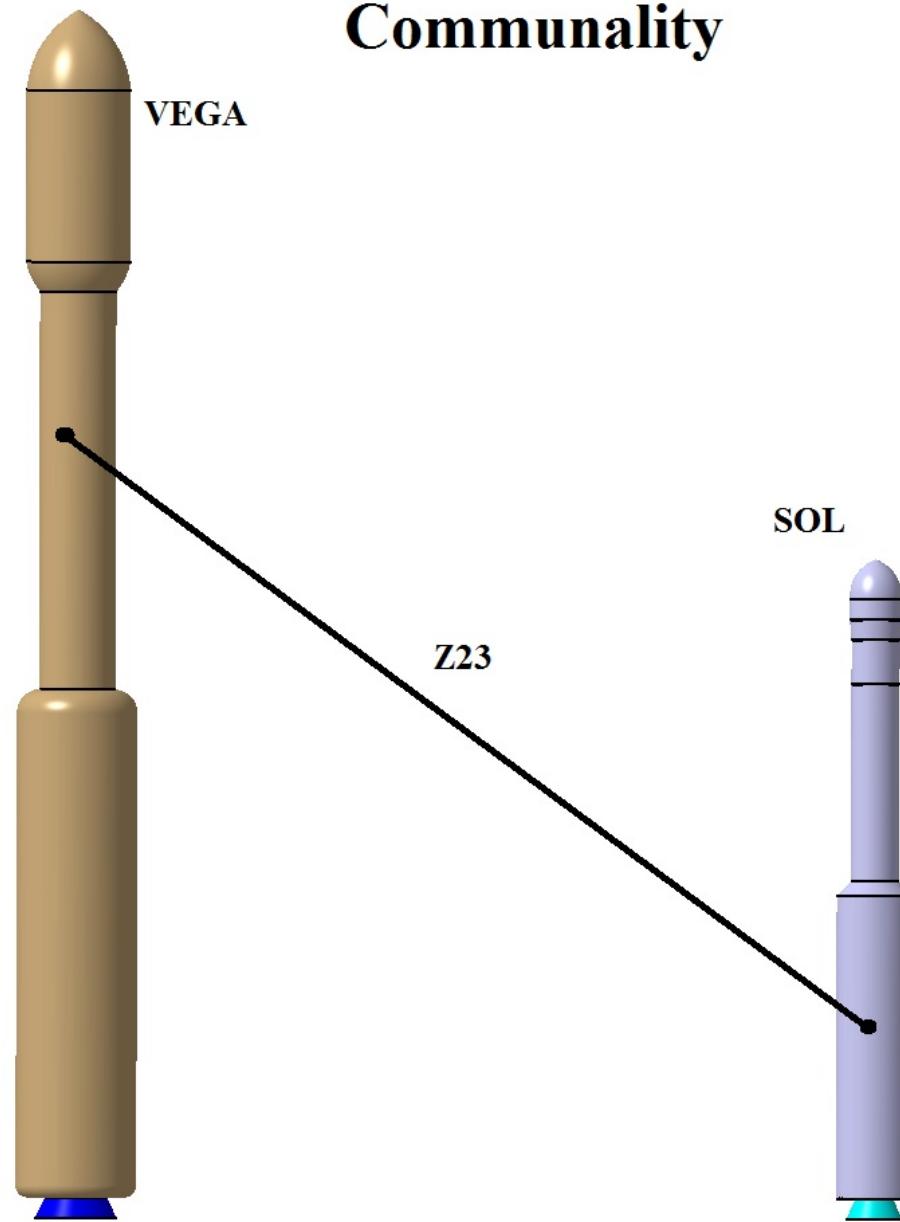


Table 1 Mechanical Characteristics

Configuration	Mass m [T]		Center of mass (from the bottom) x_{cm} [m]		Axial Moment of Inertia A [Tm^2]		Transverse Moment of Inertia B [Tm^2]	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Stage I + II + III + AVUM + P/L	34.7	10.7	10.3	6.1	17.8	3.9	550.1	129.7
Stage II + III + AVUM + P/L	8.5	2.6	4.7	2.8	2.0	0.7	31.7	6.1
Stage III + AVUM + P/L	2.0	0.6	2.2	1.5	0.5	0.2	1.1	0.4
AVUM + P/L	0.49	0.38	1.3	1.2	0.15	0.11	0.17	0.13
P/L	0.1	0.1	0.25	0.25	0.01	0.01	0.01	0.01

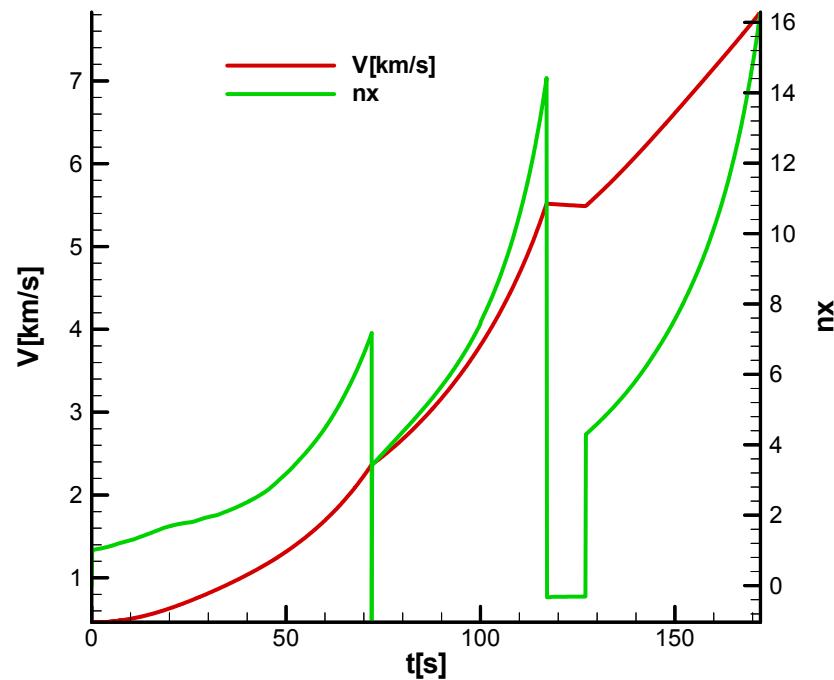
Table 2 Thrust Characteristics

Stage	Specific impulse I_{sp} [s]	Propellant mass m_p [T]	Total Impulse I_Σ [kNs]	Duration t [s]
I (V)	280	23.9	65649	72
II (V)	290	5.9	16785	45
III (V)	295	1.4	4051	45
AVUM (V)	315	0.11	340	200*

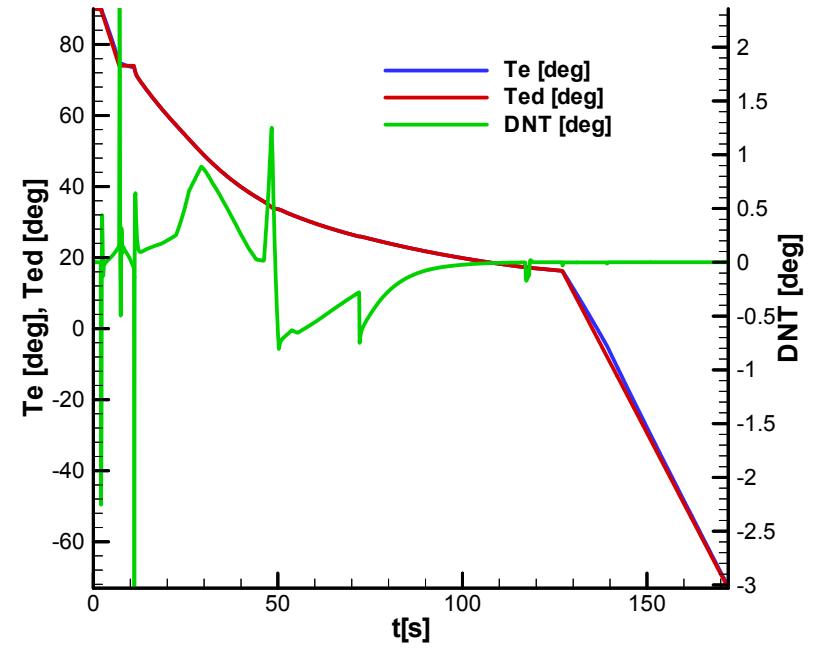
V - Vaccum

* Intermittently

Performance

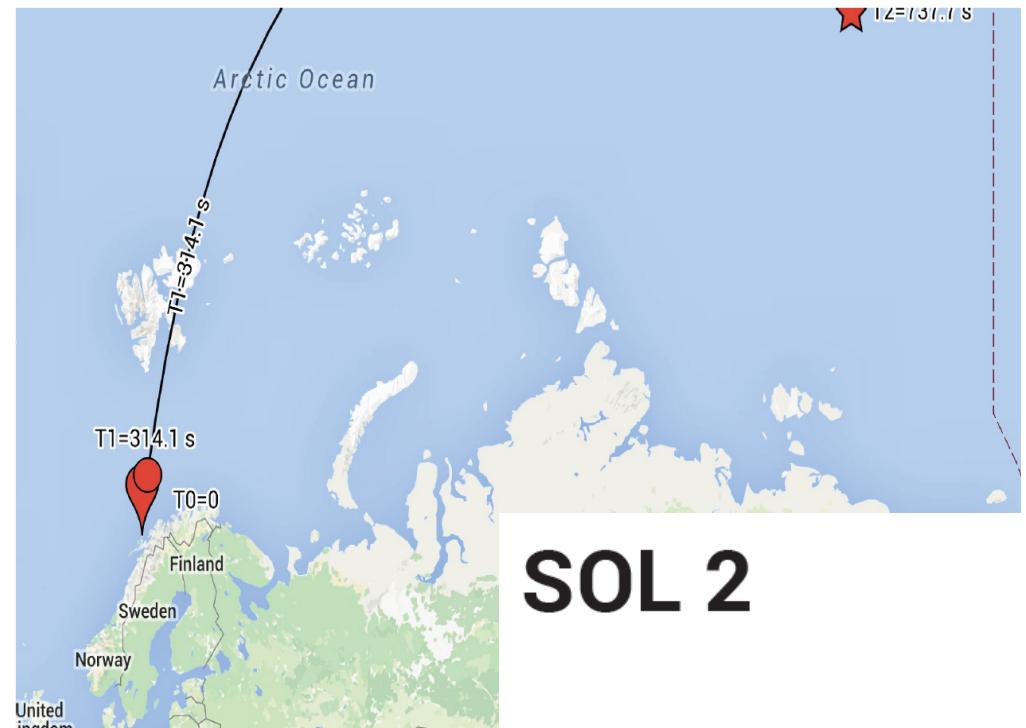


Relative velocity and axial load factor
during ascending phase



Pitch angle diagram and
thrust vector deflection

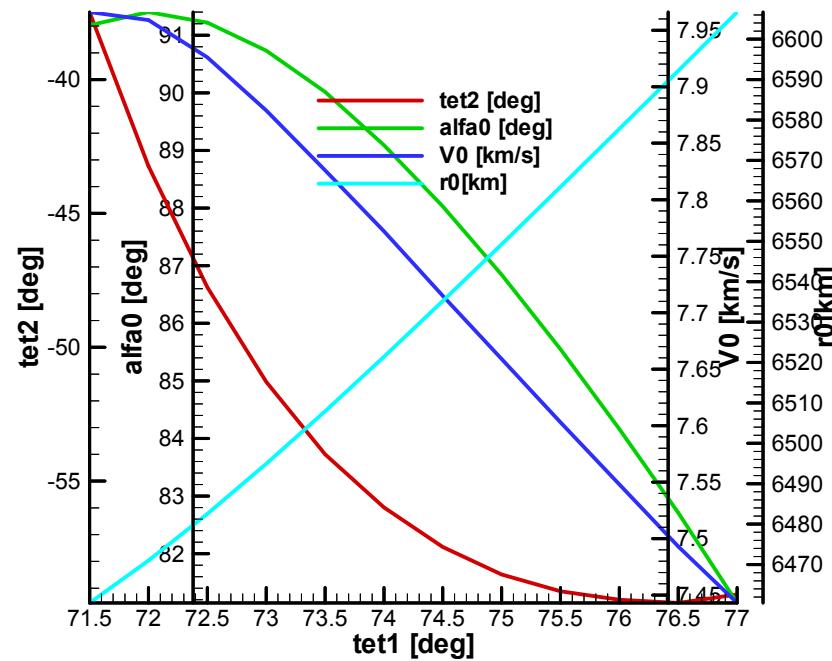
Polar orbit from Norway - inclination 87 deg



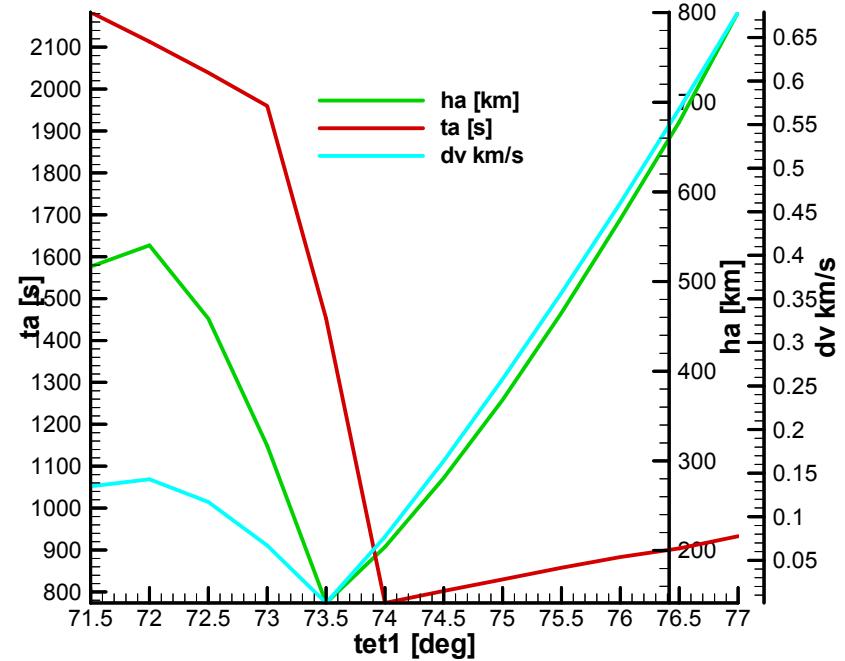
- Untitled layer
- 📍 Launch position
 - 🔴 First stage drop off
 - ⭐ Second stage drop off
 - ⌚ SOL 2

Norway Launch

Launch elements for polar orbit from Norway



Initial elements of ballistic phase



Orbital injection element

Polar Orbit from CSG inclination 83 deg

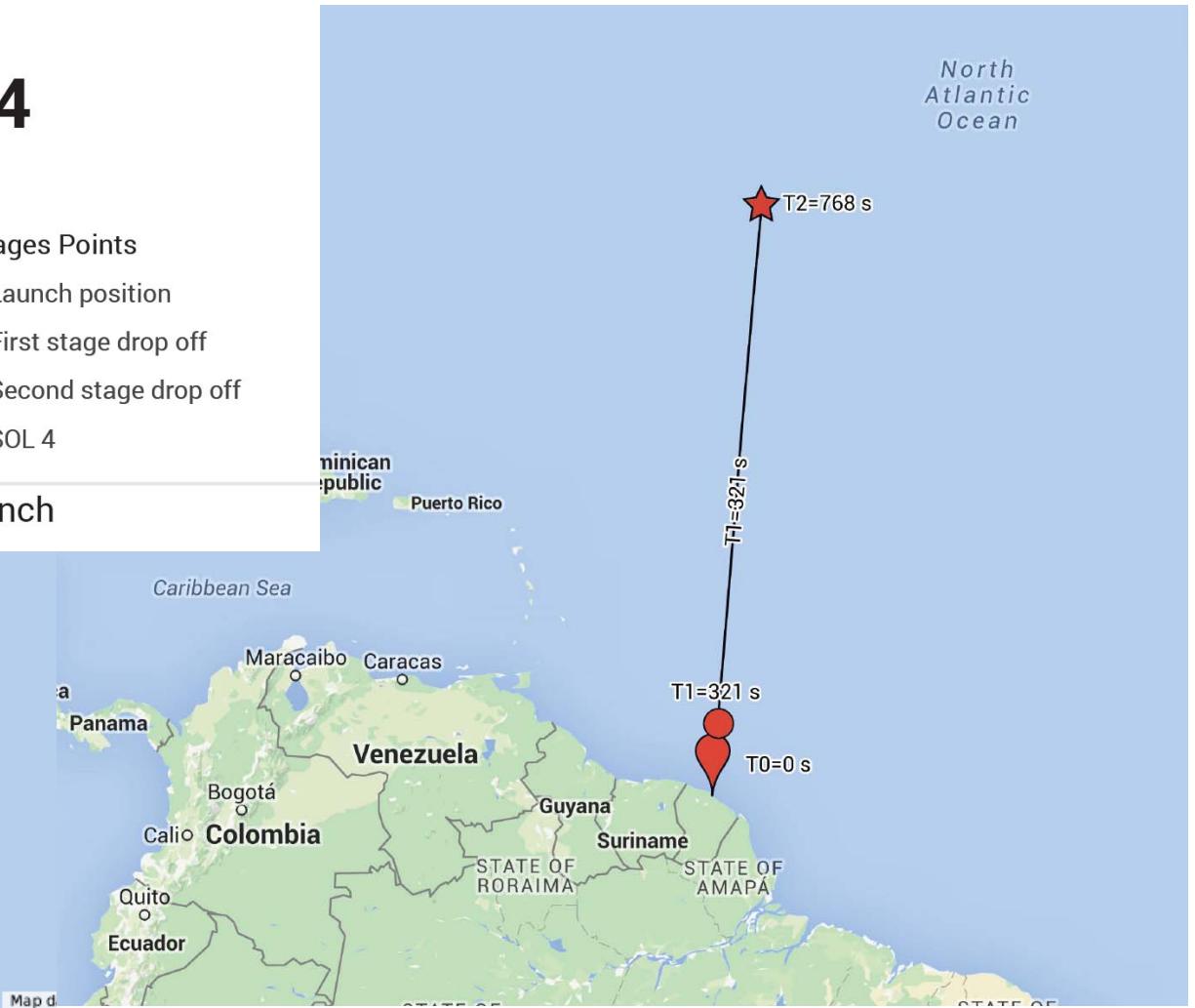
SOL4



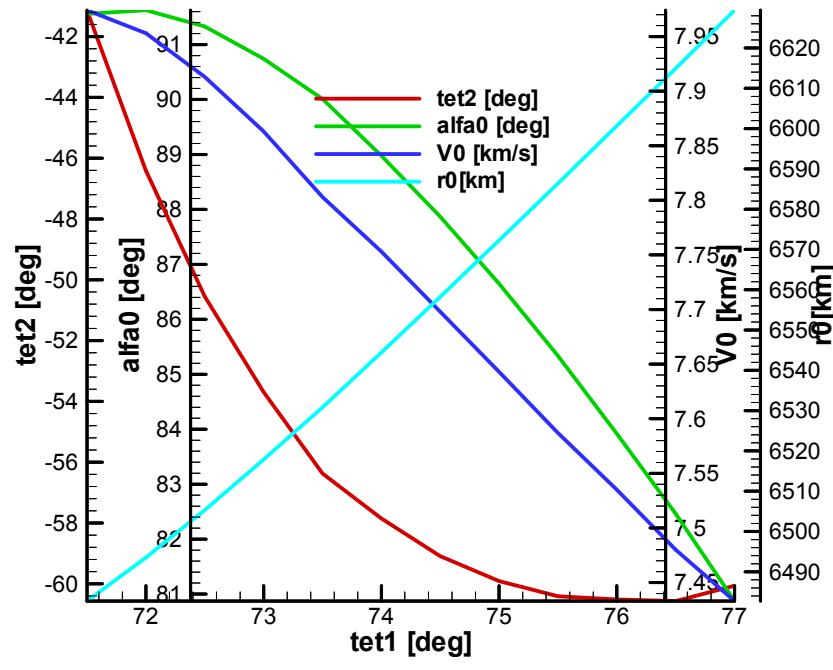
Drop Stages Points

- 📍 Launch position
- 🔴 First stage drop off
- ⭐ Second stage drop off
- 🏃 SOL 4

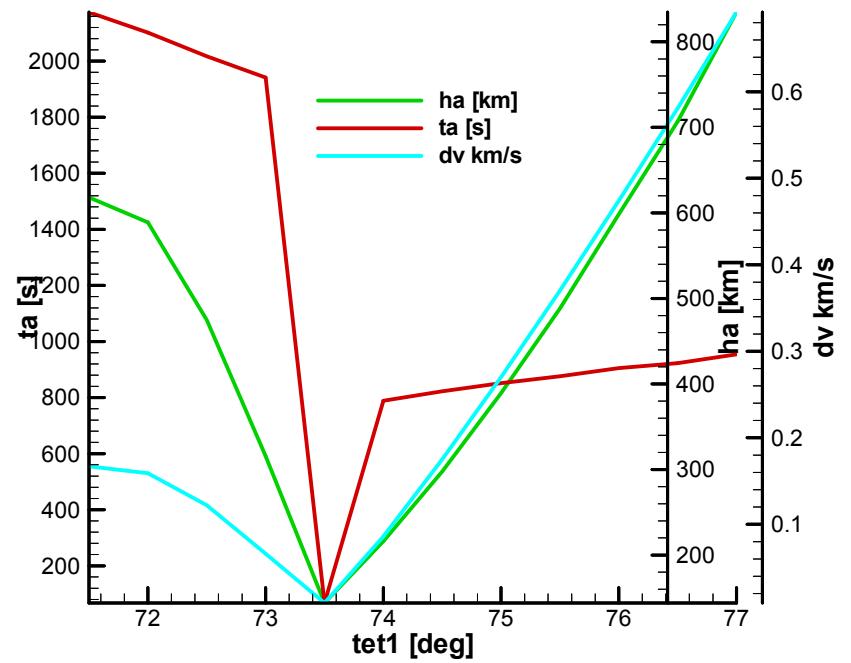
CSG Launch



Launch elements for polar orbit from CSG



Initial elements of ballistic phase

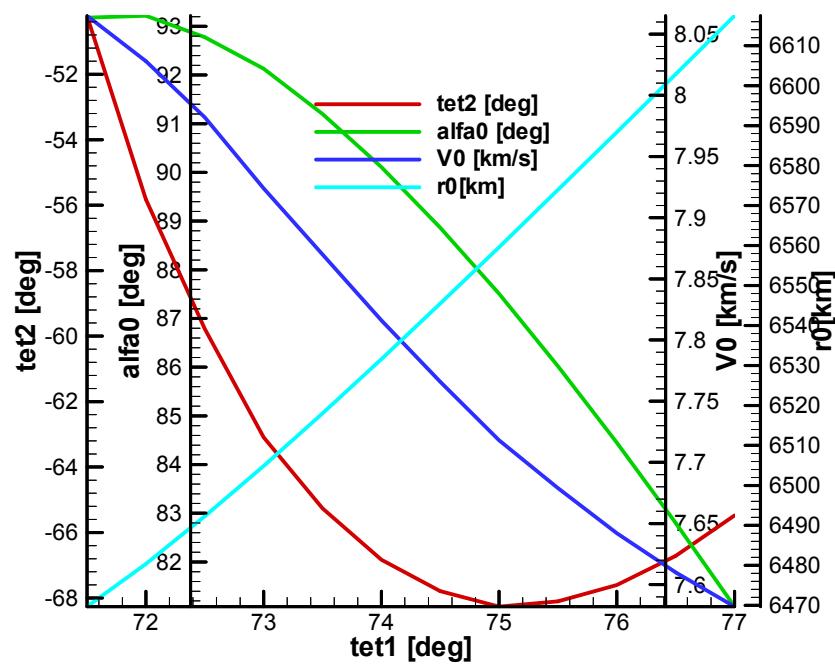


Orbital injection element

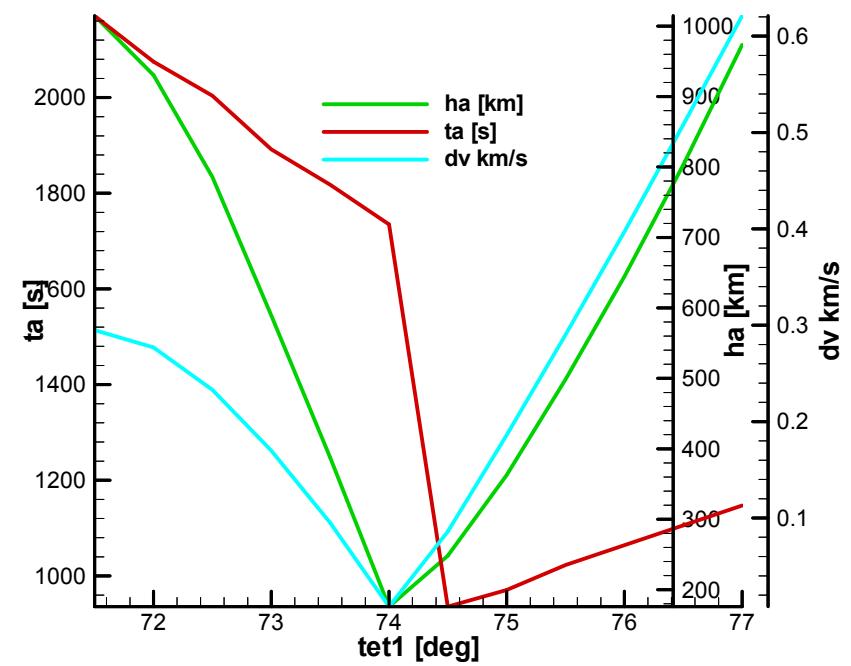
Inclined orbit from Romania - inclination 54 deg



Launch elements for inclined orbit



Initial elements of ballistic phase



Orbital injection element

Risk area for launching in inclined orbit

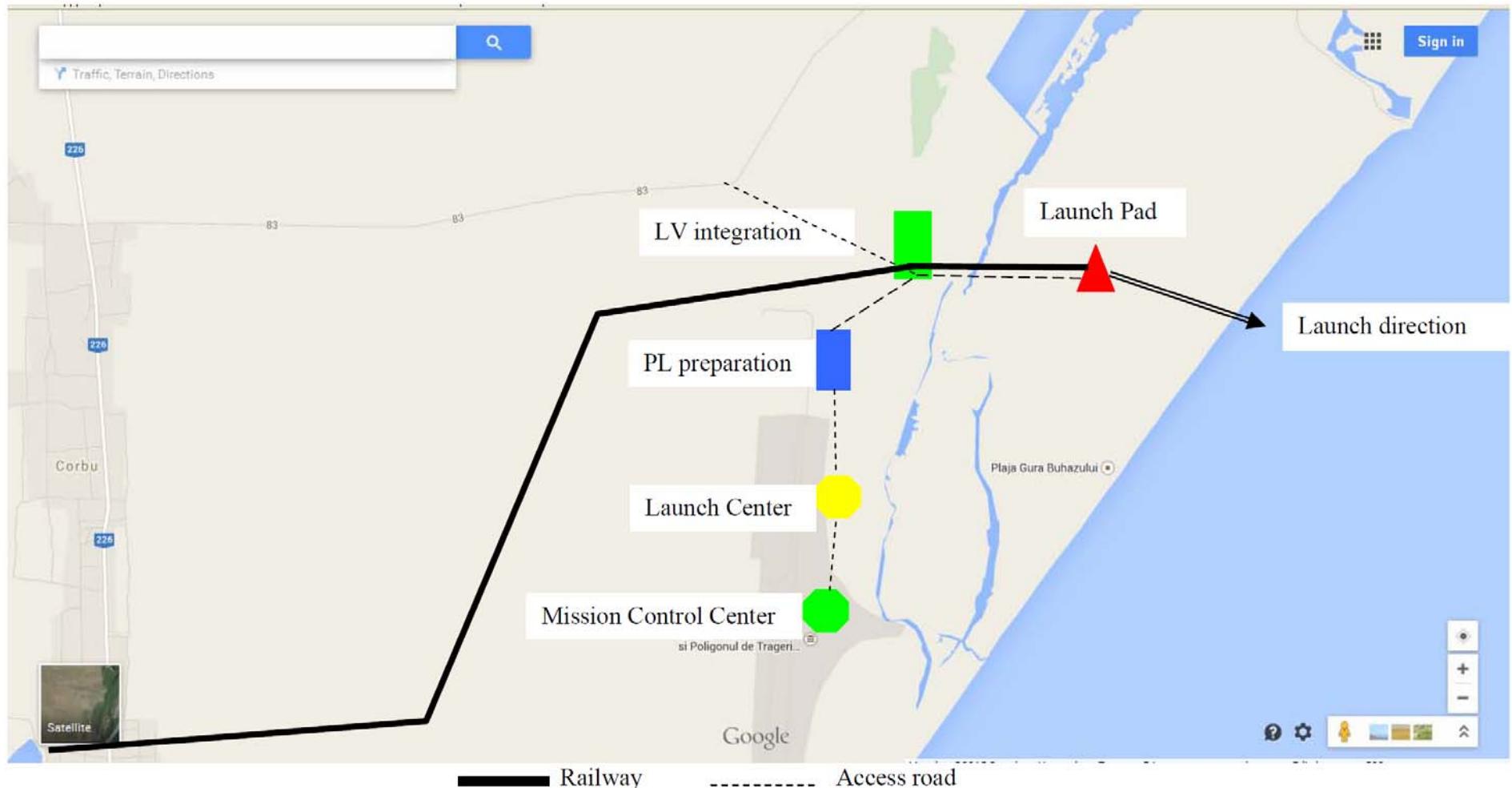
Risk area for first stage

- 📍 Launch position
- 41.9769 , 32.1166
- 41.9565,32.1177
- 42.2177,32.4128
- 42.3326,32.5515
- 42.4603,32.7085
- 42.6557,32.9101
- 42.7629,33.0028
- 42.8754,33.0880
- 43.1013,33.2302
- 43.2691,33.3143
- 43.4221,33.3897
- 43.7371,33.4021
- 📍 Risk area
- ↗ Shooting direction



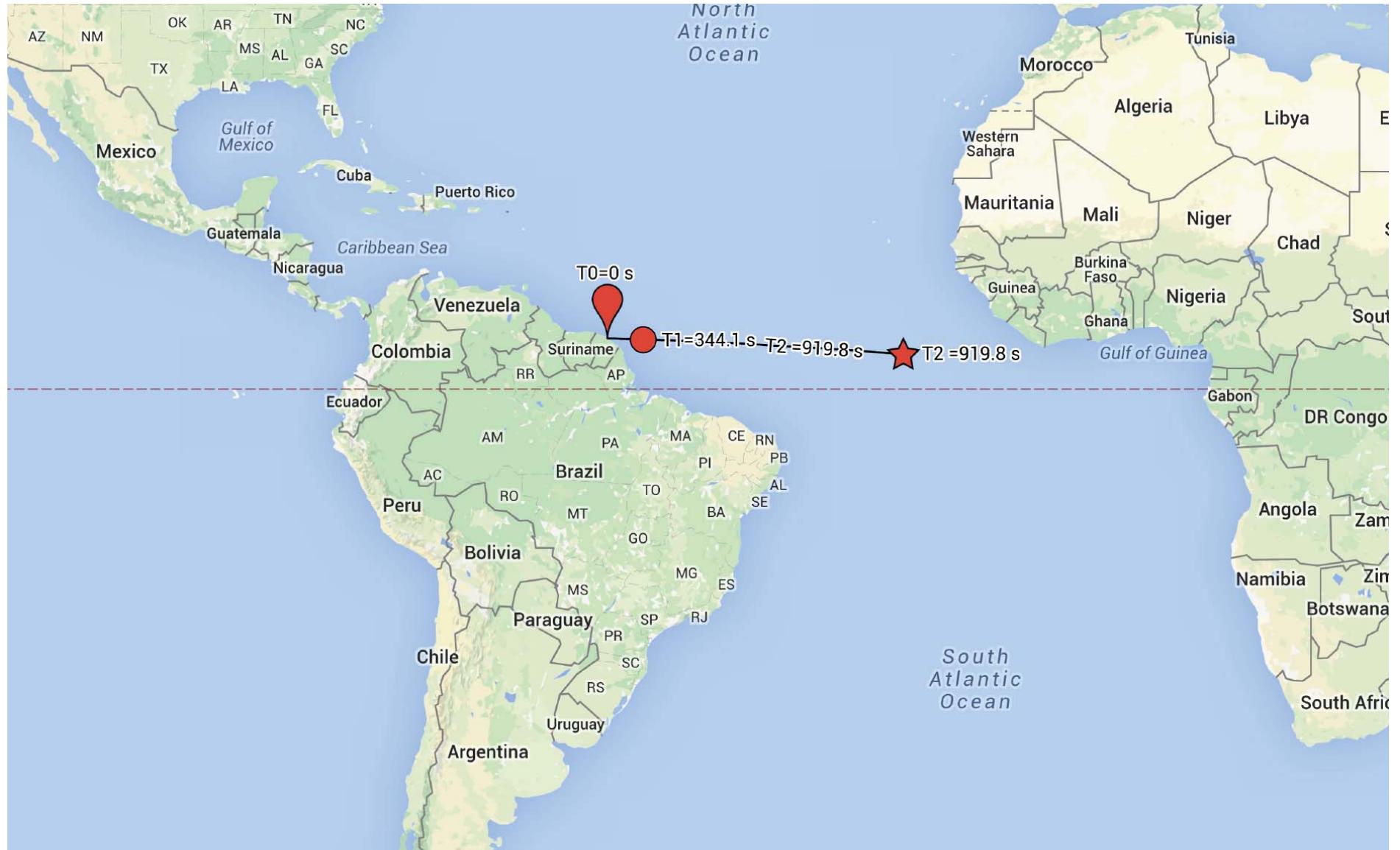
Map data ©2015 Basarsoft. Google

Launch infrastructure

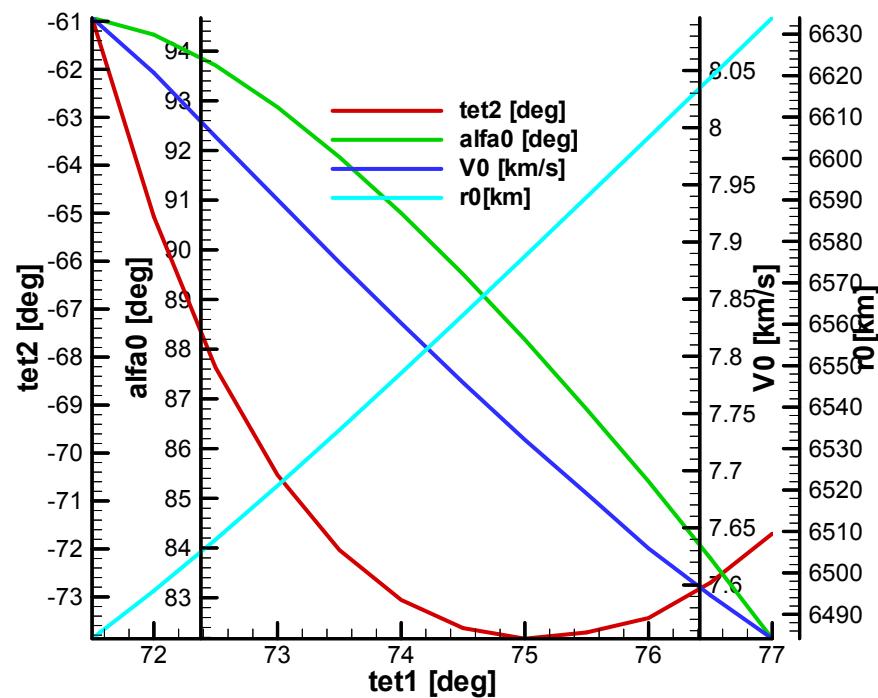


Capu Midia Launching Facilities

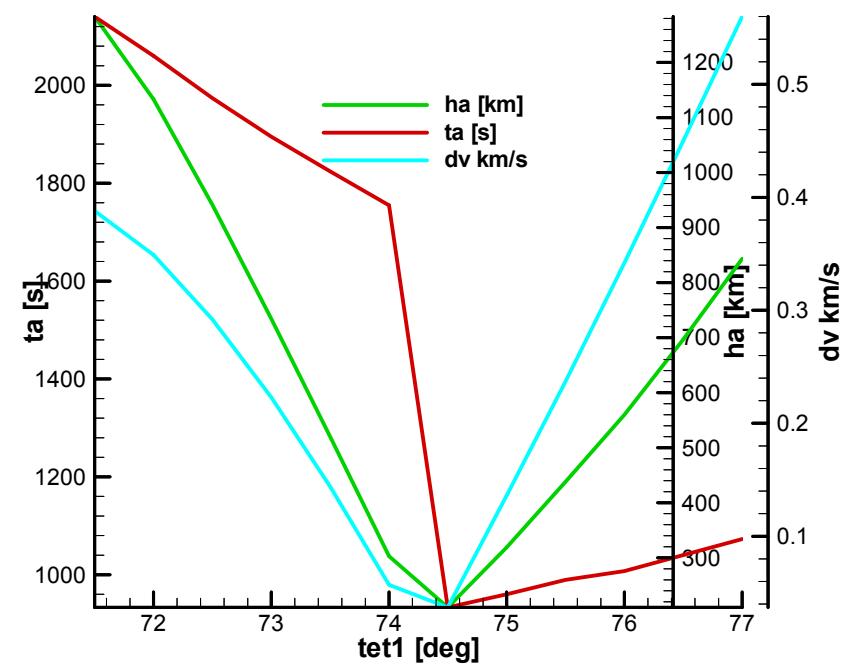
Equatorial Orbit from CSG – inclination 7 deg –



Launch elements for equatorial orbit from CSG

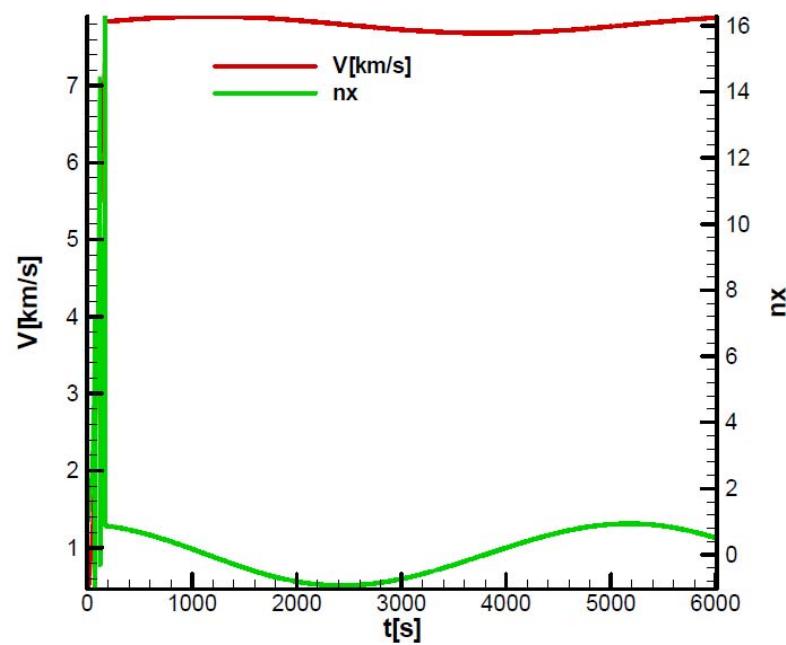


Initial elements of ballistic phase

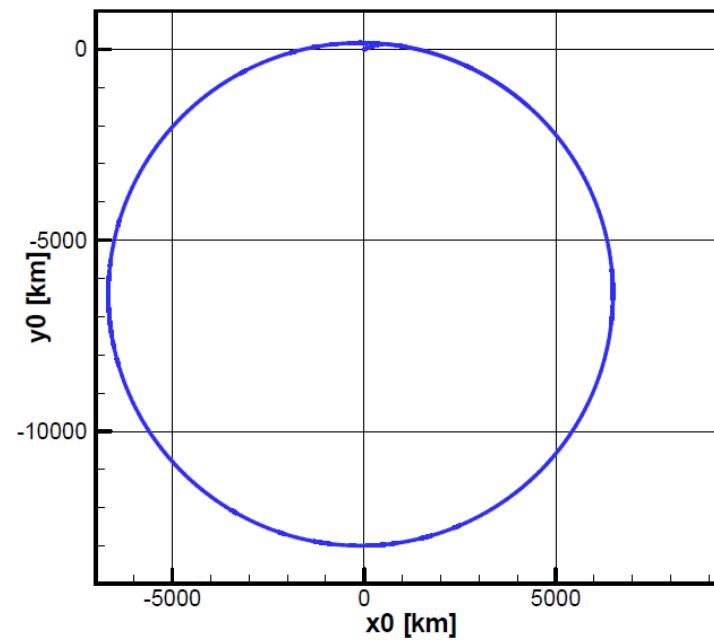


Orbital injection element

Equatorial orbit



Absolute velocity and load factor
on orbital phase



Circular orbit in start frame