

Research project meeting summary: Trajectory Module for Launcher MDAO

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- 1 Review of previous work

- 2 Key points discussed

- 3 Future actions

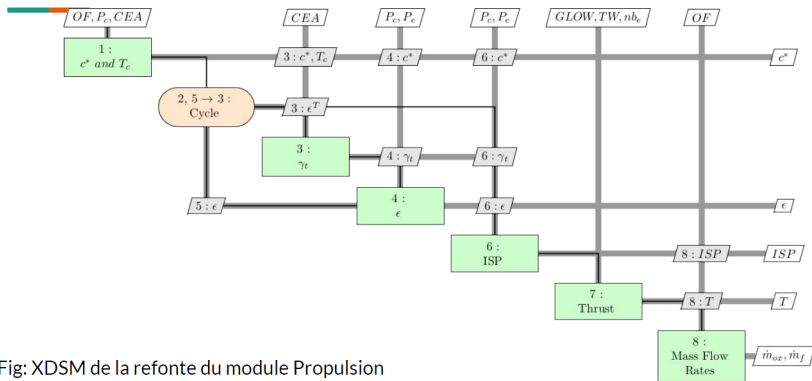


Fig: XDSM de la refonte du module Propulsion

- Optimization of propulsion for second stage only

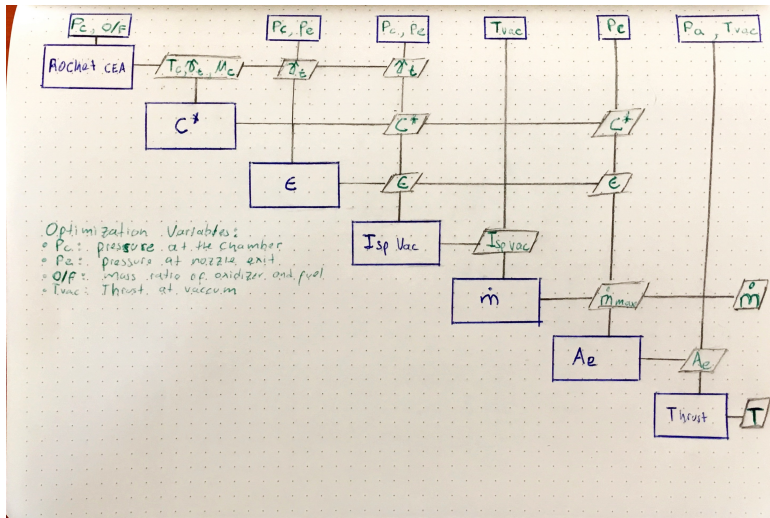
- Optimization of propulsion for second stage only
- Interpolation of outputs from Rocket CEA

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- Includes the ϵ and ISP components from LAST

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- Includes the ϵ and ISP components from LAST
- Considers variation of atmospheric pressure

Review of previous work

XDSM being implemented



- Tabulated data from Assigned Enthalpy & Pressure "hp" problem obtained from Rocket CEA online

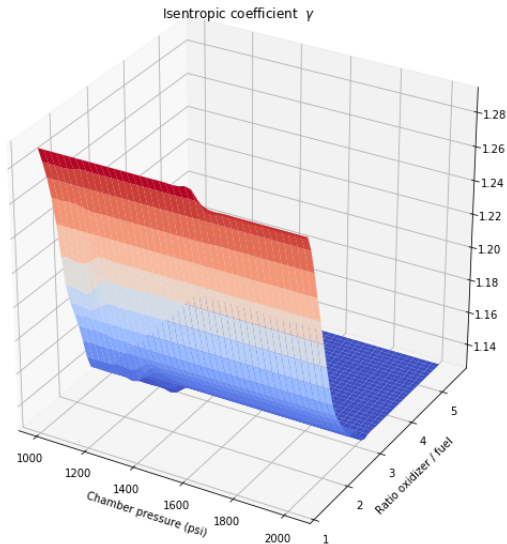
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- Interpolators:
 - RectBivariateSpline
 - Interp2D
 - Linear interpolation LAST

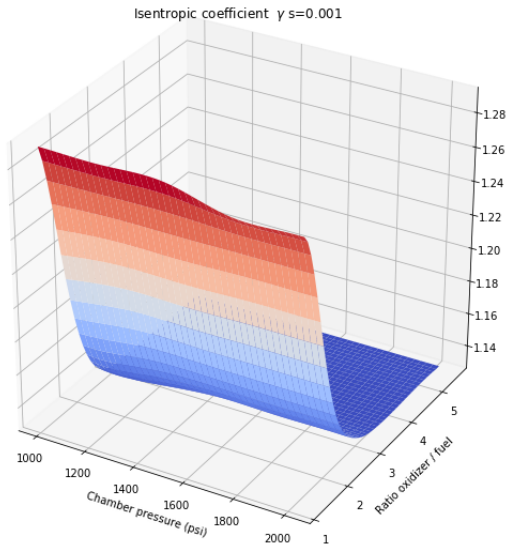
Review of previous work

Interpolation



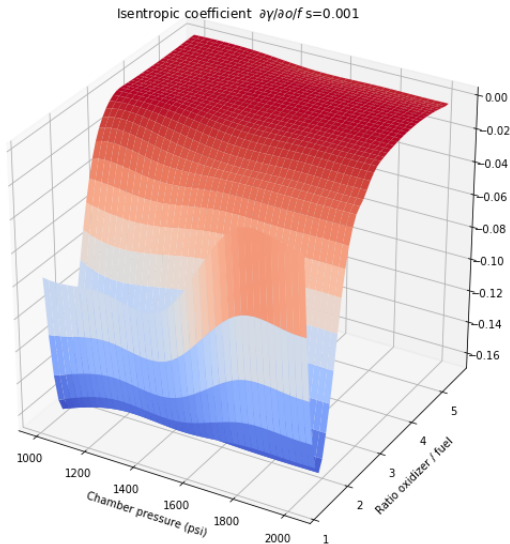
Review of previous work

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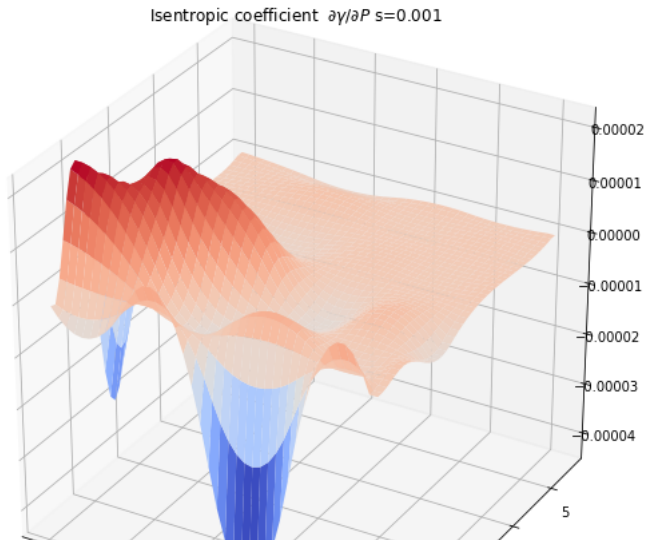
Review of previous work

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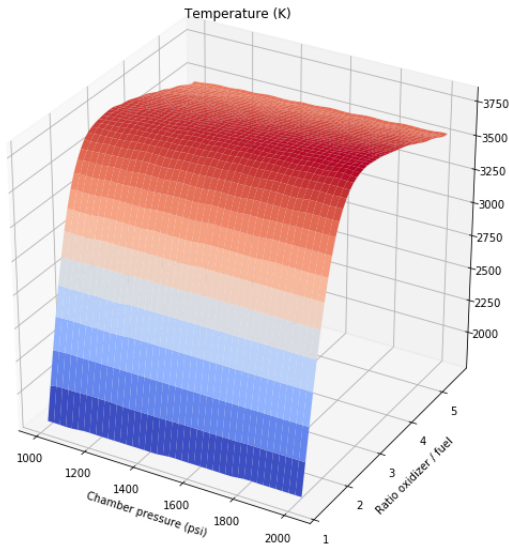
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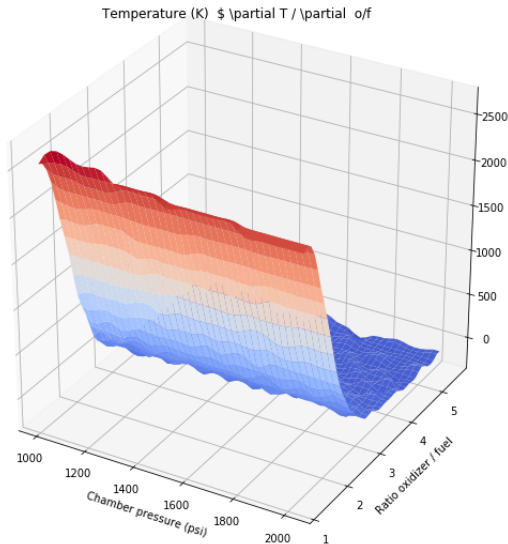
Review of previous work

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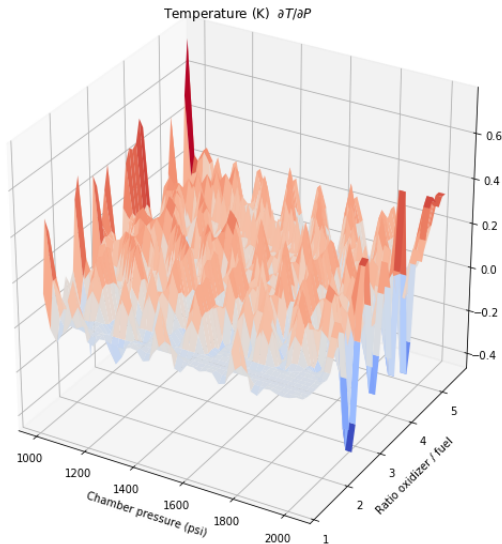
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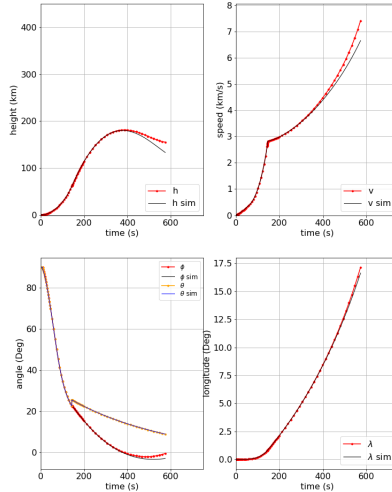
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- Exit area: $A_e \leq 0.8^2 A_{\text{crosssection}}$

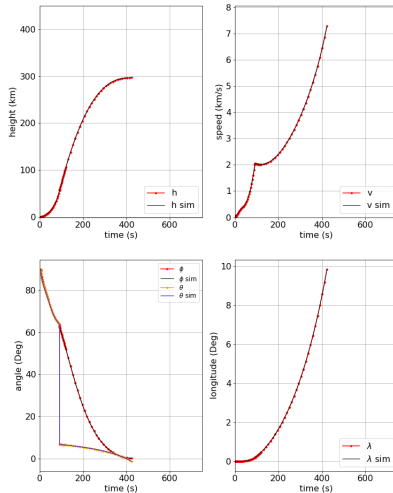
Review of previous work

Initial guess



Review of previous work

Optimization results



Solver Behavior:

- $P_e \uparrow$, I put an upper bound at 1psi
- $I_{sp} \uparrow$
- $A_e \downarrow$

Review of previous work

Optimization report

Design parameters:

Name	lower	value	upper
lift_off.t_duration	1.0	5.2896	100.0
pitch_over_linear.t_duration	1.0	1.0	100.0
pitch_over_exponential.t_duration	1.0	32.1492	100.0
gravity_turn.t_duration	1.0	53.0887	200.0
xi	-1.0	0.1914	1.0
delta_theta_pitch_over	0.0175	0.0444	0.1396
delta_theta_exoatmos	-1.0472	-0.9957	0.3491
theta_f	-1.0472	-0.024	1.0472
phase_duration_a_dp	1.0	1.0	500.0
phase_duration_b_dp	1.0	27.9309	500.0
phase_duration_c_dp	1.0	303.1452	500.0
P_c	1000.0	1123.6538	2000.0
P_e	0.1	1.0	1.0
o_f	1.2	2.7535	5.4
thrust_vac	200000.0	670794.3012	6000000.0

- The noise for the interpolation of Rocket CEA outputs may not affect in a big scale to whole optimization
- Probably a lower degree interpolator would have less noise at approximating the flat regions but then this would pose a problem with the C_2 requirements for NLP solvers. Still, it will be worth trying with the other interpolators that were mentioned
- First it is necessary to check that the propulsion component is working properly as the nozzle exit area should be taken towards higher values by the optimizer. Currently it works the other way round.

- Dr. Urbano will help me check the propulsion model. The main focus is to make sure it is working properly before integration into the main code.
- Give feedback on Dymos