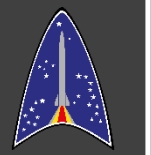
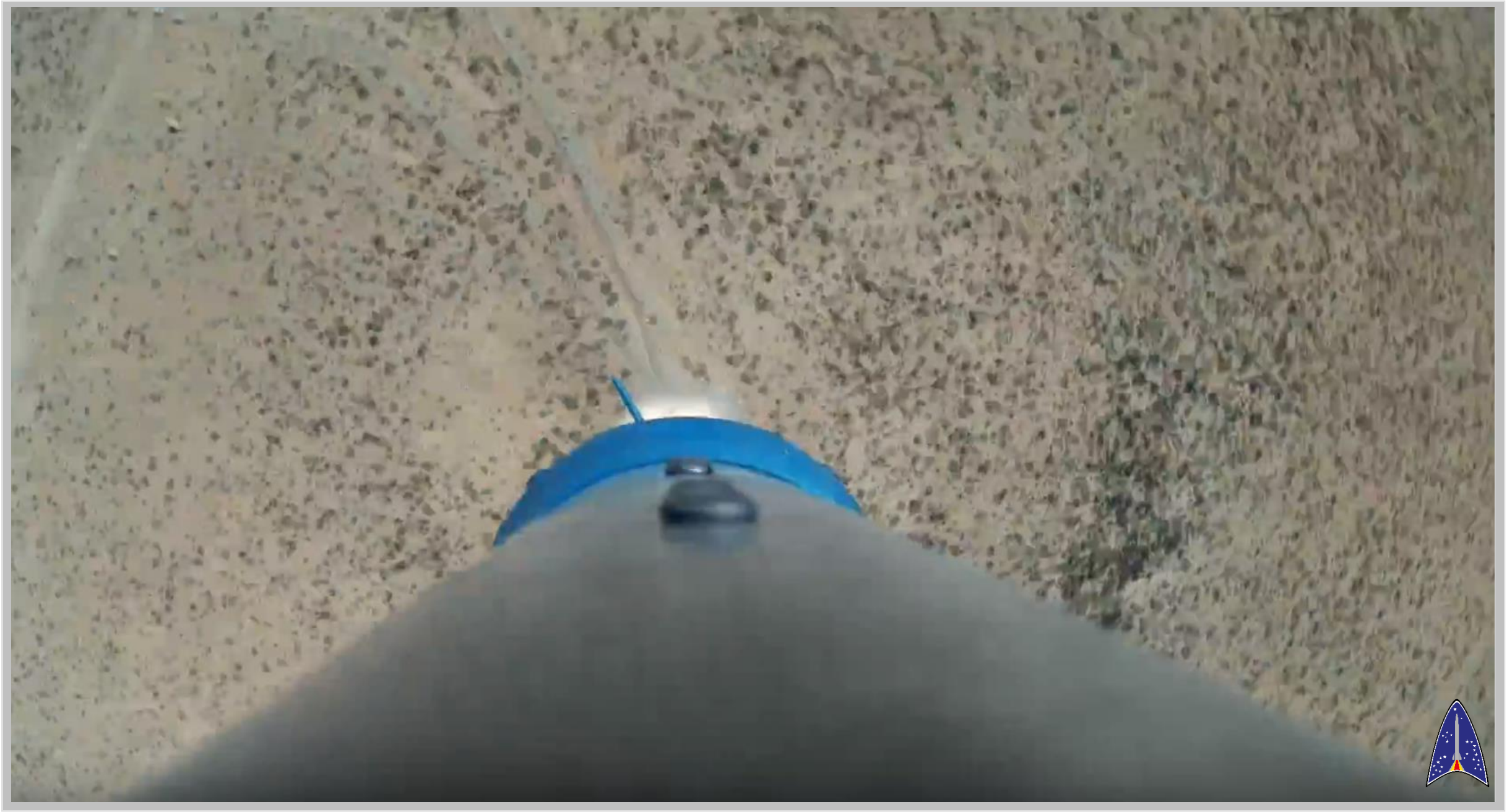
Wind Tunnel Study of an Experimental Sounding Rocket

Team 73 Project Technical Presentation to the 2018 IREC



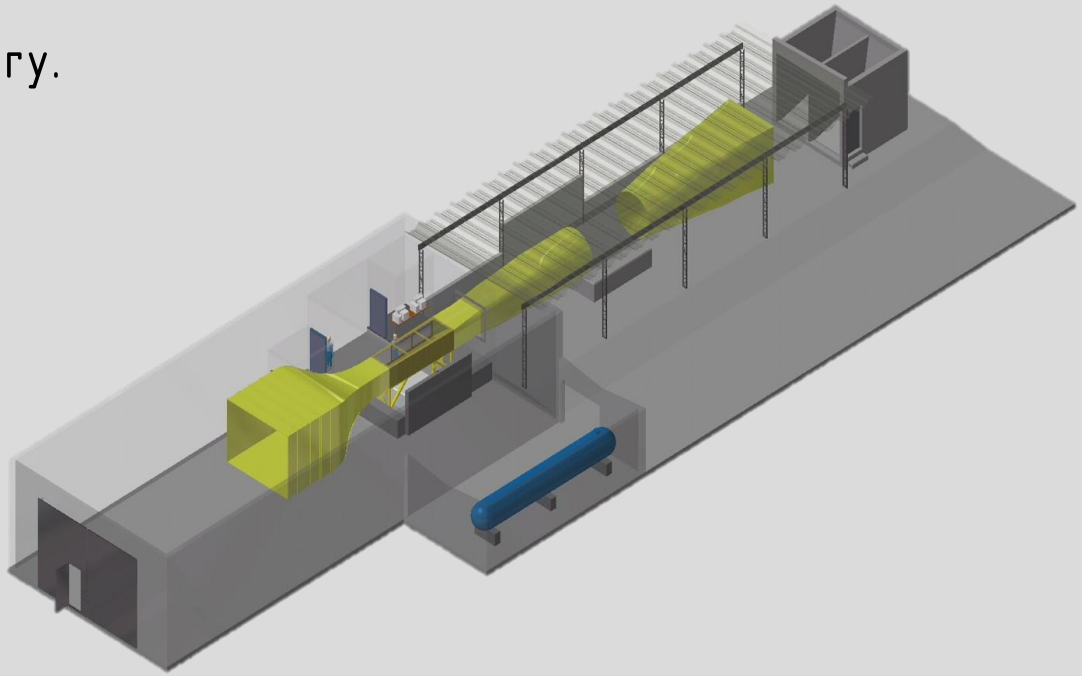
MOTIVATION

- Rocket apogee in 2017 flight was less than calculated in our dynamic six degrees of freedom simulator.
- We obtained 3806 apogee versus 3176.4 m calculated.
- Suspicion that our flight coefficients estimative were inaccurate.
- Possibilities
  - ✓ Drag coefficient was sub dimensioned.
  - ✓ The rocket rolled considerably during flight, this may drain energy from trajectory and we didn`t expected roll rotation. Probably induced by fins misalignment
- Solution
  - ✓ Experimental wind tunnel test.
- Better estimate aerodynamic coefficients.



Wind Tunnel Characteristics

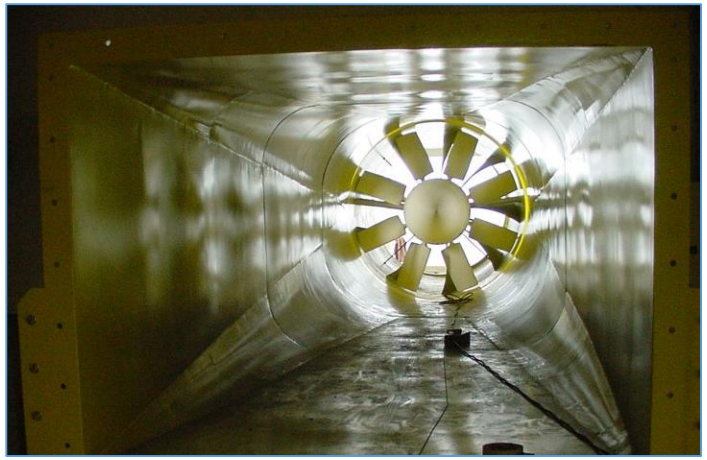
- Aeronautical Institute of Technology Feng Laboratory.
- 40 m long.
- Test section of 1.00x1.28x4.00 m.
- 200 HP 8 blades turbine.
- Turbulence level of 0.05%.
- Maximum safe wind speed of 53 m/s.
- Six degrees of freedom load cell.



Wind Tunnel

OUTLET VIEW

INLET VIEW

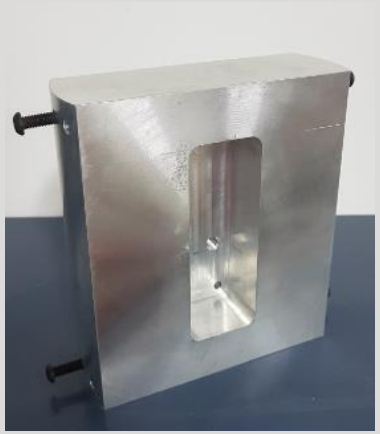


TURBINE

Rocket-Load Cell Interface

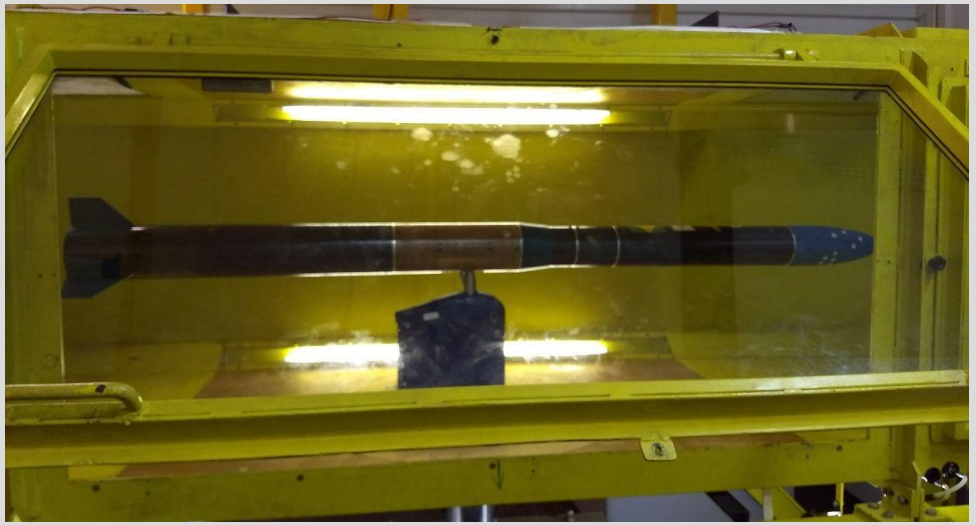
- Join tightly rocket body with the wind tunnel`s load cell.

- Low tolerance 7075 aluminum slotted part to match male adaption part of the load cell.



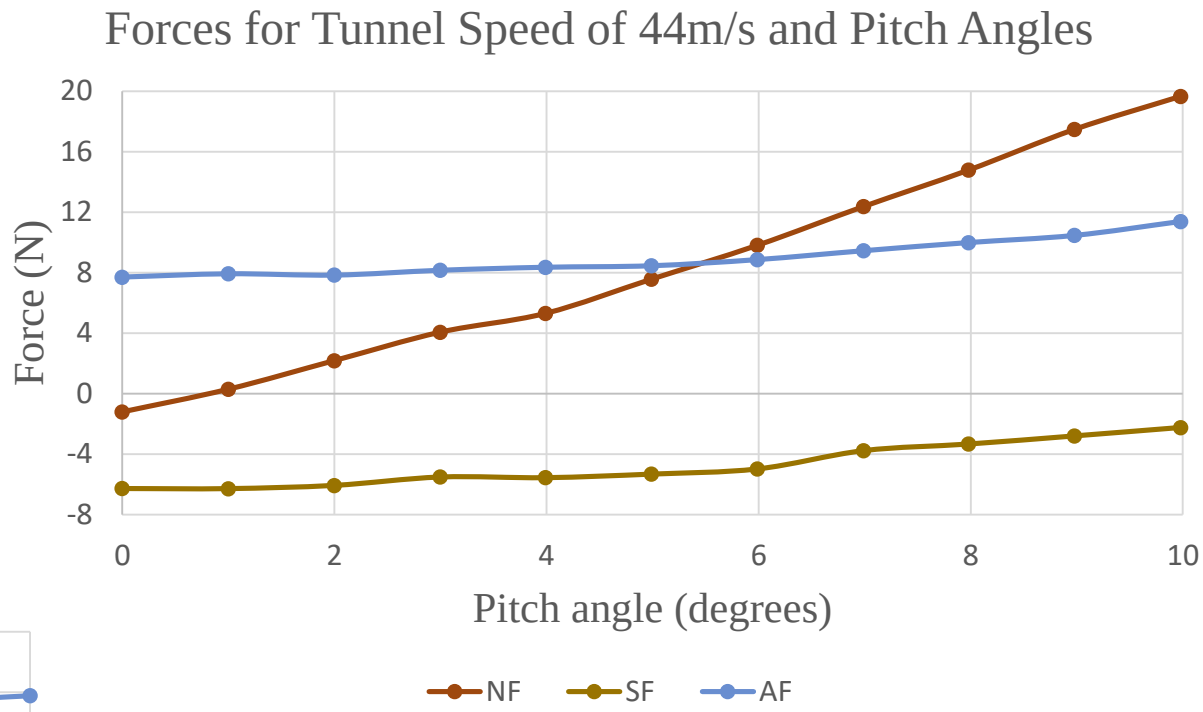
- Attached with precision bolts on the load cell and with M6 bolts in the rocket fuselage.

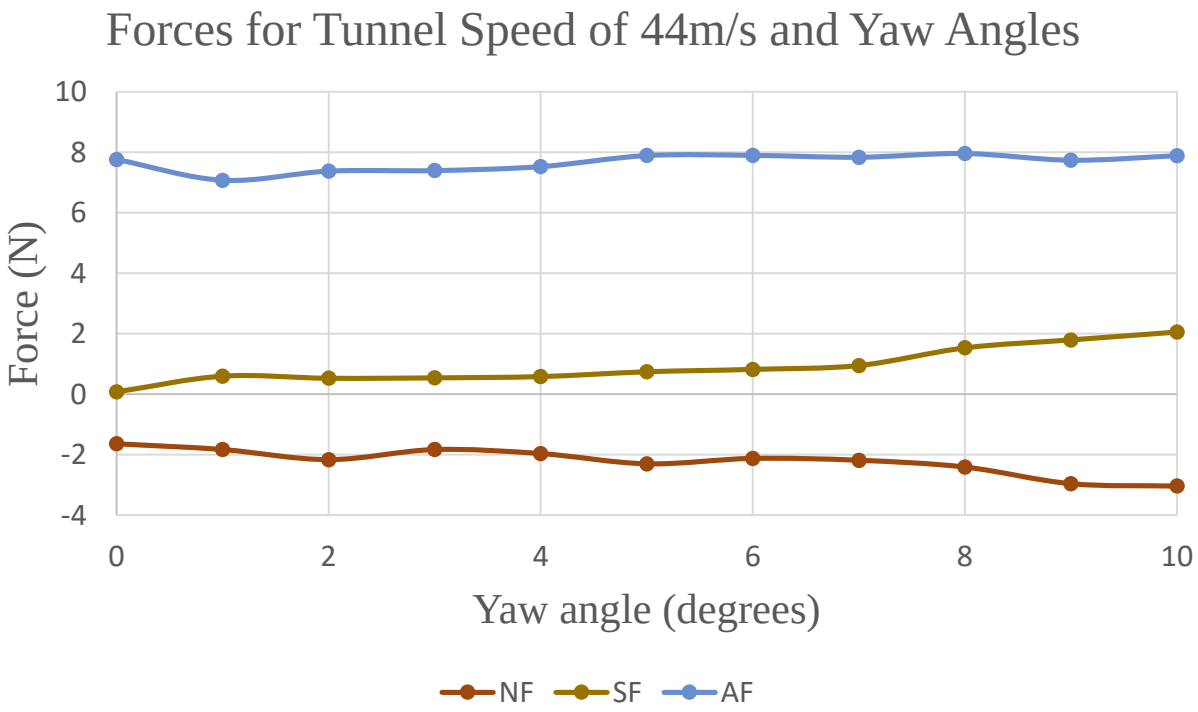
The Test



- Wind tunnel speeds: 4 m/s, 16 m/s, 35 m/s and 44 m/s.
- Pitch angle of attack: unit variation from 0 to 10 degrees.
- Yaw angle of attack: unit variation from 0 to 10 degrees.

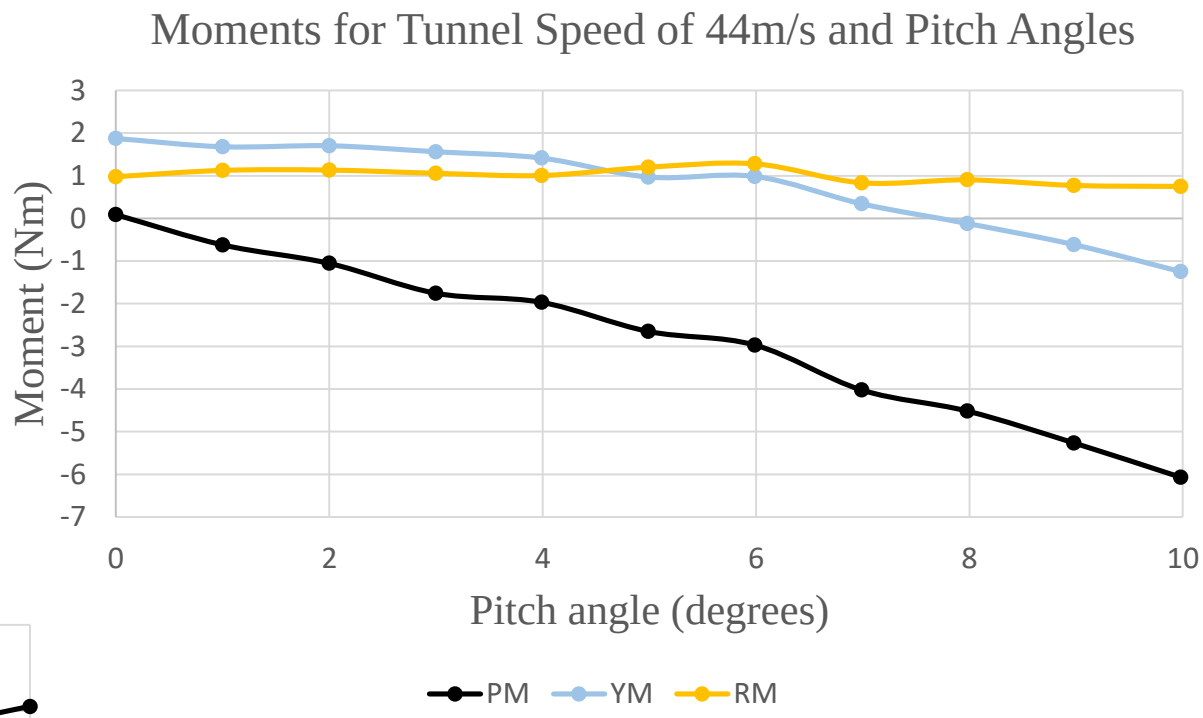
Results

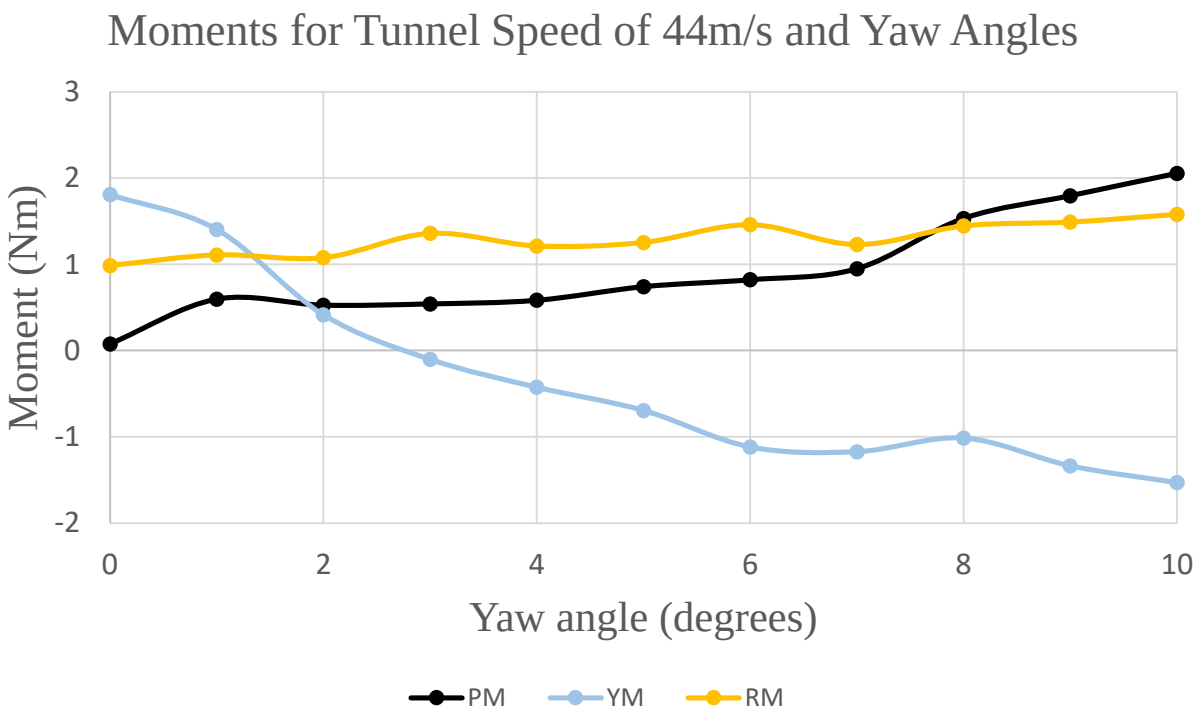




Forces

Results

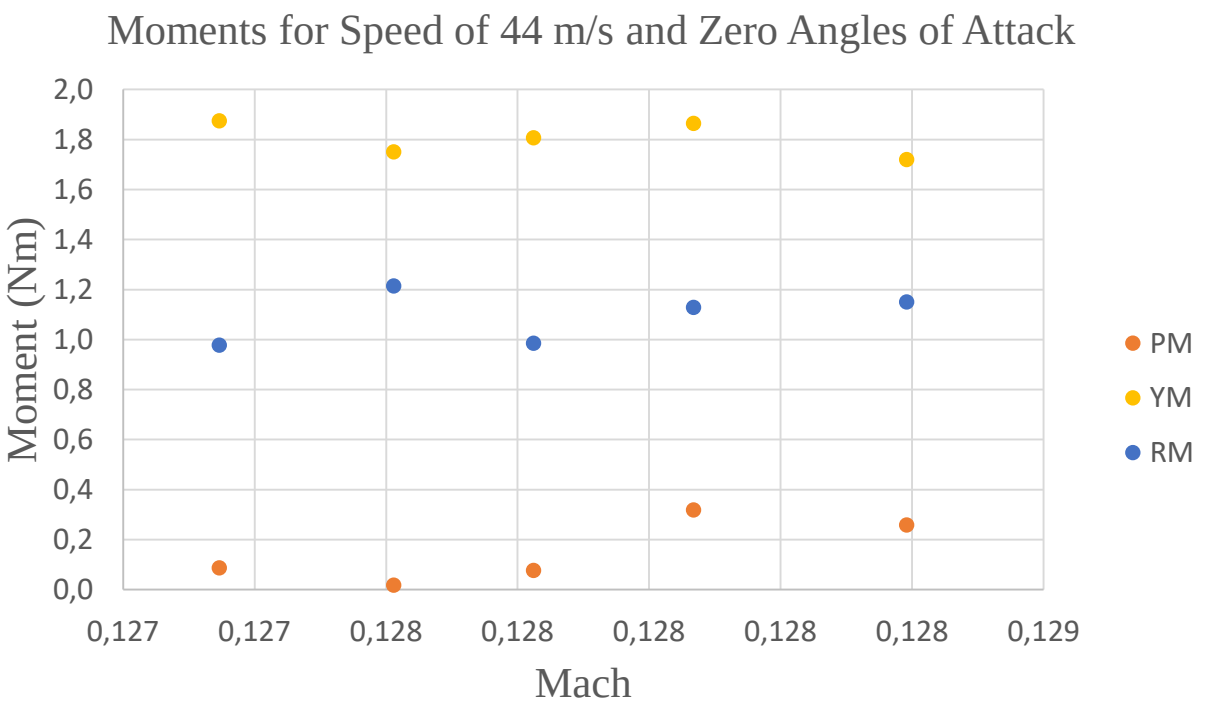


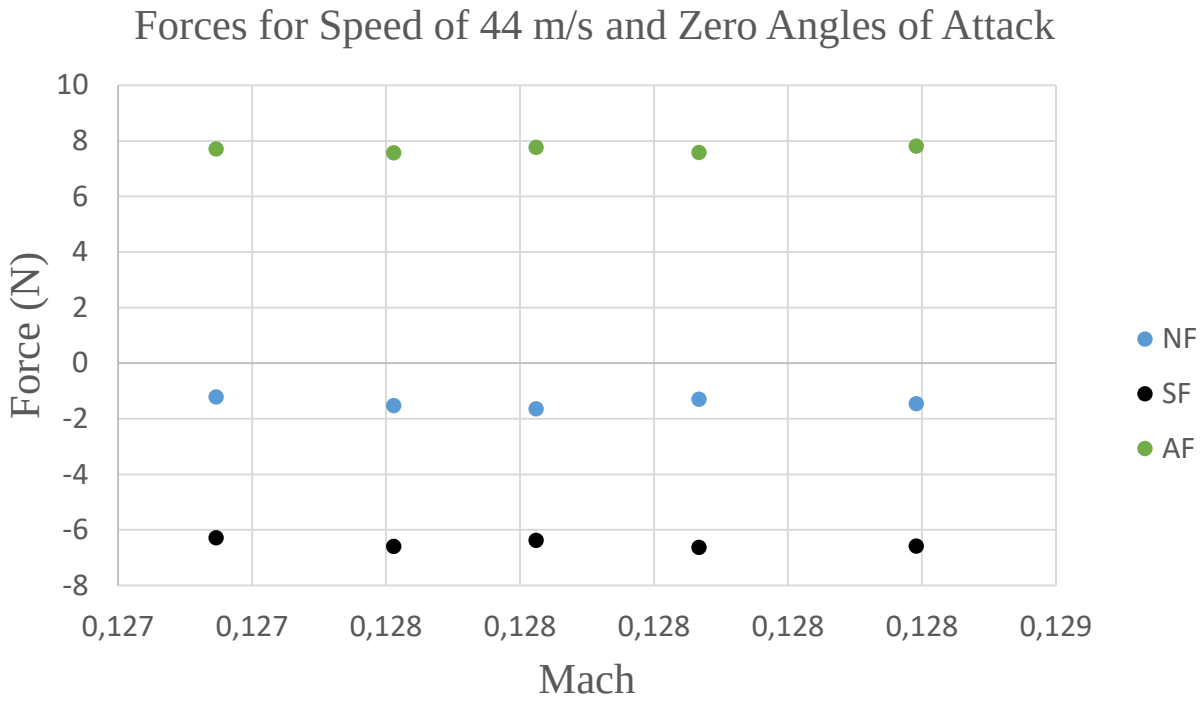


Moments

Results

Zero Angles of Attack to Cruze Flight Condition Analysis





Average Coefficients

C_N	C_S	C_D
-0.072	-0.327	0.387
C_{PM}	C_{YM}	C_{RM}
0.05	0.596	0.360

Prandtl-Glauert Transformation

- Mach number of the test: 0.13.
- Mach number of flight: 0.80.
- Match test data to flight conditions.

$$\beta = \sqrt{1 - M^2}$$

$$C = \frac{C_0}{\beta}$$

Average Coefficients

M	C_D	C_M
0.7	0.542	0.505
0.8	0.645	0.601

DATCOM Missile estimated coefficients

M	C_D	C_M
0.7	0.307	0.709
0.8	0.304	0.724

Conclusions

- Datcom's estimative of drag coefficient is below the wind tunnels result.
- The difference in apogee due to increased drag contribution is of -XXXX m.
- Little deflexion in the fins causes an considerable roll moment force.
- The characterization of roll enables the team for developing a roll control system.
- Follow on work: develop a CFD model to study and compare aerodynamic coefficients between experiment and simulation

Ackowledgement

- We thank you for the attention and thank ESRA`s organization for the opportunity of sharing our work.
- This test wouldn't be possible without Feng laboratory`s technicians support and professor's Kleine guidance.
- Finally, we thank our sponsor FIESP and NewTechnik for the support.

References

[1]Lees, L., "A Discussion of the Application of the Prandtl-Glauert Method to Subsonic Compressible Flow over a Slender Body of Revolution." *National Advisory Committee for Aeronautics*, ID. 458, No. 1127, 2005.

[2]Anderson, J. D., "Fundamentals of Aerodynamics." *McGraw Hill Education*, 5th ed., 1106 p., 2011.