CISAS G. Colombo, University of PADOVA,
Via Venezia 15, 35131 Padova (ITALY)

S.C.R.A.T. EXPERIMENT: A STUDENT EXPERIENCE

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Matteo DUZZI (matteo.duzzi@gmail.com)
Lorenzo OLIVIERI,
Alessandro FRANCESCONI

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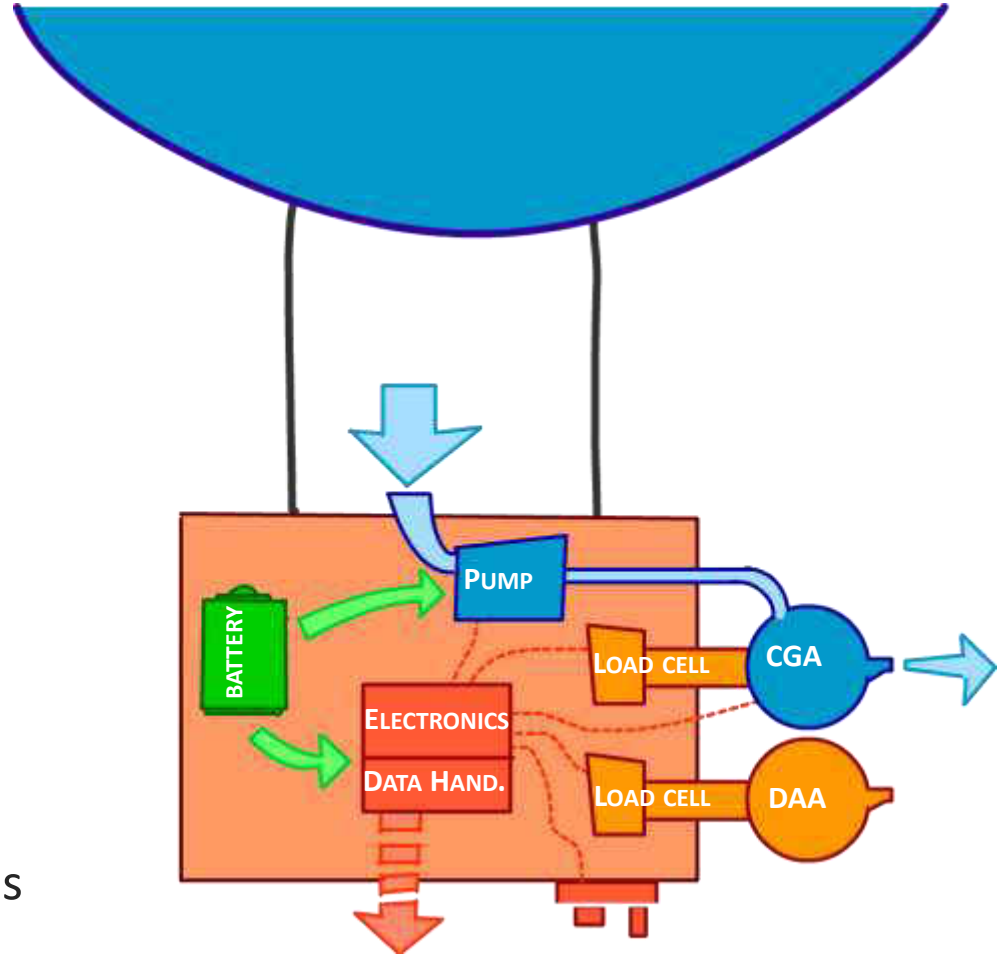


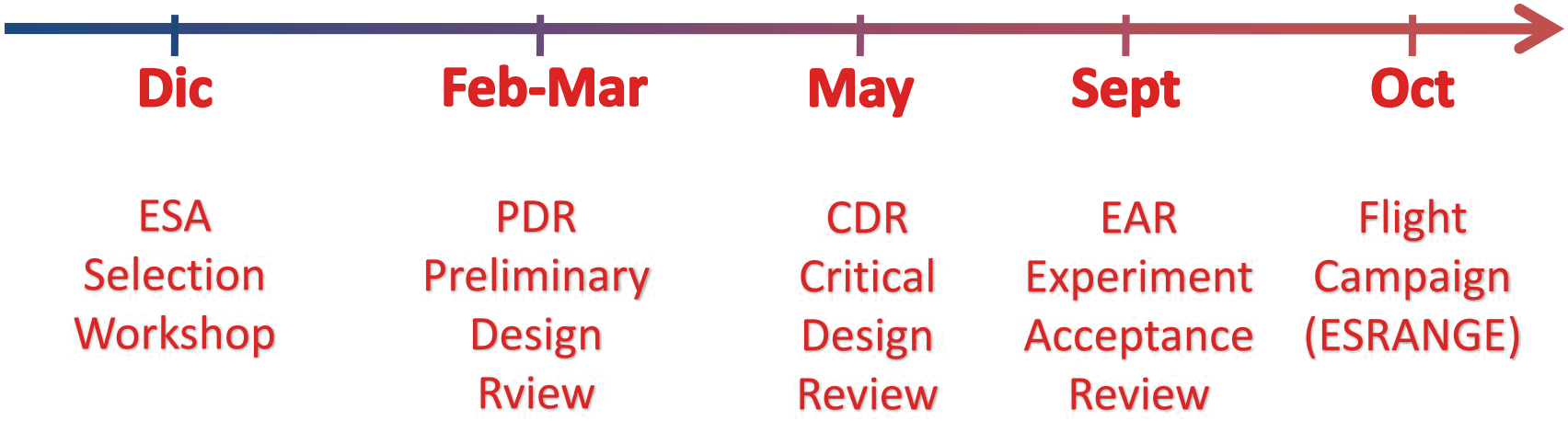
The Rexus-Bexus (Rx/Bx):

- Collaboration among ESA, DLR and SNSB
- Part of ESA «Hands-on» student activities

REXUS - Rocket EXperiments for University students

BEXUS - Balloon Experiments for University students

Standard BEXUS Schedule:



S.C.R.A.T. EXPERIMENT

S.C.R.A.T.: Spherical Compact Rechargeable Air Thruster

- Objectives:

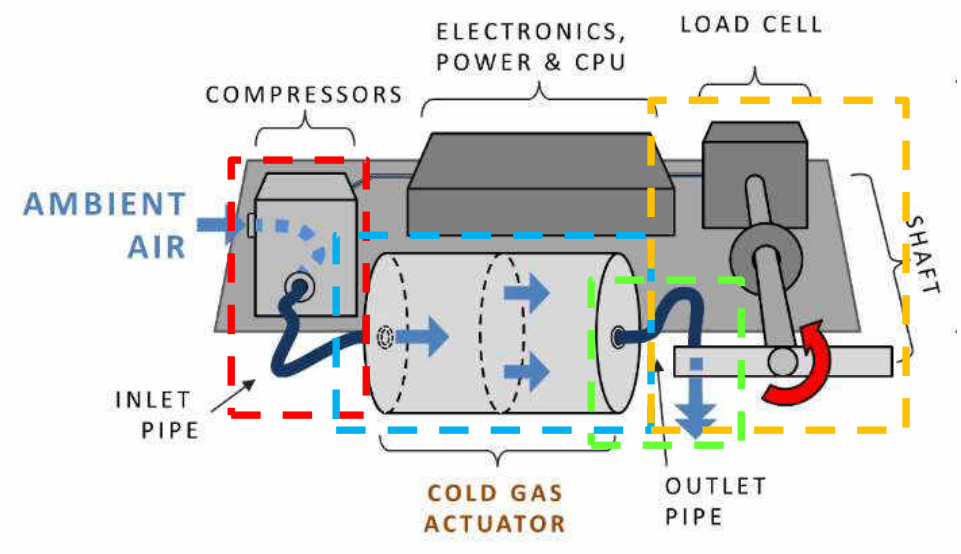
  - Development of a **cold-gas-actuator** (thrust 10-100 mN)
  - ✓ Attitude control of small balloons and airships
  - ✓ Propulsion of autonomous micro-air-vehicles (MAV)

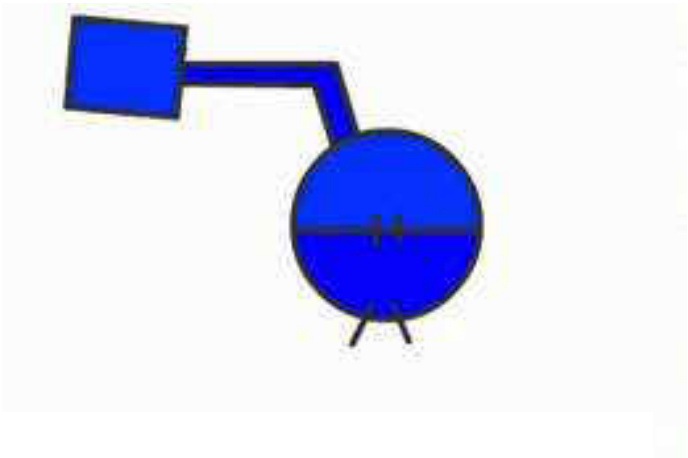
  - Test of the actuator during the stratospheric flight
  - ✓ Assessment of the performances at different altitudes (**0..35 km, pressure 3..1000 mbar, temperature 0..-80°C**)

- Main Features:

  - **Atmospheric air as propellant**
  - ➔ **Rechargeable, no on-board fuel = unlimited autonomy**

S.C.R.A.T. Working Principle





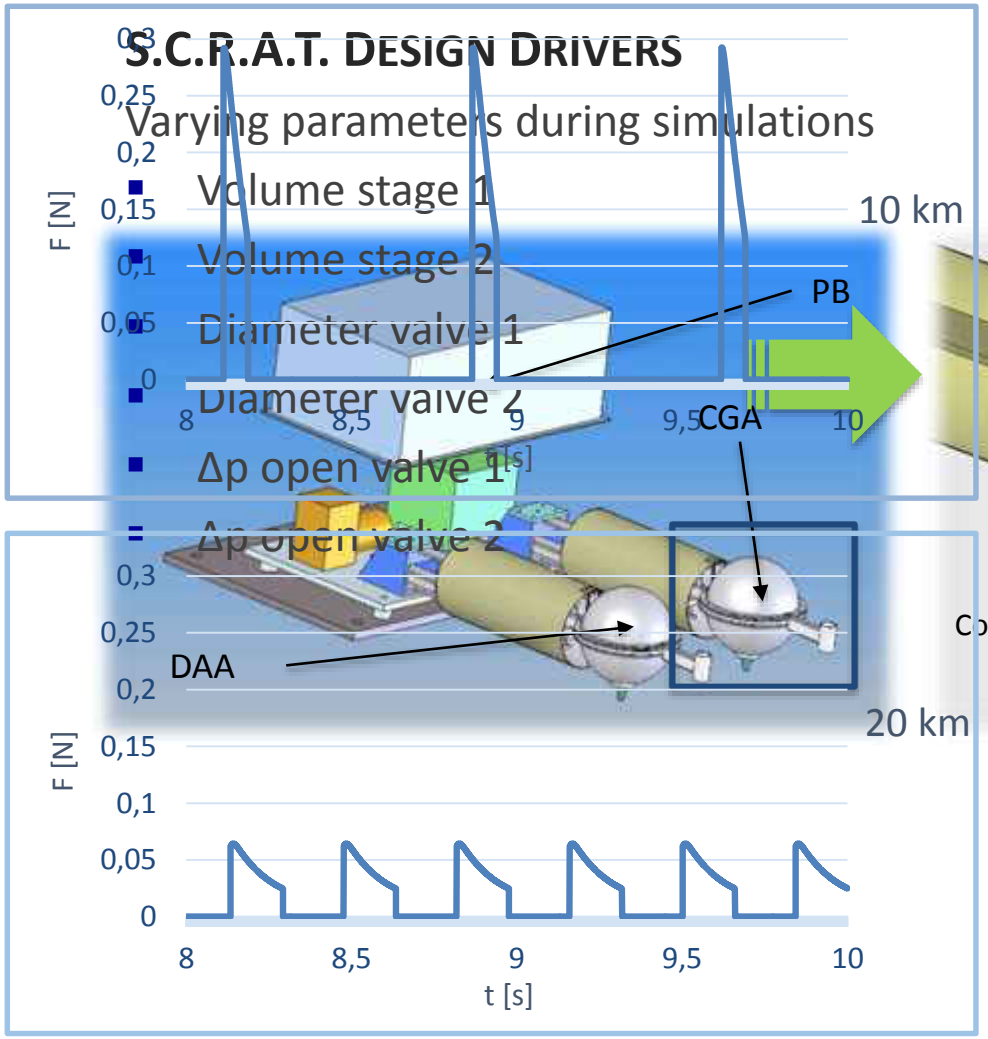
1. The micro-compressors pressurize the first stage of the actuator
2. The first valve regulates the air transfer to the second stage
3. The second check valve regulates the thrust delivering
4. The thrust delivered by the nozzle is measured by means of a torsional load cell

Rx/Bx Selection Workshop

S.C.R.A.T. Design Drivers

Varying parameters during simulations

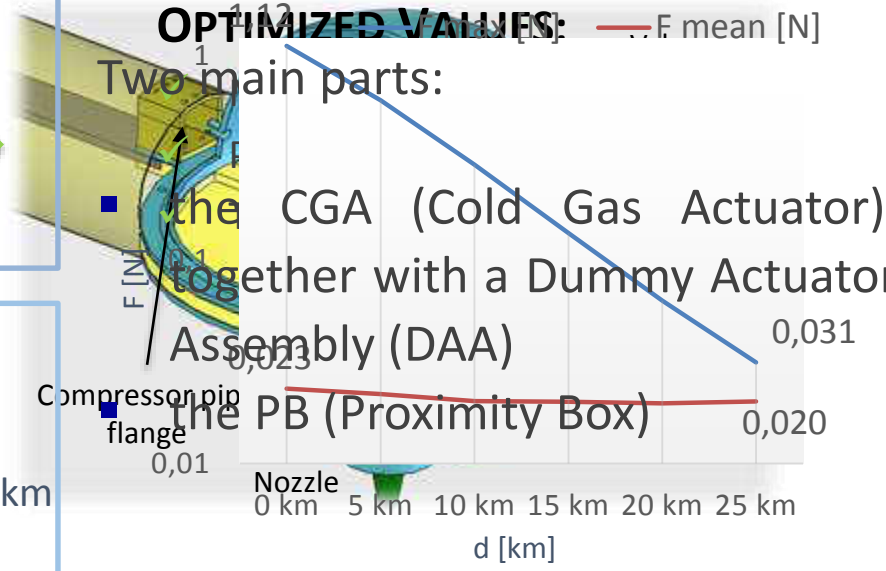
- Volume stage 1
- Volume stage 2
- Diameter valve 1
- Diameter valve 2
- Δp open valve 1
- Δp open valve 2



Optimized Values:

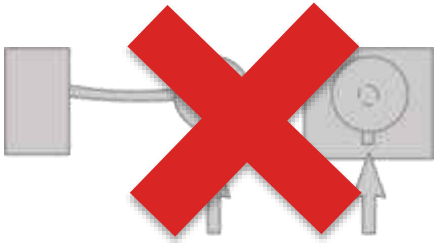
Two main parts:

- the CGA (Cold Gas Actuator), together with a Dummy Actuator Assembly (DAA)
- the PB (Proximity Box)

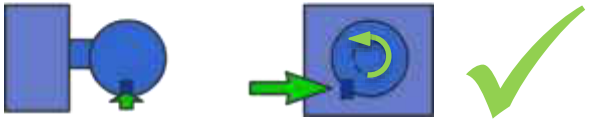


Preliminary Design Review

S.C.R.A.T. First Evolution

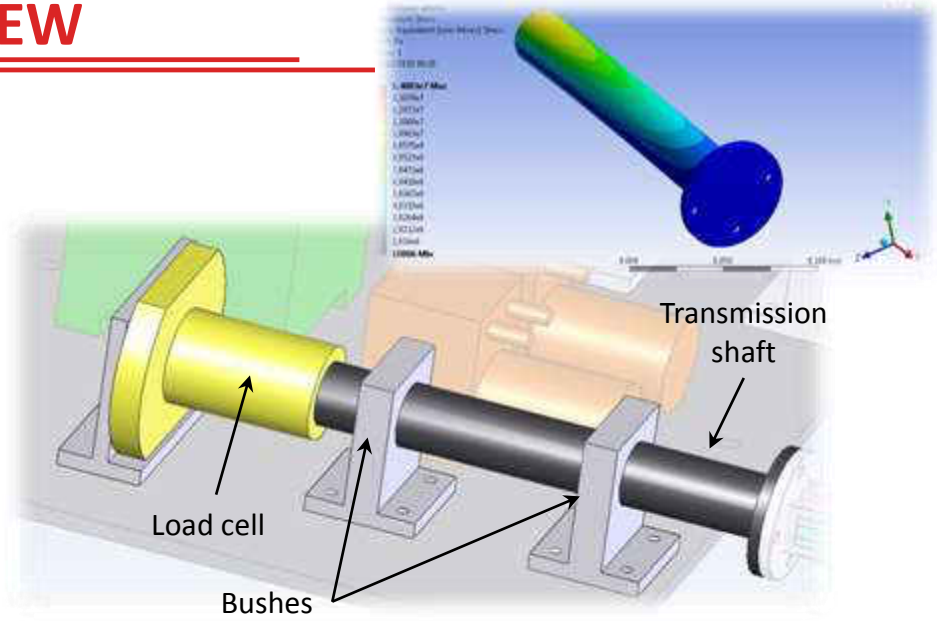


Flexural measure

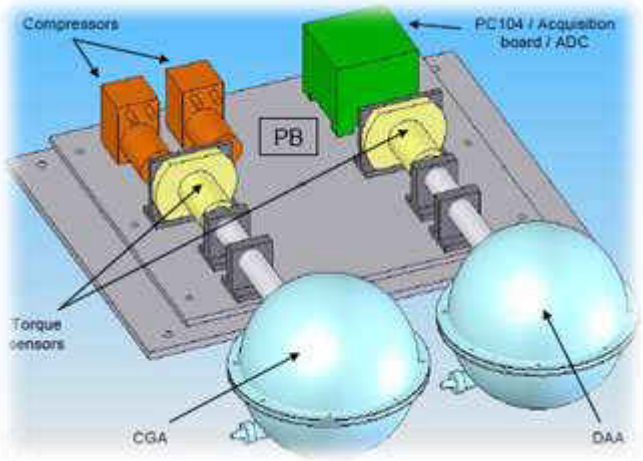


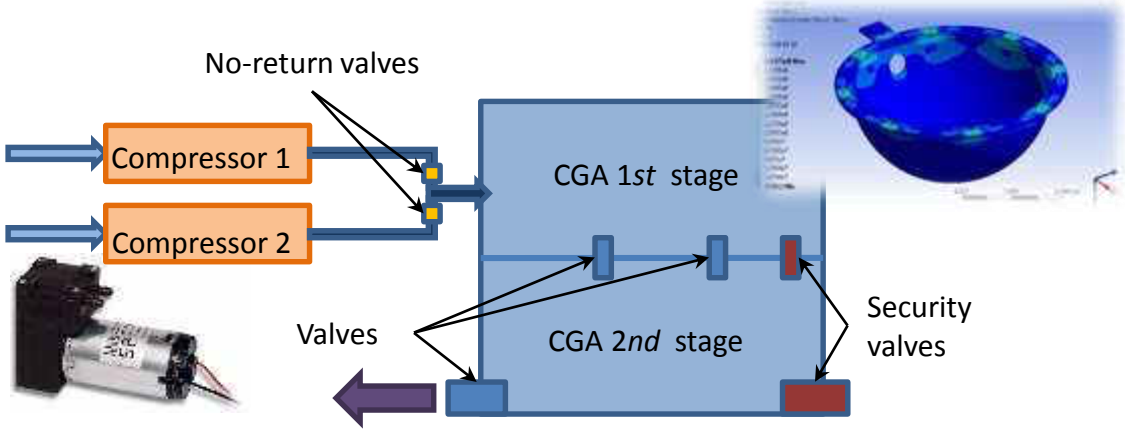
Torsional measure

Thrust measurement method



Shaft design



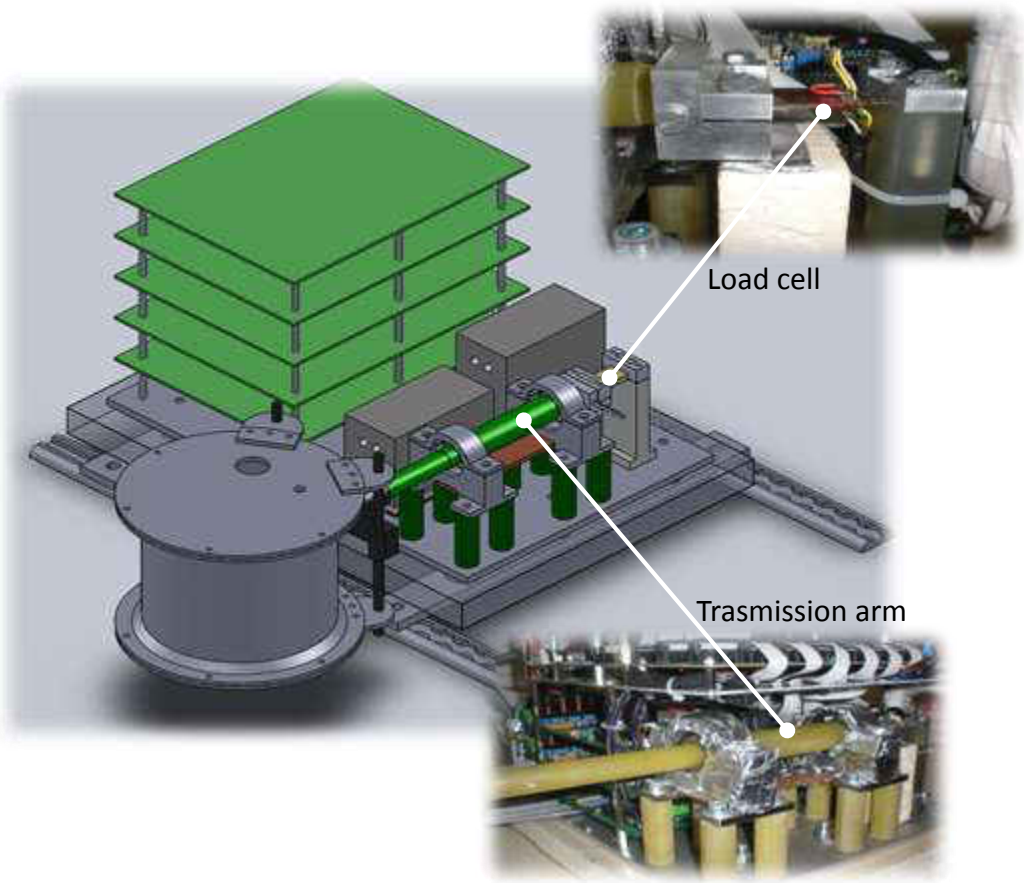


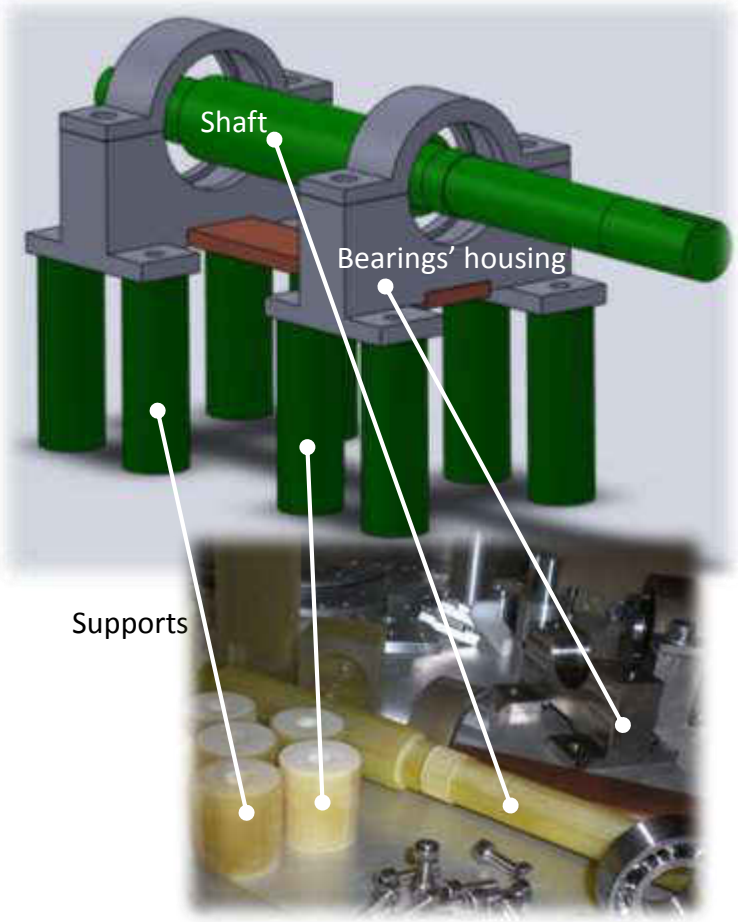
Compressors in parallel

Critical Design Review

S.C.R.A.T. Deep Evolution

- only one cylindrical vessel (the CGA) outside the gondola
- shaft to sustain the CGA and transmit the torque

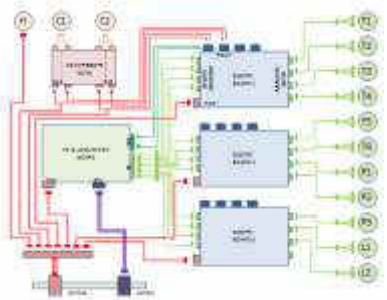


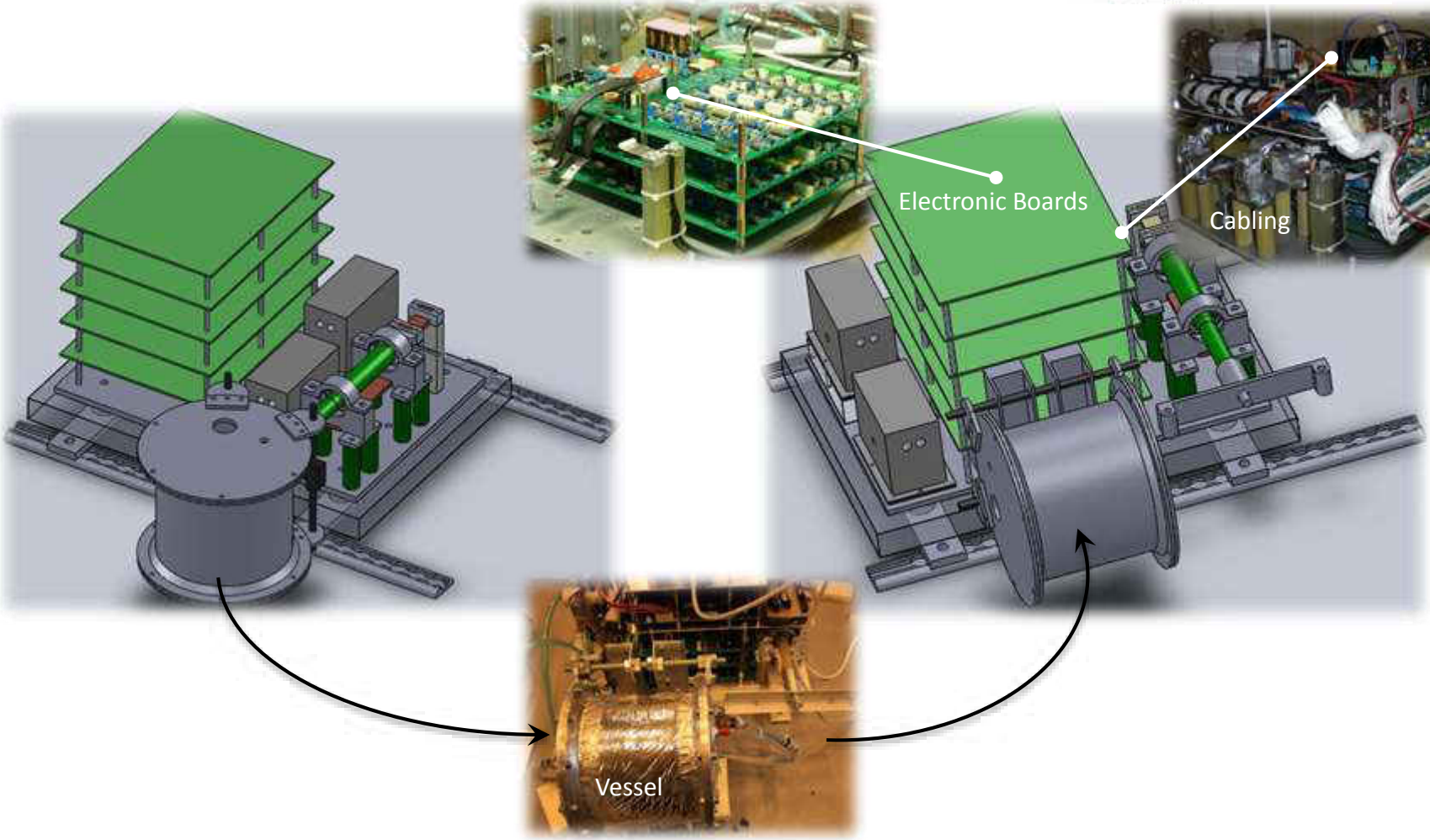


Experiment Acceptance Review

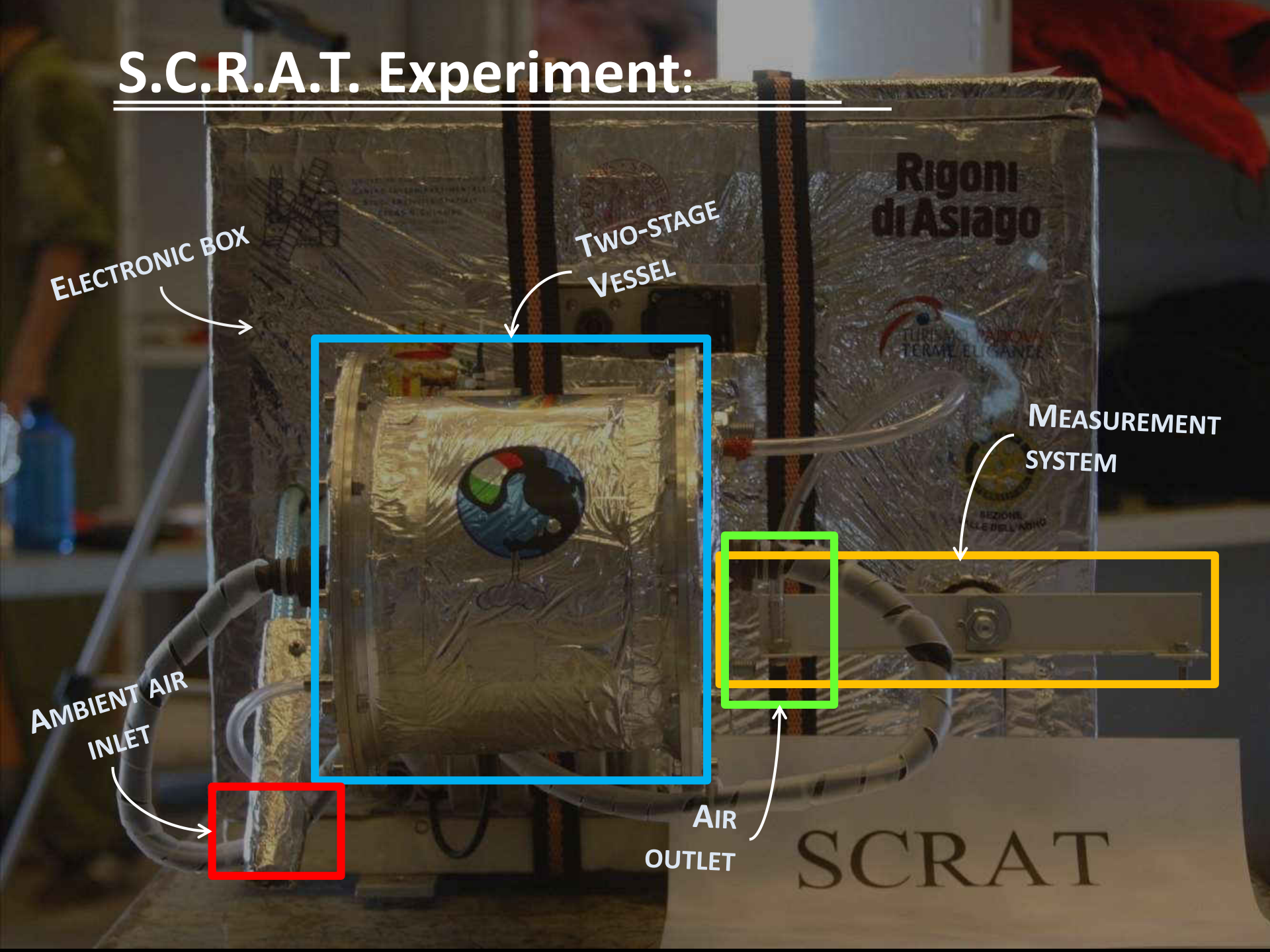
S.C.R.A.T. New Design

- CGA on two angle brachets



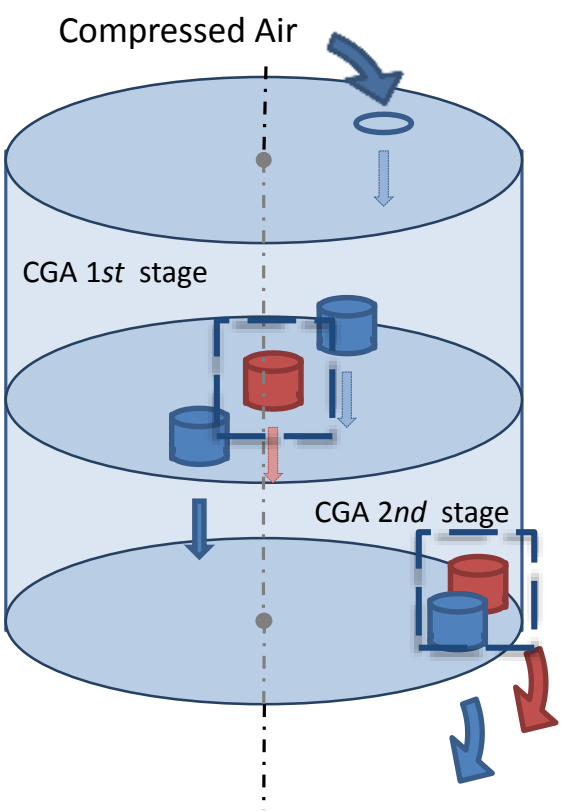


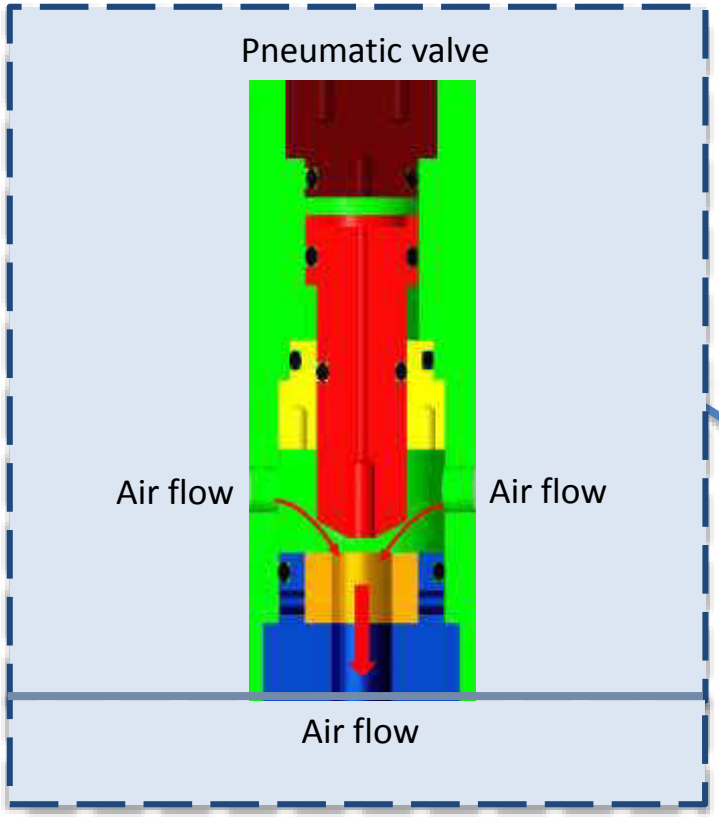
S.C.R.A.T. Experiment:



Problem Solving Approach

Valves





Prototype

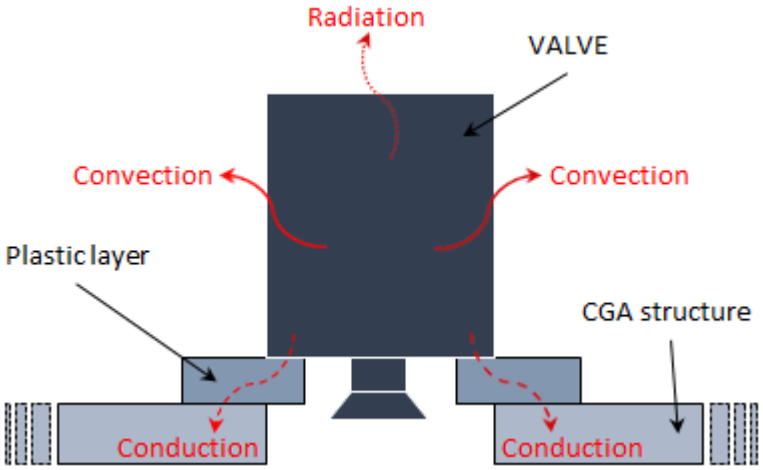
Backup solution

Problem Solving Approach

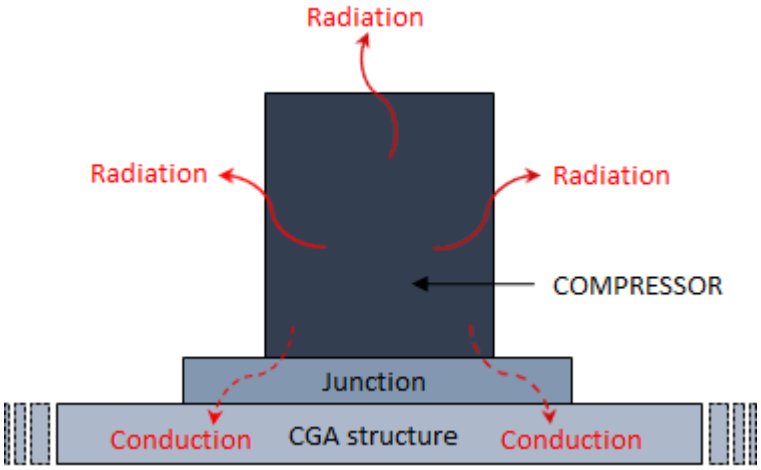
Thermal Control

Bearings

Valves



Compressors



Integration & Launch

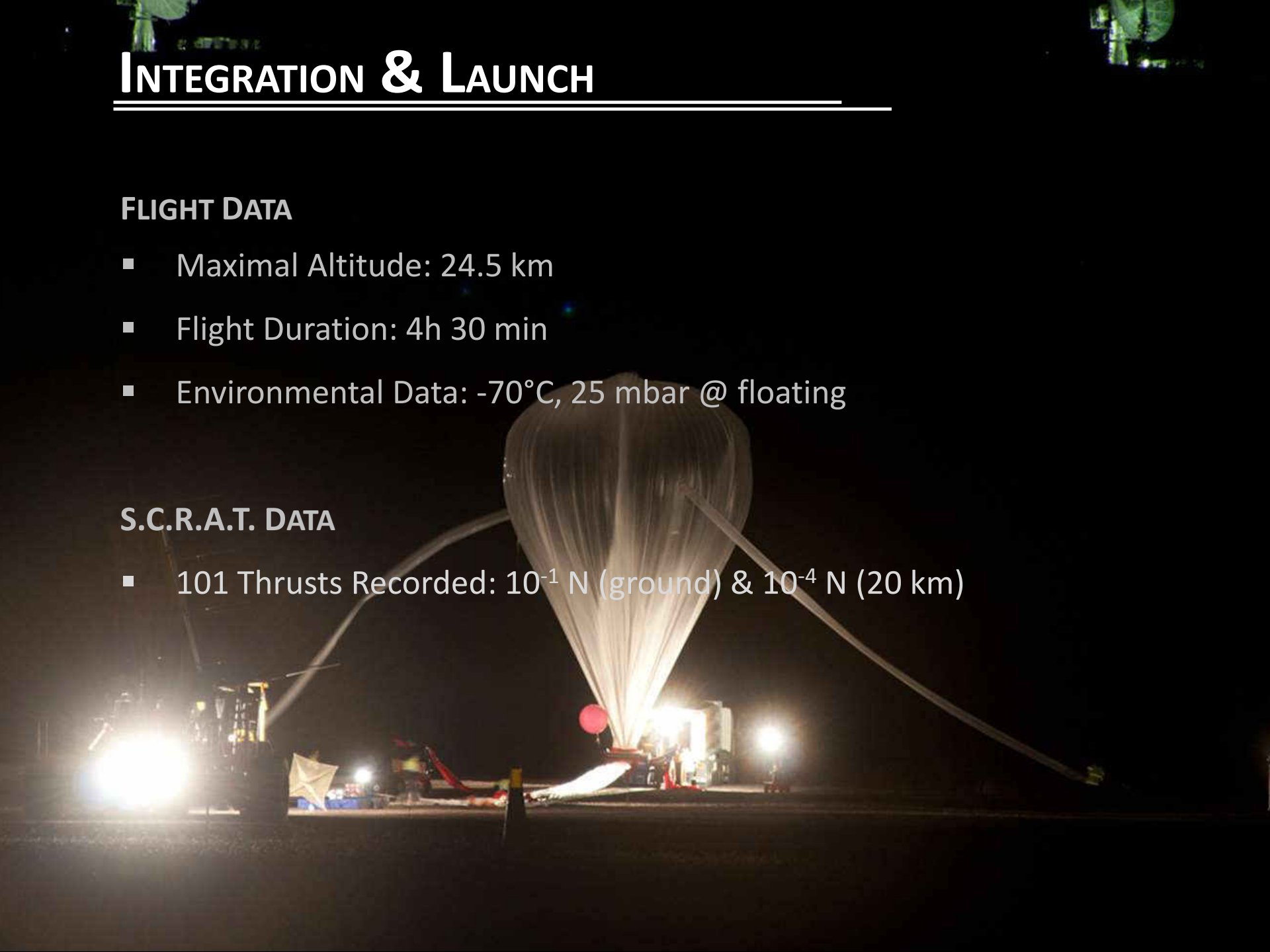
Integration & Launch

Flight Data

- Maximal Altitude: 24.5 km
- Flight Duration: 4h 30 min
- Environmental Data: -70°C, 25 mbar @ floating

S.C.R.A.T. Data

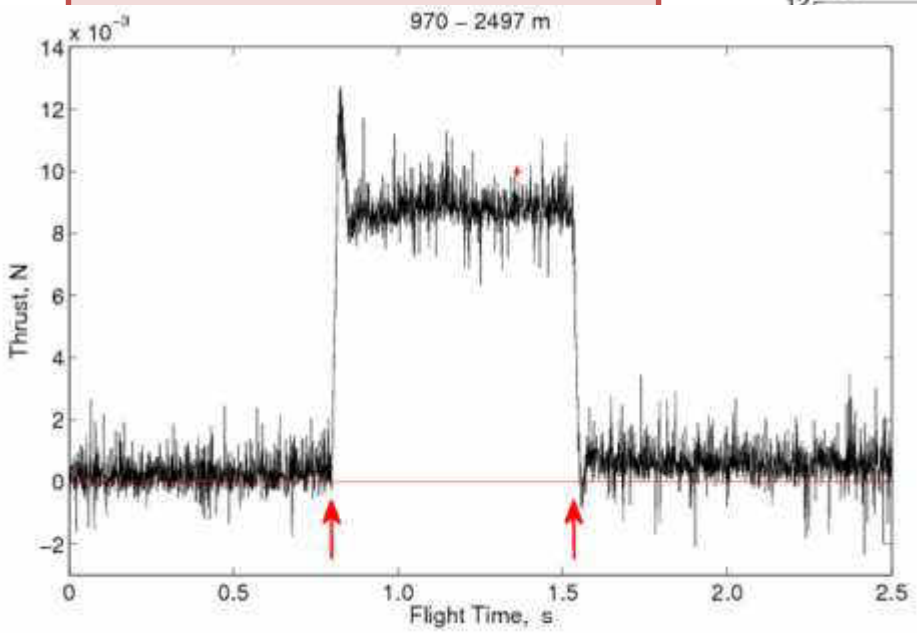
- 101 Thrusts Recorded: 10^{-1} N (ground) & 10^{-4} N (20 km)

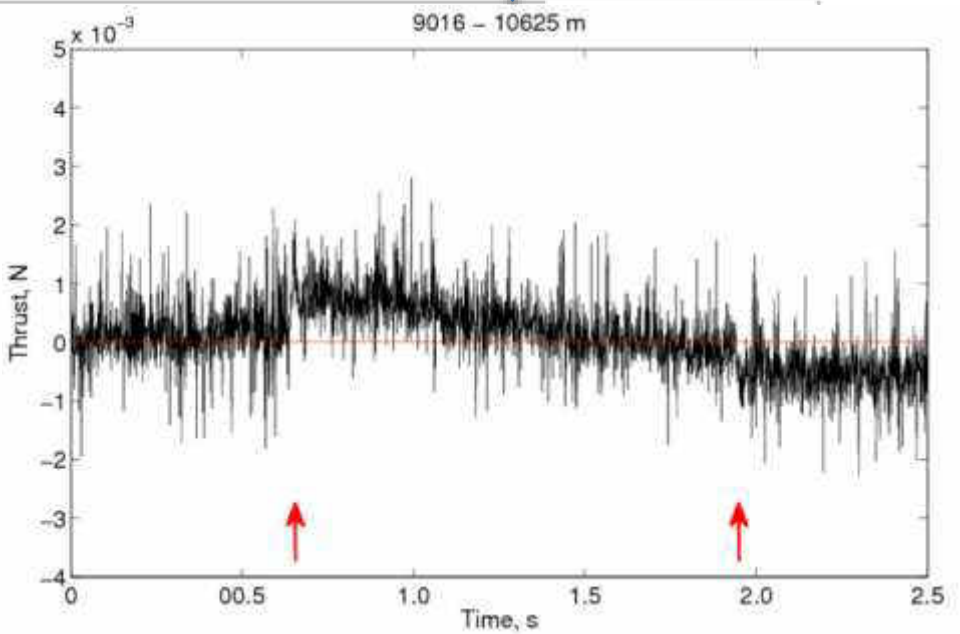


Flight & Data Analysis

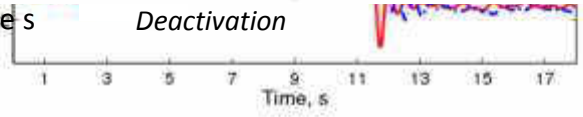
1. RAW SIGNAL EXAMINATION & PULSE IDENTIFICATION

2. FILTERING



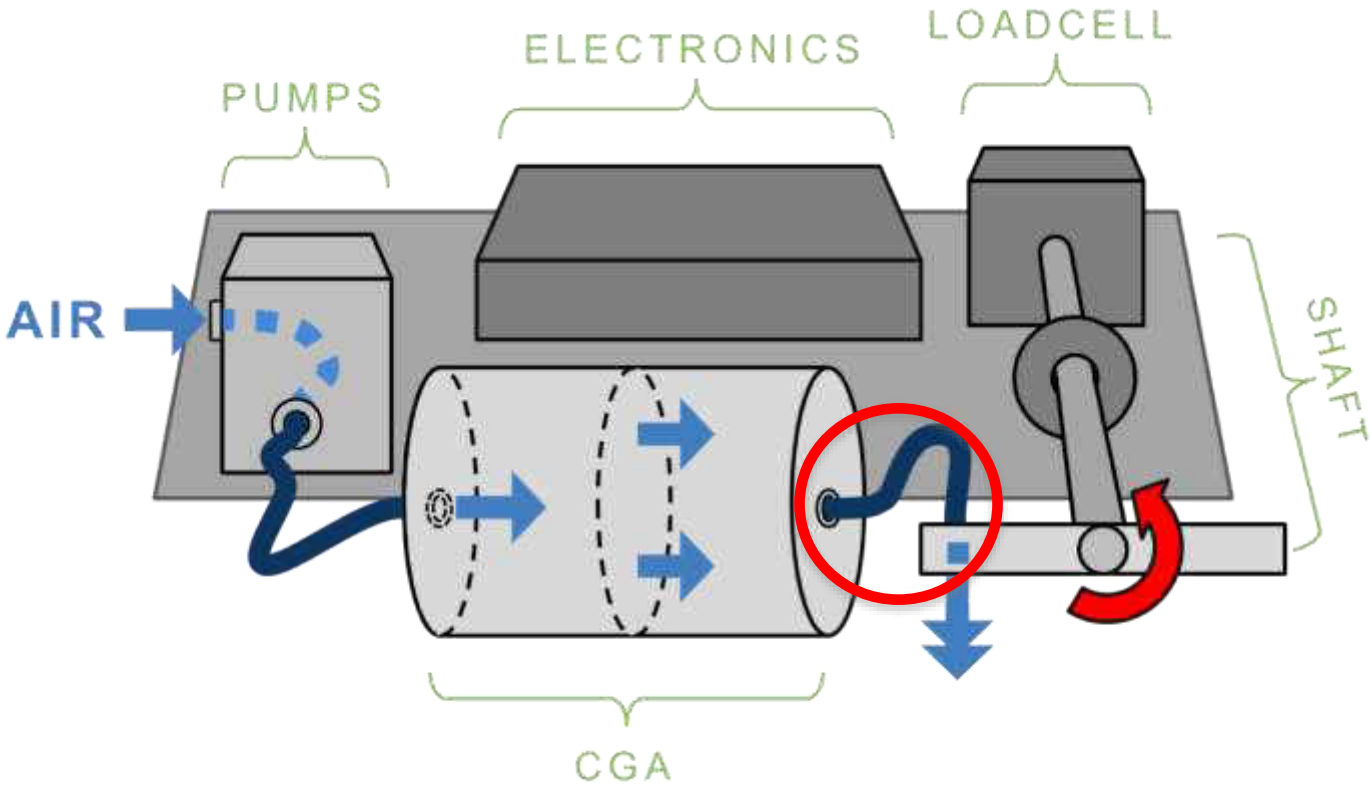


Activation Time s *Deactivation*



RESULTS (1/2)

- Discrepancy between simulations and experimental data



- CFD simulations: pipes load effect

RESULTS (2/2)

SCIENTIFIC RESULTS

- Thrusts between 10^{-1} N (ground) and 10^{-4} N (25 km)
- Total impulse in the range 10^{-2} Ns (ground) and 10^{-3} Ns (25 km)
- Respect standard CGA elaborating the same impulse, saving:

  0.25 kg/h of propellant (15 km of altitude)

  0.67 kg/h of propellant (<5 km of altitude)

SECONDARY RESULTS:

- Atmospheric and density models

Lessons Learned & Conclusions

Rexus Bexus Programme

- Possibility to participate to a real, little space mission!
- Hands-on Activity: from design to assembly & test to launch
- International Experts support

Technical Growth

- Most important lesson: keep the experiment as simple as possible
- Learn scheduling and organization

Personal Growth

- "S.C.R.A.T. Tuesday evenings"

Thank you for your kind attention.
Questions?

Matteo *Michele* *Leonardo* *Ruggero* *Federico* *Antonio*

Giulio *Lorenzo* *Marco* *Gabriele*