FELDs Experiment: a new flexible soft docking concept

Drop Your Thesis! 2014

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Introduction

Space Rendezvous & Docking

Two spacecraft get into close approach and physical connection

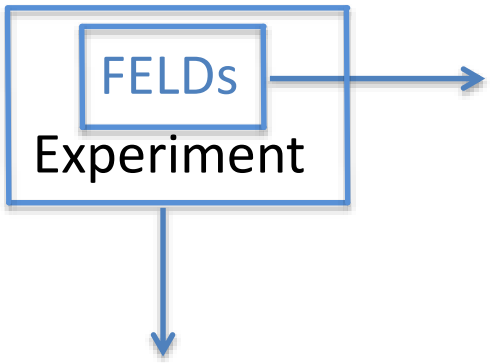
Traditional docking technologies

- Soft docking + hard lock
- Berthing + hard lock

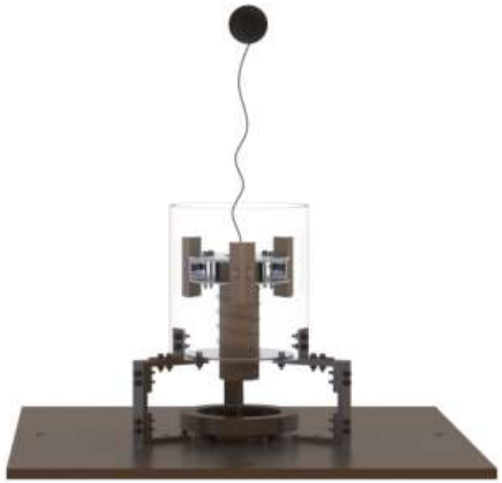
Drawbacks of traditional docking system

- Complexity (large numbers of actuators)
- High peak load trasmission
- Mass budget
- Not suitable for small satellites
- Strict alignment requirements (5 to 6 DoF control)

FELDs Experiment



Flexible
Electromagnetic
Leash
Docking
system



To study the dynamics of an innovative **electromagnetic soft docking** technology composed of a **tethered probe** in a **microgravity** environment

FELDs soft docking advantages

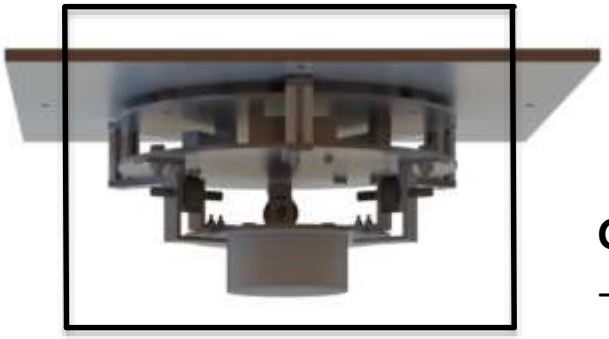
- Looser relative attitude and position control
- No need for close approach
- Self-aligning
- Non-piercing capture
- Multi-shot capability for one capture
- Scalable to Microsat

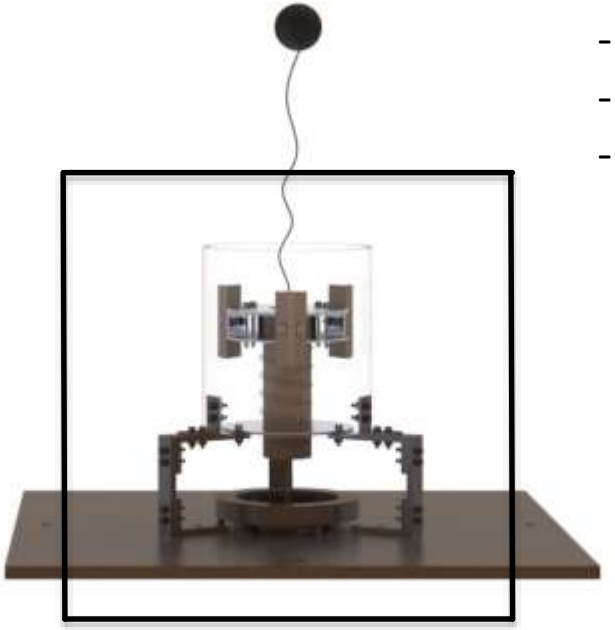
FELDs Experiment

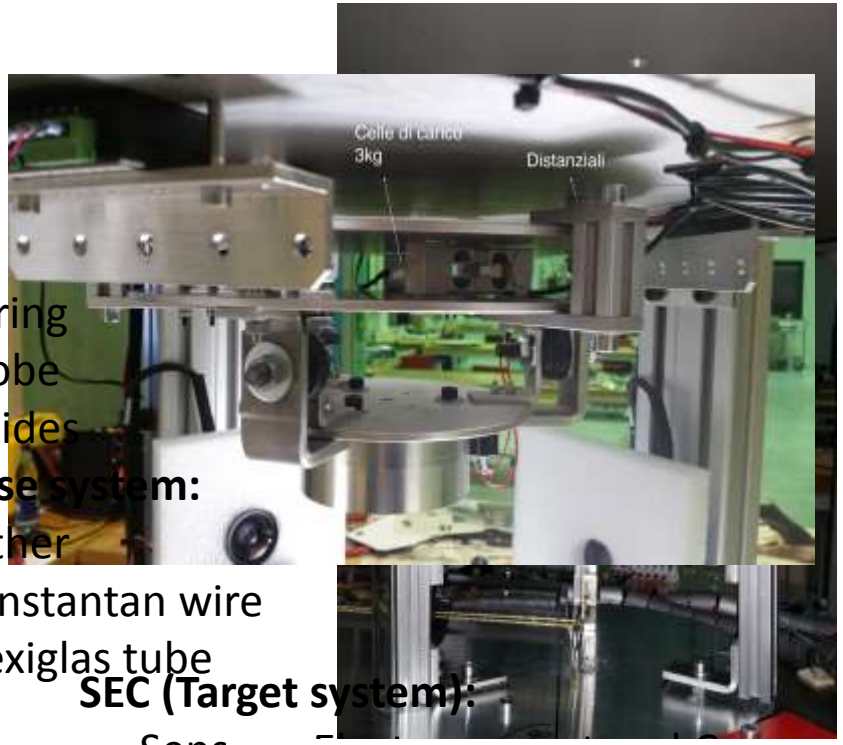
FELDs applications:

- Refueling
- Data Transfer
- Repairing missions
- Crew Transfer
- Space debris removal

The Experiment



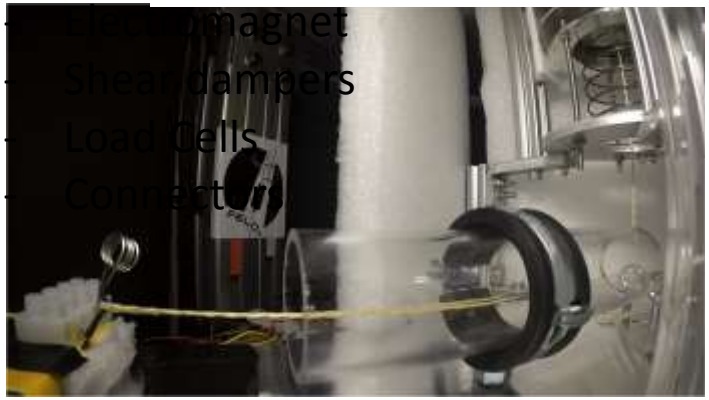




GUN:
- Spring
- Probe
- Guides

Release system:
- Tether
- Constantan wire
- Plexiglas tube

SEC (Target system):
- Sens
- Electromagnet
- Shear dampers
- Load Cells
- Connectors



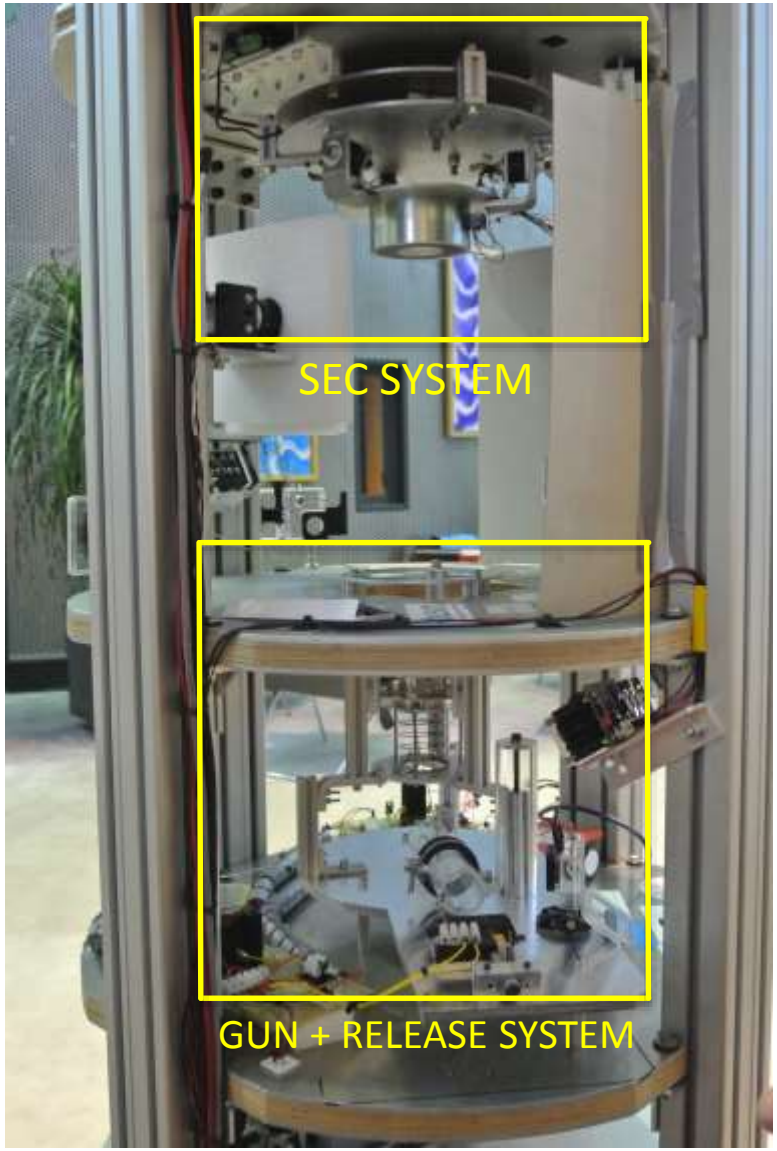
Results

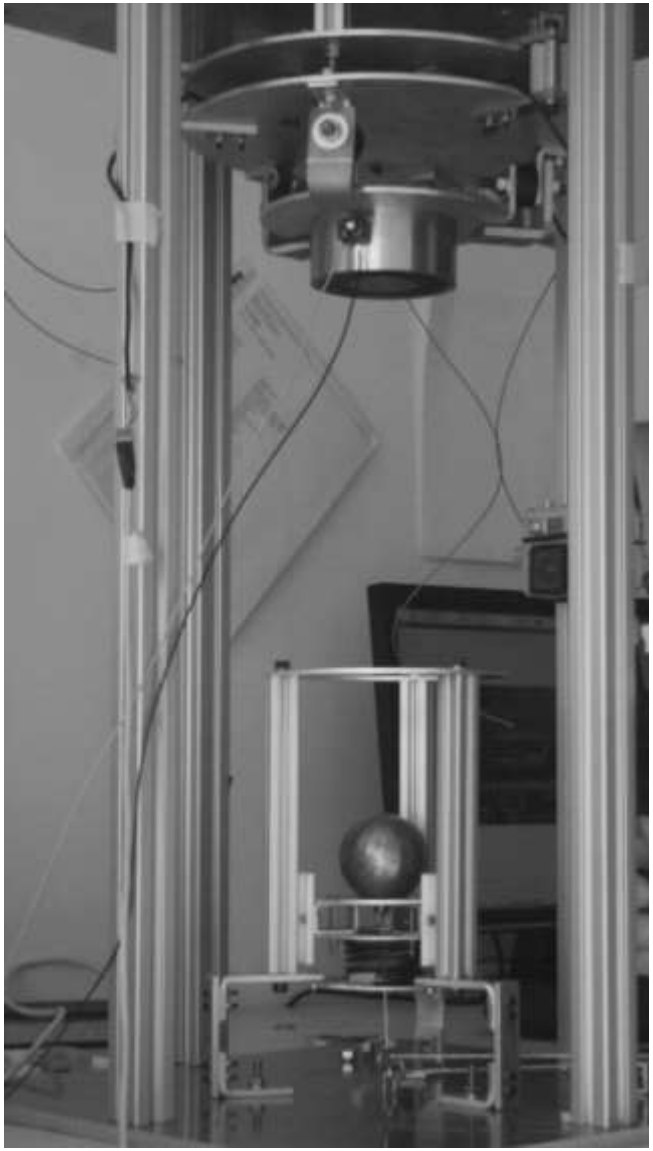
- **SEC System:**
- Measurements (Load cells, shear dampers)
- Assembly
- Vibrational model, impact model

- **GUN + Release system:**
- Friction estimation
- Spring compression (microgravity, measurements)
- Design (light, strong, materials)
- Tether material

- **Design:**
- Distance between GUN and SEC
- Assembly
- Components orders
- Stereoscopic video system
- Electronics
- Budget
- Management

The Experiment





Drop Your Thesis!

The Drop Your Thesis! (DYT) programme gives university students, from bachelor to PhD level, the opportunity to perform scientific or technological research in microgravity conditions.

Drop tower:

- Height: 146 m
- Fall: 120 m
- 4.74 s of microgravity
- 5 Drops
- Deceleration at 50 g

Drop Campaign

- 3-14 November 2014, ZARM Drop Tower, University of Bremen

Integration week:

- Assembly
- System improving
- Gravity tests (Mechanics, Electronics, Informatics)

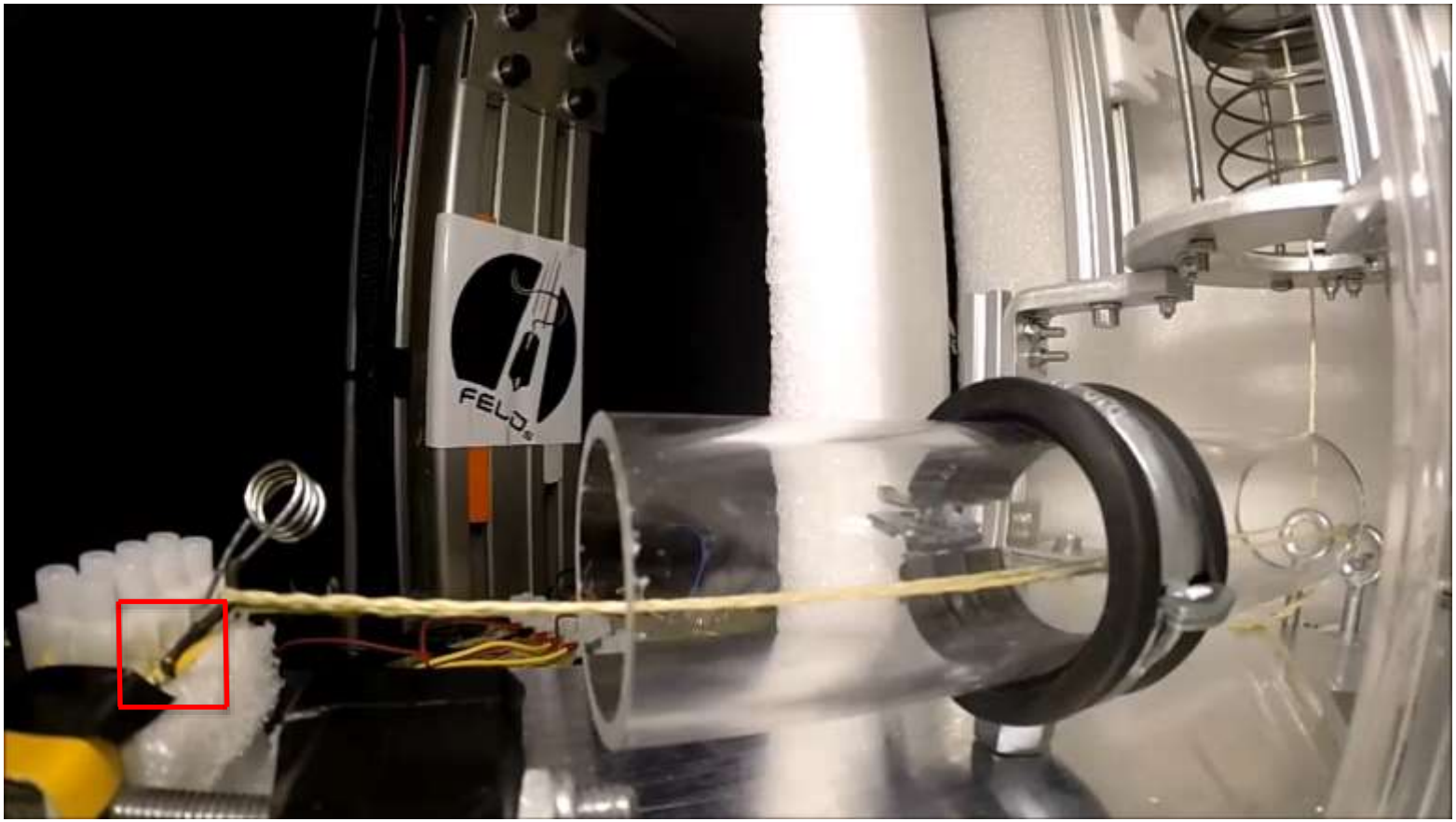


Drop week:

- 5 drops (one per day)
- Live results
- Changes & adjustements of the system day by day



FELDs Experiment – 1° Drop



- Height between SEC and GUN: 34 cm
- Spring compression: 1.2 cm
- Probe velocity: 0.14 m/s

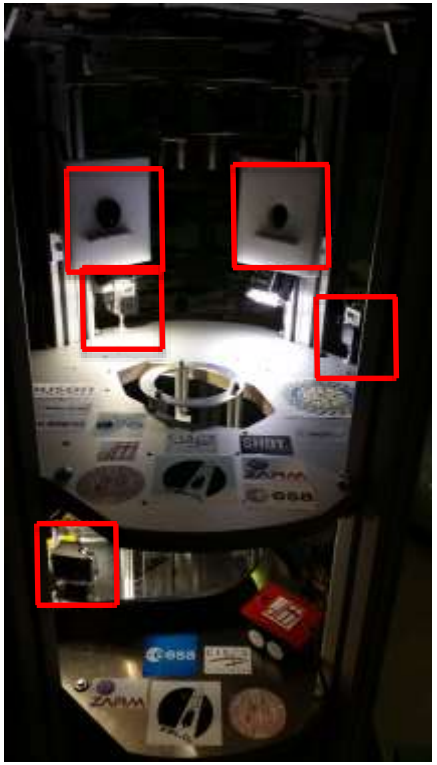
Results

- FELDs experiment gave us a **good response** for almost all the subsystems involved.
- The measurements subsystems gave us two different ways to understand our experiment behavior:

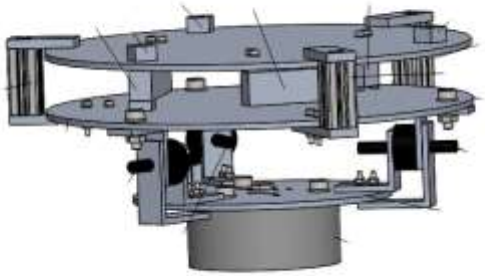
MAGNETIC FIELD ACTION

TETHER DYNAMIC RESPONSE

Thanks to the stereoscopic camera subsystem



SEC DYNAMIC

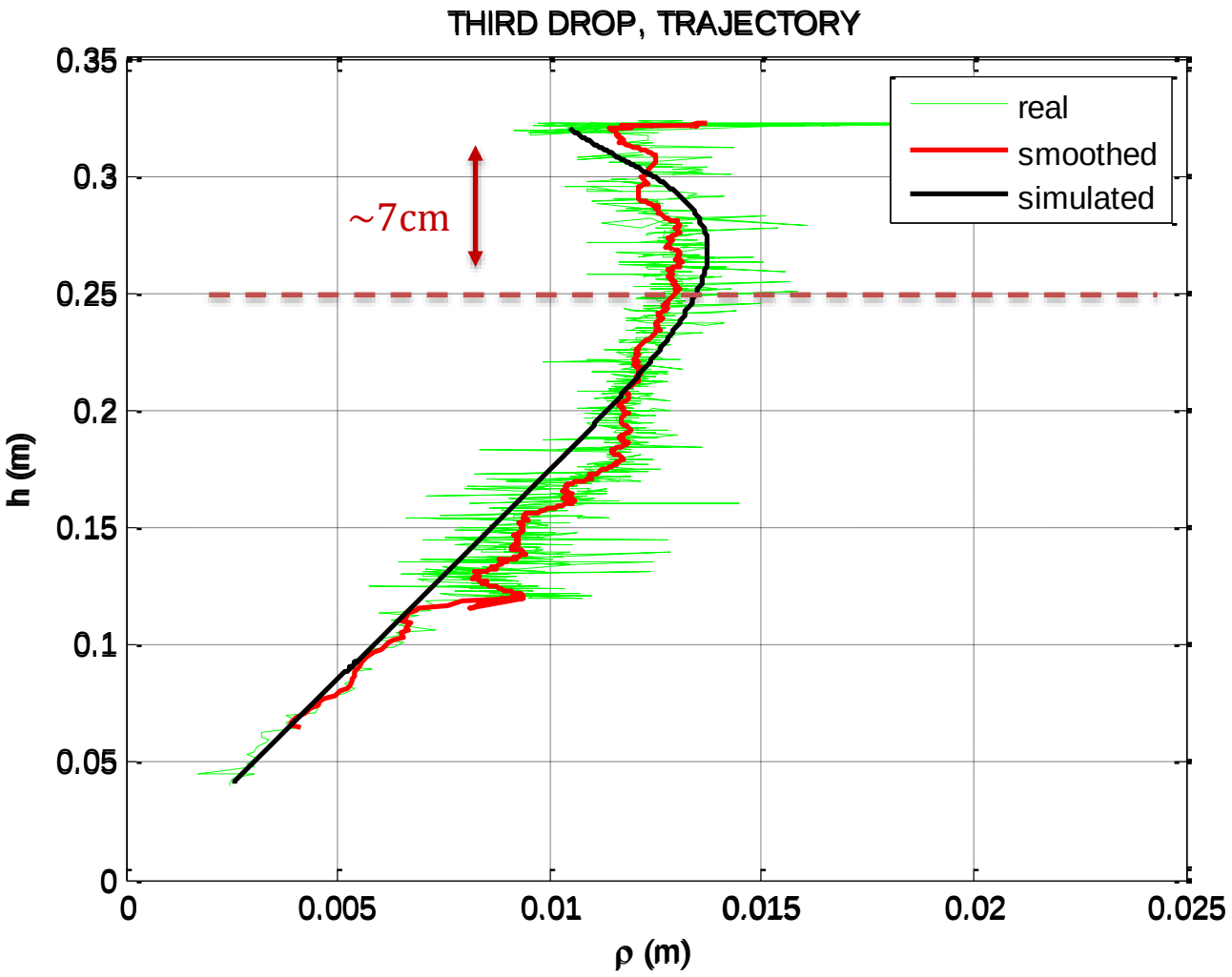


Thanks to the load cells

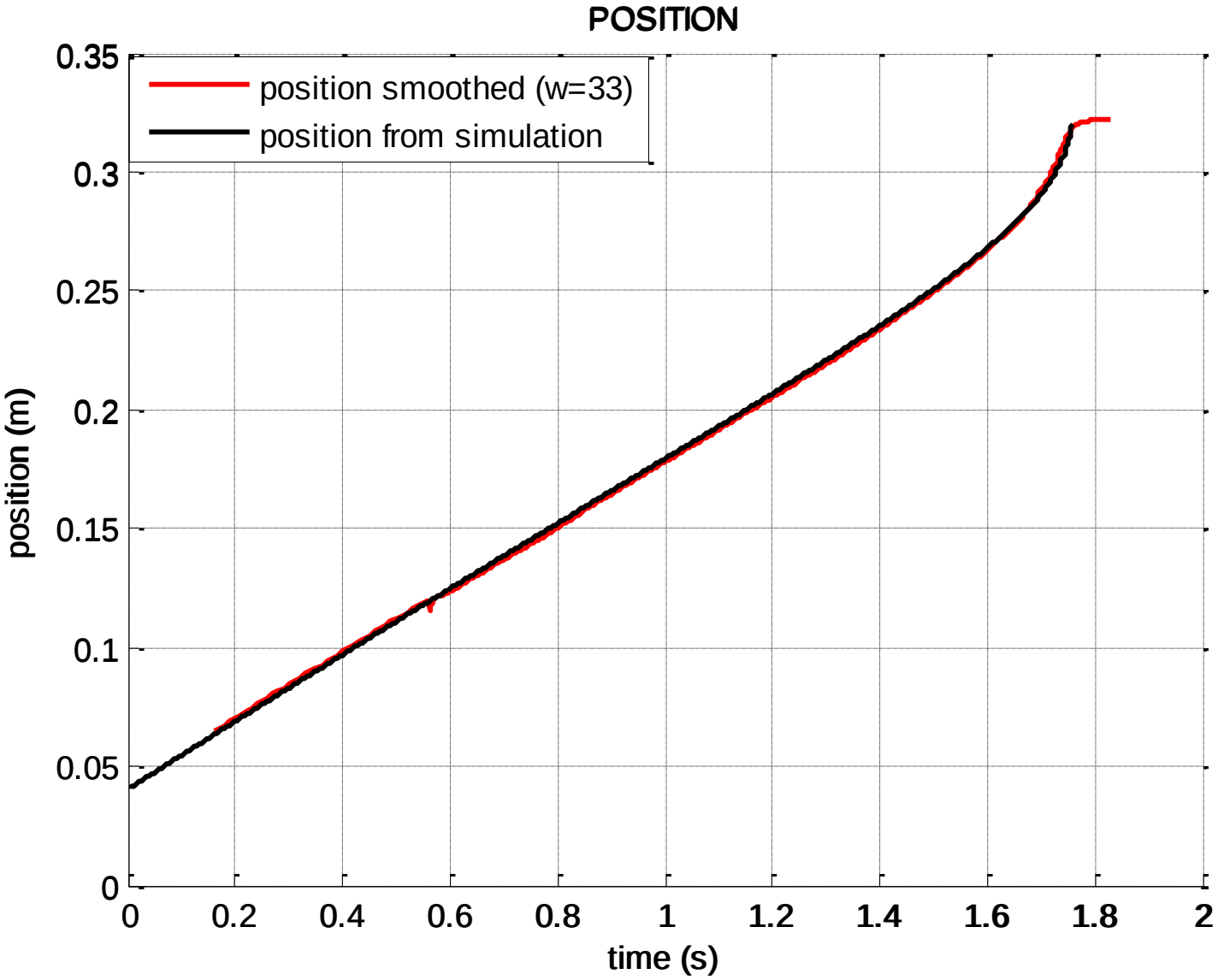
Results – Magnetic Field Action

Magnetic field goal → Prevent the misalignment

→ Facilitate the connection



Results – Tether dynamic response



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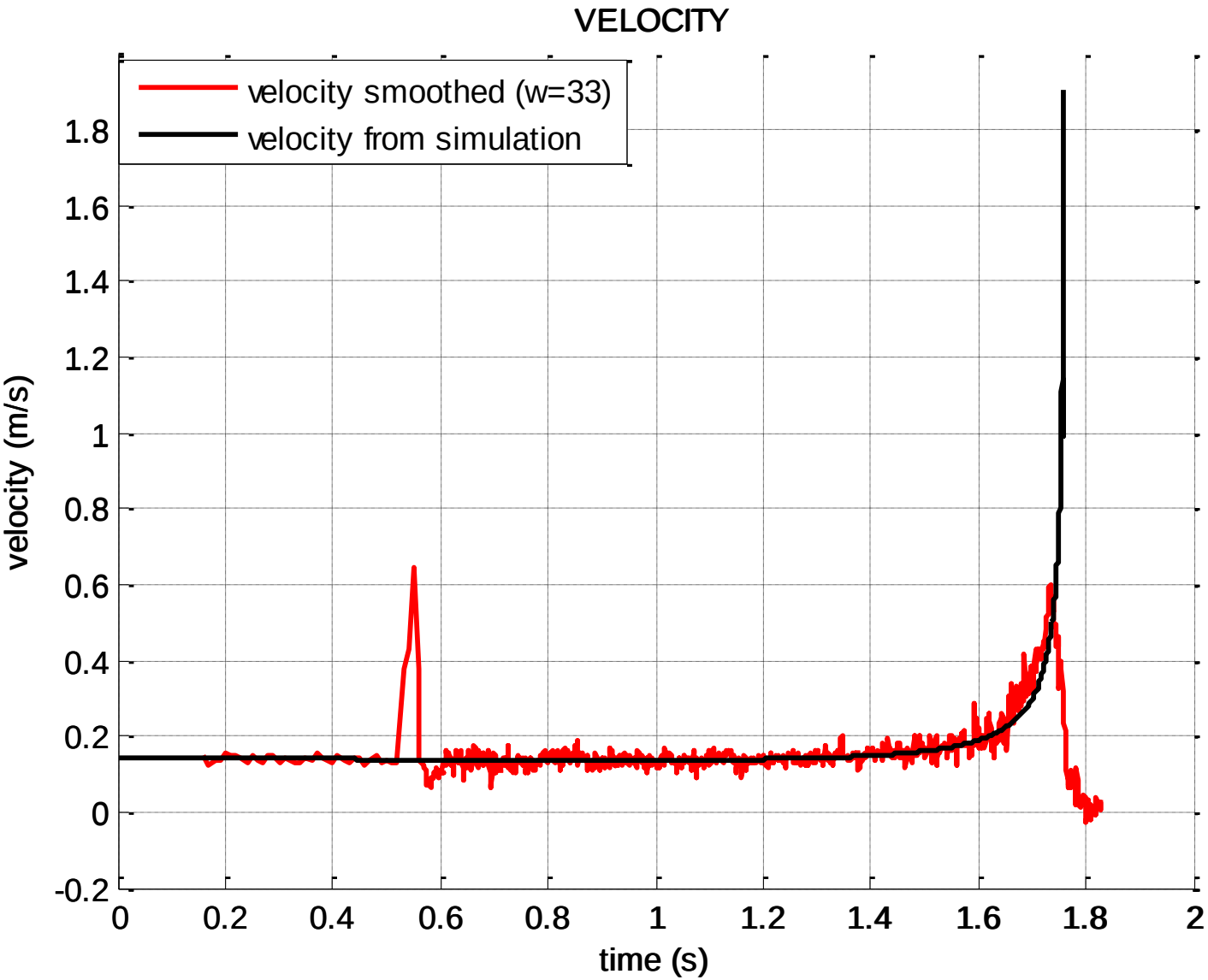
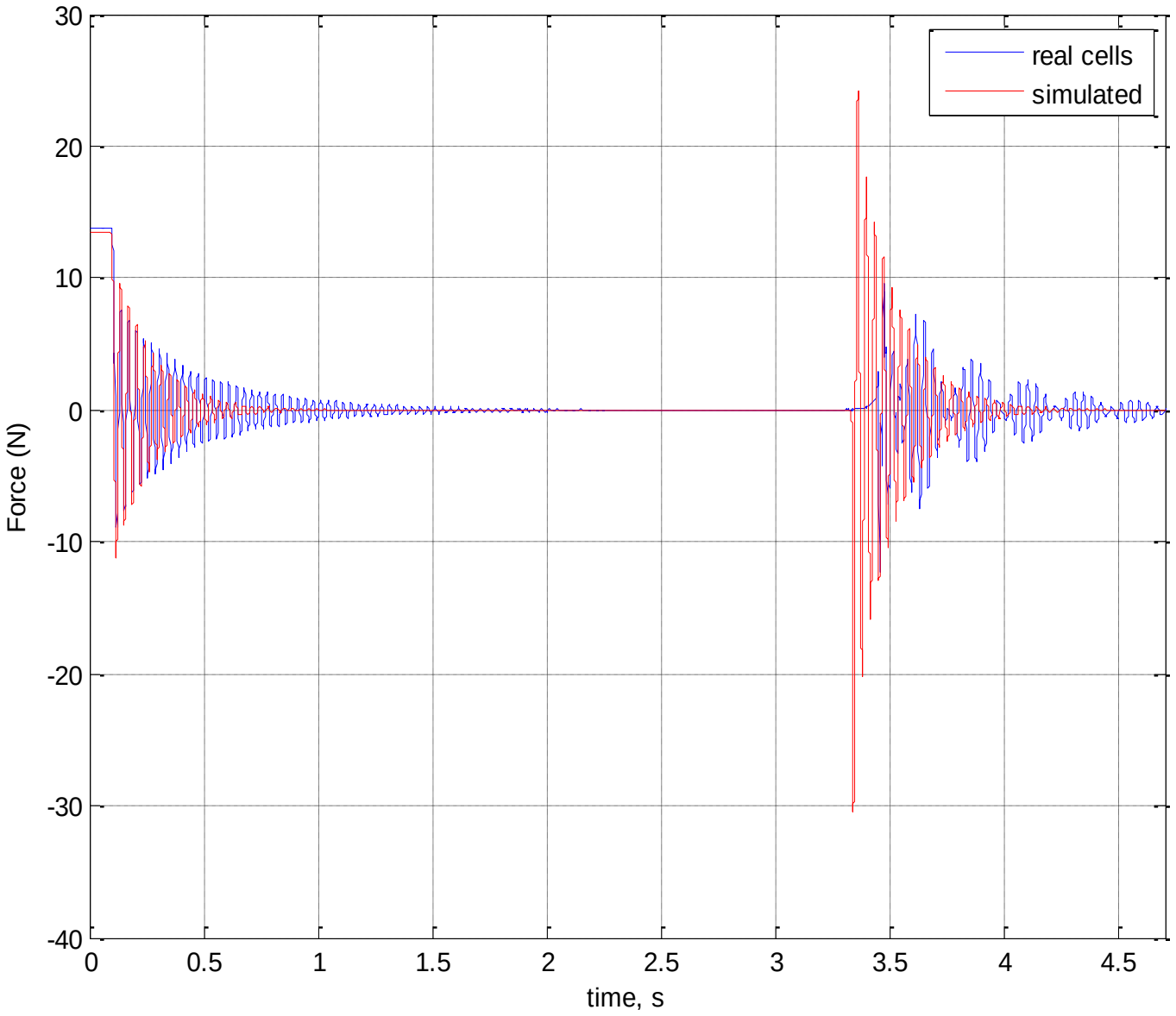


Results – SEC Response



Technical Support

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- Ing. Jan Siemen

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- **ESA (European Space Agency)**
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- Dr. Natacha Callens
- Dr. Piero Galeone

Outreach

- La stampa
- Il sole 24 ore
- Il mattino di padova
- Il Corriere della sera
- ASI website
- ESA Education section
- Rai TV

FELDs Team:

- Best team Project
- IAC2015, Jerusalem, Israel
- Winning team, Hans Von Muldau Award

Conclusions and future developments

Design Process

Building Process

→ Fundamental Learning Experiences

To work in **low gravity** requires special efforts for the design process, giving us several challenges to deal:

→ Even small forces become significant

→ Every detail needs attention, especially those negligible in normal conditions

→ The design process must anticipate all the possible outcomes during the fall

Because of this, FELDs experience gave us a special opportunity to try our skills managing this kind of behavior

Conclusions and future developments

Every drop gave us an important lesson

→ The unsuccessful drops showed the importance of the flexible tether release

→ The three successful drops gave us an encouraging feedback.

- Fitting well to the theoretical models and simulations
- Demonstrating the capability of this technology

Drop Your Thesis! Campaign revealed itself as an important experience for our future.

- Networking
- Design
- Opportunities
- Pragmatism
- Inspiration
- New experiences

Thank you for your attention!

Any questions?