

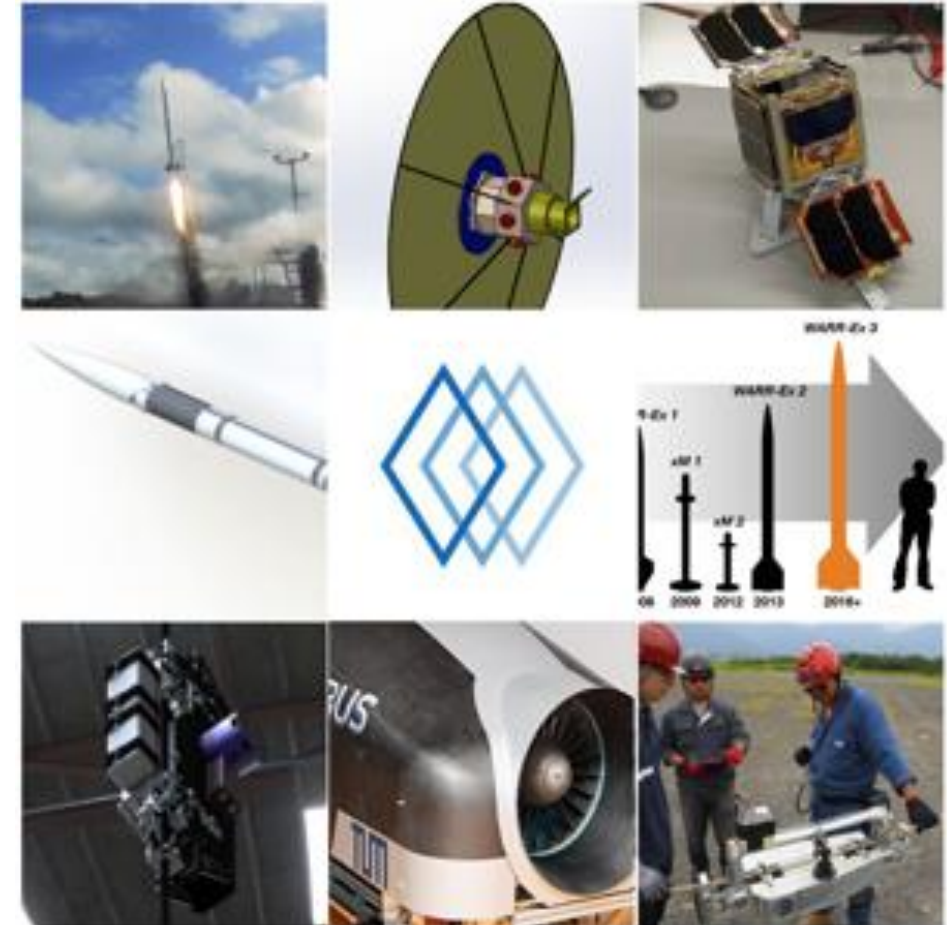
WARR Hyperloop II



About WARR

*WARR = **W**issenschaftliche
Arbeitsgemeinschaft für **R**aketentechnik
und **R**aumfahrt*

- Student group since 1962
- First German hybrid rocket (1974)
- Multiple project groups (~350 member):
 - Hybrid cryogenic rockets (WARR-Ex 3)
 - CubeSat miniature satellites (MOVE-II)
 - Space elevator prototypes/competitions
 - Interstellar space flight studies



The Vision

In 35 min from Munich to Berlin (580 km at ~962 km/h)



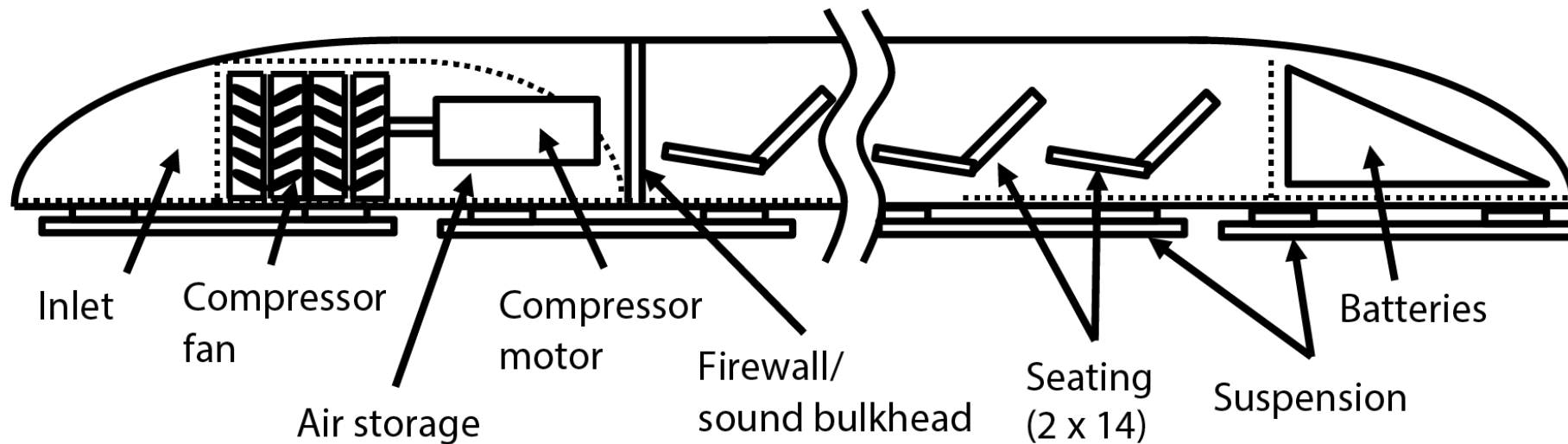
The Hyperloop Concept

High-Speed Ground Transportation System
Proposed by Elon Musk (SpaceX, Tesla) in 2013

Track: elevated vacuum tube
Speed: 1200 km/h



The Hyperloop Concept



Air bearing based capsule concept from the initial alpha study (2013)

<http://www.spacex.com/hyperloopalpha>

SpaceX Hyperloop Pod Competition



Competition vacuum tube at SpaceX, Hawthorne, California

SpaceX Hyperloop Pod Competition

- Student competition to encourage innovation and prototype development
- 1.2 km vacuum tube provided by SpaceX
- Optional pusher vehicle for propulsion



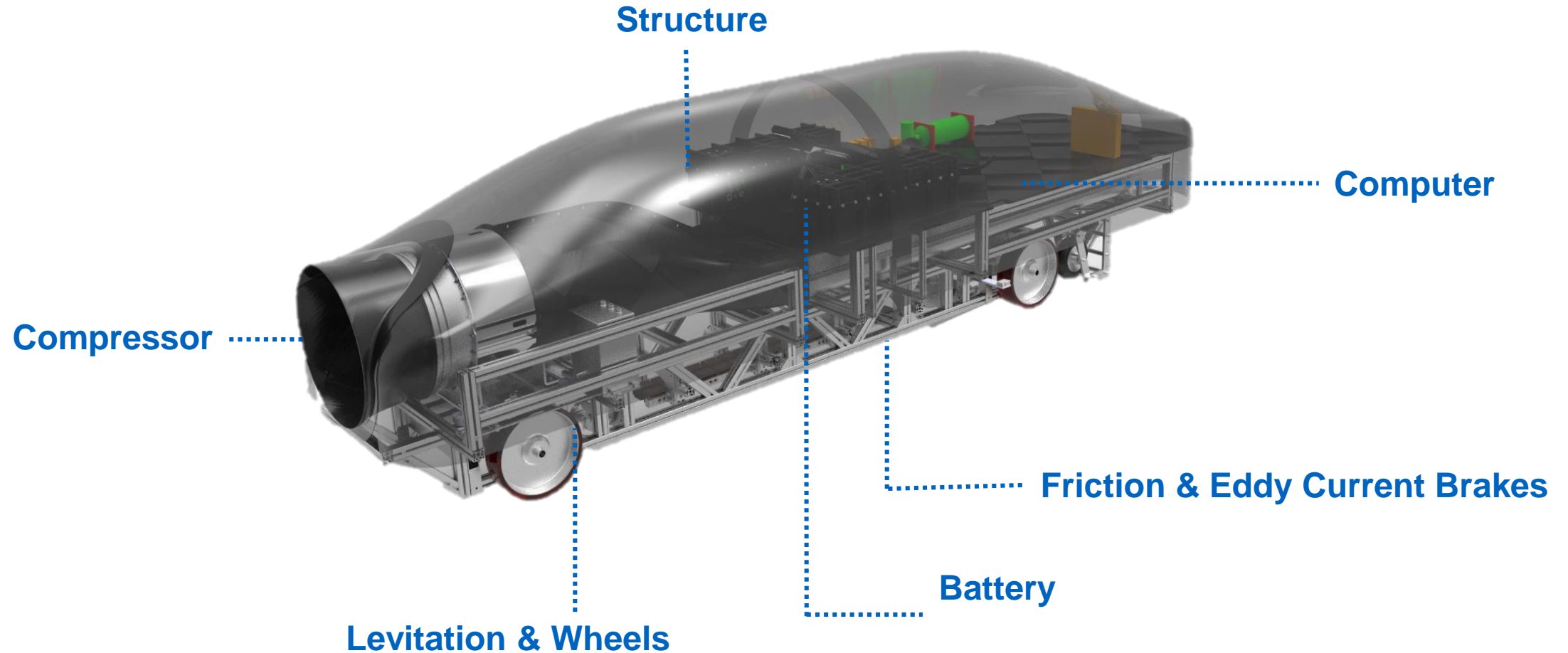
The Team



The Pod



The Pod



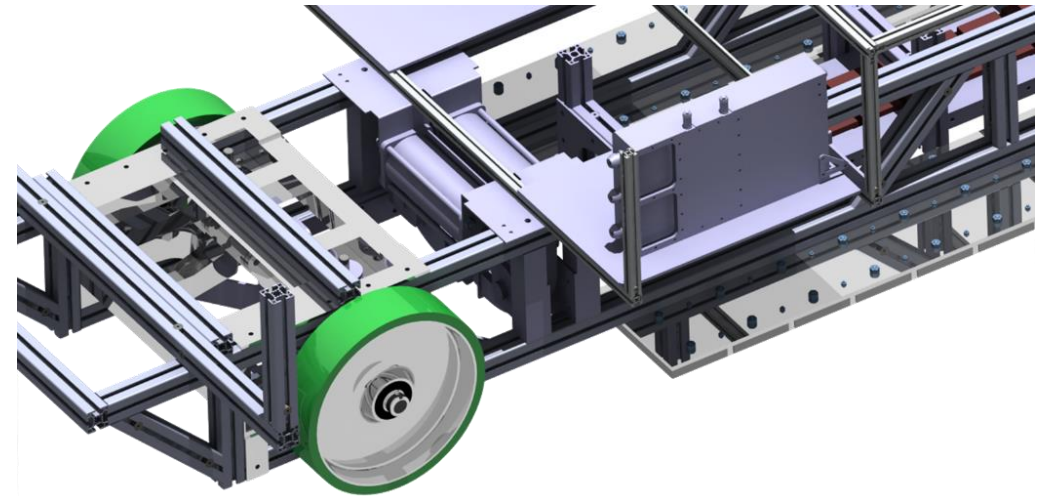
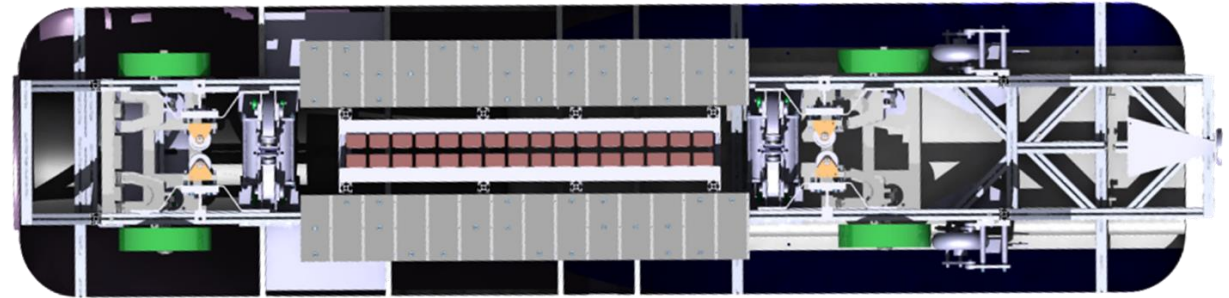
Compressor

- Low pressure compressor Larzac 04 C5 (Alphajet)
- Powered by 30 kW electric motor
- Capacitive water cooling



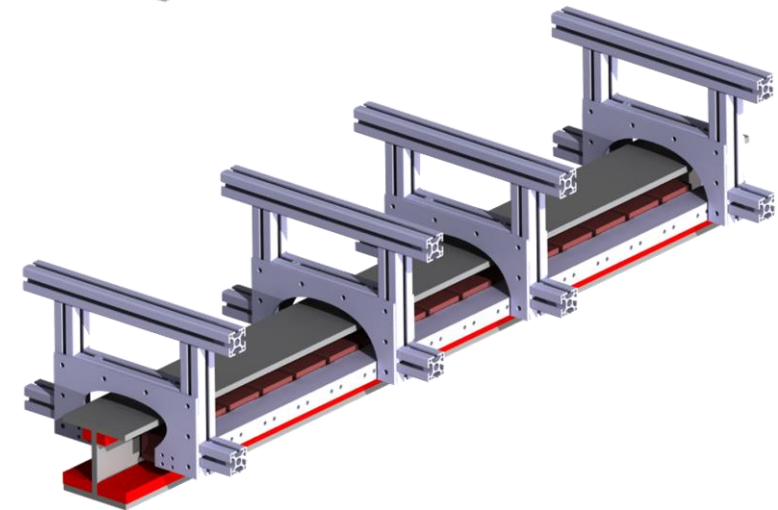
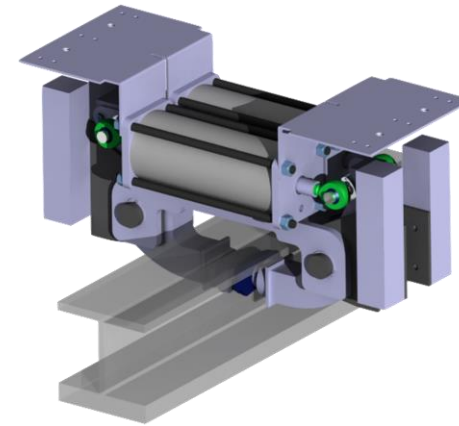
Passive Levitation

- Passive electrodynamic suspension with permanent magnets
- Lift through relative motion over conductive track
- Motion on wheels until liftoff speed



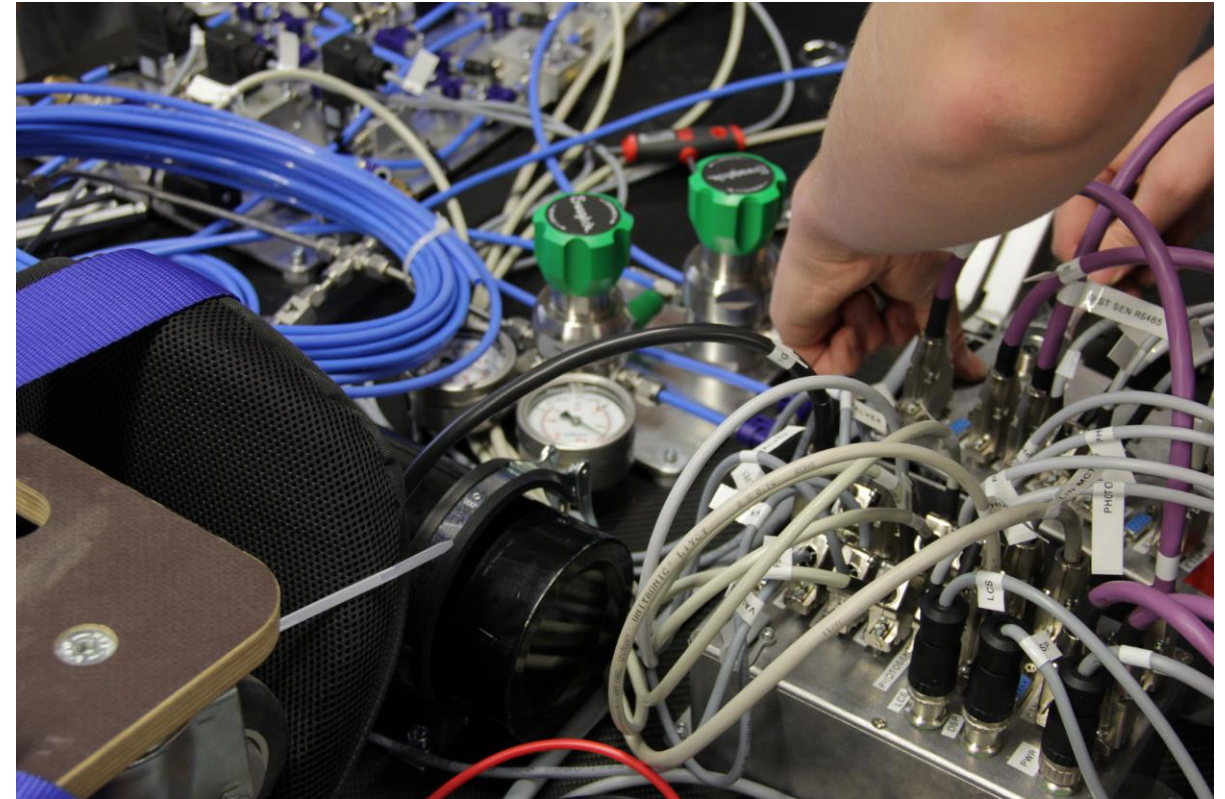
Braking

- Fail-safe, spring actuated pneumatic friction brakes
- Wear-free electrodynamic eddy current brakes



Computer

- Microcontroller based control and navigation system
- Controller communication via CAN
- Ground station control via tube network



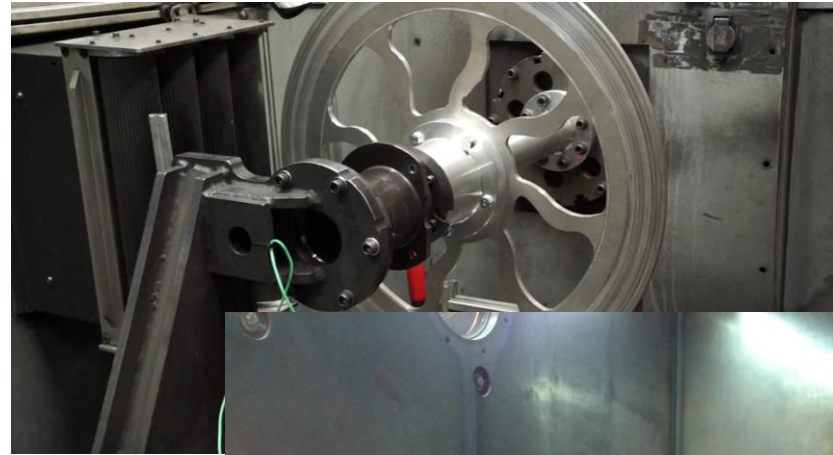
Energy Supply

- 450V Lithium Ion battery system
- Custom battery management system
- Vacuum-tight pressure container



Testing

- Subsystem level testing:
 - Braking test stand
 - Levitation test stand
 - Sensor testing
 - Vacuum testing:
 - Pneumatics
 - Electronics
 - Compressor
 - Battery testing
 - ...



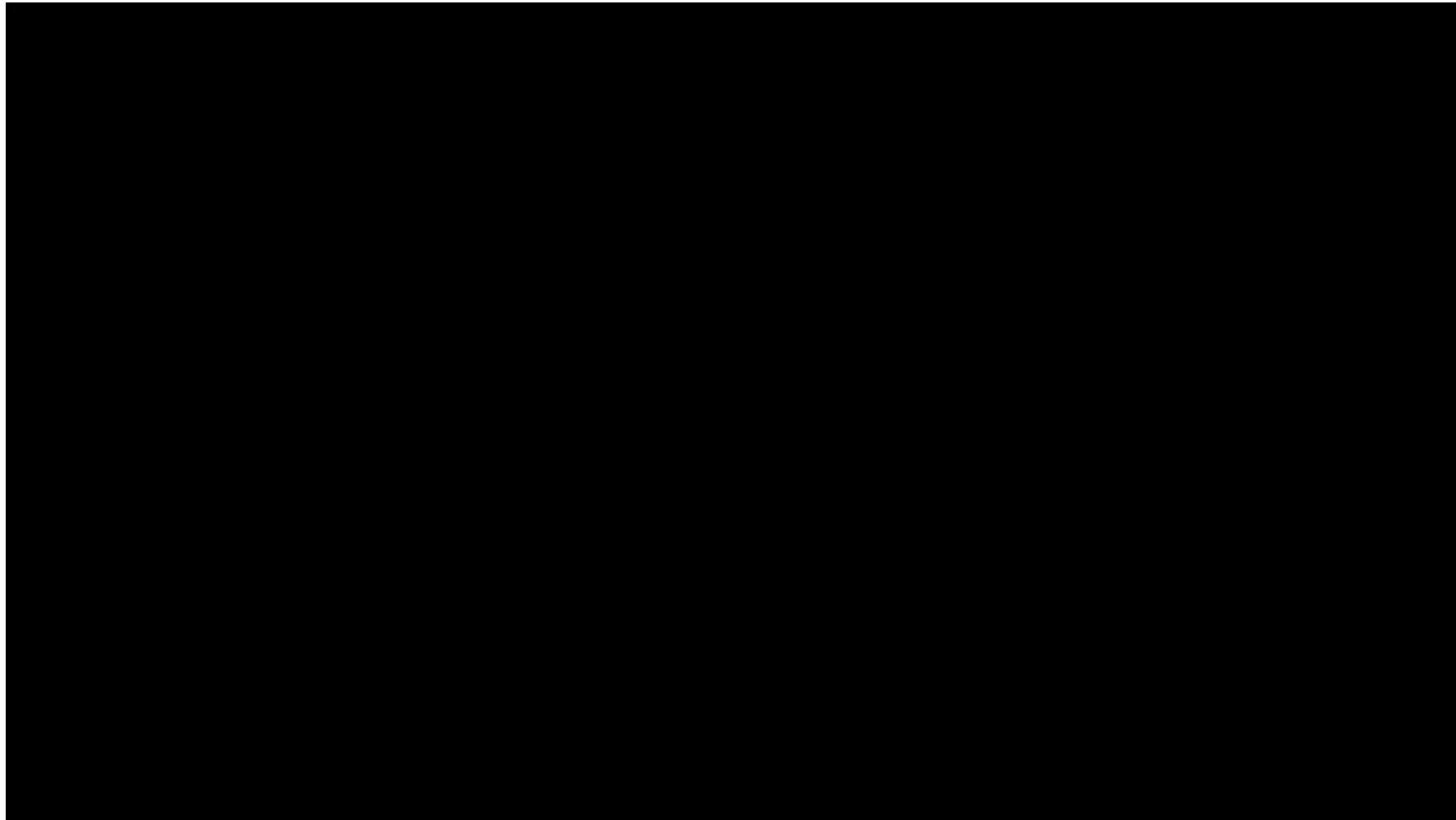
Pre-Competition



Testing Week

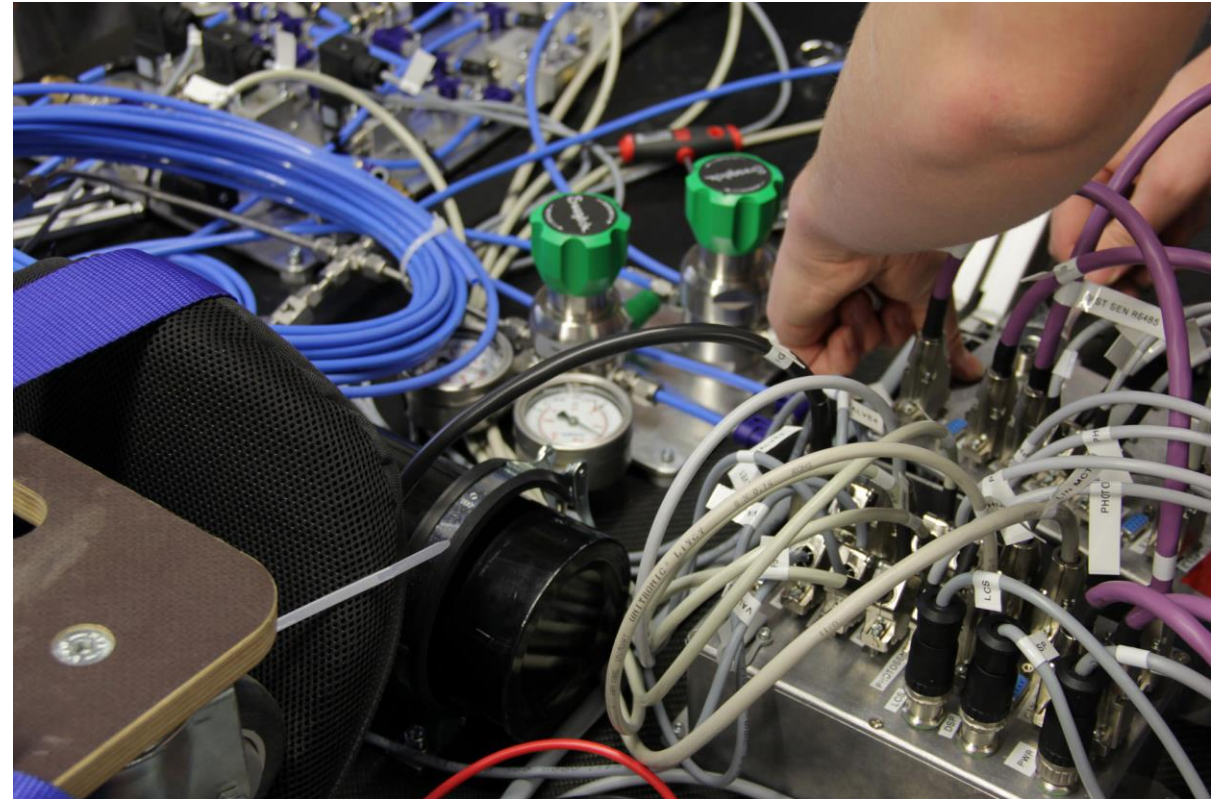


Testing Week



Lessons Learned

- Flexibility is necessary
- Testing is key
- Customs can be a pain
- Magnets produce drag



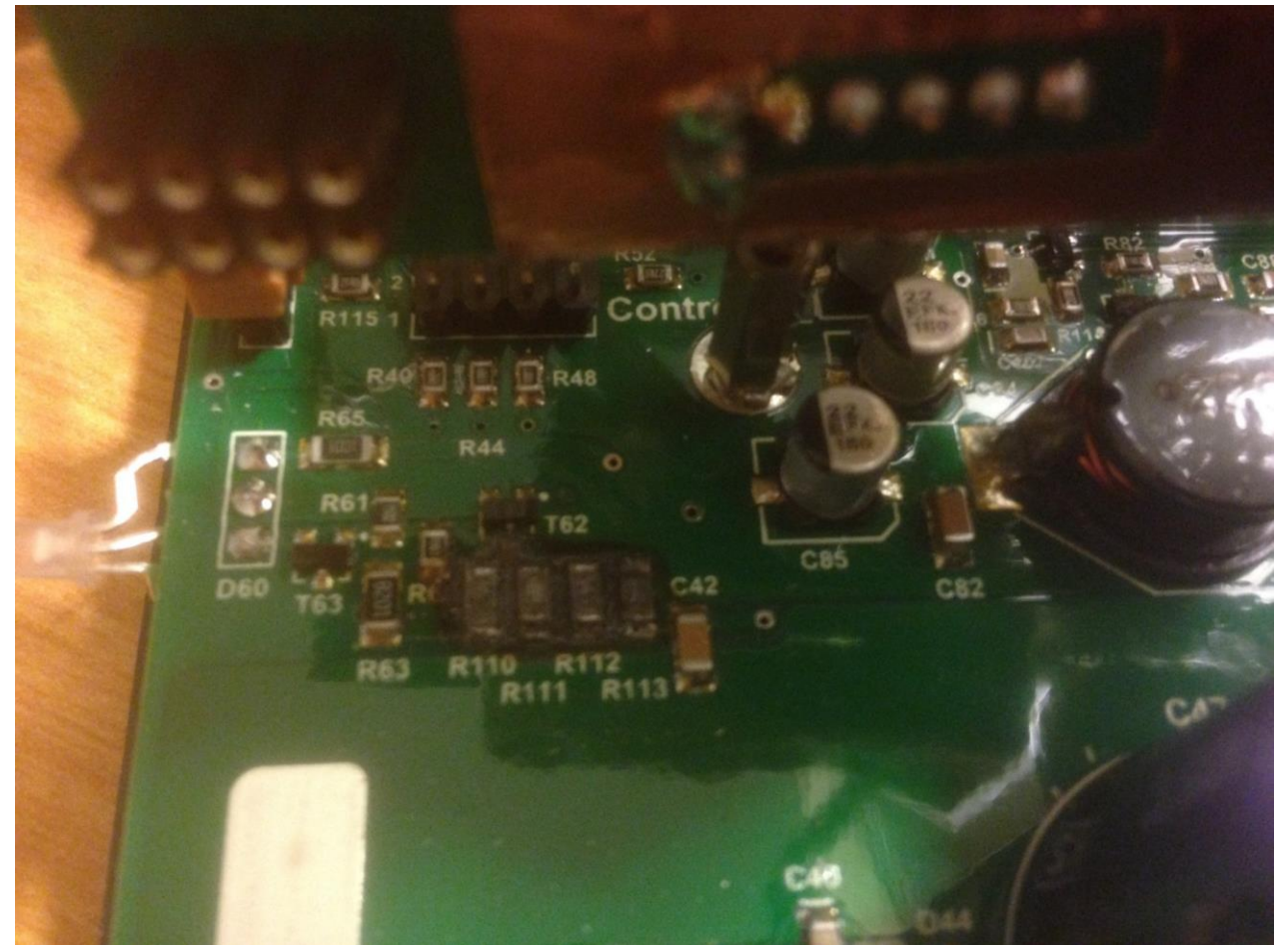
Lessons Learned

- Magnets and Batteries kept in customs for separate inspection
- Team members flew in batteries with carry-on luggage
- Know your backup plans



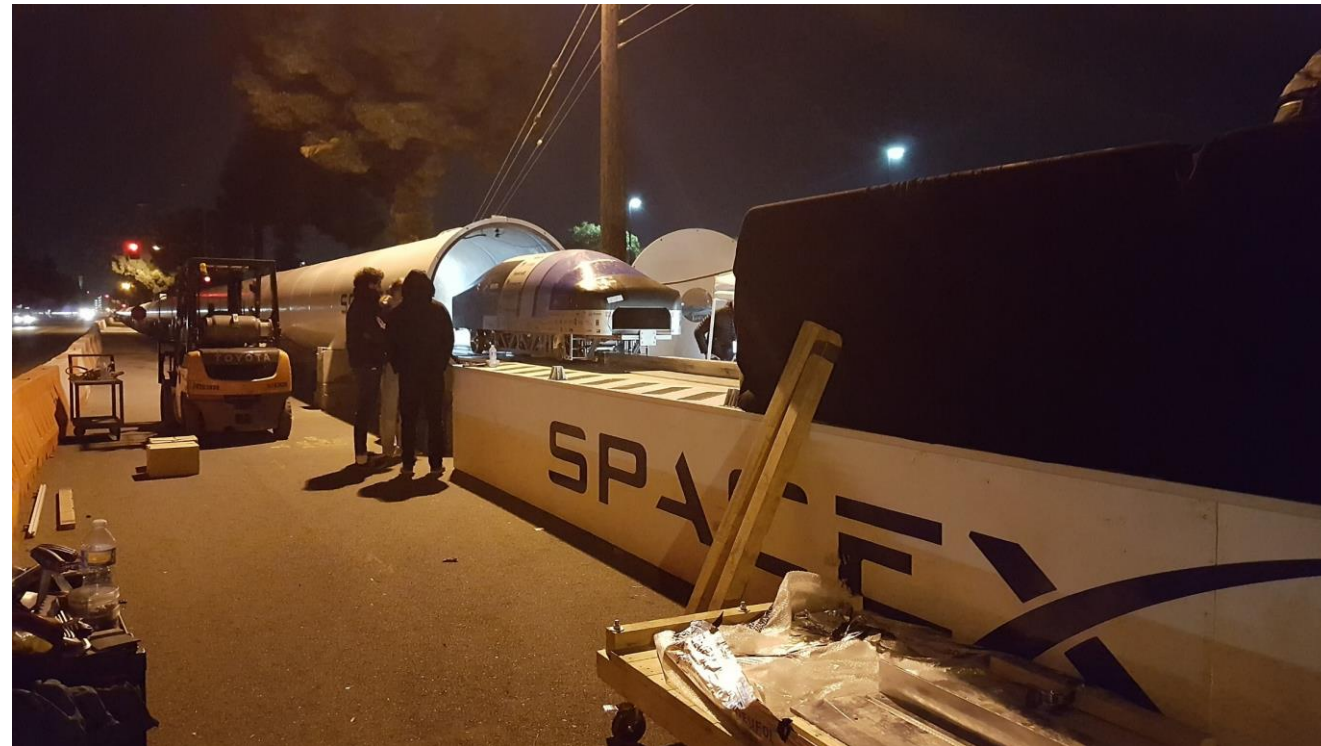
Lessons Learned

- Motor controller of low-speed propulsion blew on-site
- Any system can fail
- Have a backup system ready



Lessons Learned

- Testing always takes longer than expected
- Additional tests can be deemed necessary at any time
- Be well prepared, stay late and finish your safety checks asap



Competition Day



Lessons Learned

- Pusher vehicle performed below expectations and liftoff speed
- Magnets unmounted for competition run to reduce drag
- Be flexible in your design



The Winners



Next up?



**THE
BORING
COMPANY**

Competition II

- Competition Weekend II
25. – 27.08.2017
- Judging criteria: “Fastest Pod”
- Design Choice:
“As light and fast as possible”



WARR Hyperloop II: The Team



Pod II



Competition II vehicle unveiling in July 2017

Thank you!



AIRBUS TUM

toolcraft

**BECKER
CARBON**



bayerngas
norge

TNG TECHNOLOGY
CONSULTING

Leuze electronic
the sensor people



TRACO POWER



Li+ battery diagnostics by Liplus
fast. precise. simple.

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