Results and lessons learned from the CubeSat mission First-MOVE

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What kind of lessons can be learned with a CubeSat?

- Technical
- Educational
- Programmatic
- Science
- Commercial
- Hands-On Education
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10th IAA Symposium on Small Satellites for Earth Observation
Tuesday, April 21, 2015 | Berlin

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Design for Testability
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Testing, testing, testing

- Environment
- Subsystem
- Continuos operations

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Operations is not as easy, as it seems to be
(Test as you fly, fly as you test)
Dec. 19th 2013

First-MOVE only transmits CW beacons...

- EPS connected to all subsystems
- Transceiver in CW Beacon-Mode
- CW beacon (every 60 seconds)
- Boot of OBDH
- CW and AX.25 (every 60 seconds)
- Transceiver in Mixed Mode
- Boot completed, system idle
**December 19th 2013**

**Strongest Hypothesis:**
- Data corruption in the MRAM based boot sector

**Possible Cause:**
- Memory overlapping transients during reboot

We had to declare mission end on January 15th, 2014
Programmatic Lessons learned

- Multiple launch delays between 2009 and 2013
  - Knowledge drain
  - Adressed only partially by documentation
  - Critical for a small team -> plan with delays

- CubeSats are not “just small satellites“, they are highly integrated systems
  - Do not underestimate testing, assembly etc.
  - Need for all aspects of the product life cycle
  - Need for reviews
Technical Lessons learned

• Careful characterization of subsystems and overall system needed
  – Temperature dependencies
  – Individual functional and performance tests of all subsystems
  – Flat sat
  – Longer, continuous operation tests with the fully integrated system

• Establish process training of involved students and staff
  – ESD
  – Battery management procedures

• CubeSats are highly integrated systems
  – Mechanical integration (tolerances)
  – Establish an integration procedure
Educational Lessons learned

• Be aware of the university environment
  – Plan the project around the students‘ academic schedules
  – Drain of knowledge due to students leaving the project
  – Encouragement to stay in the project for longer time
  – Commitment out of dedication rather than short-term academic credit

• Academic and educational outreach
  – Summer Schools
  – Kick-Off events, public Milestone reviews

• Include external experts in your project
  – Hands-on education drastically enhanced by senior engineers
  – Reviews, continuous external feedback
Educational Lessons learned

Students not only benefit from doing things “right”, but also from sometimes making mistakes

We cannot create this project experience by the traditional academic curriculum

Their own “lessons learned” are engrained deeper in the student’s memories than any lecture ever could

Through hands-on education all involved students will be better prepared for their careers in engineering

The experience through First-MOVE was often a decisive asset for being selected for jobs in industry or in challenging research projects.
Conclusion

Has First-MOVE been a success?

The short mission duration prevented us from:

- Getting useful data from the solar cell experiment
- Getting down a photo

But the program laid the foundation for:

- Hands-on education (of more than 70 students) at LRT
- Satellite development and testing at LRT
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