ISISPACE CubeSats on the road to Zero Debris by 2030

Clean Space Days 2024

Agenda

Evolvement on the system architecture on LEO CubeSats up to 16U due to Zero Debris by 2030

- Zero Debris goals and their challenges
- Collision avoidance and space situational awareness
- Passivation
- 5-year rule implementation
- Dead-on-arrival

Zero Debris goals and their key challenges

Goal	Challenge
Guarantee successful disposal and **improve orbital clearance**	- Launching lower vs. reliability of de-orbit devices - Preparation for removal is not relevant LEO CubeSats
Avoid in-orbit collisions	- Collision risk is relatively low because of the small area of a CubeSat - Improvements are required on 24/7 availability for CAM while keeping costs low - Improvements are required on space situational awareness, especially soon after rideshare launches
Avoid internal break-ups	- Risk is deemed low for break-ups due to on-board energy, however the key challenge is how to prove it with high reliability
Prevent intentional release of space debris	- Compliant by design, may require additional testing for HDRMs
Improve on-ground causality risk assessment	- Not critical for CubeSats
Guarantee dark and quiet skies	- Not critical for CubeSats

Collision avoidance and SSA

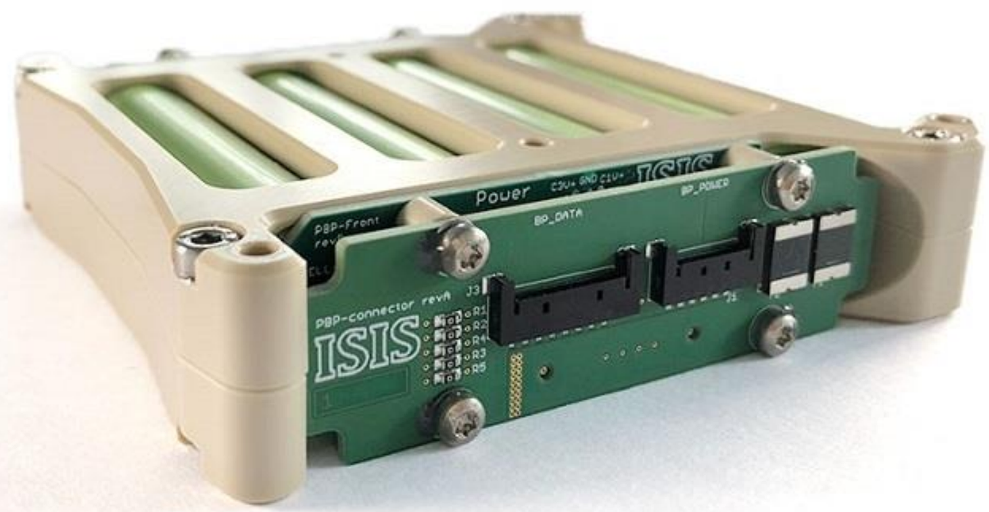
GOALs:

- **Unambiguous identification within 1 day post-launch**
- **Reliable CAM capability within 2 days post-launch**
- **Reaction time within 4 hours**

- Unambiguous identification within 1 day is a key challenge!
  - → Currently this may take weeks on rideshare launches
- Collision avoidance by 2 methods to allow for a back-up:
  - Propulsion
    - → May not always be available, e.g. not commissioned, failure
  - Differential drag
    - → Available shortly after launch
    - → Available when there is a propulsion failure
    - → It is being incorporated in STM tools
- 24/7 availability; can be done (STM service or night shifts), however, to keep costs low there is a benefit in finding solutions such that this is not required

Avoid internal break-ups, EPS passivation

GOAL: Reliability of passivation >90%, on the road to fail safe passivation



- Current implementation:
  - Demonstrate sufficiently low break-up risk by analysis
- Way forward:
  - We are planning a study on implementation of fault tolerant EPS passivation, to increase reliability without quantifying it
  - Continuation of demonstrating sufficiently low break-up risk by analysis
- Main challenge remains to prove the reliability using COTS

Deorbit within 5 years

GOAL: de-orbit within 5 years after the end-of-life with 90% reliability

- Study case 1:
  - 12U CubeSat with 4 deployable solar panels
  - Altitude until the end of the mission needs to be >580 km
- Trade space (non-exhaustive):
  - Solution 1: **Lower injection** altitude
  - Solution 2: Increase **drag**
    - 2-A: Drag device deploying at the end-of-life
    - 2-B: Larger solar panels
  - Solution 3: **Propulsion** for de-orbit maneuver
- Two step process to find a solution:
  1. Is it possible?
  2. Can we achieve the required reliability?

Trade-off

End-of-mission, altitude must be >580km

Burn-up

Operational mission | Decay after end-of-life

Duration	1 year	< 5 year
Solution 1: Lower injection altitude		
Max altitude at the start	Maximum ~505 km injection orbit	Maximum 495 km at end-of-life
Solution 2: Increase drag		
Drag area	N/A	What does the tumbling drag area need to be to re-enter within 5 years starting from 580 km? → **1.50 m2** • **Solution 2-A:** drag device, required area of drag device is calculated to be 3.0 m2 • **Solution 2-B:** increasing solar panels → drag area needs to increase 6 times
Solution 3: Propulsion		
Delta-V	N/A	About 70 m/s Delta-V needed when starting at 580 km

Trade-off

End-of-mission, altitude must be >580km

Burn-up

Operational mission | Decay after end-of-life

Duration	1 year	< 5 year
Solution 1: Lower injection altitude	**Not compliant with mission requirement**	
Max altitude at the start	Maximum ~505 km injection orbit	Maximum 495 km at end-of-life
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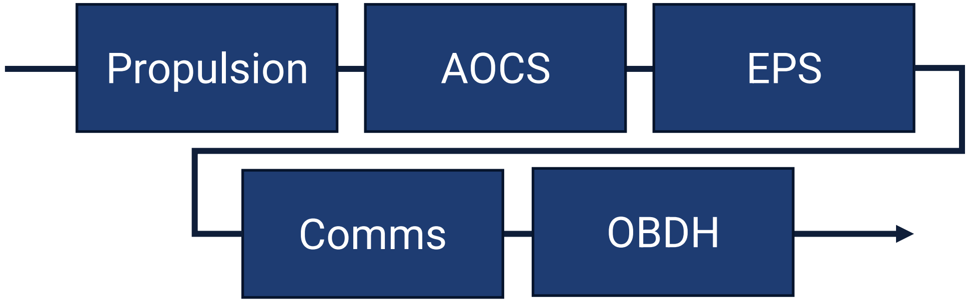
Solution 3: Propulsion		
Delta-V	N/A	About 70 m/s Delta-V needed when starting at 580 km

Trade-off - can we prove the reliability?

- Solution 2-A: drag device
  - Depends on the reliability of the drag device itself + the reliability of the trigger (if needed)
  - Some drag devices on the market are fully stand-alone
- Solution 3: propulsion for a de-orbit maneuver
  - Depends on the reliability of the propulsion system, and nearly entire platform (AOCS, EPS, comms, OBDH)



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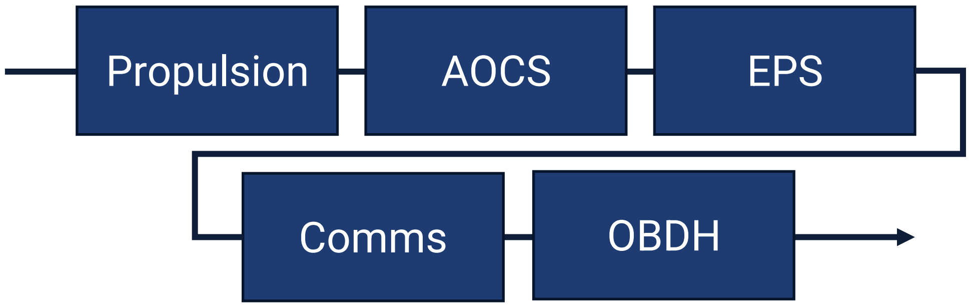

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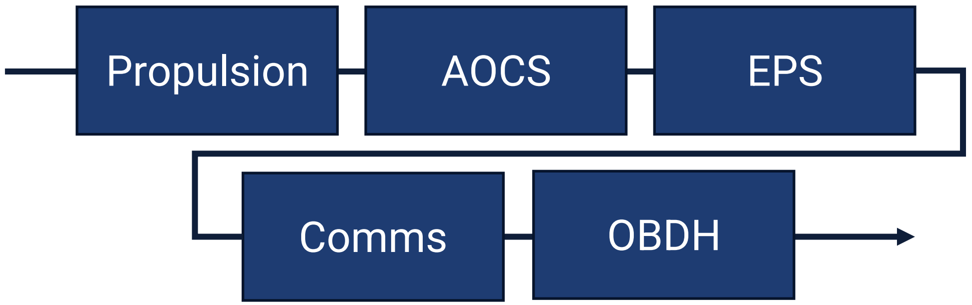

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Drag device is the best solution

→ this trade-off illustrates the benefit of any stand-alone deorbit device

Deorbit within 5 years – trade space

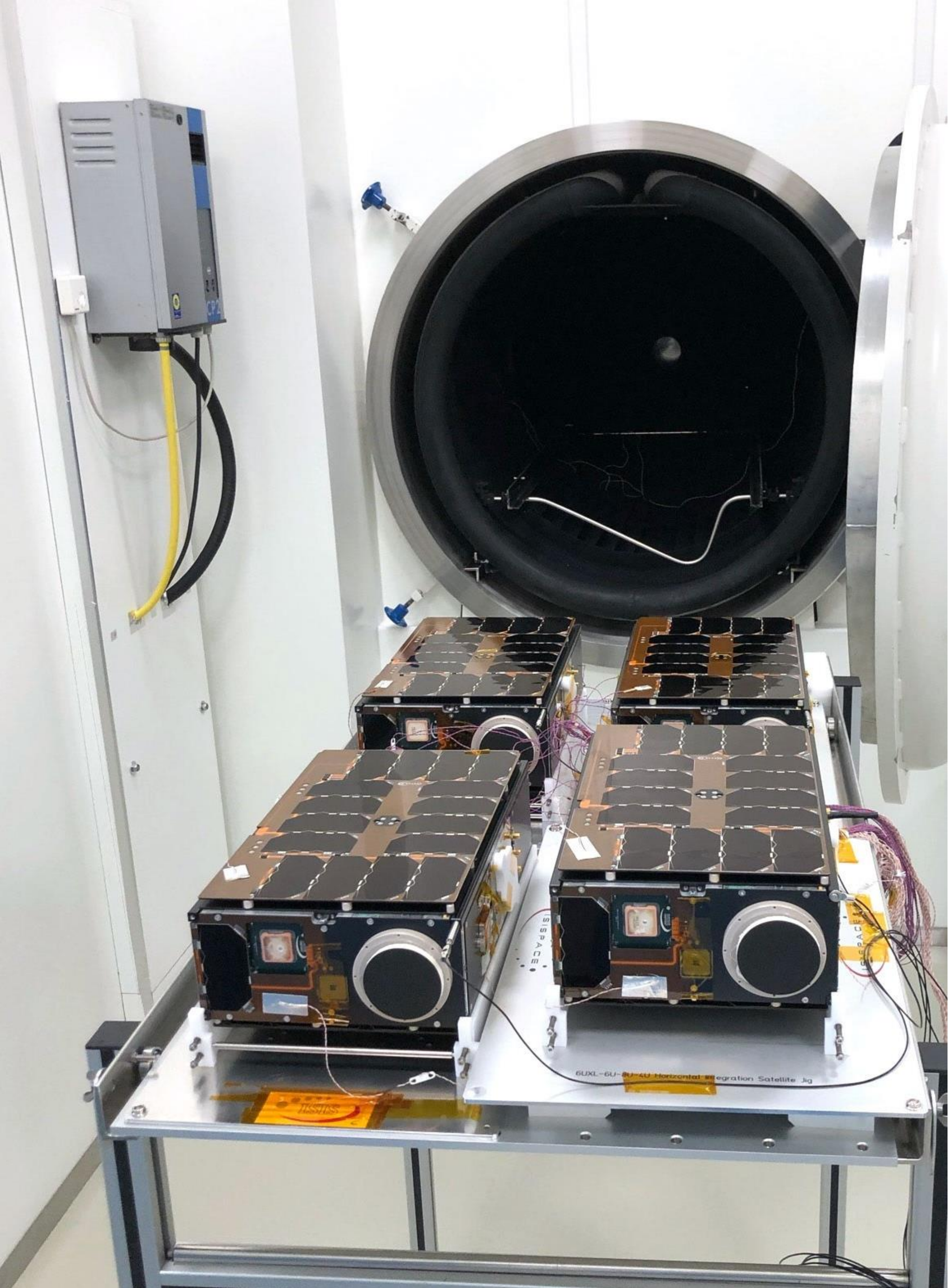
GOAL: de-orbit within 5 years after the end-of-life with 90% reliability

- Study case 2:
  - **Launch altitude is not critical**
- Trade space:
  - Solution 1: **Lower injection** altitude
  - Solution 2: Increase **drag**
    - 2-A: Drag device deploying at the end-of-life
    - 2-B: Larger solar panels
  - Solution 3: **Propulsion** for de-orbit maneuver

Best option, propulsion can be used for station keep if the mission lifetime is critical

Dead-on-Arrival

- The Dead-on-Arrival scenario can be very limiting when calculating the maximum orbit injection altitude, and it is contributing to the debris problem
- ISISPACE Deep Space Deployer (first launch on HERA) includes an umbilical with an electrical interface for health checks
- The deployer has a clear use case on Earth to avoid Dead-on-Arrivals



Conclusion

There are several key solutions to be studied:

- Reliable passivation solutions
- Differential drag maneuvering for collision avoidance
- Solution to avoid 24/7 availability
- SSA after rideshare launch for fast S/C identification
- Reliable drag devices or other independent end-of-life solutions
- Propulsion for station keeping and collision avoidance
- Dead-on-arrival solution, such as an adapted deployer