A GUIDE TO SELECTING AN ADCS FOR A SMALL SATELLITE MISSION

15 September 2021

Introduction: Today's presentation

- About CubeSpace
- Which factors influence an ADCS system design
- Buy off-the-shelf or build it yourself?
- Lessons we've learned, along with some interesting real-world examples

Content

- **Introduction**
- ADCS Design
- Buy vs. Build
- Lessons Learned

Introduction: CubeSpace

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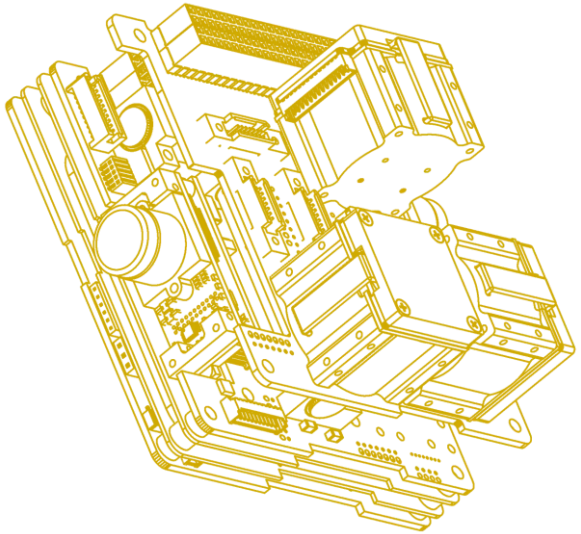
FLIGHT-PROVEN, FLEXIBLE
ADCS SOLUTIONS

2014
FIRST FLIGHT



1600+
PRODUCTS DELIVERED

50+
MISSIONS IN ORBIT USING OUR ADCS

100+
CUSTOMERS GLOBALLY

STELLENBOSCH
SOUTH AFRICA

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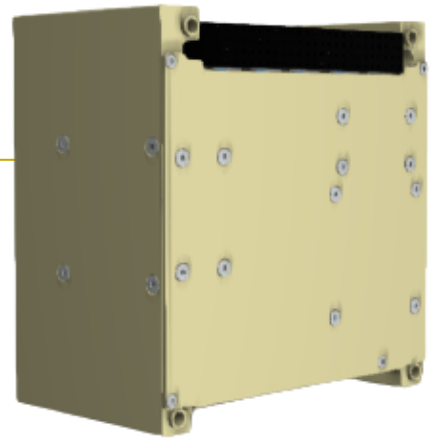
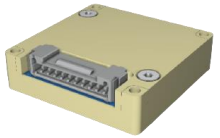
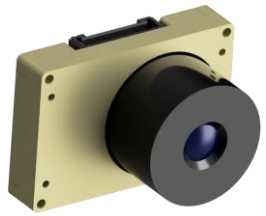
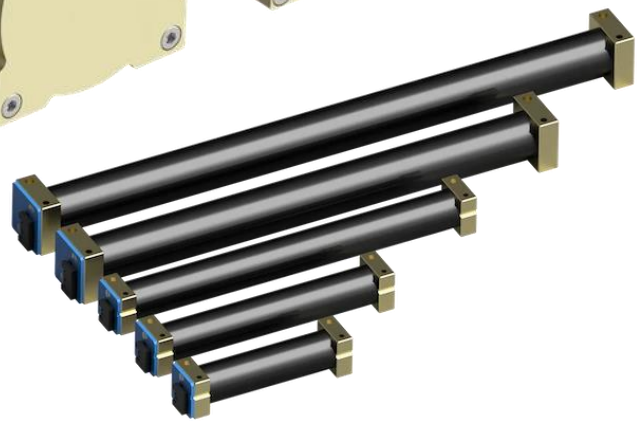
Introduction: CubeSpace



- Fully integrated ADCS solutions
- Standalone components
  - Reaction wheels
  - Magnetorquers
  - Fine sun sensor
  - Infra-red horizon sensor
  - Star tracker
  - Magnetometers







- Learn more about our Gen 2 ADCS products here

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Introduction: CubeSpace

- Facilities
  - ISO Class 8 clean room and dark room
  - Helmholtz cage
  - Vacuum chamber with thermal control
  - Humidity controlled thermal chambers
  - 8kN Vibration table
  - IPC Class 3 certified staff

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ADCS Design: Requirements

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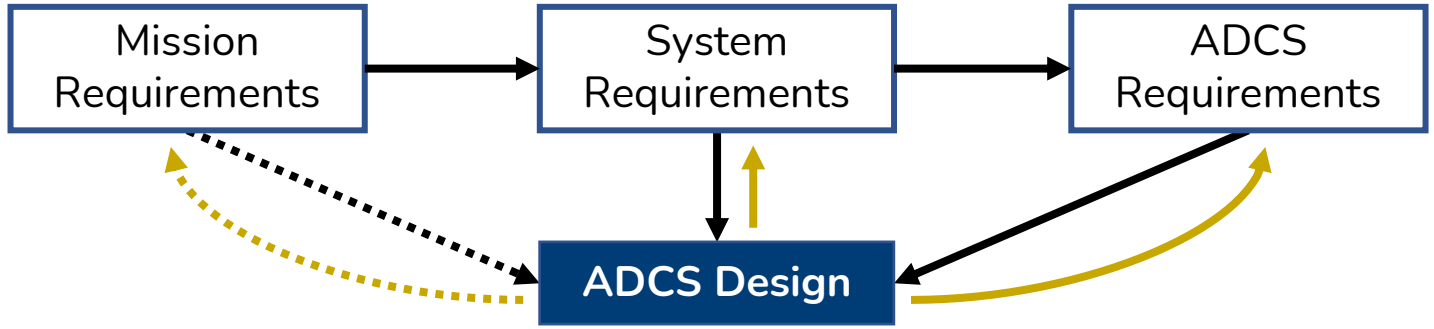
- ADCS design influenced by different requirement levels

Level	Mission	System	ADCS
Requirement	Launch = Kickoff + 12 months	Payload must be on a deployable boom	Slew 90° in 60 s
ADCS design implication	Buy off-the-shelf, no time to build	Must include gravity gradient controller	Reaction wheels at least X size

- Typical top-down requirements model does not seem to work for modern small-sat missions
- Concessions/trade-offs made on all levels



ADCS Design: Components

- Component selection
  - Flows down from ADCS requirements
  - How many of each sensor? Risk vs. budget
  - Actuator sizing:
    - Torquers → analysis of in-orbit disturbance torques (simulation)
    - Wheels → slew requirement, satellite size, etc. (simulation)
- Component placement
  - Available panel area for sensor mounting an protrusion?
  - Sensor FoV, especially when using deployable structures
  - Required ADCS modes:
    - Where should your payload point? Your antennas?
    - Will sensor FoV be impeded/obscured in certain modes?
    - *"Is one sun sensor enough?"*

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Buy vs. Build

- Options:
  1. Buy entire system
  2. Buy standalone components, build system (what about software?)
  3. Build entire system
- Various stakeholders in this decision
  - Technical
    - E.g. cannot find off-the-shelf solution to meet requirements
  - Commercial
    - E.g. company pushes outsourcing rather than vertical integration
  - Programmatic
    - E.g. project timeline does not allow self-build option
- Mostly three deciding factors: **Risk, Time, Cost**

Buy vs. Build: Pros and Cons

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	Buy	Build
Pros	• **Leverage years of ADCS experience** (supplier and other customers) • Shortest lead-time • Zero development cost	• System can be tailor-made for mission • No dependency on 3rd parties • Supports vertical integration strategy
Cons	• System not always optimised for every mission • Supplier dependency • ~~Higher cost per system~~ • Not really, if you consider NRE	• Requires full development team (ADCS, Elec, Mech, SW) • Development time is years • Massive investment (NRE) • Increased risk (low TRL)

Buy vs. Build: Selecting Supplier(s)

- Many options out there – choose carefully
- Reliability
  - TRL (evidence?)
  - Reputation in the industry (other users?)
- Supply stability
  - Lead time, especially for large orders
  - Will they still be around for your next mission?
- Integration into your mission:
  - Mechanical / Electrical / Software interfaces – configurable?
  - Available ADCS modes – can this be expanded?
  - Ease of operations
- Support
  - Documentation
  - Ground support equipment (GSE) – Hardware and software

Cost

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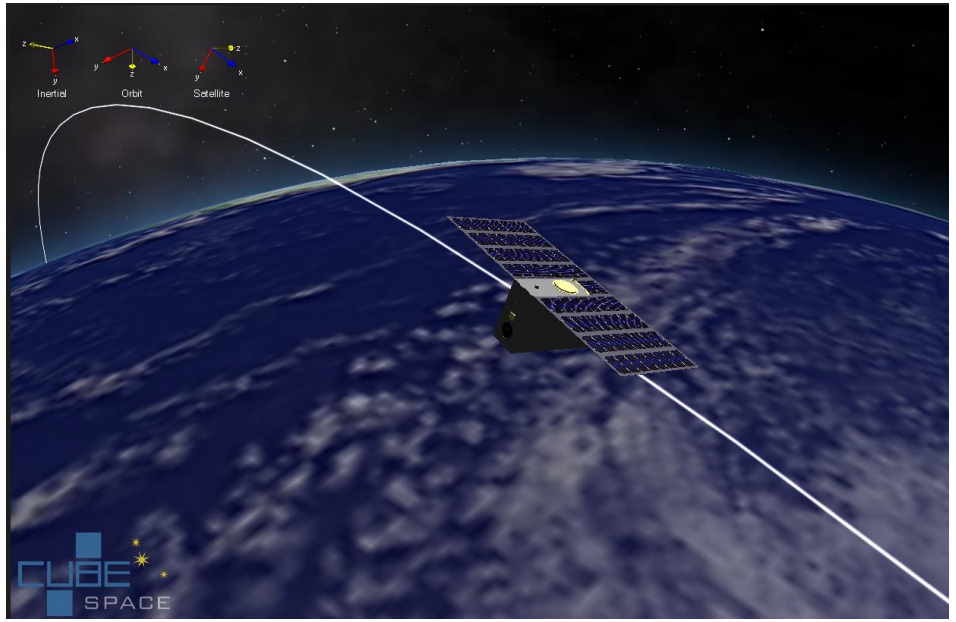
Lessons Learned: Building an ADCS

- If it is new, it usually takes longer than you expected
  - Always add margins (time, budget, etc)
  - Hire a good project manager
- You *rarely* get it right the first time
  - Allow for mistakes to be made
  - Add design iterations to the schedule
  - Test, test, test!
- You **must** have a simulation tool!



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  - Building an ADCS
  - Test & Integration
  - In-orbit

Lessons Learned: Test & Integration

- Make sure you understand the ADCS coordinate frame (not necessarily equal to your CAD frame)
- Take care of your magnetometer
  - Most important sensor
  - Easily disturbed (sources: solar panels, fasteners, EPS, EM-valves)
  - Deployable (primary) magnetometer as well as redundant magnetometer is recommended
  - Test in all spacecraft operational modes!
- Avoid having deployable appendages in sensor FoV

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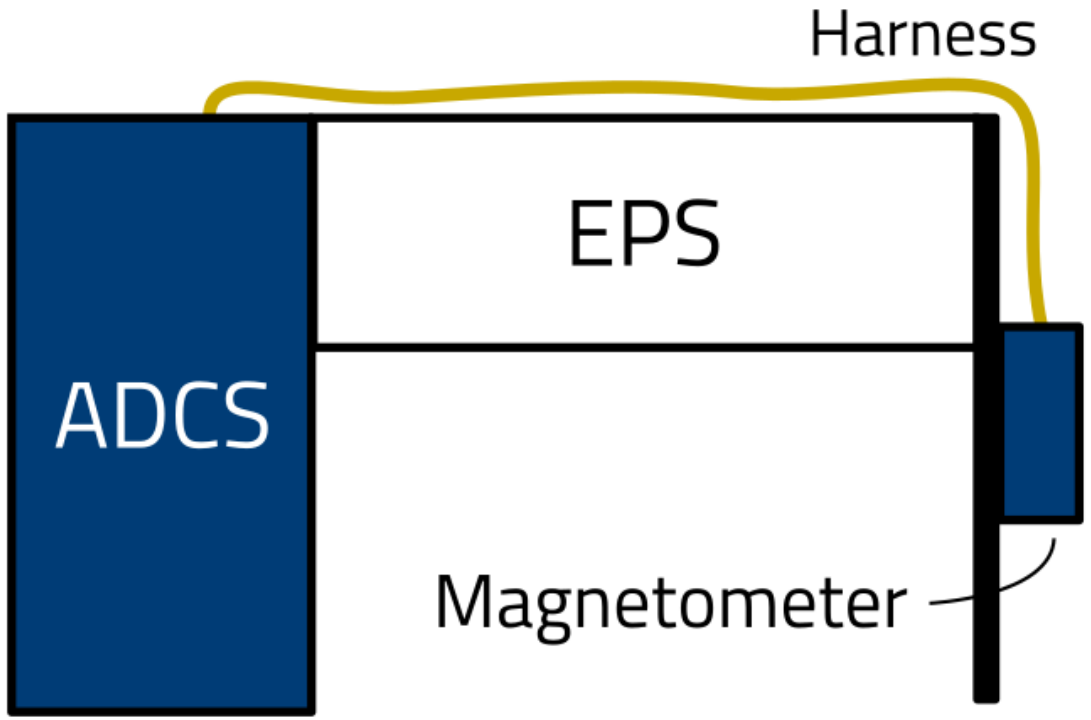
Lessons Learned: Test & Integration

- Watch out for ground loops
- EMI, especially when using harnesses
  - Example: Magnetometer harness running across EPS



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Lessons Learned: In-Orbit

- Add margins to exclusion angles
  - Example: Atmosphere clearly visible in eclipse to star trackers
- Have a safe mode for high spin rates
  - Example: Accidental spin-up of satellite, CubeADCS successfully detumbles from 140°/s
- Check polarities of actuators
  - Example: Spin-up instead of spin-down

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QUESTIONS?

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