



## Orekit, high end flight dynamics accessible to small cubesat teams



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# AGENDA

- cubesat projects maturation
- flight dynamics needs
- open source
- conclusion



# cubesat projects maturation

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## cubesat vs. big programs

- small teams
  - one instrument
  - team focusing on data gathering
  - scientists “scratching their own itch”
- big teams
  - several instruments
  - one team per instrument
  - one team for platform
  - one team for ground segment
  - one team for flight dynamics
  - one team for...



- cubesat
  - as long as it does not fall...
  - no resources allocated to this task (or skills available)
  - no maneuvers
  - will find TLEs on the web for visibility computation
  - just need a screen to display a beautiful Keplerian trajectory for VIPs
- big program
  - precise orbit determination (down to centimeter accuracy sometimes)
  - station keeping / collision avoidance
  - events prediction
  - housekeeping (wheels unloading, safe mode recovery, synchronization...)
  - mission planning



## things are changing

- cubesats are not anymore reserved for student projects
  - high-value science with accurate data
  - evaluation of new technology
- new missions concepts
  - formation flying
  - constellation
- new subsystems
  - propulsion
  - localization



flight dynamics needs

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## high accuracy positioning

- accurate scientific data needs georeferencing
- formation flying relies on relative positioning
  - for operations
  - for data interpretation
- GNSS receivers
  - autonomous point positioning
  - raw measurements
    - code
    - phase
- accuracy needs
  - external data
  - ground post-processing





- included in CubeSat specification since 2014
  - rev 12 (2012): no pressure vessels over 1.2 standard atmosphere
  - rev 13 (2014): any propulsion system shall be designed...
- requires dedicated services
  - orbit determination (TLE are clearly not enough)
  - maneuvers planning
  - low thrust maneuvers require special handling (optimization)



open source

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- Community Over Code
  - Apache Software Foundation most recognized motto
  - People and skills are important
  - I believe it is true
- There is no such thing as a flight dynamics community
  - Some FD manager told me this once
  - I believe it is false
- Numbers
  - one team/entity/company/agency is no community
  - two people can be a community
  - it starts at two, and then grows up as people get word



- space flight dynamics library
- open-source since 2008
  - Apache license
  - open governance (meritocracy)
- Increasing community
  - industry, agencies, academics
  - operationally used by numerous flying projects
- broad spectrum
  - from mission analysis to operations
  - from simple use to research
  - from trade-offs to centimeter level computation
  - smartphone/desktop/cloud



conclusion

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## Conclusion

- Cubesat teams focused on science data
  - flight dynamics needs increase
  - specific skills and tools are required to address these needs
- open source tools exist
  - they address from mission analysis to operation
  - they are extremely accurate and highly validated
- they are backed by vibrant and helpful communities
  - seek help/tools from them