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The Outernet

A novel satellite communication relay constellation

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- Increased number of CubeSat Launches
- Most using UHF/VHF frequencies
- Why a similar groundstation for each?

Introduction

ESL

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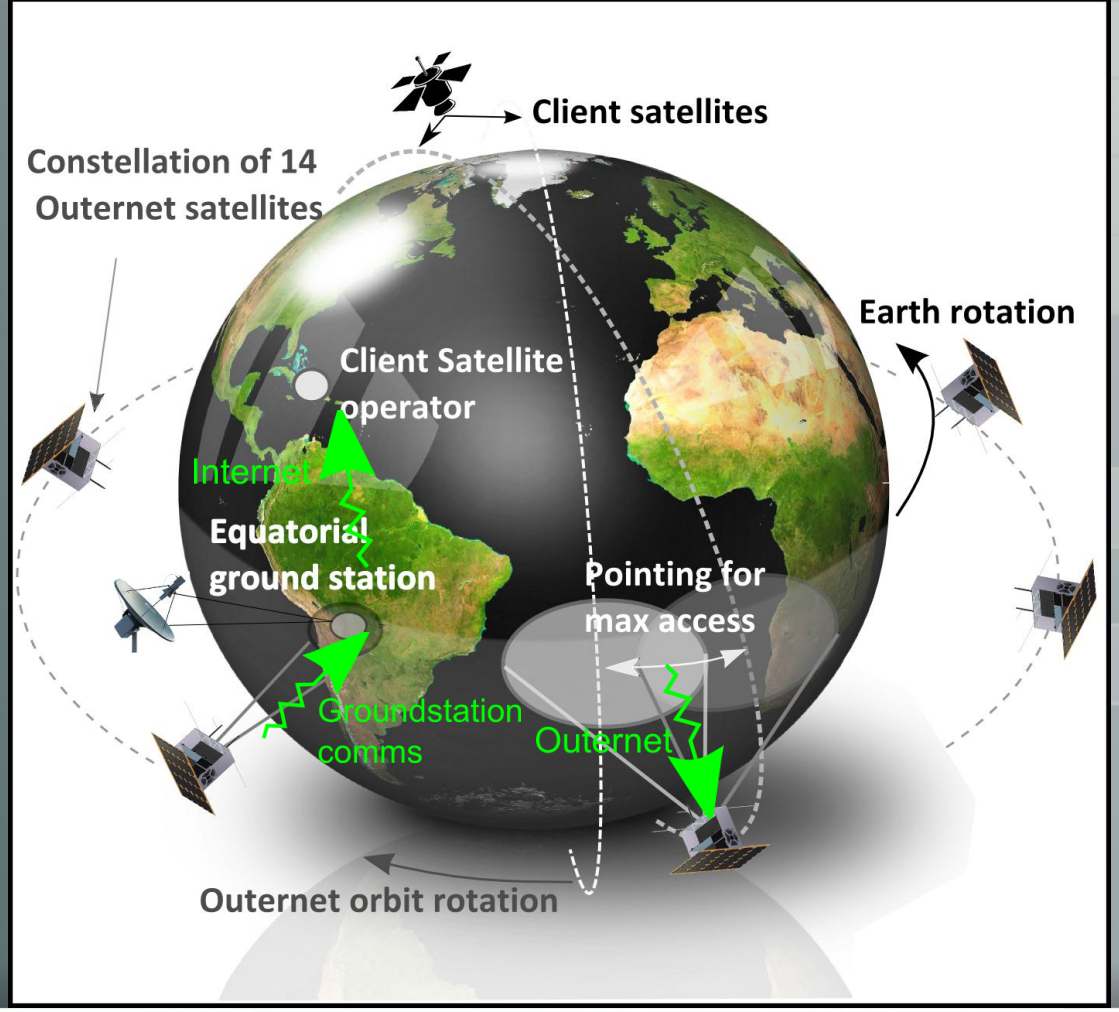

Concept/Proposition

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- Altitude of 900km
  - Higher than most LEO satellites (clients)
  - Long communication window with GS
  - Below Van Allen radiation belt
- Equatorial orbit
  - Pass equatorial GS every orbit
  - Does not pass South Atlantic Anomaly

Orbit Selection

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- Client pass Outernet twice each orbit
  - More passes/day than classical GS
- Each Outernet satellite independent
  - Modular
  - Expandable
- Outernet simulates GS, no reconfiguration for client satellite needed
- Advantages over amature radio, such as: data encryption and throughput

Motivation

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- Phase 1 (demonstration of concept)
  - Build first satellite with in-house products and expertise
  - Work with ISIS for launch
  - Test with existing CubeSats
- Phase 2(expansion of constellation)
  - Design larger improved/refined satellite
  - Iteratively launch and improve

Implementation

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- Technical Design
  - Satellite Design
    - Comms equipment
    - ADCS
    - Power/Thermal
  - Constellation Design
    - Constellation Structure/Access Times
    - Phasing/Deorbiting

Outline

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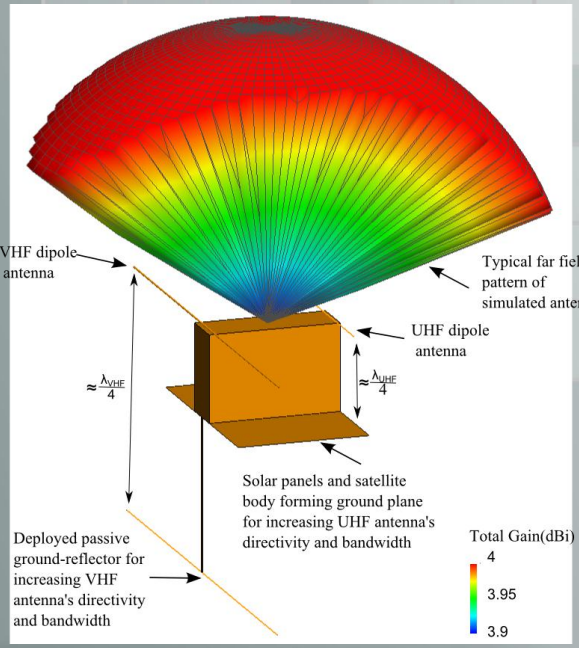
- Communication requirements
  - Maximum access time
  - Large bandwidth
- Antenna design
  - Simple dipole antenna
  - Passive reflector
    - UHF -> solar panels
    - VHF -> deployable
  - Pitch tracking



Communication design

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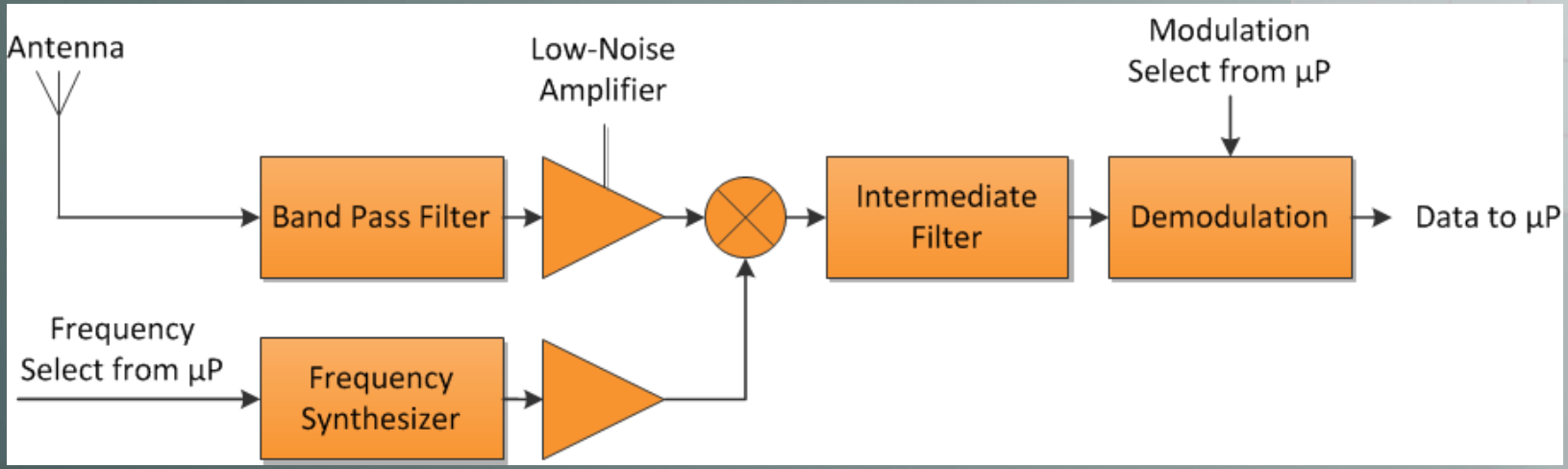
- Transceiver electronics
  - Doppler shift max = 20kHz
  - Software based synthesizers
  - Adjustable de/modulation schemes



Communication design (cont)

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- Momentum-biased stabilised
- Control modes
  - Detumbling
  - Phasing
  - Pitch-tracking
  - Momentum dumping

ADC design

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- Power
  - Foldable Z-axis panels
  - Peak operation -> 16W
  - Normal operation -> 10W average
- Thermal
  - Thermal simulation
  - Within recommended operating temperature

Power and Thermal

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- Number of satellites affect:
  - Communication requirements
  - Data throughput
  - Financial costs of constellation

Constellation Size

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Constellation Size

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- Number of satellites affect:
  - Communication requirements
  - Data throughput
  - Financial costs of constellation
- Results
  - Constellation of 14 satellites chosen
  - Analytical results show at least one pass each orbit for satellites below 700km
  - Numerical simulation confirms
  - Average between 17 - 875kB per pass

Constellation Size

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- Phasing
  - Space satellites evenly in orbit
  - Four week Hohmann transfer
  - 27g of fuel for each satellite
- Deorbiting
  - Use left over fuel to lower orbit
  - Use drag enhancer to deorbit aerodynamically
  - Estimated deorbit time of 14 years

Phasing and deorbiting

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- Phase 1 Budget
  - First Satellite Cost
    - Employ 15 Engineers for 18 months
    - All COTS components
    - COTS Groundstation
  - Operational costs
    - 2 Engineers for 10 years
    - Other technical (power, internet…)
  - Total budget of €1.5M (Estimate)
  - Each additional satellite €0.4M (Estimate)

Budget

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- Benefits for humankind
  - Multiple applications
  - Enhances benefits of all missions using the system
- Environmental advantages
  - Less land and material consumed by not building multiple groundstations
  - Would aid disaster management and earth observation satellites

Environmental

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- Outernet is solution to redundant GS-problem
- Encrypted, private access to satellite data
- Significant Increase in data throughput and communication opportunities/day
- Low cost and easy to build/test prototype
- Modular design - suited for expansion
- Benefits all satellite applications
- Building an infrastructure for the future

Conclusion

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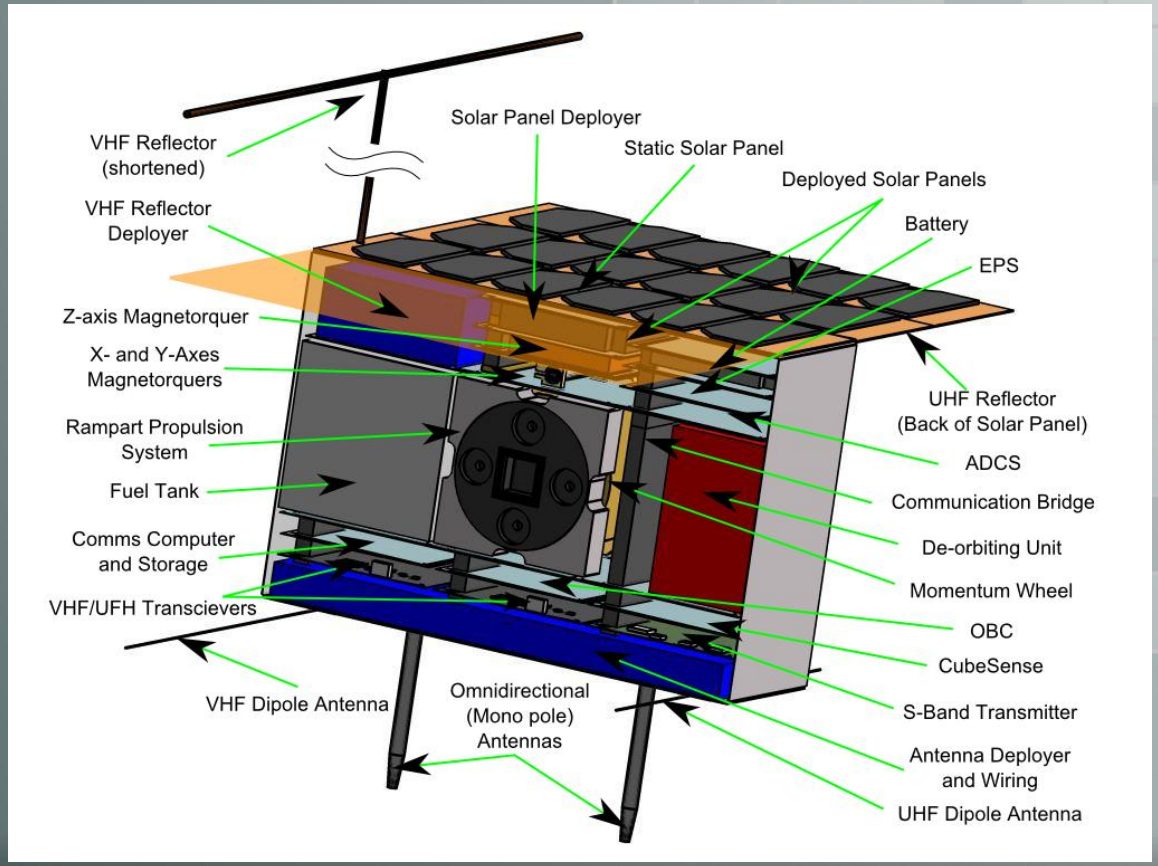
Conceptual CAD model



Questions?