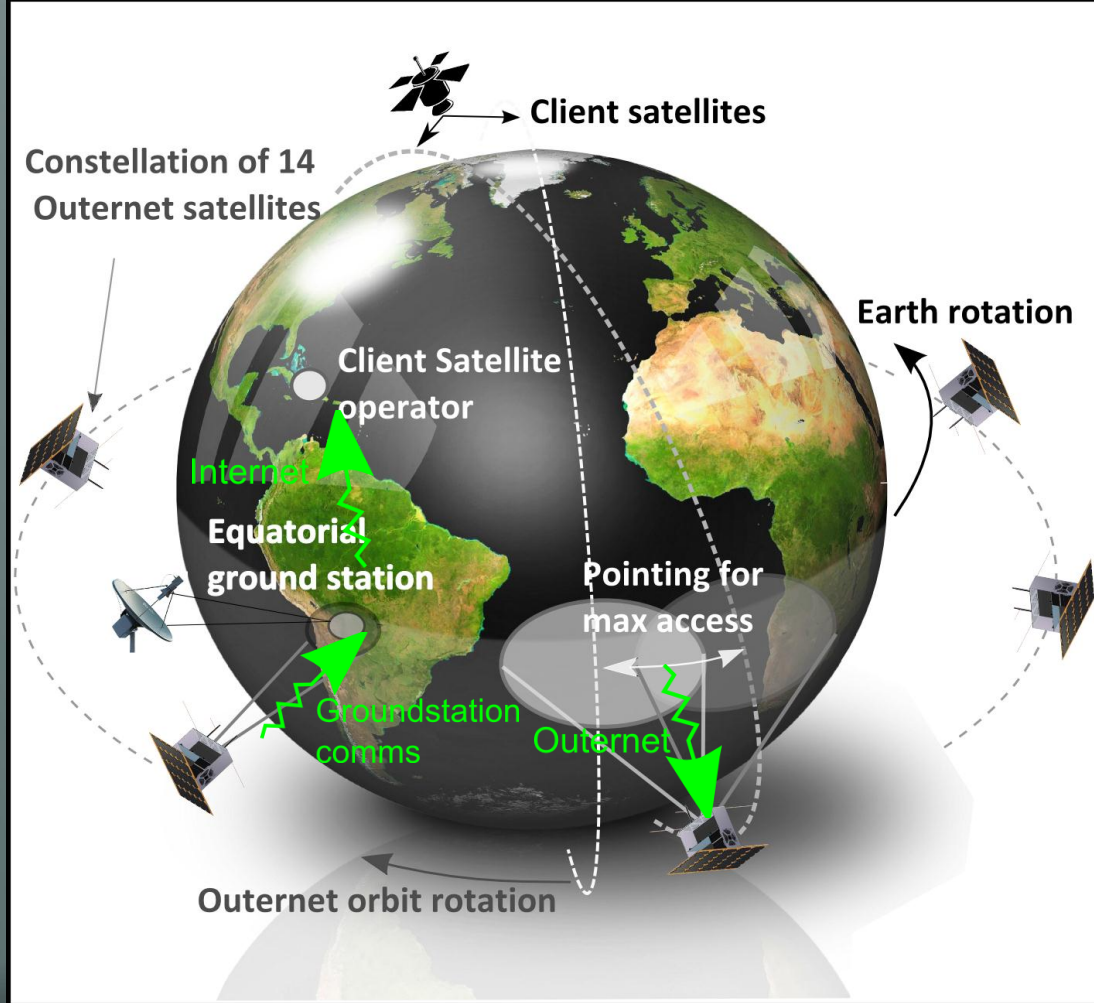


The Outernet

A novel satellite communication
relay constellation

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



- 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

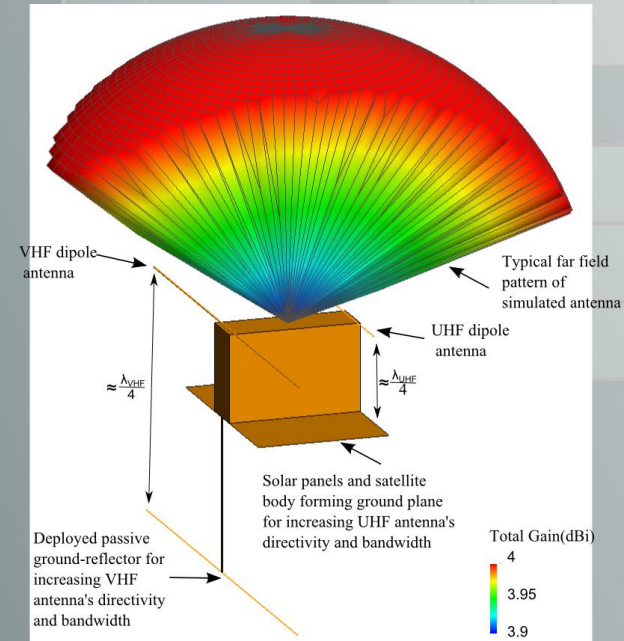
- Client pass Outernet twice each orbit
 - More passes/day than classical GS
- Each Outernet satellite independent
 - Modular
 - Expandable
- Outernet simulates GS, no reconfiguration for client satellite needed
- Advantages over amateur radio, such as:
data encryption and throughput

- 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

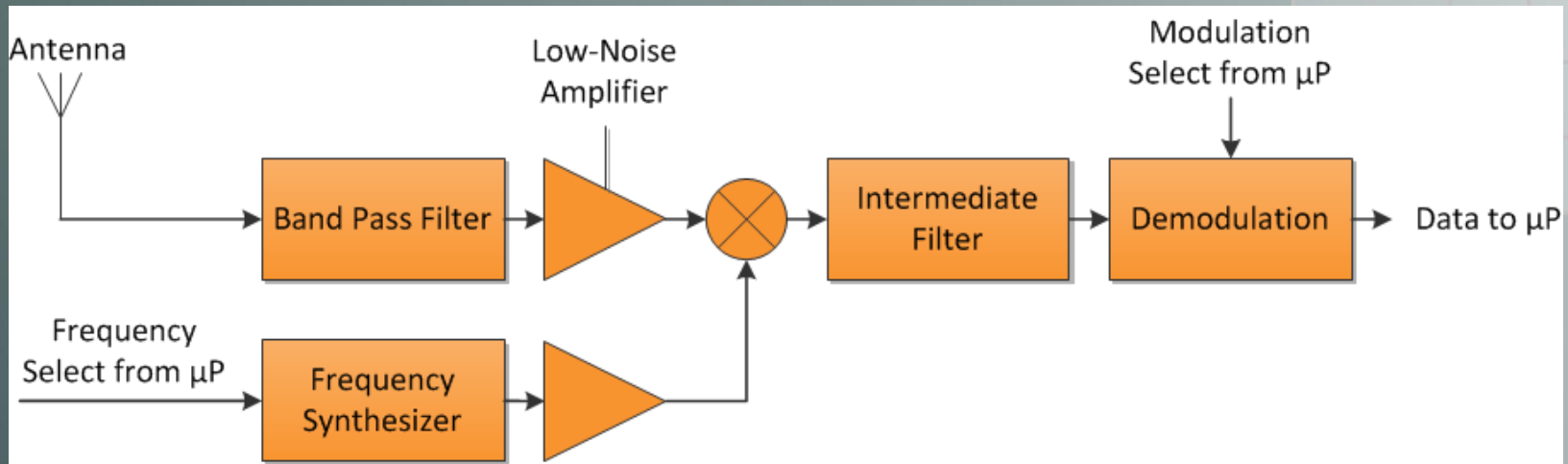
• Technical Design

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

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



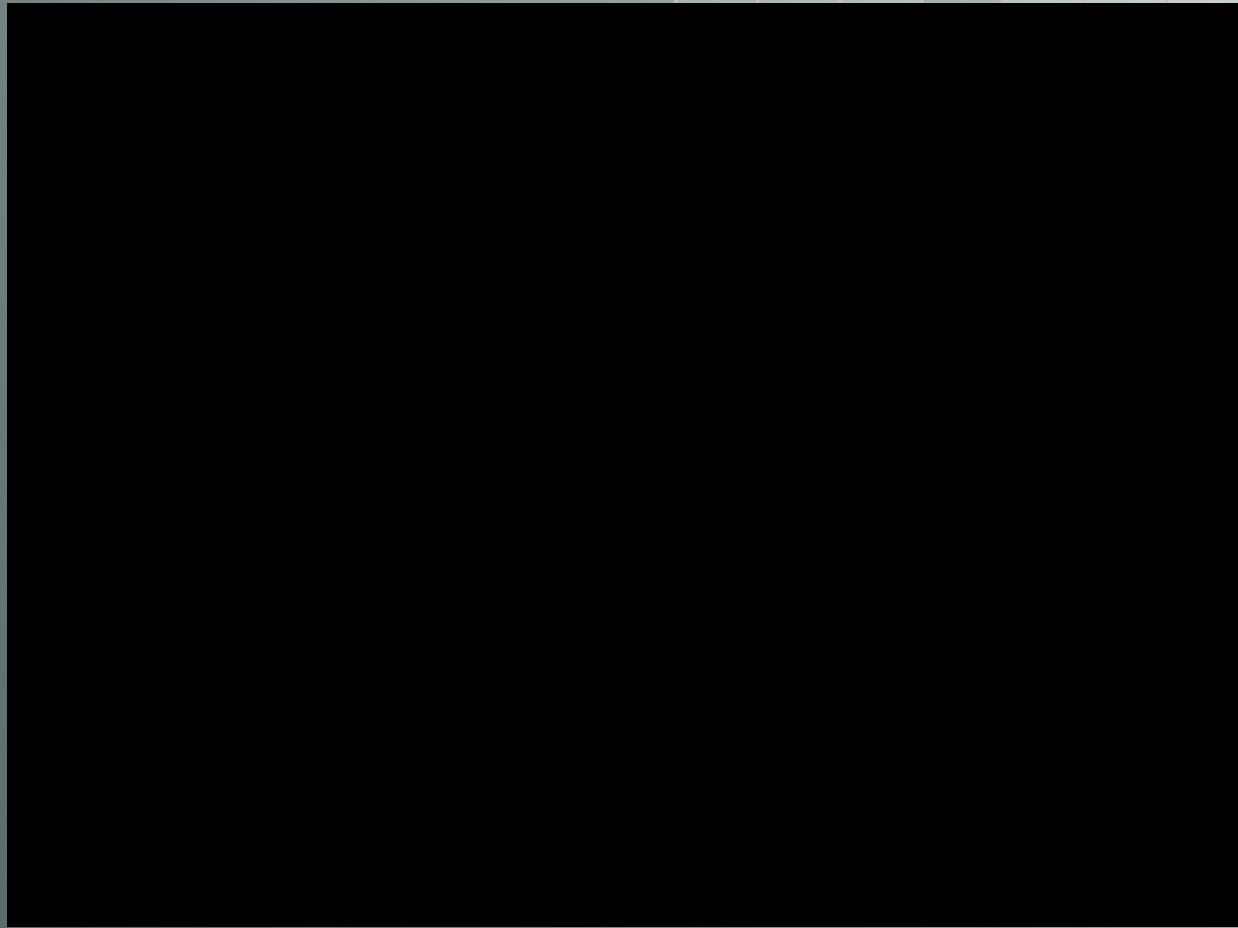
- Transceiver electronics
 - Doppler shift max = 20kHz
 - Software based synthesizers
 - Adjustable de/modulation schemes



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

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

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



- 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

- 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

- 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)

- 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

- 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

Conceptual CAD model

