Extending 1U Communications

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The 1U Mission: The Problem

Have a solution looking for a problem to solve.

The physical constraints of a 1U satellite combined with our traditional design approaches have kept us from achieving funded missions at the 1U level.
The 1U Mission: The Problem

Typical 1U Mission:

- Solar Input \( \sim 1.5 \text{ Watt Hr/Orbit} \)
- Radios Consume \( \sim 2 \text{ Watt Hr/Contact} \)

A contact orbit is generally negative power margin.
The 1U Mission: The Concept

Traditional Spacecraft Design
Payload/Bus Centric
Power, structural, and communications are determined based on the sensor/mission onboard

‘New’ 1U Design Suggestion
Link Budget Centric
Every spacecraft uses a finite allocation of RF spectrum, thus is ultimately designed by the link budget
The 1U Mission: The Link Budget

• Each value in a link budget translates to at least one power, structural, or Degree of Freedom value

• The most defining, controllable, and neglected segment of the link budget is the ground station.

• 1U Missions need capable ground stations to compensate for limited on orbit resources
Designing from the Ground Up: The Ground Station

Ground antenna and RF capabilities
• Beg, borrow, or pay for using neighbors big dish

Ground station locations
• Strive for geographically dispersed ground stations in mid latitudes to cover a multitude of orbits
• Partner with CubeSat community and entities outside of CubeSat community
Designing from the Ground Up: Orbit

Acquire the proposed TLE’s

- CubeSats are ‘blessed’ as secondary payloads. We generally know the orbits we will receive well in advance.
- Can not efficiently design a satellite without a projected orbit
Designing from the Ground Up: Link Budget

Ground Stations and FCC Define

• Frequency
• Bandwidth
• Power Level

Link Budget…KISS…Excessive analysis hinders

Flow to CubeSat Requirements:

• Radio
• Antenna
Designing from the Ground Up: Radio to Deriving Requirements

Remaining mission components can then be selected through systems engineering trades

- Data Flow and Storage
- Sensor Capability
- Failure Recovery
- Radio Availability
- Power Architecture

Further room can be found in RF link budgets by altering the method of communications.
1U Mission Radio Selection: Adopt Terrestrial Methods

Adopt principles from low power sensor grids such as Mote Networks

- Wakeup and interrogate
- Stochastic
- Power available monitor
1U Mission Radio Selection: Combating Power Consumption

Consumed Power During RX – The parasite, slow death

Mitigation Methods:
• Ground station initiated reception
• Periodic reception

Consumed Power During TX – The predator, quick death

Mitigation Methods:
• Response only
• Clamps
• Timeouts
• Beacon only in sunlight
1U Mission Radio Selection: Combating Power Consumption

Receive:
- Periodic
- < 50 mW

Initiated
- Check > X dB
- RSSI
- Receive
1U Mission Radio Selection: Combating Power Consumption

Transmit:
- Response
- Timeout
- Clamp
1U Mission Conclusions

1U Missions are viable if properly designed:

– RF link is primary design driver
– Increasing ground station capability greatly reduces spacecraft requirements

1U Developer must have:

– Access to radio inner workings, protocol design
– Knowledge of all satellite subsystems for ultimate trades to maximize mission performance