Extending 1U Communications

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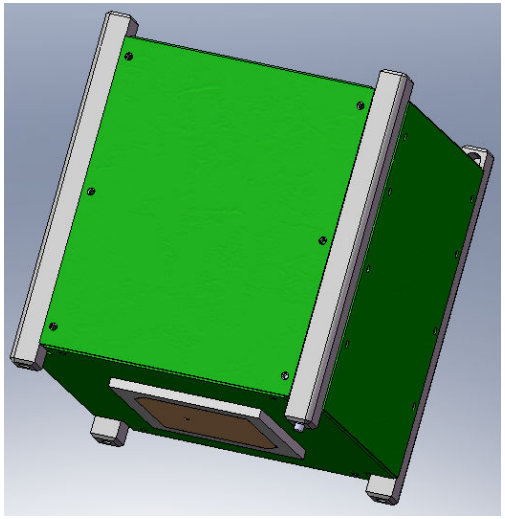
The 1U Mission: The Problem



Have a solution looking for a problem to solve.

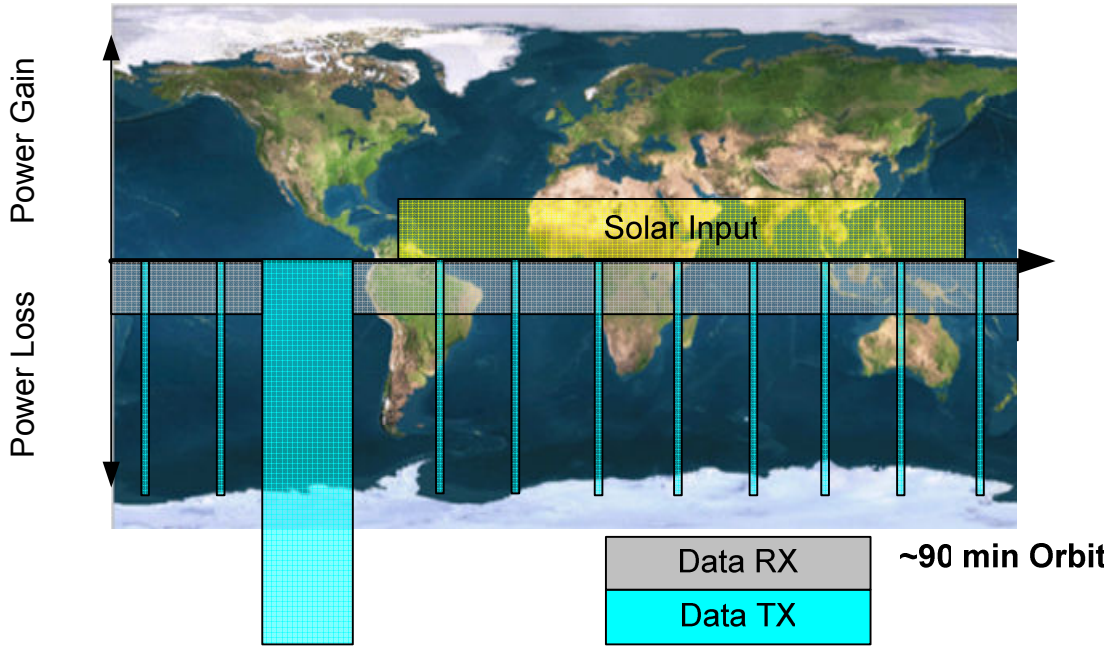
The physical constraints of a 1U satellite combined with our traditional design approaches have kept us from achieving funded missions at the 1U level.

The 1U Mission: The Problem

Typical 1U Mission:

- Solar Input ~1.5 Watt Hr/Orbit
- Radios Consume ~2 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

SRI

U of M

MSU

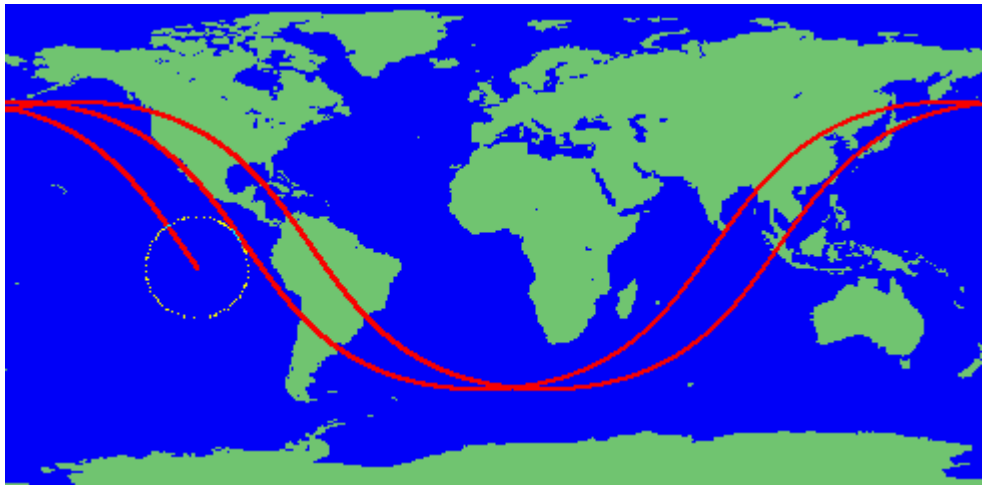
Ground station locations

- 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:

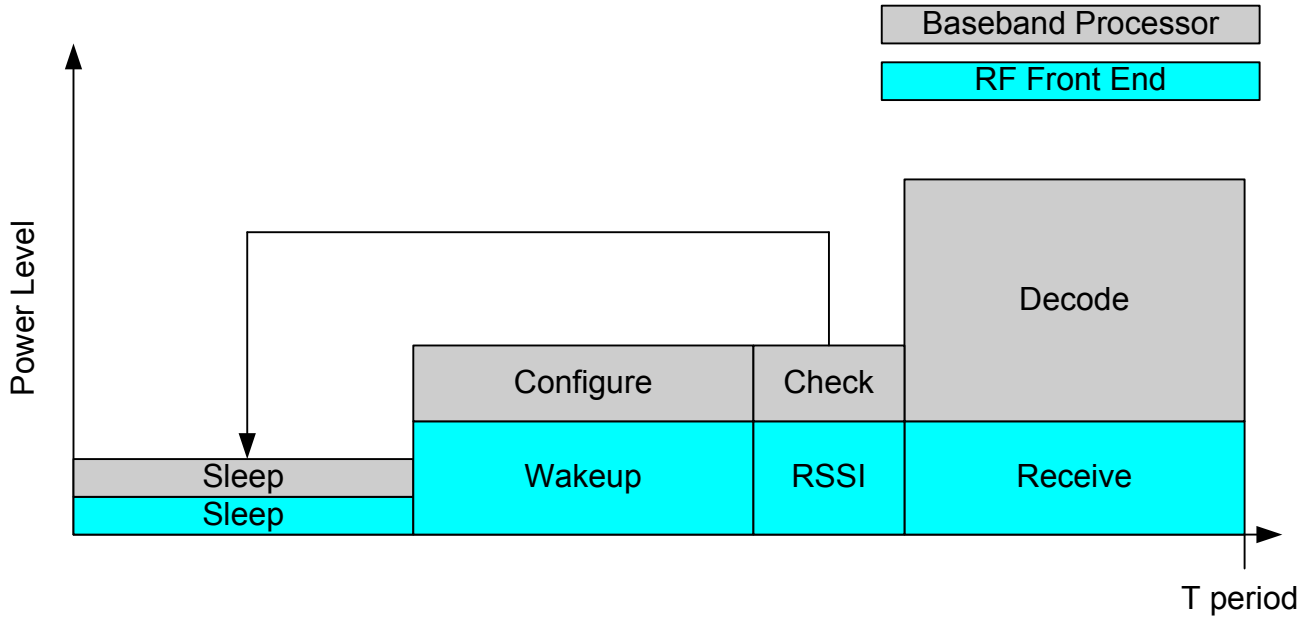
- Response only
- Clamps
- Timeouts
- Beacon only in sunlight

1U Mission Radio Selection: Combating Power Consumption

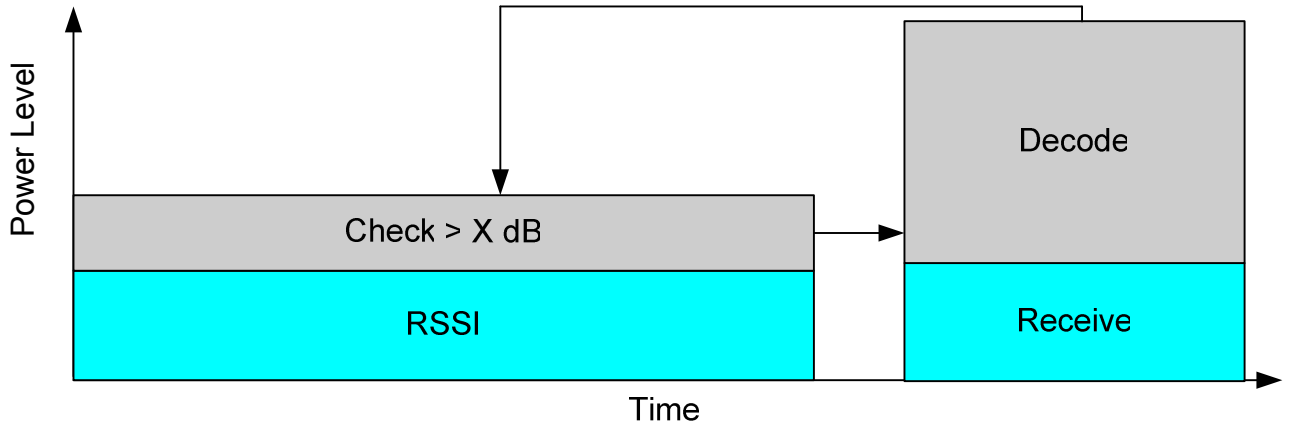
Receive:

Periodic

< 50 mW



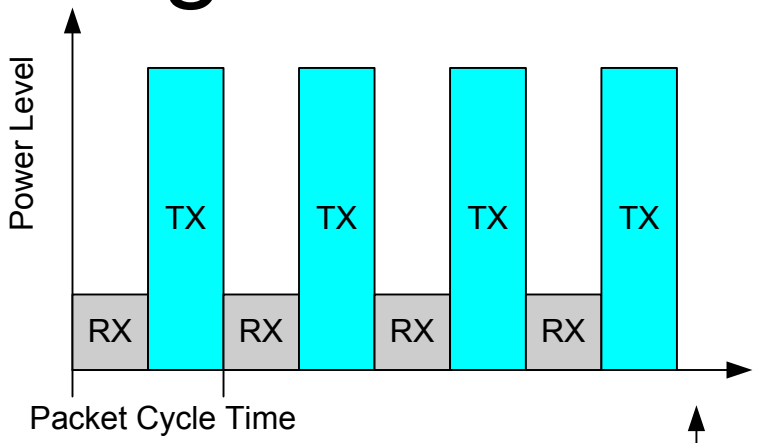
Initiated



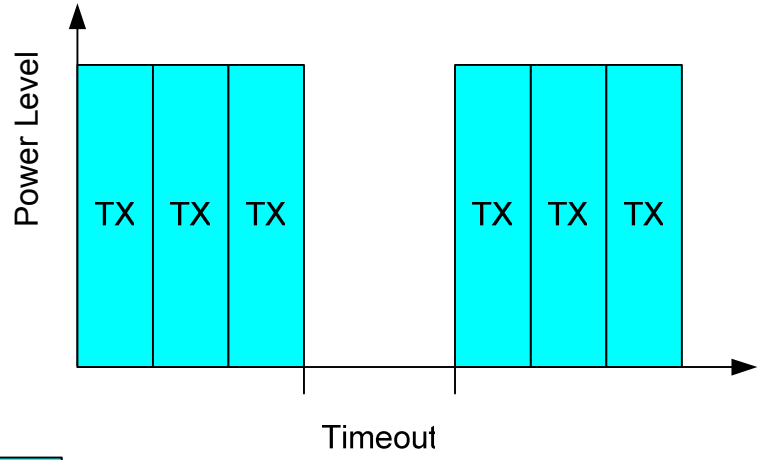
1U Mission Radio Selection: Combating Power Consumption

Transmit:

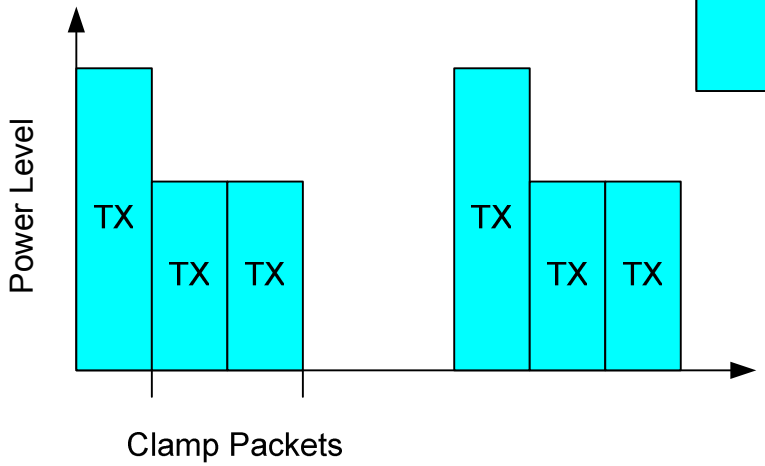
- **Response**



- **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