

Adaptive Radio Technologies, LLC

The Firehose Adaptive Radio

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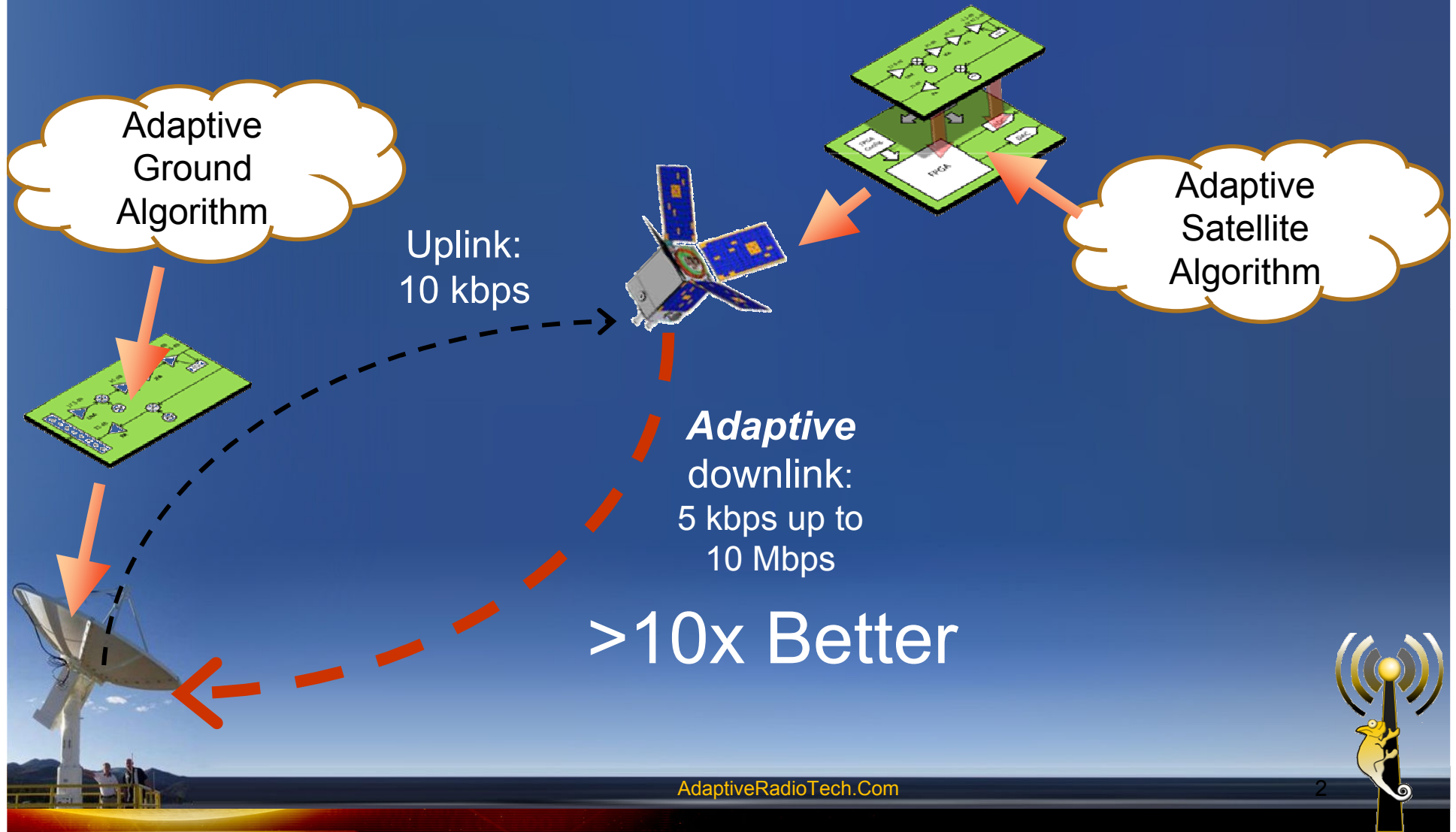
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Firehose: Adaptive Software Defined Radio



Firehose: Overview

- Adaptive software defined radio system
 - Designed to maximize Bits/Joule
 - 33 dB adaptability (20+ data rates)
- Simple to use
- 10 Mbps peak downlink rate
- 4 dB of coding gain (LDPC FEC)
- Full Duplex
- $\frac{1}{2}$ W Tx power



Firehose: How it works

Channel Bandwidth Limit

6 passes from a day in the life of CFESat

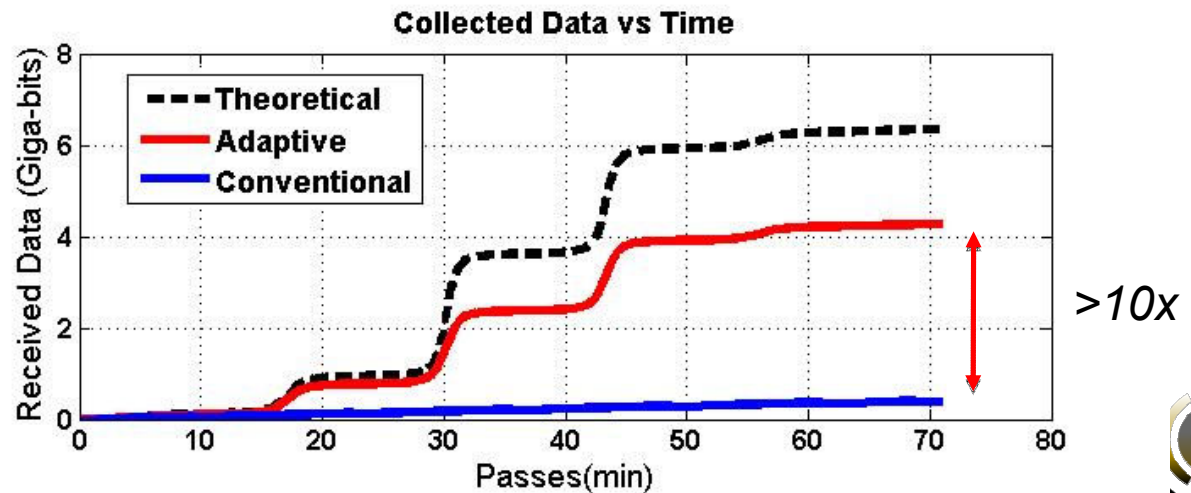
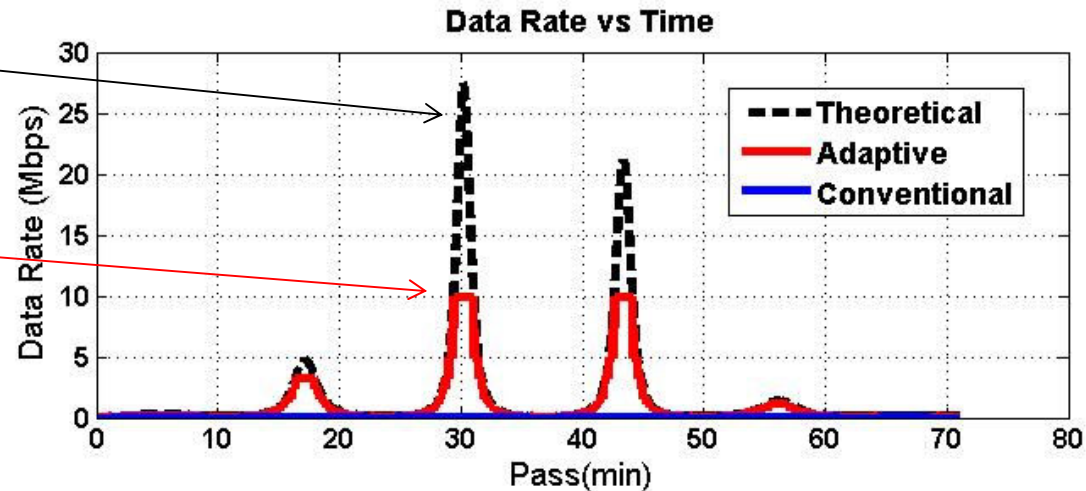
Link Optimization

Channel varies:

- Range
- Noise (EI Angle)
- Pointing (pol/pattern)

Rate changes

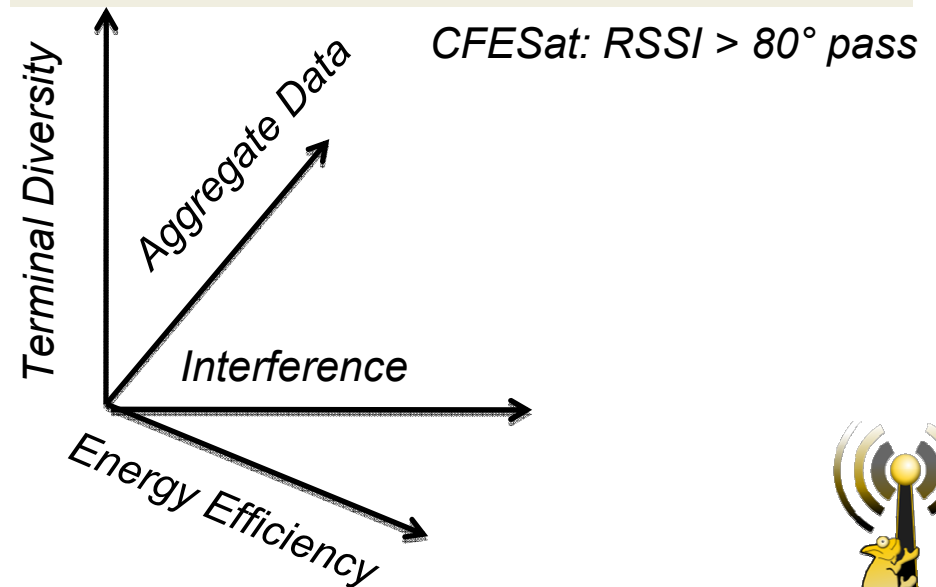
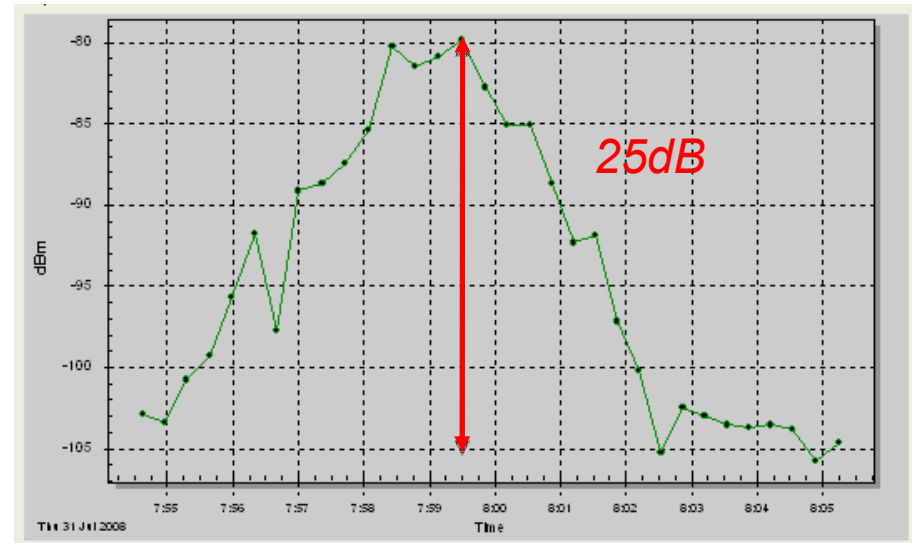
- Auto-negotiated
- No user coding
- Instant
- Glitch free



Firehose: Benefits

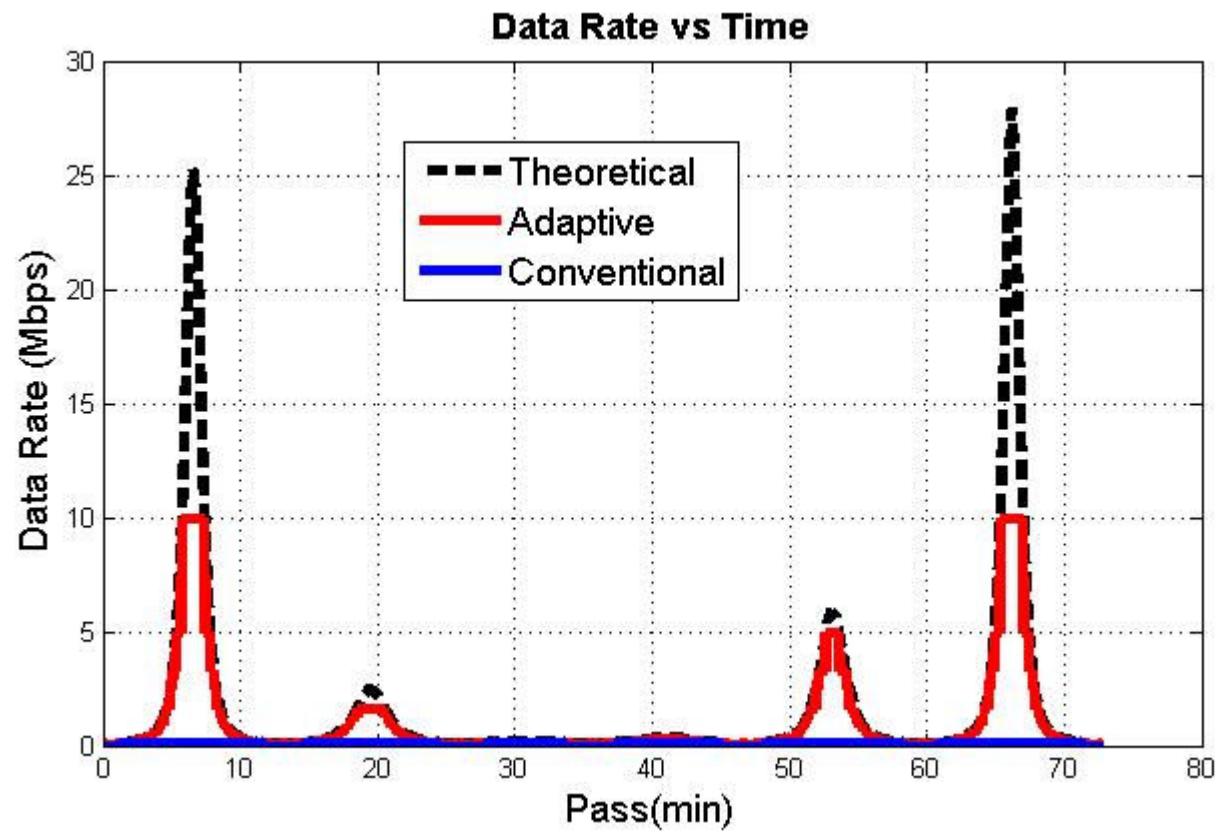
Advantages

- CubeSat compatible
- up to **10x** more data and
- **10x** greater efficiency
- Greater reliability
- Upgrade after launch
- Improved tolerance against interference



Example Scenario #1

One day of 6 contacts from 560km, 35° circular orbit
Nadir pointing spacecraft (6 dB patch)
Los Alamos NM Ground station (2.4m tracking dish)



Adaptive Radio
Total data: 4.6 Gb/day
Average data rate: 1.06Mbps

vs. **Conventional**

Total data: .42Gb/day
Average data rate .096Mbps

Ratio: 10.98



Example Scenario #2

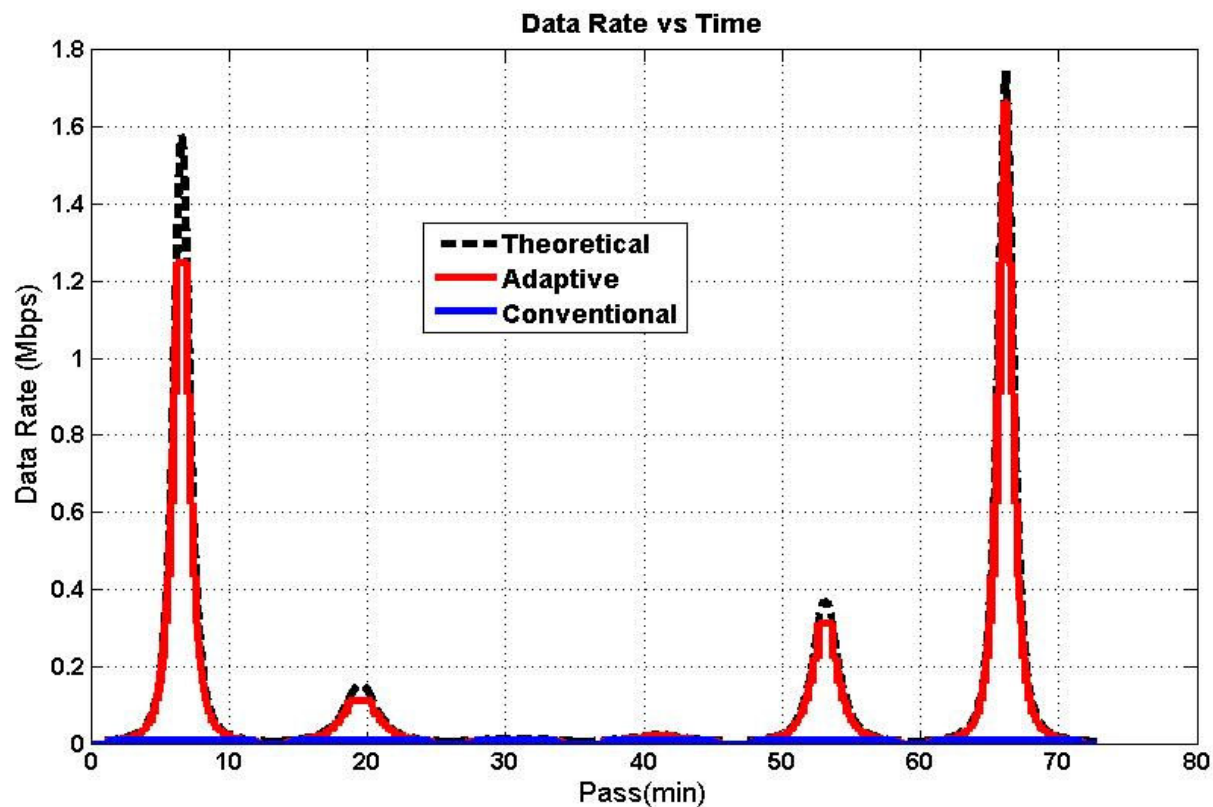
Same day of 6 contacts
Nadir pointing spacecraft (6 dB patch)
Los Alamos, NM Ground station (.6m tracking dish)

Adaptive Radio
Total data: 367 Mb/day
Average data rate: 84 kbps

vs. **Conventional**

Total data: 26 Mb/day
Average data rate: 6 kbps

Ratio: 13.94



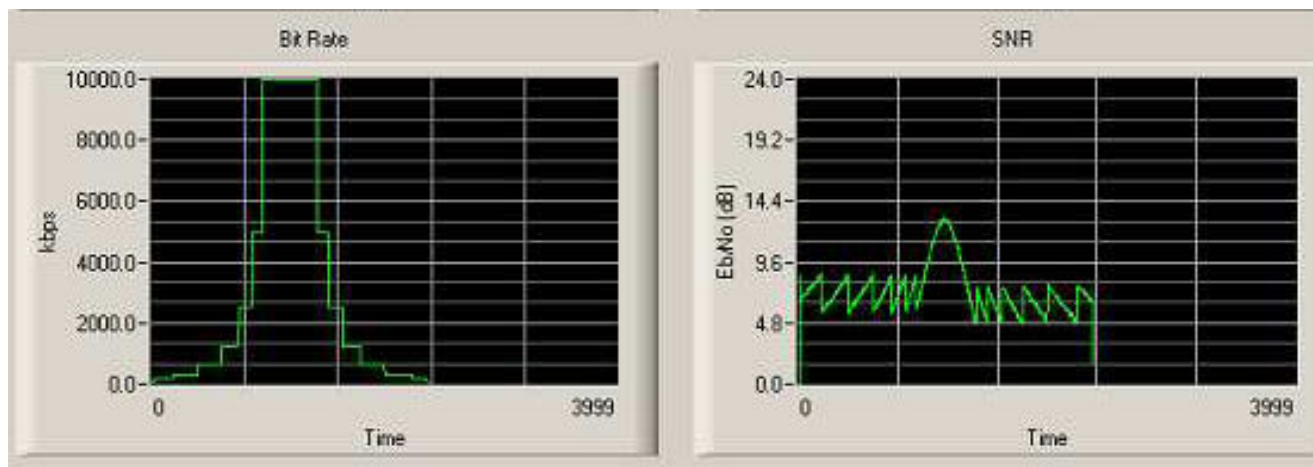
Estimate Performance Yourself

Download link calculator

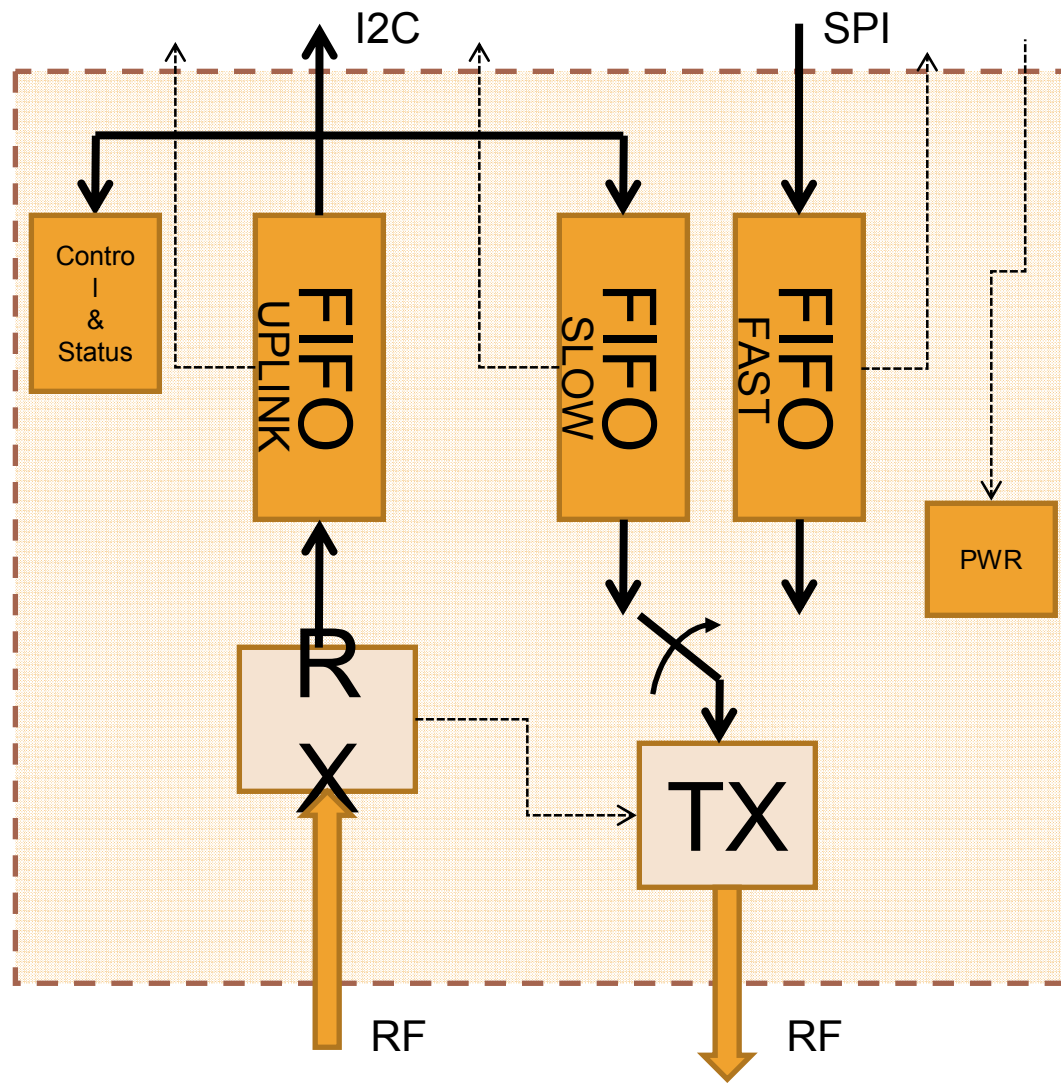
<http://AdaptiveRadioTech.com/calculator>

Requires Matlab, Satellite Tool Kit (AGI, Inc)

1. Generate an access report from STK
2. Enter antenna specifics in linkObj.m
3. Explore
4. Please give us feedback (info@AdaptiveRadioTech.com)



Radio Architecture



- Simple binary interface
- Discrete flags & power control
- Control & Status
 - I2C default
- High speed downlink
 - SPI default
- Low speed priority downlink
 - I2C default
- 3.3V data interface



Satellite Interfaces

- Data Interface Options
 - SPI, I2C, RS422/485 UART, serial LVDS, RS232 UART
- Power < 6W peak
 - 3.3V , peak 1.1 A
 - 5V , peak .48 A
- Mechanical
 - CSK/PC104 footprint
 - < 165g
- RF : Frequencies can be customized to user requirements
 - 900 MHz 9.6 kbps uplink
 - 2.4 GHz 10 Mbps downlink
 - 50 Ohm SMA antenna interfaces (two)
- Downlink: 30 MHz spectrum
- Uplink: 30 KHz spectrum

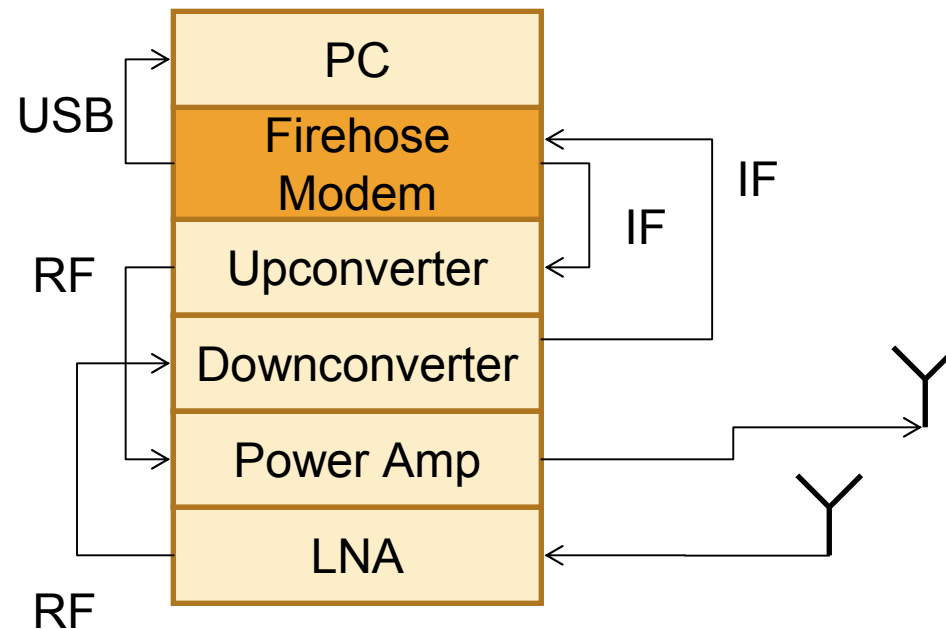


Satellite Radio State of Health

- Voltage
 - 1.2V, 3.3V, 5.0V
- Current
 - 3.3V & 5.0V
- Temperature
 - Processor
 - Power Amplifier
 - PCB
- RF power
 - Forward & reverse TX power
- Status
 - Current data rate
 - FIFO status
 - Receive signal strength indicator



Ground Station



The Firehose modem integrates into the typical ground station IF chain (either 70 or 140 MHz) and communicates with your PC via USB



Future Developments

- Summer 2010
 - Environmental testing
 - Field trials
 - Packaging GS modem
 - Software interface
- Delivery Fall 2010 (can be accelerated)
- Encryption
- Multiple Access capability
 - Multiple CubeSats in formation
- Automatic Repeat Request (ARQ)
 - Incorporates onboard flash
- Higher peak data rates
- Complete compact mobile ground terminals
 - USB connected
 - Tracking .6m Rx dish
 - Tracking Tx helical



Conclusion:

Maximize the Data Rate

1. Use a Firehose radio system
2. Locate the ground station at a latitude = orbit inclination
3. Control satellite attitude (antenna pointing) to align boresight
4. More gain
5. More power

Firehose

- **10x data & energy efficiency**
- **Greater reliability by providing substantial link margin**
- **Performs well in the presence of interference**
- **'Upgrade' after launch**
- **A clear path to multiple access**



Comparisons

- Adaptive systems in wide use
 - IEEE 802.11
 - Adaptive Coding & Modulation
 - WiMax
- Not optimized for maximum bits/Joule
- Not available for CubeSat application
- Do not have the necessary adaptability (30+ dB)
- Variable systems
 - Require development of complex control software at user level
 - May drop data during rate changes
 - Require synchronization of the ground station and satellite rate changes
 - Do not have sufficient range of supported data rates
 - May be problematic in the event of surprises (interference or attitude anomaly)

