Flight of *FRNCS-P*, *QuickSAT/Xen* and *LinkStar* on the *RADSat* CubeSat Mission

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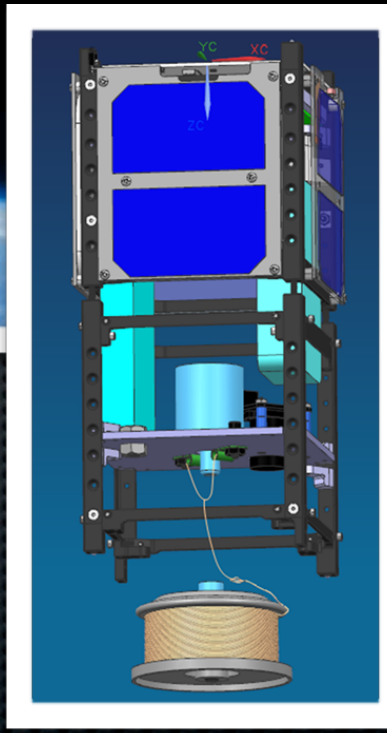
Cubesat Workshop

sci_Zone, Inc.

Today's Presentation...

- The *RADSat* Mission
- *QuickSAT - Xen* and *VMS*
- The *LinkStar* Radio
- Roadmap and Next Steps

RADSat Mission



- *2 U CubeSAT*
- *Tethered Satellite Mission!*
- *Deployed from Nanoracks Platform*
- *Launch - Tentatively Late Fall 2015*

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Mission Concept

ISS Deployment

Startup, Charge Batteries, Systems Checkout

Attitude Control, Separation, Tether Deployment

200m Tether

Science Ops, Gravity Gradient Stable Orientation

Camera records separation

Commands, Data

Ground Station

Onboard sensors measure stability

Deorbit

Science Objectives

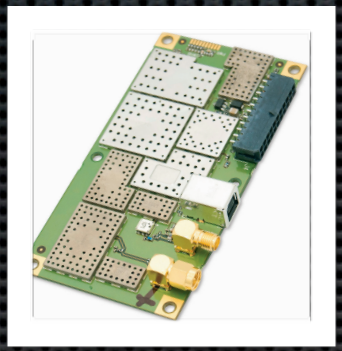
Primary	1. Characterize the properties of a 2U cubesat in free flight. 1. Power generation / energy demand 2. Thermal cycling 3. Attitude 4. ***Downlink capability*** 2.Characterize the properties of a 2U cubesat with active attitude control. 3.Characterize and demonstrate the deployment of a tether and study the system dynamics.
Secondary	1. Obtain imagery of separation and tether deployment. 2. Activate / operate secondary payload.
Tertiary	1. Characterize vehicle autonomous operations – nominal operations 2. Characterize attitude control and operations – combined vehicle 3. Characterize passive attitude control and operations – separated vehicles 4. Characterize vehicle autonomous operations – simulated failure operations

Mission Objectives

Primary	***1. Downlink data*** ***2. Uplink and execute commands*** 3. Separate cubesats 4. Deploy tether to full extent 5. Detumble the combined vehicle 6. Achieve controlled stable attitude (pre separation) 7. Achieve passive stable attitude (post separation)
Secondary	1. Obtain imagery of separation 2. Autonomously identify orbit and propagate vehicle state 3. Activate / operate secondary payload
Tertiary	1. Test on-board software autonomous downlink 2. Test attitude control with simulated hardware failure

QuickSAT and *LinkStar*

- *LinkStar* Duplex Radio
  - *Full Duplex radio*



- FRNCS-P Flight Computer
  - *First flight of the BeagleSpace architecture*
  - *Flight Certification of QS/VMS*

- QuickSAT/Xen Space Hypervisor
  - *First Space Hypervisor*

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QuickSAT/Xen

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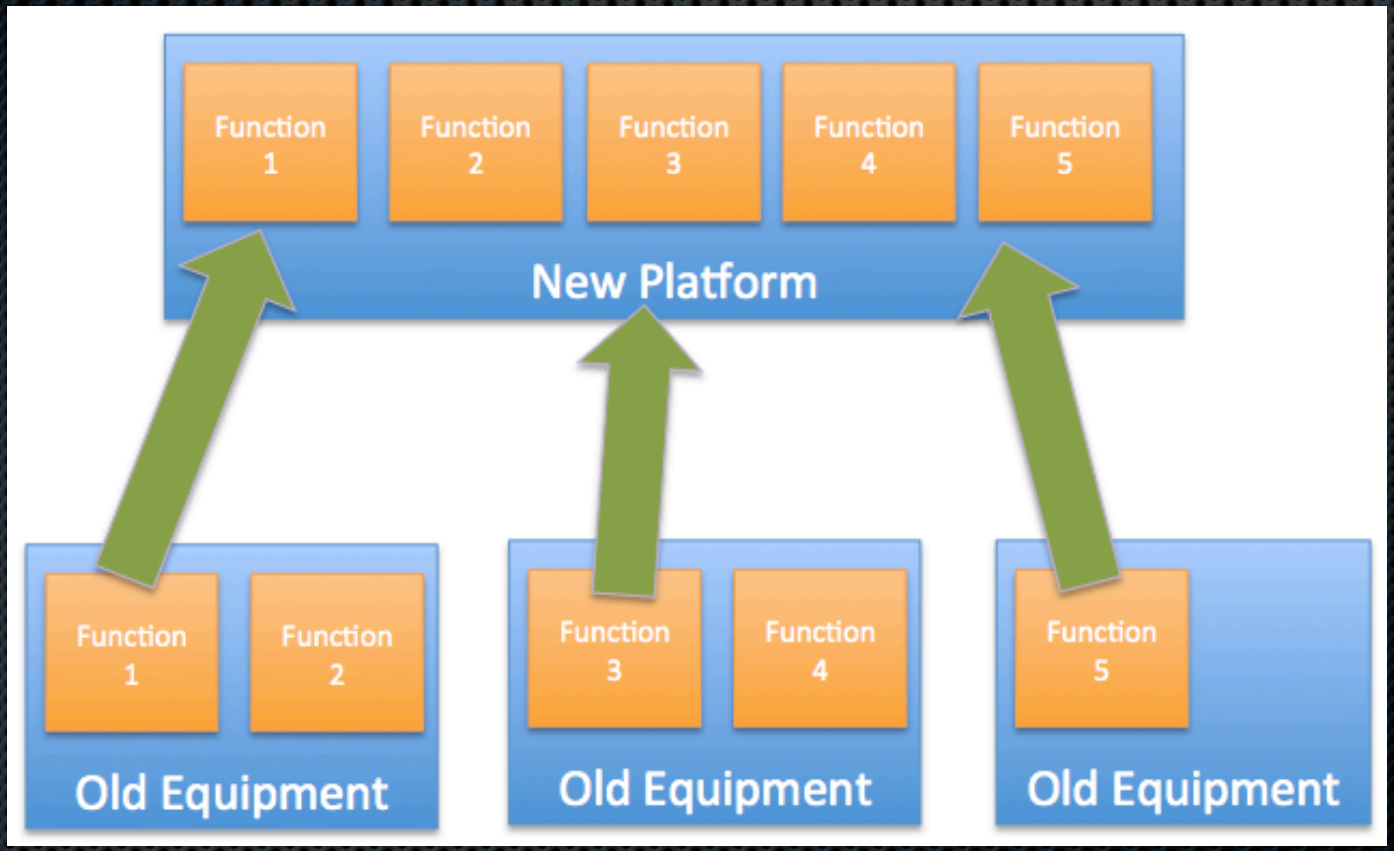
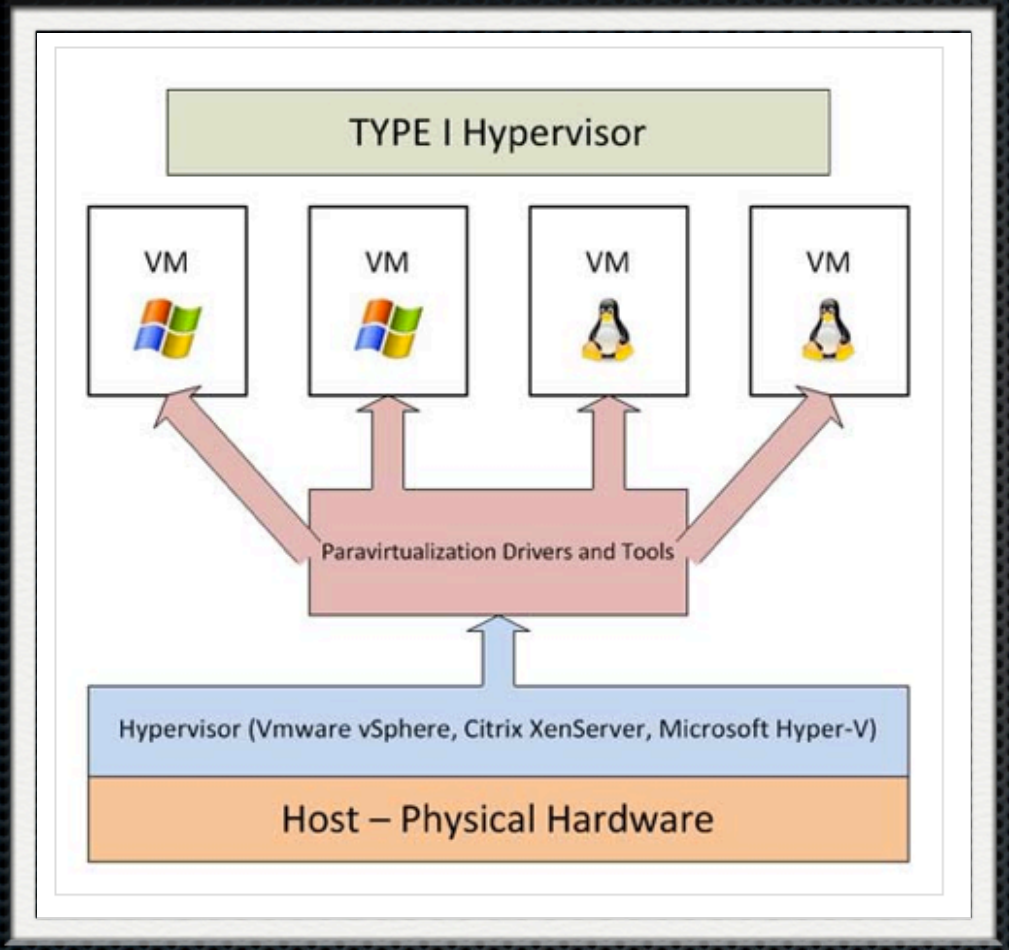
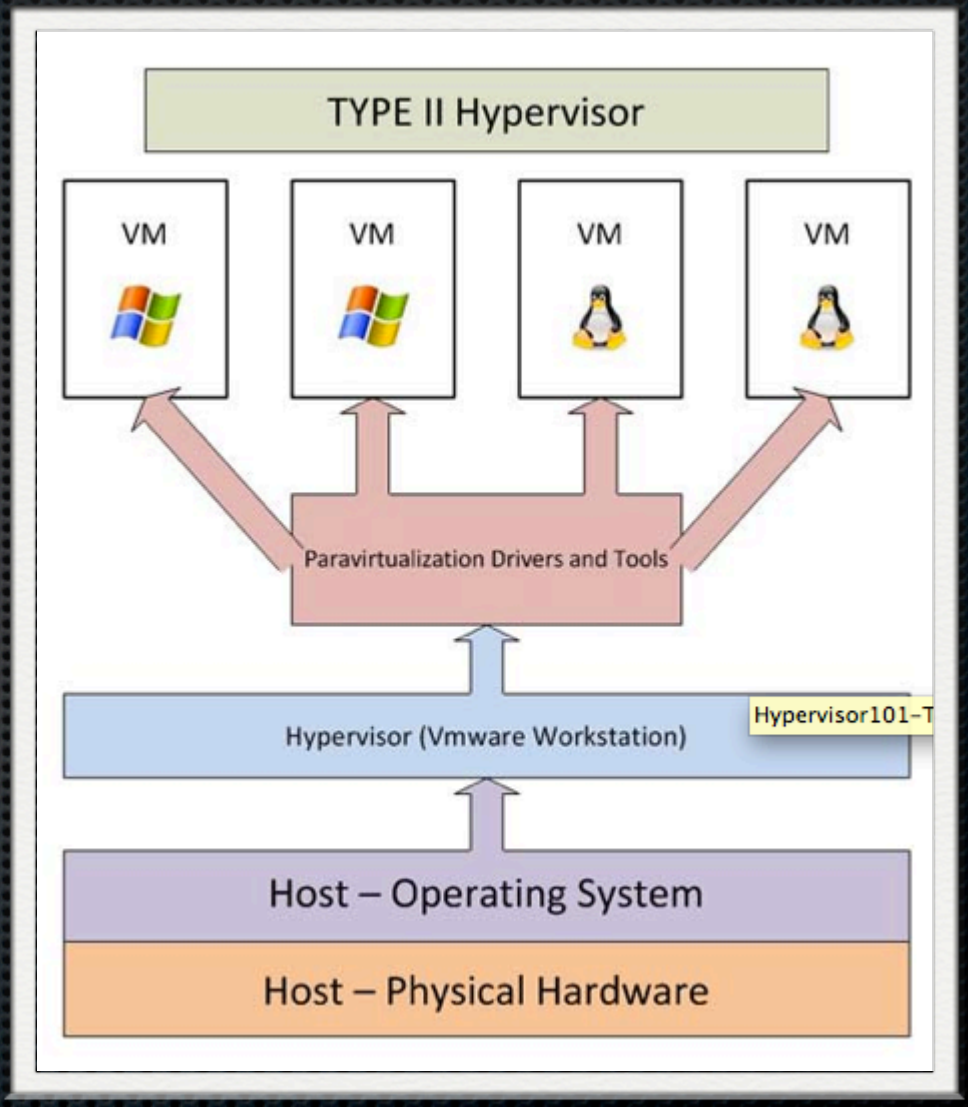
Sustain Legacy Systems by Migrating Functionality to the Hypervisor



Types of Hypervisors...





QuickSAT/Xen *is an adaptation of Xen, a Type I Hypervisor*

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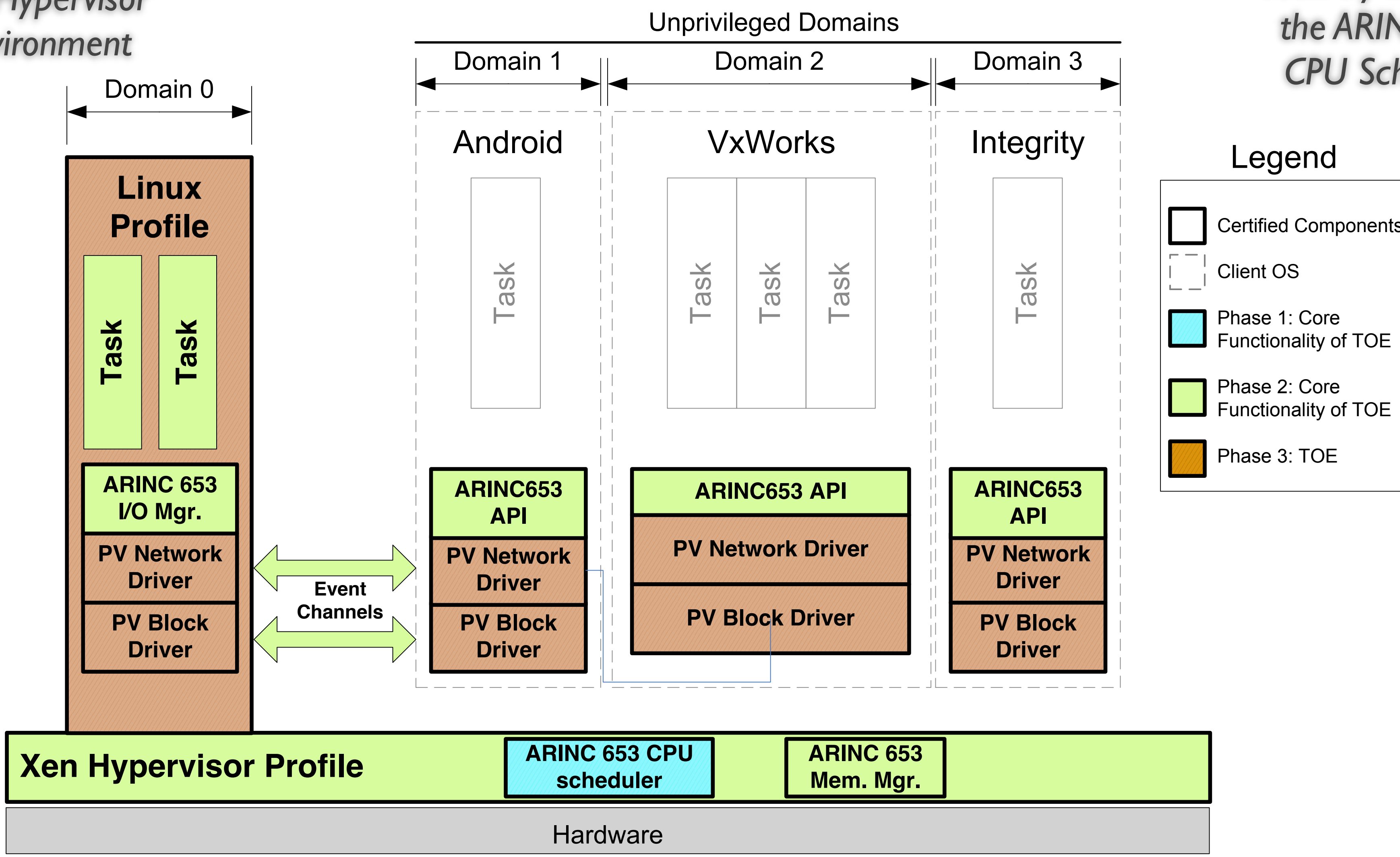
Benefits

- Security
  - Multiple Independent Levels of Security (MILS EAL6+) by Formal methods mathematical proof of correctness
  - Isolates software into their own partitions, regulates information transfer
- Safety
  - DO-178C Certification with Design Assurance Level A
  - Certification artifacts
- Performance
  - Low overhead virtualization
  - Low latency via ARINC 653 I/O interrupt
  - Multicore
- Integration
  - Efficiently upload and build virtual machines from the lab or ground station
  - Build VMs from QuickSAT/Designer - automatic parameter definition
  - VMs operation based on modes of operation

The Xen Hypervisor Environment

DOM0 Controls the Hypervisor Environment

Multiple "Virtual Machines" securely linked via the ARINC 653 CPU Scheduler



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QuickSAT/Vehicle Management System (VMS)

Your window into your satellite

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How It Began...

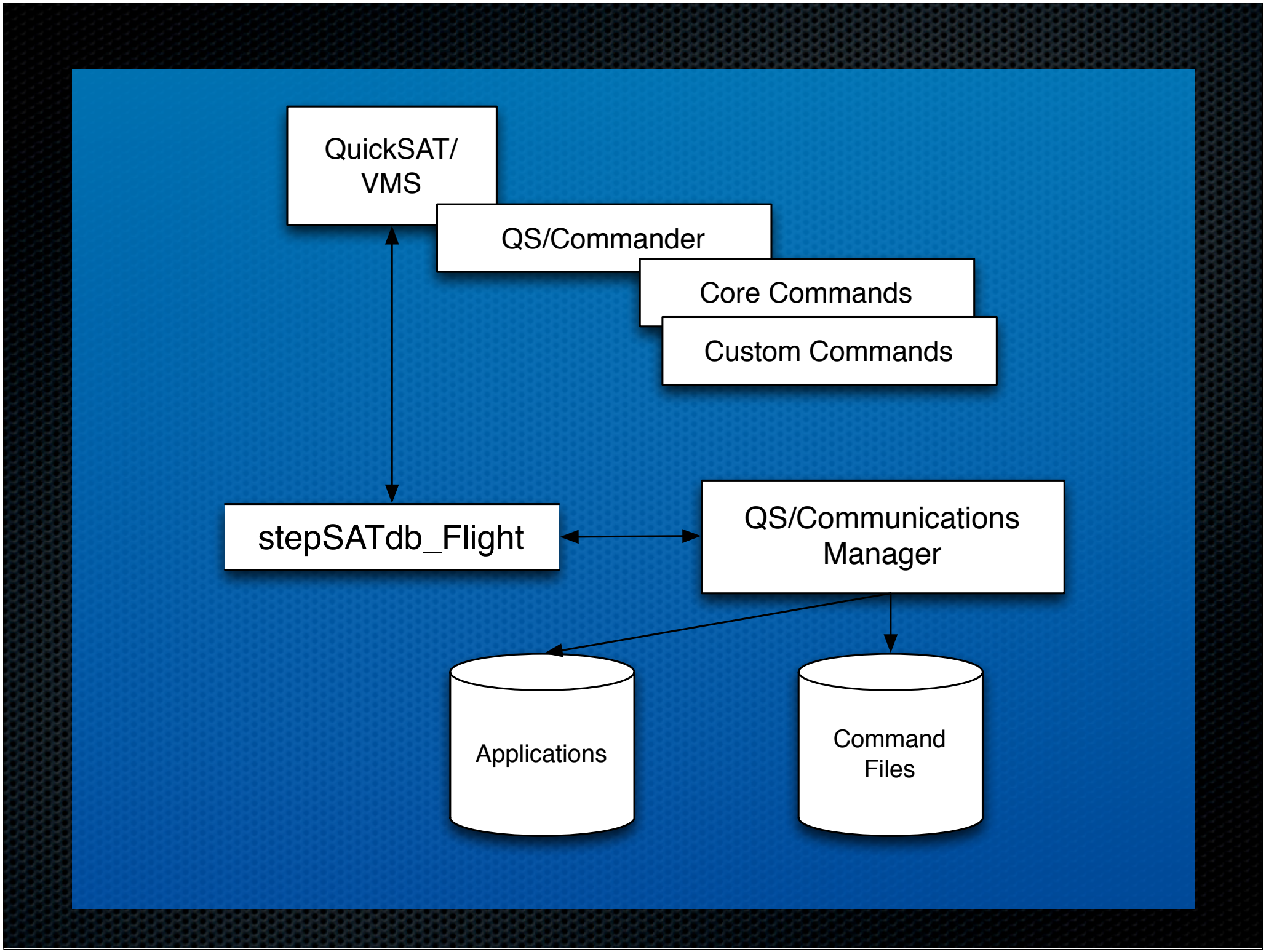
- sci_Zone commercialized QS code to support the GE Aviation Aircraft Health Management System Project.
- sci_Zone entered into an agreement with GE to use the open source QuickSAT APIs on their “Operational Ground Program” (OGP).
- QuickSAT/Vehicle Management System (VMS) created as an expanded version of the OGP program.

QuickSAT/VMS

- Broad Use: *Aviation, Satellites, Cars*
- A complete Flight Management System
- Vehicle Health Management & Monitoring
- Vehicle Commanding Services
- Communications services
- Test/Monitoring interface

QuickSAT/VMS

- Can serve as a stand alone ground station or part of an expanded environment
- Customizable
- Utilizes open source software where possible
- Works on a range of flight hardware
- Web based - PCs, Tablets, etc.
- Certified DO178B for Aviation


QuickSAT/
VMS
QS/Commander
Core Commands
Custom Commands
stepSATdb_Flight
QS/Communications
Manager
Applications
Command
Files

QuickSAT/Designer

- Parts Management
- Parameter Defn
- C&DH
- Mission Flight Plan
- Scheduler
- Xen Tools
- Define Modes
- Mission Conops & Analysis

v6.0

QuickSAT/VMS

- Flight Management
- File Transfer
- Health Monitoring
- Communications
- Configuration Support
- Ground Control

v3.5

Xen

- MCP 1.0
- MCT 1.0

FRNCS

Flight computer

ARM-15, -8, -7
Intel Support

LinkStar Radio & *QuickSAT*

LinkStar: A Paradigm Shift

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Small Satellite Comm Issues

- Difficult to find
- Difficult to acquire
- Limited ground communications

Enter LinkStar...

LinkStar Quality Satellite Comm Link
“the Edge of Exploration”

- Reliable and seamless data link
- Many communications systems associated with CubeSat failures and require significant flight hardware and tracking time/cost
- Complements high-data rate downlinks
  Beacon GPS, Health, Back-up and Sample data sets

The Foundation: *Globalstar*

- GlobalStar Constellation
  - 32 LEO Satellites (1400 km)
  - Provides global data and voice services for ~ 300,000 customers
- Used primarily for infrastructure/wildlife monitoring
  - Oil Rigs
  - Shipping Containers
  - Gas pipe-lines
  - Endangered animals
- *LinkStar* developed by *sci_Zone* for a range of applications
  - Data links via the GlobalStar network
    - Payload commanding
    - Data downlinks
    - Recovery tracking (with GPS)

Globalstar Be Heard.

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LinkStar Product Features

- Anytime, anywhere satellite TT&C
- Estimated +70% orbital coverage for Duplex based radios; over 95% for Simplex based radio!
- Common FCC Satellite-to-Satellite License
- No Amateur bands
- Radio astronomy interference was eliminated by limiting the GlobalStar units to operate at 1616.25 MHz with a bandwidth of +/- 1.25 MHz
- No satellite to ground license required

LinkStar Product Features

- No deployables
  - 2 cm x 2 cm patch for simplex
  - 2.5 cm diameter circular patch for duplex
- Rapid acquisition - simplex beacons within 15 seconds
- Data rates
  - 9600 kbps maximum
  - *LinkStar* can compliment traditional high speed radios
  - *LinkStar* can serve as a primary radio depending mission data requirements.

Globalstar Be Heard.

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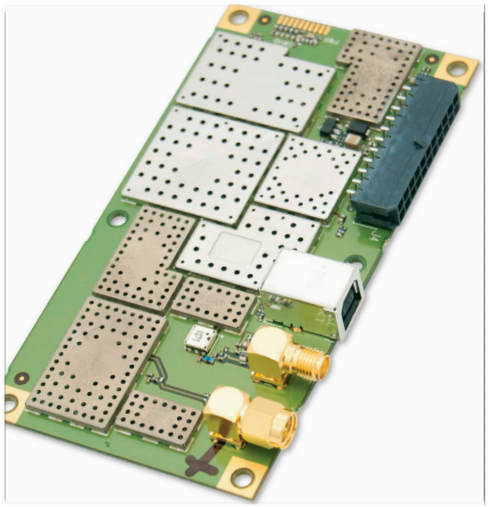
LinkStar Product Features

- Ground station over Internet Protocol (IP)
  - *Access your spacecraft from anywhere!*
- Piggy-backs on established 2 billion dollar network
- Low Cost
  - No Ground Station
  - No tracking
  - Proven system



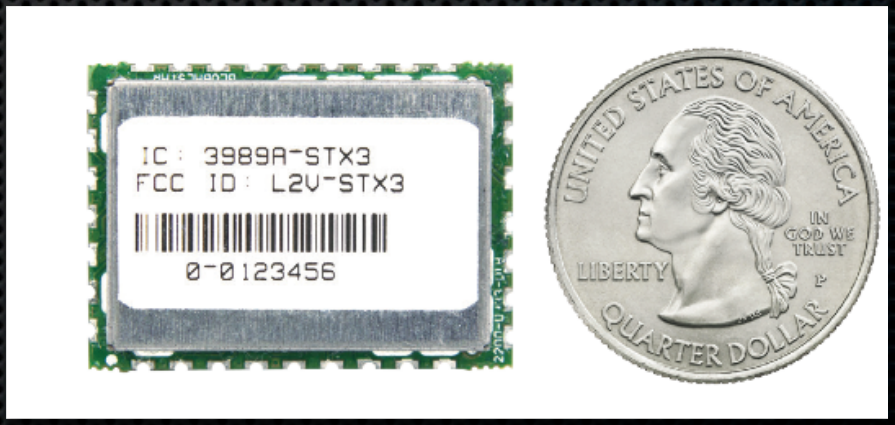
Operating Frequencies	Transmit: 1610 MHz – 1626.5 MHz Receive: 2483.5 MHz – 2500 MHz
Maximum transmit power	+31dBm EIRP (passive antenna), +34 dBm (active antenna)
DC input voltage	+4.7V to 5.1V

Power Consumption @5VDC input (estimated)

State	Min	Typical	Max	Units
Shutdown	0.0	0.65	1.0	mW
Standby	0.5	0.5	1.1	W
Transmit	2.2	3.65	5.0	W

LinkStar-STX3
Simplex Gen 3 Features

- Small form factor
  - Power
    - 350 mW Tx power
  - Dimensions
    - 28.7mm x 20.57mm x 4.13mm
  - Electrical
    - Accepts 3.3 V to 12 V
    - TTL Data Protocol
  - Near Global Coverage!



Many ways to configure *LinkStar*

The heart of our communications system. Pick Simplex, Duplex or both!
Includes ARM-8 based flight computer system. Low power, but powerful and flexible. Allows your satellite to become a node on the internet!

LinkStar → QuickSAT/ VMS

"Vehicle Management System" - A complete flight management system - monitor, control, communications and commanding.

Monitor the health of your satellite on the ground or in space. Can also be used to control your satellite and serve as the core to your ground control system

+

+

Multicore and multiple boards, ARM based and linked together.

FRNCS-M

QuickSAT/ XEN

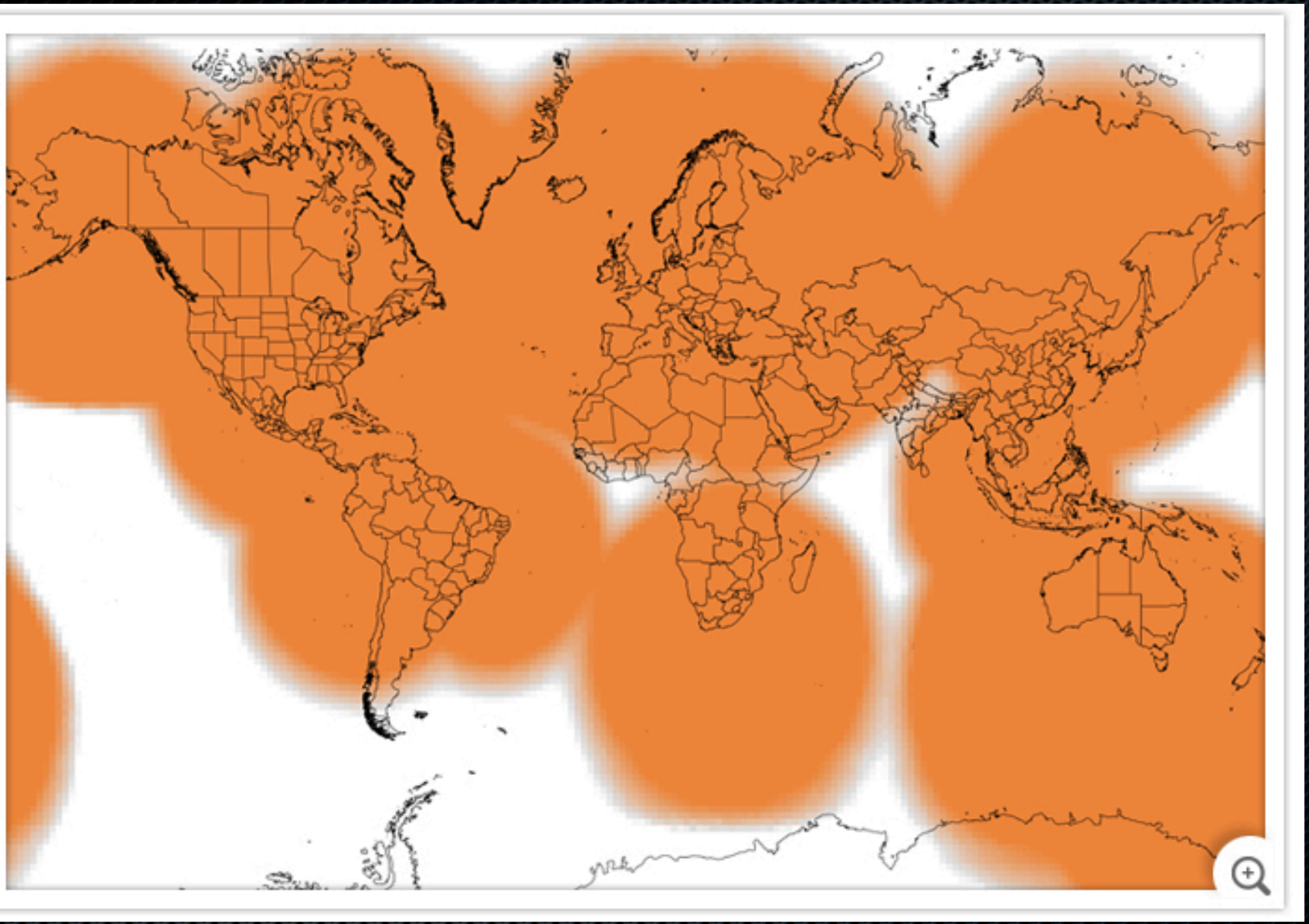
Our premier hypervisor environment - define virtual machines and payloads. Provides for a robust and secure environment

+

QuickSAT/ Designer

Design your satellite - and automatically configure both the satellite and your *LinkStar* radio!

Add one or all these pieces to your LinkStar environment!



Globalstar Be Heard.

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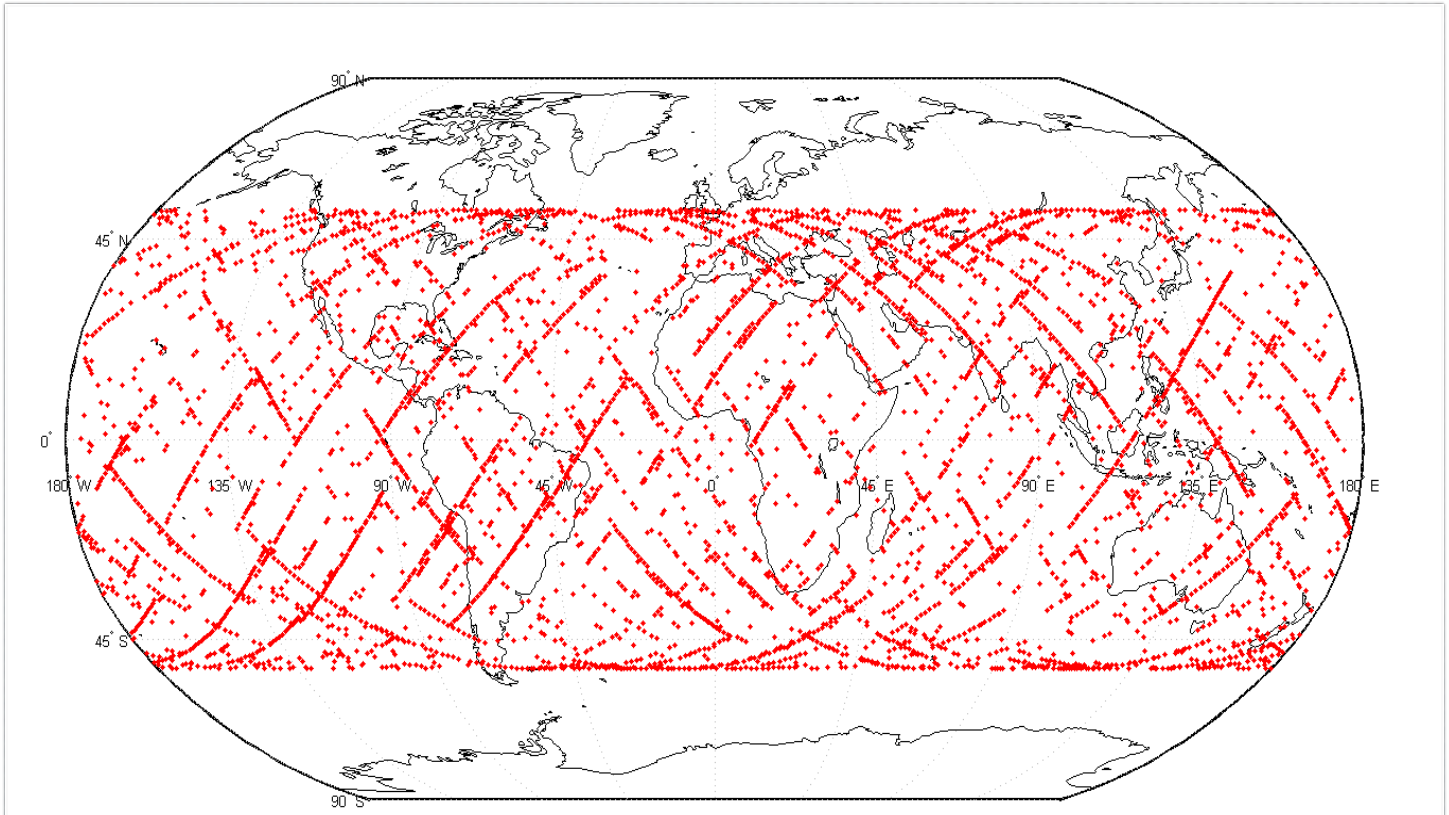
Preliminary TSAT Coverage Map Using the Gen2 based simplex radio



Beacon Cycle

- 32 beacons
- One every 5 seconds
- 15 minute dwell
- over 40,000 packets received

- 45% packet throughput on a tumbling satellite

Near Global Data Downlink Coverage

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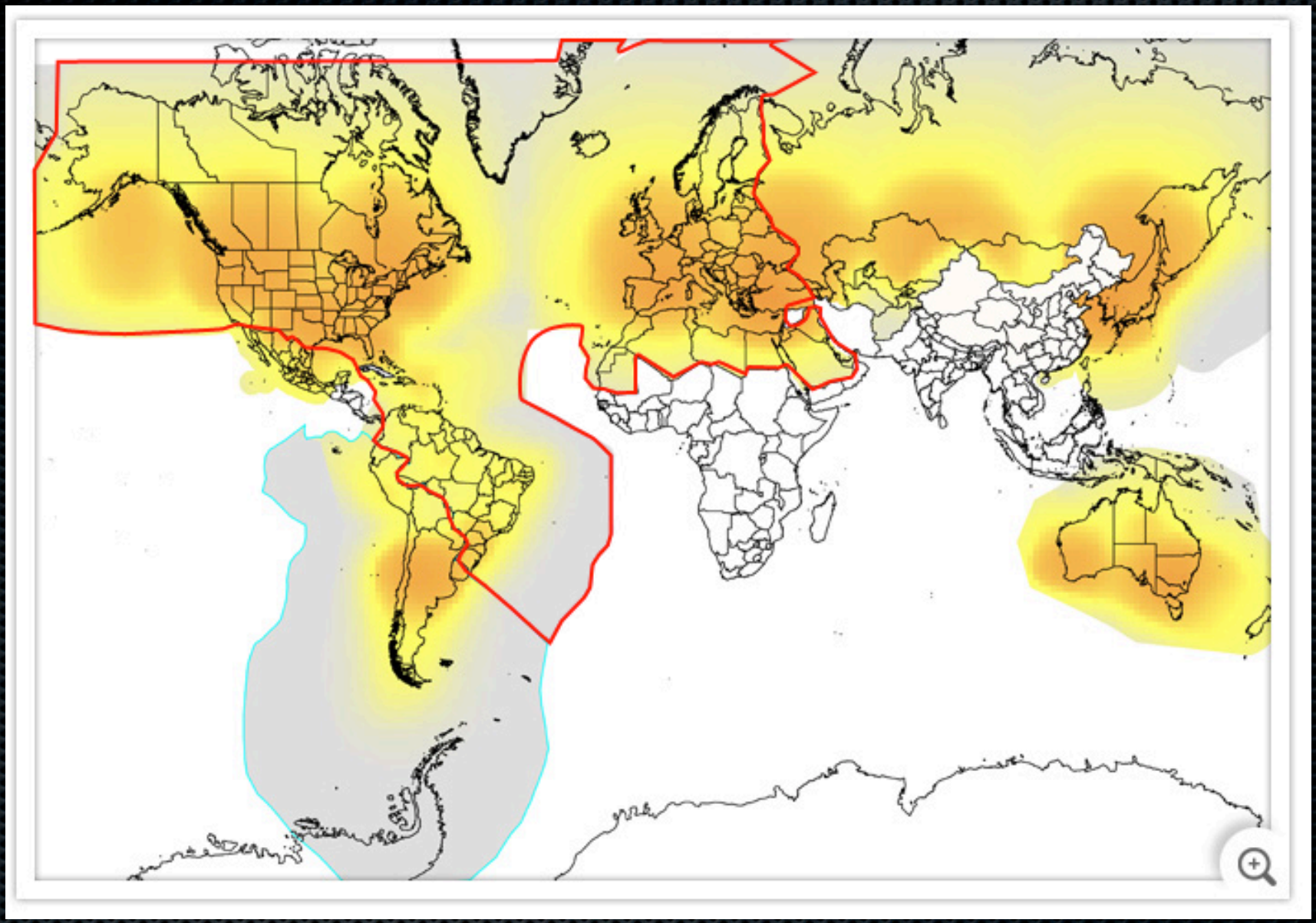

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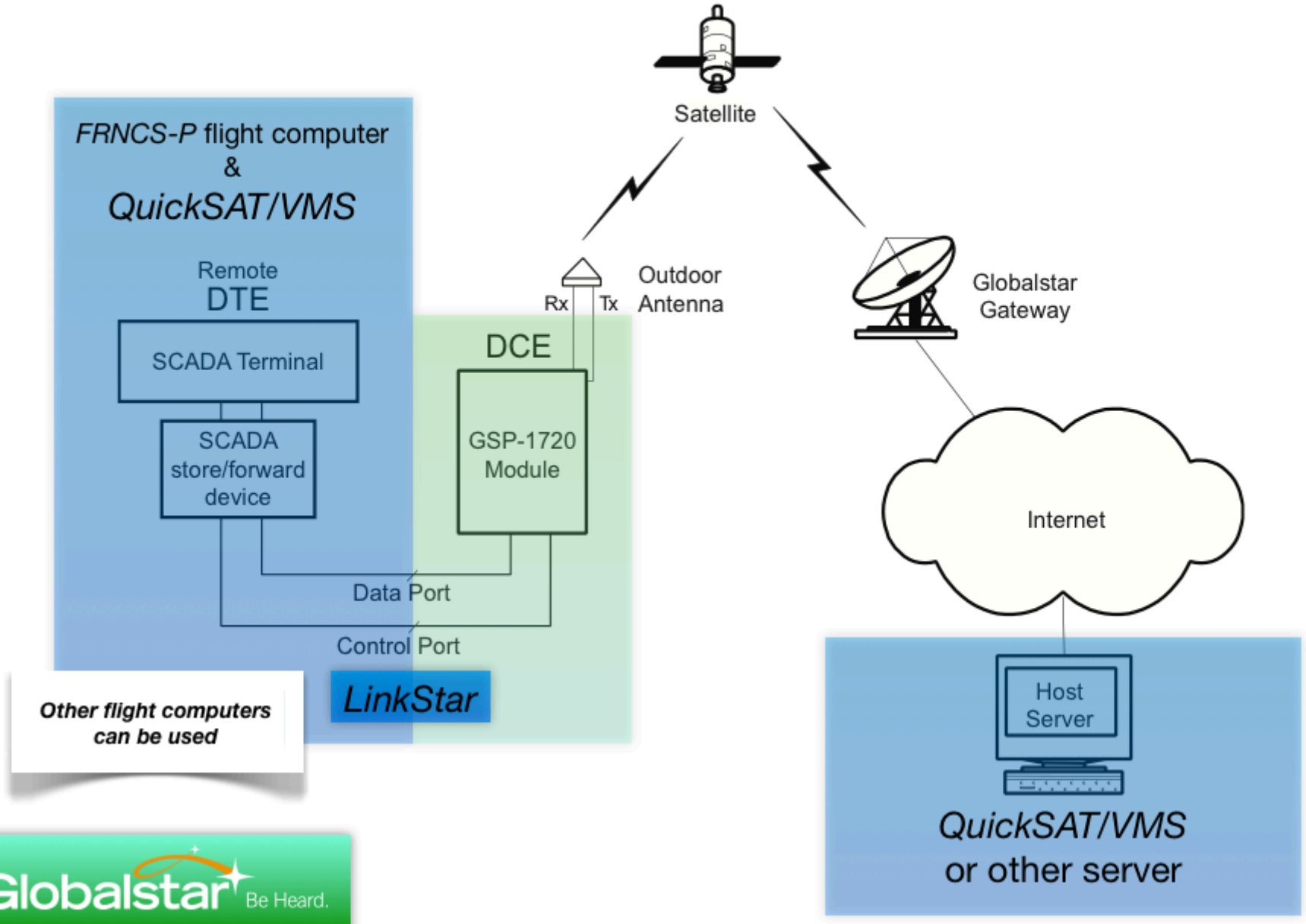
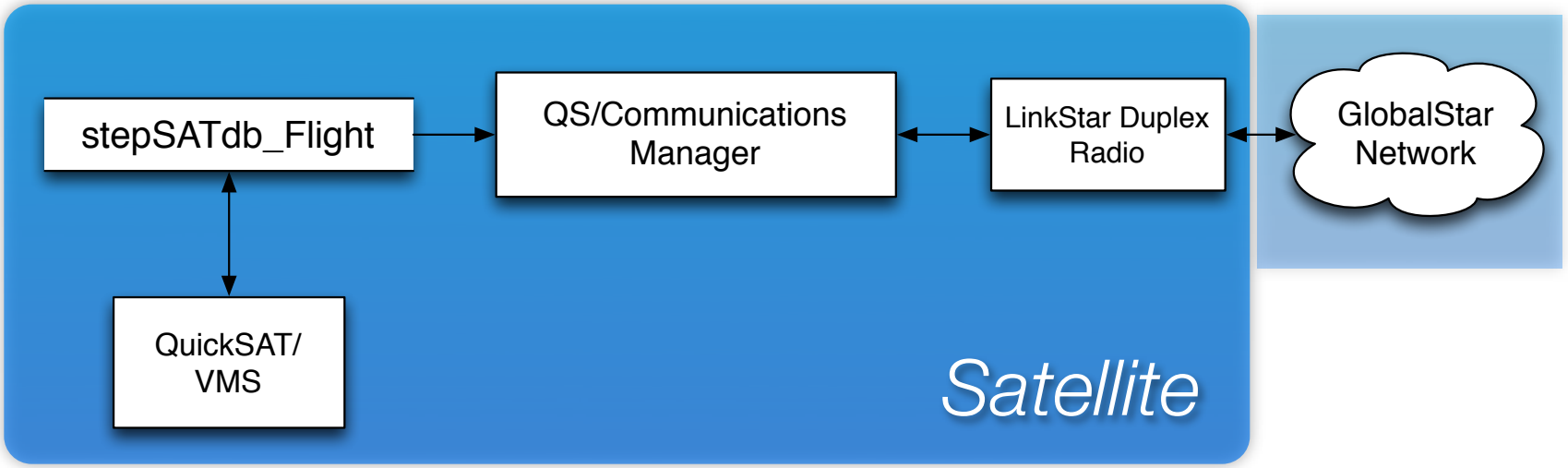
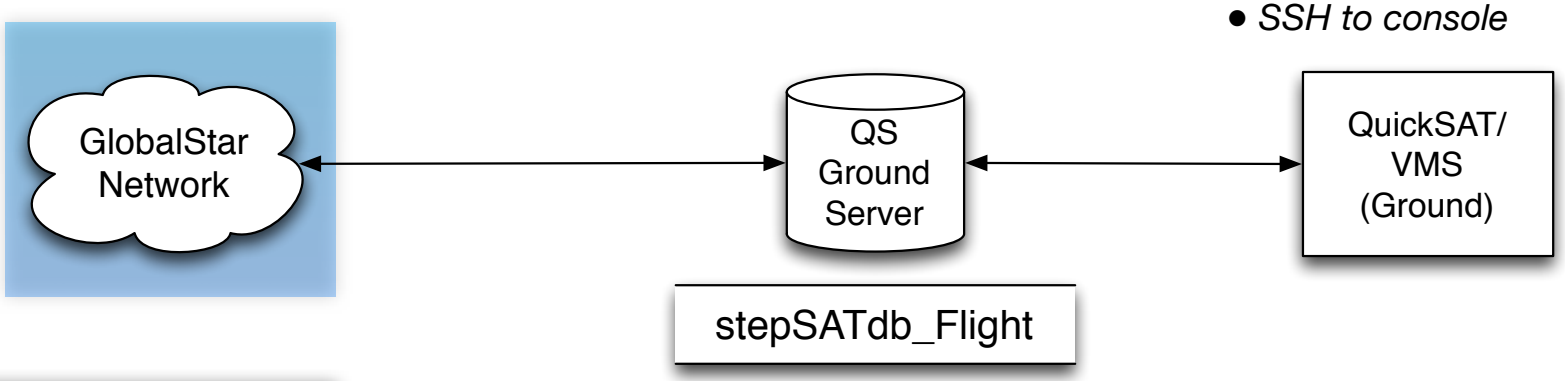
Baseline Communications Scheme with LinkStar



Satellite to Ground

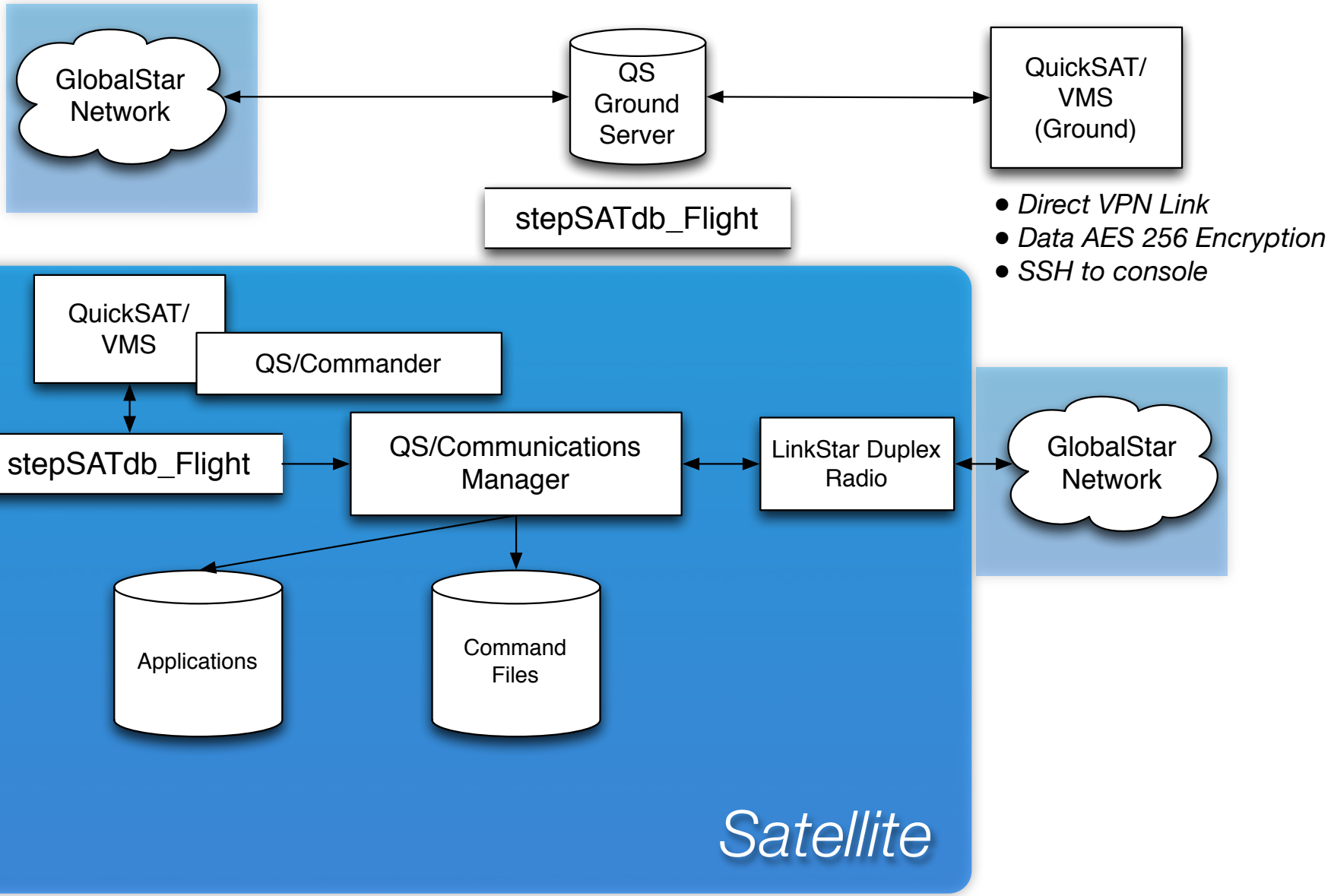


- *Direct VPN Link*
- *Data AES 256 Encryption*
- *SSH to console*



Globalstar Be Heard.

Ground to Satellite



FRNCS-P

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High Speed Computing in Space

- Supports Multiple ARM Processors & Boards
- Internal/External Networking
- Single and Multi-Core
- Configure for flight using QuickSAT/Designer
- Comes with QuickSAT/VMS for ground station front end, systems monitoring and payload health management and for command, control support, and functions as communications gateway

RADSat will fly a BeagleBone Black (Rev C) with the BeagleSpace architecture.

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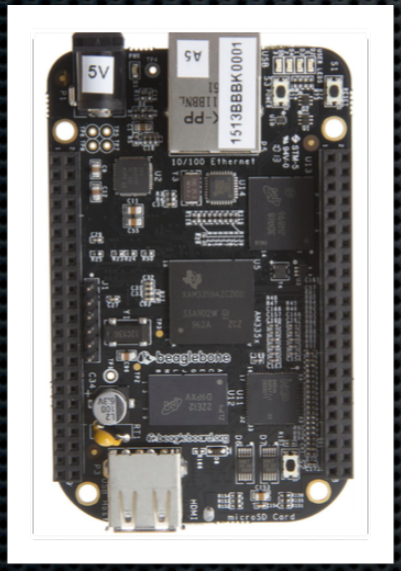
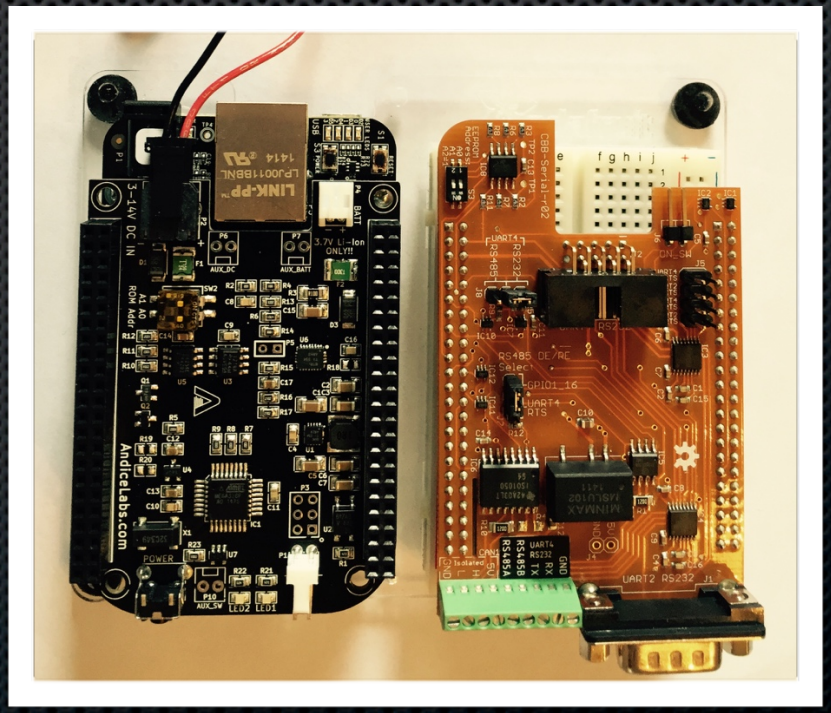
The Details

Processor	Sitara AM3359AZCZ100 1GHz, 2000 MIPS (ARM 8)
SDRAM Memory	512 MB
On Board Flash	4 GB
Software	Debian (7.6), PHP, C, MySQL, QuickSAT/VMS

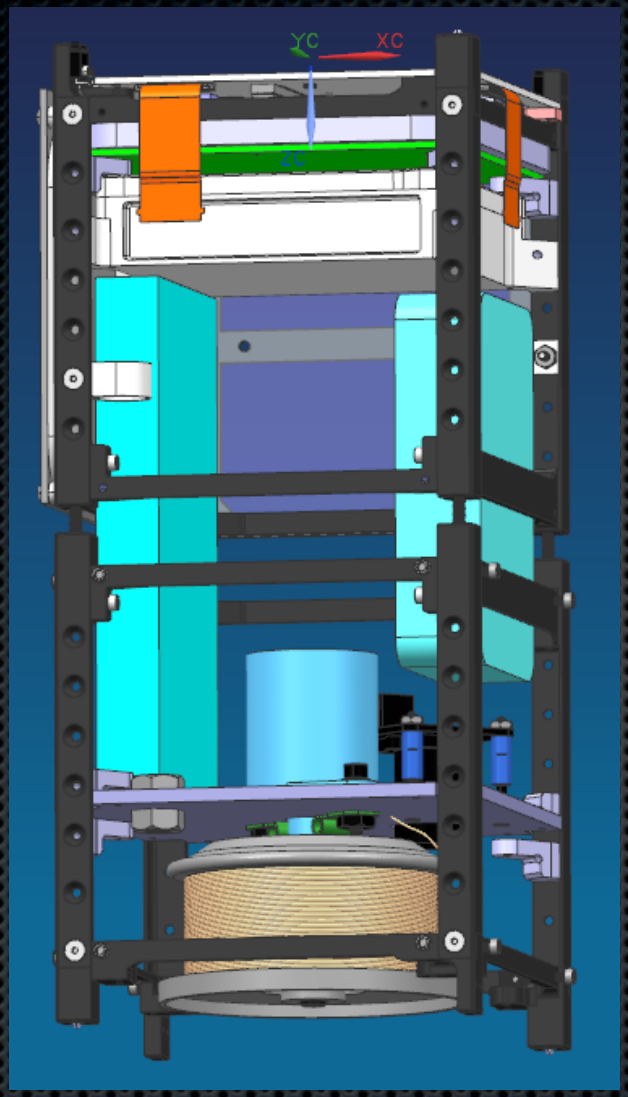


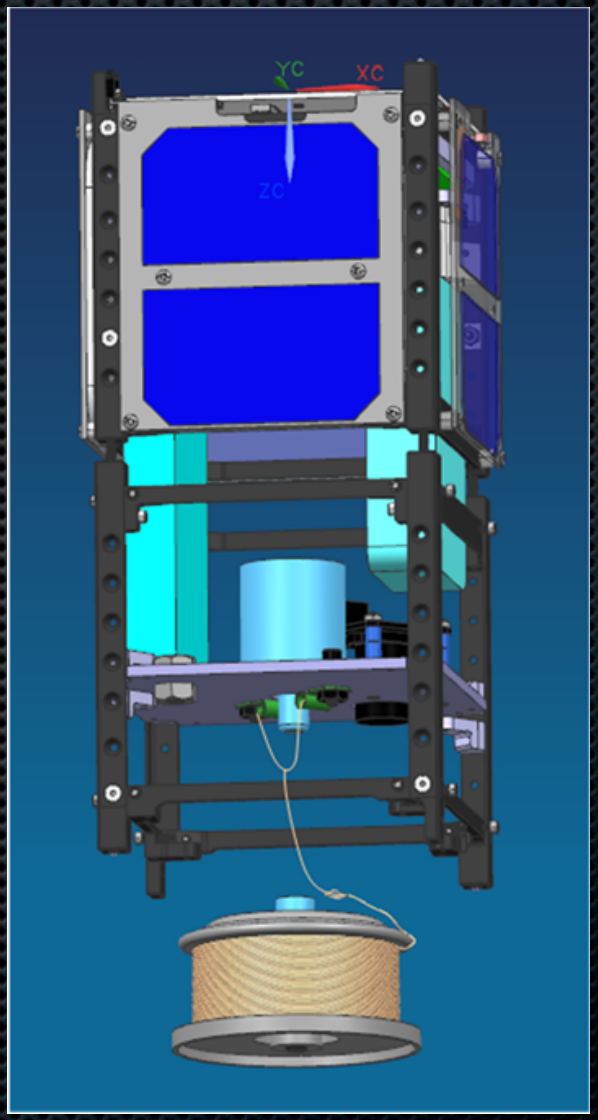
BeagleBone Black
(rev C)



- Power Cape
- Serial Cape

- **Coming soon:**
Beagle Space Cape with STX3, rate gyros, magnetometer, and accelerometer





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Schedule

- Work started with the Boeing team in March 2015
- June, 2015 - Software PDR
- Late August, 2015 - Software CDR
- September - Delivery for Test & Integration
- Fall - Ship to NanoRacks
- Late Fall - Launch
- January/February 2016 - Deploy
- Jan/Feb 2016 through March - Mission Operations

Next STEP - Join the Fun!

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