

# *Linkstar,* a *Globalstar* Based Duplex Radio for Satellites In LEO - Architecture and Test Results

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*30<sup>TH</sup> ANNUAL AIAA/USU  
CONFERENCE ON SMALL SATELLITES  
Pre-Conference Workshop*

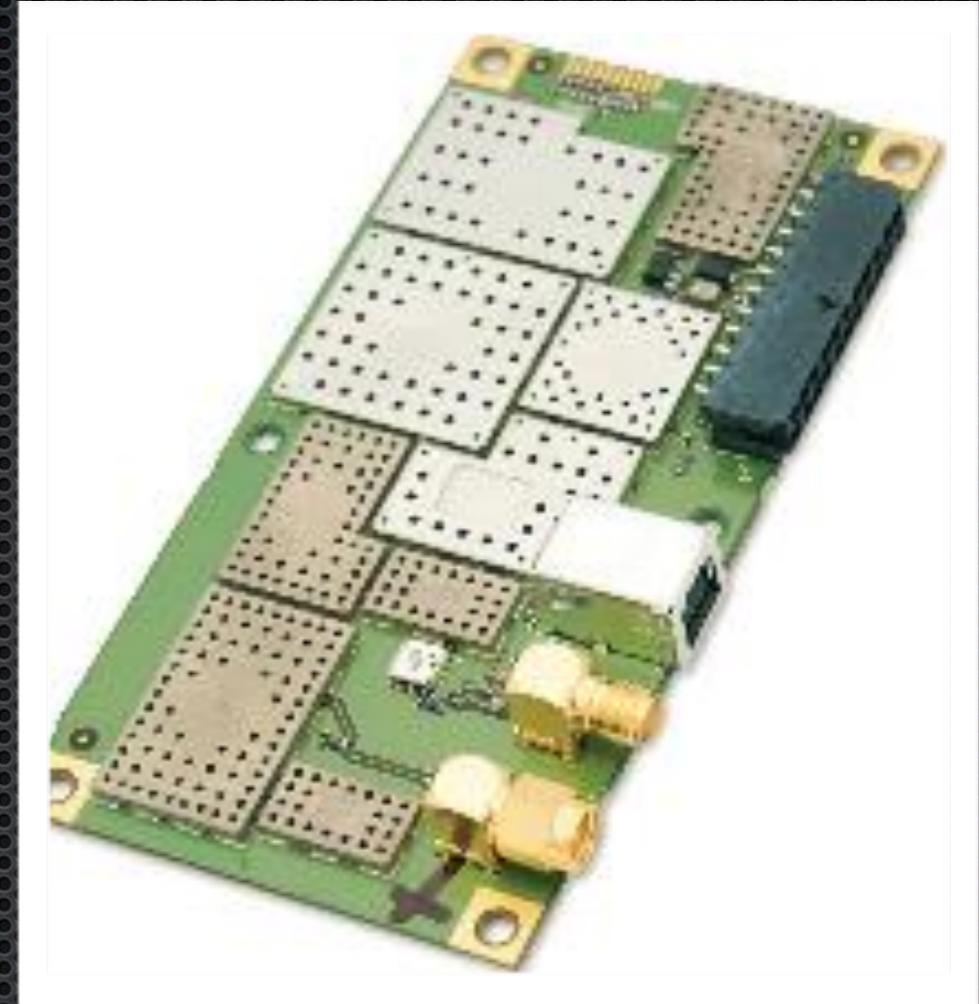
# *LinkStar*

*A Paradigm Shift in Satellite Communications*

*Why bother with  
Amateur Bands...?*

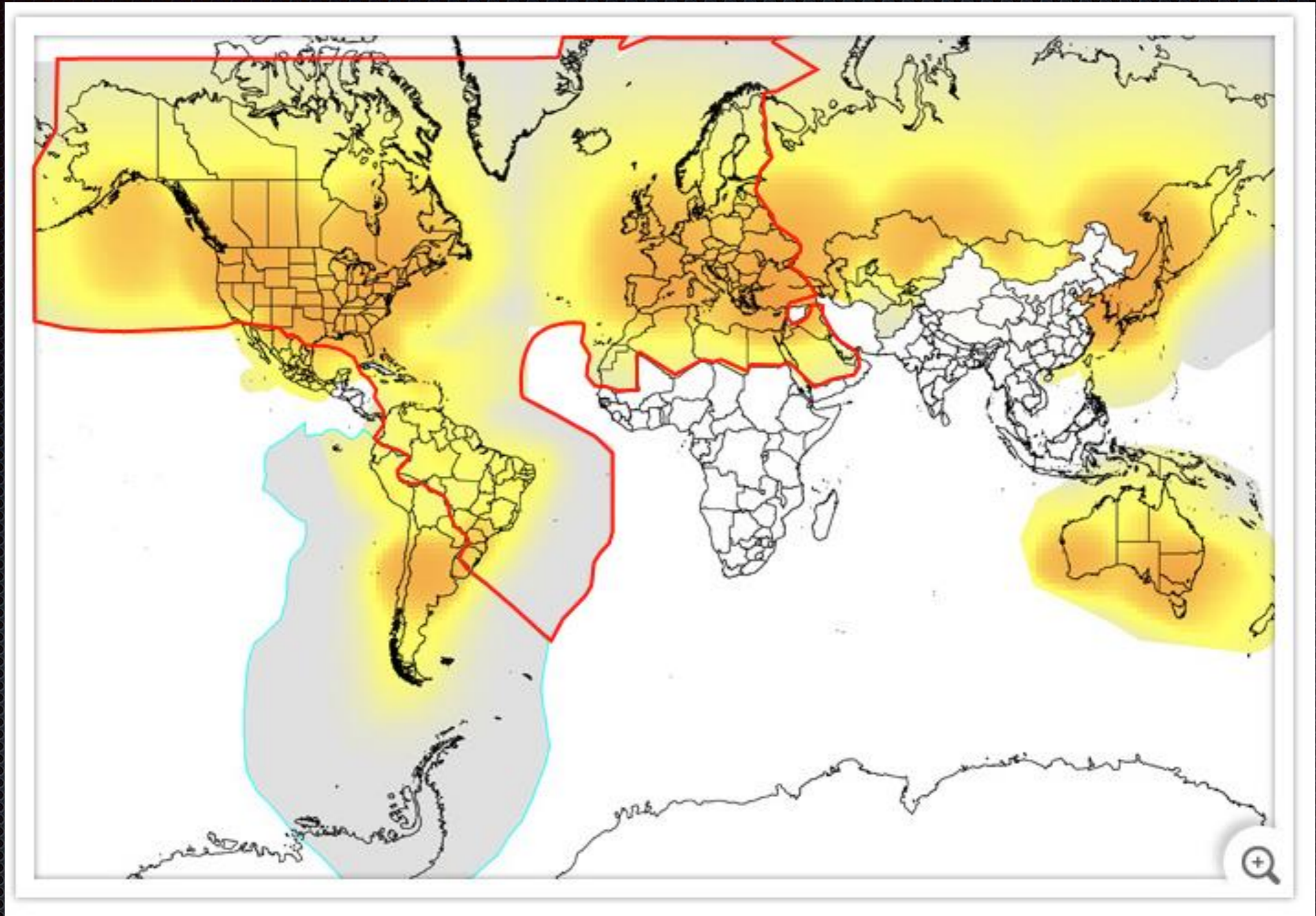
# *LinkStar* Duplex Product Features

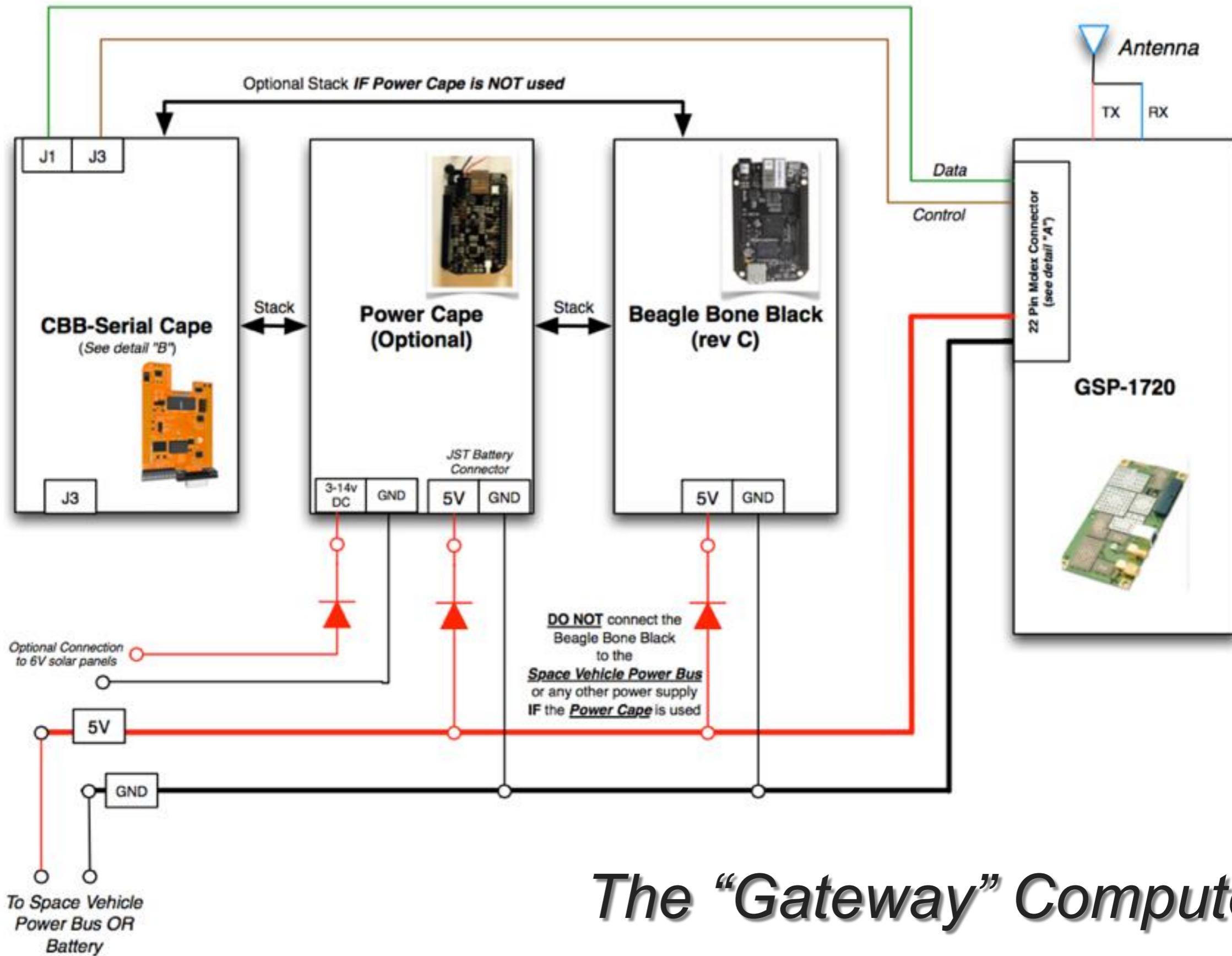
- No deployables
  - 5.72 cm diameter circular patch for duplex
- Rapid acquisition
- Data rates
  - 9600 bps maximum
  - SMS Uplink Messaging
  - *LinkStar* intended to compliment traditional high speed radios
  - *LinkStar* can serve as a primary radio depending project and product data requirements.



# *LinkStar* Product Features

- Almost anytime, anywhere vehicle Telemetry, Tracking and Control
- Large, global coverage area
- Common FCC Satellite-to-Satellite License
- No Amateur bands
- No satellite to ground license required
- Globalstar will work with sci\_Zone on obtaining FAA and FCC licenses
- Ground station over Internet Protocol (IP)
- *Access your vehicle from anywhere!*
- *Piggy-backs on established 2 billion dollar network*
- *Low Cost*





# The "Gateway" Computer

# LinkStar-STX3

*A Simplex Radio*

# LinkStar 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!

### LinkStar-STX3 (alone and with cape)

Operating Temperature Range: -40 to +60 °C  
Digital Power Supply Operational Voltage: 2.0 to 5.0 Volts  
RF Power Supply Voltage: 3.0 to 5.0 Volts

Parameter	Test Conditions	Min	Typ	Max	Unit
TX output power	-40-85° C, Vcc=Vrf=3.3 volts, 50 ohm load	17.0	17.5	18.0	dB
Transmit mode supply current	-40-85° C, Vcc=Vrf=3.3 volts, 50 ohm load	315	325	350	mA
Active mode supply current	25° C, Vcc = 3.3 volts		2.3	2.5	mA
Standby mode supply current	25° C, Vcc = 3.3 volts		12	50	µA
Sleep mode supply current	25° C, Vcc = 3.3 volts		8	40	µA



sci\_Zone, Inc.

[www.sci-zone.com](http://www.sci-zone.com)



# The *LinkStar-STX3*

- Beacon payload data only
  - GPS
  - Battery life
  - Flight Data
- No control capability
- Full coverage U.S. for UAV, Near Space, Vessels, other vehicles
- Near global coverage in space



	LinkStar	LinkStar-STX3
Communications Type	Duplex	Simplex
Data Rate	9600 BPS	36 Byte Packets
Input Power	~ 4 W	350 mW
Pointing Required?	Yes, $\pm 40^\circ$	No
Internet Access in Orbit	Yes	No
Coverage	~ 40%	Near 95%
Messaging	Uplink only - 35 bytes	Downlink only - 36 bytes
QuickSAT/VMS	Yes!	Yes!

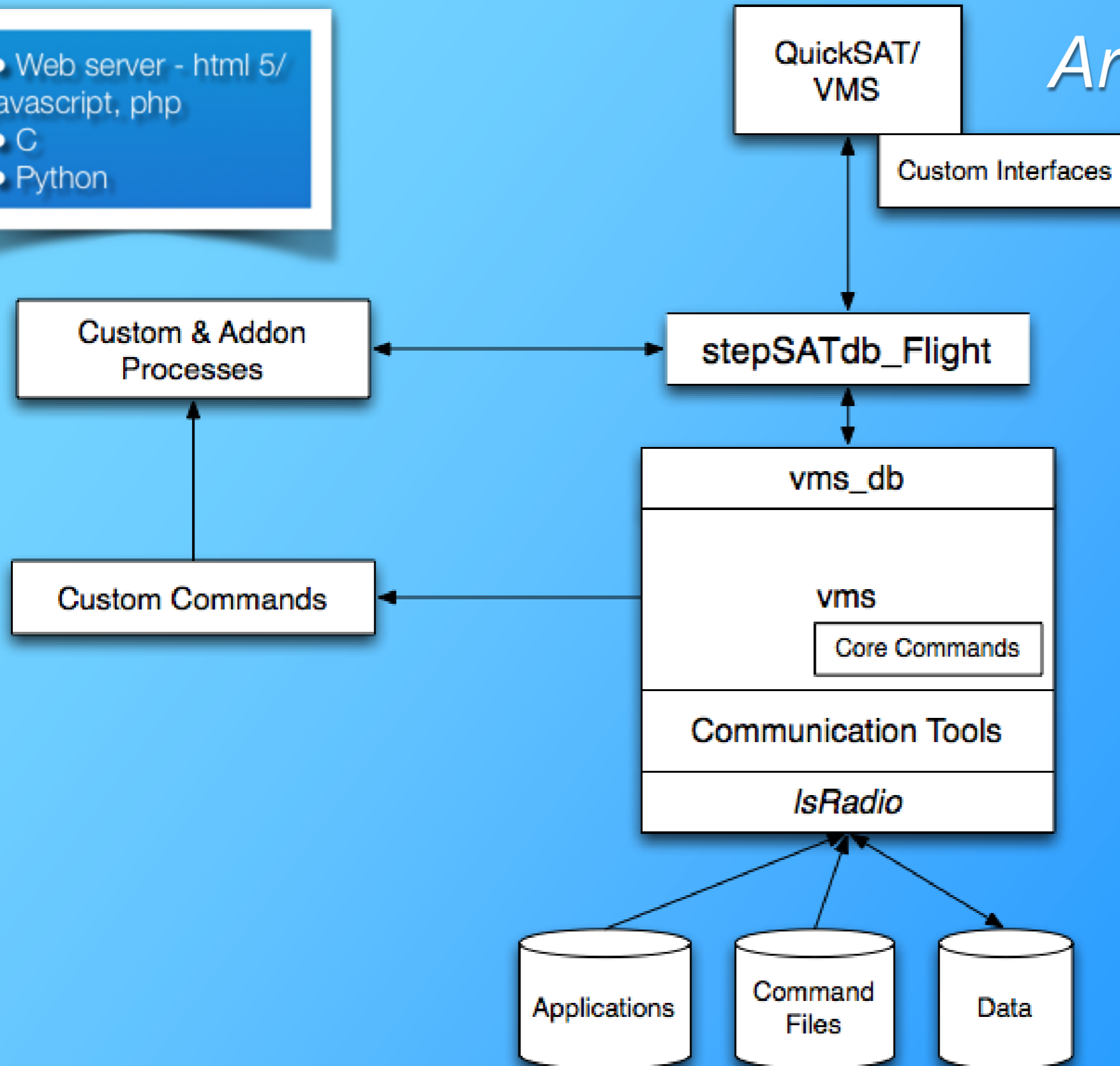
# QuickSAT/VMS

*Flight and Health Management*

*with a Communications Framework*

# Architecture

- Web server - html 5/ javascript, php
- C
- Python





# QS/VMS

Vehicle Management System

Identifier: RADSat Ground Station

Sessions

Update Location

Logout

Admin

Last DB Capture: 08/02/2016 @ 22:02:12  
 Current Recording Session: 86  
 Mission Phase: Ground Test  
 Mode of Operation: Ground Test  
 Current VMS Command: No Commands Pending

No Signal PRIMARY   
 Last Sync with FRNCS: 2016-08-02 22:02:08

Configuration »

Mission Operations - Operations »

Telemetry »

FRNCS Maintenance

Schedule

Comm

Operations

Ethernet Comm Status: Link Active

Serial Line Status: Link Not Installed

Gateway: FRNCS-P

## FRNCS Software Status

Search:

ID	Name	Status	Stat
0	mcp	On Host - App Operational	100
VM1: Domain 1			
1	prime	On Host - VM Operational - App Stopped	100
VM2: Domain 2			
2	prime	On Host - VM Operational - App Stopped	100

Showing 1 to 17 of 17 entries

### LinkStar Duplex Status

Phone Number: 2542191646  
 esn: 11601218333  
 Call Type:  
 Call Duration: 435  
 Call Number: #777  
 Provider: GSTAR USA  
 Service Available: YES  
 Service Mode: GLOBALSTAR  
 Call State: IDLE  
 Registration: YES  
 RSSI: 0  
 Roaming: NO  
 Gateway: 1

### LinkStar Duplex Location

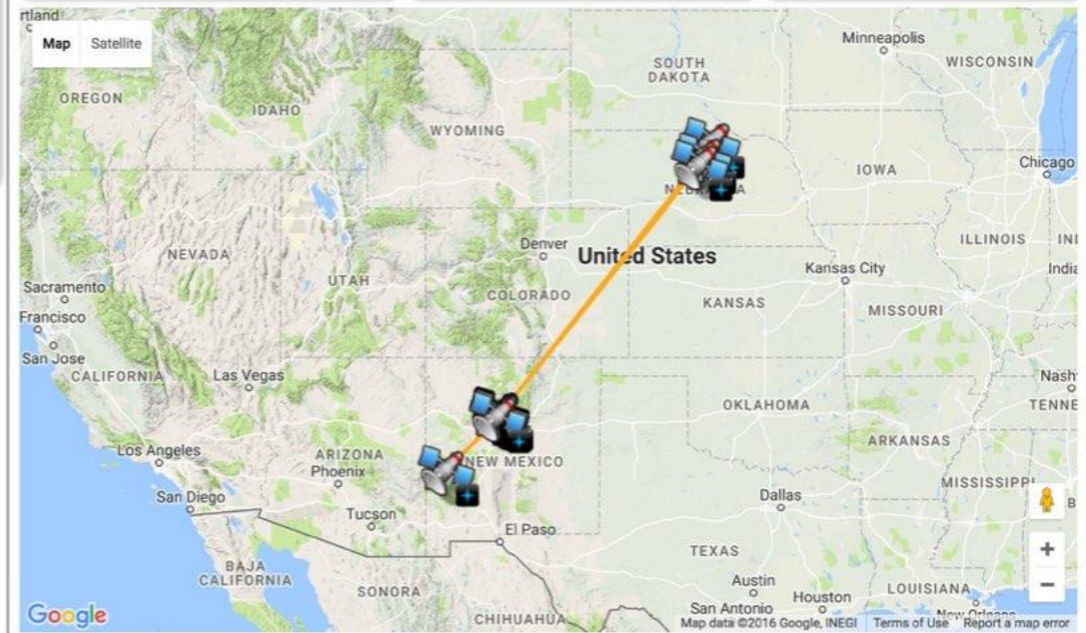
Last Read Position  
 Time of Day: 2016:216 03:01:06  
 Latitude (N): 035 Deg 16' 40"  
 Longitude (W): 106 Deg 37' 47"  
 Position Error: < 5 km

### GPS Position

Latitude (N):  
 Longitude (W):  
 Altitude:  
 Heading:  
 H. Speed:  
 V. Speed:

### VMS Map Settings

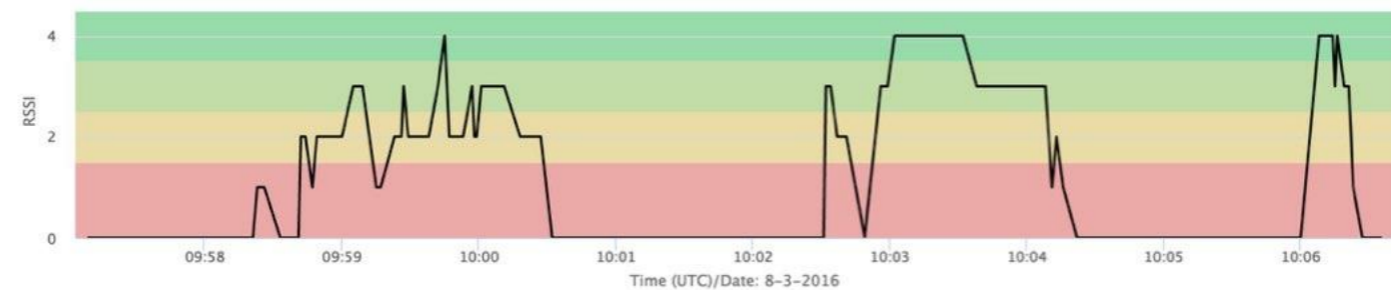
Error Circle:   
 Show Flight Path:   
 # Prior Markers: 20  
 Source: LinkStar



### LinkStar Duplex Historical Signal Strength

# Plot Points: 200

#### Historical RSSI Signal Strength



# QS/VMS

Vehicle  
Management  
System

Identifier: FRNCS-P/RADSAT

Sessions

Update Location

Admin

Logout

Last DB Capture: 06/30/2015 @ 02:59:54  
Current Recording Session: 73  
Mission Phase: Operating Mode  
Mode of Operation: Mission Science/Operations  
Current VMS Command: No Commands Pending

GSTAR USA



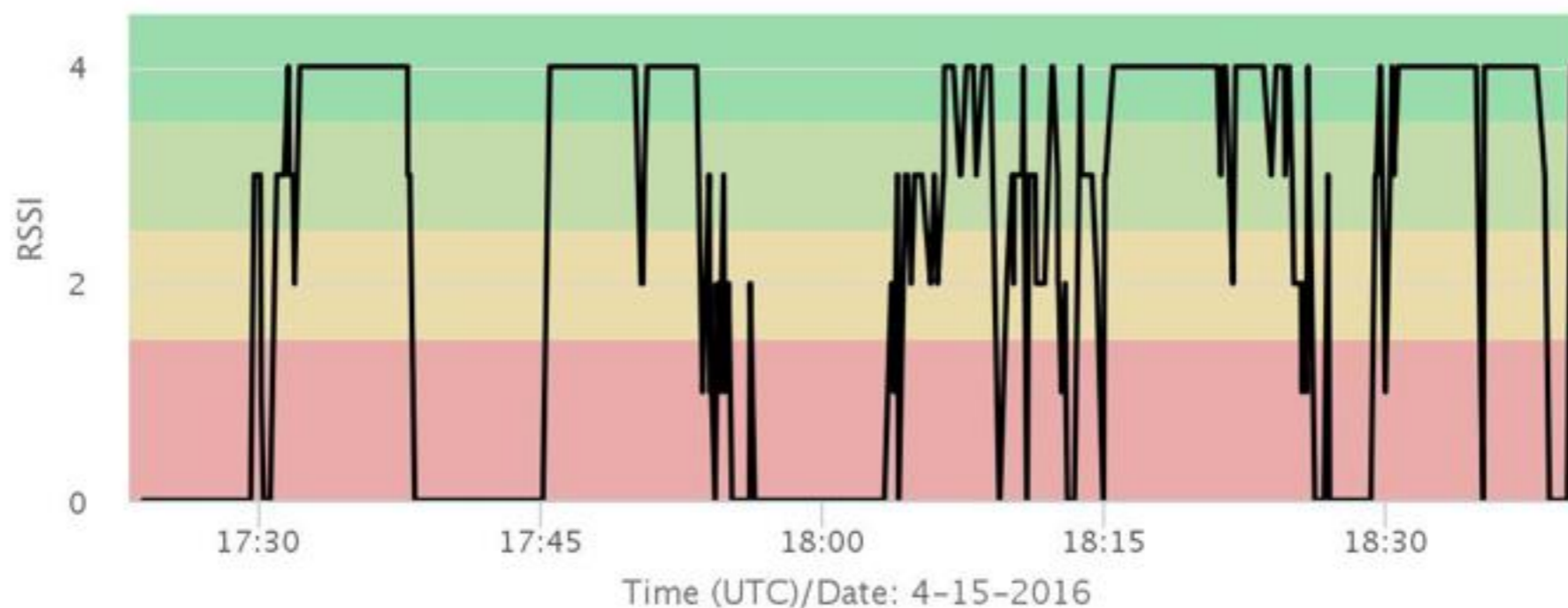
TEST



Last Sync with FRNCS:

06/30/2015 @ 02:59:54

## Historical RSSI Signal Strength





# QS/VMS

Vehicle Management System

Identifier: RADSat Ground Station

Sessions

Update Location

Logout

Last DB Capture: 08/04/2016 @ 13:09:48  
Current Recording Session: 86  
Mission Phase: Ground Test  
Mode of Operation: Ground Test  
Current VMS Command: No Commands Pending

GSTAR USA PRIMARY  
Last Sync with FRNCS: 2016-08-04 09:58:34

- Configuration »
- Mission Operations »
- Telemetry »
- FRNCS Maintenance
- Schedule
- Comm - LinkStar/Duplex

LinkStar

Connection

## LinkStar Duplex Settings

Save LinkStar Parameters → Save Parameters

LinkStar Connected:  Data Port: /dev/ttyO2 Control Port: /dev/ttyO4 Max State Records Stored: 1000  
Roaming Enabled:  Poll Rate (sec): 39 "Number of Records"/download: 100 Dwell Rate (sec): 0

## LinkStar Duplex Status

Phone Number: 2542191646  
esn: 11601218333  
Call Type: TIA\_PPP\_M  
Call Duration: 254  
Call Number: #777  
Provider: GSTAR USA  
Service Available: YES  
Service Mode: GLOBALSTAR  
Call State: CALLINPROG  
Registration: YES  
RSSI: 4  
Roaming: NO  
Gateway: 11

## LinkStar Duplex Location

### Current Position

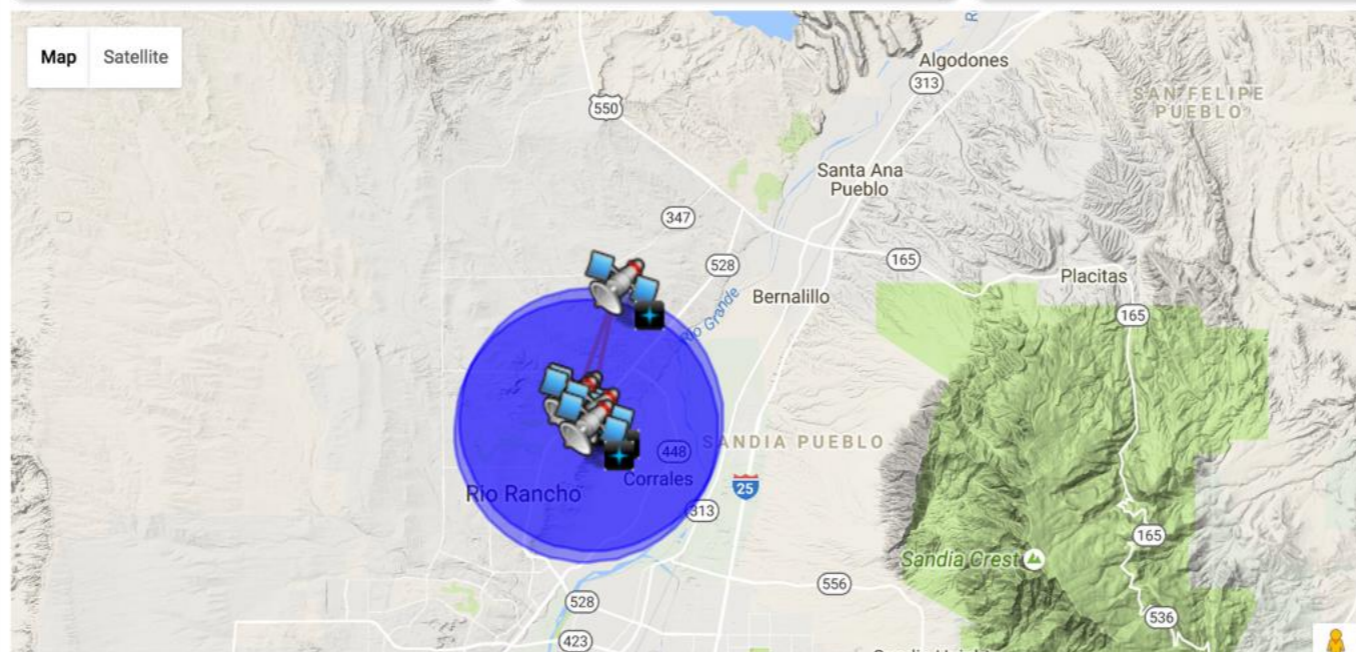
Time of Day: 2016:216 08:16:48  
Latitude (N): 035 Deg 17' 17"  
Longitude (W): 106 Deg 37' 48"  
Position Error: < 5 km

### GPS Position

Latitude (N):  
Longitude (W):  
Altitude:  
Heading:  
H. Speed:  
V. Speed:

## VMS Map Settings

Error Circle:   
Show Flight Path:   
# Prior Markers: 5  
Source: LinkStar



“Test Like You Fly!”

# Packet Definition - EASY!

## Define Parameters

QuickSAT/Designer,  
phpmyadmin,  
Existing Definitions

## Build Packets

QuickSAT/VMS  
Packet Builder

## View Packets

QuickSAT/VMS  
STX3 Viewer

The screenshot shows the 'LinkStar-STX3 Data Manager' interface. At the top, it displays 'Identifier: RADSat SV' and 'Last DB Capture: 04/15/2016 @ 10:22:14'. Below this, there are tabs for 'Satellite Data', 'Packet Definition', and 'Vehicle Information'. The 'Flight Data' tab is active, showing 'Flight Object Data'. A table lists data points with columns for 'Time (UTC)' and 'Data'. The data points are:

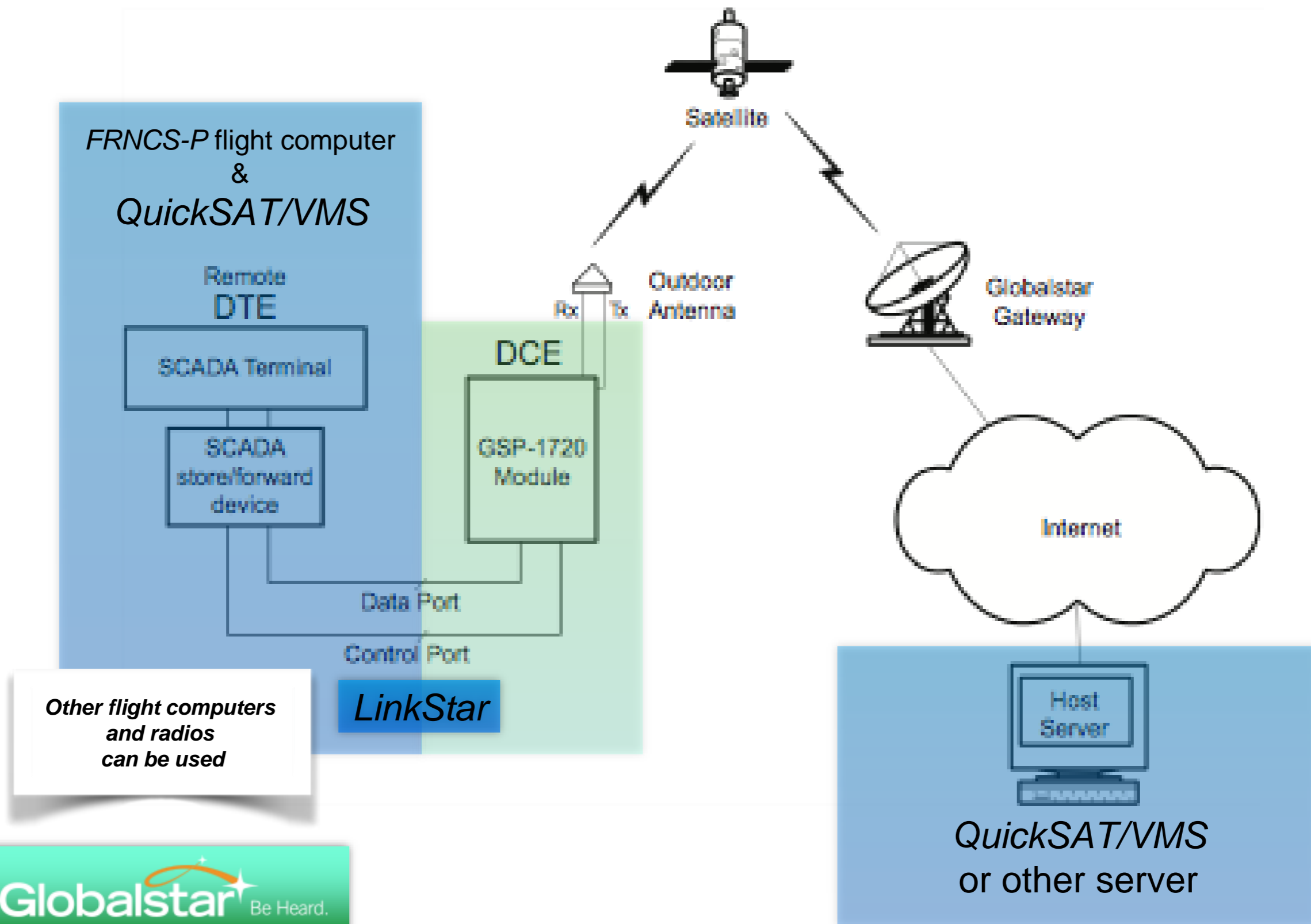
Time (UTC)	Data
2016-03-03 19:47:00	GPRMC,194709.000,A,3506.0000,N,10907.0020,W,2.03,221.11,030316,A,77
2016-03-03 19:48:00	GPRMC,194809.000,A,3506.0000,N,10907.0020,W,2.03,221.11,030316,A,77
2016-03-03 19:45:09	GPRMC,194509.000,A,3506.0000,N,10907.0020,W,2.03,221.11,030316,A,77

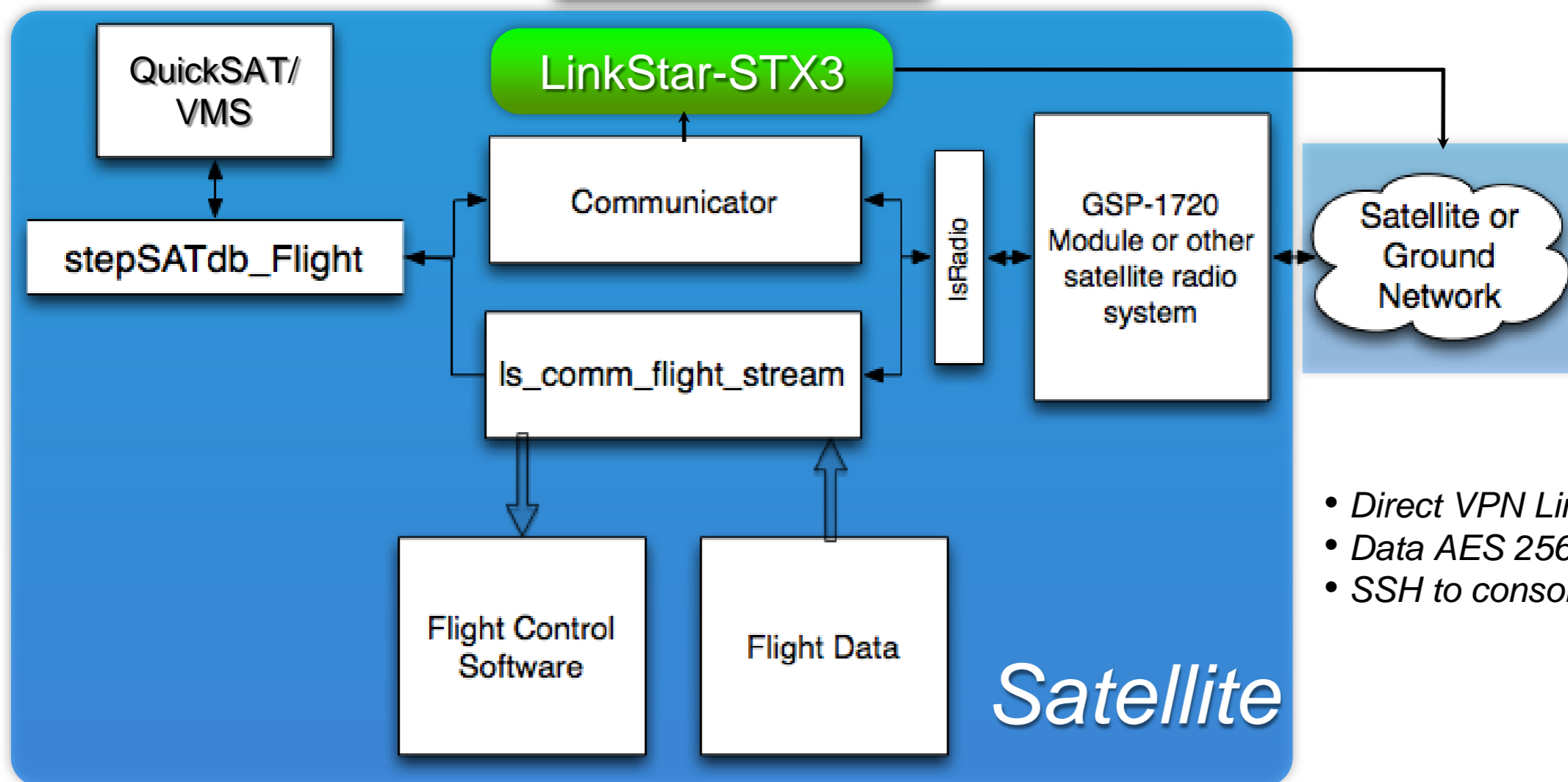
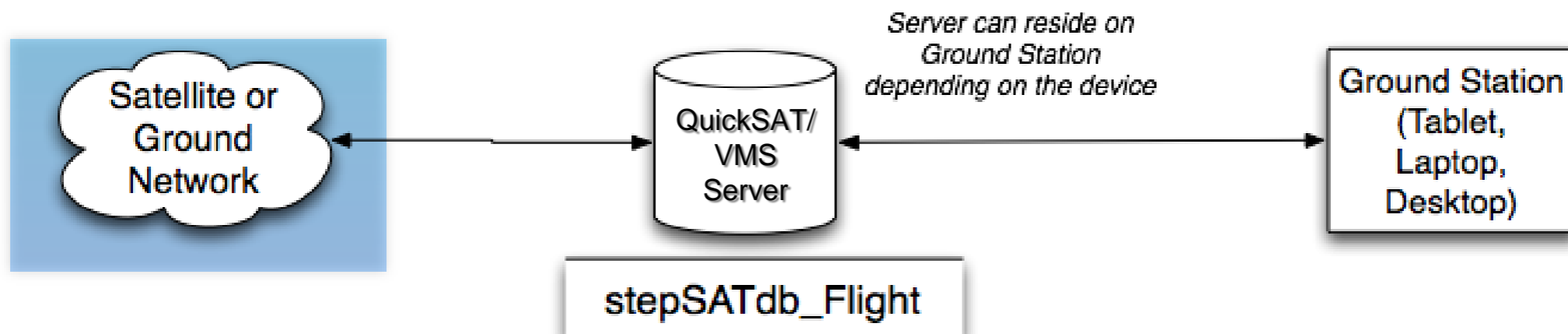
The screenshot shows the 'STX3 Viewer' interface. It features a table with columns: 'Valid?', 'ID', 'Name', 'ATA Code', 'Time', 'Value', and 'Units'. The table contains 10 rows of data for '19\_1\_0\_47' packets. Below the table, there are two line graphs. The top graph is labeled 'FC\_BAT\_TEMP FC\_BAT\_T' and the bottom graph is labeled '"47\_3\_0\_1398"'. Both graphs show 'Test Units b' on the y-axis and time on the x-axis.

Valid?	ID	Name	ATA Code	Time	Value	Units
●	27_00_110	"19_1_0_47"	2700	14:20:23.7	-0.459	Test Units b
●	27_00_110	"19_1_0_47"	2700	14:20:24.1	0.657	Test Units b
●	27_00_110	"19_1_0_47"	2700	14:20:24.7	-0.747	Test Units b
●	27_00_110	"19_1_0_47"	2700	14:20:25.2	0.323	Test Units b
●	27_00_110	"19_1_0_47"	2700	14:20:25.7	-0.905	Test Units b
●	27_00_110	"19_1_0_47"	2700	14:20:26.1	0.627	Test Units b
●	27_00_110	"19_1_0_47"	2700	14:20:26.6	-0.058	Test Units b
●	27_00_110	"19_1_0_47"	2700	14:20:27.2	-0.597	Test Units b
●	27_00_110	"19_1_0_47"	2700	14:20:27.7	0.323	Test Units b
●	27_00_110	"19_1_0_47"	2700	14:20:28.2	-0.747	Test Units b



# Baseline Communications Scheme with LinkStar





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

# Test Program

QuickSAT - Xen

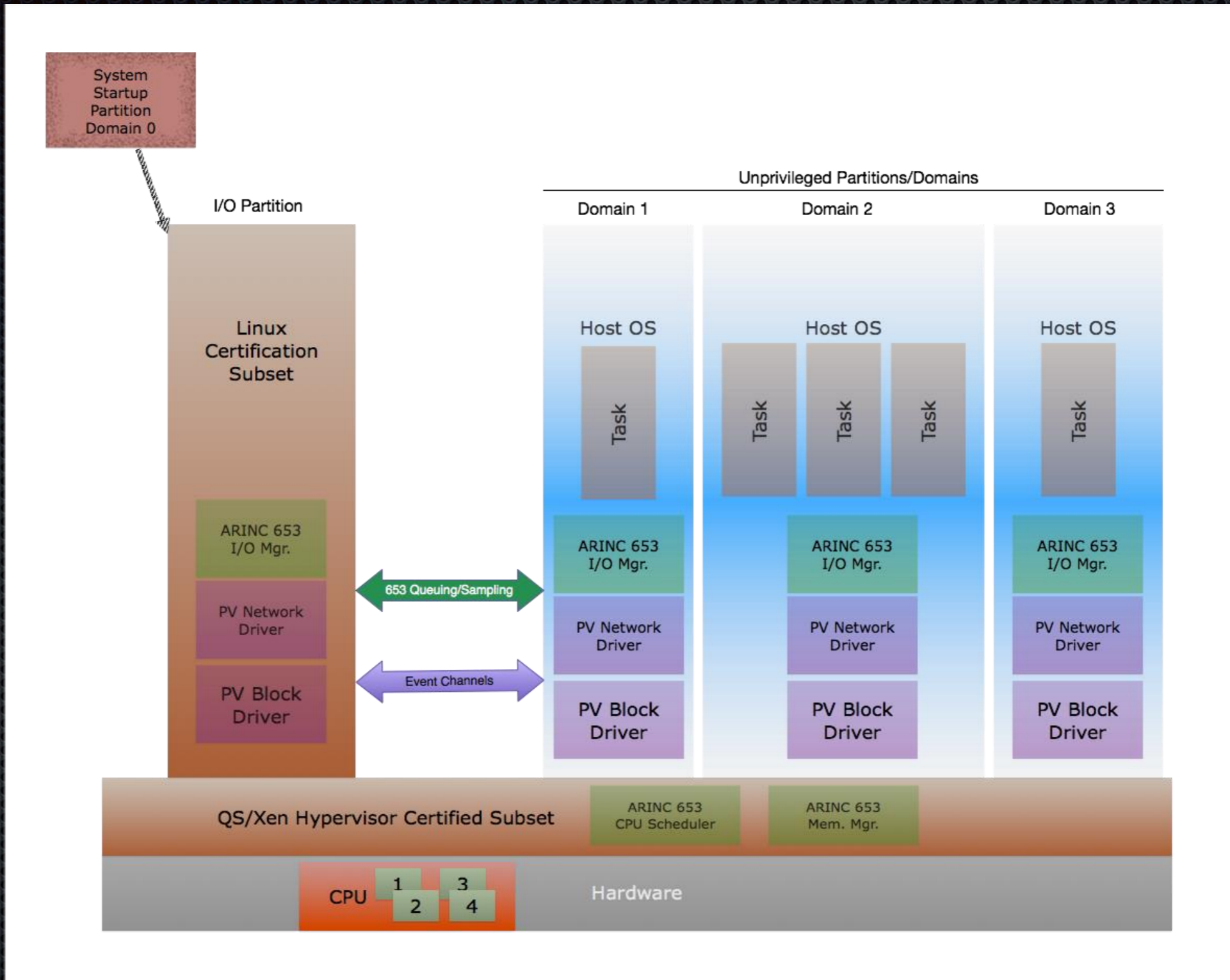
# The Problem

Need a Safe AND Secure embedded platform solution, without compromising Performance...

Security concerns in safety-critical systems are now paramount; and Aerospace & Defense, Medical, and Automotive markets are all demanding a solution.

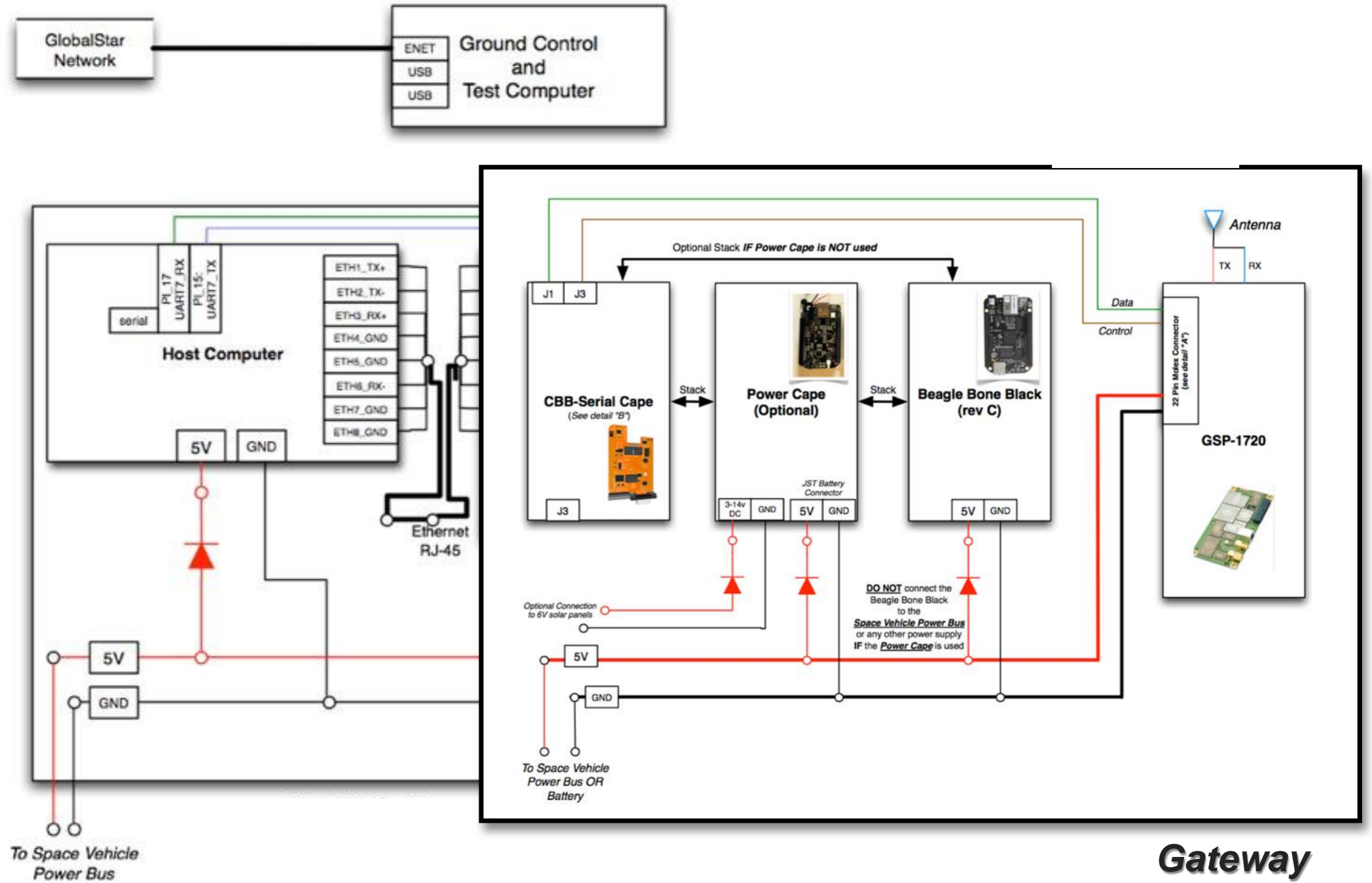
...QuickSAT/Xen open-architecture hypervisor with unrestricted licensing of Xen provides safety, security, and performance on an embedded platform.

# The Xen Hypervisor Environment



# Ground & High Altitude Balloon Flight Test Program

- Key Tests:
  - QuickSAT/VMS Flight Management System Operations on DARPA Test System
  - Relay data from “Satellite” to the ground station
  - Add EIGHT Virtual Machines from the “Gateway”
  - Add One Virtual Machine from the Ground Station
  - Remove all Virtual Machines



# Configuration for the Demonstration and for the *High Altitude Test Flights*

# Results

- ALL Virtual Machines (VM) Installed and removed as planned
- Data transmitted to the ground station
- Command and Control of VM from ground station

```
mirage@cubietruck:~$ sudo xl list
Name                               ID   Mem VCPUs  State  Time(s)
Domain-0                            0   512   2    r----- 178.5
prime_mirage_test_app00001          4    32   1    -b----  0.9
sine2_mirage_test_app00001          5    32   1    -b----  0.4
cosine_mirage_test_app00001         6    32   1    -b----  0.3
sine1_mirage_test_app00001          7    32   1    -b----  0.3
cosine_test_app00001                8   128   1    -b---- 16.2
sine2_test_app00001                 9   128   1    -b---- 15.2
sine1_test_app00001                10  128   1    -b---- 15.2
prime_test_app00002                 11  128   1    -b---- 14.4
prime_test_app00001                 12  128   1    -b---- 14.1
mirage@cubietruck:~$
```

Ethernet Comm Status: ● Link Active  
Serial Line Status: ● Link Not Installed  
Gateway: FRNCS-P

## FRNCS Software Status

Remove VM from Host

Search:

ID	Name	Status	State Code	State
1	prime	On Host - VM Operational - App Stopped	100	Operational
VM2: Domain 2				
2	prime	On Host - VM Operational - App Stopped	100	Operational
VM3: Domain 3				
3	sine	On Host - VM Operational - App Stopped	100	Operational

Showing 1 to 17 of 17 entries

## Schedule

CSV Excel PDF Copy

Search:

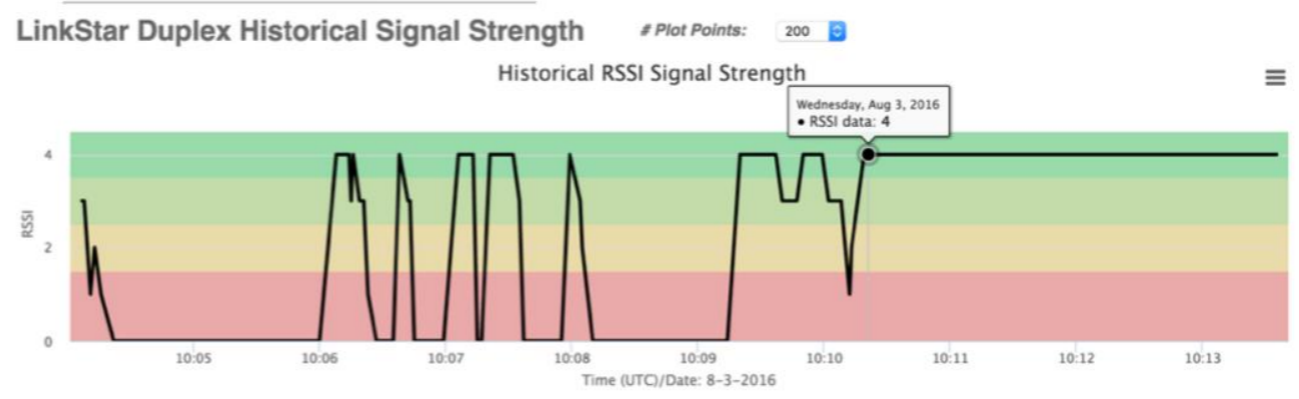
Event Date/Time (UTC)	Multiplier	Event Name	Status	User	Date/Time Completed (UTC)	Mode of Operation	Flight Leg	Mission Phase
2015-08-10 08:15:40	1	TEST	Pending	Admin	-	Mission Science/Operations	Primary	Operating Mode



# Results

- Flight and LinkStar system data synced with the ground
- Data included signal strength, location, VM data

```
mirage@cubietruck:~$ ssh mirage@19
mirage@cubietruck:~$ sudo xl list
Name          ID Mem VCPUs  State Time(s)
Domain-0      0  512  2      r----- 178.5
prime_mirage_test_app00001  4   32  1      -b----- 0.9
sine2_mirage_test_app00001  5   32  1      -b----- 0.4
cosine_mirage_test_app00001  6   32  1      -b----- 0.3
sine1_mirage_test_app00001  7   32  1      -b----- 0.3
cosine_test_app00001        8  128  1      -b----- 16.2
sine2_test_app00001        9  128  1      -b----- 15.2
sine1_test_app00001       10  128  1      -b----- 15.2
prime_test_app00002       11  128  1      -b----- 14.4
prime_test_app00001       12  128  1      -b----- 14.1
mirage@cubietruck:~$
```



-02 at

mation

Show

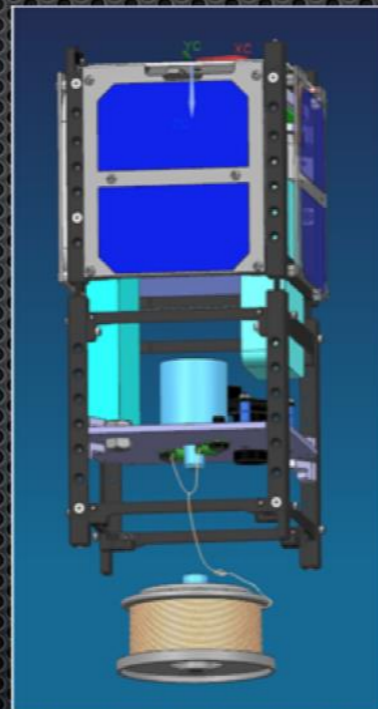
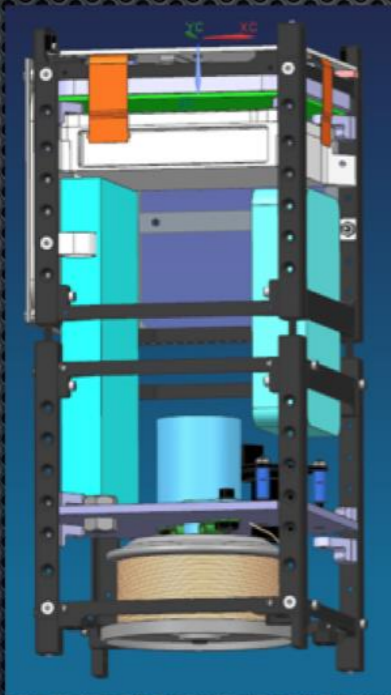
SATdb f

doze Stuff

16-08-02 at

# Future Missions

- DARPA High Altitude Balloon Test Flights
  - Flights in late August and October 2016
- Boeing *RADSat* Mission, February 2017
- New Mexico State University INCA Mission, 2018

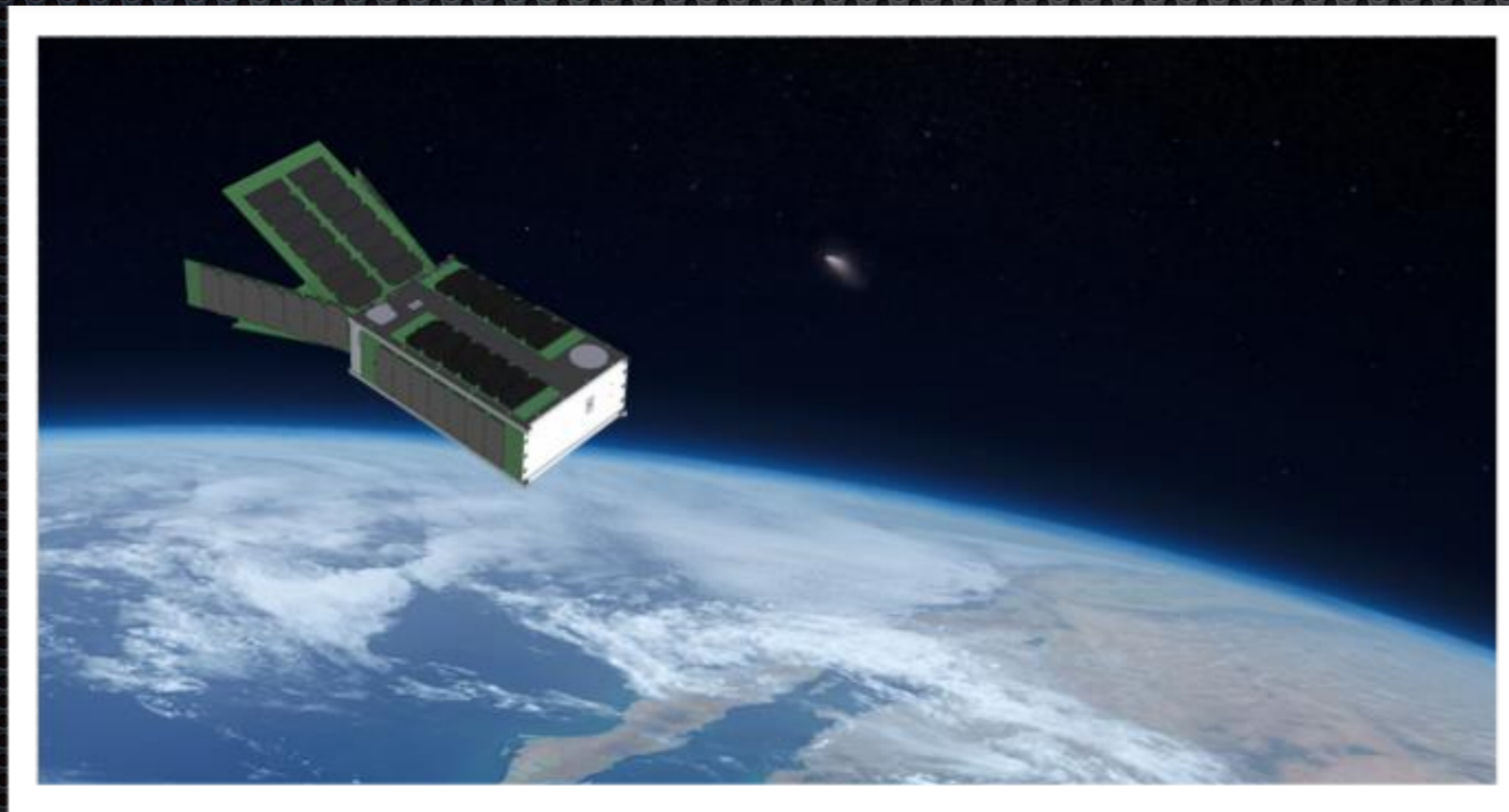
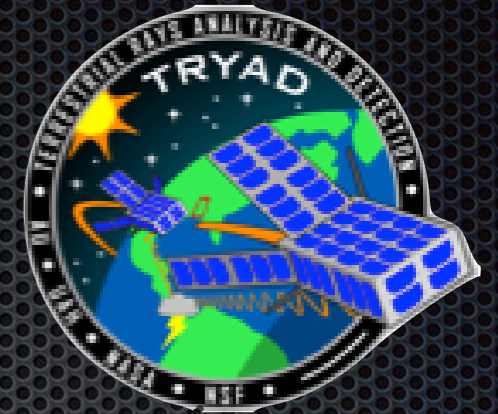


Auburn University

# TRYAD Mission

Terrestrial Ray Analysis and Detection

- Goal: To detect Terrestrial Gamma Ray Flashes in coincidence with ground lighting strike data and characterize the Gamma Ray beam geometries
- Two TRYAD 6U CubeSats at ~500km altitude, ~50° inclination.



*Data rates  
up to 256 kbps!*

Featuring the *LinkStar-HD* System!

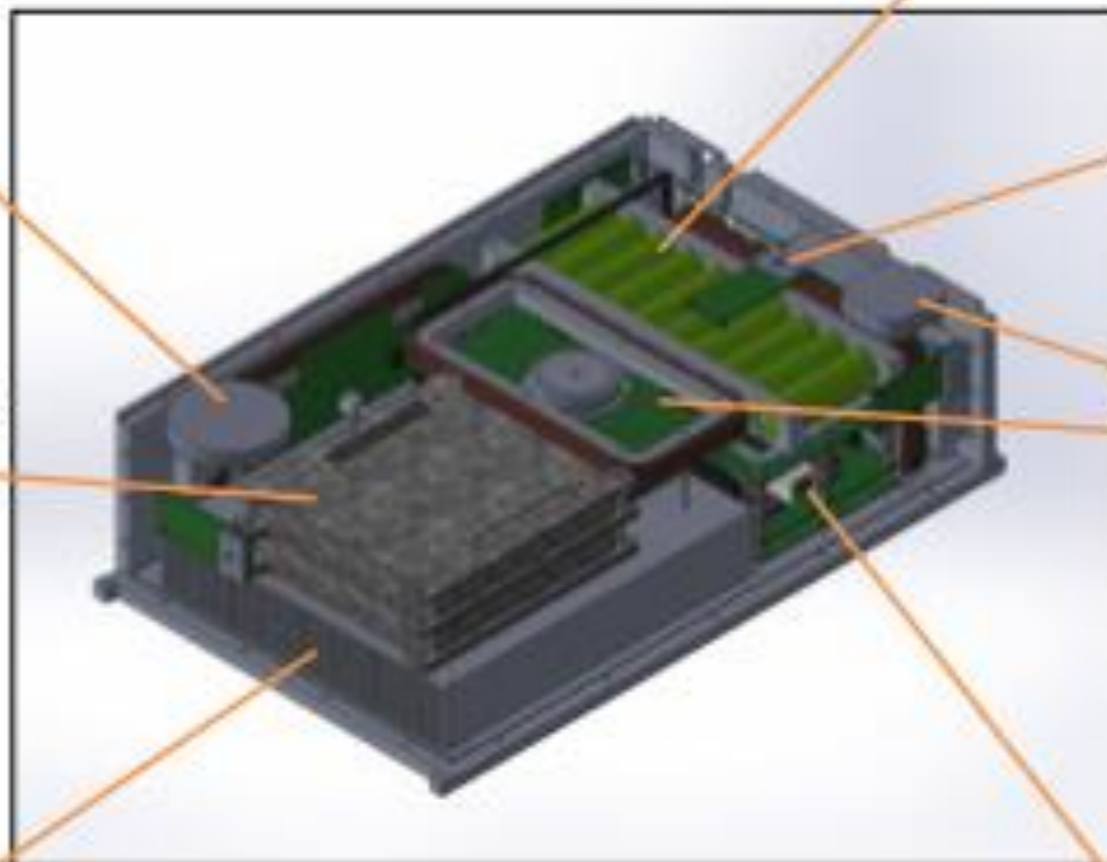
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Linkstar Duplex  
Satellite Radio  
(real time command  
& telemetry)

PULSAR S/X – Band SDR  
Radios 300kbps/  
150Mbps (NASA MSFC,  
NEN)

Science Payload:  
Gamma Ray  
Scintillation Detector  
(UAH, NASA GSFC)



**Electrical Power System**  
DHV solar cells  
Li ion batteries  
MPPTs, Current sensing,  
Bus switching, protection

**Attitude Determination &  
Control System**  
Sun sensors  
Magnetometers  
3-axis rate gyros  
Novatel GPS  
3-axis reaction wheels &  
magnetorquers  
Servo-controlled  
deployable fins for station  
keeping via diff. drag

**Command & Data  
Handling System**  
(Embedded Linux,  
Beaglebone Black)

# Next STEP - Join the Fun!

- email: [andrew\\_santangelo@sci-zone.com](mailto:andrew_santangelo@sci-zone.com)
- web: [www.quick-sat.com](http://www.quick-sat.com)

