The LinkStar-STX3 Architecture

A New Generation of Simplex Based Radios for Near Global Communications

13th Annual Cubesat Developers Workshop
Andrew Santangelo
sci_Zone, Inc.
LinkStar-STX3

- Company Information
- Background
- The LinkStar-STX3
- QuickSAT/VMS
- Ground Communications
- Future missions...
sci_Zone, Inc.

- Located in Holland, Michigan and Rio Rancho, New Mexico
- Core competencies: software development, satellite design, systems engineer, DO178B, and Flight Systems.
- Customers include GE Aviation, AFRL, DARPA, NASA Glenn, Boeing, Pumpkin, DornerWorks and Leidos
Background

LinkStar: A Paradigm Shift
QuickSAT/Vehicle Management System (VMS)

Multiple Options

- S-Band radios
- Amateur Radios
- Iridium
- Ka Band
- “Newly invented” radios
- LinkStar...
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
LinkStar Duplex

Product Features

- No deployables
- 2.5 cm diameter circular patch for duplex
- Rapid acquisition
- High data rates limited
  - 9600 bps maximum
- LinkStar intended to compliment traditional high speed radios
- LinkStar can serve as a primary radio depending project and product data requirements.
**LinkStar Product Features**

- Ground station over Internet Protocol (IP)
- **Access your vehicle from anywhere!**
- Piggy-backs on established 2 billion dollar network
- Low Cost

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| Operating Frequencies | Transmit: 1610 MHz – 1626.5 MHz  
Receive: 2483.5 MHz – 2500 MHz  
+31dBm EIRP (passive antenna), +34 dBm (active antenna)  
+4.7V to 5.1V |
|-----------------------|--------------------------------------------------|

<table>
<thead>
<tr>
<th>Maximum transmit power</th>
<th>DC input voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Consumption</td>
<td>@5VDC input (estimated)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>State</th>
<th>Min</th>
<th>Typical</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shutdown</td>
<td>0.0</td>
<td>0.65</td>
<td>1.0</td>
<td>mW</td>
</tr>
<tr>
<td>Standby</td>
<td>0.5</td>
<td>0.5</td>
<td>5.0</td>
<td>W</td>
</tr>
<tr>
<td>Transmit</td>
<td>2.2</td>
<td>3.65</td>
<td>5.0</td>
<td>W</td>
</tr>
</tbody>
</table>

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**sci_Zone, Inc.**

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

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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
<table>
<thead>
<tr>
<th>Feature</th>
<th>LinkStar</th>
<th>LinkStar-STX3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communications Type</td>
<td>Duplex</td>
<td>Simplex</td>
</tr>
<tr>
<td>Data Rate</td>
<td>9600 BPS</td>
<td>36 Byte Packets</td>
</tr>
<tr>
<td>Input Power</td>
<td>~ 4 W</td>
<td>350 mW</td>
</tr>
<tr>
<td>Pointing Required?</td>
<td>Yes, ±40°</td>
<td>No</td>
</tr>
<tr>
<td>Internet Access in Orbit</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Coverage</td>
<td>~ 40%</td>
<td>Near 95%</td>
</tr>
<tr>
<td>Messaging</td>
<td>Yes - up and down 144 Bytes</td>
<td>Downlink only</td>
</tr>
<tr>
<td>QuickSAT/VMS</td>
<td>Yes!</td>
<td>Yes!</td>
</tr>
</tbody>
</table>
Notes:
1. Place the P8 | P9 connector footprint on the PCBA "Bottom", then install the part from the "Top".
QuickSAT/VMS

Flight and Health Management

with a Communications Framework
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).
- LinkStarAV/Vehicle Management System (VMS) created as an expanded version of the OGP program.

sci_Zone, Inc.
www.sci-zone.com
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
Architecture

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

- QuickSAT/VMS
- Commander
- Core Commands
- Custom Commands

- stepSATdb_Flight
  - vms_db
    - vms
    - communicator
      - Is_comm_flight_stream

- IsRadio

- Applications
- Command Files
- Data
Historical RSSI Signal Strength

Time (UTC)/Date: 4-15-2016

sci_Zone, Inc.
www.sci-zone.com
### Ethernet Comm Status
- **Link Active**

### Serial Line Status
- **Link Disabled**

### Active Board
- **Host_1**

### FRNCS Software Status

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Status</th>
<th>State Code</th>
<th>State</th>
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<tbody>
<tr>
<td>VM1: Domain 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>prime</td>
<td>GATEWAY Storage</td>
<td>80</td>
<td>FRNCS Storage</td>
</tr>
<tr>
<td>VM2: Domain 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>prime</td>
<td>GATEWAY Storage</td>
<td>80</td>
<td>FRNCS Storage</td>
</tr>
<tr>
<td>VM3: Domain 3</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>sine</td>
<td>GATEWAY Storage</td>
<td>80</td>
<td>FRNCS Storage</td>
</tr>
<tr>
<td>VM4: Domain 4</td>
<td></td>
<td></td>
<td></td>
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Showing 1 to 5 of 5 entries

### Schedule

<table>
<thead>
<tr>
<th>Event Date/Time (UTC)</th>
<th>Multiplier</th>
<th>Event Name</th>
<th>Status</th>
<th>User</th>
<th>Date/Time Completed (UTC)</th>
<th>Mode of Operation</th>
<th>Flight Leg</th>
<th>Mission Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015-08-10 08:15:40</td>
<td>1</td>
<td>TEST</td>
<td>Pending</td>
<td>Admin</td>
<td>-</td>
<td>Mission Science/Operations</td>
<td>Primary</td>
<td>Operating Mode</td>
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</tbody>
</table>
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<td>Mission Science/Operations</td>
<td>Primary</td>
<td>Operating Mode</td>
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Showing 1 to 1 of 1 entries

### Command Log

<table>
<thead>
<tr>
<th>Time of Command (UTC)</th>
<th>Command</th>
<th>Command State</th>
<th>Command Data</th>
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</thead>
<tbody>
<tr>
<td>2014-04-23 02:10:53</td>
<td>REMOVE_VMAPP</td>
<td>Success</td>
<td>1</td>
</tr>
<tr>
<td>2015-02-17 21:43:57</td>
<td>REMOVE_VMAPP</td>
<td>Success</td>
<td>1</td>
</tr>
<tr>
<td>2015-02-17 21:55:58</td>
<td>REMOVE_VMAPP</td>
<td>Success</td>
<td>2</td>
</tr>
<tr>
<td>2015-11-18 20:00:14</td>
<td>REMOVE_VMAPP</td>
<td>Success</td>
<td>2</td>
</tr>
<tr>
<td>2015-11-18 20:01:27</td>
<td>ADD_VMAPP</td>
<td>Success</td>
<td>1</td>
</tr>
<tr>
<td>2015-11-19 09:39:46</td>
<td>ADD_VMAPP</td>
<td>Success</td>
<td>3</td>
</tr>
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</table>

Showing 1 to 31 of 31 entries

### System Message Log

<table>
<thead>
<tr>
<th>System Message Time (UTC)</th>
<th>System Message</th>
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<tbody>
<tr>
<td>2014-04-23 20:23:20</td>
<td>Success - VM/App &quot;prime_test_app00001&quot; installed</td>
</tr>
<tr>
<td>2014-04-23 20:23:20</td>
<td>Command Success</td>
</tr>
<tr>
<td>2014-04-23 20:25:24</td>
<td>Success - VM/App &quot;cosine_test_app00001&quot; installed</td>
</tr>
<tr>
<td>2014-04-23 20:25:24</td>
<td>Command Success</td>
</tr>
</tbody>
</table>
Baseline Communications Scheme with LinkStar

FRNCS-P flight computer & QuickSAT/VMS

Remote DTE
- SCADA Terminal
- SCADA store/forward device

DCE
- GSP-1720 Module

Satellite
- Outdoor Antenna
- Globalstar Gateway

Internet

Host Server
- QuickSAT/VMS
- or other server

Other flight computers and radios can be used

sci_Zone, Inc.
www.sci-zone.com
Packet Definition - EASY!

Define Parameters
QuickSAT/Designer, phpmyadmin

Build Packets
QuickSAT/VMS Packet Builder

View Packets
QuickSAT/VMS STX3 Viewer

sci_Zone, Inc.
www.sci-zone.com
Many ways to configure *LinkStar*

**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!

**FRNCS-M**

- Multicore and multiple boards, ARM based and linked together.

**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.

**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!
Future Missions

- DARPA High Altitude Balloon Test Flights
- NASA UAV Project
- Boeing RADSat Mission
- And several Universities coming online...
QuickSAT
Take your satellite from idea to flight!

QuickSAT/Designer
Design and Mission Planning from idea to flight!

QuickSAT/Xen
Security, Reliability and Software Rad-Hardening!

QuickSAT/VMS
Talk to your satellite!

LinkStar
Communications for the Rest of us!

FRNCS
ARM Computing for the Future!

sci_Zone, Inc.
www.quick-sat.com
Next STEP - Join the Fun!

- email: andrew_santangelo@sci-zone.com
- web: www.quick-sat.com