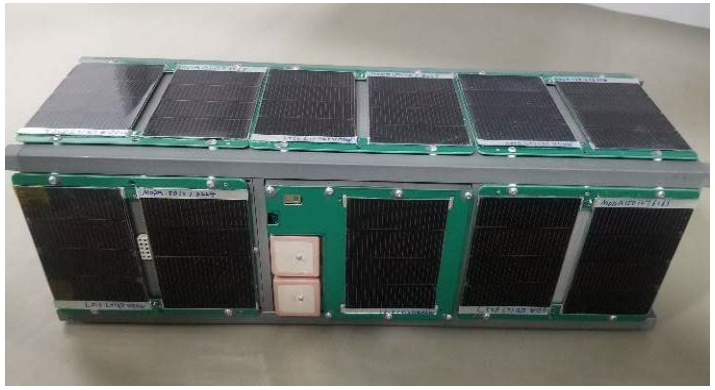
Technological Solutions for Failure Management:

"Black Box" RF Sat-Link for Space Debris, Mission Success, and Risk Mitigation



NearSpace Launch, Inc. (NSL)

10.20.2022

Matthew Voss

Chief Operations Officer

NearSpace Launch

Agenda

Overview of NSL

EyeStar S3

Flight heritage and data from NSL's 24/7 radio connected to Iridium network

Black Box Review

for Spacecraft tracking and failure management.

Upgrade to EyeStar S4

What is Next and Questions

NSL Team

NSL team has delivered and in orbit

over 100+ SmallSat and 180+ EyeStar.

NSL Team

PI and Chief Scientist: Dr. Hank Voss, 40 years of experience at Lockheed, Prof. Taylor University, NSL

Chief Engineer: Mr. Jeff Dailey, 30 years of experience in Industry, Prof. Taylor University, NSL

Project Engineer: Mr. Matt Orvis, 8 years of experience, Grad school and NSL

Chief Operations Officer: Mr. Matt Voss, 15 years of experience in Business and MBA, NSL

Senior Engineer: Mike Schuckel 25+ years of experience in Imbedded systems, NSL

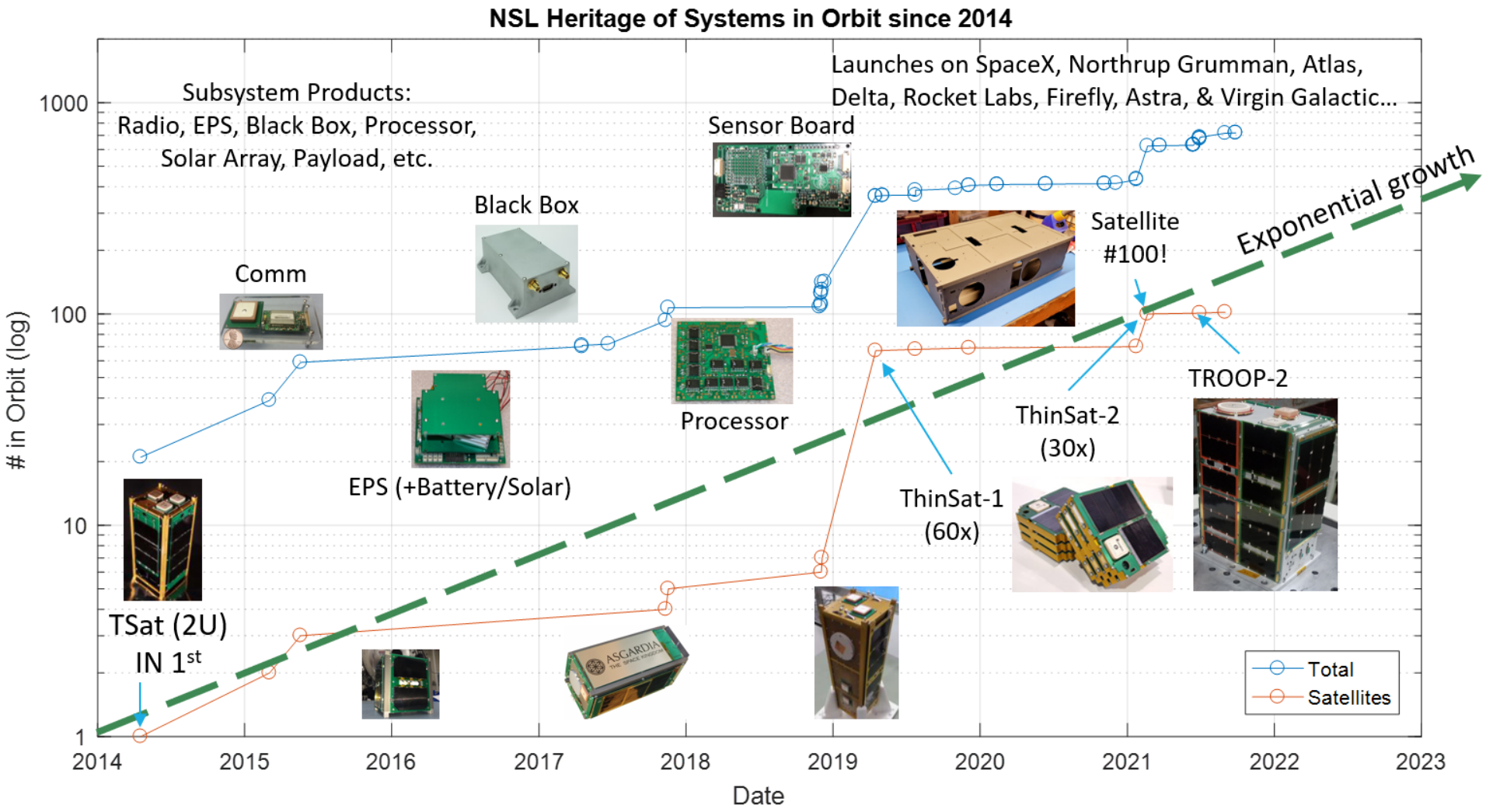
System Engineer: John Pugsley

Facilities Equipment

Three locations: 1. Central office and Clean Room 2. Engineering, testing and clean room 3. Machine shop and manufacturing.

NearSpace Launch

NSL Flight Heritage



NearSpace Launch (NSL)

Heritage:

800+ systems and subsystems with flight heritage past 5 years.

Team:

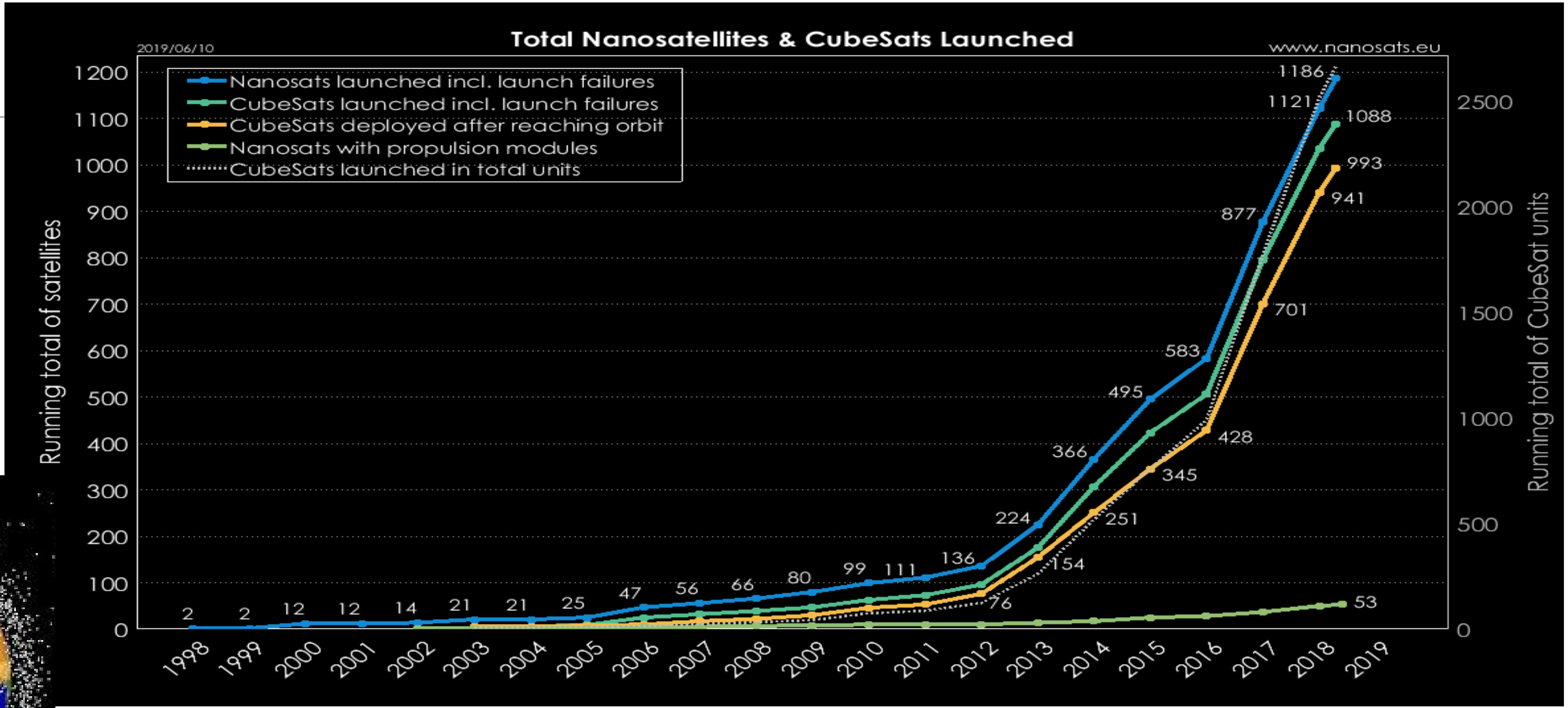
Founders have over 70 years of experience in space science and engineering plus a strong and growing team. Based in Upland, Indiana transition into expanded fulfillment center June. 2022

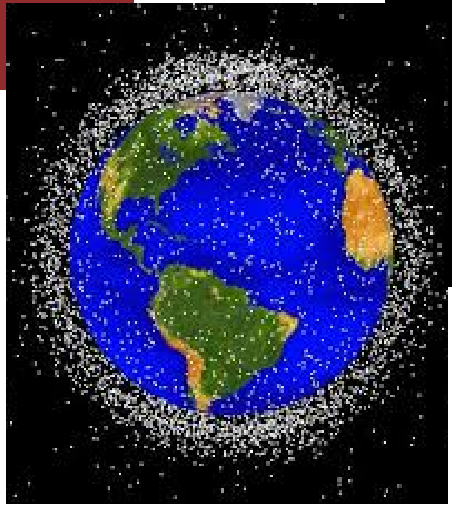
Customers include:

SSC, AFRL, NASA, DOD, Air Force, DARPA, Boeing, NanoRacks, Spaceflight, Rocket Lab, MIT, Etc.

Small Sat Growth

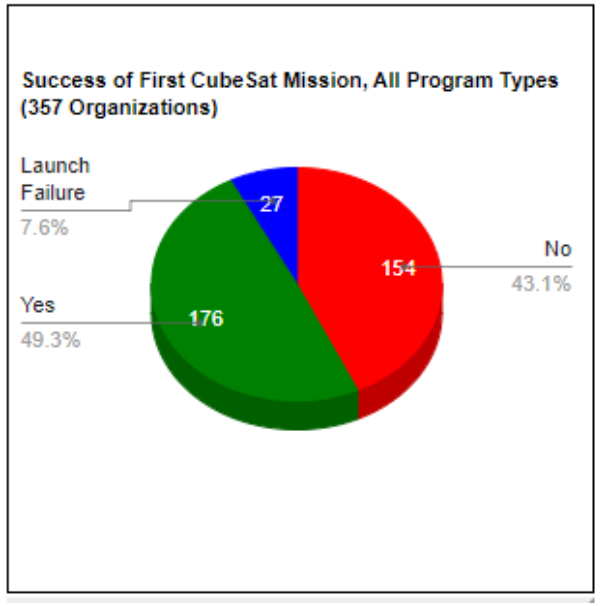
Growth-Big Picture

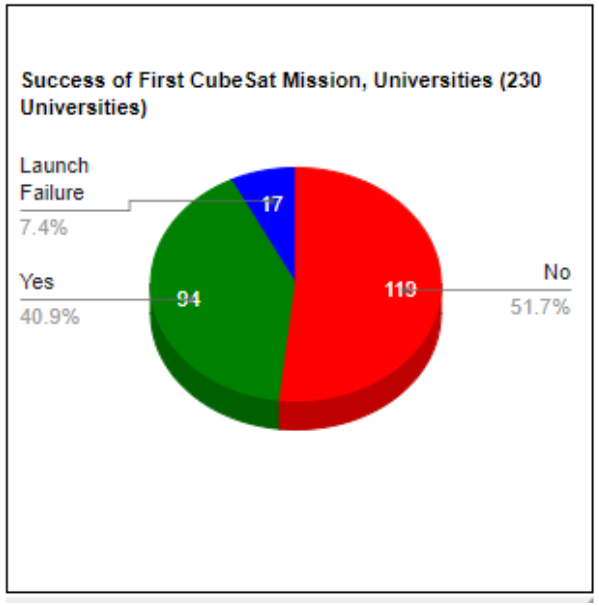


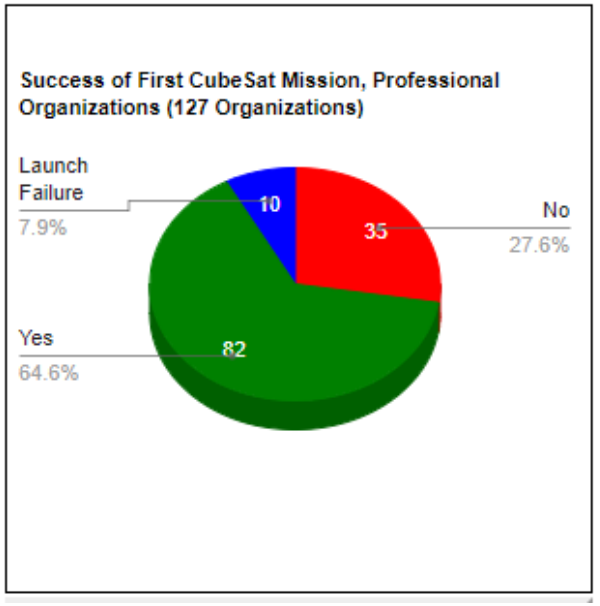


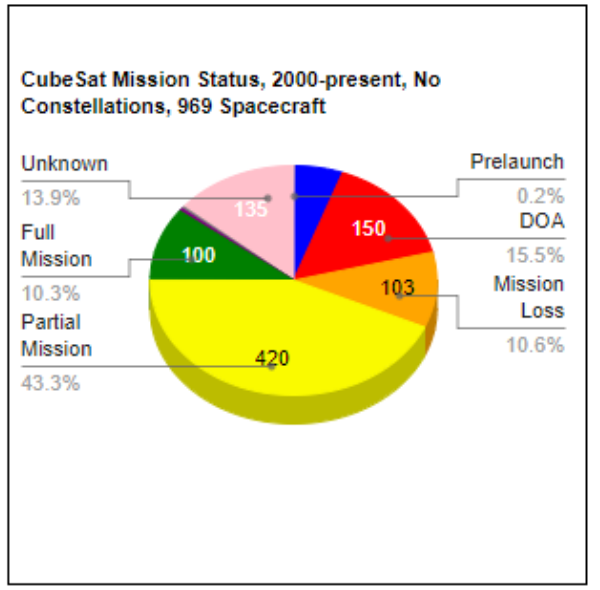
The SmallSat market is rapidly growing in demand

CubeSat Mission Success

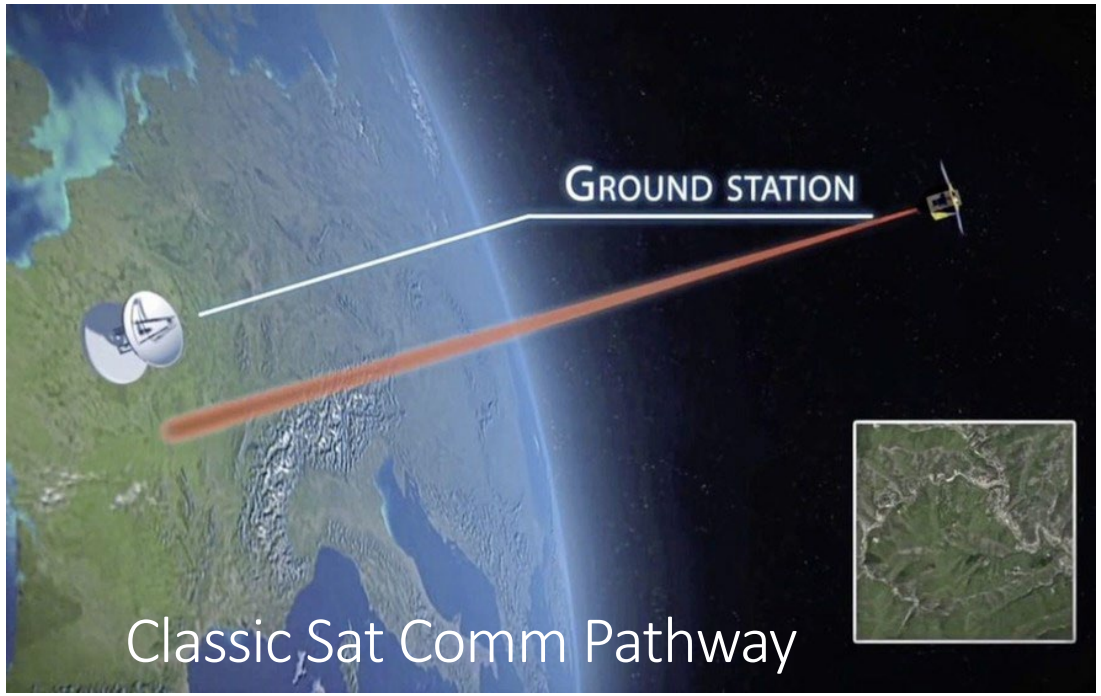




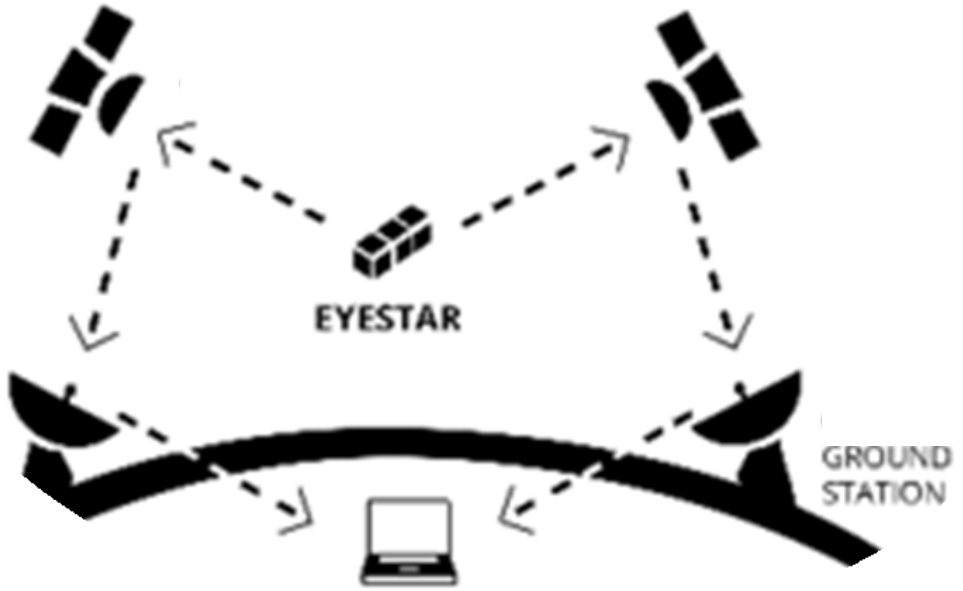




Data from M. Swartwout
https://sites.google.com/a/slu.edu/swartwout/cubesat-database/repeat-success?authuser=0



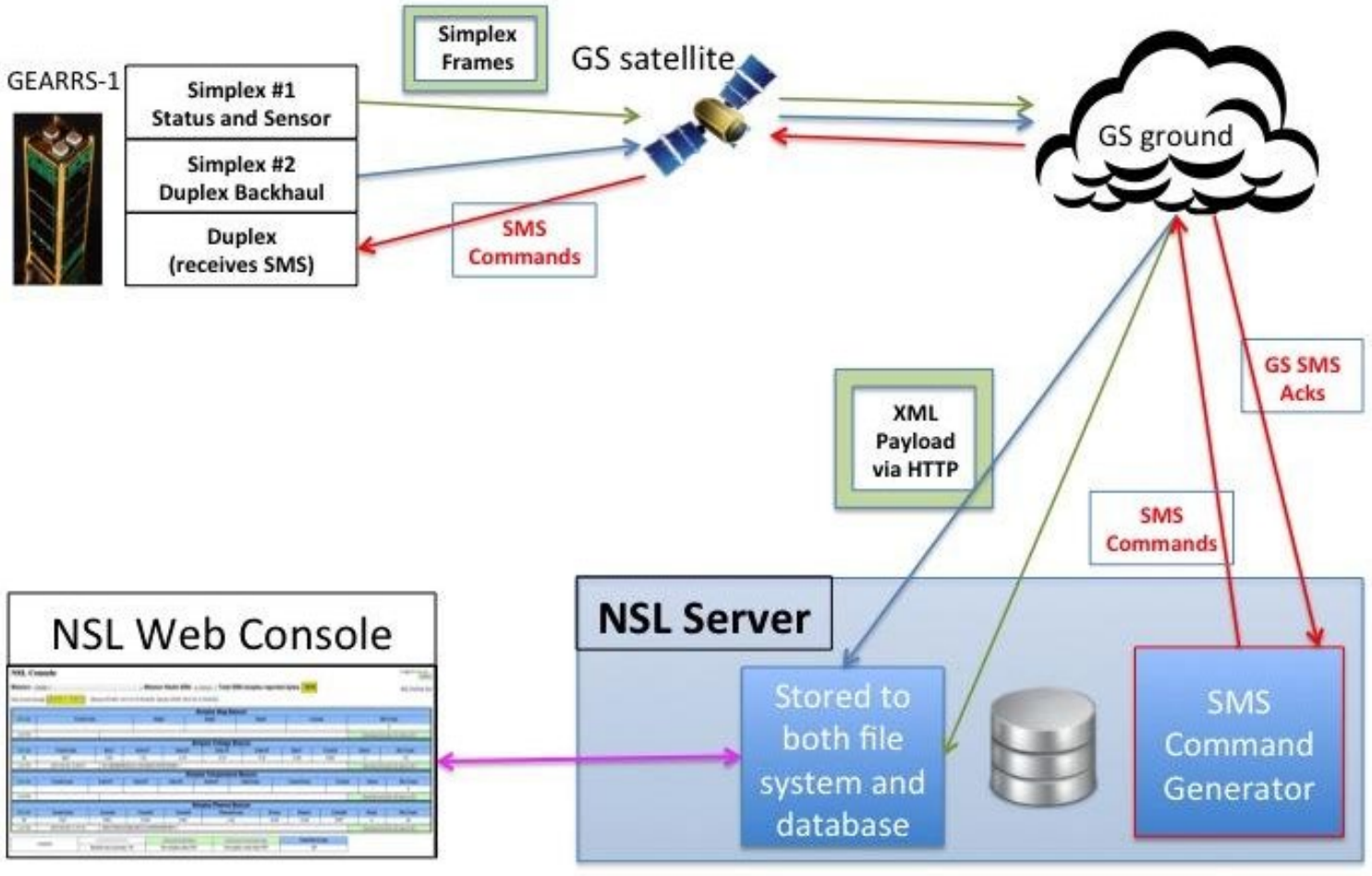
Classic Sat Comm Pathway



NSL EyeStar Comm Pathway

Simplex: STX-3 (or STX-2): 200 Kbytes/day, 9 Bytes/sec

NSL EyeStar Radio architecture



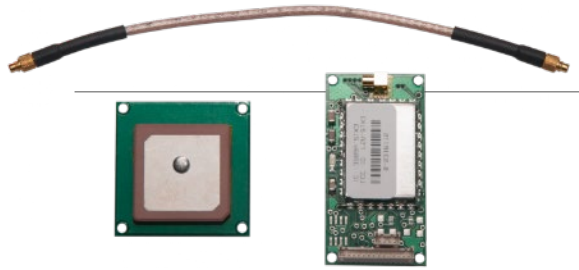
NSL EyeStar Radios Connected to

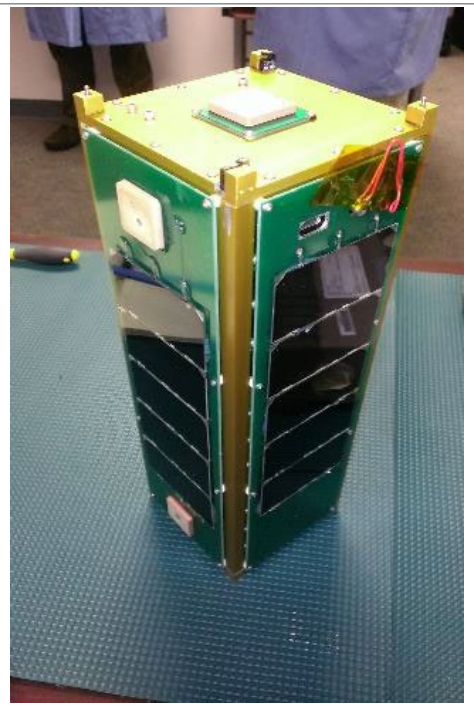
iridium® connected

Simplex: STX-3 (or STX-2): 200 Kbytes/day, 9 Bytes/sec

Globalstar

NSL EyeStar Radios





Simplex: STX-3 (or STX-2): 200 Kbytes/day, 9 Bytes/sec

180+ Radios flown in orbit to DOD, NASA, Industry, & Universities

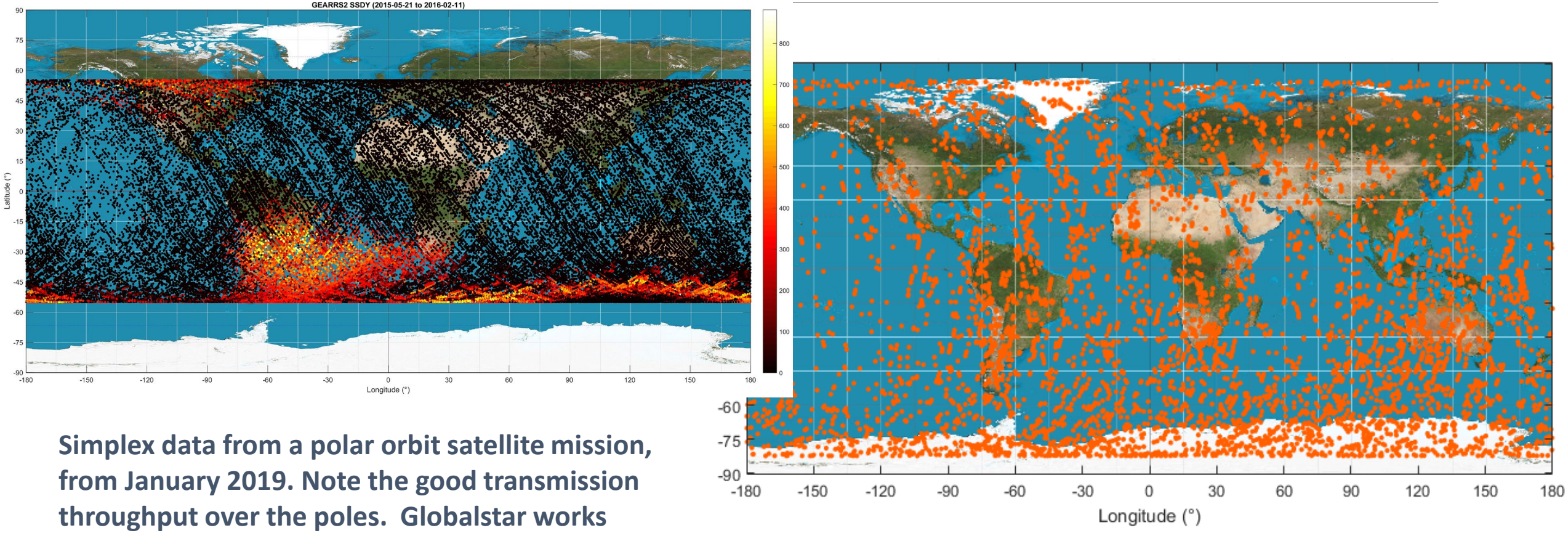
EyeStar Advantages

- Low power/cost/size
- 24/7 Data collection with latency of several seconds
- Turn-on data in seconds
- Global Anywhere/Anytime data
- Connecting while 12 RPM tumbling
- Validated in LEO Orbit
- Value added network
- weeks turn around time

Digital and analog downlink

GEARRS2 Globalstar Coverage

GEARRS2 Simplex raw data projection and sampling Normalization

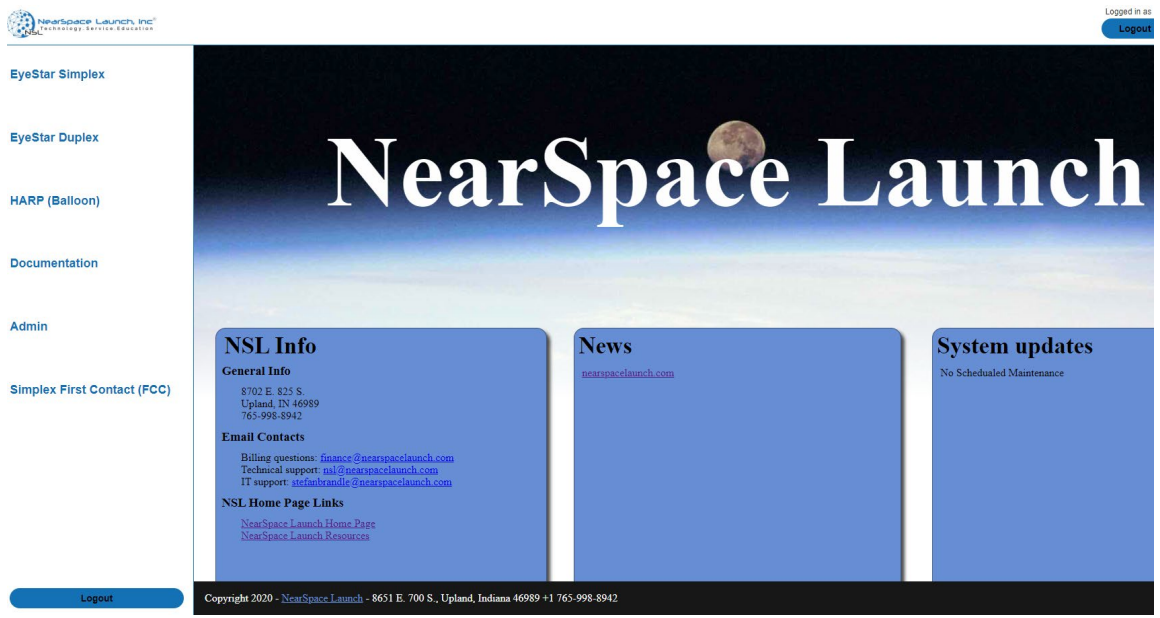


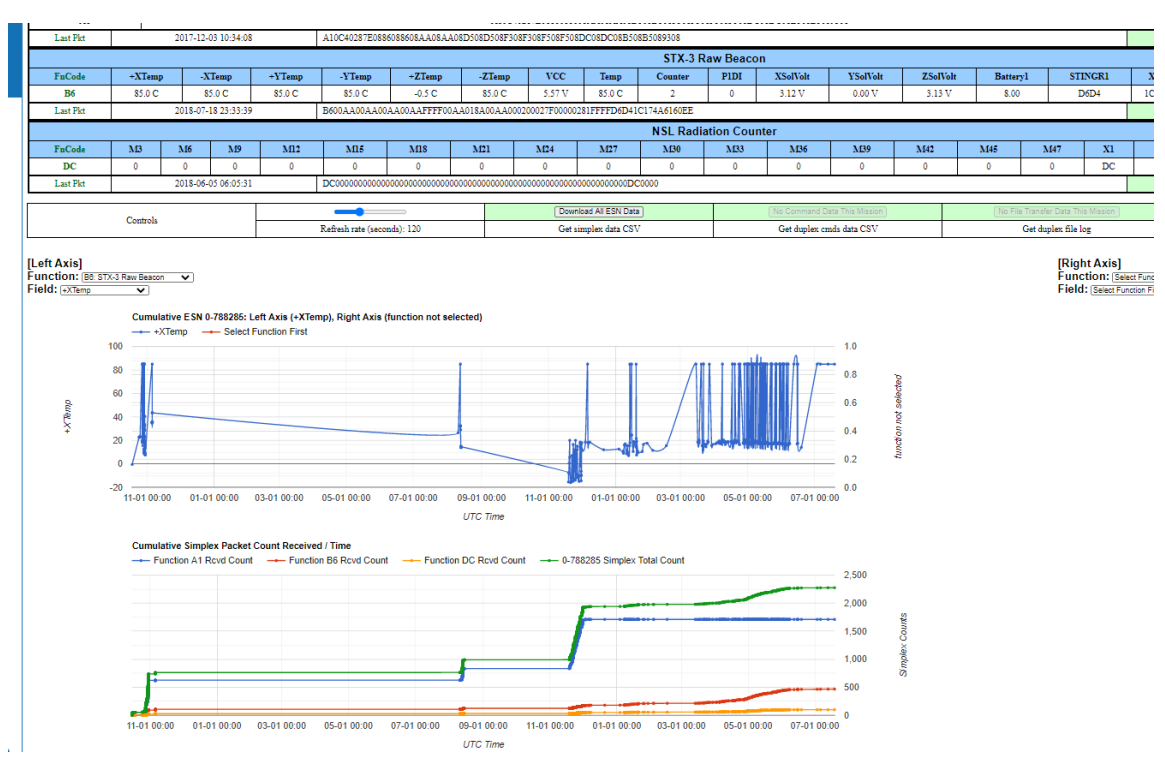
Simplex data from a polar orbit satellite mission, from January 2019. Note the good transmission throughput over the poles. Globalstar works well over the poles for satellites.

Connection in Tumble

EyeStar Simplex still connecting at 12+ RPM

NSL Console


NearSpace Launch Inc
Technology. Service. Education.
Logged in as
Logout
EyeStar Simplex
EyeStar Duplex
HARP (Balloon)
Documentation
Admin
Simplex First Contact (FCC)
NearSpace Launch
NSL Info
General Info
8702 E. 825 S.
Upland, IN 46989
765-998-8942
Email Contacts
Billing questions: finance@nearspacelaunch.com
Technical support: nsl@nearspacelaunch.com
IT support: stefanbrandle@nearspacelaunch.com
NSL Home Page Links
NearSpace Launch Home Page
NearSpace Launch Resources
News
nearspacelaunch.com
System updates
No Schedualed Maintenance
Logout
Copyright 2020 - NearSpace Launch - 8651 E. 700 S., Upland, Indiana 46989 +1 765-998-8942


Last Pkt 2017-12-03 10:34:08 A10C40287E088608608AA08AA08D508D508F308F508F508DC08DC08B508B5089308
STX-3 Raw Beacon
FnCode -XTemp -XTemp -YTemp -YTemp -ZTemp -ZTemp VCC Temp Counter P1DI XSolVolt YSolVolt ZSolVolt Battery1 STINGR1
B6 85.0 C 85.0 C 85.0 C 85.0 C -0.5 C 85.0 C 5.57 V 85.0 C 2 0 3.12 V 0.00 V 3.13 V 8.00 D6D4
Last Pkt 2018-07-18 23:33:39 B600AA00AA00AA00AAFFFF00AA018A00AA00200027F00000281FFFFD6D41C174A6160EE
NSL Radiation Counter
FnCode M3 M6 M9 M12 M15 M18 M21 M24 M27 M30 M33 M36 M39 M42 M45 M47 X1
DC 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 DC
Last Pkt 2018-06-05 06:05:31 DC0000000000000000000000000000000000000000000000000000000DC0000
Controls
Refresh rate (seconds): 120
Download All ESN Data
Get simplex data CSV
No Command Data This Mission
Get duplex cmds data CSV
No File Transfer Data This Mission
Get duplex file log
[Left Axis]
Function: B6: STX-3 Raw Beacon
Field: +XTemp
[Right Axis]
Function: Select Func
Field: Select Function Fi
Cumulative ESN 0-788285: Left Axis (+XTemp), Right Axis (function not selected)
+XTemp
Select Function First
+XTemp
function not selected
UTC Time
Cumulative Simplex Packet Count Received / Time
Function A1 Rcvd Count
Function B6 Rcvd Count
Function DC Rcvd Count
0-788285 Simplex Total Count
Simplex Counts
UTC Time

First Black Box flown

Black Box “Standard”

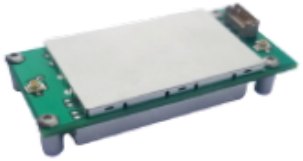
13cm x 13.8cm x 4.4cm

Launched December 3, 2018

EyeStar-S3

End-to-End System, 24/7 connected to Globalstar constellation, with latency of seconds , Max 600 Kbytes/day, Anywhere-Anytime, 100% On-orbit success, Flight Ready, TRL 9, Compliant with new FCC requirements

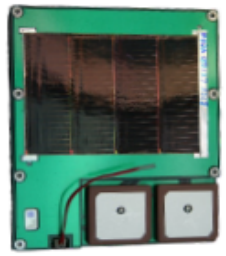
EyeStar-Tag



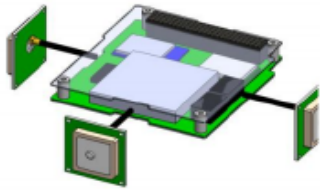
The 22 gram 5.3x2.5x0.9cm Tag and S3 can ID its satellite with Integrated GPS within a few minutes after turn-on while in LEO orbit from pole to pole 24/7. The Tag can track damaged satellites or identify problems early, several hours before ground station contact. TLE can be produced and sent automatically to the 18th Squadron and for the payload team within minutes of orbit deployment. The Black Box subsystems are TRL 9.

Black Box-Patch

140 gram 10x8.3x0.9cm Black Box and S3 can ID its satellite with GPS within a few minutes after turn-on while in LEO orbit from pole to pole 24/7. The Black Box is an independent barnacle that can track damaged satellites or identify problems early, several hours before ground station contact. TLE can be produced and sent automatically to the 18th Squadron and for the payload team within minutes of orbit deployment. The Black Box subsystems are TRL 9.



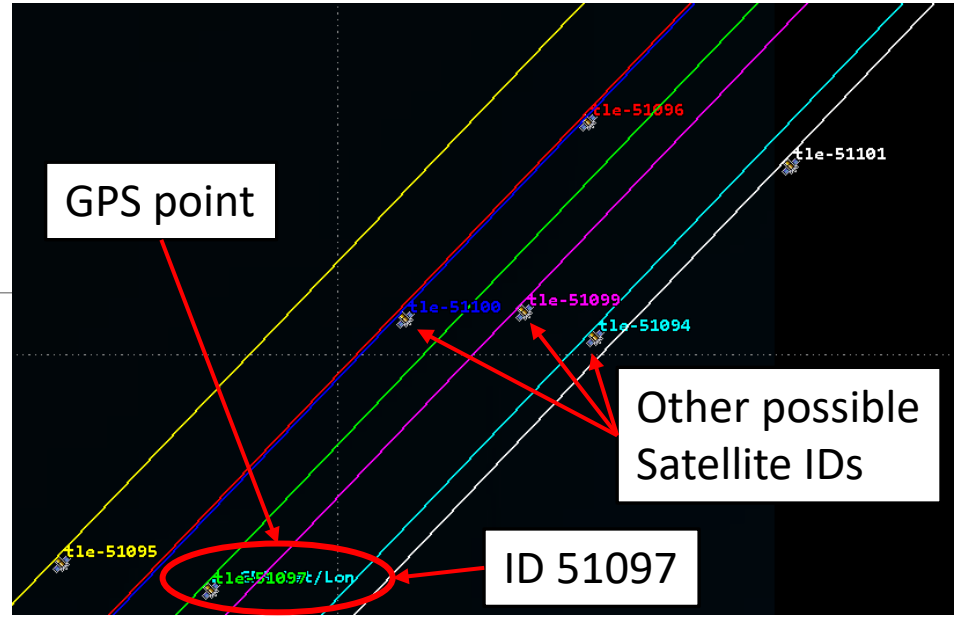
Black Box PC 104



9x9.6x1.3 cm Black Box and S3 can ID its satellite with GPS within a few minutes after turn-on while in LEO orbit from pole to pole 24/7. The Black Box is an independent system that can track damaged satellites or identify problems early, several hours before ground station contact. TLE can be produced and sent automatically to the 18th Squadron and for the payload team within minutes of orbit deployment. The Black Box subsystems are TRL 9.

Black Box-Standard

140-gram Black Box and S3 can ID its satellite with GPS within a few minutes after turn-on while in LEO orbit from pole to pole 24/7. The Black Box is an independent barnacle that can track damaged satellites or identify problems early, several hours before ground station contact. TLE can be produced and sent automatically to 18th Squadron and for the payload team within minutes of orbit deployment. The Black Box subsystems are TRL 9.



UNIT		EYESTAR TAG	BLACK BOX PATCH	BLACK BOX PC104	BLACK BOX STANDARD
SIZE L X W X H	cm	5.3 X 2.5 X 0.9	10 X 8.3 X 0.85	9 X 9.6 X 1.3	8.9 X 7.1 X 4.1
WEIGHT	g	22	140	NA	350
POWER	v	7.2	7.2	7.2	7.2

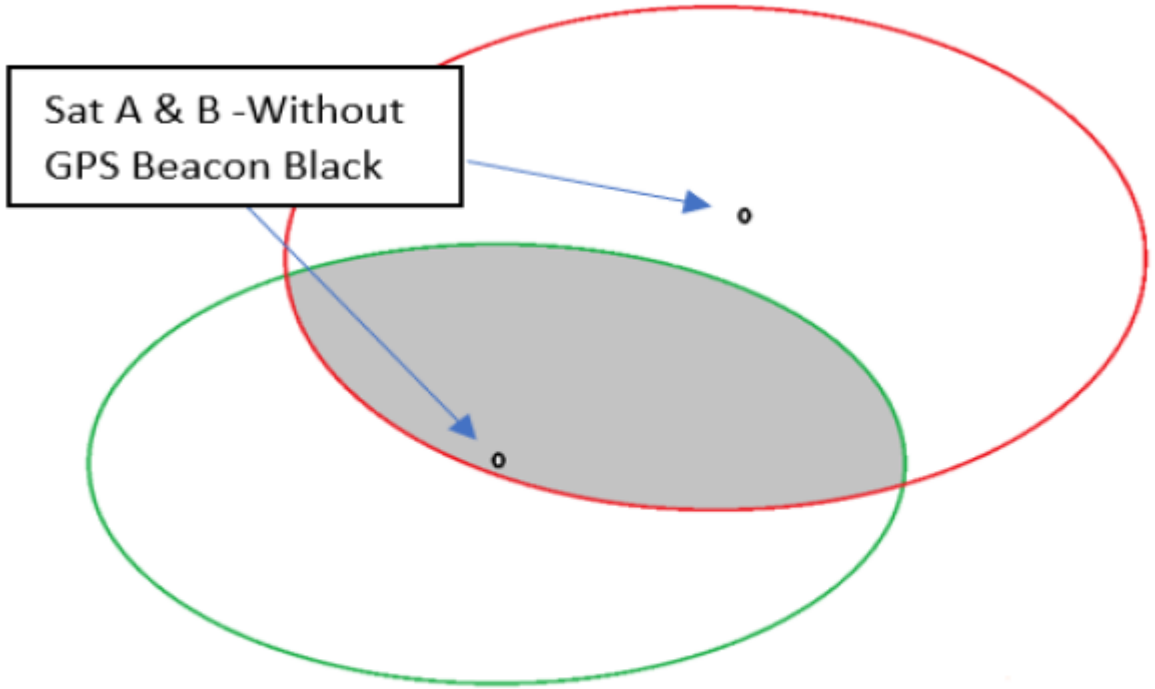


Fig. 2. The ellipse represents collision cross-sections. Gray area represents intersection of two satellites without beacon GPS conjunction boxes.

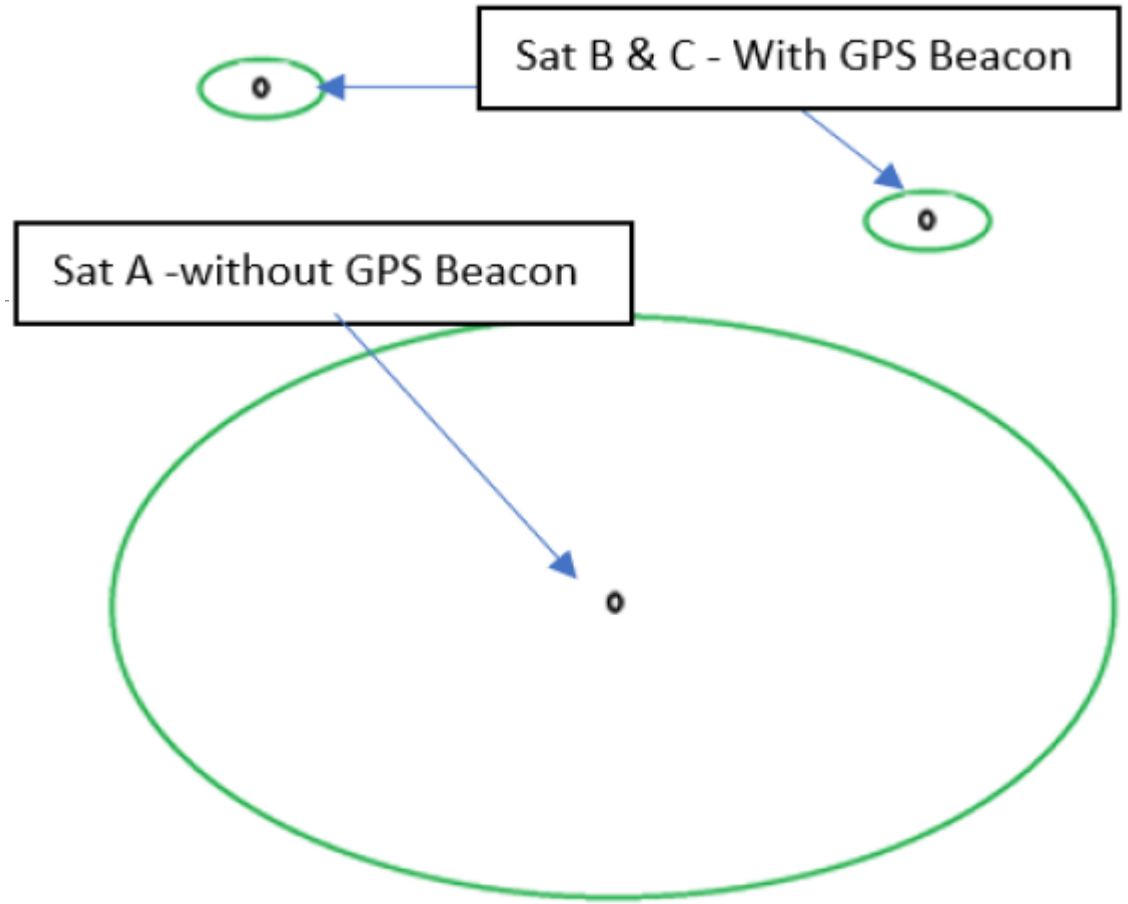
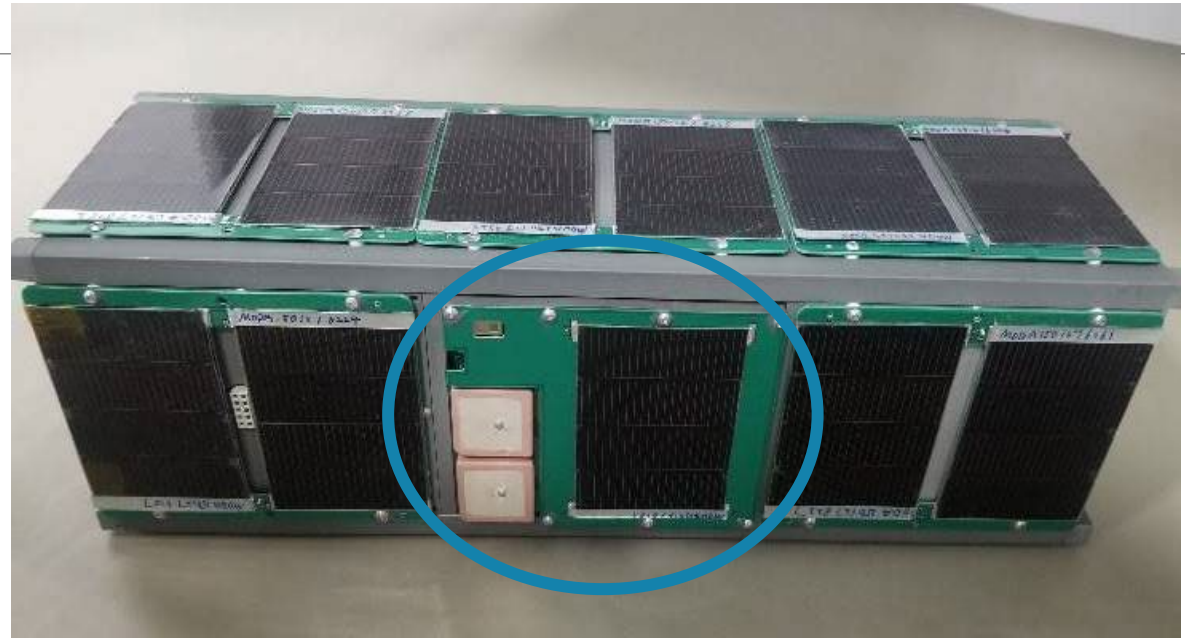


Fig. 3. Example of three satellites. Sat B and C shows conjunction shrinking due to GPS Beacon Black Box. The ellipses represent collision cross-sections.

Black Box Systems



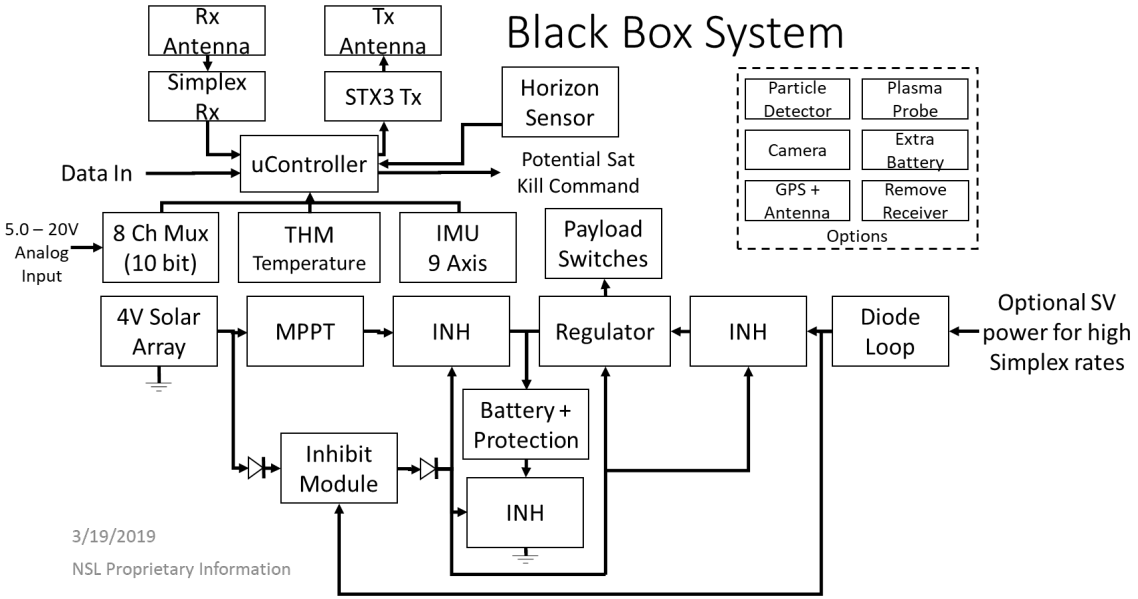
TechConnect INNOVATION AWARD 2020

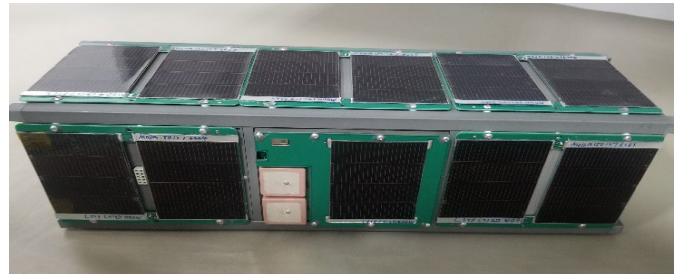
U.S. AIR FORCE SBIR

HYPERSPACE CHALLENGE

“Black Box” Satellite Self- Identification

RF Sat-Link for Mission Success, Risk Mitigation and Space Debris





Black Box Patch

10cm x 8.3cm x 1.45cm

Black Box Patch on a 3U CubeSat

PRODUCT	EYESTAR S3	FLIGHT PROCESSOR	RT SHIELDING	SERIAL INTERFACE	A/D INPUTS	FRAME	SIMPLEX RX	NSL GPS	3RD PARTY GPS	DC-DC ISOLATION	BATTERIES	SOLAR ARRAY	9 AXIS IMU	HORIZON SENSOR	PARTICLE DETECTOR
BLACK BOX PATCH	✓	✓	✓	✓	✓	✓	✓	✓	●	✗	✓	✓	✓	✓	✓
BLACK BOX TAG	✓	✓	✓	✓	✗	○	○	✓	○	✗	✗	✗	○	○	○
BLACK BOX STANDARD	✓	✓	✓	✓	✓	✓	●	●	✓	●	●	●	●	○	●
BLACK BOX PC104	✓	✓	✓	✓	✓	✗	✓	✓	●	●	●	○	✓	●	●

✓ INCLUDED ✗ NOT INCLUDED ● INTEGRATED OPTION ○ ADD ON OPTION

EyeStar S4 Crossover mission

Compare capabilities from EyeStar S3 Simplex via Globalstar to EyeStar S4 Half-Duplex via Iridium

Figure 1: NearSpace Launch joins Astra's EyeStar-S4 CrossOver Mission on 3/15/2022

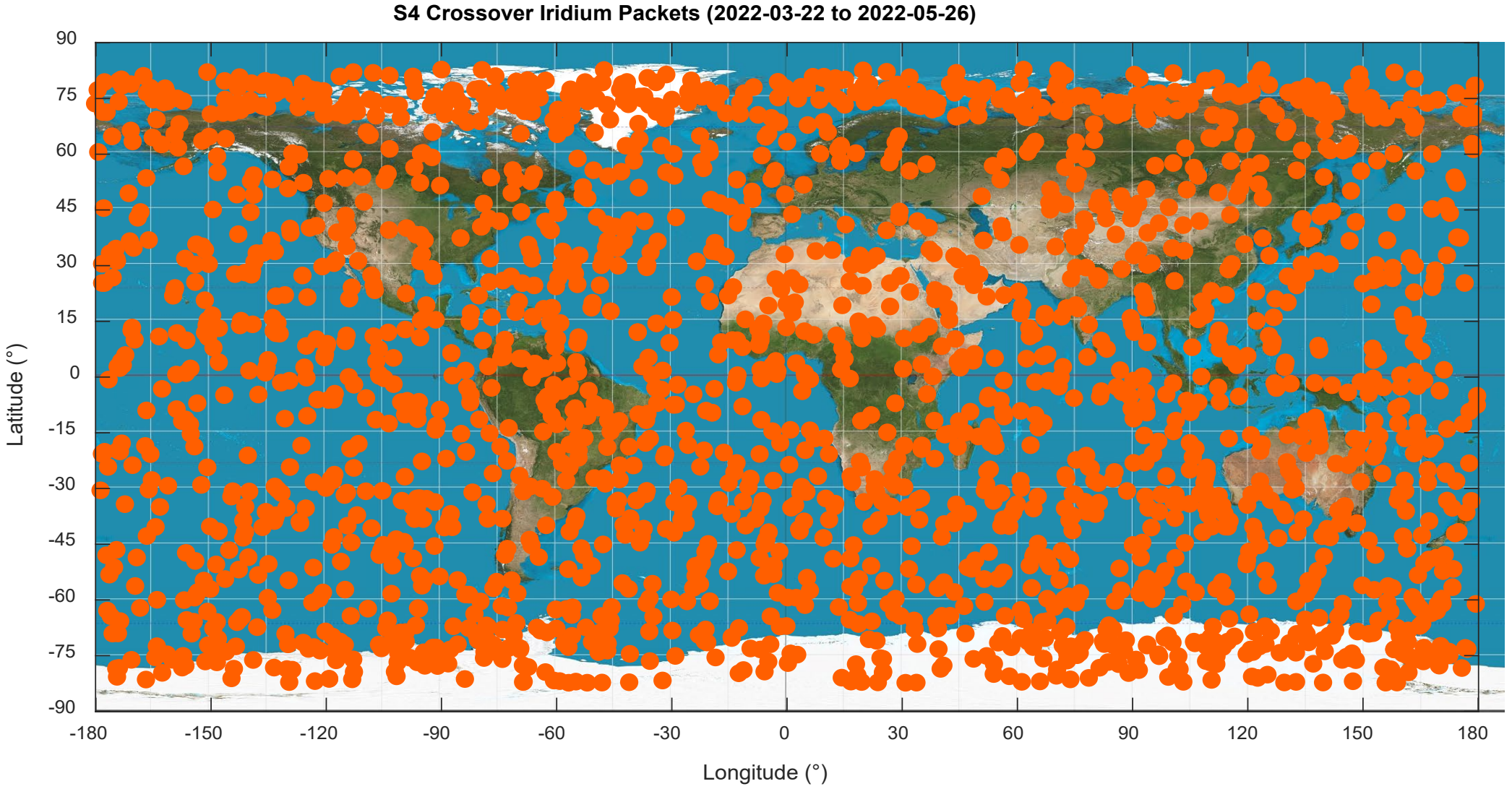


Figure 1 **Global Iridium coverage data of transferred packets from the S4-Crosoover mission. Using the Iridium TX firmware within the EyeStar-S4. Note the full global coverage, with increased connectivity over the polar** regions.

Moving from EyeStar S3 to Eyestar S4

Carryover from S3 to S4

- Small form factor
- 24/7 data with global coverage
- Low latency and VLEO down to 110km.
- Full ground segment included
- Data livestreaming to online console
- Small patch antenna
- Autonomous beacon mode

Upgrades from S3 to S4

- Accessing Iridium constellation with fuller coverage area
  - Less dropouts and good polar coverage
- Added Uplink capability for commanding
- Higher data rate
  - Still being quantified
  - Over 80% throughput over earth
- Lower overall power
- Better tumbling performance
- Interfaces directly with NSL GPS

Spec	GEARRS-3	S4-Crossover	TROOP-3
Launch Date	1/13/2022 23:46:00 UTC	3/15/2022 16:31:00 UTC	5/25/2022 19:31:42 UTC
Rocket	VOX Launcher One	Astra Rocket 3	SpaceX Falcon-9
Orbit	SSO, 500x500, 90°	SSO, 550x498, 97.5°	SSO, 534x539, 97.5°
Tip off	~2.5 RPM	< 60 RPM	< 8 RPM
Current Tumble	~2.5 RPM	< 40 RPM	< 8 RPM
Radios	S3, BB-P (S3, GPS), GPS	S3, S4, GPS	S3, S4, GPS
Sensors	Mag, Plasma, PIN, Solar V, BUS+, Bat V/Q	Solar Temp, Bat V/Q, Mag	Bat V/Q, PIN
Uplink	NA	Yes	Yes
Downlink	Yes	Yes	Yes

Resources

Small Sat Conference 2022

- Thin CubeSats and Compact Sensors for Constellations in VLEO to Deep Space

Small Sat Conference 2021

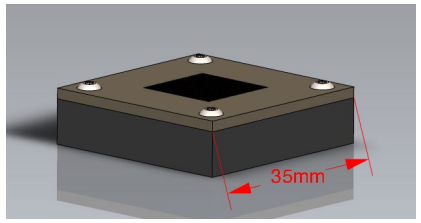
- ID, GPS Tracking, 24/7 Tag Link for CubeSats and Constellations: Flight Results

Small Sat Conference 2019

- Architecture & Manufacture for 1/7U to 27U 60 ThinSat Constellations: Flight Results
- “Black Box” RF Sat-Link for Space Debris, Mission Success and Risk Mitigation

Black Box Next Steps
SPACEWERX - STTR Phase I

Intergrade the Autonomous 24/7 EyeStar Black Box Commanding with µStamp Collision Avoidance Thruster (Black Box-MCAT)



Objectives and Key Metrics: Integrate Black Box EyeStar comm system that shrinks the conjunction window between satellites while enabling a collision avoidance thruster. The Key Metrics are to complete a PDR and feasibility Study of integrating the 24/7 Black Box including GPS system with University of Tennessee thruster system.

THE UNIVERSITY OF TENNESSEE KNOXVILLE

Zero Waste 24/7 Autonomous Black Box Tracked Satellite The Recycled Constellation (Black Box – ZW)

Objectives and Key Metrics: Integrate Black Box EyeStar comm system that shrinks the conjunction window between satellites while enabling a space weather particle detector to collect data. The Key Metrics are to complete a commercial feasibility study of space weather instruments and integrate the 24/7 Black Box system for second life mission. Creating recycled constellations of Space Weather Black Boxes as secondary missions after primary missions are complete.

TAYLOR UNIVERSITY

Questions/Discussion

NearSpace Launch Inc.(NSL)

mattvoss@nearspacelaunch.com

765.998.8942

Rapid Orbit Testing to raise TRL

TROOP & RAPSAT Payload Train

- Launching every **90 to 180 days** on Falcon 9 and Astra Launches
- Raise payloads TRL by hosting for 3-5 year in orbit missions
- **Autonomous Satellite** transmit 24/7 payload data via Sat to Sat EyeStar Radio
- Send flight telemetry plus critical mission data
- Diagnostics include: Temperature, Voltage, Particle detector, IMU, GPS options and more
- 15 minute integration to ESPA Rings

TROOP-1

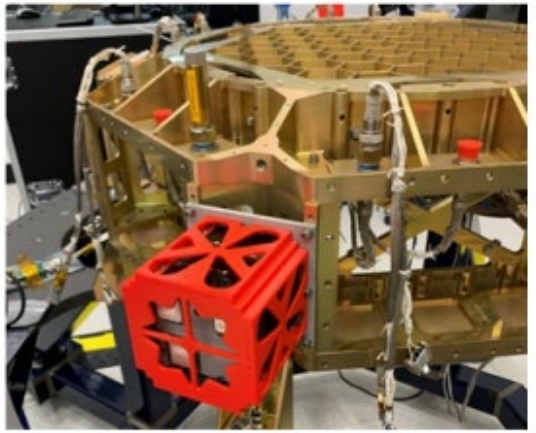


Figure 20 Picture of TagSat-1 (TROOP-1) mounted to the SHERPA deployment ring for

TROOP-2

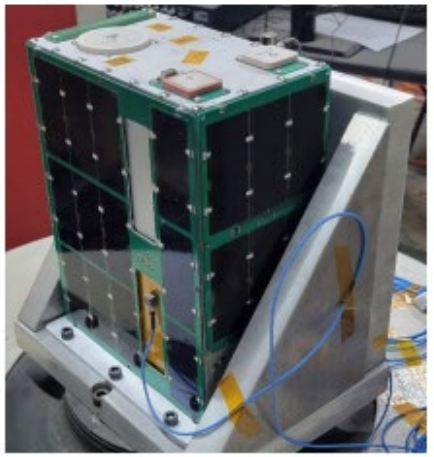
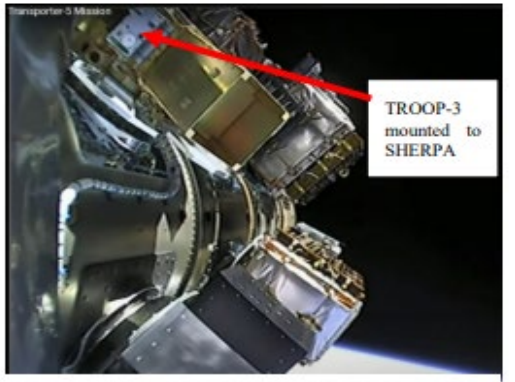


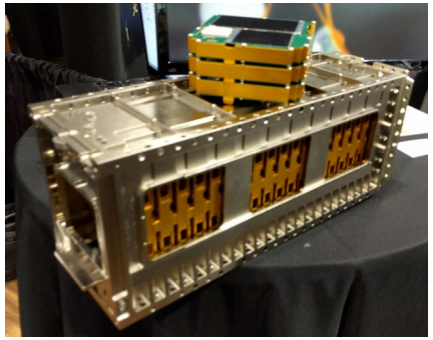
Figure 22 TagSat-2 (TROOP-2) Mounted to a vibe table for vibration testing ahead of delivery.



ThinSat

NSL Current Commercial 21-ThinSat 3U

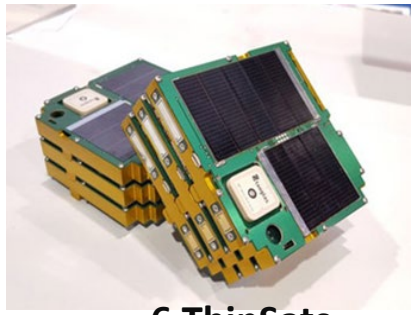
- **60 ThinSats were launched** off NG-11. Declared mission success by customer. 52 of 60 Sats connected within first hour, others came online later that day. (See Figure 1 depiction) It was primary a program that study very low earth orbit with academia. NSL also had it own sensors on all ThinSat
- NSL is currently developing a ThinSat constellation for Space Weather.
- NSL is delivering second constellation of 30+ ThinSat October 2020 and manifested for Feb 2021



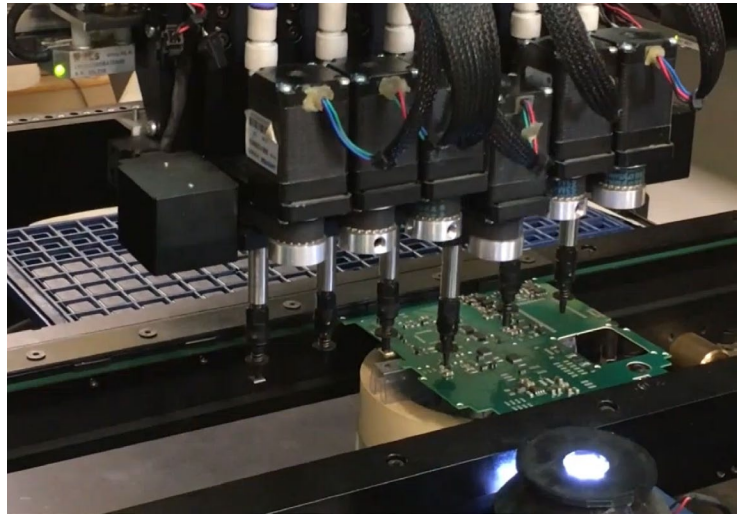
21-ThinSat 3U inside Standard CubeSat Launcher
17 x 112 x 114mm

Further detail see 20+ page flight results published paper at SmallSat 2019 (Attached Volume V)

Deployment of 60 ThinSats on Apr 2019
(Figure 1)



6 ThinSats



Robotic Assembly of 100 ThinSat