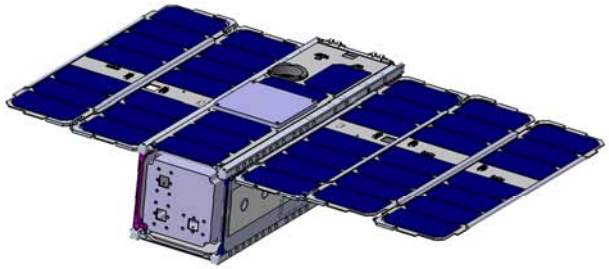
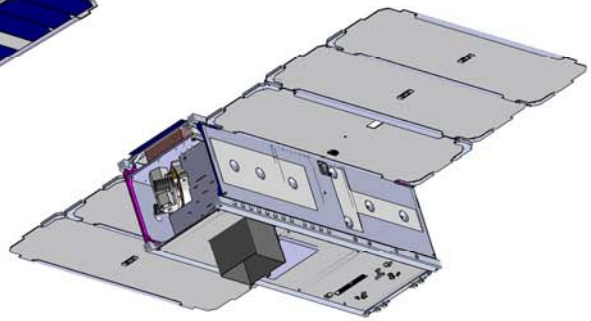
Space Environmental NanoSat Experiment (SENSE)





Capt George Sondecker
SENSE Program Manager

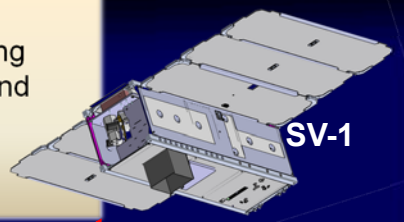
Overview

- SENSE Mission Overview
- Space Vehicle Bus and Payloads
- Data Products and Users
- Rapid Development Timeline
- Lessons Learned through SV Operations On Orbit
- Back-Up Photos

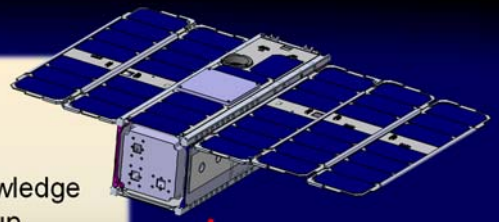
Space Environmental NanoSat Experiment (SENSE)

OBJECTIVE: SENSE is a space weather demonstration for evaluating the cost-effectiveness and resiliency of CubeSat architectures for augmenting or performing future operational missions. Additionally, SENSE is a risk reduction pathfinder for the Common Ground Architecture (CGA) and the Global Space Telemetry Resource (GSTR) antenna suite.

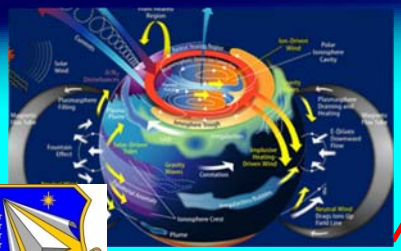
SENSE Overview:
- Mission: Space Environmental Monitoring
- Architecture: Two 3U CubeSats & Ground
- Mission Life: 1yr
- Launch: Nov 2013, ORS Enabler 3
- Orbit: 500km Alt, 40.5° Inclination



Bus Performance:
- Mass: 4kg
- Power: 10W Avg, 37W Peak
- ADCS: <0.5° pointing, <0.3° knowledge
- Data Rate: 1Mbps down, 4kbps up
- Encryption: AES256 Type II



GAIM Ionospheric Model



Sensors and Measurements:
1. CTECS: Electron Density (TEC), Scintillation
2. CTIP: Ionospheric Structure
3. WINCS: Temps & Composition of Ions & Neutrals
4. Dosimeter: Cumulative Radiation

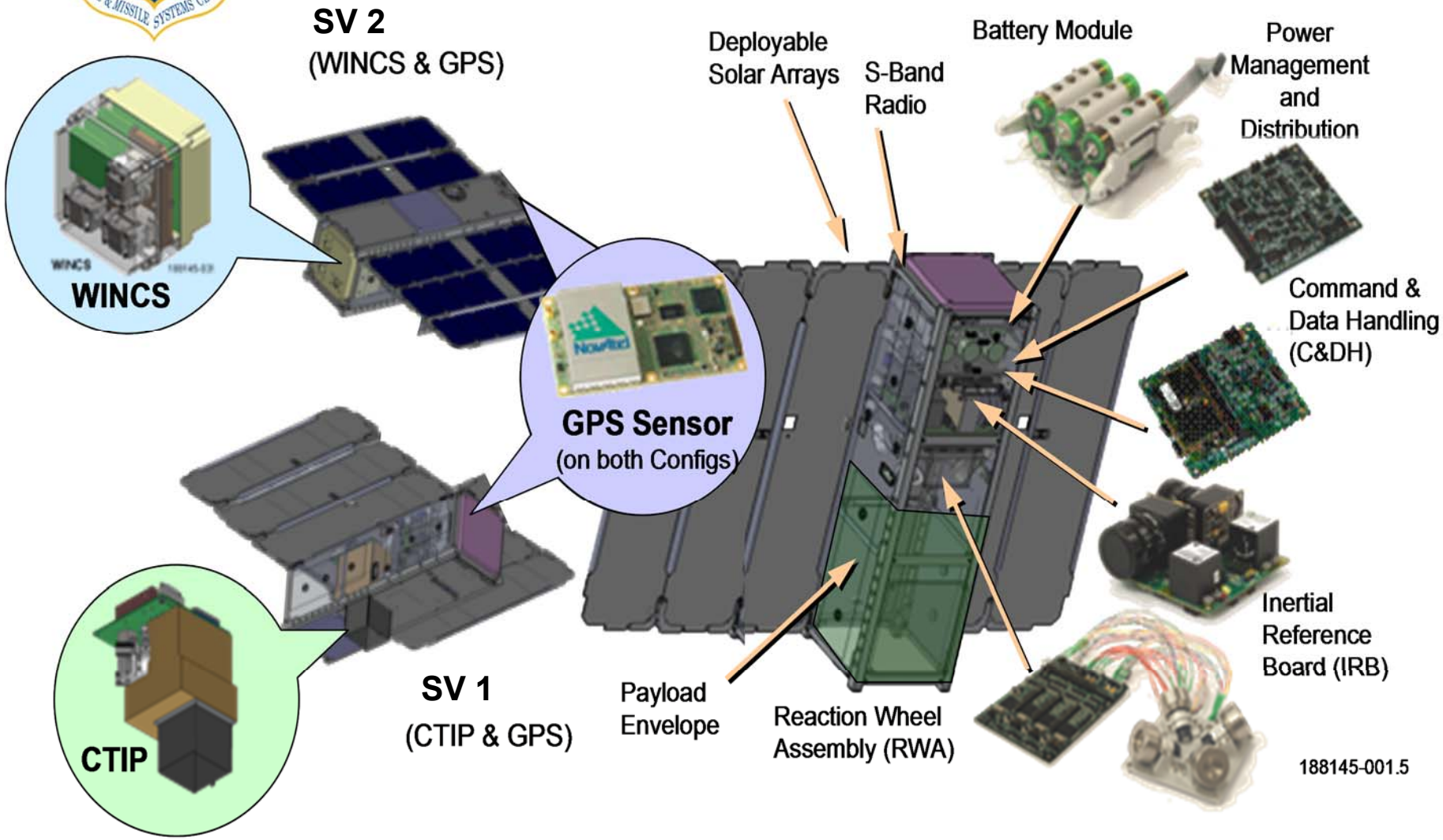
Kirtland AFB, NM

Blossom Point, MD

AFSCN

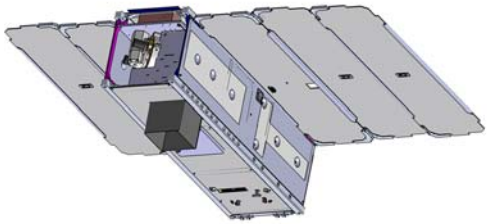
Ground System:
- Sites: Manzano NM, Blossom Point MD, AFSCN
- Common Ground Architecture (CGA) multi-mission, lights-out operation
- Leave-behind asset for future missions (SMC/IS WFOV)

SENSE Bus

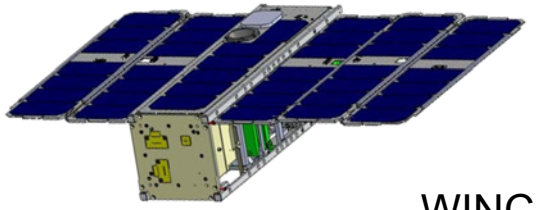

SV 2
(WINCS & GPS)
Deployable
Solar Arrays
S-Band
Radio
Battery Module
Power
Management
and
Distribution
WINCS
GPS Sensor
(on both Configs)
Command &
Data Handling
(C&DH)
Inertial
Reference
Board (IRB)
CTIP
SV 1
(CTIP & GPS)
Payload
Envelope
Reaction Wheel
Assembly (RWA)
188145-001.5

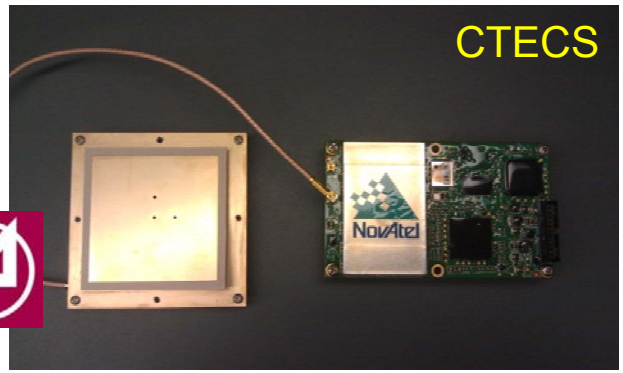
Space Weather Sensors

SV-1: CTIP + CTECS

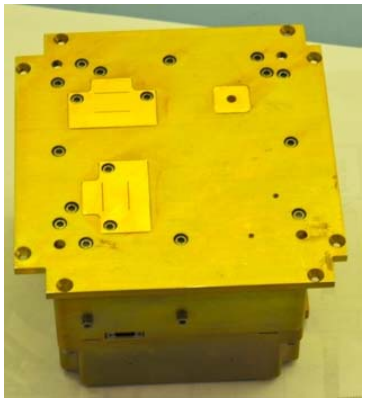


SV-2: WINCS + CTECS



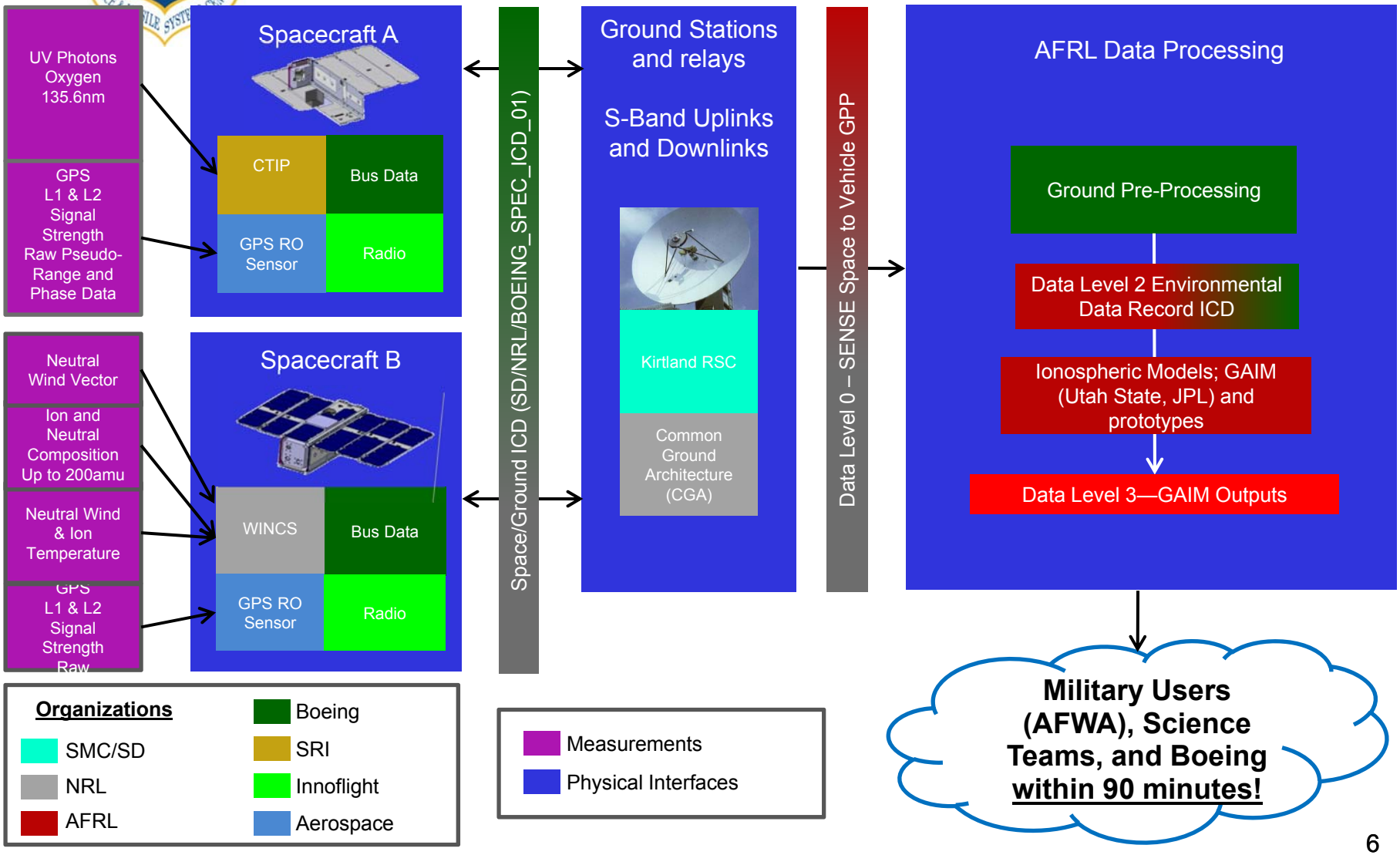


WINCS

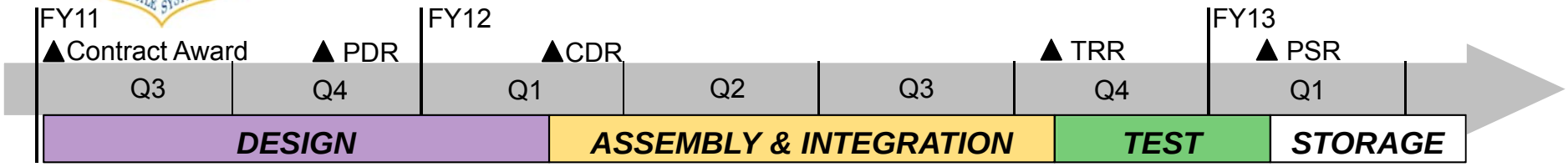


Compact Tiny Ionospheric Photometer (CTIP)	CubeSat Total Electron Content Sensor (CTECS) (x2)	Winds Ions Neutrals Composition Suite (WINCS)
Measures 135.6 nm UV nightglow giving ionospheric density variation and structure	Measures amplitude and phase variations of occulting GPS signals giving ionospheric density and scintillation	Measures ram fluxes of ions and neutral particles giving local electric field, densities, neutral winds, and temperatures

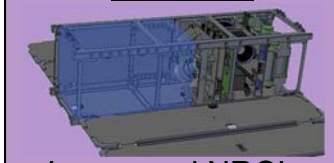
SENSE Data Flow



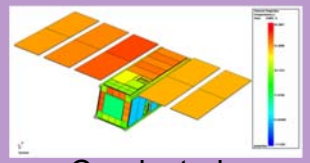
SENSE SV Development



DESIGN



Leveraged NRO's Colony II bus



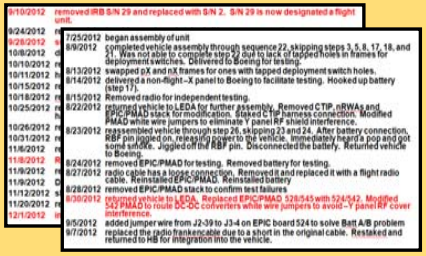
Conducted extensive M&S

S-Band XCVR

Developed functional prototypes to reduce risk

ASSY & INTEGRATION

SV Assembly at Boeing Phantom Works



Maintained Detailed Assy Logs

TEST

1. HW/SW Compatibility Test
   - Executed 19 test scripts to verify subsystem & SV functionality
2. Environmental Test

Vibration

TVAC

3. Day-In-The-Life Test
   - 24hr LEO rehearsal
   - Operators at RSC commanded FMs via CGA
   - Verified SV compatibility with ground system

STORAGE

SV delivery to AFRL for storage

SMC/XR accepts HW delivery

Enhanced *mission assurance* provided by thorough *process execution* and extensive *testing*

On-Orbit Lessons Learned

- **Space vehicle discrimination methods *must* improve if NanoSatellites are to be used in future operational architectures**
- **Small Satellite ≠ Low Complexity**
- **Many SENSE space vehicle subsystems performing exceptionally well:**
  - **Li-Ion batteries**
  - **S-band radio**
- **Common Ground Architecture:**
  - **Versatile and stable software platform**
  - **Enables resilient command and control in contingency operations**

SV-1 Integration

SV-2 Integration

Summary

- **SENSE is SMC's premier rapid development effort which will demonstrate the capability of CubeSats to perform space missions in an affordable and resilient manner.**
  - **Acquired under Air Force acquisition procedures employed for all space vehicle**
  - **Delivers three first generation miniature sensors; WINCS, CTIP, CTECS.**
  - **Addresses 2 of 12 Space Weather Gaps**
- **A distributed ground architecture with leave-behind capability to fly the next minimally-manned satellite mission.**

CTIP

CTECS

WINCS

SUPPLEMENTARY SLIDES

SENSE Ground Terminal at KAFB, NM