Ionospheric Neutron Content Analyzer (INCA)

New Mexico State University

Melissa Moreno
On behalf of the INCA Team

Mission Overview

Primary

INCA will be a demonstration flight for a novel neutron detector for measurements supporting Space Weather Prediction. The detector is capable of measuring both the energy and direction of neutrons (2-15 MeV energy range) using a double scatter technique.

Secondary

INCA will measure the neutron flux to look for both a latitude dependence and temporal variations. These measurements will help to improve current Space Weather models and mitigate threats to space and airborne assets.

Tertiary

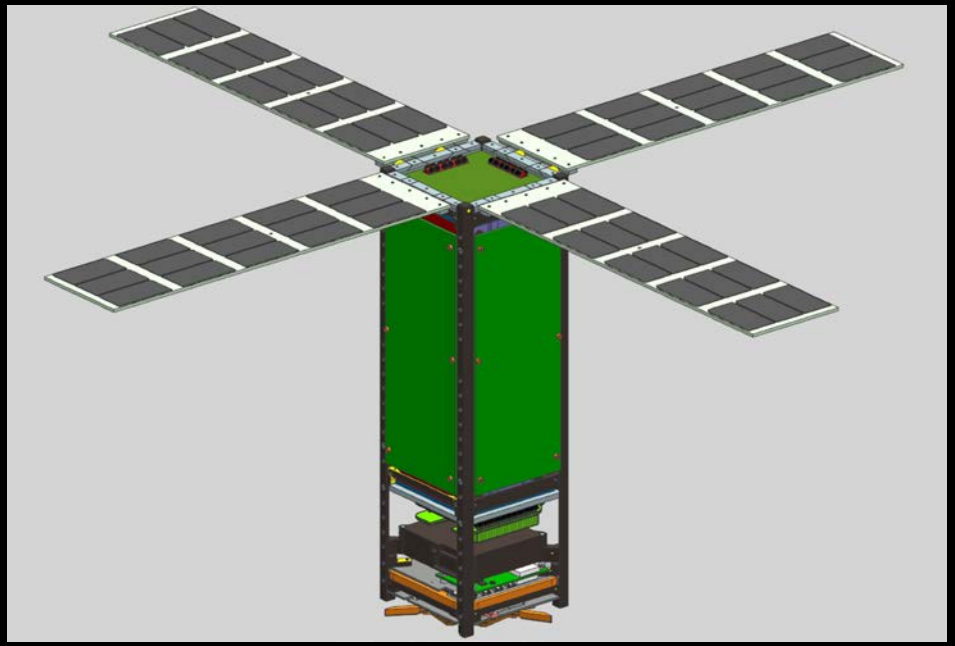
INCA will explore the dependence of the neutron flux as a function of solar activity.

Quaternary

INCA will search for primary solar neutrons.

Mission Overview (cont.)

- 3U CubeSat - 10cmx10cmx30cm
- Deployable solar panels
- Side solar panels
- Deployable antennas
- Avionics located in the rear 1U
- Neutron Detector located in the front 2U



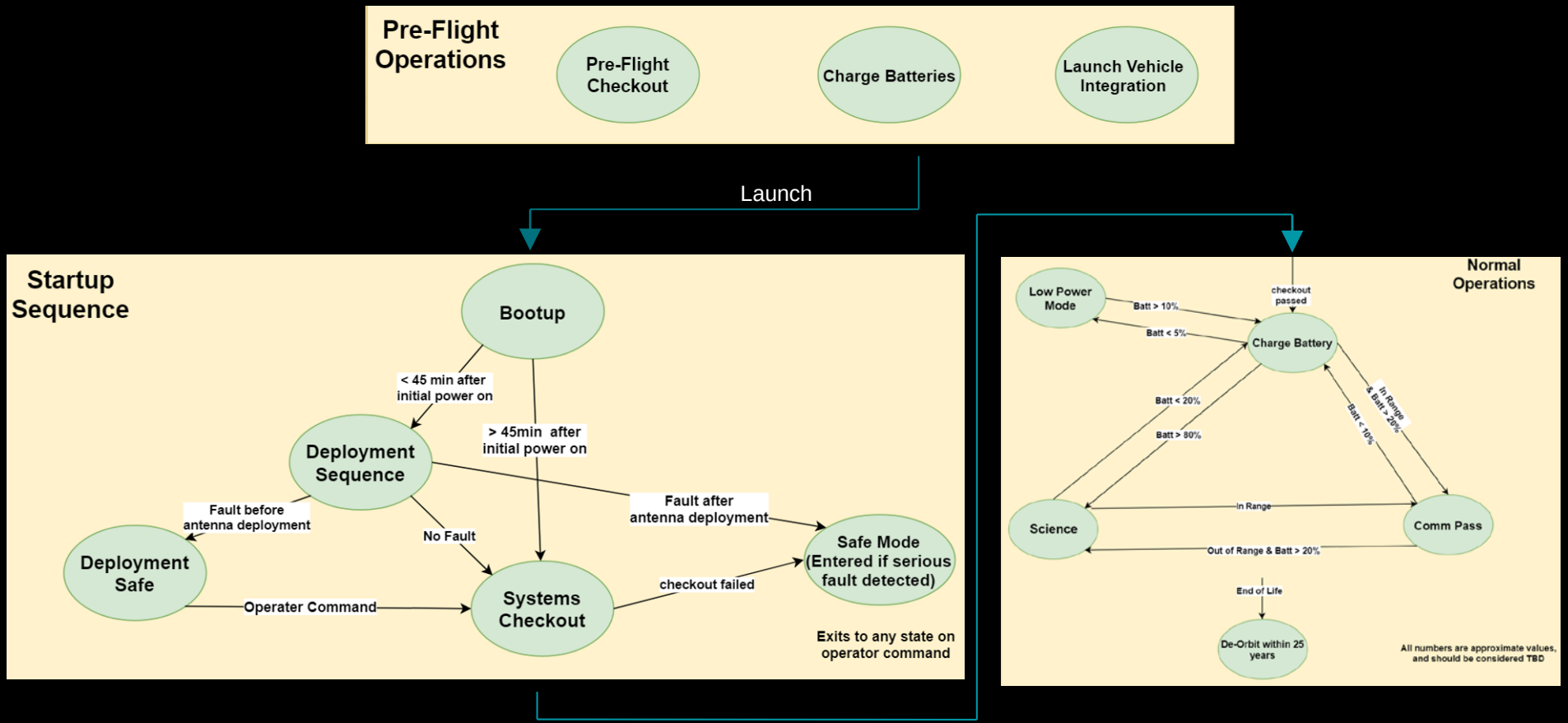
- Circular orbit
- 500 km altitude
- 90 degree inclination
- Orbital period of 94.62 minutes

Launch

- Takes off from Spaceport located in Mojave, California
- Air launches over the Pacific
- Launch is scheduled for early 2018

Images courtesy of Virgin Galactic

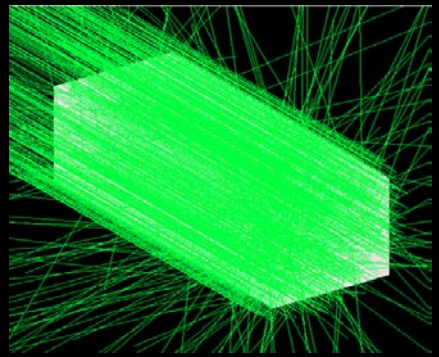
ConOps


Pre-Flight Operations
Pre-Flight Checkout
Charge Batteries
Launch Vehicle Integration
Launch
Startup Sequence
Bootup
< 45 min after initial power on
> 45min after initial power on
Deployment Sequence
Fault before antenna deployment
Fault after antenna deployment
No Fault
Deployment Safe
Operater Command
Systems Checkout
checkout failed
Safe Mode (Entered if serious fault detected)
Exits to any state on operator command
Normal Operations
Low Power Mode
Batt > 10%
Batt < 5%
checkout passed
Charge Battery
Batt < 20%
Batt > 80%
In Range & Batt > 20%
Batt < 10%
Science
In Range
Comm Pass
Out of Range & Batt > 20%
End of Life
De-Orbit within 25 years
All numbers are approximate values, and should be considered TBD

Physics/Payload

Detector Modeling

- Using GEANT/MEGALib
- Using solar and ionospheric histogram data to model the radiation sources and incorporating constraints of the detector



GEANT model of detector using solar histogram data

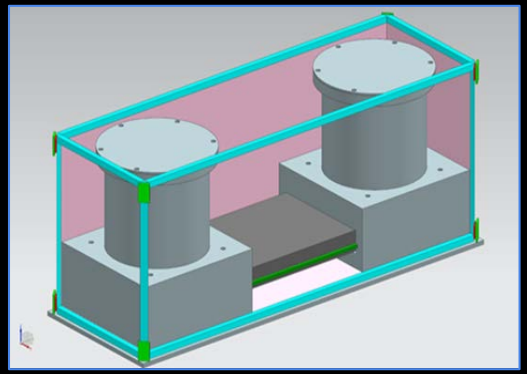
Radiation Environment Modeling

- Using SPENVIS/System Toolkit's SEET addon
- Produced radiation data tables for various orbital parameters
- Researched same hardware implemented on other CubeSat missions

Radiation testing in NMSU physics lab

Electromagnetic Interference Mitigation

- Designed workflow of round robin type testing
- Developed methodology for flatsat testing and assembled modes testing

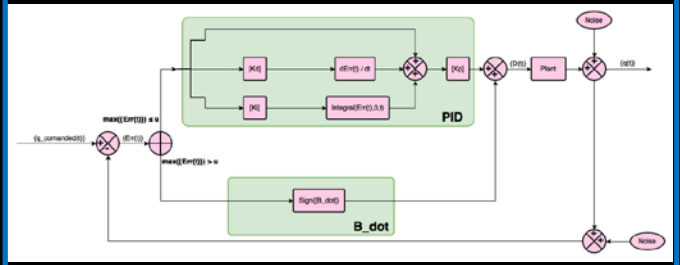


NX model of detector

Attitude and Determination Control

Simulation/Controller Design

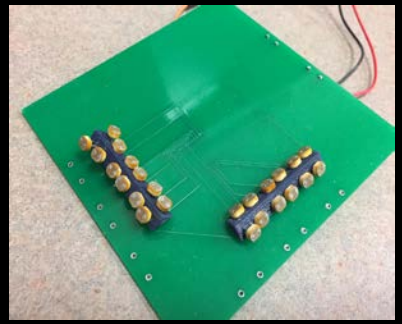
- Custom attitude simulation using MATLAB
- Implementing a Bdot bangbang controller and PID controller for during and after detumble state
- Using a Kalman filter for situational awareness



Controller design diagram

Custom Sun Sensor Design

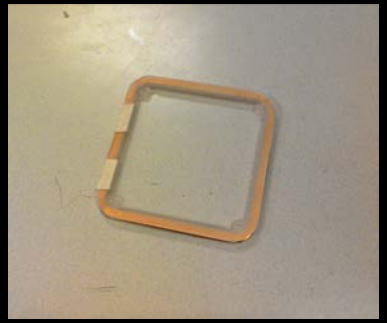
- Must be accurate to 2 degrees
- Includes 3D printed wedges and Wheatstone bridge to increase photodiode sensitivity
- Integrated temperature sensor for thermal monitoring



Custom sun sensor

ADC Hardware

- Manufactured custom 3D printed air core magnetorquer
- Using integrated rate gyros
- Using integrated magnetometers

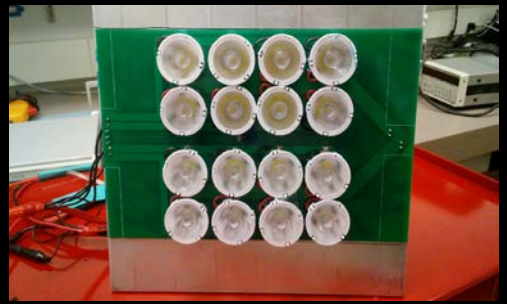


Manufactured air core magnetorquer

Electrical Power System

LED Solar Simulator

- 16 High Luminous Efficacy Cool White LEDs
- Designed for 29.1 V and 8.4 A where current is adjusted for proper solar simulation testing
- Heat sink designed and manufactured at NMSU



Led solar simulator

Battery Testing

- Two cell 37 Wh Polymer Lithium-ion battery pack
- Using Arduino Uno to obtain voltage and current data
- Planning for a stand alone test to determine various parameters

Single battery replica

Deployable Solar Panel Design

- Consists of 15 cells, 3 strings of 5 cells connected in parallel
- Designed for 2.75 V and 1.23 A
- Includes temperature sensor and nichrome wire configuration

Deployable solar panel test setup

Communication & Command and Data Handling

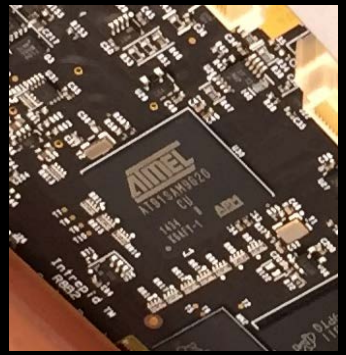
Uplink and Downlink Communication

- UHF Radio for command and telemetry
- UHF Radio running in the amateur bands
- Using Global Star beacon for basic status of satellite

Tyvak UHF radio

Main Control of Satellite

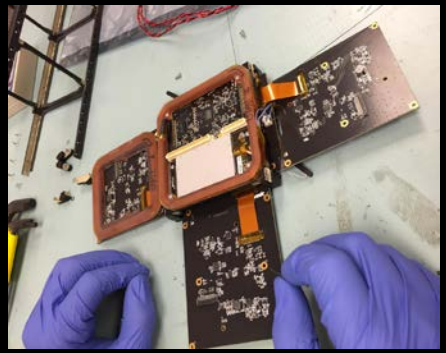
- Using Atmel ARM9 processor
- Embedded Linux allows large flexibility
- Low power - Operates at 300mW



Atmel ARM9 processor

Tyvak System

- Fully integrated with ARM processor
- Integrated sensors for avionics bus
- Control over all systems from main processor

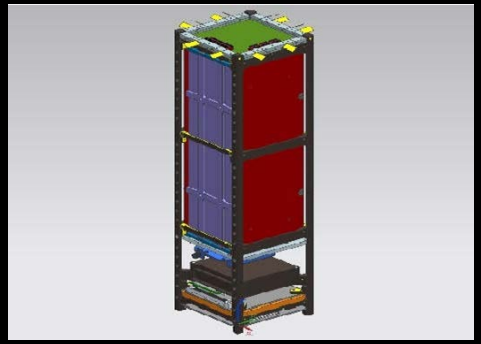


Full Tyvak system

Structures

Mitigation of Failure

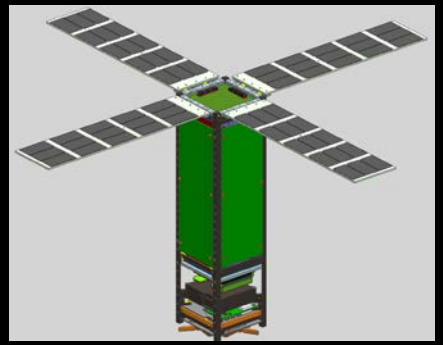
- Implemented a modified BostonU research design for a spring solar panel hinge design
- Adjusted model component spacing and mitigated heat issues
- Will add rubber damping to compensate for failures shown after running software and physical vibrations testing



NX model of structure excluding solar panels

Physical Design Requirements

- Designed rails for detector and “clips” for side solar panels for secure attachment
- Implementation of a deployable solar panel system that fits in case for launch



NX model of complete structure

Manufacturing

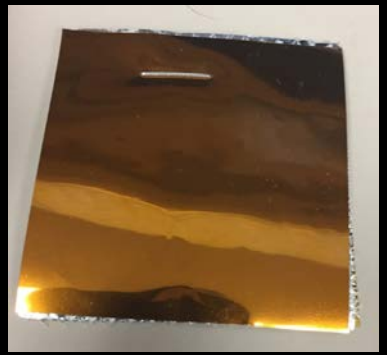
- 3D printed prototype components for design and fit checks
- Detector case / other small solid metal components manufactured at NMSU
- Epoxy, metal plating, general materials, and electronics are ordered as parts and assembled by hand

3D printed hinge model design test

Thermal

Thermal Protection

- Will use Mylar in order to reflect radiation
- Will be adding a nichrome solar shield for shielding of the sun's radiation



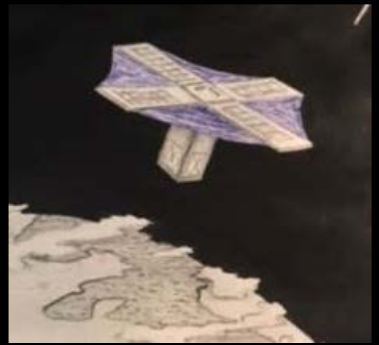
Sample of Mylar material

Thermal Model

- In depth mathematical model produced using MATLAB
- Thermal modeling consists of modeling the body, deployable solar panels and payload at an ideal orbit
- Have an approximate that the body will reach 50°C, deployable solar panels 40°C and payload 30°C

Thermal Testing

- Plan to place satellite in a vacuum chamber where it will cycle through to maximum and minimum temperatures
- Plan to record the functionality of the satellite at the maximum and minimum temperatures and after overall testing
- Planning to test through Air Force Research Lab



Nichrome solar shield concept

NM STATE UNIVERSITY

Questions?