



# **Sandia National Labs**

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## **Summer Internship Summary**

### **Project Lab V**

**July 23, 2012**

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Organization 5513  
Student Intern**

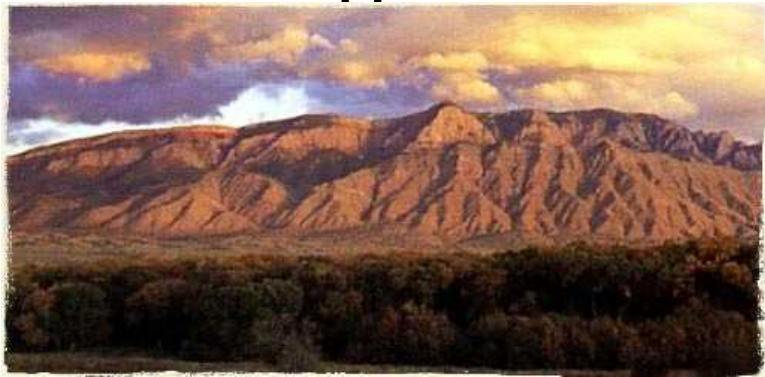
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,  
for the United States Department of Energy's National Nuclear Security Administration  
under contract DE-AC04-94AL85000.



# Sandia Overview

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- **Located in Albuquerque, NM on the Kirtland Air Force Base.**
- **Sandia National Labs is one of the DOE's National Nuclear Security Administration laboratories and is an entity known as a Federally Funded Research and Development Center (FFRDC)**
- **Was created in 1945 out the nuclear weapons work in Los Alamos.**
- **Vision - "On behalf of our nation, we anticipate and solve the most challenging problems that threaten security in the 21<sup>st</sup> century"**
- **Sandia performs broad research spanning applied to theoretical, but traditionally is known as an engineering laboratory that delivers applied R&D solutions.**





# Decision Support Systems (DSS)

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- **DSS is a group at Sandia that develops first-of-a-kind tasking, collection, processing, exploitation, and dissemination systems for non-proliferation and national security missions.**
- **DSS is made up of eight different departments and 100+ staff at Sandia.**



# Department 5513 – Tasking, Planning, Mission Management

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- **CPS – Command and Pointing Subsystem.**
- **As a software team within DSS, CPS work includes:**
  - **Commanding**
  - **State of Health**
  - **Tasking and Planning**
  - **Forward Pointing**
  - **Geolocation**
  - **Station Keeping**
  - **Analysis**

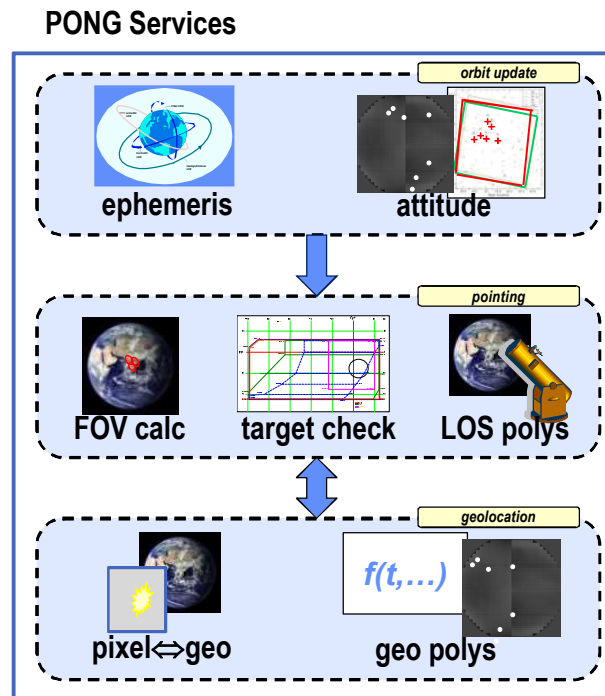


**CPS**

*Point at the Right Place at the Right  
Time with the Right Configuration  
to Collect Useful Data!*

# Department 5513 - PONG

- Subgroup within CPS.
- PONG – Pointing, Orbitology, Navigation and Geolocation.





# Technical Tools and Software

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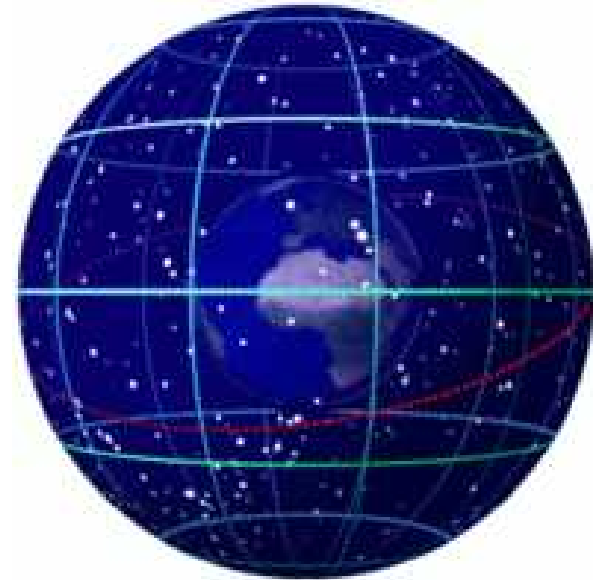
- **Unix**
- **F-Secure** – used for secure remote login.
- **Perl**
- **XML** – used to run the command and store OSIM data
- **C++**
- **EMACS** – text editor
- **OSIM** – Orbitology simulator
- **CVS** – concurrent versioning system
- **Pointing Server**
- **pmake**
- **CORBA**
- **dbx**



# Underlying Satellite Theory

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- **The celestial sphere**
- **Defining a coordinate system is an important first step to celestial geometry**
- **Celestial coordinate systems consists of a sphere surrounding a point of origin**





# Underlying Satellite Theory

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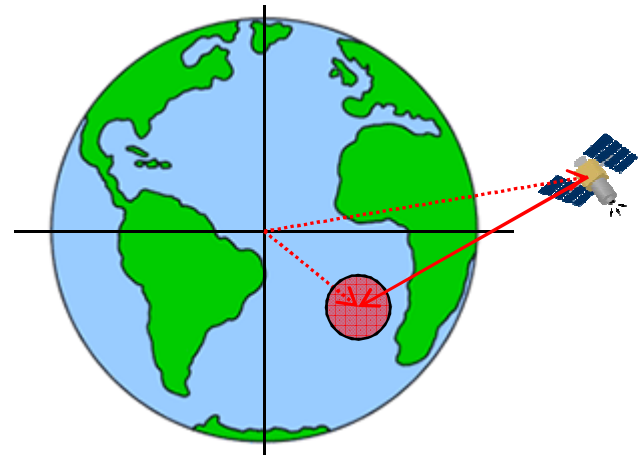
- **Different Coordinate Systems include:**

Coordinate System	Azimuth Coordinate	Elevation Coordinate	Applications	Typical Origin
Celestial Coordinates	Right Ascension	Declination	Inertial measurements, astronomy	The observer
Earth-Fixed	Longitude	Latitude	Earth applications	Earth center
Spacecraft-Fixed	Azimuth	Elevation	Spacecraft measurements, attitude analysis	Reference mark on spacecraft
Local Horizontal	Azimuth	Elevation	Directions relative to central observer	The observer
Ecliptic Coordinates	Celestial longitude	Celestial latitude	Planetary motion	The Sun

# Pointing Polynomials

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- **Time-varying Vectors (High Order Polynomials)**
- **Polynomial Generation.**
- **Factors to Consider:**
  - **Ephemeris and Attitude**
  - **Rotation of the Earth**
  - **Orbit of the Satellite**
  - **Visibility of Target**
  - **Position of the Sun**
  - **Glint from the Sun**
  - **Limits of Sensor Motion**
  - **Look Angle**





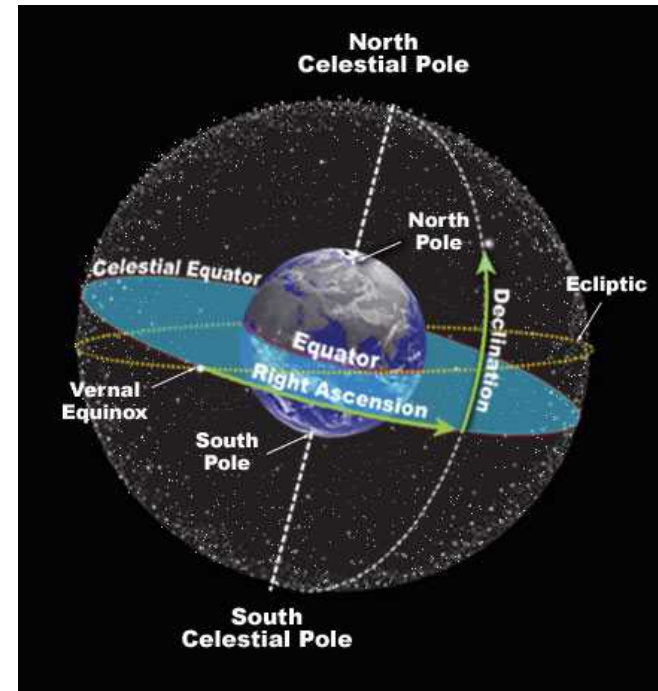
# Types of Targets

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- **Right Ascension/Declination (Ra/Dec) Direction Targets – mostly stars**
- **Earth Targets**
- **Azimuth/Elevation (Az/EI) Targets – point within field of regard**
- **Stow, Unstow, Safe Passage**

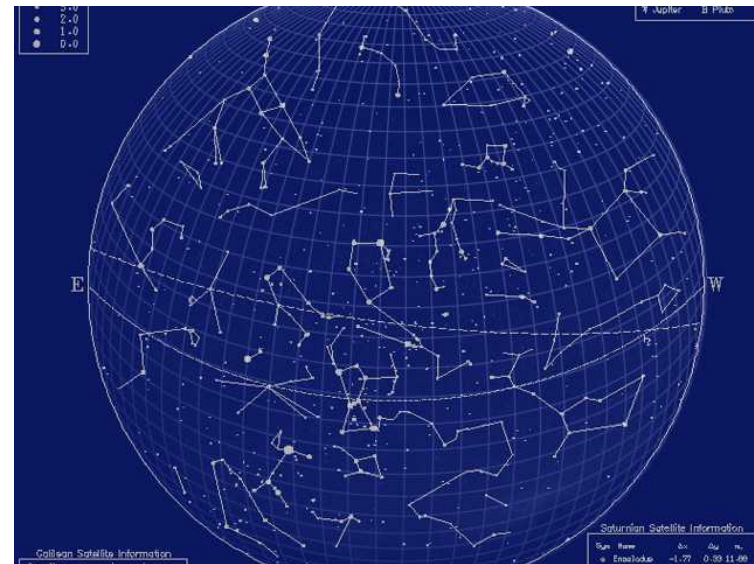
# Direction Targets

- **Direction** – a single Ra/Dec
- **Star** – Ra/Dec of a star
- **Cluster** – Ra/Dec of a group of stars
- **Dark Space** – Ra/Dec of an absence of stars
- **Nav Star** – finds two stars useful for navigation



# Direction Targets

- **N Star** – N stars spaced evenly around the Earth. First star selected randomly.
- **Cal Star** – Ra/Dec of randomly selected star that meets certain spectral requirements
- **Direction Pixel Move** – Ra/Dec traced by a row or column of pixels
- **Direction Spiral** – a spiral out determined by a radial angle and angle of revolution
  - A second direction spiral was tested with a sharper spiral. This is modeled by breaking the spiral up into two different polynomials.





# Earth Targets

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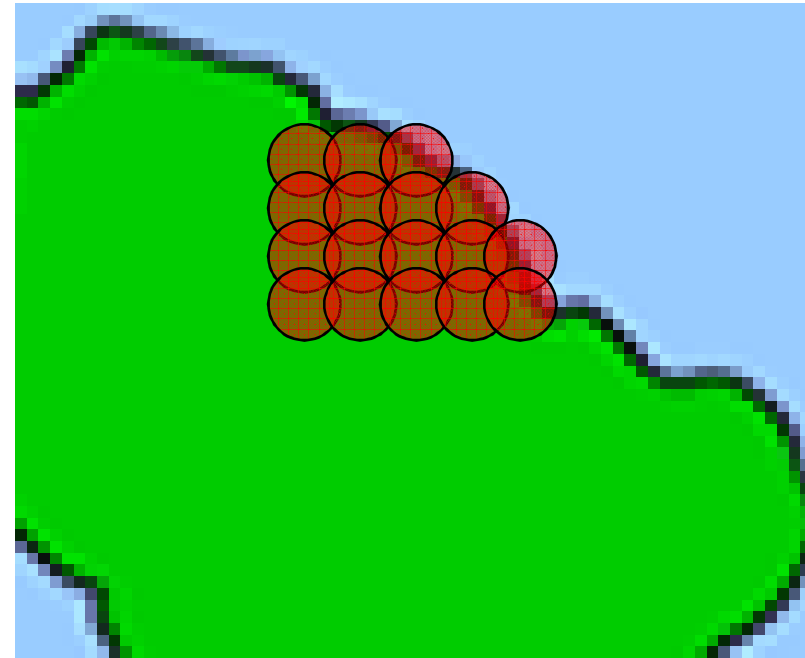
- **Earth – stares at a Lat/Long**
- **Near Earth – stares at an altitude above a Lat/Long**
- **Earth Pixel Move – drags a row or column of pixels across a specific Lat/Long**



# Earth Targets

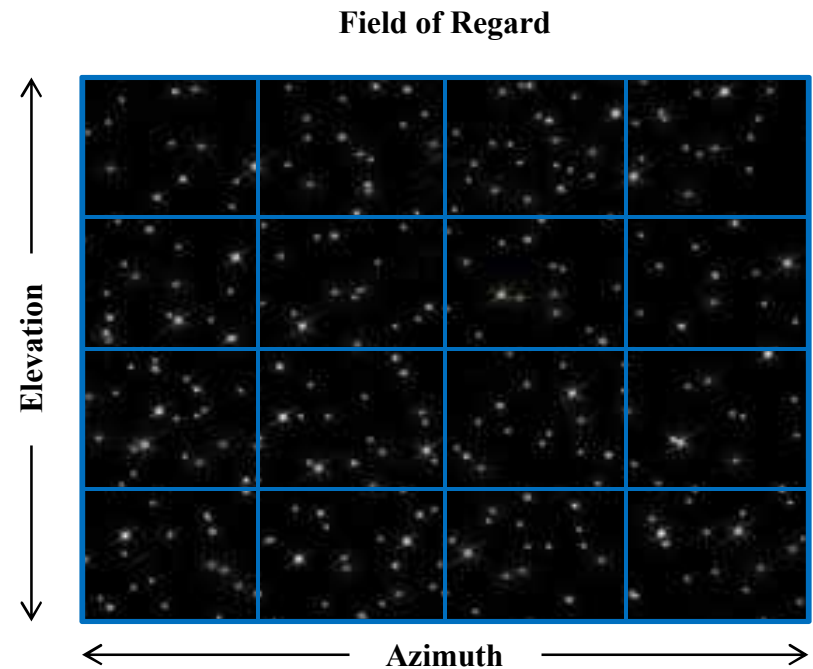
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- **Mosaic Circle** – patterns a series of boresights in a circle.
- **Mosaic Polygon** – patterns a series of boresights across a number of vertices.
- **Step Stare** – cycles through several different target types.



# Az/EI Targets

- **Az/EI Direction** – sensor stares at a specific Az/EI
- **Az/EI Move** – spans across a row or column across a specific Az/EI





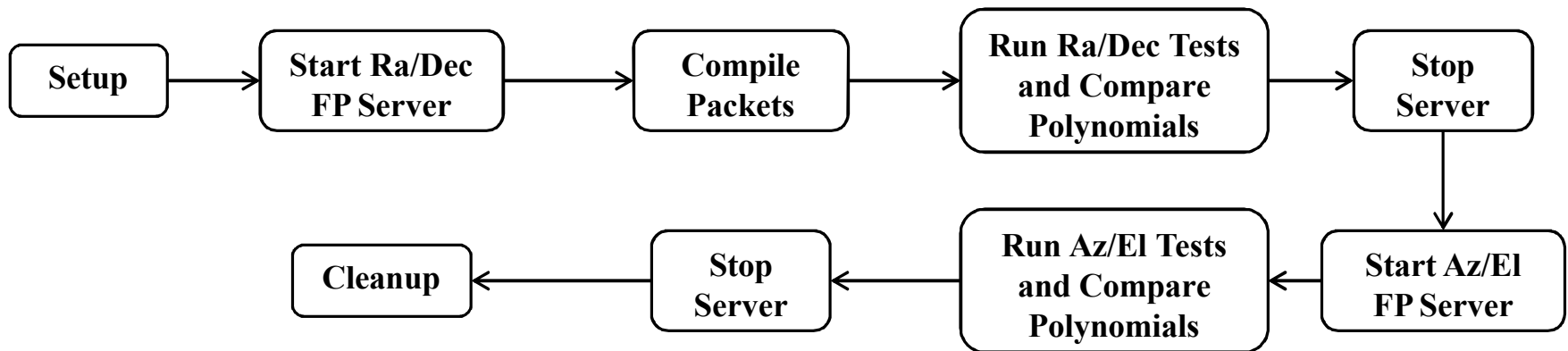
# **Stow, Unstow and Safe Passage Target Types**

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- **Stow** – stores the sensors to prevent solar damage.
- **Safe Unstow** – brings the sensor out of stow to a safe location
- **Safe Passage:**
  - Stowing the sensor is expensive and associated with certain risks.
  - Safe Passage moves the sensor through a solar outage in predetermined path.

# The Test Harness

- The test harness runs all the different target types to ensure and checks that all the polynomials are generate correctly.
- If changes are made, the test harness can check that all target types are still working correctly.





# Project Description

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- **The Test Harness is designed to verify and validate pointing polynomials generated for all the different target types.**
- **Over time, the Test Harness has fallen into disrepair.**
- **This summer, my job was to debug and refactor the current test harness to meet testing requirements and provide a more stable platform for future development.**



# Setup

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- **First, the test harness runs all the setup procedures which:**
  - **Creates softlinks to the correct ephemeris files.**
  - **Creates softlinks to the zeroed out earth model**
  - **Creates files to predetermine the selected cal\_star, n\_star, darkspace and nav\_star targets**
  - **Creates files that determine the users IRON and ORB\_PORT for the tester\_overrides.cfig**



# Starting the Forward Pointing Server

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- **Next, the test harness runs the Forward Pointing Server.**
- **The specified `tester_overrides.cfg` ensures Ra/Dec polynomial generation.**
- **A delay was added to allow the Server enough time boot up before the first test is run.**





# Compile Packets

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- **CompilePackets.xml** runs all the different target types and ensures that polynomials are generated and packets of these polynomials are compiled for all of the target types.





# Comparing the polynomials

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- **insertCoeffsVettingRaDec.xml runs all the target types.**
- **The generated polynomials are parsed into a specific file format.**
- **These polynomials are then compared to polynomials generated by OSIM at the same dates and times.**
- **The polynomials must match the ones generated in OSIM within a given maximum angular separation and average angular separation.**



# Az/EI polynomials

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- **Once all the Ra/Dec polynomials have been compared, the server is restarted for all the Az/EI targets.**
- **This time, the server uses a different `tester_overrides.cfg` which enables the generation of Az/EI polynomials.**





# Completion of the Test

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- **Once all the Az/EI tests have been run, the test harness shuts down the Pointing Server and performs all the clean up operations.**
- **Ceanup.xml removes all the temporary files generated in the setup stage.**





# Bugs Encountered

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- **Simple problems:**
  - “dark\_space” vs “dark space”
  - compareTesterOutput.pl
  - hard\_az\_el to az\_el\_move
  - Direction Spiral – higher degree polynomials
- **More complicated problems:**
  - Problems with the environment
  - Long tests – off by 360 degrees
  - Direction Spiral – ending at start point
  - Az\_El earth – getting kicked out of the test



# The Final Product

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- **All the tests run within the test suite.**
- **All relevant tests pass.**
  - **Except for Az/EI Earth targets which are only used for testing purposes.**



# Questions?