

Lunar Satellite Attitude Determination System



**SENIOR DESIGN
PROPOSAL PRESENTATION**

TEAM EPOCH

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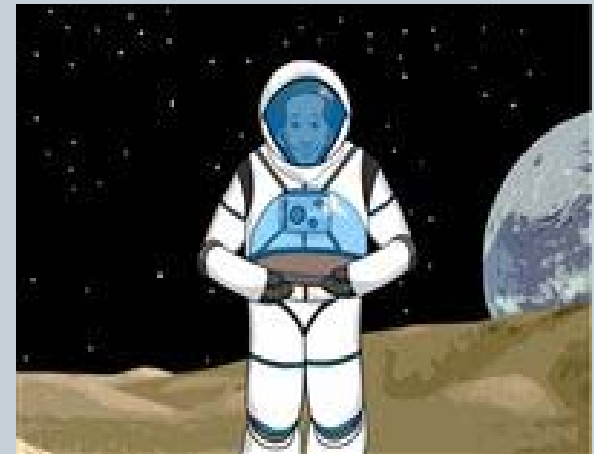
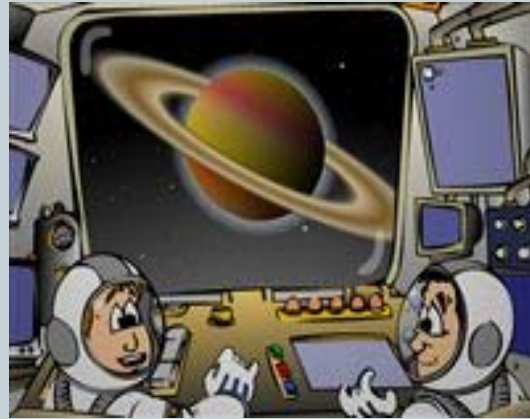
WARREN, DANA (PROJECT MANAGER)

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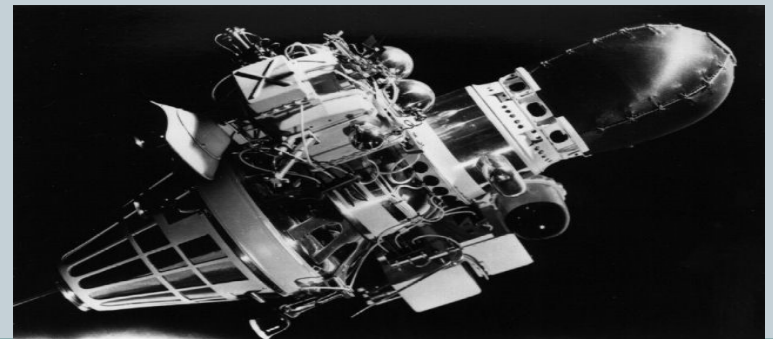
Background: Lunar Satellites



Manned (Orbital and suborbital) & Unmanned (Earth Orbit and Lunar Orbit)

Lunar Satellites include:

- [Clementine](#)—US Navy mission, orbited Moon, detected hydrogen at the poles
- [Luna 1](#)—first lunar flyby
- [Luna 2](#)—first lunar impact
- [Luna 3](#)—first images of lunar far side
- [Luna 9](#)—first soft landing on the Moon
- [Luna 10](#)—first lunar orbiter
- [Luna 16](#)—first unmanned lunar sample retrieval
- [Lunar Orbiter](#)—very successful series of lunar mapping spacecraft
- [Lunar Prospector](#)—confirmed detection of hydrogen at the lunar poles
- [SMART-1](#) ESA—Lunar Impact
- [Surveyor](#)—first USA soft lander
- [Chandrayaan 1](#) —first Indian Lunar mission



Background: Attitude Determination

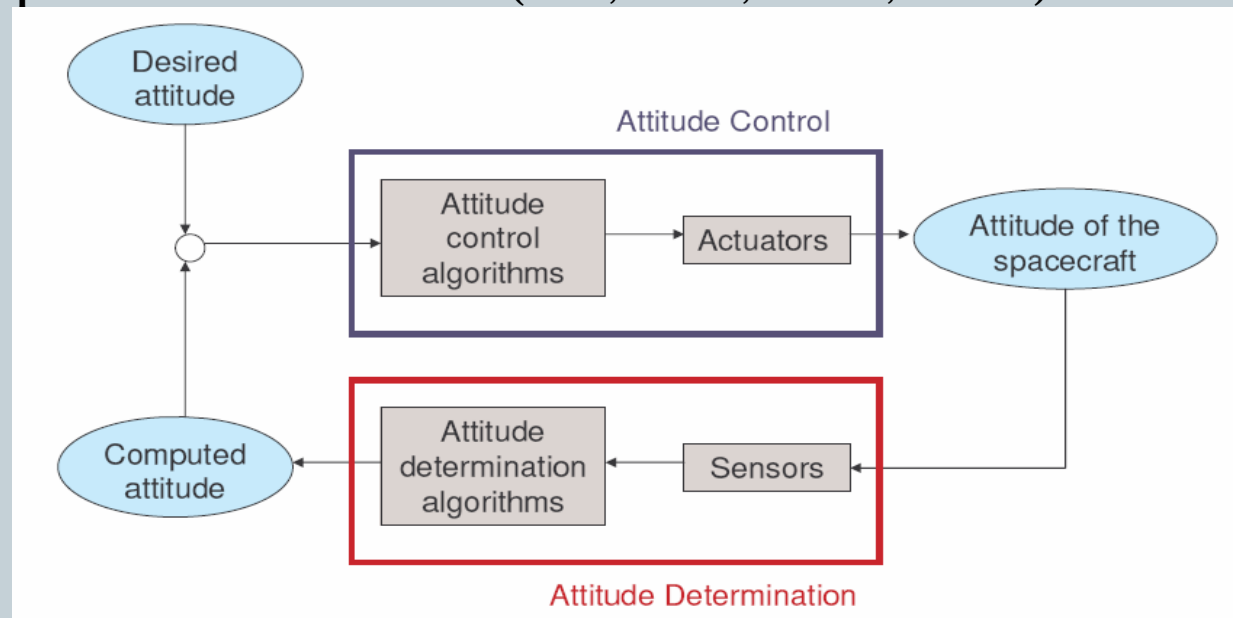


- **Spacecraft:** A vehicle intended to be launched into space.
- **Attitude:** Orientation in space or transformation between a body frame and a reference frame.
- **Attitude determination:** Computing the spacecraft attitude from optical sensor measurements and ephemeris information. (Sun, Stars, Earth, Moon)

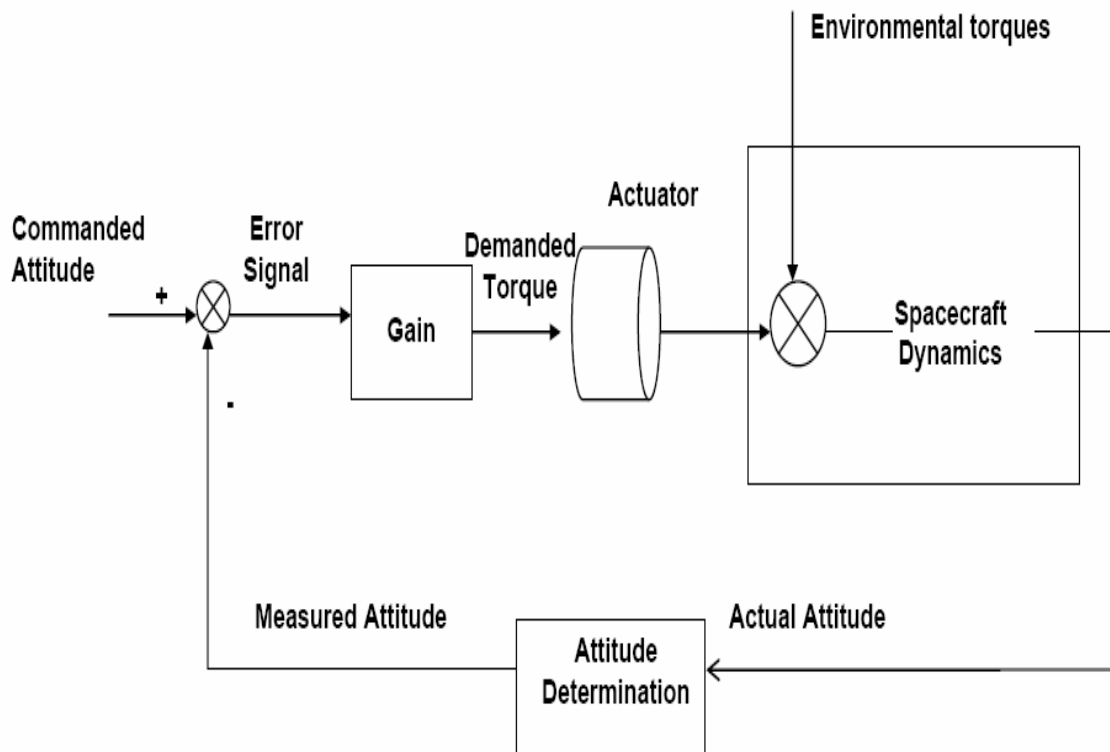
WHY?

Torques (Disturbance)

- Gravity gradient
- Solar radiation
- Atmospheric drag
- Magnetic torque
- Internal Forces



Background: Systems



Closed loop (actuators controlled on board), **Active** (uses electricity or propellant).

Problem Formulation



- Customer wants to fly a simple, low- cost spacecraft near the Moon.
- A simple system to determine the attitude is needed.
- Design system, Build prototype, **Test prototype on Ground.**
- No magnetic field or GPS.
- Sun and/or Moon observations (not simultaneous)
- Coarse degree of accuracy needed
- Onboard Processing (real mission), External computer Processing (prototype).

Current Status of Art



-Deterministic Method

- Measurements of two vectors in body frame
- Know these vectors in the reference frame
- Ephemeris, calculations (need to know position in orbit)
- Find the rotation matrix, i.e. the attitude

-Estimation Method

- Measurements of one vector in body frame
- Recursive process
- State estimation
- Facilitated by gyros measurements

-Example

LRO- Lunar Reconnaissance Orbiter



Current Status of Art



Current Systems' main focus (Advantage)

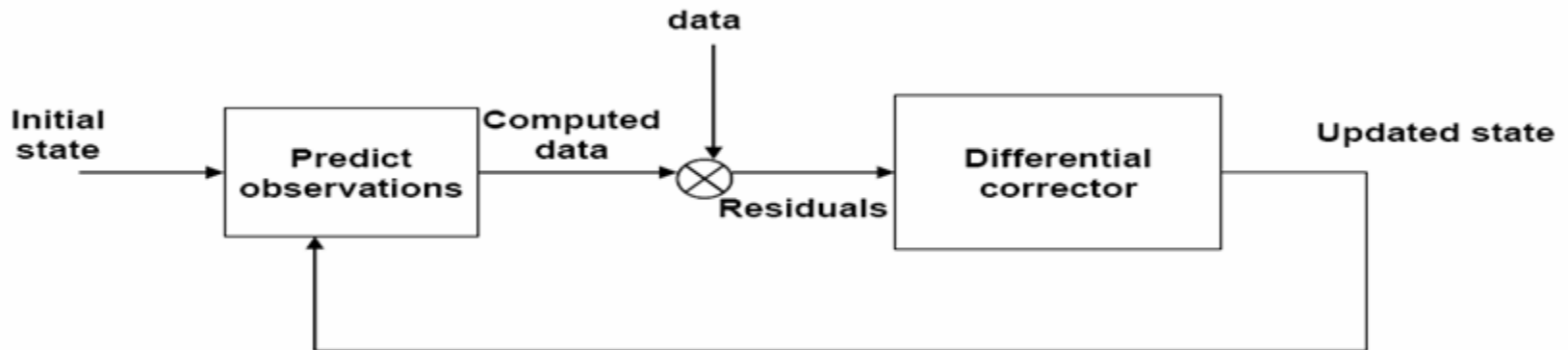
- Null rotation rates to prevent data corruption

Achieved by

- Rate Sensors
- Sun Sensors
- Occasional Star tracker usage
- Reaction Wheels

Disadvantage

Sequential Estimation (Iterative), Required Algorithm (Complex)

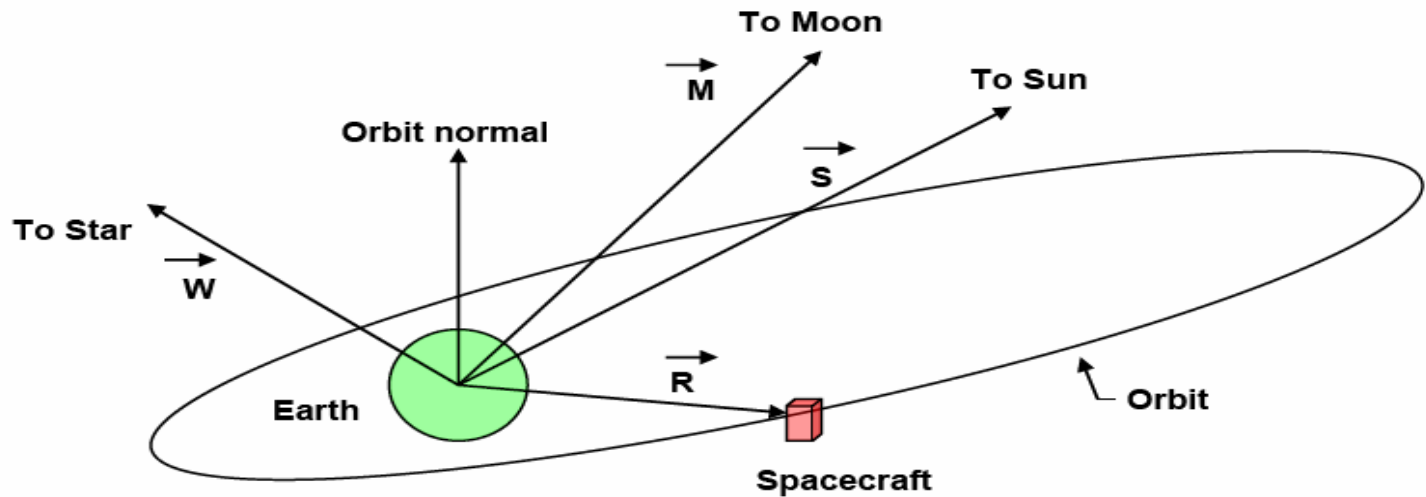


Solution Approach



Impractical to use a real satellite. Hence the following:

- Earth Rotation (orbital motion)
- Servos or stepper motors (attitude motion)
- Box mounted on a tripod with a simple Sun or Moon optical sensor
- Control loop driving a servo to track the Sun or Moon.



Attitude Representation



Representation of attitude

- Frame of reference
 - Inertial frame
 - Orbit frame

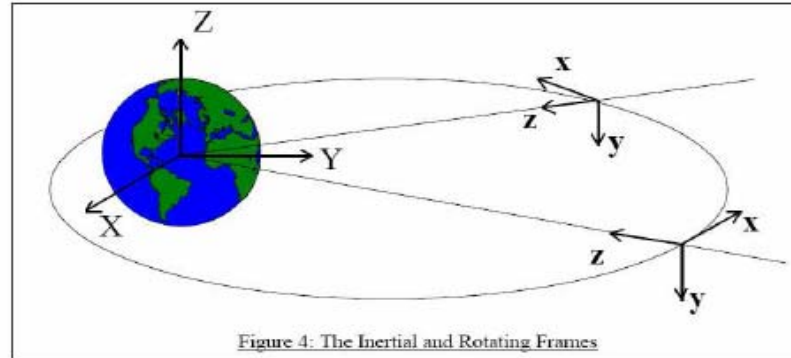
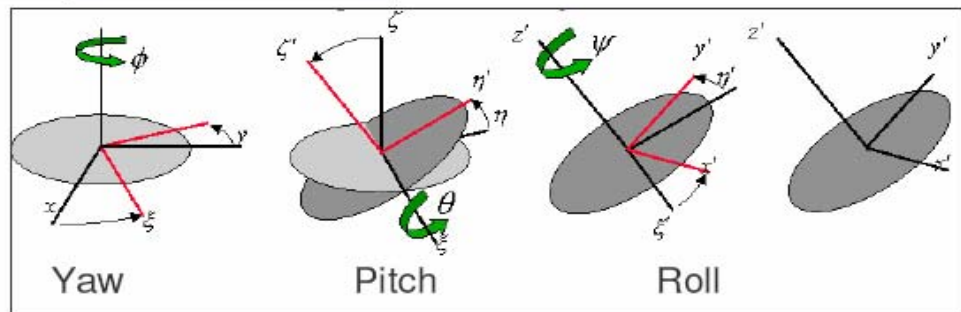
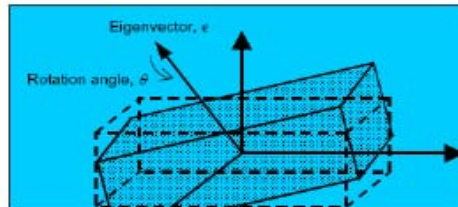


Figure 4: The Inertial and Rotating Frames

- Give orientation with respect to that frame
 - Euler Angles
 - Quaternion

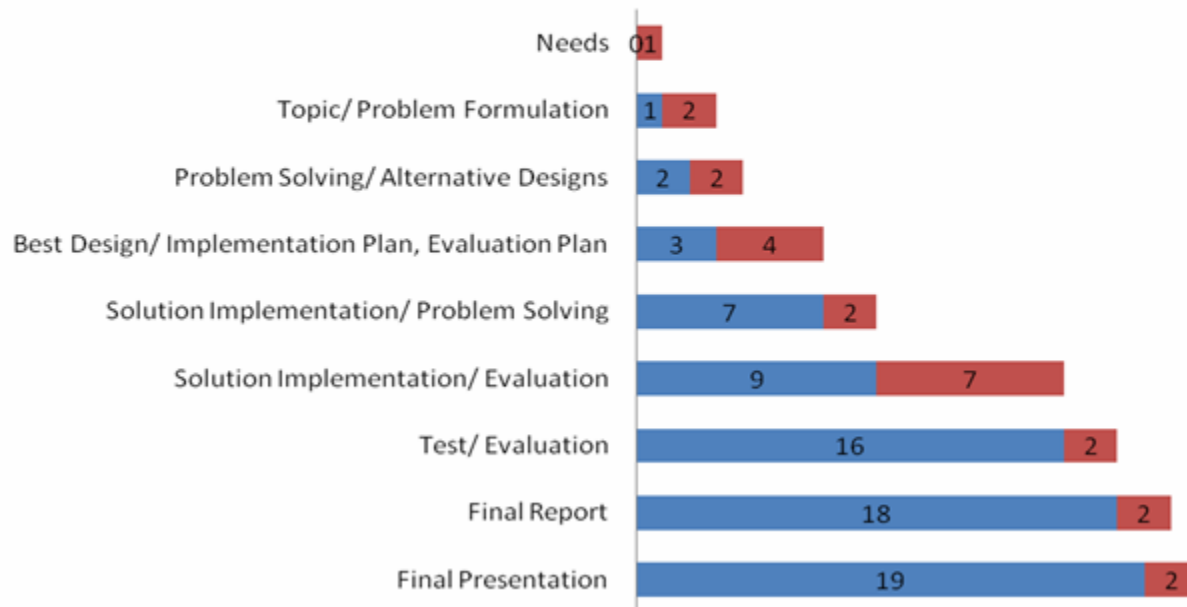


Tasks



LUNASAT Timeline

■ Start ■ Duration



Project Management



Danah – Project Manager.

- Checks up on individual tasks
 - Enforce timelines
- Keeps track of meeting minutes
- Makes sure that all individual assignments are combined together appropriately.

Oluwayemisi – Lead Researcher.

- Research problem and constraints
 - Implement solution



Tolulope– Lead Developer.

- Simulation
- Code writing

Verification Plan and Deliverables



- **Lunar Satellite Attitude Determination System**
 - Input: Optical Sensors
 - Control Unit: Computer
 - Output: Visual

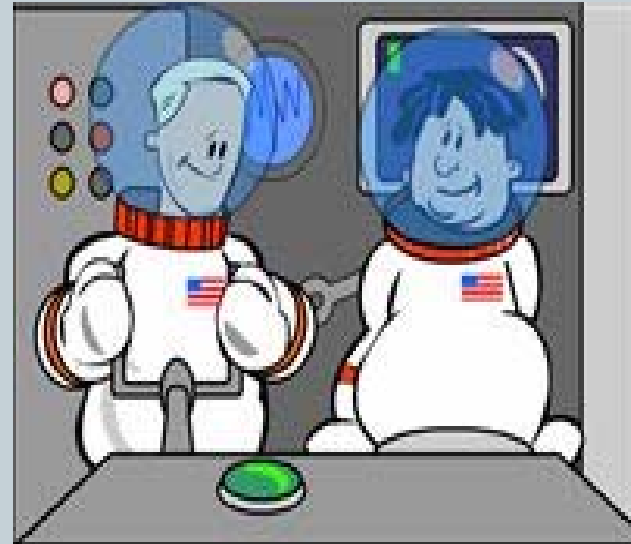
- **Demonstration Environment**
 - Gravity
 - Random Torques



Cost and Resources



- Total Cost < \$1000
- Sensors
- Computer
- Box (Container)
- Less than 10 watts of power.



Conclusion



- Attitude determination and control = key component of satellite inspection and orbital rendezvous missions
- Simple Attitude determination System is needed.
- Prototype would be tested on ground
- Prototype would make use of Optical Sensors
- Finish Date: March 2010

Questions

