Lunar Satellite Attitude Determination System

SENIOR DESIGN
PROPOSAL PRESENTATION

TEAM EPOCH
KUPOLUYI, TOLULOPE (LEAD DEVELOPER)
SONOIKI, OLUWAYEMISI (LEAD RESEARCHER)
WARREN, DANAH (PROJECT MANAGER)

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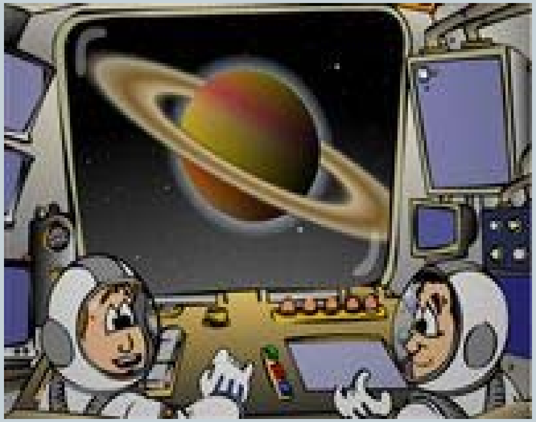
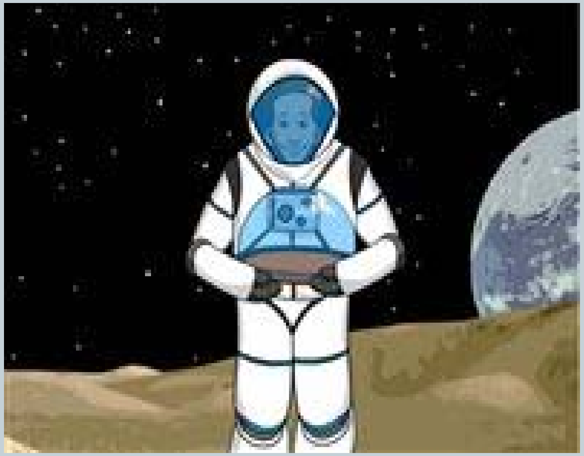




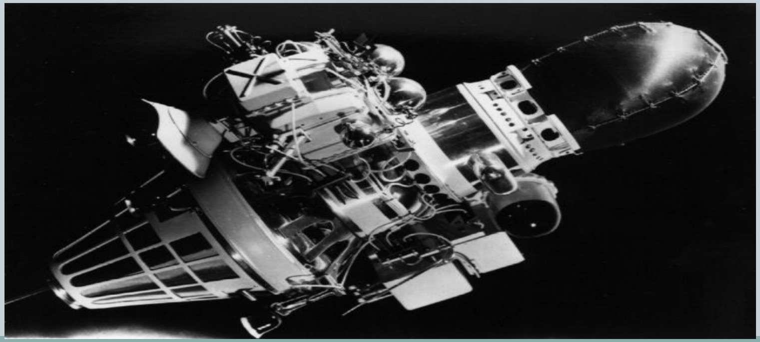
Background: Lunar Satellites

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



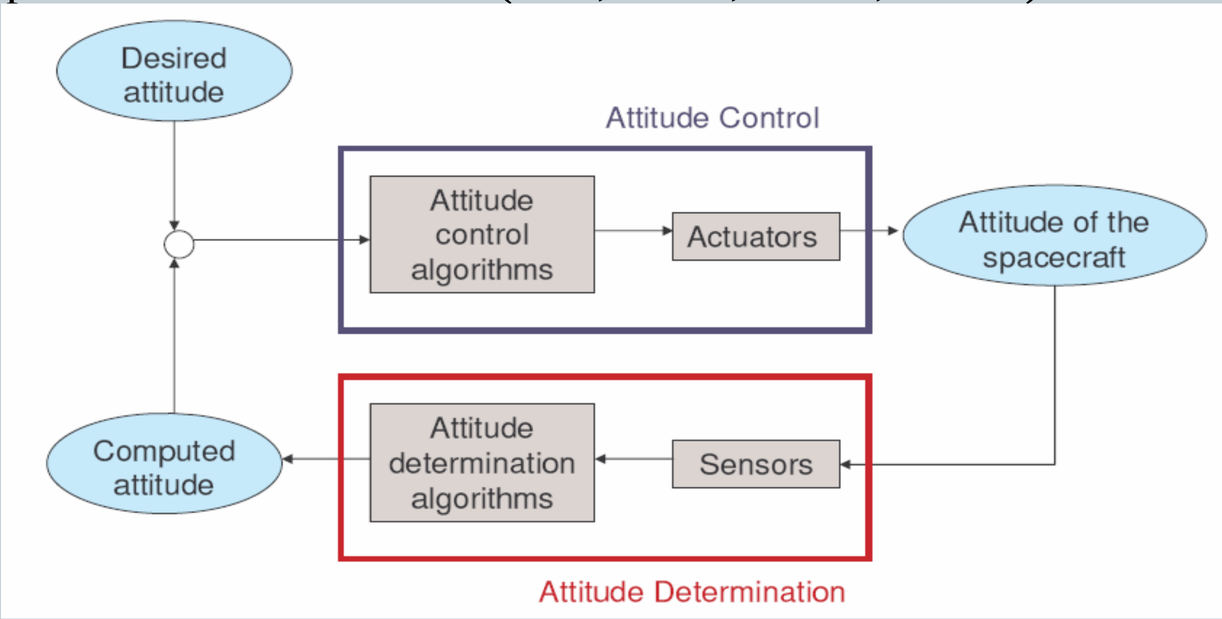
Background: Attitude Determination

- 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)

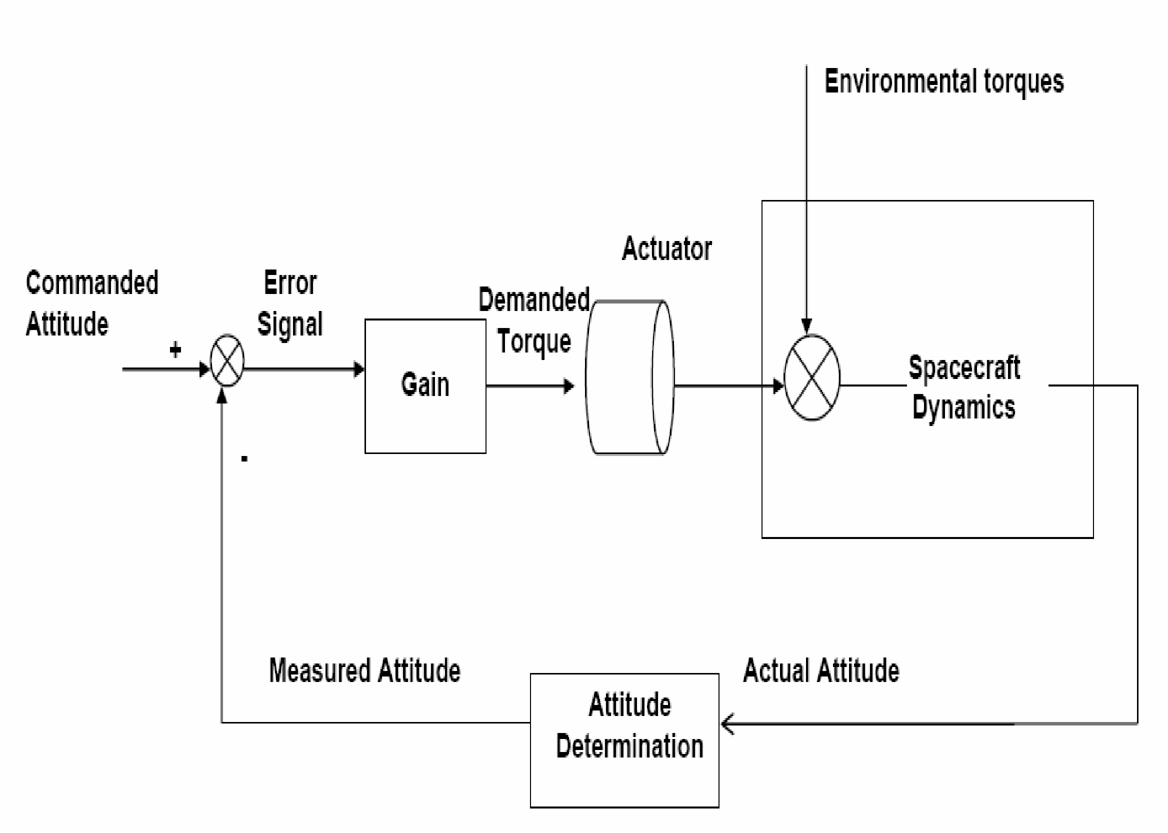
WHY ?

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

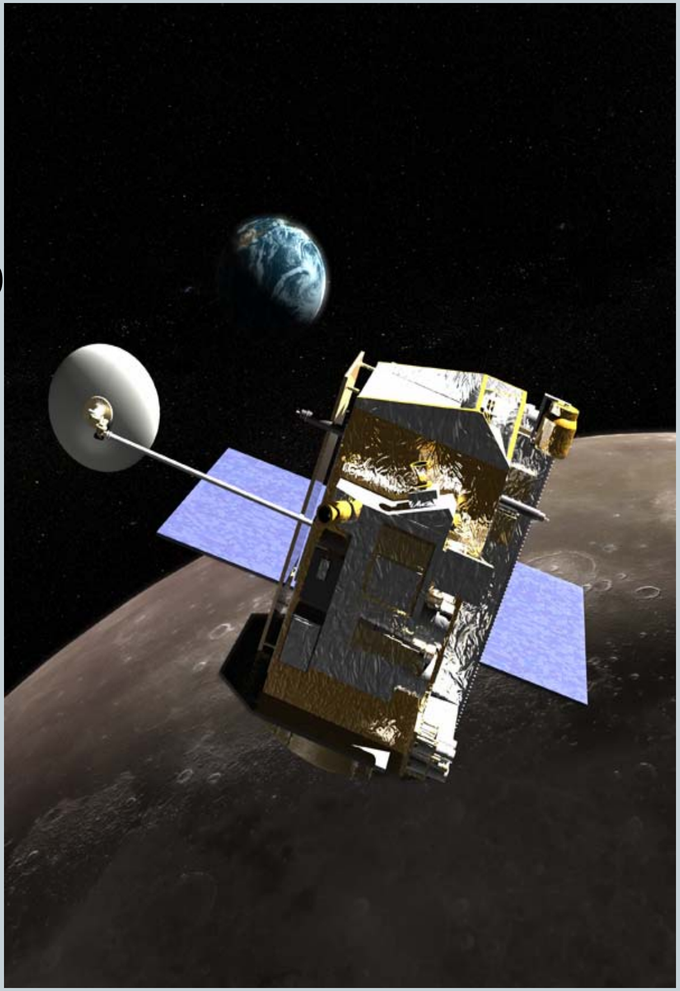
- Measurements of two vectors in body frame
- Know these vectors in the reference frame
- Ephemeris, calculations (need to know position in orbit)
- Find the rotation matrix, i.e. the attitude

-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)

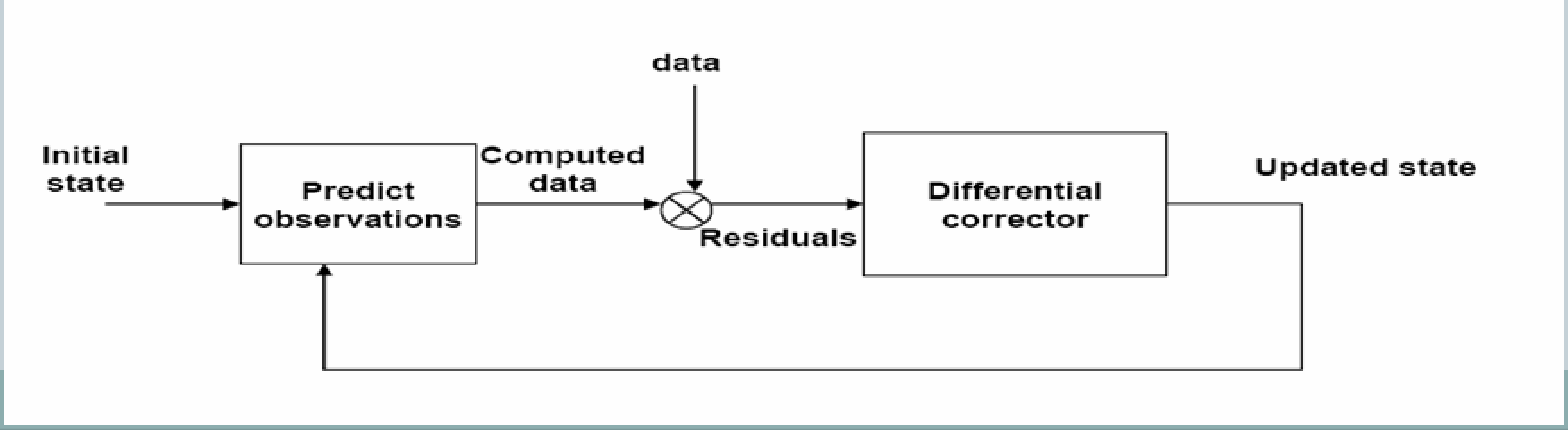
- Null rotation rates to prevent data corruption

Achieved by

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

Disadvantage

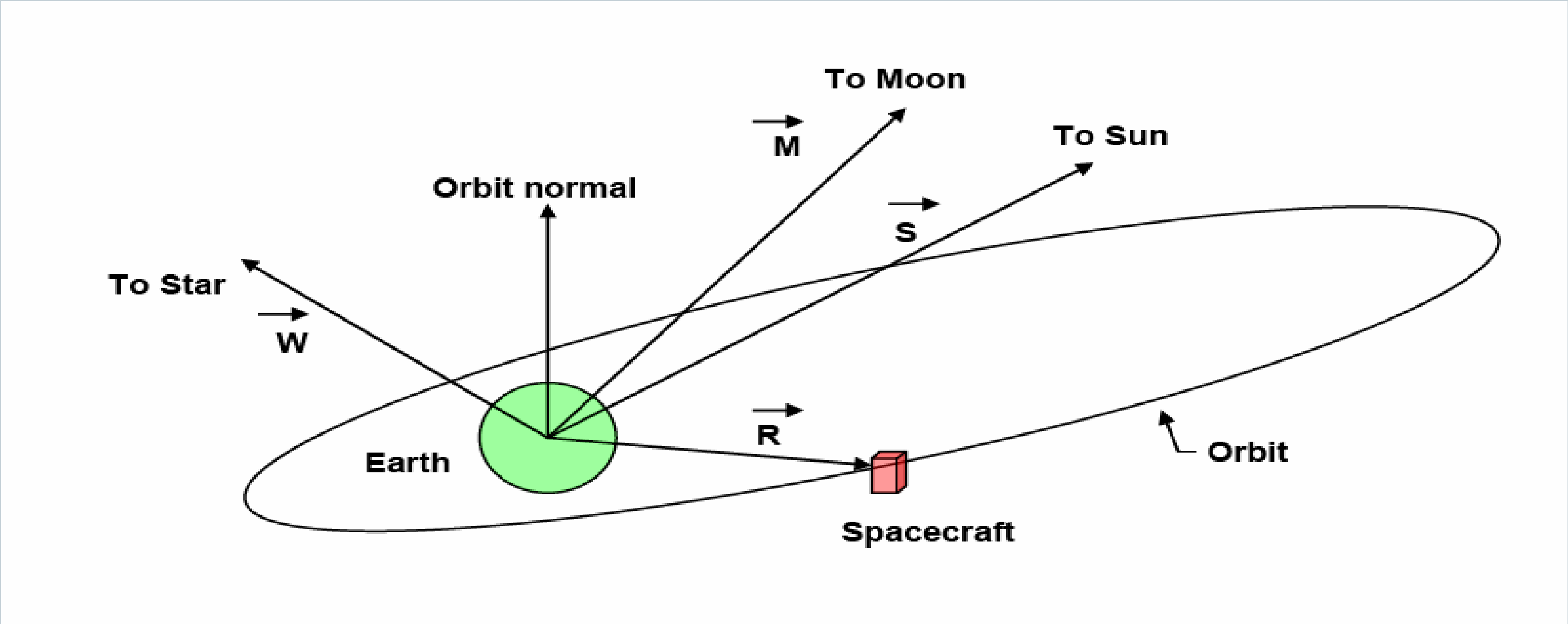
Sequential Estimation (Iterative), Required Algorithm (Complex)



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

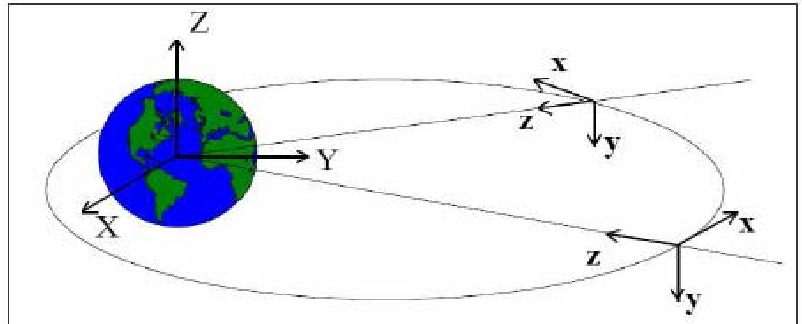
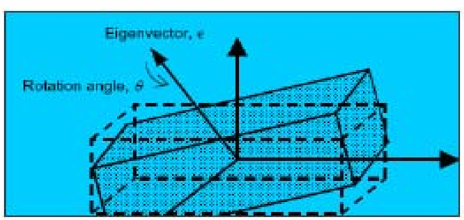
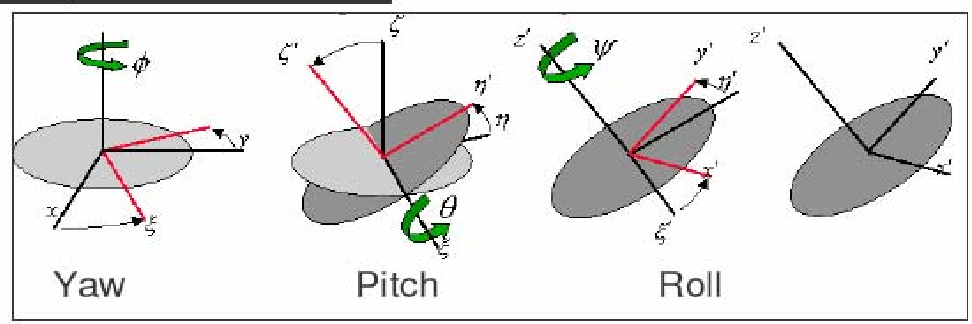


Figure 4: The Inertial and Rotating Frames

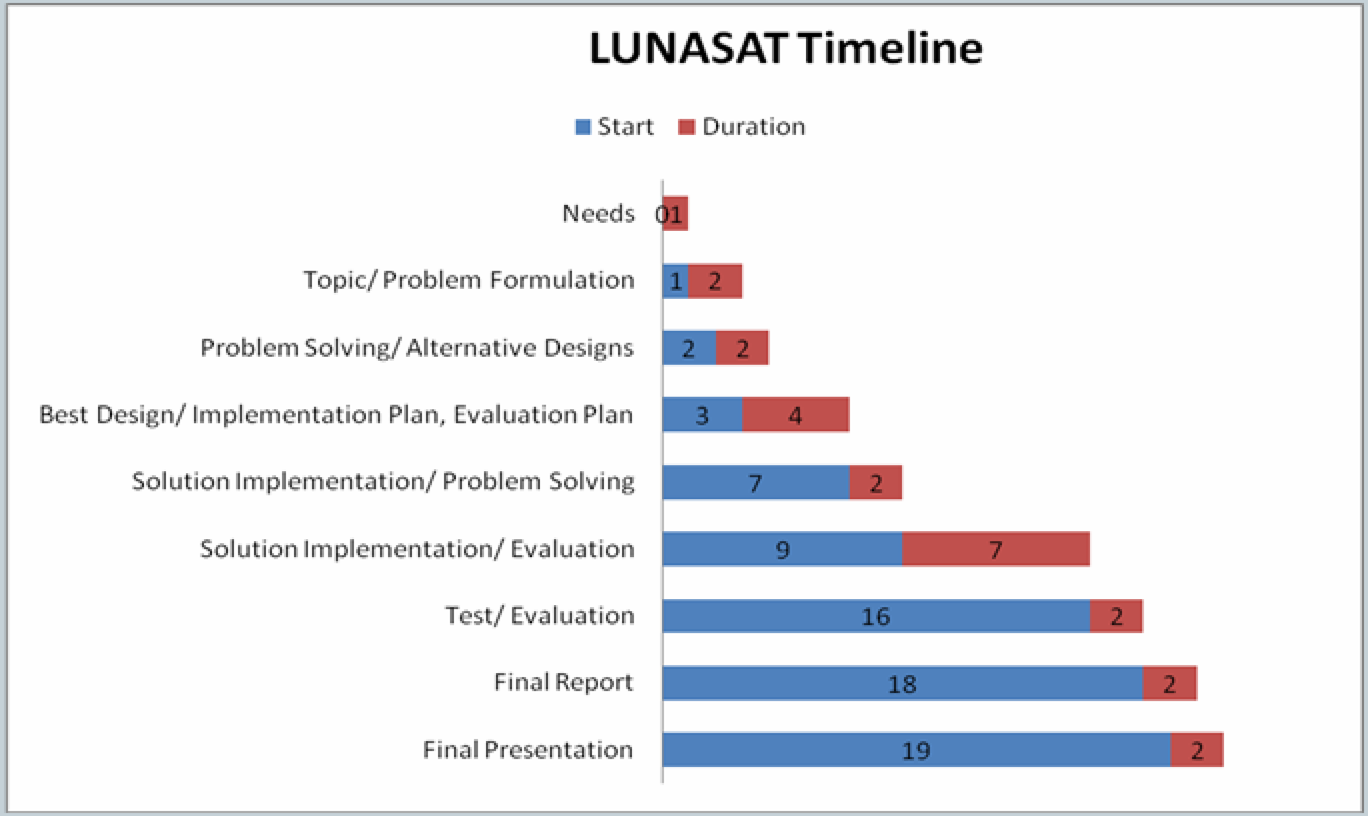
- Give orientation with respect to that frame
  - Euler Angles
  - Quaternion





http://ssdl.stanford.edu/ssdl/images/stories/AA236/A06Fall/Lectures/lecture-16.pdf

Tasks

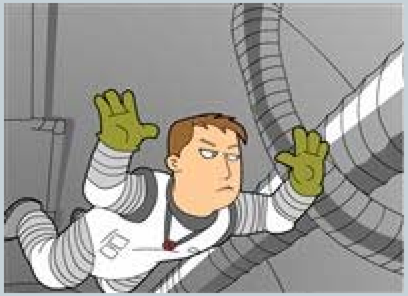


LUNASAT Timeline
Start
Duration
Needs
0
1
Topic/ Problem Formulation
1
2
Problem Solving/ Alternative Designs
2
2
Best Design/ Implementation Plan, Evaluation Plan
3
4
Solution Implementation/ Problem Solving
7
2
Solution Implementation/ Evaluation
9
7
Test/ Evaluation
16
2
Final Report
18
2
Final Presentation
19
2

Project Management

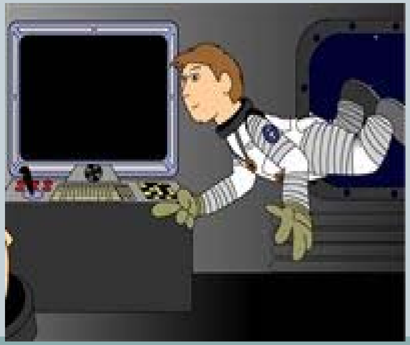
Danah – Project Manager.

- 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

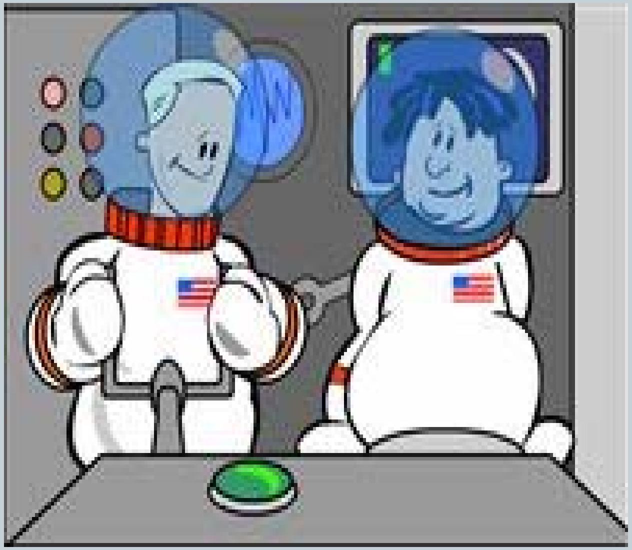
- **Demonstration Environment**

  -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

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