Stellar Gyro
An Innovative New Approach to Achieving High Pointing Accuracy in Eclipse

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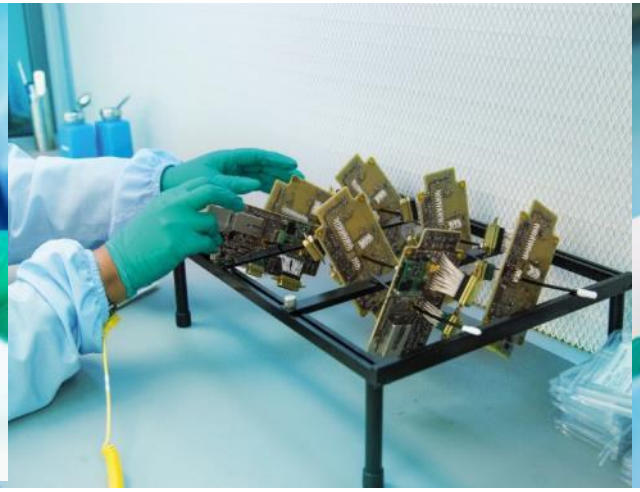
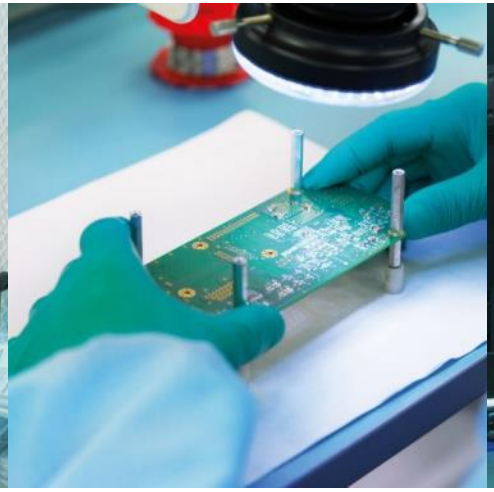
Presentation at UN BSTI Conference
12 December 2017

AGENDA

1. *Company Profile*
2. *Problem Statement*
3. *Stellar Gyro: Concept*
4. *System Benefits*
5. *Simulation & Test Results*
6. *ACS System-on-a-Board*
7. *Road map (way forward)*

COMPANY : NewSpace Systems

- NewSpace Systems is a South Africa, privately owned advanced manufacturer of **high-quality space components and subsystems.**
- Facilities in Somerset West, South Africa and the United Kingdom.
- Focus on excelling in the small satellite market, with particular emphasis on the constellation market.
- Products developed and manufactured in accordance with ESA standards to ensure quality and competitiveness on a global scale ISO9001:2015 accredited


PROJECT : Problem Statement

Addresses the problem of a ***high-quality attitude estimate*** throughout orbit, including ***during eclipse***.

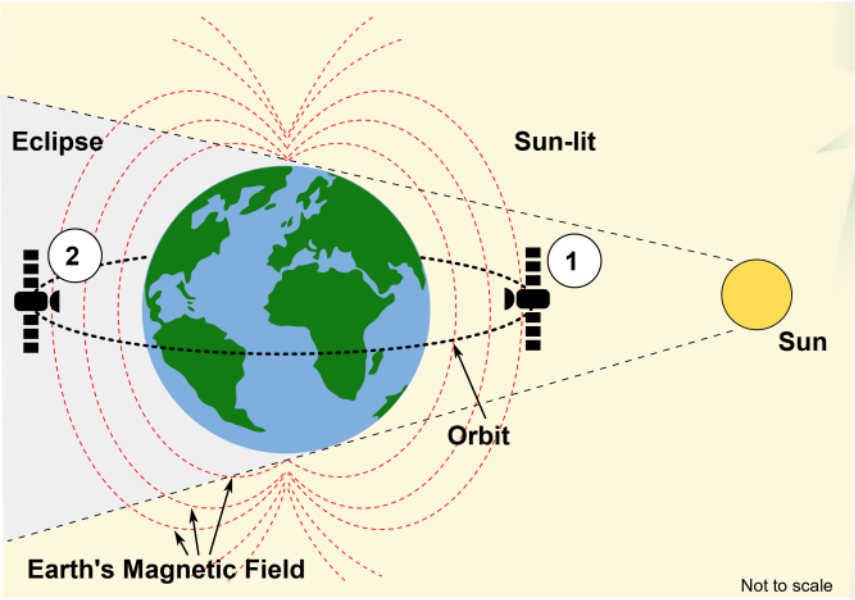
Problem during Eclipse:

- No sun-vector measurement. Often magnetometer only.
- Attitude knowledge obtained by propagating rate information from the rate gyroscopes ***at the cost of drift***.
- The stellar gyroscope solution, effectively eliminates drift.

Current Alternatives:

- Star Tracker
- Earth horizon sensor

Both add significant cost and complexity.

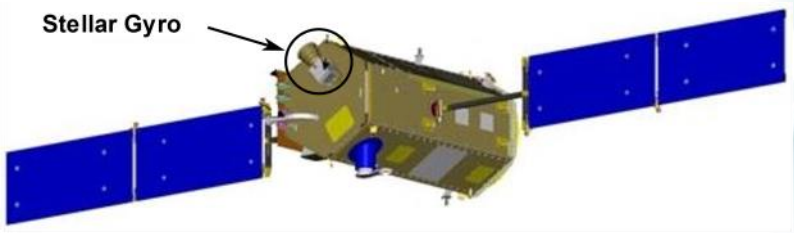


Sensor	Typical Performance
Sun Sensor	0.05° - 3°
Magnetometer	0.5° - 3°
Horizon Sensor: Fixed Head	< 0.1° - 0.25°
Horizon Sensor: Scanning	0.05° - 1°
Star Tracker	0.0003° - 0.01°
Rate Gyroscope	Drift rate: 0.003°/hour - 1°/hour
Stellar Gyro	Drift rate: None; 0.01° - 0.1°

[James R. Wertz] **Space Mission Analysis and Design**, 3e (1999)

STELLAR GYROSCOPE : Concept

Satellites use a combination of sensor and actuator systems to ensure the intended orbit of the satellite is followed and to calculate the necessary adjustments.



Source: https://upload.wikimedia.org/wikipedia/commons/e/e6/OCO.jpeg [modified with permission]

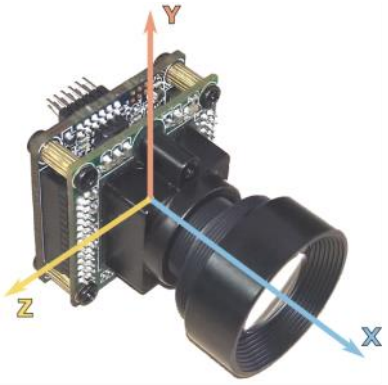
Stellar Gyro: Optical sensor subsystem capable of inferring three-axis attitude propagation based on the displacement of a series of stars between successive image frames.

Process Overview:

1. Capture successive star images
2. Extract star locations from images
3. Match star locations between image frames
4. Estimate angular rates using successfully matched stars

BENEFITS : Why Change?

- No Baffle (small volume)
- Resilient to radiation damage
- Resilient to objects in field of view
- Low (processing) power
- No obstruction of Nadir face
- Easier alignment
- Low cost
- **BUT – circa 1º knowedge**



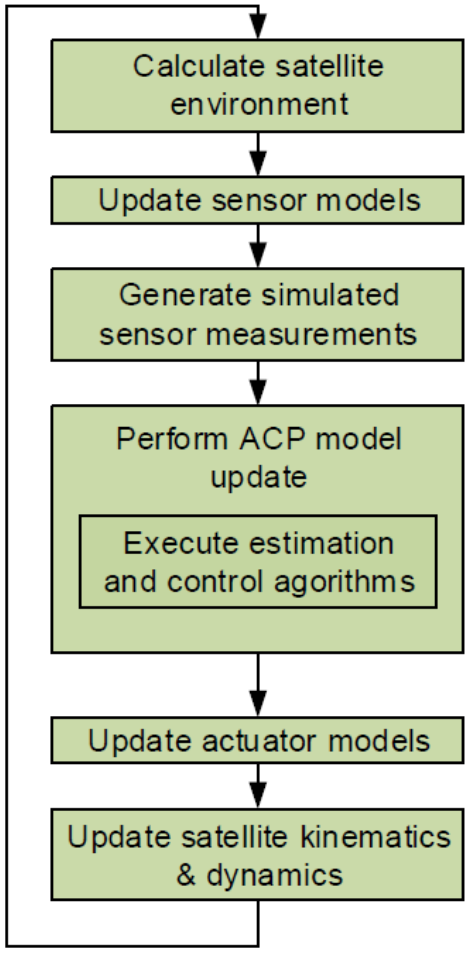
SIMULATIONS : Process

Simulation Process:

- Simulation scenario consisting of a 3U CubeSat in LEO.
- Different estimation techniques were employed to estimate the attitude of the satellite.
- Estimated attitude in each case is used as input to a momentum bias control scheme.

The following attitude sensors are modelled:

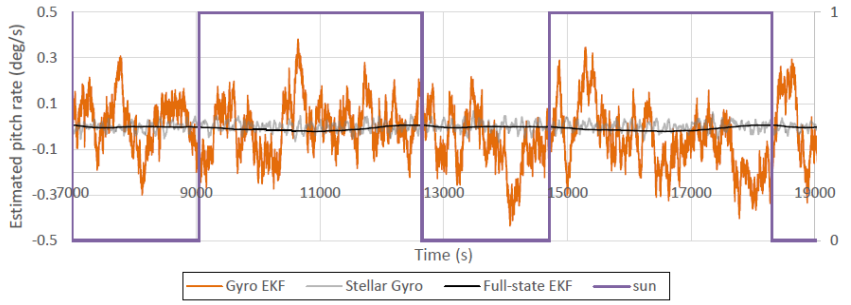
- Sun Sensor, Magnetometer, Stellar Gyroscope, MEMS Rate Sensors



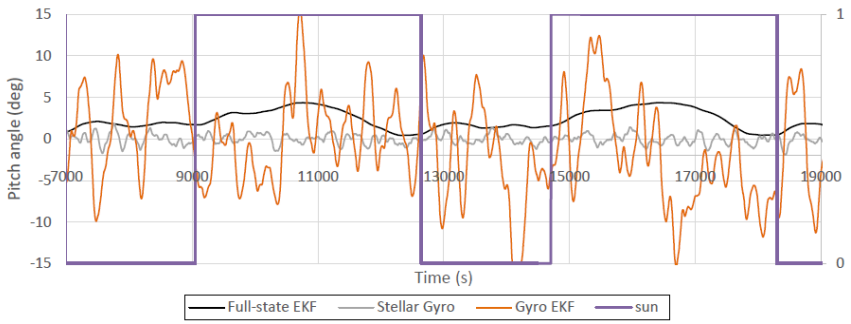
SIMULATIONS : Results

Simulation Results:

- Simulation scenario consisting of a 3U CubeSat in LEO.
- Different estimation techniques, each making use of a different set of sensor measurements, were employed to estimate the attitude of the satellite.
- Estimated attitude in each case is used as input to a momentum bias control scheme.



Error in estimated pitch rate over two orbits, for the full-state EKF and Stellar gyro estimation modes

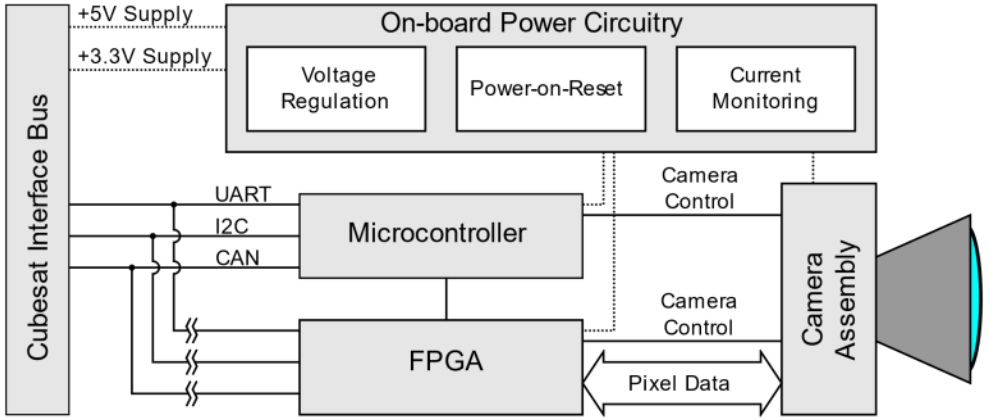


Pitch angle over two orbits, for the full-state EKF and Stellar gyro estimation modes

STELLAR GYROSCOPE : NSS Design

- Builds on the foundation of study/research work undertaken by University of Kentucky and SSBV
- Compatible with the popular CubeSat specification (aimed at affordability and accessibility).
- Built using COTS components.
- Favours flight proven components from established NSS products.
- Applies efficient, well established algorithms to the stellar gyro problem.

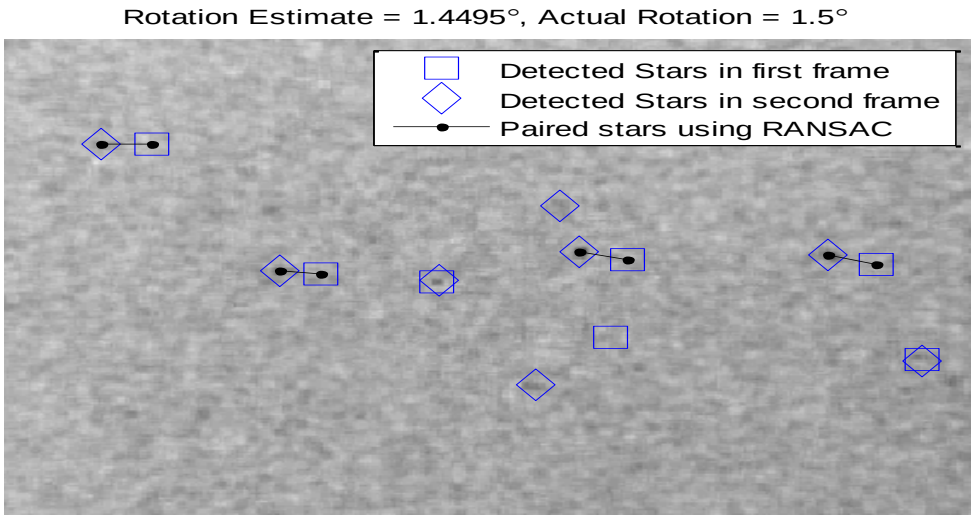
NewSpace Systems Stellar Gyroscope

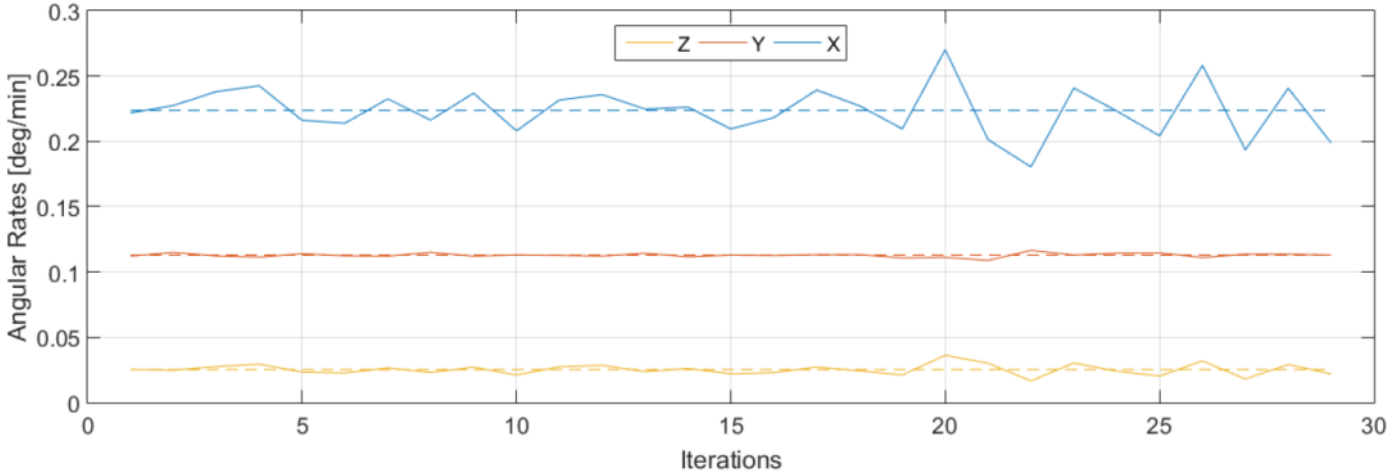


Overview of System Architecture

NIGHT-SKY TESTS : Results

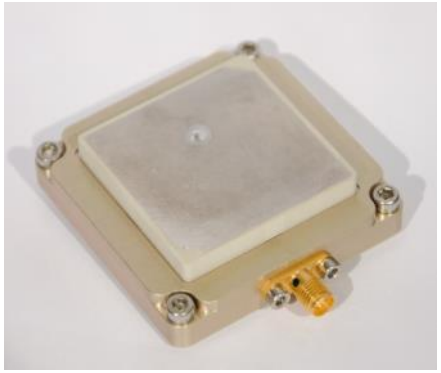
- Images taken of night sky
- Rotation of Earth taken as reliable rate measurement
- Demonstrated highly accurate measurement of rate

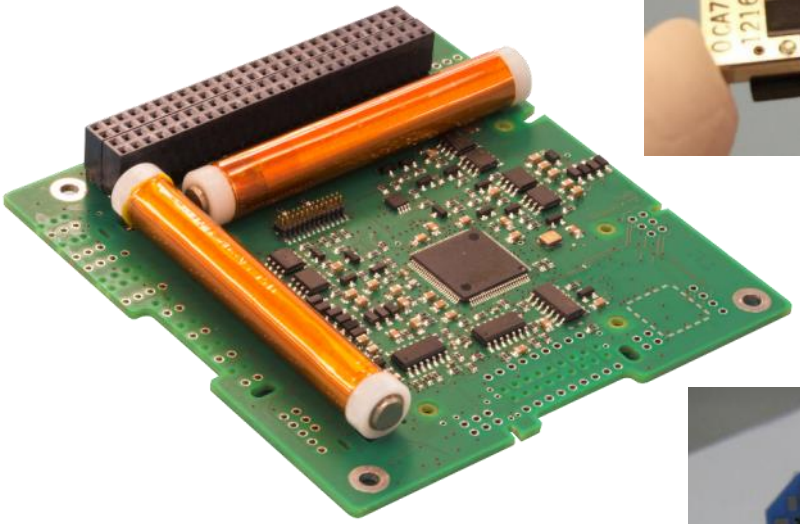


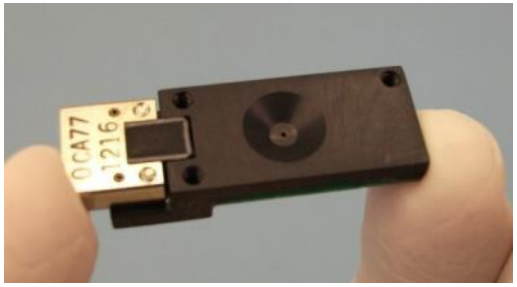


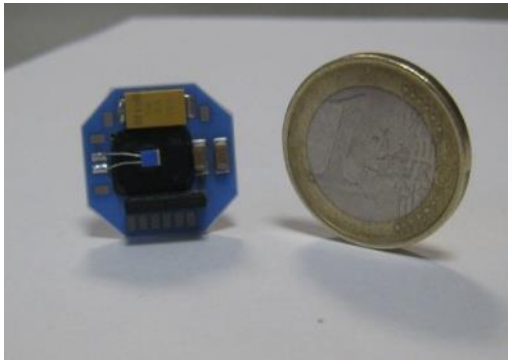
Estimated angular rates using actual star field night sky images

PRODUCT : Road map









FREE HARDWARE! : Needs a Flight

- Needs a launch Q3/Q4 2018 [or Q1 2019]
- Sufficient Bandwidth for whole image downloads
- Suggested to be used as a payload only

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Thank you for your time!
Questions?