Making The Invisible Visible

Precision RF-Emitter Geolocation from Space By The HawkEye 360 Pathfinder Mission

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HawkEye 360
Geolocation of Terrestrial & Aerial RF Emitters from Space
RF Geo-location: Applications

- Communication Interference Detection
- Spectrum Mapping
- Emergency Response
- Transportation Activity Tracking
Application Case: AIS

• AIS data is not universally reliable
• Pirates or illegal fishing fleets “spoon” AIS emissions or “go dark”
• HE360: Demonstrate independent geolocation of vessels, either via AIS emissions, or other well-known emissions of ships
The Team

Payload & Algorithms

‘COMET’ Propulsion

‘NEMO’ Microsatellite

HawkEye³⁶⁰

DSI

UTIAS SFL
Space Flight Laboratory
The Mission

Basis of Geo-location: RF Signal Time & Frequency Difference of Arrival (TDOA & FDOA)

Ground footprint of each spacecraft
The Payload

- Identical payloads on all Hawks
- SDR + RF Front-End
- Frequency Range:
  - VHF (AIS)
  - UHF (TETRA, EPIRB, FRS)
  - L-band (ADS-B, SatCom)
  - S-band (Marine radar)
  - X-band (Marine radar)
  - Ka-band (VSAT)
The Platform

• HE360 Pathfinder Employs SFL’s NEMO (Next-generation Earth Monitoring and Observation) microsatellite platform
• 20cm x 27cm x 44cm, 13.4kg
The Platform: External

- Platform T&C: 4kbps UHF Rx, 2Mbps S-band Tx
- Payload T&C: 2Mbps S-band Rx, 50Mbps X-band Tx
- Inter-satellite Link: 4kbps S-band
The Platform: Internal

- Dual-tray design
- Magnesium structure
- Significant payload volume allocation
The Platform: Propulsion

- Water-fueled
- $182\text{s } \text{i}_{\text{sp}}$
- 18mN thrust
- $96\text{m/s } \Delta V$
The Platform: Avionics

Power:
- Modular Power System
- 27W Peak Power @ EOL WCH

C&DH:
- HKC & ADCC
- Dual-redundant

AOCS:
- L1/L2 GPS Rx
- Coarse Pointing (2σ): 2.1° (on-orbit result)
The Formation

- HE360 Pathfinder leverages SFL’s pioneering experience in low-cost, nano/microsat precision formation flying
The Formation: Geometry

- Target orbit: 575km, 10:30 LTDN SSO
- 125km in-track & 20km peak-to-peak cross-track separation
- Required formation Control: 5km (1\(\sigma\))
- Two deputy (controlled) and one chief (uncontrolled, reference) satellite
The Formation: Implementation

• Ground-based custom Matlab software suite.
• Absolute and relative state estimation and prediction using GPS L1-only or GPS L1+L2 with Kalman filtering / smoothing.
• Formation initialization and station keeping using differential mean orbital elements and optimal control concepts for path planning and maneuver positioning, including thrust timing constraints.
• Designed to minimize fuel consumption, and maximize commercial operations up time.
• Only 17m/s fuel (>80% fuel margin) expended over 2-year mission.
• Please attend the Student Competition for more details!!
The Future

• Launch: Nov 2018, SpaceX
• First ‘Pathfinder’, then Full Commercial Constellation
  • 18 Satellites
  • Three planes (97°, 63.5°, 44°)
  • Two clusters of three satellites per plane, separated 180° in phase

18-satellite constellation re-visit rate