GOMX-1 Flight Experience and Air Traffic Monitoring Results
GomSpace at a Glance

• A space company situated in Denmark
  – Nano-satellite products & platforms
  – Micro-satellites (tailored products)
  – Re-entry systems & micro-gravity R&D
• Established in 2007
• Experienced management team with background in defense, cyber and space
• Has export of space hardware to customers in more than 40 countries spanning the globe
• Design and integration by GomSpace
• Manufacturing by capable defense suppliers in the region of North-Jutland in Denmark
GomSpace Main Activities

• Nano-Satellite Subsystems off the shelf
  – Batteries, solar panels, power supply & distribution
  – On-board computers and software
  – Radio communication systems and antennas
  – Attitude control hardware and software

• Complete nanosat platforms
  – Reference platforms for payload integration by customers
  – Platform design, integration and test to customer reqs.

• Payloads
  – Software defined radio technology and applications

• Contract work where competencies apply
  – Involvement in projects by the European Space Agency
  – Involvement in other international projects
Current ADS-B system Overview

**Automatic**
Position and velocity information is automatically transmitted periodically (at least once every second) without flight crew or operator input. Other parameters in the transmission are preselected and static.

**Dependent**
The transmission is dependent on proper operation of on-board equipment that determines position and velocity and availability of a sending system.

**Surveillance**
Position, velocity, and other airplane information are surveillance data transmitted.

**Broadcast**
The information is broadcast to any airplanes or ground station with an ADS-B receiver. Current mode S ATC transponders are interrogated and then send a reply.
Why Space Based ADS-B?

• Important problems addressed
  – Oceanic regions not covered by ground-statiosn
  – Expensive to deploy & maintain gndst. in sparsely populated areas (Greenland)
  – Cannot deployed in some countries due to political and economical conditions.

• Roll-out
  – Approx. 30,000 commercial aircraft in operation
  – 70-85% of aircraft are equipped today
  – Mandated use of ADS-B from:
    • Hudson Bay area 2010, Australia from 2013, Europe from 2015, USA from 2020

• Value Generation
  – More efficient air space regulation
  – Leading to potential 16x flight in most fuel efficient corridors between the continents
The GOMX-1 Mission

• Goals
  – Be among the first to demonstrate reception of ADS-B signals in space
  – Validate signal models for access QoS
  – Demonstrate benefits to ATM stake-holders

• Project Partners
  – GomSpace (prime)
    • Project/mission management
    • Satellite design and construction
    • ADS-B receiver design and construction
  – DSE Airport Solutions
    • Data validation and correlation to existing data sources
  – Aalborg University
    • R&D support for software defined radio techniques
    • Contribute to development of business models

• Launch: 21st of November 2013
Space Segment Overview

• **Platform**
  – Based on GomSpace’s COTS port-folio
  – 20x10x10 cm in stowed config. 2 kg
  – 4k8 up/downlink in UHF

• **Payload**
  – Deployable helical antenna, ~10dBi
  – Discrete front-end, FPGA based baseband processing
  – On board database in μC of raw and decoded ADS-B
  – FPGA and μC on-orbit reconfigurable

• **Orbit**
  – Near SSO
  – Perigee: 598km, apogee 835km
Launch & Early Operations

21st of November:
• Launch by Dnepr from Yazny
• Signal acquisition
• Two-way com and large scale telemetry retrieval

22nd of November:
• Active de-tumble of satellite
• ADS-B antenna release and confirm
• First ADS-B data retrieved

23rd of November:
• First file-based operations
• TLE object identified

25th of November:
• Switch to autonomous operations outside office hours
Space Based ADS-B Overview Data

Plot of plane positions on Northern Hemisphere (one dot per plane per orbit max).

*Note:* ADS-B payload receives many more plane positions (up to 200/s) than can be downlinked via UHF.
Raw Samples (synchronized)

Four samples after log-amp detector acquired over Europe. Note disturbance from DME pulses. Red line indicated start of frame data. Preamble used for synchronization. Blue sample is false detection / garbled signal.
Not all Airspaces are Equally Attractive...
The Middle East
Polar View
Occasionally, the FPGA configuration experiences a bit flip which could change its behavior. The configuration (stored in SRAM) is continuously monitored for bit flips and the payload is rebooted if one is found.

[Proton data from CSSWE CubeSat]
Power Balance

GOMX-1 groundtrack from 2014.03.14 18:45 to 2014.03.14 20:25

Battery Voltage [V] vs. Time of orbit [min] starting at 2014.03.14 18:45 UTC

Current [mA]
Spacecraft Temperatures: Interior

EPS & Battery

OBC & COM

Temperature [deg C]

Time of orbit [min] starting at 2014.03.14 18:45 UTC
Spacecraft Temperatures: Exterior

![Diagram of space satellite with temperature graphs showing exterior temperatures over time. The graphs compare temperature variations in different axes (PV+X, PV+Y, PV-X, PV-Y, PV-Z) against time of orbit.]
Current Spacecraft Operational Status

• Platform systems continue to be in excellent health

• Attitude control:
  – Larger than expected residual magnetic dipole moment.
  – Source isolated to ADS-B antenna.
  – Cannot be handled by nominal controller for Nadir tracking
  – Spacecraft stable and with X-axis aligned to local magnetic field with slow rotation around X. ADS-B antenna scanning Earth regularly.

• Payload Operations:
  – Radiation event FPGA bootstrapping circuit on ADS-B payload 7 May 2014
  – Receiver currently not operational and with a slim chance of recovery
  – Database with 6 months of unique data
GOMX-1 Conclusions

• **GOMX-1 Mission Conclusions**
  – Very successful demonstration mission
  – Important lesson learned on magnetic cleanliness
  – Payload needs updated design with higher radiation resilience

• **Next steps with Space Base ADS-B**
  – Updated ADS-B receiver design to fly in 2015 on GOMX-3
  – Looking at regional solution for niche business cases
  – R&D in comms technology for fast data dissemination
Thank You