AIS: Technology Development to Commercialization

NSAW – 2010

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Mission Development Group
COM DEV Ltd
Outline

COMDEV / MDG Overview
The AIS Problem
The Trials

Simulations,

Harbour/Aircraft

Quick AIS

NTS – The Nano-satellite that Could
Spinoff into Commercial Industry (exactEarth)

Current Mission Designs

HIP-1
ADS-1B
M3MSAT

Summary
COM DEV / MISSION DEVELOPMENT GROUP
COM DEV at a Glance

- In operation since: 1974
- 2009 Revenues: $240M
- Size: 1377 + employees – 5 facilities
- Patents: 200 granted or pending
- Public Ownership: TSX-CDV
- Satellite Contracts to date: 700+

Most prolific supplier of payload equipment for commercial communication satellites
Since 1975

Since 1982

Since 1995

Since 1979

Since 1987

Since 1995

Since 1987

Since 1995

Since 1990

Since 1990

Since 1984

Since 1987

Relationships with all satellite primes – lasting decades.
COM DEV is the world's most prolific supplier of satellite equipment with products and sub-systems on more than 700 satellites and counting.
Wide Range of Challenging Activities

SEARCH AND RESCUE
transponder payloads for satellite-based beacon tracking

ASTRONOMICAL IMAGERS
large aperture, low-distortion systems for imaging the universe from UV to FIR

ISR FROM SPACE
automatic identification system for global mapping of shipping traffic

ATMOSPHERIC REMOTE SENSING
sensitive pollution mapping, atmospheric composition and dynamics, weather and climate monitoring

SPACE SITUATIONAL AWARENESS
high accuracy, high sensitivity monitoring of space resident objects.

SPACE ENVIRONMENT
in-situ plasma composition and dynamics analysis for space weather monitoring

SPACE EXPLORATION
custom instruments for robotic and manned exploration

FINE GUIDANCE SENSORS
accurate, autonomous real-time attitude transducers allowing spacecraft to navigate by the stars
Mission Development Group

- Officially stood up in 2008
- Mandate is to provide space-based mission solutions to a variety of problems using microsatellites.
- AIS is the first problem that was addressed.
- Focus is on ‘microspace’ approach: Quick response, dedicated team with wide skill sets, may use COTS parts, subcontractors and subject matter experts as required.
  - “micro” space is at the other end of “big” space
- Microspace philosophy is a way to get to orbit at lower cost and take smarter risks.
SPACE BASED AIS

Video
WHAT IS AIS?
Terrestrial AIS

- Automatic Identification System (AIS) as specified by IMO, is a ship and shore based broadcast system, operating in the VHF maritime band.

- AIS is capable of sending and receiving ship information such as identity, position, course, speed, ship particulars and cargo information to and from other ships and shore stations.

- It can handle over 4,000 reports per minute and updates information as often as every two seconds.

- AIS uses Self-Organising Time Division Multiple Access (SOTDMA) technology. “Cells”

- Shipboard AIS provides automatic and accurate information regarding risk of collision by calculating Closest Point of Approach (CPA) and Time to Closest Point of Approach (TCPA).

Terrestrial, Line-of-sight system, Self Organized within Cells ~40 nm.

Not designed for reception from space.
AIS From Space

- Some important technical questions need to be addressed:
  - AIS signal strength from space
    - Ships pitch/roll and use dipole antennas with deep overhead null
    - Gain/Size of antenna on satellite [vs. size of satellite]
  - Field of view from space
    - Many cells in view simultaneously
    - Signal ‘Collisions’
    - Can signals be decoded?
    - What is probability of detection?

Typical satellite field of view
Many SOTDMA cells
THE TRIALS
Path to AIS Feasibility

- Extensive, high-fidelity simulations (2005)
- Aircraft AIS trials at 29,000 ft. (2007)
- NTS AIS nano-satellite launch (2008)
AIS Simulator: Signal Propagation Models

Satellite ephemeris, Doppler shift, receive antenna gain, receiver noise accounted.

Faraday rotation in ionosphere dependent on day/night.

Reflection & De-polarization due to Sea State

Pitch and roll of the ship varies gain to satellite and sea surface.

Simulator generates AIS signals at the satellite that can be sent to a decoding processor and collision statistics calculator.
Simulator Output

Satellite near pole
Little traffic in FOV

Satellite near southern tip of Greenland

GMSK AIS signals received at satellite, demodulated to baseband. Collisions are apparent.

One second AIS reception at satellite

Moving ship traffic
NTS Characteristics

- Limited AIS data storage capacity (90 seconds of sampled baseband data, both AIS channels)
- Limited AIS data downlink capacity (32 kbps)
- Field of view: 5200 km diameter. (Altitude: 630 km)
- Attitude control: magnetically damped. Antenna gain null points Nadir near the poles.

CONCEPT OF OPERATION:

Demonstration satellite only! Proof of concept for detection algorithms. Take 90 seconds of AIS observation, and then download this over the slow downlink over a period of about 3-4 days!
Introduction to the NTS Spacecraft

- Envelope: 20 x 20 x 20 cm cube
- Mass: 6.5 kg
- Power provided by 24 cells distributed evenly on all sides. Available power for the payload:
  - Peak: 8 Watts
  - Orbit Average: 0.75 Watts
- Payload and communication antennas launched in deployed state
- Communications
  - Uplink: 4 kbps at UHF
  - Downlink: 32 kbps at S-Band
  - 4 whip antennas
The First Space AIS Payload
NTS launch: April 2008

NTS Spacecraft

X-POD
Over 16,000 ships – tiled 90 second snapshot

COM DEV AIS
WHAT CAN AIS BE USED FOR?
Surveillance and Security

Search and Rescue

Arctic Vessel Monitoring

Environmental Monitoring
Satellite Constellation
- Detects AIS Class A Signals
- Initial Satellite launches – mid 2010
- Full 6 satellite constellation by 2014
- <2 hour global revisit rate
- Secure downlink

Earth Stations
- Downlink signals
- Data Pre-Processing
- 3 Initial Earth Stations
- 3 additional stations for full constellation
- Secure transfer to Data Center

Data Center
- Located in highly secure facility in Canada
- Decollide signals into AIS messages
- Convert messages into industry standard formats
- Filter and forward messages to Customer

Customer Delivery
- Industry standard files such as NMEA, OTH-Gold KML, or XML
- Only authorised data is distributed
- Commercial Display System
- Integration into Custom Display System

End-to-End, Highly Secure Solution for Increased Maritime Domain Awareness
THE SPACECRAFTS?
ADS-1B

- Microsatellite
- S-Band TM/TC
- C-Band Payload Downlink
- 2 Polarizations / 4 Channels
Hosted Indian Payload (HIP-1)

- Resource Sat-2 (ISRO)
- Two Polarizations / 4 Channels
- S-Band Data Downlink
M3MSat
• Microsatellite (95Kg)
• S-Band TM/TC
• C-Band Payload Downlink
• 2 AIS Payloads each with 2 Polarizations / 4 Channels
• Low Data Rate Systems (Trial Experiment)
HOW IT ALL WORKS?
Define and Monitor Areas of Interest
Monitor Coast Lines

- Monitor vessel traffic in coastal areas
- Feed back to SAR aircraft
- Historical tracking of ships in and out of coastal ports
Monitor Marine Protected Areas

- Monitor vessel traffic in sensitive areas
- Automated Alerts based on:
  - Approaches
  - Intrusions and Exits
  - Vessel Speed
- Historical and Statistical Data of MPA traffic

The Gully MPA
Questions?