The Ability of a Small Satellite Constellation to Tip and Cue Other Commercial Assets

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Overview of Paper

– Utilize small satellites to tip-off or cue larger EO satellites.
  – Automated Identification System (AIS) small sat
  – Synthetic Aperture Radar (SAR) small sat
  – EO satellites GeoEye-1 and IKONOS

– Address a specific case of Maritime Domain Awareness (MDA).

– Monitor ship activities over large areas that Coast Guard or other vessels can not currently cover.

– Look at both routine and ad hoc global satellite coverage of high-interest areas.
Technical Background

• Utilize existing and under construction assets

• exactEarth exactAIS™
  – Payloads on 2 SpaceQuest built satellites, ResourceSat-2
  – Launch of payload SSTL-built satellite July 2012
  – 4600km Field-Of-View
  – Unparalleled rate of detection: 2,171 ships in 9 min. detection rate of 241 ships per minute.

• Surrey NovaSAR system
  – S-band 750km swath 30m resolution Maritime mode
  – Launch in 2014
  – exactAIS™ payload to fly on NovaSAR

• GeoEye GE-1 and IKONOS
  – IK 11km swath and a 0.82m pan resolution
  – GE-1 15.2km swath and a 0.41 pan resolution
Simple Process Flow

- **Identify Area of Interest (AOI)**
  - Due to large amount of continuous data acquired, data over AOI should already exist in exactEarth© or acquired quickly

- **SAR Collection acquired**
  - SAR and AIS fused to facilitate vessel analysis and detection

- **Tip off EO for projected location of vessel**
  - Analyze EO imagery to characterize the vessel

- **Generate report using details of AIS, SAR and EO vessel imagery chip.**
Orbits

• To maximize data correlation, the satellites need near-coincident coverage of shipping lanes/open seas.
• AIS, GE-1 and IK already in 98° sun synch orbits
• SAR orbit options:
  • 98° sun synchronous orbit or ~58° inclined orbit
  • Dawn-Dusk or 10:30 am LT
• Simulation done to ensure orbits provide coincident coverage of the shipping lanes.
• In the chosen 98° sun synchronous orbit, the SAR satellite would be common with the GeoEye satellites ensuring maximum tip-off ability.
Marine Protected Areas Scenario #1

- MPA utilized is the Tarium Niryutait Marine Protected Area in the Canadian Arctic on the Beaufort Sea coast.
  - MPAs are protected from fishing and other activities yet cannot be adequately monitored well using ground based assets for violations.
- AIS data provides warning of vessel approaching MPA with position, speed and course direction.
- Positional Data projected forward in time for SAR detection.
Marine Protected Areas Scenario #1
(continued)

• SAR is acquired and merged with the AIS data to locate and identify the vessel.

• Using vessel-specific details the appropriate estimate of movement and precise EO tasking required is created.

• EO satellite is tasked and images the questionable vessel to characterize and identify the vessel.

• Total scenario time was less than 12 hours from when the vessel was first detected.
Environmental Safety Violation Scenario #2

• The AIS detects a “suspicious” vessel in port which has been known to practice poor maintenance or has been previously fined for leaking oil in the shipping lanes.

• The vessel is tagged as a known violator.

• 24 hours later, the AIS detects the vessel movement from the port.

• SAR satellite is cued and images the vessel in question.

• Analyzed SAR Data is merged with AIS data.
Environmental Safety Violation Scenario #2 (continued)

- It can be seen on the SAR image that a large oil slick is forming behind the vessel in question.

- EO cued and image taken to confirm the oil leakage.
- The vessel is identified and fined.
- The oil slick SAR information can be used as input to models predicting the spill movement and an oil spill response can be formulated and implemented.
Reporting

• Providing Watch Floor or Operation Center reporting would get data to the right people at the right time.
• This would shorten timelines for tactical responses of detected non-broadcasting vessels, vessels with violations and trespassing while it was occurring.
• The report could contain the most important data.
  • Vessel ID or lack thereof
  • Vessel imagery chip
  • Threat summary
  • See sample reports in more detail in paper
Users

- A consolidated report would be used primarily by the Maritime Safety Agencies, Coast Guard or Navies of national governments.
- Sharable reporting with State, Local, Tribal, Native, Aboriginal entities, Coalition partners, NGOs and other international entities.
- Archive in a Data Warehouse
  - Report
  - Raw full res imagery
  - AIS Vessel tracks
  - USG and Industry standards
  - Web services
  - MDA Common Operating Infrastructure (COI) data sharing vocabulary
Summary

• The timeliness and accuracy of commercial satellites can be harnessed and cued to support the MDA mission.

• By using a constellation of AIS, SAR and EO satellites in the Maritime Domain Awareness arena violations and other Maritime activities can be identified and made available to a user community.

• Data Warehouse using standards for services to deliver and discover the data along with a COI vocabulary would provide a historical archive.

• This leverages existing capabilities such as exactEarth’s AIS and GeoEye’s EO satellites in concert with the new NovaSAR satellite to better meet user timelines and Maritime needs.
Thank You

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