What happens in Las Vegas stays in Las Vegas!

What happens at Sea goes all over the World!

And has a HUGE Impact on all people on Earth.

– Safety
– Security
– Environment
– Economy & Resources
C-SIGMA

Collaboration in Space for

*For International Stewardship of the Maritime Environment and its Resources
*For Maritime Safety
*For Security

Global Maritime Awareness

Guy Thomas  g.guy.thomas@c-sigma.org

Photo Courtesy of MDA
Background

• As the US Science & Technology Advisor for MDA for 10+ years, 2001-2012, we looked at every Platform, from satellites to undersea vehicles, and every Sensor, Processing, Fusion, Analysis, Display/Decision Aid and Dissemination system, we could find.

• By mid-2005 it was obvious commercial Space would be THE crucial/core component to Global Maritime Awareness.

• This brief is the result of that Research, which continues to this day.
Satellite Navigation
Father of GPS

Where, When, Why, and How?
1958

SPUTNIK 1

Johns Hopkins University
Applied Physics Lab (APL)

Submarine Launched
Ballistic Missiles
Satellite AIS (S-AIS) is having a similar effect on the Maritime World as GPS

S-AIS is changing how it works
At its CORE
Also created at JHU/APL
It is an Interconnected World
Except in the Maritime Domain
In 2008
Satellite AIS (S-AIS) Changed All that!
The Collaborative Information Environment in the Maritime Domain

March 2002
MARITIME SITUATIONAL AWARENESS *
Needed for:
- Security
  - Counter Smuggling
    - Drugs
    - People
    - Arms
    - Goods/Counterban
  - Counter Piracy
- Safety
- Environmental Protection
- Resource Conservation
- Disaster Mitigation
- Disaster Recovery

* It is Feasible to Use One Center For Global Coordination & Collaboration of all Space Assets!
4 GLOBAL COMMONS

1) Maritime
2) Air
3) Space
4) Cyber

Major Recent Advancements in Last 2, Space & Cyber,
Potentially HUGE Effects on Maritime
Especially MSA
Quotes from NATO MSA Meeting
April 2016

1. Establish a Global MDA
   A. Coordinate & Synchronize
   B. Command, Procedures, & Coordinate
   C. Develop Linkage between MDA Organizations

2. Need Leadership and Vision
   A. Provide Focus on MSA
   B. Need to Collaborate both Regionally & Globally

Proposed Way Ahead:
Use Development and Deployment of Space-Based MSA as Focus for World-Wide MSA
MDA Manifesto (2002)  
(according to Guy Thomas)  

From Each According to their Ability  
To Each According to their Needs  

No where more true than in  
SPACE-Based MSA  

Makes for a better, safer, more secure WORLD!
Four Types of Satellites

- Satellite AIS
- Synthetic Aperture Radar
- Optical Imager
- Communications (M2M/SMS/LRIT)

- Each makes a Unique Contribution
- See C-SIGMA Core Brief for more Details
Satellite AIS
The Game Changer

Most Significant Change to Maritime Operations since the Screw propeller

(Yes, More Significant than GPS!)

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Space Systems are Very Cost Effective

- Space Systems makes terrestrial systems (Ships & planes) many times more effective
- Space Systems, tell decision makers where to pinpoint their search.

- HUGE Saving of Fuel, Time and Wear
- Dramatically increases effectiveness of Terrestrial Systems
S-AIS

Created to provide Maritime Security to USA, its use has expanded far beyond:

- Environmental Protection
- Maritime Resource Protection
- Safety
- Commodities Trading
- Route Planning
- Ship Maintenance

+ + +
WHAT IS AIS?

- Mandated by the International Maritime Organization (IMO) to be installed on hundreds of thousands of larger vessels
- ORBCOMM worked on S-AIS concept from October 2001 with Johns Hopkins’ Applied Physics Laboratory (JHU/APL)
- ORBCOMM pioneered the collection of AIS data from space in 2004 with the US Coast Guard
- ORBCOMM launched first 6 Sat Constellation in 2008.

ORBCOMM provides the industry’s most comprehensive AIS service
• ORBCOMM launched 11 next generation December 2015  **19 now on orbit**

• Reporting to 16+ Ground stations

Time late down to just a few minutes, Globally

• exactEarth plans to launch 30+ in the next 4 years (?), with cross-link reporting, taking time late late to very near real time.

• Spire Global is in the process of launching 40+ which will also have reporting periods in the few minutes.
Sufficiency Latency is here now

Latency = Time from Collection Opportunity-to-Collection-to-Report

With completion of ORBCOMM constellation

Latency < 10 minutes in the most populated areas of the world.

< than a minute in many areas & instances due to global distribution of ORBCOMM Ground Station allow direct reporting from ship-to- satellite-to-ground station-to-user.
ORBCOMM’s Satellite AIS System

- ORBCOMM leverages its established commercial M2M satellite business, recent satellite deployments and established infrastructure worldwide to provide global AIS data service.
AIS TODAY

- 19 Satellites + 16 Global Ground Stations
- Multiple Best-in-Class Terrestrial AIS Data Partners
- 23+ Million Messages Daily and > 180,000 Vessels Daily
- OG2 provides near continuous coverage with average revisit rates of 8-15 minutes and less than 10-minute latency worldwide.
A snapshot in time:
Orbiting satellites provide near continuous coverage
ORBCOMM GATEWAY
EARTH STATIONS

Gateway Earth Station

- Washington
- Arizona
- New York
- Georgia
- Morocco
- Italy
- Kazakhstan
- Korea
- Japan
- Curaçao
- Brazil
- Argentina
- South Africa
- Oman 2017
- Malaysia
- Australia
GLOBAL AIS DATA

• Terrestrial AIS provides real-time coverage in various locations around the world.

Satellite AIS data provides near-real-time complete global coverage.
AIS APPLICATIONS BEYOND COLLISION AVOIDANCE

- Surveillance and security
- Search and rescue
- Data fusion with sensors
- Counter piracy
- Environmental monitoring
- Incident investigation
- Logistical tracking
- Energy/commodity tracking
- Fishing regulation compliance
AIS is used by increasingly diverse participants in the shipping industry

Commodities
- Supply & demand
- Competitive analysis
- Commodity flows
- Floating inventories
- Ship availability
- Supply chain disruptions

Shipping
- Freight supply & demand
- Ship benchmarking
- Ship op-nss optimization
- Route planning
- Cargo availability
- Bunker procurement

Maritime Services
- Bunker services
- Spare parts & maintenance
- Port agency & inspections
- Tugs, pilots, etc.

Regulatory & Compliance
- Port authorities
- Traffic control
- Government agencies
- Illegal activity
- Illegal fishing
- Class society inspection

Finance
- Hull insurance
- Cargo insurance
- Equity research
- Economy research
- Derivative trading

How does this change the shipping industry?

- Global and local commodity flows fundamental data for the trading community
- Proactive marketing, identifying opportunities to offer services based on real activity
- Companies that use analytics become stronger and waste less resources and are more efficient
Worldwide average fish consumption is 160 million tons per year, China consumes one-third. Regulations are required to prevent overfishing and allow replenishment of supply.
S-AIS Competition Heats Up

Both Spire and exactEarth/Harris have recently launched S-AIS constellations with latencies of < 1 minute.

 mê What are these new, faster systems worth?
 mê “Better is the mortal enemy of good enough.”
                                                                                        Winston Churchill
                                                                                        during the Battle of Britain

 mê ORBCOMM has added low cost 2 ways comms
hali
Ground-Breaking Combination

AIS Class B – M2M Small Vessel Tracking Device

Combination of AIS Class B with ORBCOMM 2-way satellite network

Comprehensive and economic solution for small vessel tracking

Introduced March 2017
Since 2008, ORBCOMM has had two complementary systems:

- **M2M two way comms** (used primarily for status reports)
- **AIS**

**HALI combines the best of both**

- Self contained
- Optional battery or connection to shipboard power.
- HALI broadcasts its position on both M2M and AIS frequencies at the same time,
- Doubles chance of reception on 40+ OBBCOMM satellites
- Send preprogrammed safety and status messages containing name, position and status of sender.
How Hali works

Local

Class-B AIS is broadcast to nearby vessels and terrestrial AIS stations

1. Attach

Powerful and tamper-proof hardware for vessels of all sizes

Global

Class-B AIS is broadcast to both satellite AIS & M2M receivers

2. Collect

Acknowledged AIS & M2M satellite data, anywhere in the world

Reliable

ORBCOMM’s entire 2-way proprietary global satellite network

3. Deliver

Web-based platform with 24/7 support in multiple languages
S-AIS
Now paired with space-based Imaging

- **Radar**
  - Day/Night,
  - Good/Bad Weather

- **Optical**
  - High Definition
COLLABORATIVE COLLECTION

S-AIS & SARSATS

A TRUE SYNERGISM
Commercial Space Radar Capabilities

• **RADARSAT-2 Canada** (1 now, 3 in CY15)
  - Large scan area well-suited for ocean surveillance
  - Quad – Polarimetry
    - 4 images simultaneously w/different combinations
  - Large collection capacity (28 min/orbit)
  - Canadian Mission: coastal surveillance, oil exploration

• **TerraSAR-X Germany** (1 now, 4 in CY15)
  - World’s most geometrically accurate imaging system
  - Excellent data quality and RNIIRS levels
  - Great change detection products
  - TANDEM-X (launch summer of 2010)
    - Generate best global digital elevation model
  - German Mission: National Pride, Science, $$

• **COSMO-SkyMed Italy** (3 now, 8 in CY15)
  - Full constellation provides good repeat coverage
  - Good RNIIRS levels for ground collections
  - Great large area scan & precision imaging sensor
  - Italian Mission: Illegal immigration, soil subsidence
BASIC SARSAR Modes

ScanSAR Mode
- Resolution 16 m
- Swath width: 106 km
- $h_{satellite}$
- $\Theta_1 = 20^\circ$
- $\Theta_2 = 45^\circ$

StripMap Mode
- Resolution 3 m
- Swath width: 90 km
- $h_{satellite}$
- $\Theta_1 = 20^\circ$

Spotlight Mode
- Resolution 1 m
- Performance Range
- Full Range
- Centre of rotation

Courtesy of Infoterra
BASIC SARSAR Modes with Resolution

- **Spotlight**
  - resolution: << 1 m
  - possible identification of tanks (T72, Leo, ...)

- **Strip Map**
  - resolution: 1.0 m
  - possible recognition of airplanes (Transport, Fighter, ...)

- **ScanSAR**
  - resolution: 3.0 m
  - possible detection of infrastructure (roads)
  - resolution: 16.0 m
  - possible detection of coarse land cover features

**Identification** → **Recognition** → **Detection**
2nd Part of the C-SIGMA Equation

Optical Systems

High Res Optical Satellites:

e.g. EROS-A1, EROS-B, OrbView, QuickBird, WorldView, IKONOS, Spot Image, GEOEYE

• Suitable for Ship Classification
  • Coverage from 8KM to 16.5KM
  • Resolutions from .5 to 1.80m (Panchromatic)
• Agile satellites with up to 12 hour to revisit times
• Some include direct tasking to support Tactical Surveillance applications
This 1-meter resolution image was collected November 20, 2008 by the IKONOS satellite. The image shows the SIRIUS Star, the Saudi-owned crude oil carrier Hijacked by Somali pirates, anchored approximately 5 miles off the Somali coast.

(IKONOS is 10 years old....)
Freighter off-loading at Casablanca, Morocco

½ meter resolution photo of Collected on October 25, 2008 by GEOEYE
Dynamic Data Analysis

- **Goal:** Detect suspicious ship behavior from position tracking data
- **Approach:** Define a set of discrete zones and predict the ship movements in the grid

**Challenges:**
- Prediction precision
- Lack of positive examples
- Ship traffic variability
- Privacy vs. security tradeoff

**Scenarios:**
- Vendor data distribution
- Regional data distribution
Dynamic Data Analysis (DDA)

Generates Knowledge & Understanding from Diverse Data

- Over 12 organizations
- Very sophisticated DDA systems
- High Tech Race for Supremacy

& The Winner is EVERYONE
Global Focus
Regional Execution?
www.C-SIGMA.space
Maritime Domain Awareness (MDA)
Is not Rocket Science!

MDA is a lot harder!
(many more variables)

German Aerospace Engineer
The Information Continuum

DATA
Collect

INFORMATION
Process/Fuse

KNOWLEDGE
Analysis

UNDERSTANDING
Display/Decision Aids

WISDOM
Leader’s Input
EO + M2M/IoT + PL = the Future

Natural Synergism

EO = Earth Observation
IoT = Internet of Things (core component is M2M)
M2M = Machine to Machine
PL = Precision Location (AIS & S-AIS in Maritime Ops)
QUESTIONS?

Fire Away!
Backups
Sense - Decide - Act Cycle

* Collaborative Information Environment
US National Space Policy

Presidential Policy Directive #4 (PPD-4)

28 June 2010

Implementation Task #1

• Tasks Committee to “Build C-SIGMA”
  – IGNORED
  – “No Money”

• Very Shortsighted

• Frustrating!

• Bureaucracy is the BANE of us all......
National Space Policy (PPD-4) Implementation Task #1

“(U) Working through the National Maritime Domain Awareness Coordination structure, the Secretaries of Defense, Homeland Security, Transportation, State and Commerce, will develop an unclassified, international available program to foster international collaboration using civil and commercial space systems to enhance global maritime domain awareness to provide: enhanced safety of life at sea; increased mutual security of all users of the maritime domain; improved protection of the maritime environment and the resources of the sea; improved flow of commerce; and better monitoring of the condition and performance of the Marine Transportation System.”
ORBCOMM Constellation (snapshot)
MARSEC COE

Uniquely Placed
Unique Opportunity

Lead the Global Deployment of
Space-Based Maritime Awareness
C-SIGMA VII
19-20 April 2017
EMSA, Lisbon, Portugal

Collaboration in Space for International Global Maritime Awareness

www.C-SIGMA.org
Horizontal Fusion/Integration

The Way Ahead

Sense
Process
Fuse/Analyze
Decide
Act

Smart Agents for Sensor Control and Decision Assistance

Common Distributed Virtual Data Base

Smart Agents for Data Mining

Smart Agents for Anomaly Detection

NCCT  GNCST  DCGS  AADC

UNCLAS  SECRET  MIDB  MISLE  BBR  SSI  LES  UNCLAS  INTERPOL  Lloyds  BBR  SBU

Information Extraction

Smart Agents for Data Mining

Smart Agents for Anomaly Detection

Smart Agents for Sensor Control and Decision Assistance
SPACE-BASED
MARITIME SITUATIONAL AWARENESS
WHERE 3 GLOBAL COMMONS
CONVERGE

You Cannot Surge Trust!
It needs to be earned.

ADM Mike Mullen