

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

Photo
Courtesy of

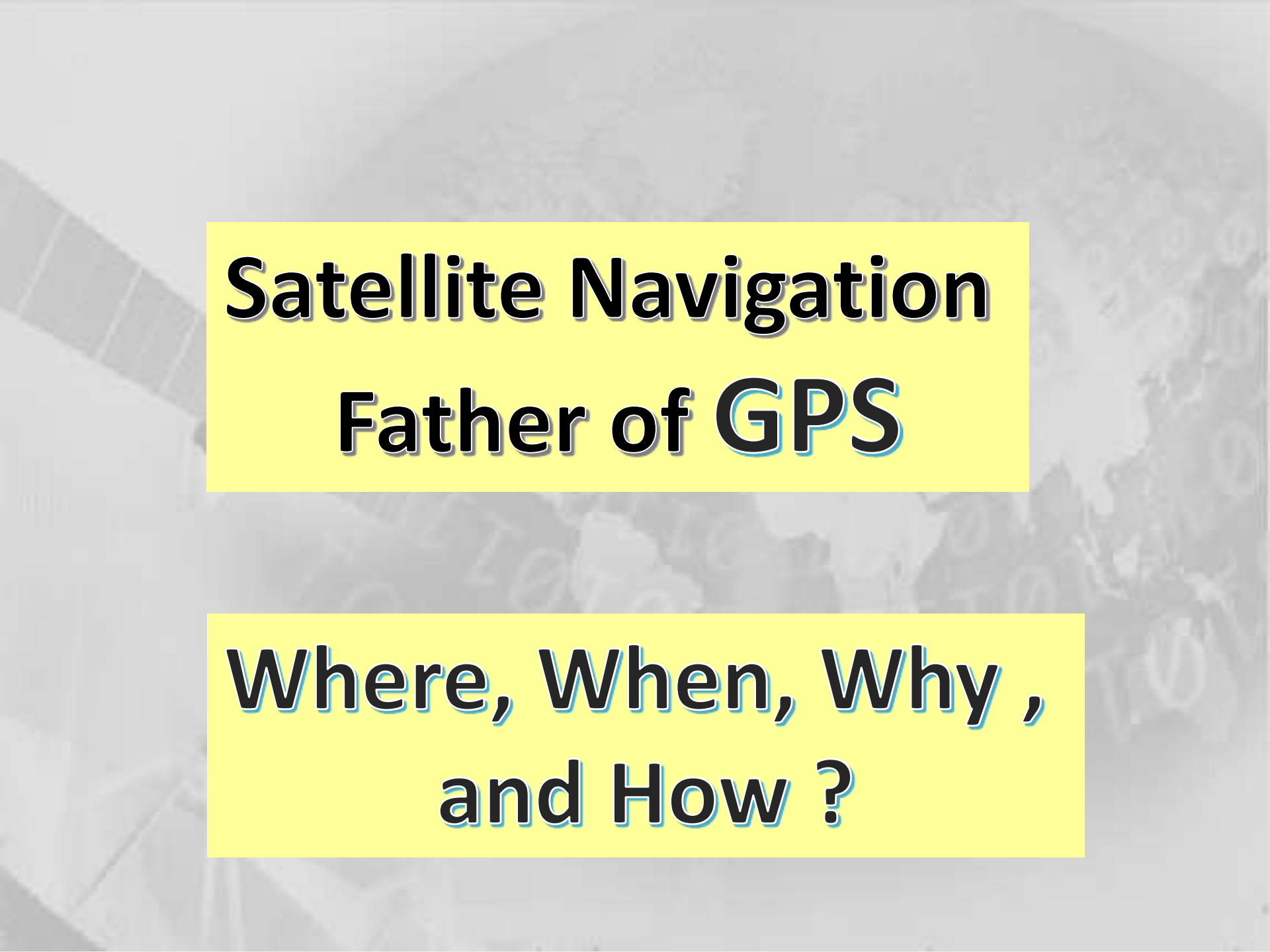


Guy Thomas

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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.

The background of the slide features a faint, grayscale image of a satellite in the upper left corner and a world map in the lower right corner. The satellite is shown from a side-on perspective, revealing its solar panel arrays. The world map is centered on the Atlantic Ocean, showing the continents of North and South America.

Satellite Navigation

Father of GPS

**Where, When, Why ,
and How ?**

1958

SPUTNIK 1

**Johns Hopkins University
Applied Physics Lab (APL)**

**Submarine Launched
Ballistic Missile**

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

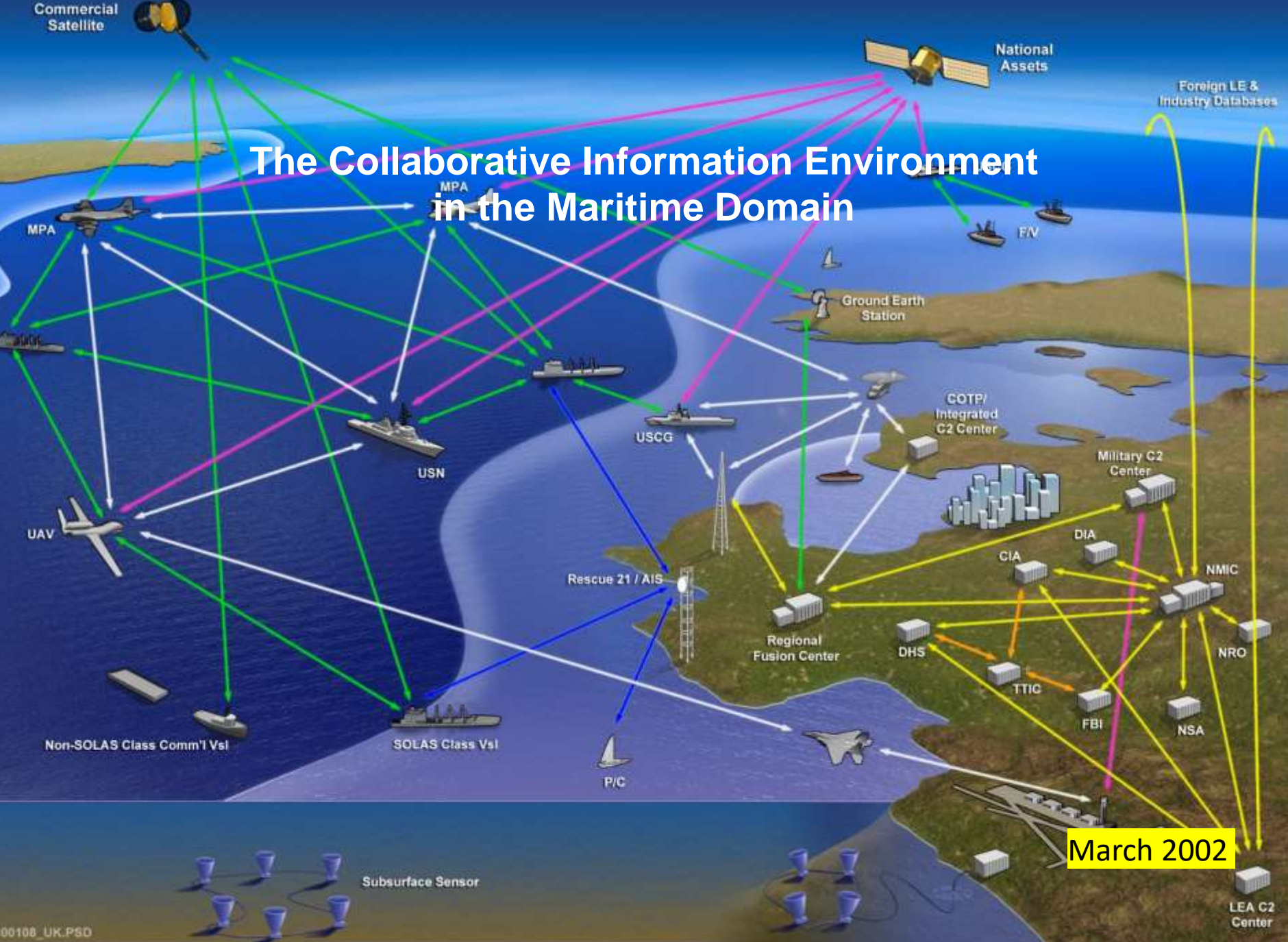
S-AIS is changing how it works

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!**



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

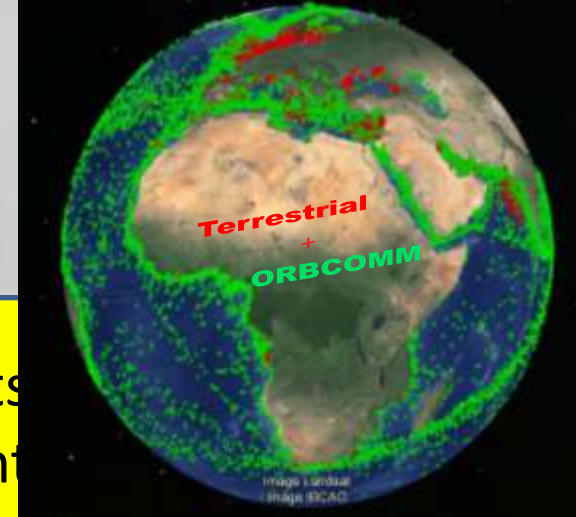
- Space Systems makes terrestrial systems (Ships & planes) many times more effective
- Space Systems, tell decision makers where to pinpoint their search.
- HUGE Saving of Fuel, Time and Wear
- Dramatically increases effectiveness of Terrestrial Systems

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?



- ance system that broadcasts
her data via VHF (line of sight)
- 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 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

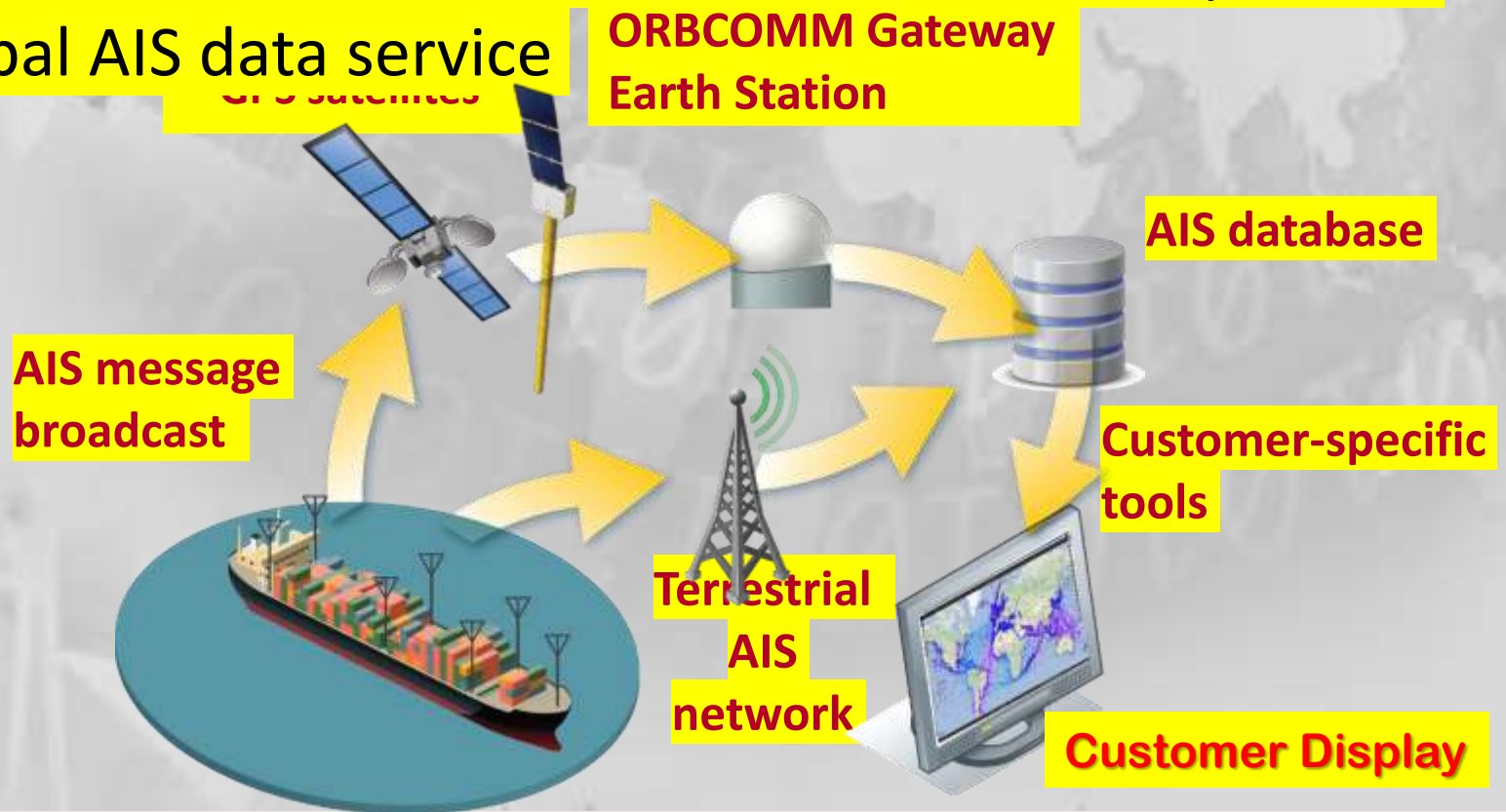
With completion of ORBCOMM constellation

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.

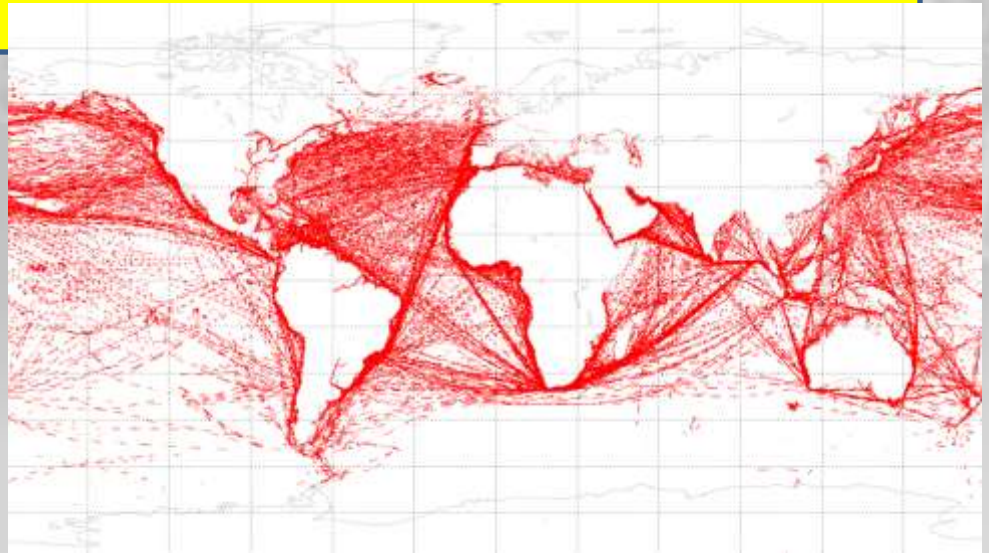
ORBCOMM's Satellite AIS System

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

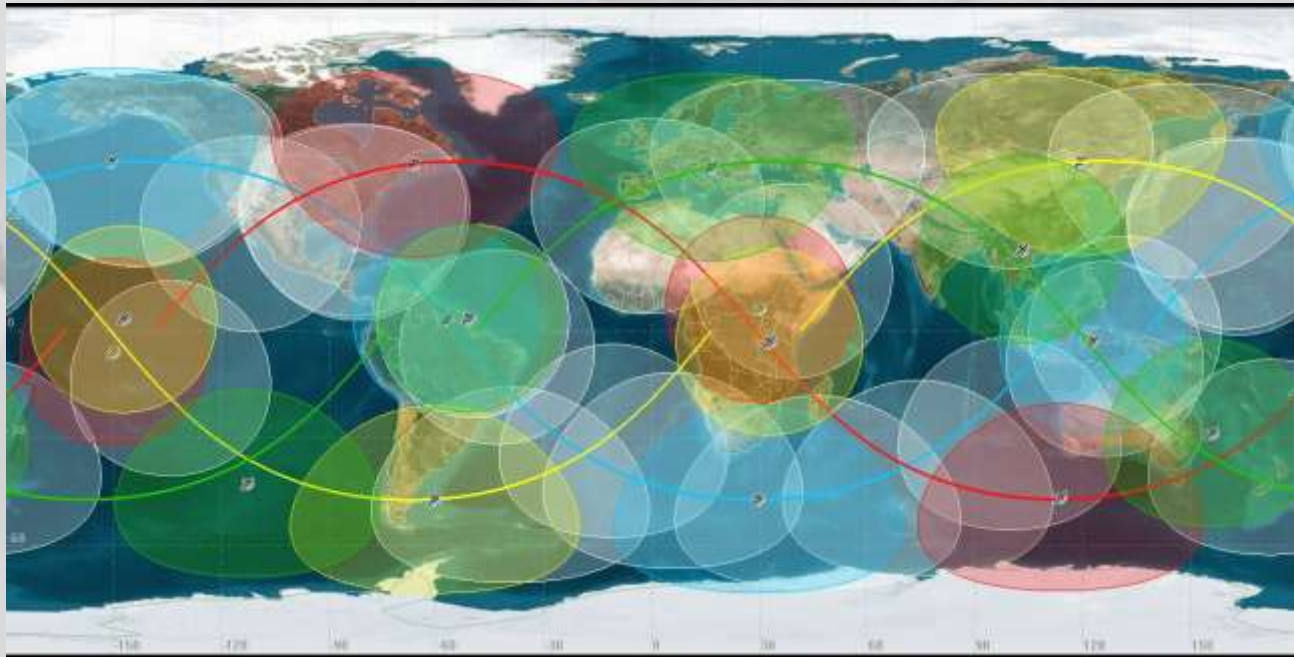


AIS TODAY

- 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.



ORBCOMM CONSTELLATION – SATELLITE FOOTPRINTS



A snapshot in time:
Orbiting satellites provide near
continuous coverage

ORBCOMM GATEWAY EARTH STATIONS

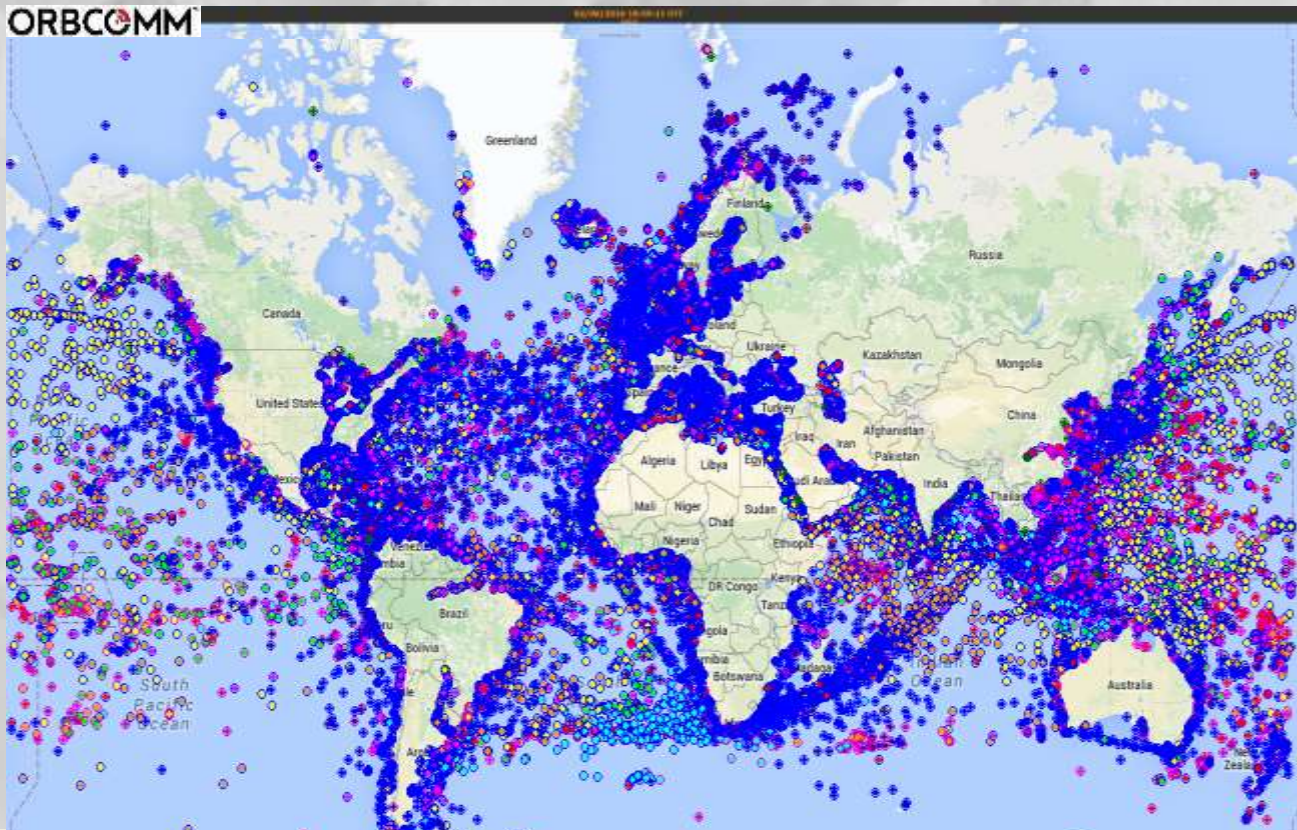


GLOBAL AIS DATA

- Terrestrial AIS provides real-time coverage in

ORBCOMM

Satellite AIS data provides near-real-time complete global coverage



AIS APPLICATIONS BEYOND COLLISION AVOIDANCE

Government



Surveillance and security



Search and rescue



Data fusion with sensors

Government

Commercial



Counter piracy



Environmental monitoring



Incident investigation

Commercial



Logistical tracking

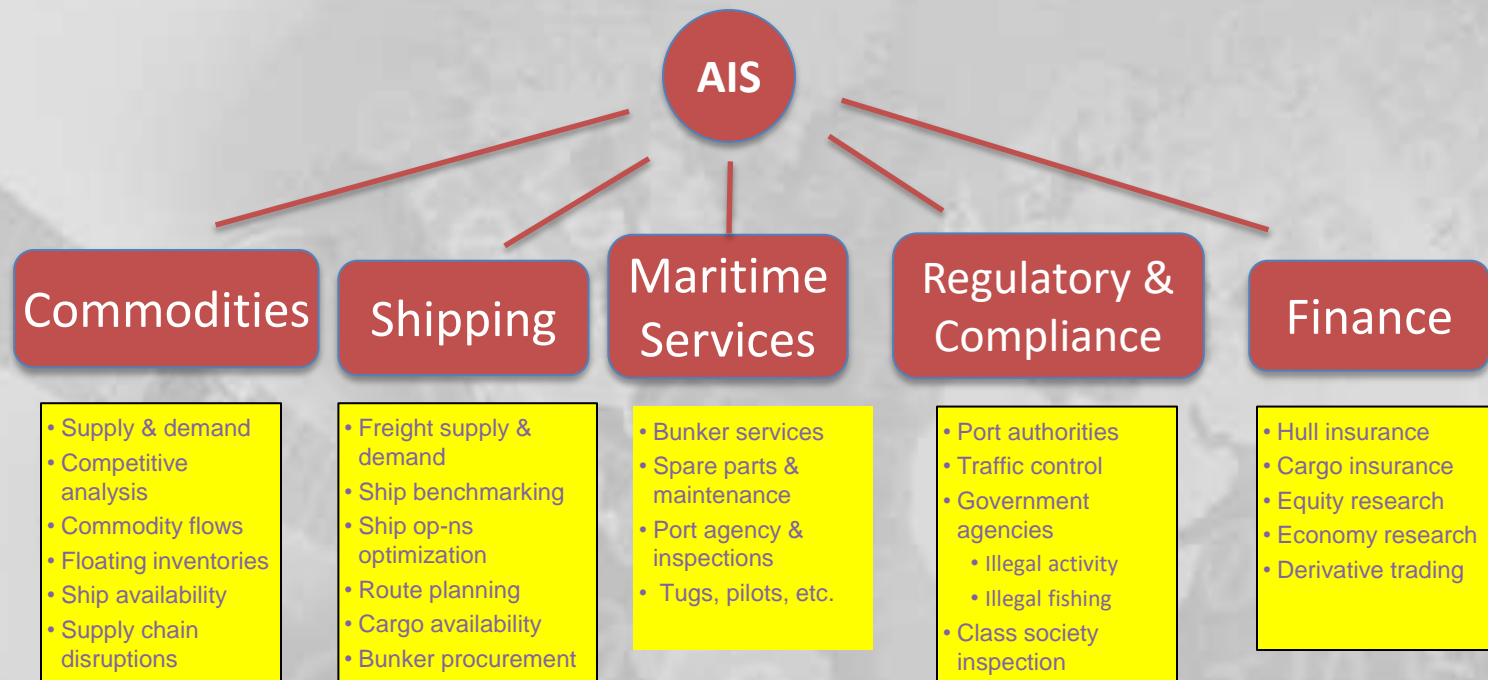


Energy/commodity tracking



Fishing regulation compliance

AIS is used by increasingly diverse participants in the shipping industry



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

AIS IN USE:

FISHERY COMPLIANCE

- 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**.

❖ What are these new, faster systems worth?

❖ “Better is the mortal enemy of good enough.”

Winston Churchill

during the Battle of Britain

➤ **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+ ORBCOMM 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

Global



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

Reliable



ORBCOMM's entire 2-way proprietary global satellite network

1. Attach



Powerful and tamper-proof hardware for vessels of all sizes

2. Collect



Acknowledged AIS & M2M satellite data, anywhere in the world

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

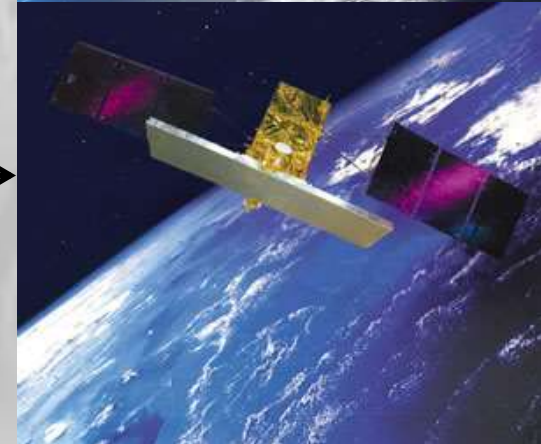
S-AIS & SARSATS

A TRUE SYNERGISM



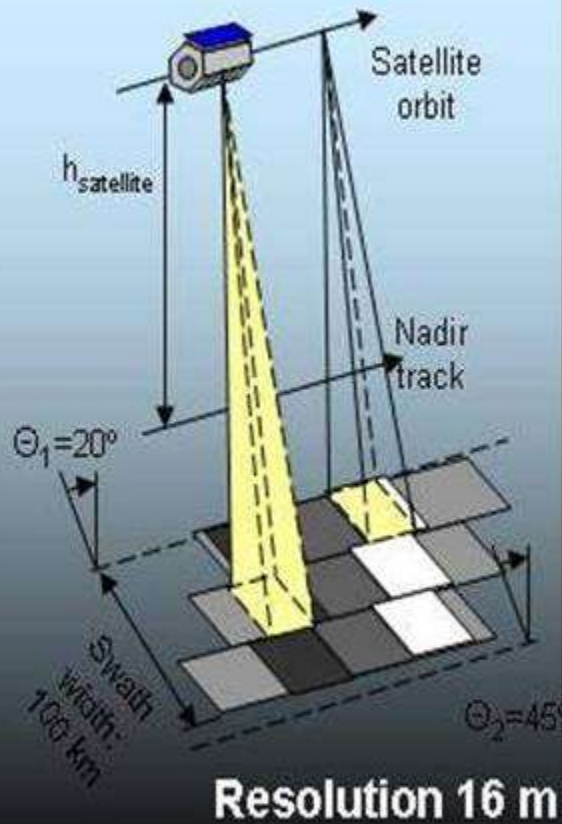
Commercial Space Radar Capabilities

- **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

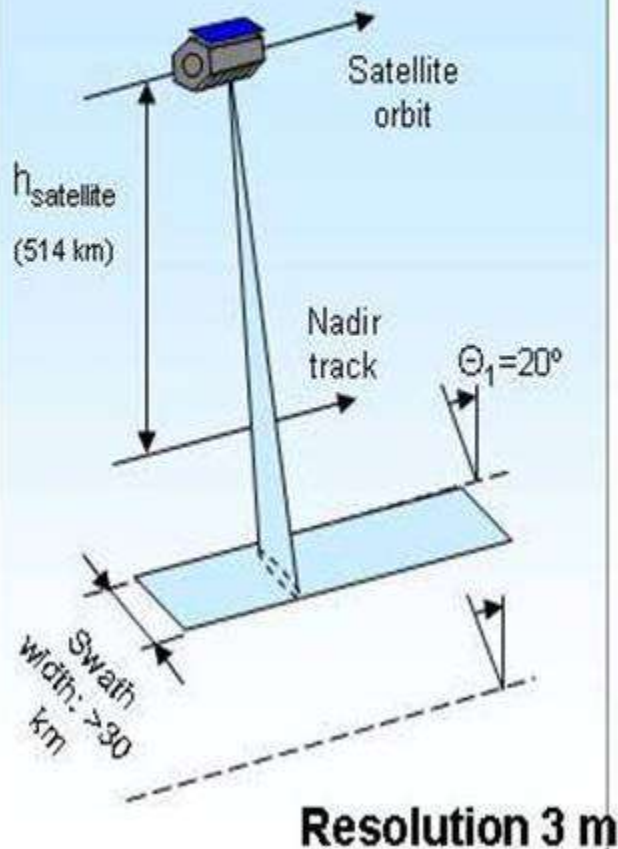


BASIC SAR SAR Modes

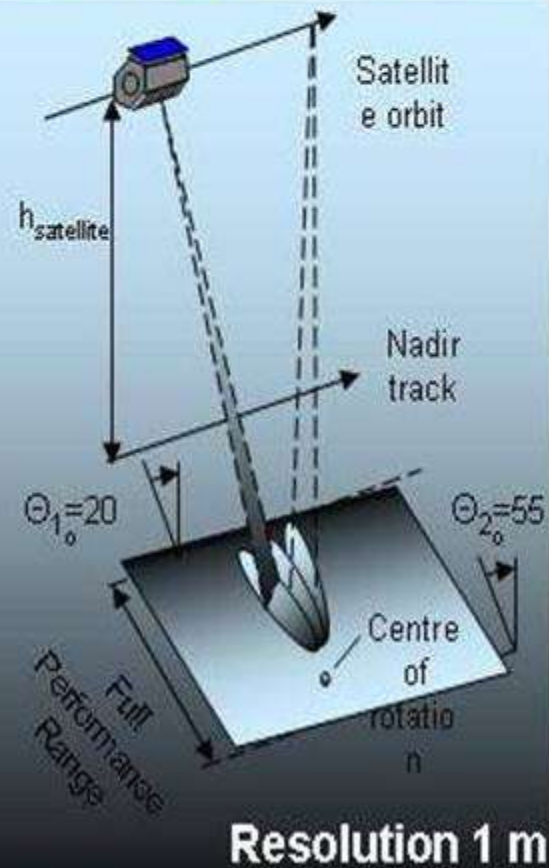
ScanSAR Mode



StripMap Mode



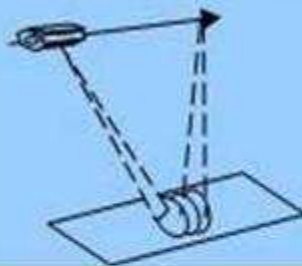
Spotlight Mode



Courtesy of

BASIC SAR SAR Modes with Resolution

Spotlight



Strip Map



ScanSAR



res.: $\ll 1$ m

identification of tanks possible (T72, Leo,...)



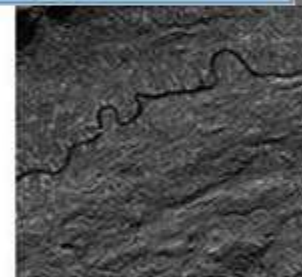
res.: 1.0 m

recognition of airplanes (Transport, Fighter,...)



res.: 3.0 m

detection of infrastructure (roads)



res.: 16.0 m

detection of coarse land cover features

Identification

Recognition

Detection

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



Photo courtesy of GEO-EYE

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



Photo courtesy of GEOEYE

1/2 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

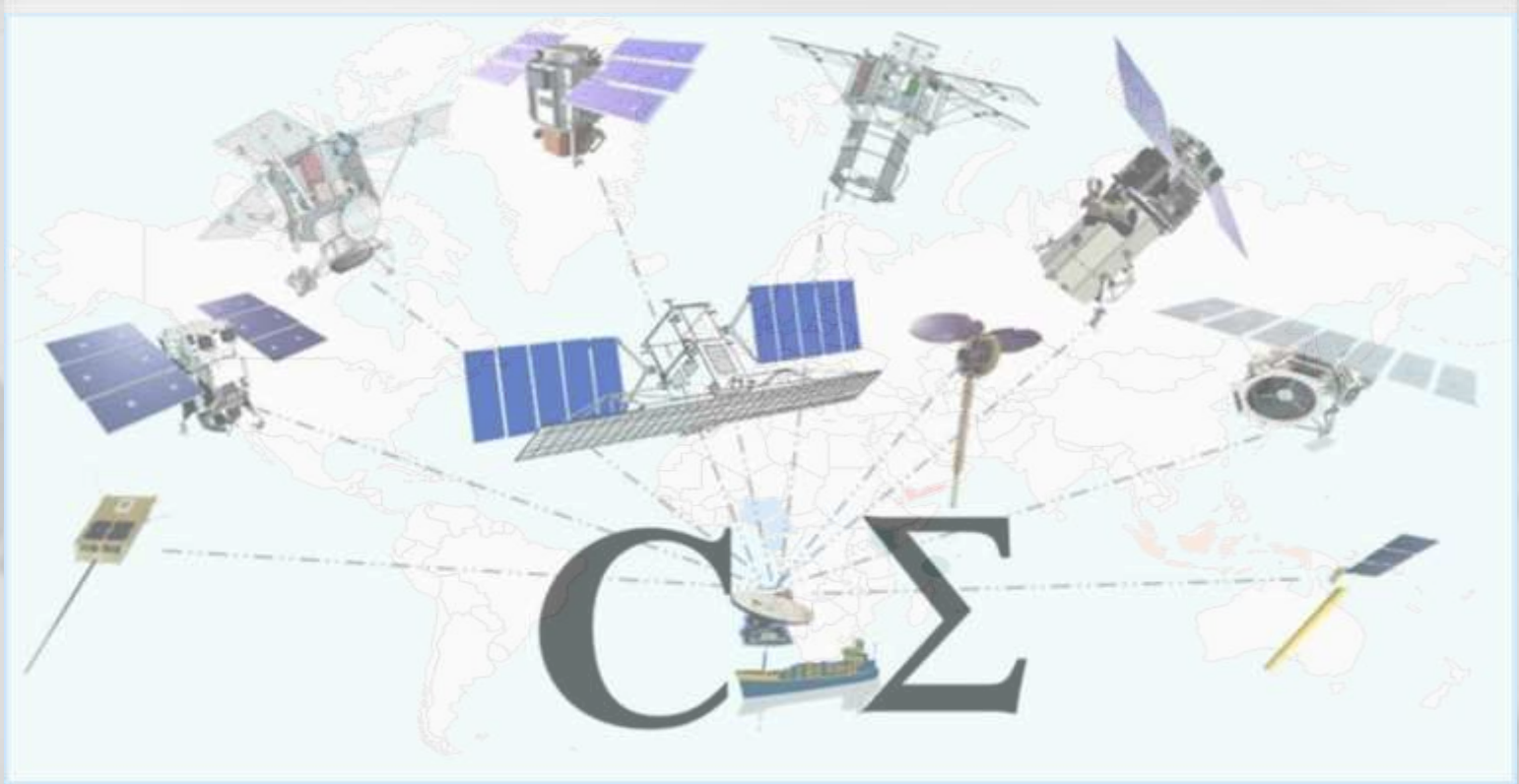


Dynamic Data Analysis (DDA)

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

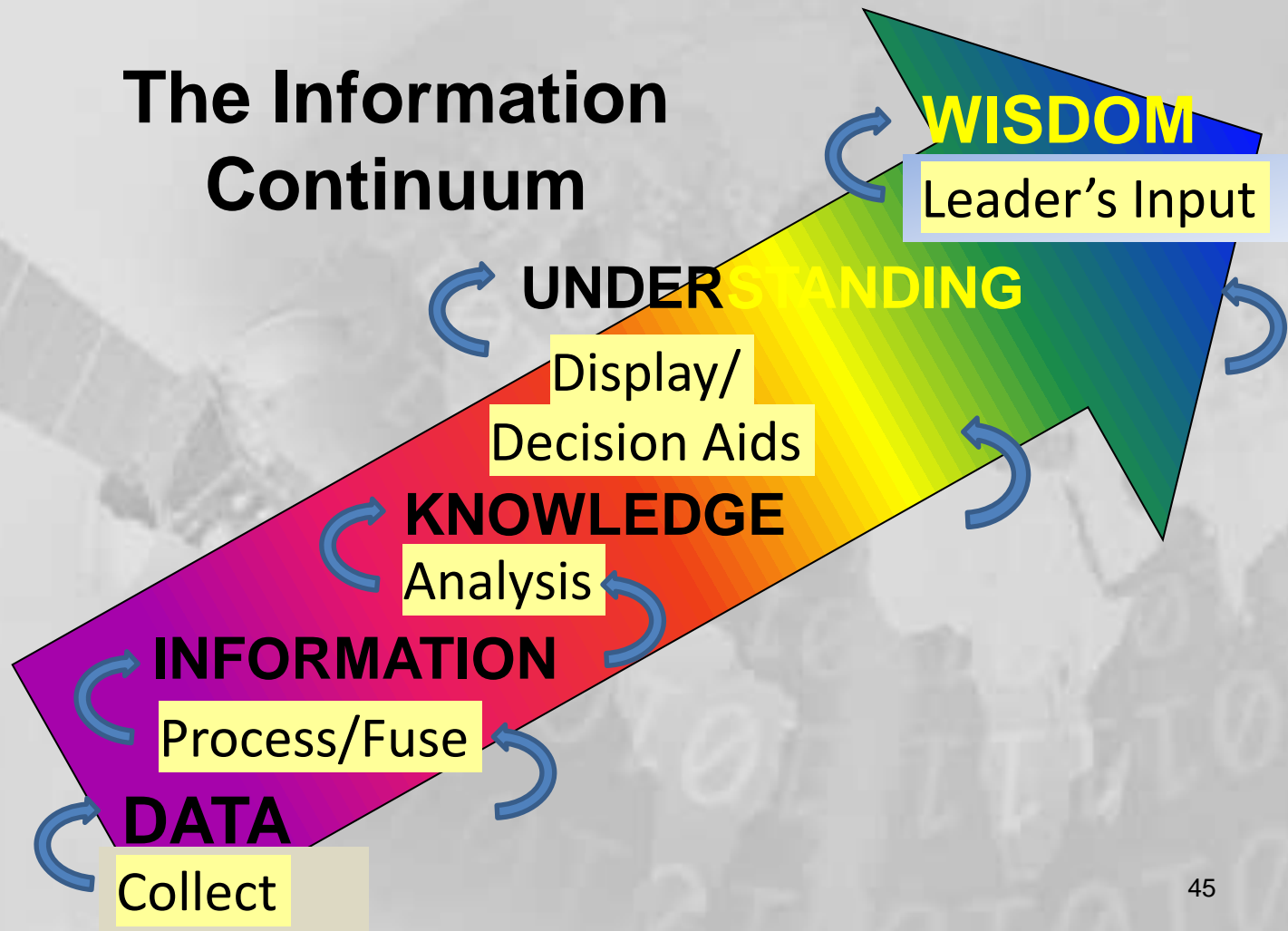
Maritime Domain Awareness (MDA)

Is not Rocket Science!

**MDA is a lot harder!
(many more variables)**

German Aerospace Engineer

The Information Continuum



**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 ?

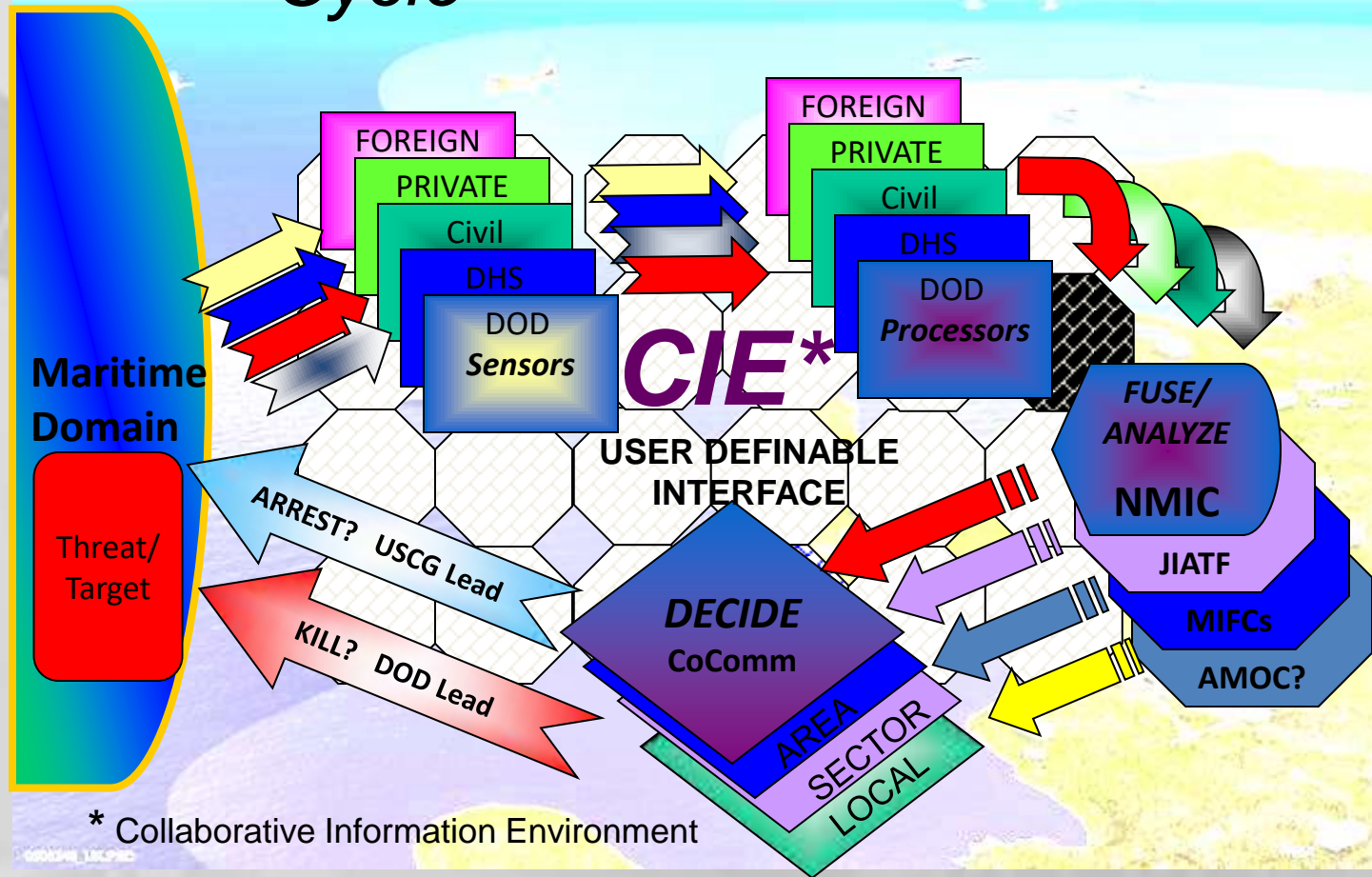


Fire Away!

The background is a light gray composite image. It features a globe in the center, overlaid with faint binary code (0s and 1s). A satellite with solar panels is visible on the left side, angled towards the center.

Backups

Sense - Decide - Act Cycle



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.....

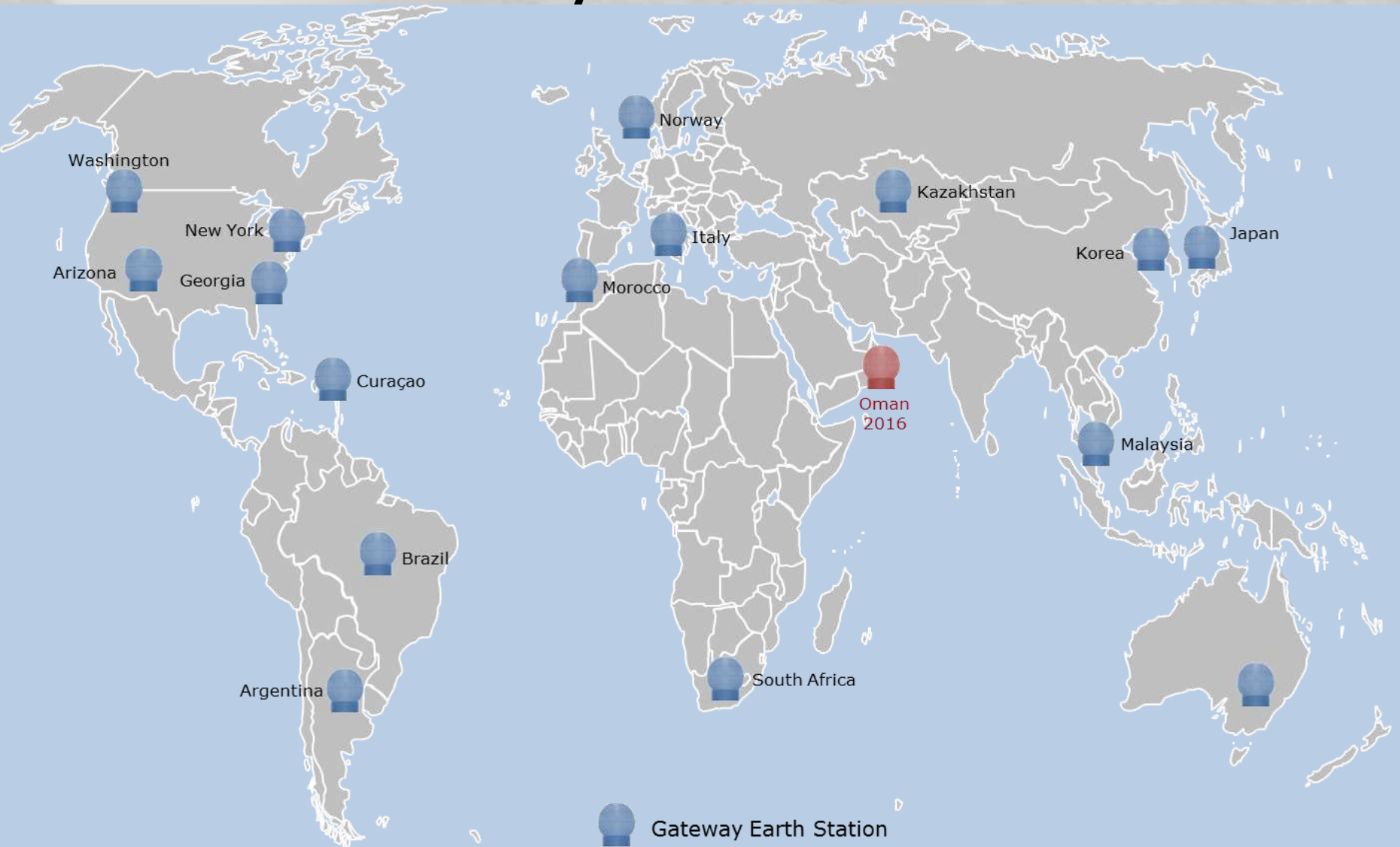
National Space Policy (PPD-4)

Implementation Task #1

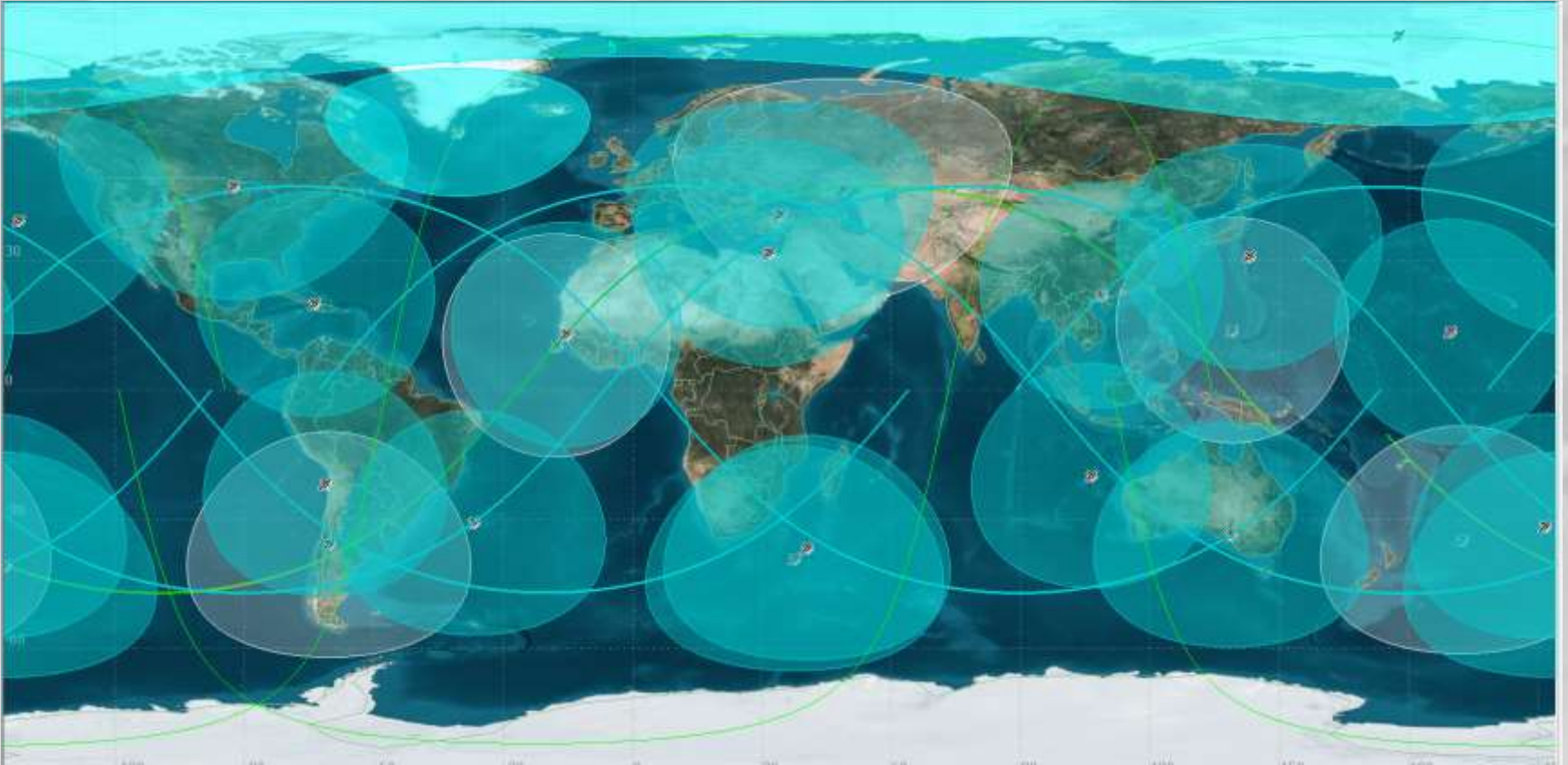
“(U) Working through the National Maritime Domain Awareness Coordination structure, the Secretaries of Defense, Homeland Security, Transportation, State and Commerce, will develop an unclassified, international available program to foster international collaboration using civil and commercial space systems 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

Gateway Earth Stations



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



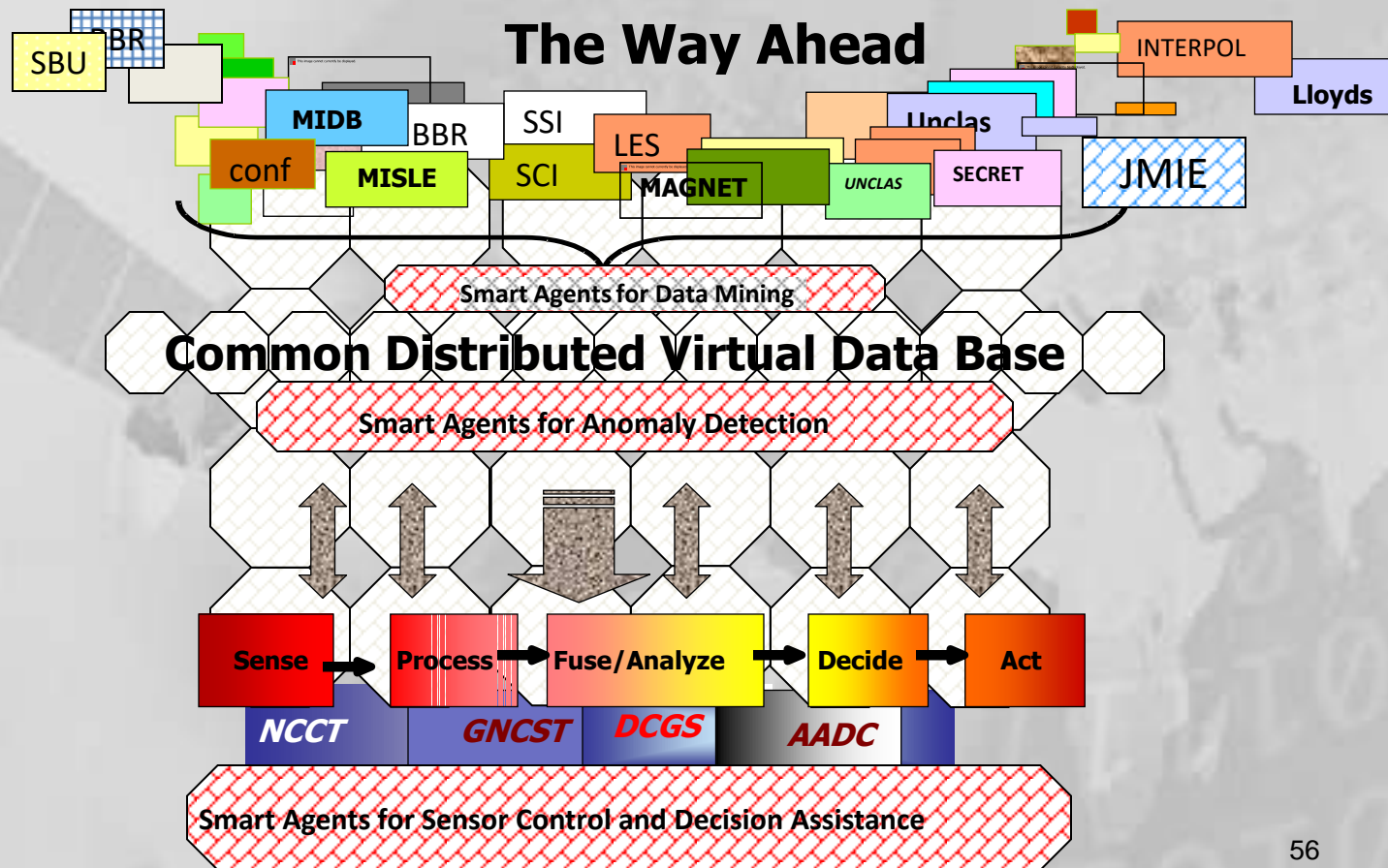
**Collaboration in Space for
International Global Maritime Awareness**

C-SIGMA

www.C-SIGMA.org

Horizontal Fusion/Integration

The Way Ahead



A faint, light gray world map is visible in the background of the slide, centered behind the yellow text box.

SPACE-BASED MARITIME SITUATIONAL AWARENESS WHERE 3 GLOBAL COMMONS CONVERGE

**You Cannot Surge Trust!
It needs to be earned.**

ADM Mike Mullen