
GLOBAL SPACE PARTNERSHIP
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
MDA
Guy Thomas
george.g.thomas@uscg.dhs.gov

C-SIGMA

Providing Environmental Monitoring*

Increasing Security*

Enabling Safety Efforts*

Guarding Natural Resources*

- Fish
- Energy
- Mineral

GLOBALLY!

**Maritime & Otherwise*

C-SIGMA

Not a Program

Not a Canned Solution

Not Even a Proposal

Governance is NOT Discussed

Is an Technology Examination

Is an Awareness Effort

A Call to Action!

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C-SIGMA

- **Special Thanks to:**
  - * **CSTARS** – University of Miami
  - * MacDonald Detweiler & Associates (MDA)
  - * Johns Hopkins University/Applied Physics Lab (JHU/APL)
  - * Ball Aerospace
  - *DLR

C-SIGMA Concept

USE TODAY'S COMMERCIAL SATELLITE TECHNOLOGY

- Inexpensive
- Readily available
- Worldwide coverage
- Wide choice of sensors

AUTOMATE ALL PROCESSING

- Get results fast
- Keep it simple and easy to use
- Minimize manpower and user intervention

C-SIGMA Concept (continued)

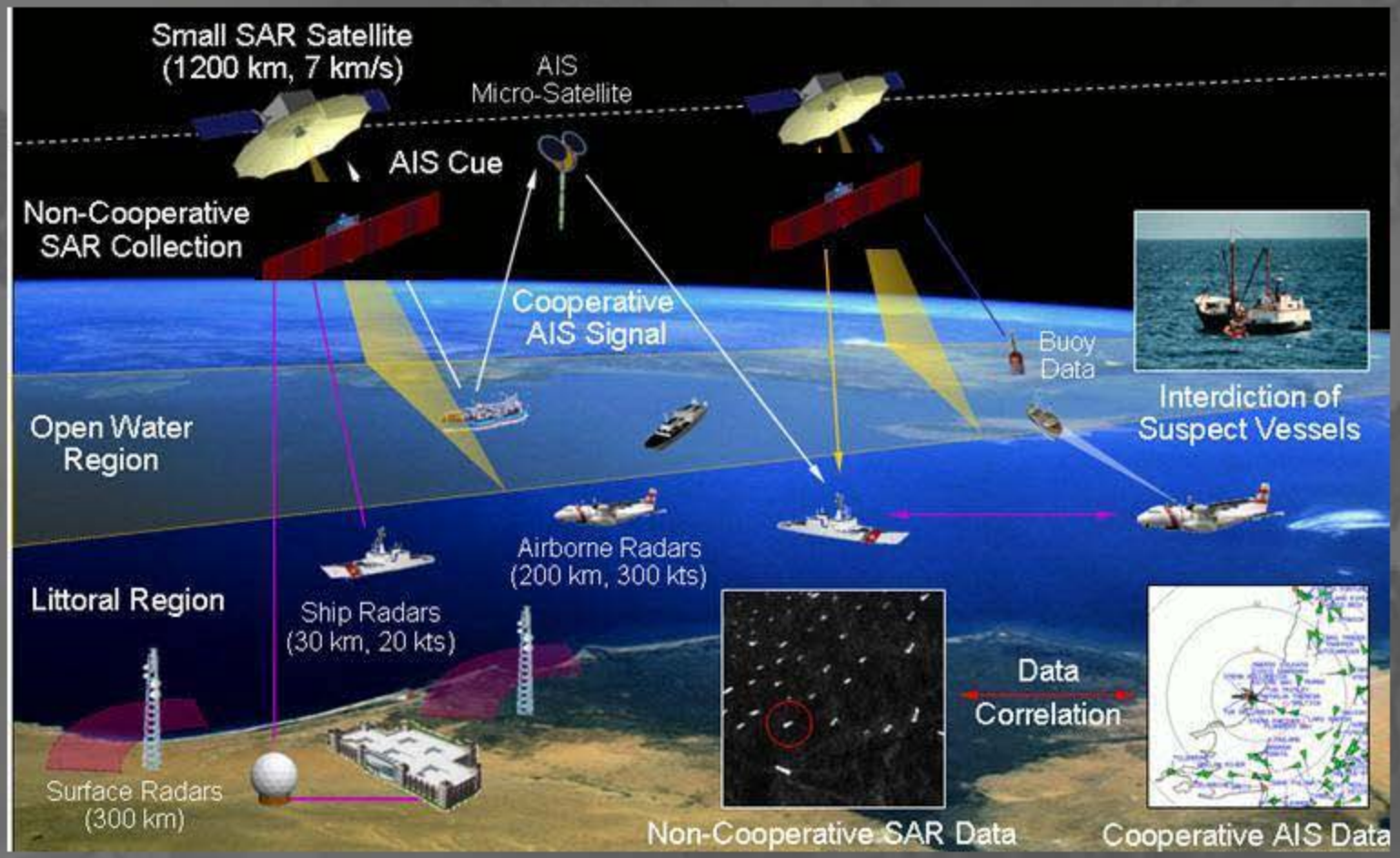
Be able to monitor large Ocen Areas
* Wide Area Persistent Surveillance

Able to re-survey area quickly

Accurately detect Vessels of interest
* Minimize false hits
* Increased Probability of Detection

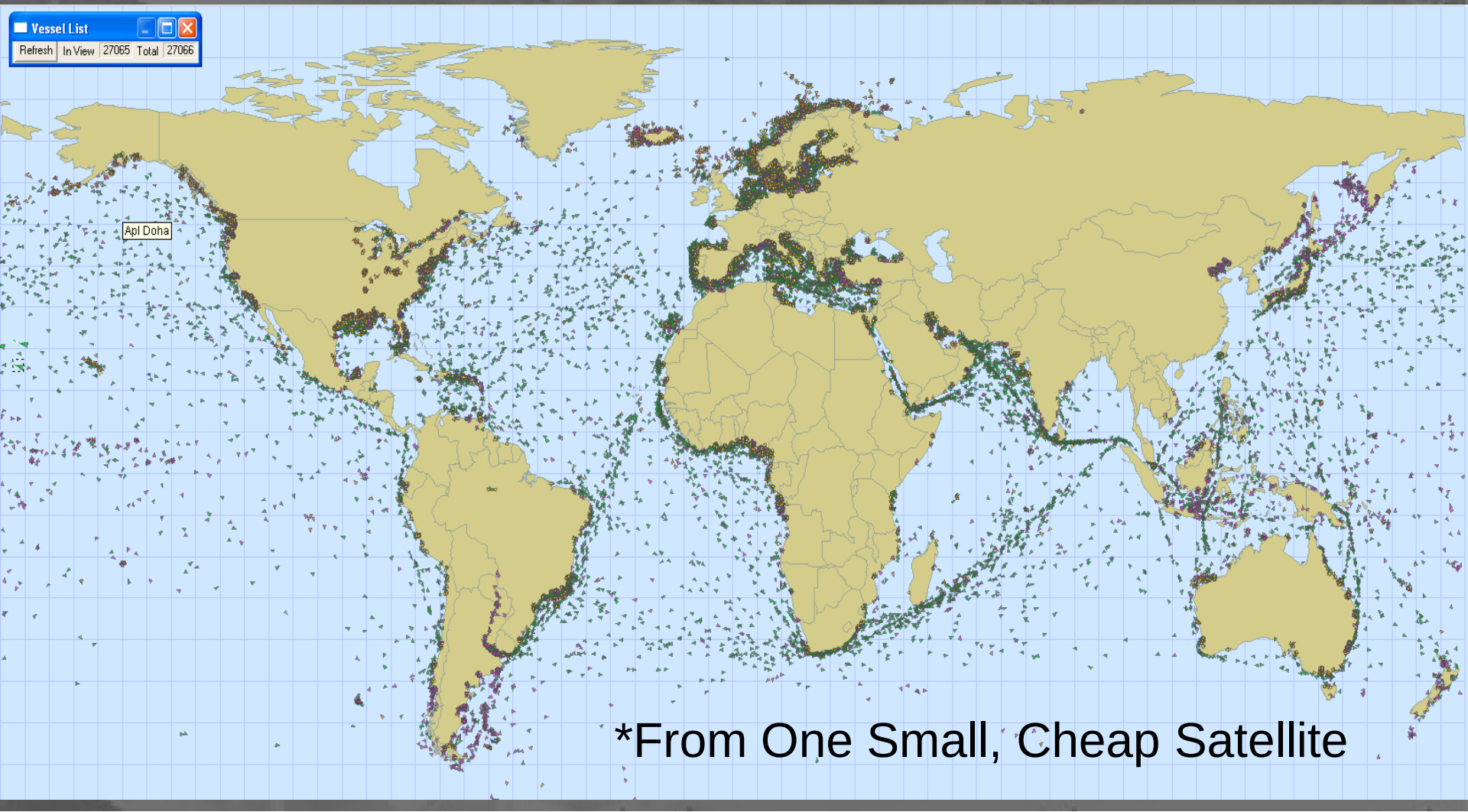
LiMES

Global Maritime Awareness



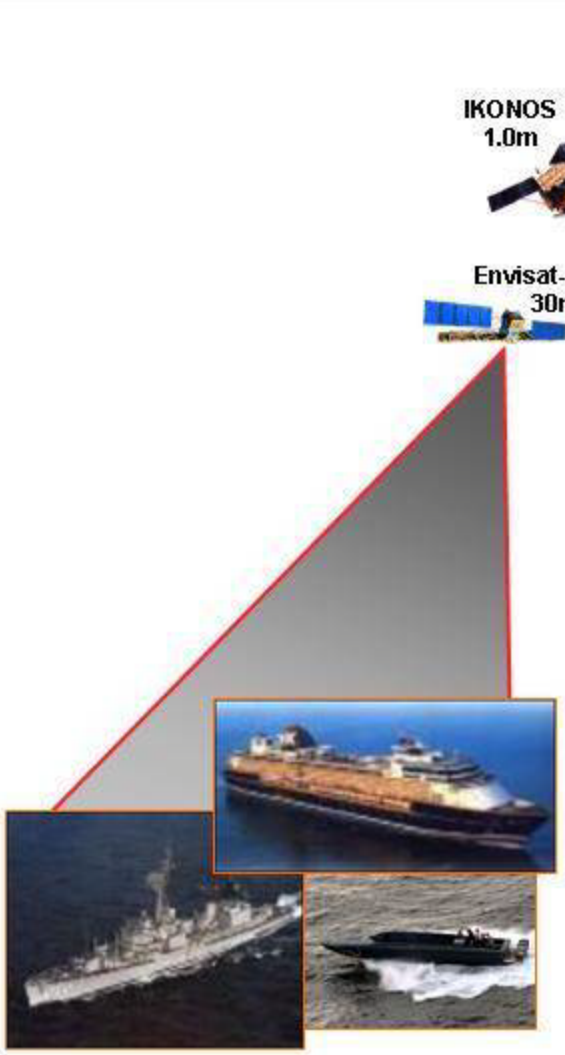
Collaboration is THE Silver Bullet

Combined MSSIS & S-AIS*



*From One Small, Cheap Satellite

C-SIGMA Concept



Orbview 3
1.0m

IRS P6
5.0 – 56m

IKONOS
1.0m

RADARSAT1
8.0m – 30m

Envisat-ASAR
30m

SPOT 2/4/5
2.5-20m

CSTARS Ground Station

Intelligence Support Centers
SouthCom, NorthCom

Downlink	Process	Intelligence
Direct Downlink in Mask:		< 60 minutes
Store & Foreward:		< 2.5 hours (90 min + 60 min)

Courtesy CSTARS

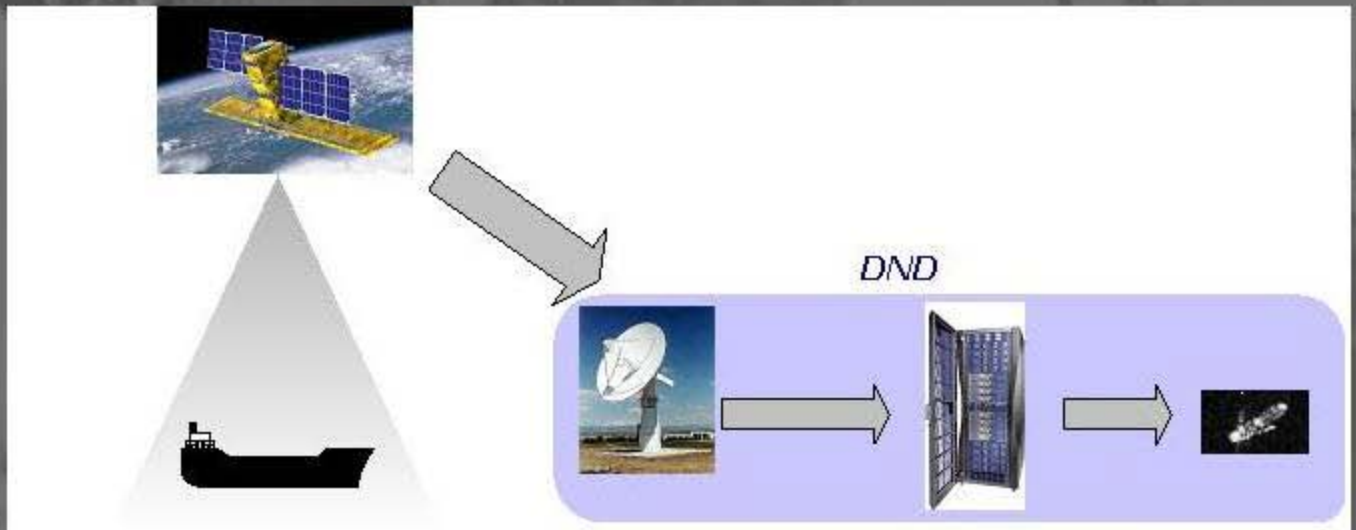
Important Factors re Maritime Awareness from Space

- **Integrated into Existing Surveillance Efforts**
- **Data Latency Drives Relevance of data & Provides cross-cueing opportunities**

- **Applications:**
  - **Detection: Wide Area Surveillance requires reliable detection**
    - **Largest Possible Swath & Shortest Revisit Time**
  - **Classification: AIS & Other Self Reporting Systems (or lack thereof)**
  - **Identification: High Resolution EO/IR**

Data Latency

- Drives Tactical Relevance of Data
- Drives Cross Cueing Opportunities



Acquire Target	Downlink Data	Process
Time to complete Task	Real-Time	5-30 minutes

Courtesy of MDA

4 Types of Satellites
(at a minimum)

- Synthetic Aperture Radar (SAR)
- EO/IR Imaging
- AIS Collectors
- Transponders

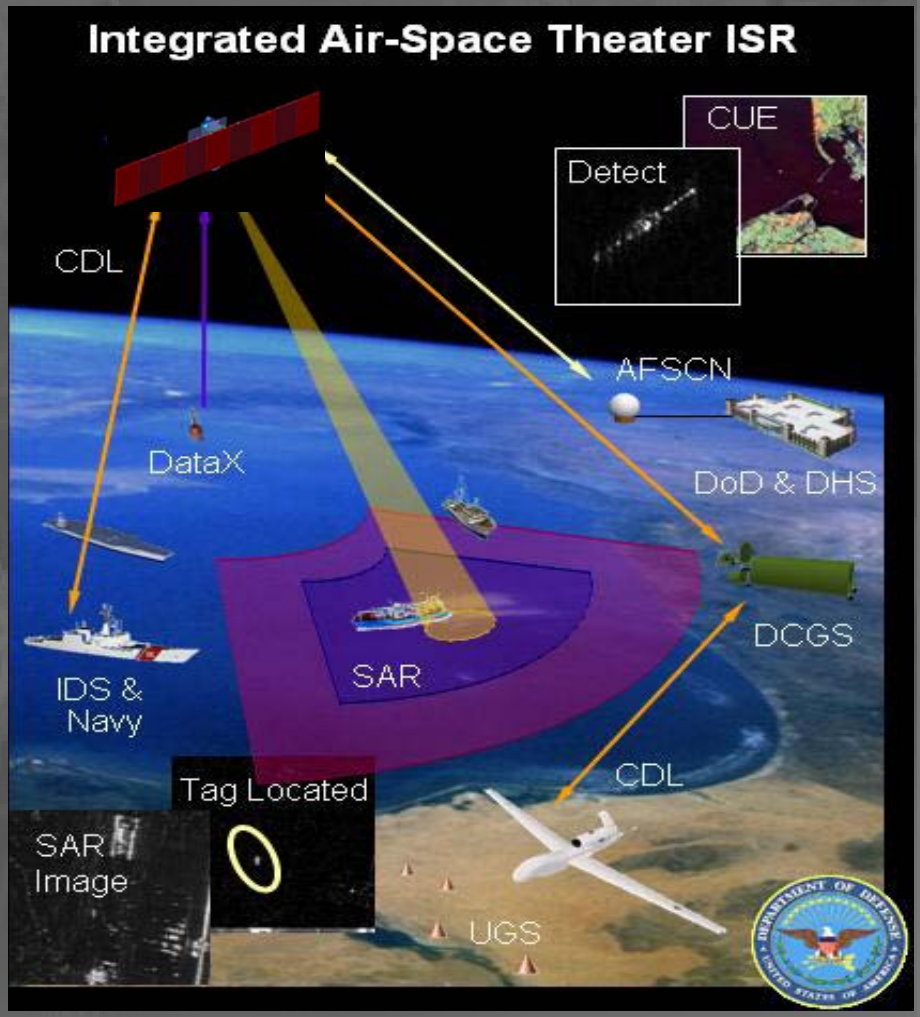
Each makes UNIQUE contributions

1st Part of C-SIGMA Equation

SARSats

Space-Based SAR Provides Global Access

- **All-Weather, Day-Night, Dynamically-Tasked, Tactical-Resolution SAR**
  - Optimized for large area collections Cues higher-resolution systems - Tipping & Cueing
- **Repeat Orbit**
  - Nominal 24 Hour Repeat
  - Optimal CCD over wide area
  - Maritime Domain Awareness
  - Non-SAR Mode for Vessel Detection
  - SAR mode for wake detection
- **Simultaneous SAR Imaging & Tagging**
- **TPED using existing ISR Infrastructure**
  - Theater tasking/downlink
  - Automated CCD Processing

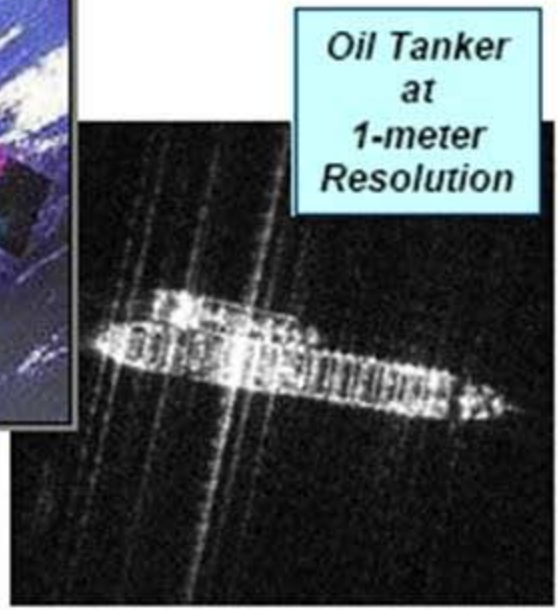


Analysis of Change Indicates Potential Activities of Interest

Courtesy of Ball Aerospace


RADAR SAT 2
Courtesy of
MDA

Cosmos Sky Med



Technology

- Constellation of four X-band SAR imaging satellites with multi-polarization

The So What

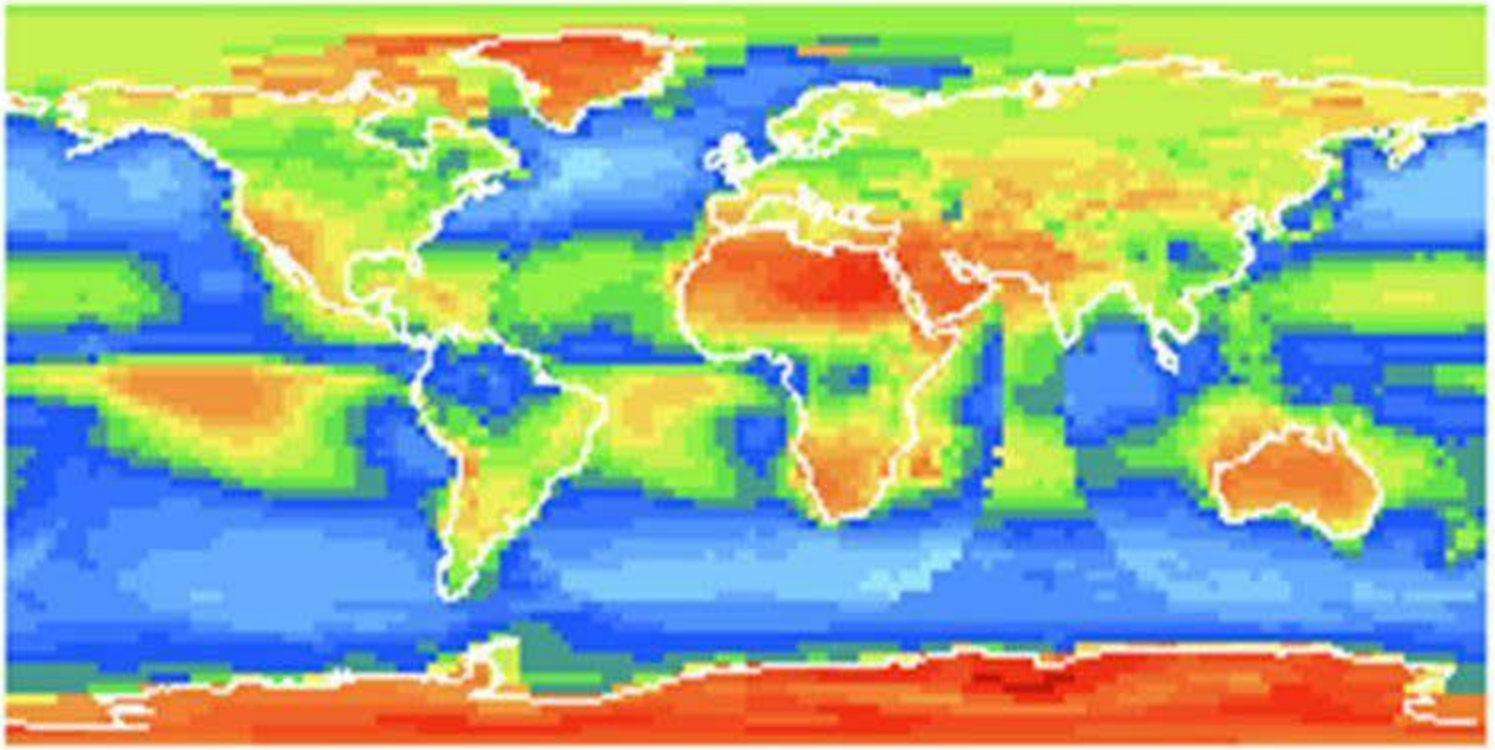
- Resolutions from sub-meter in spot-light mode through several tens of meters
- Rapid revisit, improved persistence, 24-hr, global coverage
- The only commercial imagery satellite constellation with this capability
- Dual-use system for defense and civil applications

SARS launched in Last Year

	RADARSAT II	TerraSAR-X	Cosmo - SkyMed
Manufacturer	MDA - Canada	EADS Astrium GmbH/DLR – Germany	Telespazio - Italy
Commercial Imagery Provider	MDA - Canada	infoterra - Germany	eGeos- Italy
Band & Polarity	C-band multi-polarimetric	X-band multi-polarimetric	X-band multi-polarimetric
Orbit / Repeat / Revisit	Sun-Synchronous Polar / 24 days / Hours north of 48 latitude	Sun-Synchronous / 11 days / 2.5 days	Sun-Synchronous / 6 hours / Less than 12 hours
Satellites in Constellation	One operational with a Tandem planned	One operational, undergoing acceptance testing with a TanDEMX planned	Four with two operational, one awaiting launch (23-24 Oct 08), one in build
Modes & Resolution in Meters	Ultra-Fine – 3 meters Fine – 8 meters ScanSAR – 50 meters + 7 add'l beam modes	Spotlight – 1 meter Strip Map – 3 meters Scan SAR – 18 meters	Spotlight – sub-meter HIMAGE – 3 meters WideRegion - tens of HugeRegion - >tens of
NIIRS (Estimated)	3	5	6
Projected Life	7 years	5 years	5 years

Why SAR?

World-wide Cloud Cover Prevalence (8 year mean average)

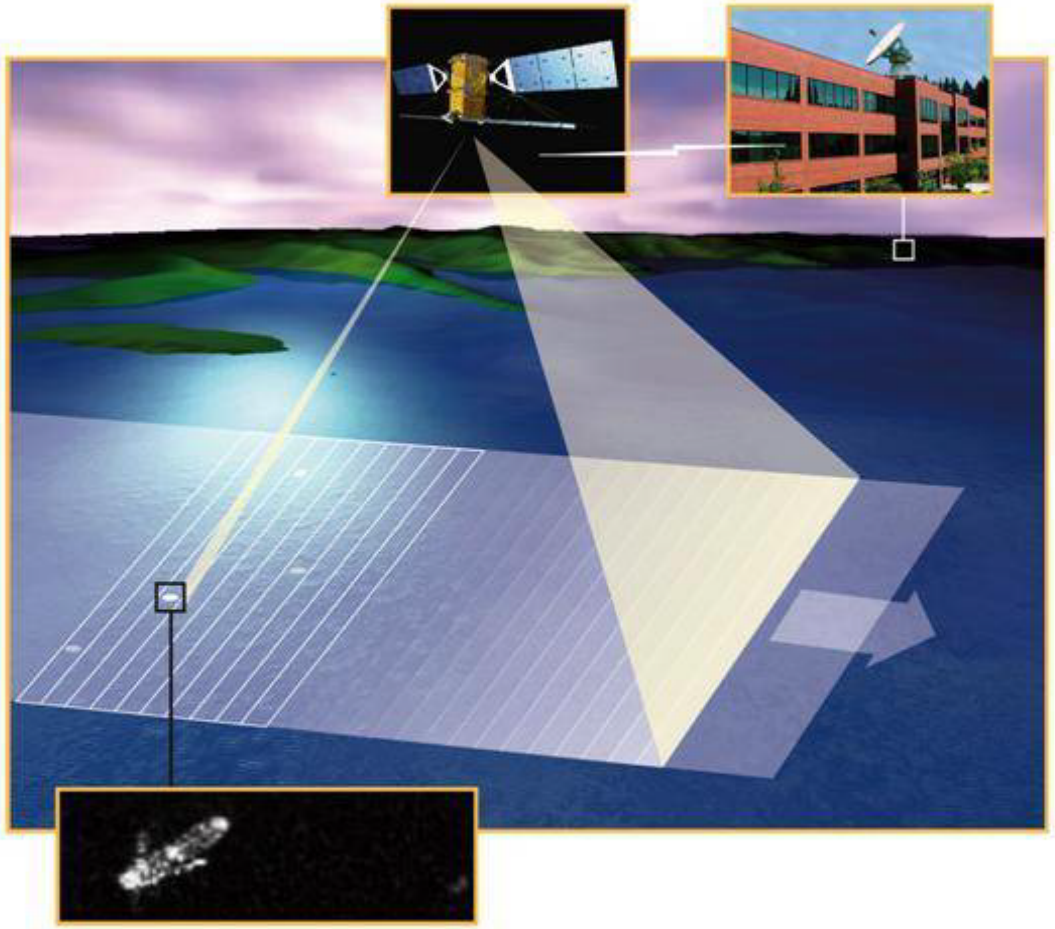


Cloud Amount (%)

0 20 40 60 80 100

Courtesy of infoterra

SARSAT CONOPS

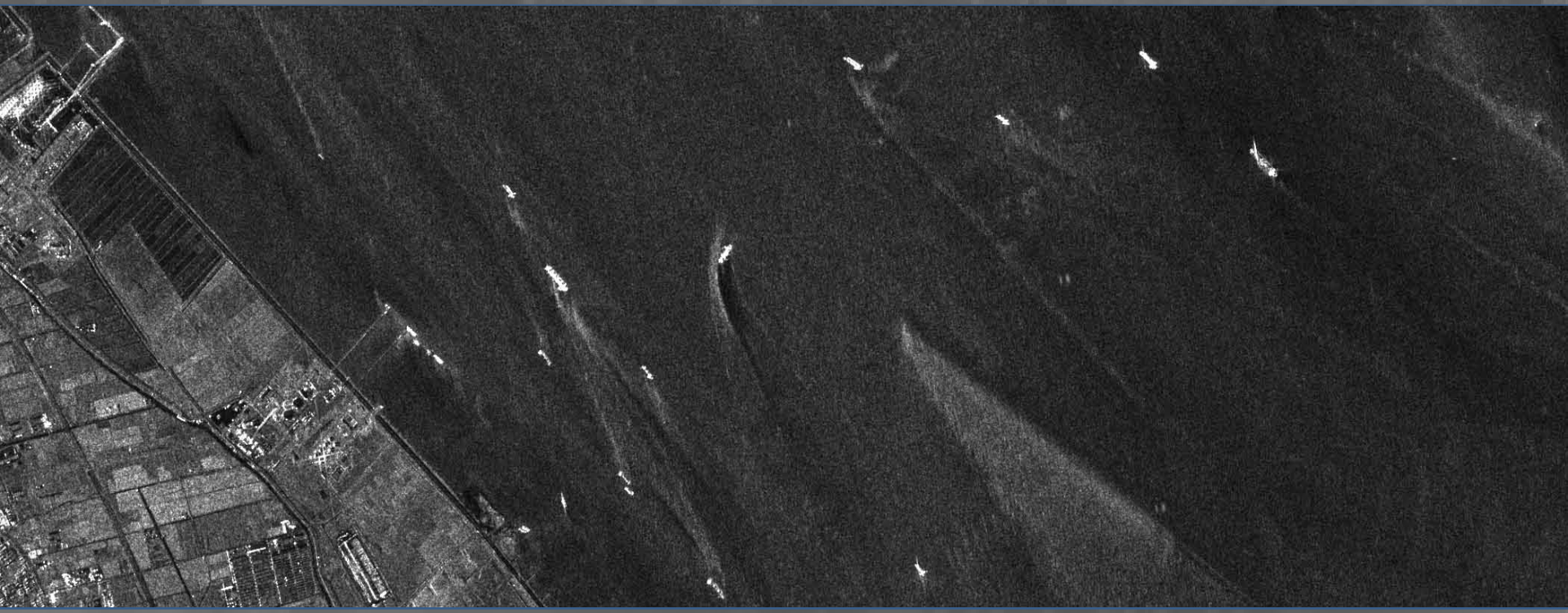


Courtesy MDA

--SARSAT systematically images areas of interest

- Ground System receives, processes and detects targets in real time, uplinking probable target coordinates back to RADARSAT-2.
- RADARSAT-2 places a 10m resolution beam on probable targets to capture an image of the target.
- Ground System creates a 10m image chip and derived Target Detection Report.

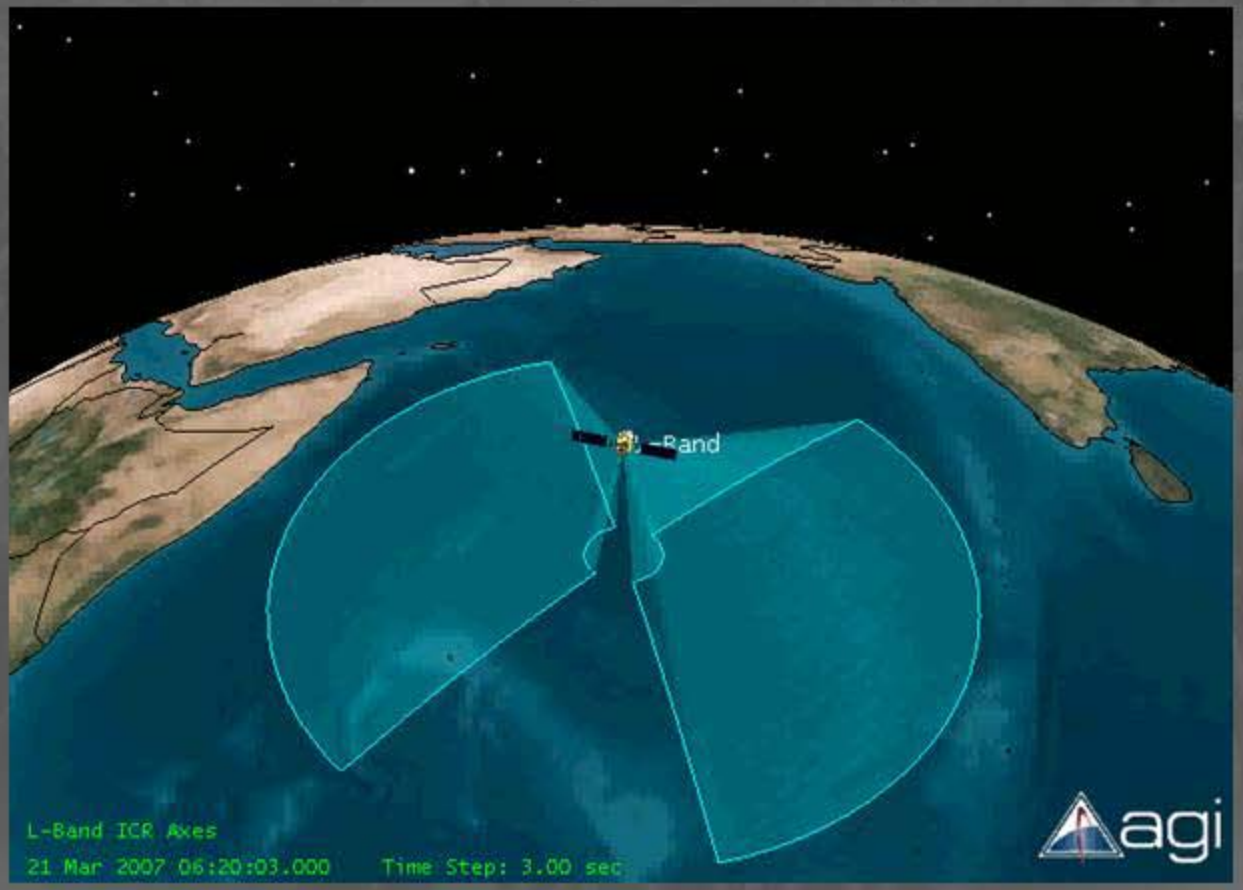
Cosmo-SkyMed 1,



StripMap-HI imaging mode; 5 m resol.
13 Nov 2007 16:13 UTC,
Descending orbit, Left looking

2-D AESA Offers Agile Collection Capability

- No need to slew vehicle
- No missed collect if on wrong side of vehicle track
- Greatly increases area coverage rates

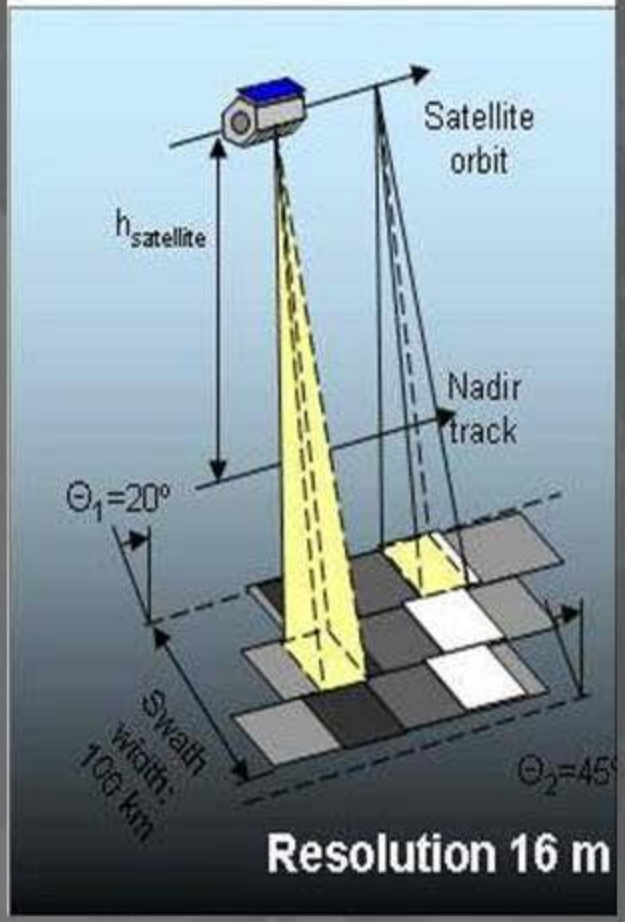


Nadir Facing 2-D Electronically Steered Phased Array Offers Agile Collection with Tasking on Either Side of Vehicle Track

Courtesy Ball Aerospace

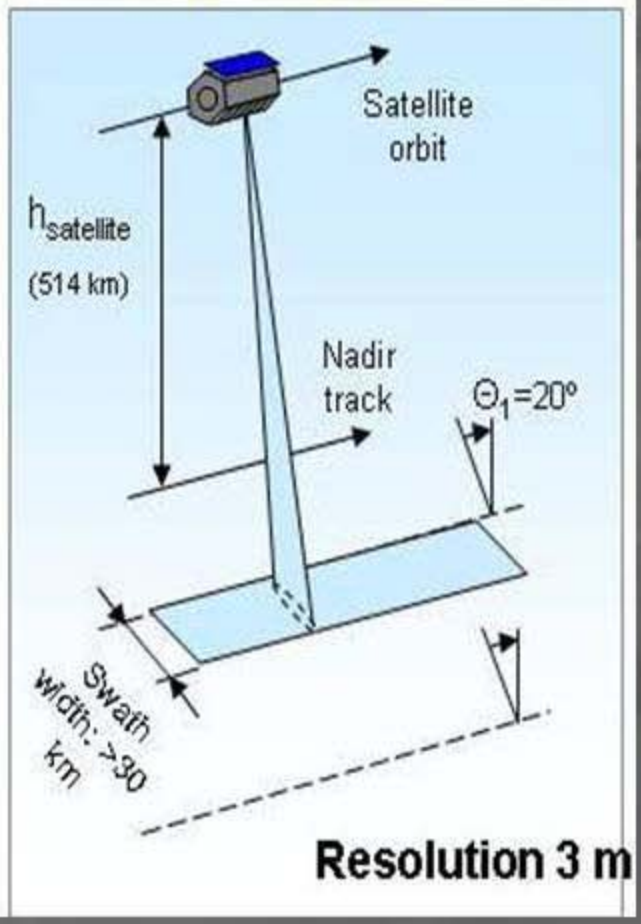
BASIC SARSAR Modes

ScanSAR Mode



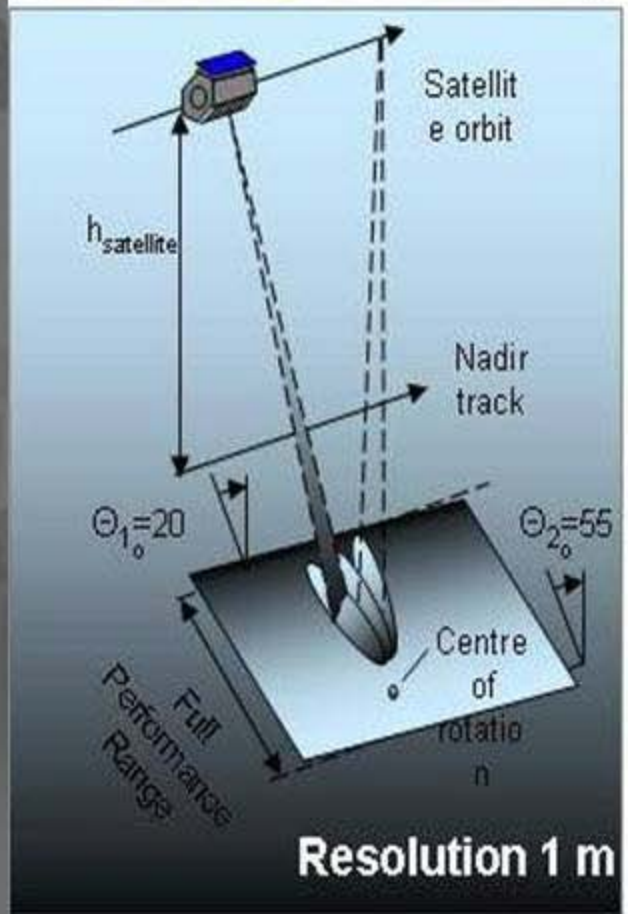
Resolution 16 m

StripMap Mode



Resolution 3 m

Spotlight Mode



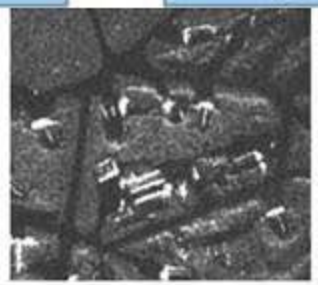
Resolution 1 m

Courtesy of infoterra

BASIC SARSAR Modes with Resolution

res.: << 1 m

identification of tanks possible (T72, Leo,…)

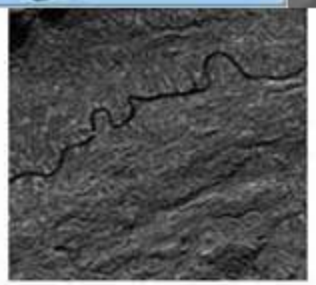


res.: 1.0 m

recognition of airplanes (Transport, Fighter,…)

res.: 3.0 m

detection of infrastructure (roads)

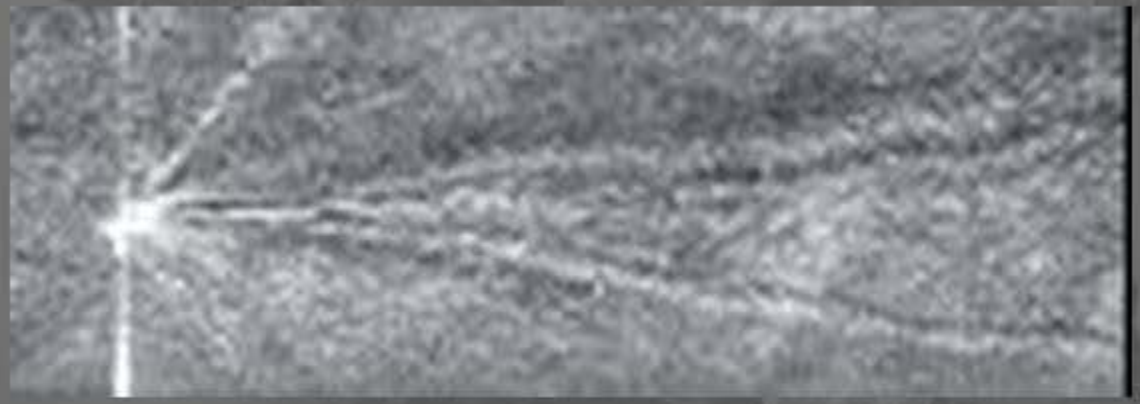


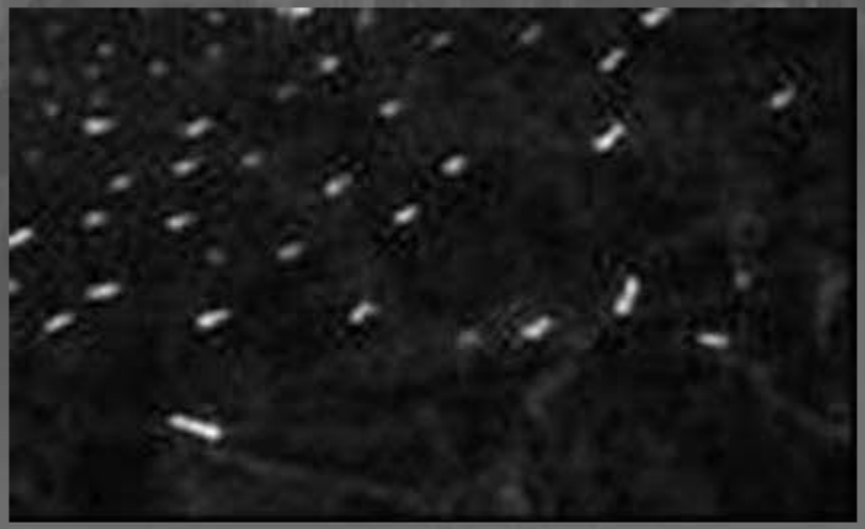
res.: 16.0 m

detection of coarse land cover features

L-Band SARSat

Wake and Ship Detection

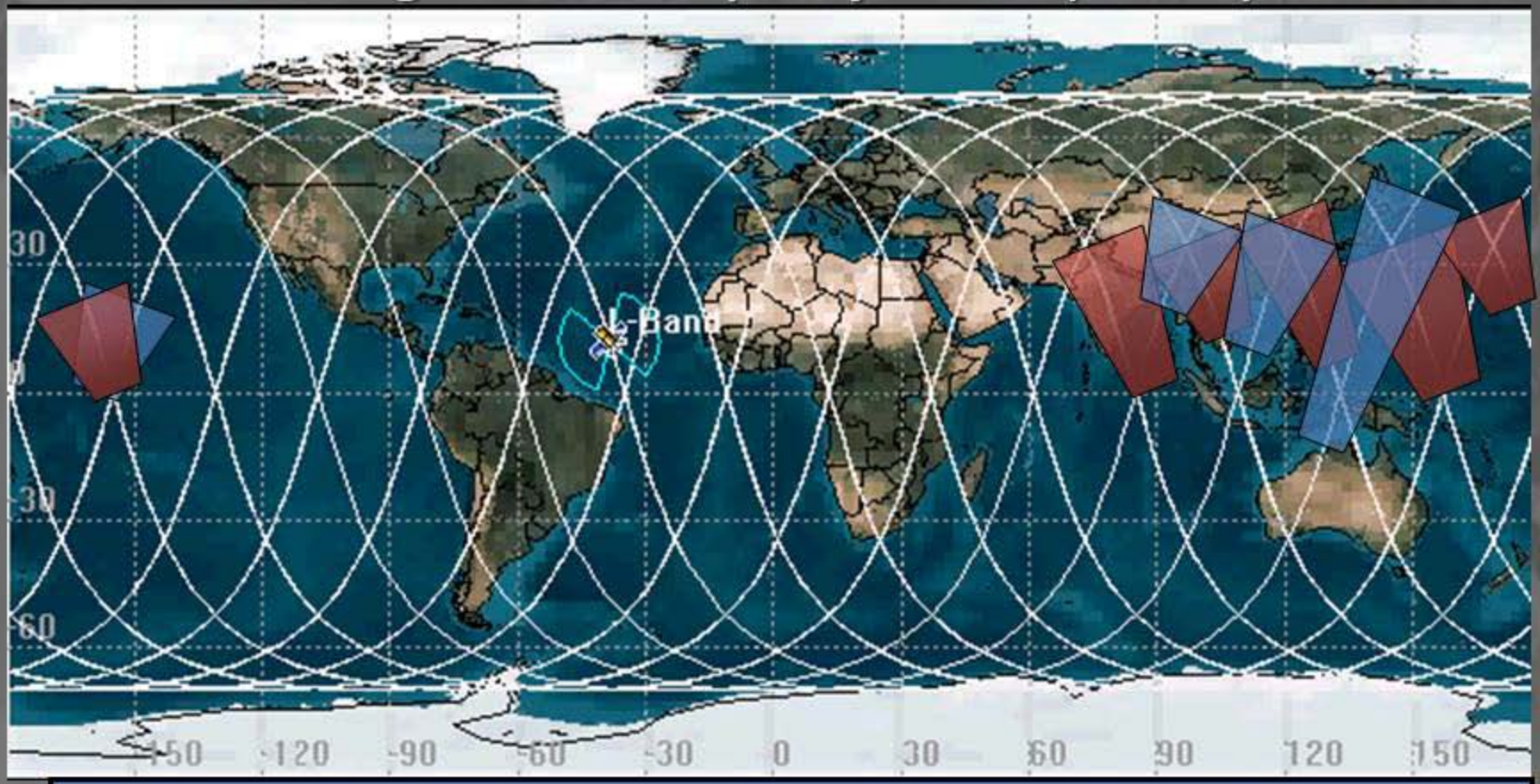




Courtesy of
Ball Aerospace

L-Band SAR CONOPS

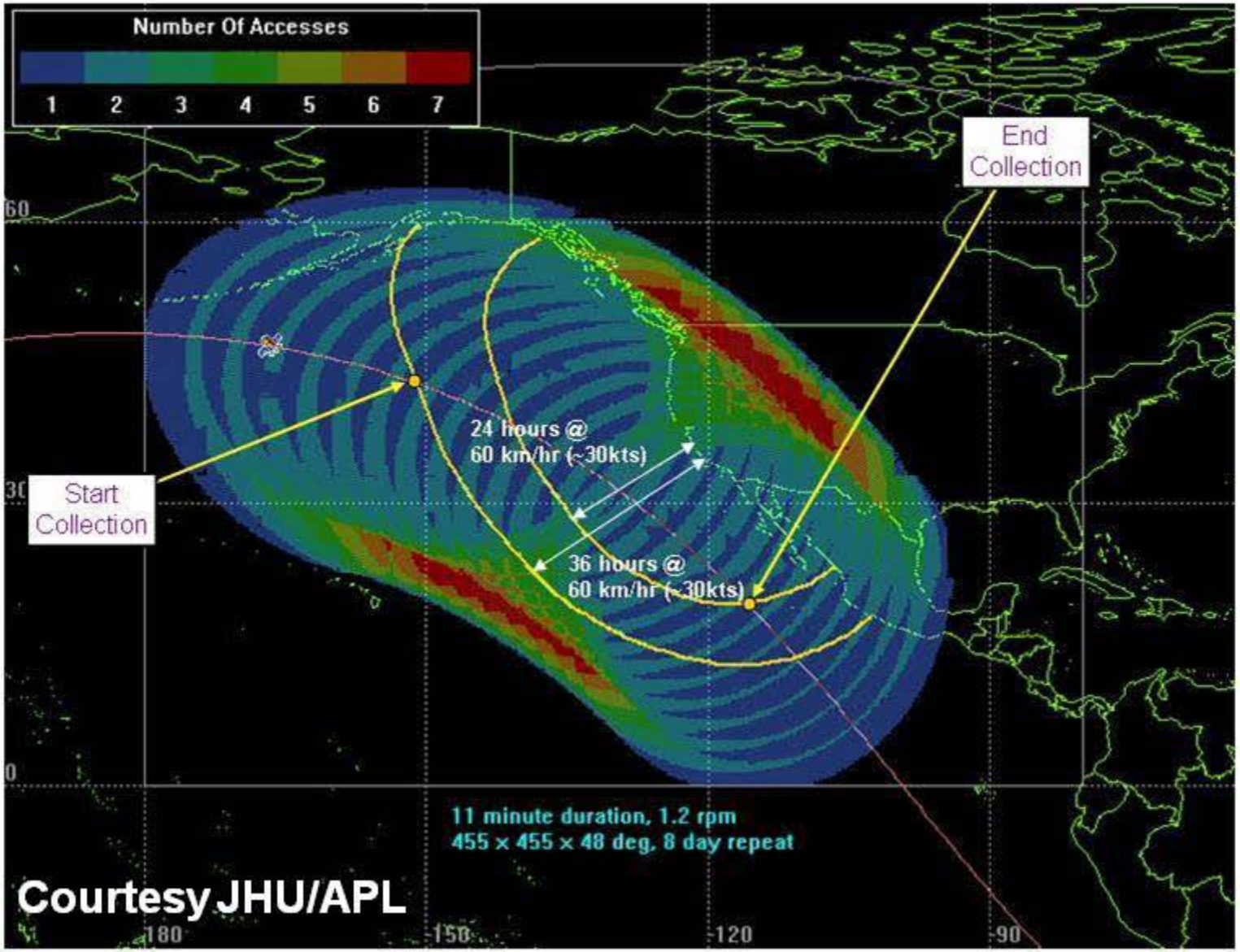
- Circular orbit 518 km altitude
- 70 Degree Inclination (Family of orbits possible)



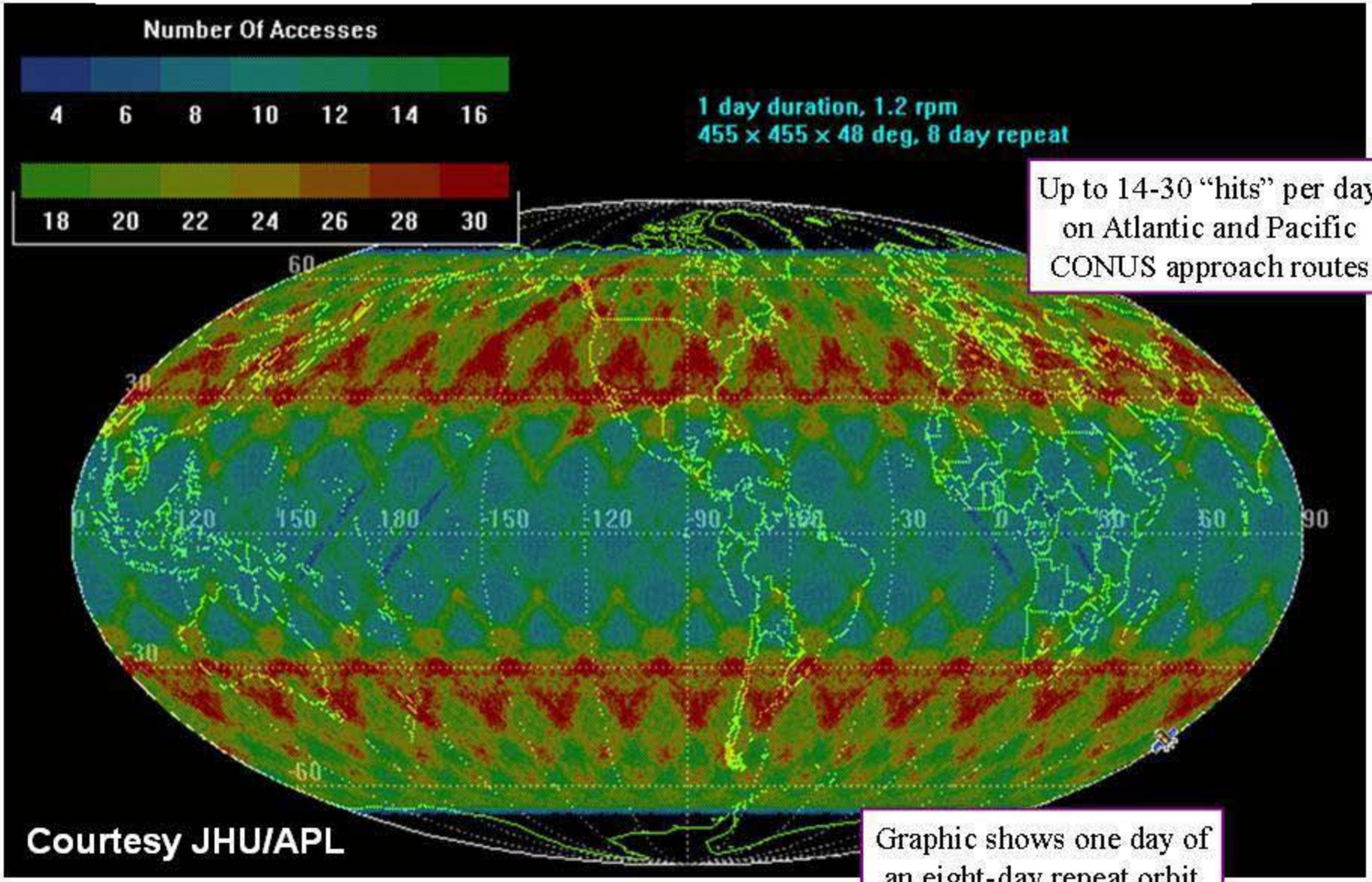
- ***LEO Orbit Tuned for CCD Exact Repeat of Target Viewing Geometries Within 1 Day***
- **Surveil all ocean areas twice a day, detecting all vessels above 25m.**

Courtesy Ball Aerospace

IMAGING OPPORTUNITIES PER PASS



ACCESSES PER DAY, SPINNER ARRAY



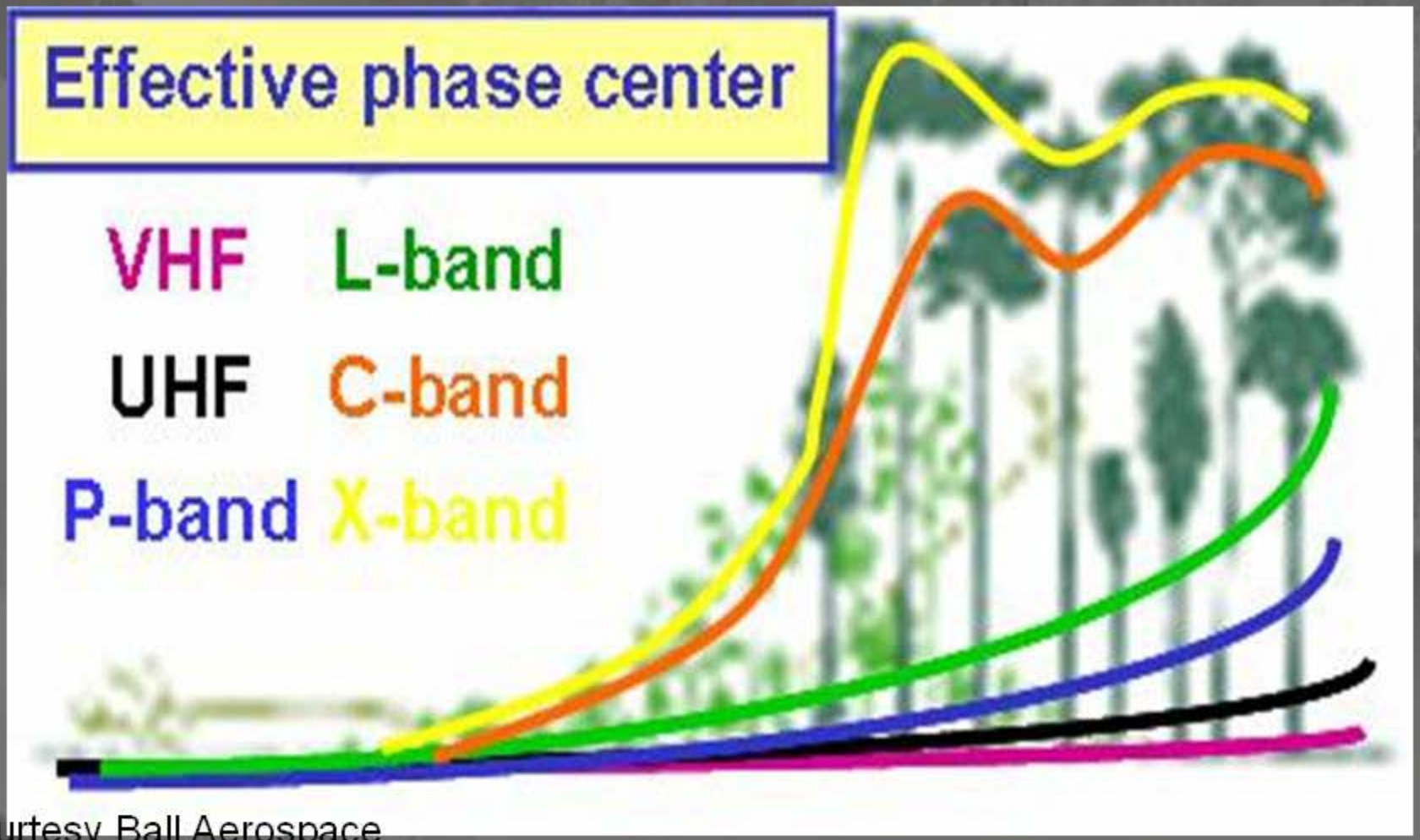
Up to 14-30 "hits" per day on Atlantic and Pacific CONUS approach routes

Graphic shows one day of an eight-day repeat orbit

L-Band SAR Daily Collection

Courtesy Ball Aerospace

Frequency & FoPen
(Also applies to Wake Detection)



Courtesy Ball Aerospace

Optical Systems

High Res Optical Satellites:

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

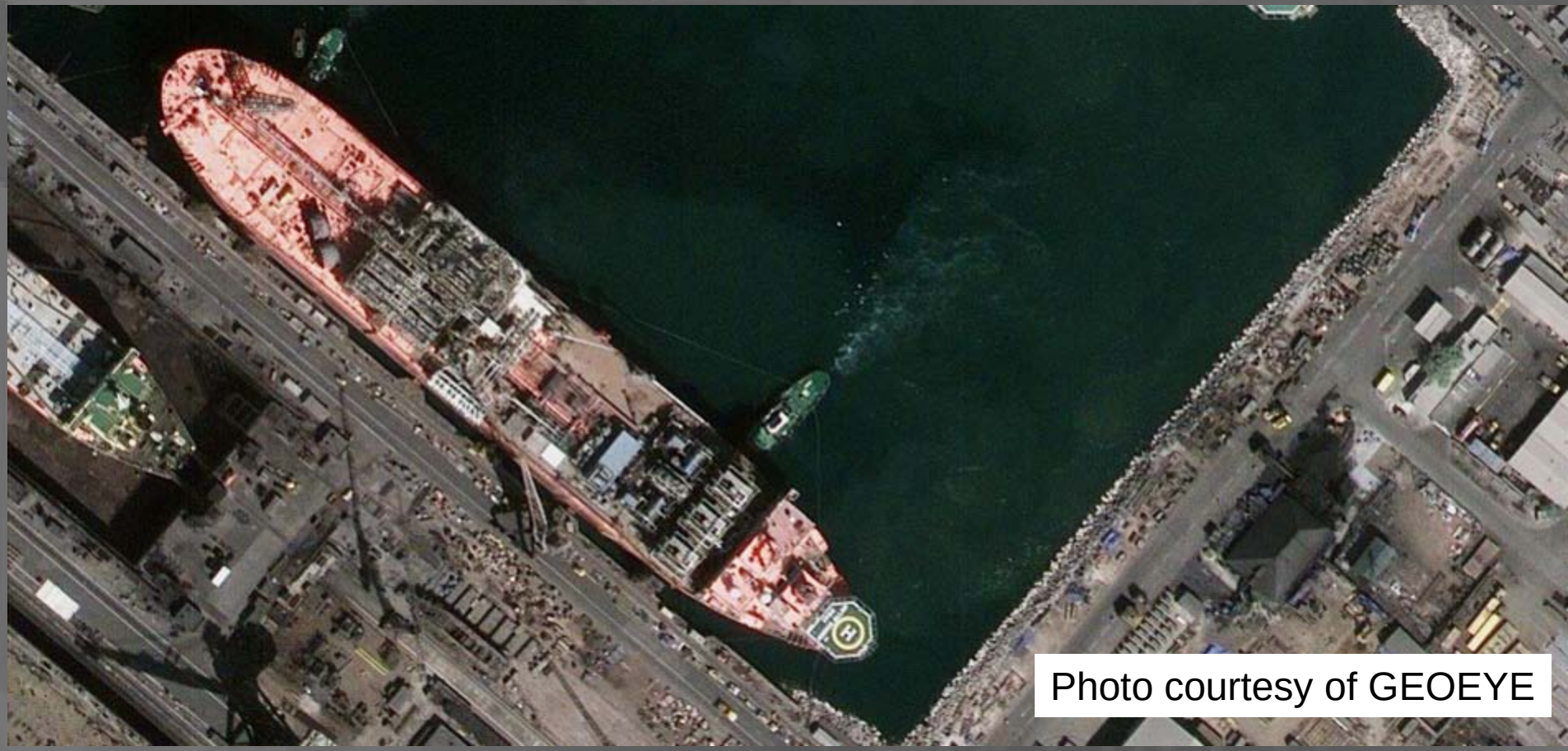
- Suitable for Ship Classification
  - Coverage from 8KM to 16.5KM
  - Resolutions from .5 to 1.80m (Panchromatic)
- Agile satellites with up to 12 hour to revisit times
- Some include direct tasking to support Tactical Surveillance applications

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



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

GEOEYE's First Pictures

Data Latency: Ground Systems can provide imagery in minutes

- Data downlink: real-time
- Processing: immediately after downlink
- Images can be processed in priority order
- Pipelined product generation + image processing
- First Images can be delivered minutes after the target was acquired

- Currently, a commercial buy has latency of 4 - 48 hours

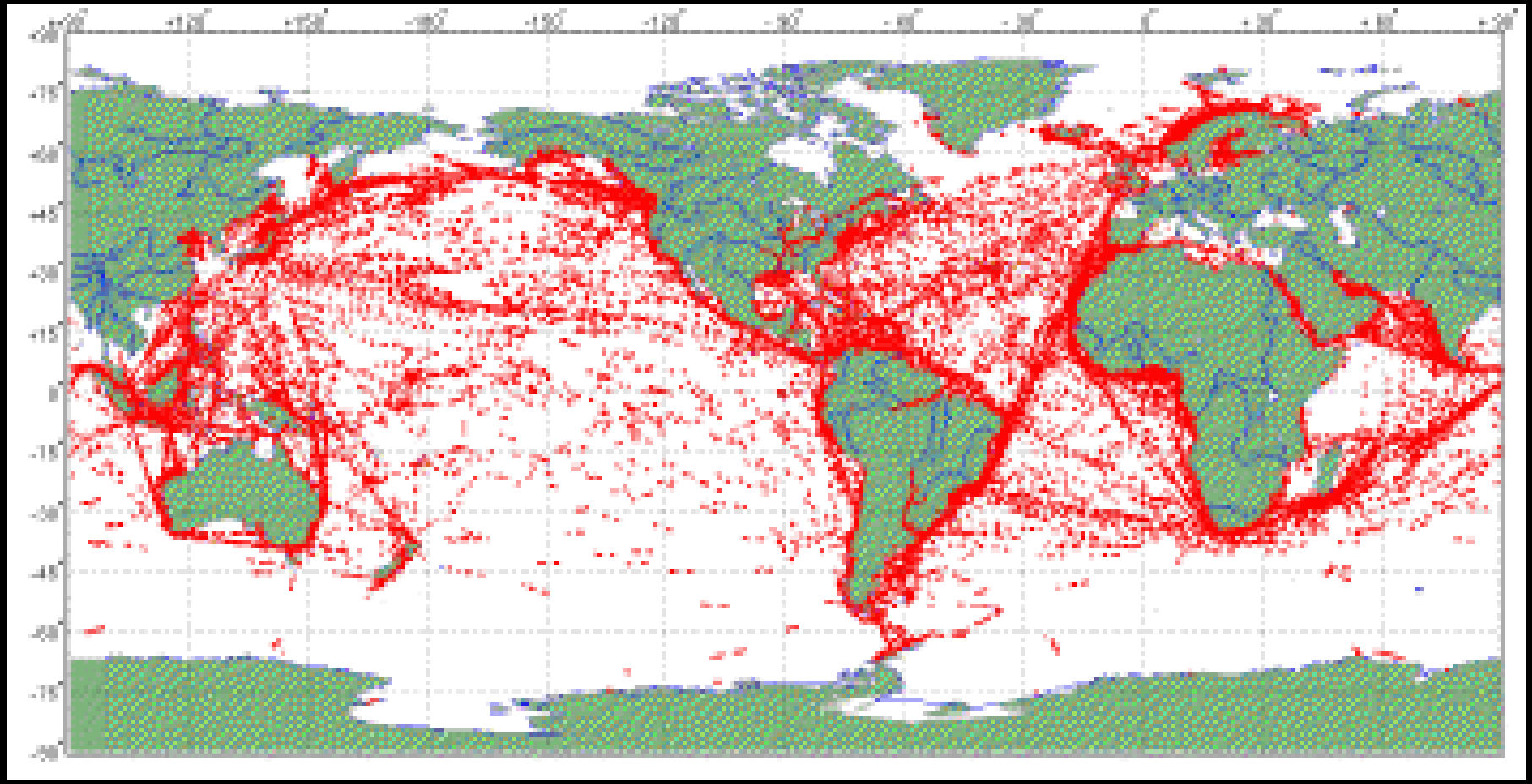
3rd Part of the C-SIGMA Equation

AIS

CRUCIAL NEW COMPONENT

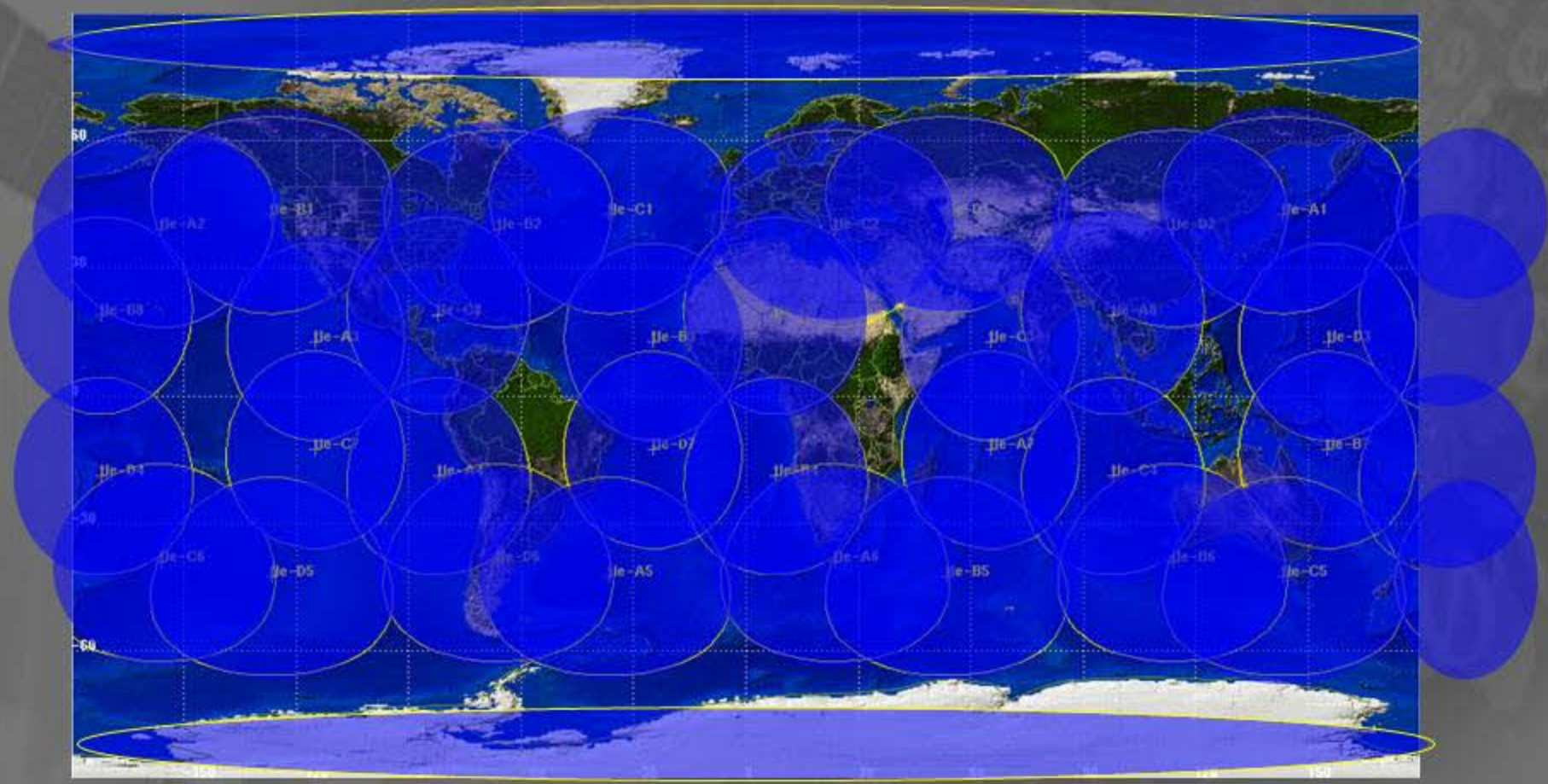
LETS YOU KNOW WHO THE ***GOOD*** GUYS ARE

Over 25,000 Unique Vessels Tracked Daily

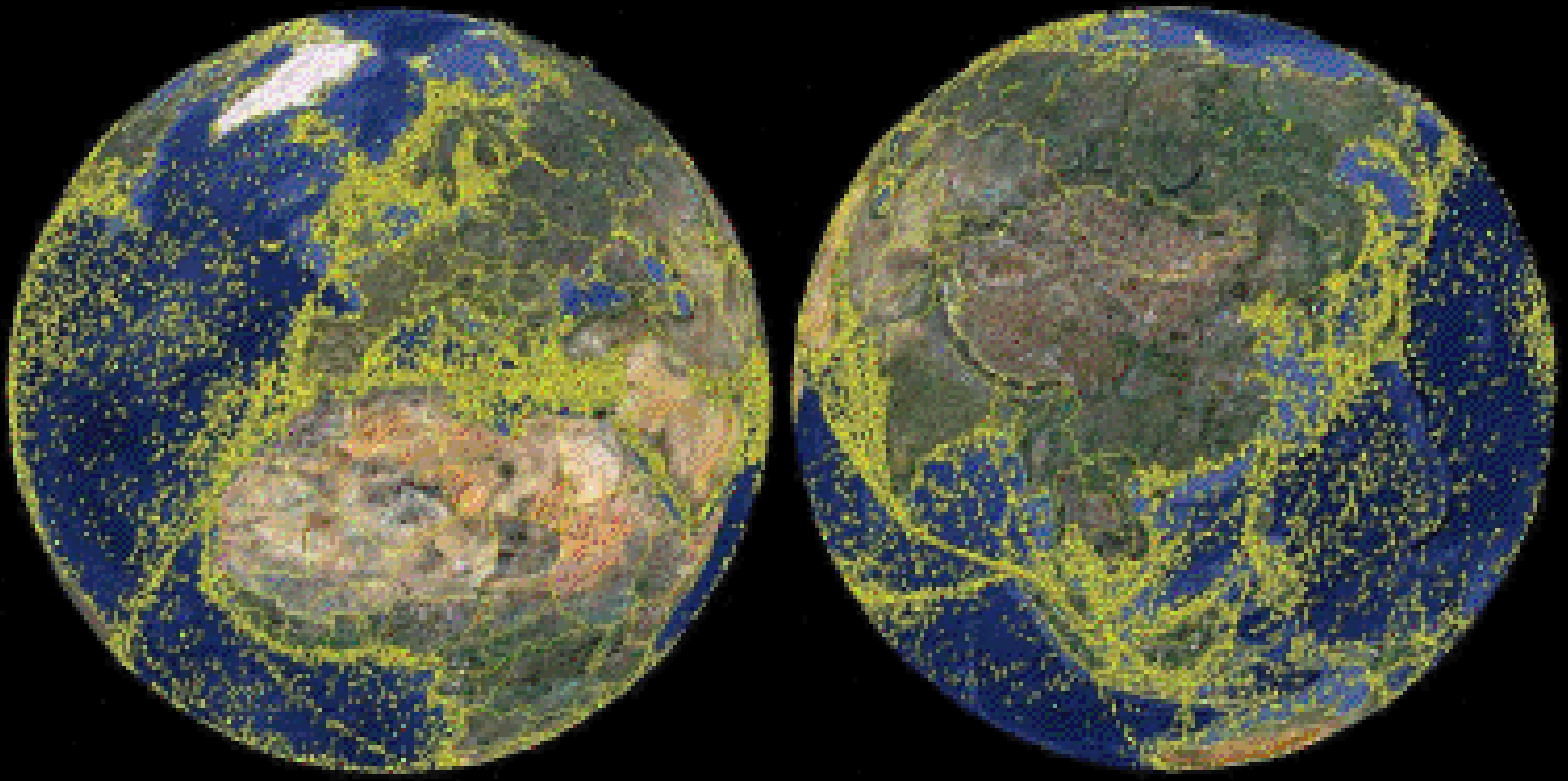


AIS Detections
from a Single Pass

Full OrbComm AIS Satellite Coverage



Over 65,000 Unique Vessels Identified to Date



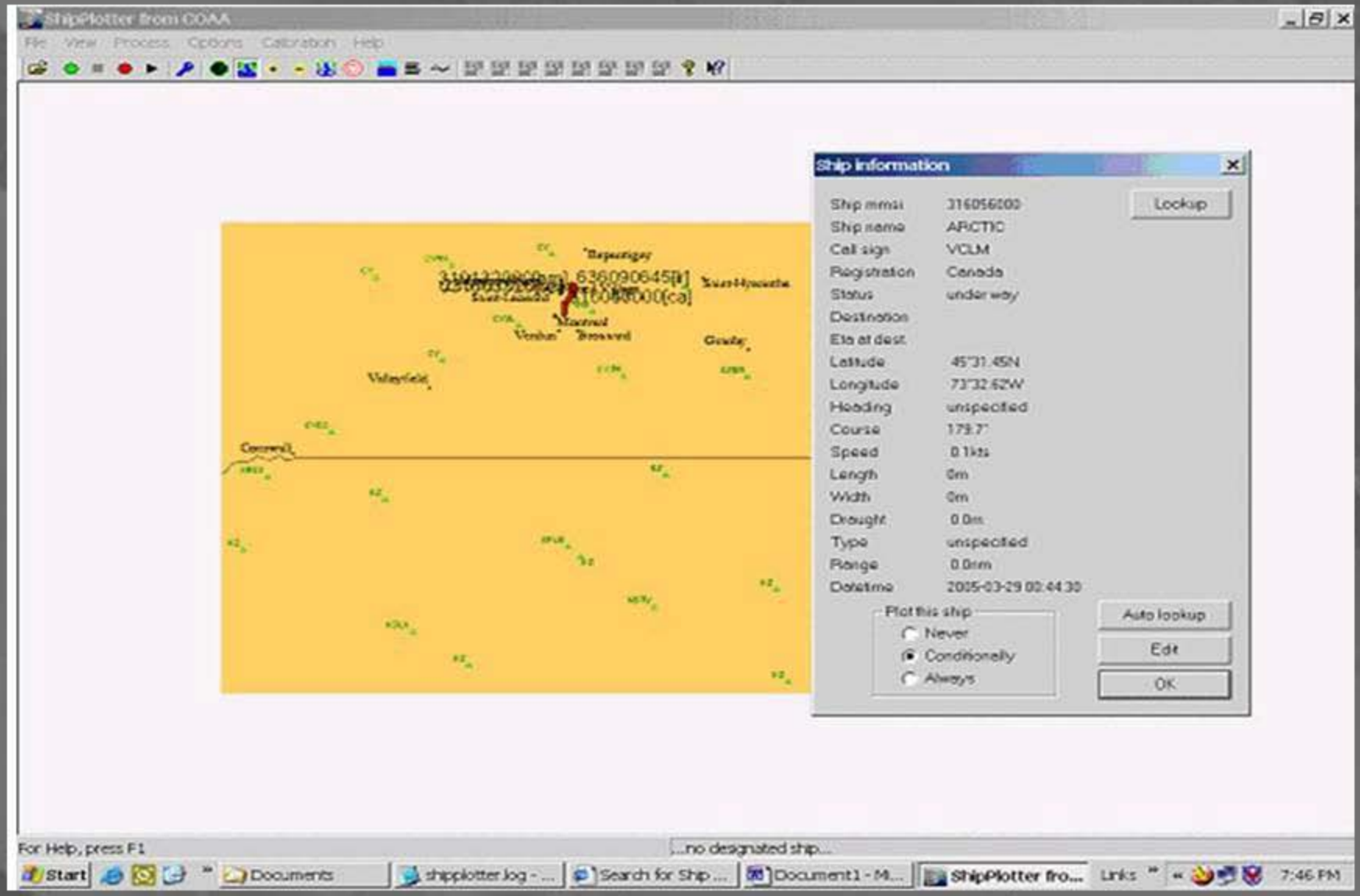
Comparison of Shore-Based Vs. Satellite Based AIS Receivers

Shore-BasedMSSIS Data

SpaceQuest AIS Data

AIS Messages collected during one 24-hour period.

AIS Screen


ShipPlotter from COAA
File View Process Options Calibration Help
Ship Information
Ship mmsi 316056000
Ship name ARCTIC
Call sign VCLM
Registration Canada
Status under way
Destination
Eta at dest.
Latitude 45°31.45N
Longitude 73°32.62W
Heading unspecified
Course 179.7°
Speed 0.1kts
Length 0m
Width 0m
Draught 0.0m
Type unspecified
Range 0.0nm
Datetime 2015-03-29 00:44:30
Lookup
Plot this ship
Never
Conditionally
Always
Auto lookup
Edit
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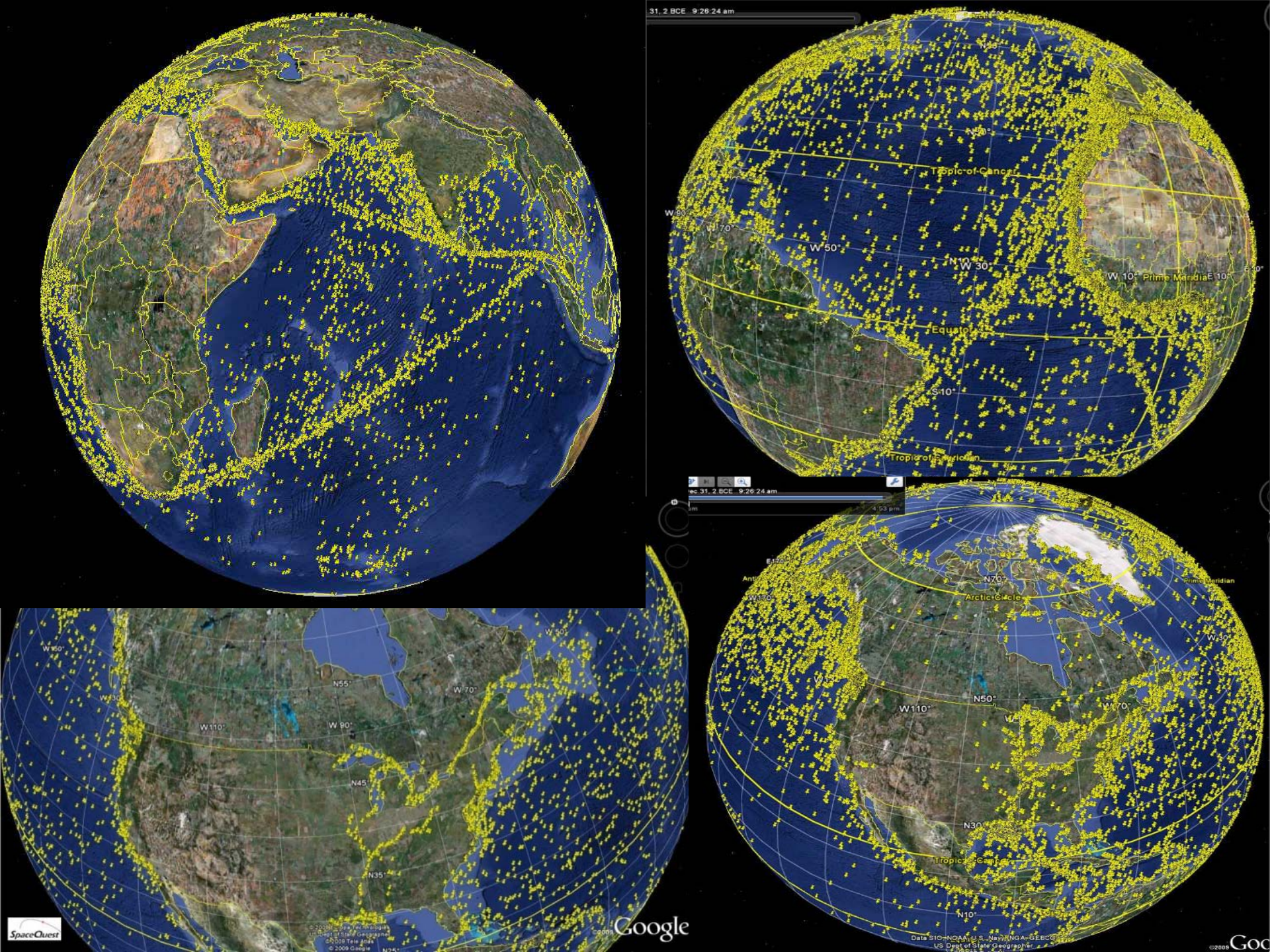
31, 2 BCE 9:26:24 am
Tropic of Cancer
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Prime Meridian
E 10°
Equator
S 10°
Tropic of Capricorn
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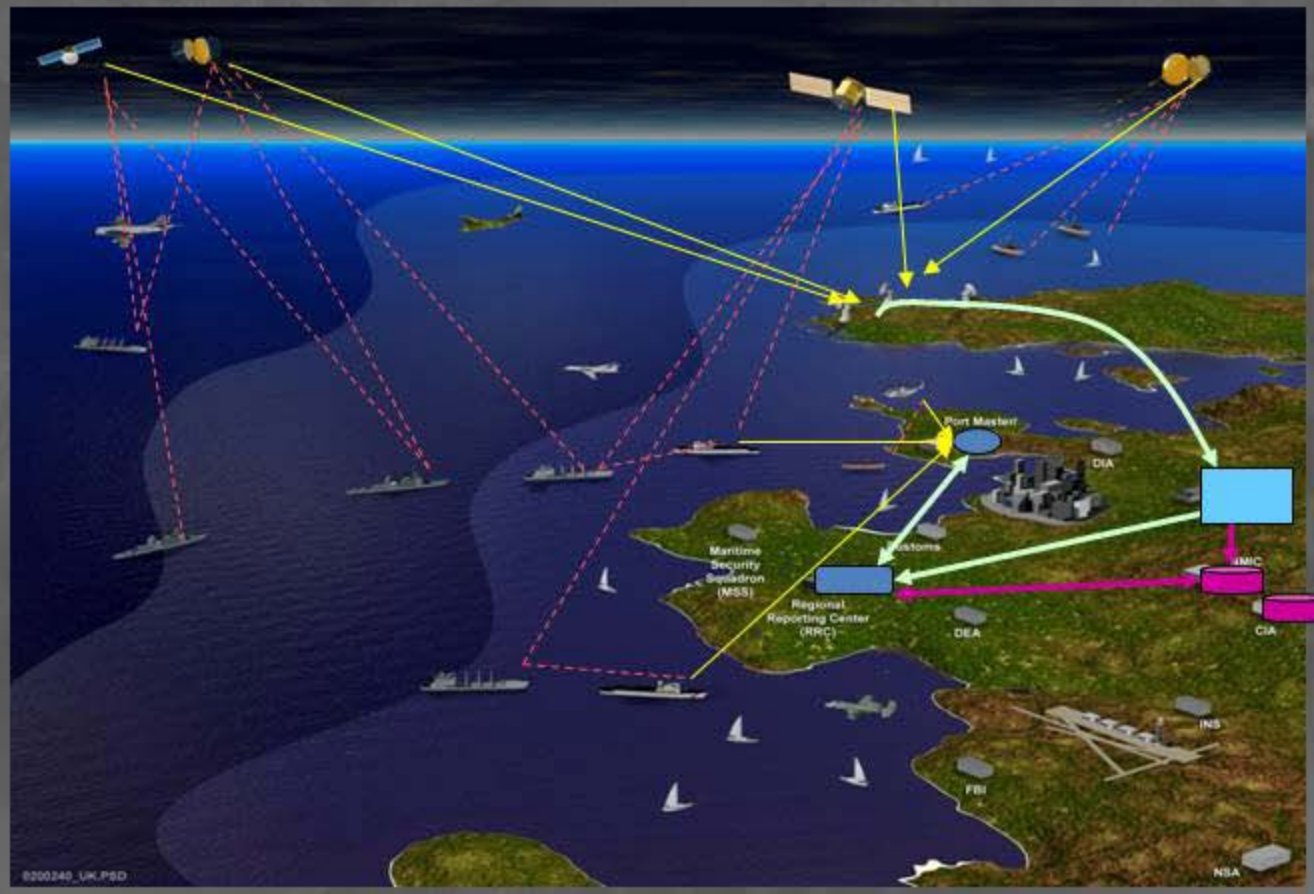
Arctic Circle
W110°
N50°
N30°
N10°
W 90°
N55°
N45°
N35°
SpaceQuest
Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
US Dept of State Geographer

4nd Part of the
C-SIGMA Equation

Transponder Systems

VMS

- IMARSAT
- ORBCOM
- Iridium
- Global Star
- Etc.



Often overlooked, not very sexy?

The Real Maritime IFF System?

AKA
Self Reporting Systems

- Tracking , (fishers +), trucks, status change,
- Formatted Message
- Can be programmed to report
  - On a time schedule (every hour, every 30 minutes, etc.)
  - By geographic limit (cross a boundary)
  - Upon event (door open, temperature out of limits, etc.)
  - Combination of rules (e. g. LRIT)
  - Upon demand from shore

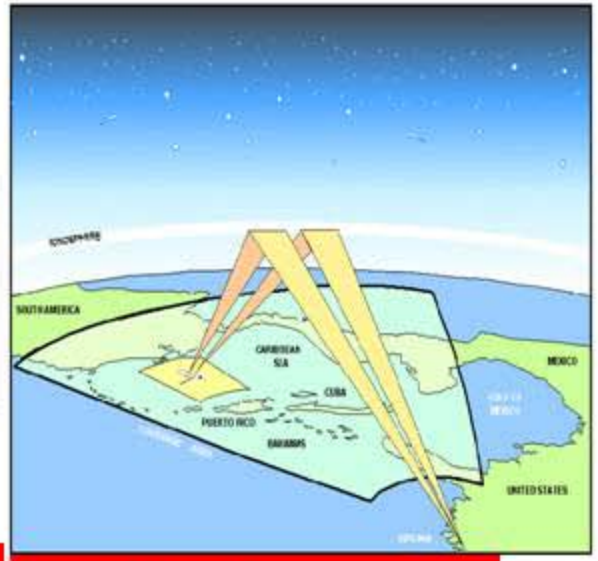
Dynamic Data Analysis

- **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

Cross Cueing provides Tactical Surveillance

- **ITEMS OF INTEREST FROM ONE SENSOR CAN BE ASSISGNED HIGH PRIORITY FOR COLLECTION BY OTHER SENSORS,**
- **BOTH SPACE BASED AND TACTICAL, E.G.**



You <u>CANNOT</u> do it ALL from SPACE

Routine Event

C-SIGMA Event Timeline

A. Commercial Satellites equipped with AIS receivers (S-AIS) continuously Detect s all AIS emitters in area of interest .

B. Several Commercial Comm Satellites collect all ship positions reported via LRIT, VMS and private systems.

C-SIGMA Event Timeline

1. Radar Satellite images area of interest on routine pass.

2. Central processing facility correlates contacts detected via RadarSat to S-AIS, VMS and LRIT data. Detects three vessels of interest &

3. Alerts appropriate ground stations to task HR imaging satellite(s) to image the areas where the three vessels of interest can next be accessed, based on Traffic Patterns

C-SIGMA Event Timeline
Routine Event

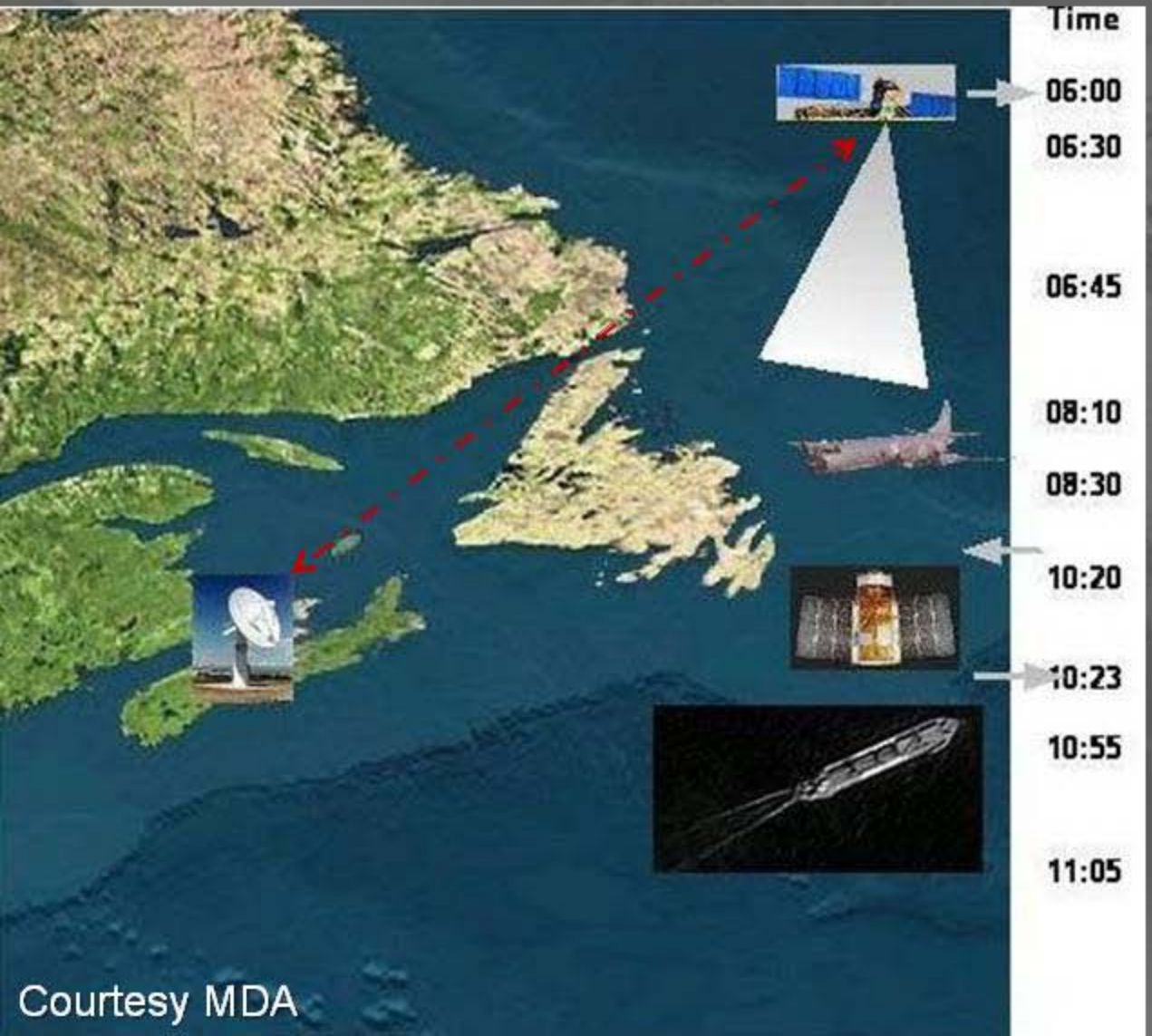
4. All three resulting images are studied for items of interest, anomalous activity.
   -------- One unit is deemed suspicious

5. MPA is dispatched for a closer look, and Cutter is diverted to intercept, if needed.

6. MPA detects possible illegal activity and maintains track until….

7. Cutter arrives on scene and boards

Cross Cueing Timeline



Courtesy MDA

RADARSAT collects with Scan SAR

East Coast Satellite Ground System (ECSGS) Detects unk Target with no AIS.

TRINITY determines EROS-1A could image Target at 1023

MOSIC tasks ECSGS to image target

AUROA launched to intercept Target at 1200

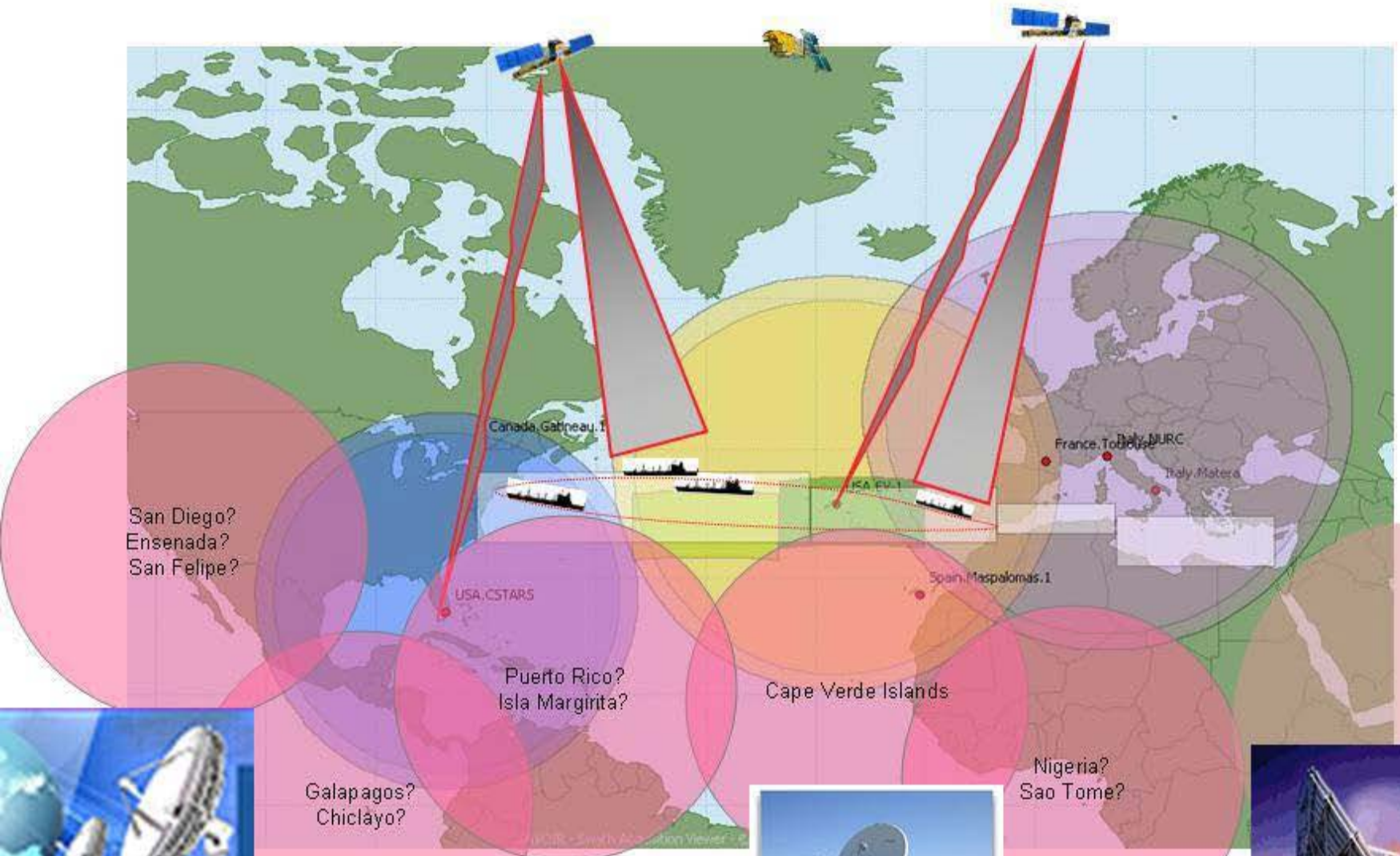
Image command uplinked to EROS-1A

EROS-1A images Target

ECSGS sends message with coordinates, heading and 1.0m resolution image to MOSIC

MOSIC IDs ship and informs AUROA crew. Based on ID as friend crew cancels reaction and resumes normal patrol.

Proposed Network of Ground Stations



Three more in Hawaii, Midway and Alaska

All of the foregoing begs the question:

"HOW?"

Initial Steps:

1. Set up International committee ?
2. Coordination office at ……? ESA? USCG? Canada? US DHS?
3. US coordination led by - USCG? Transportation? DHS? State? ???

Immediate Next Steps

C-SIGMA Exploratory Workshop

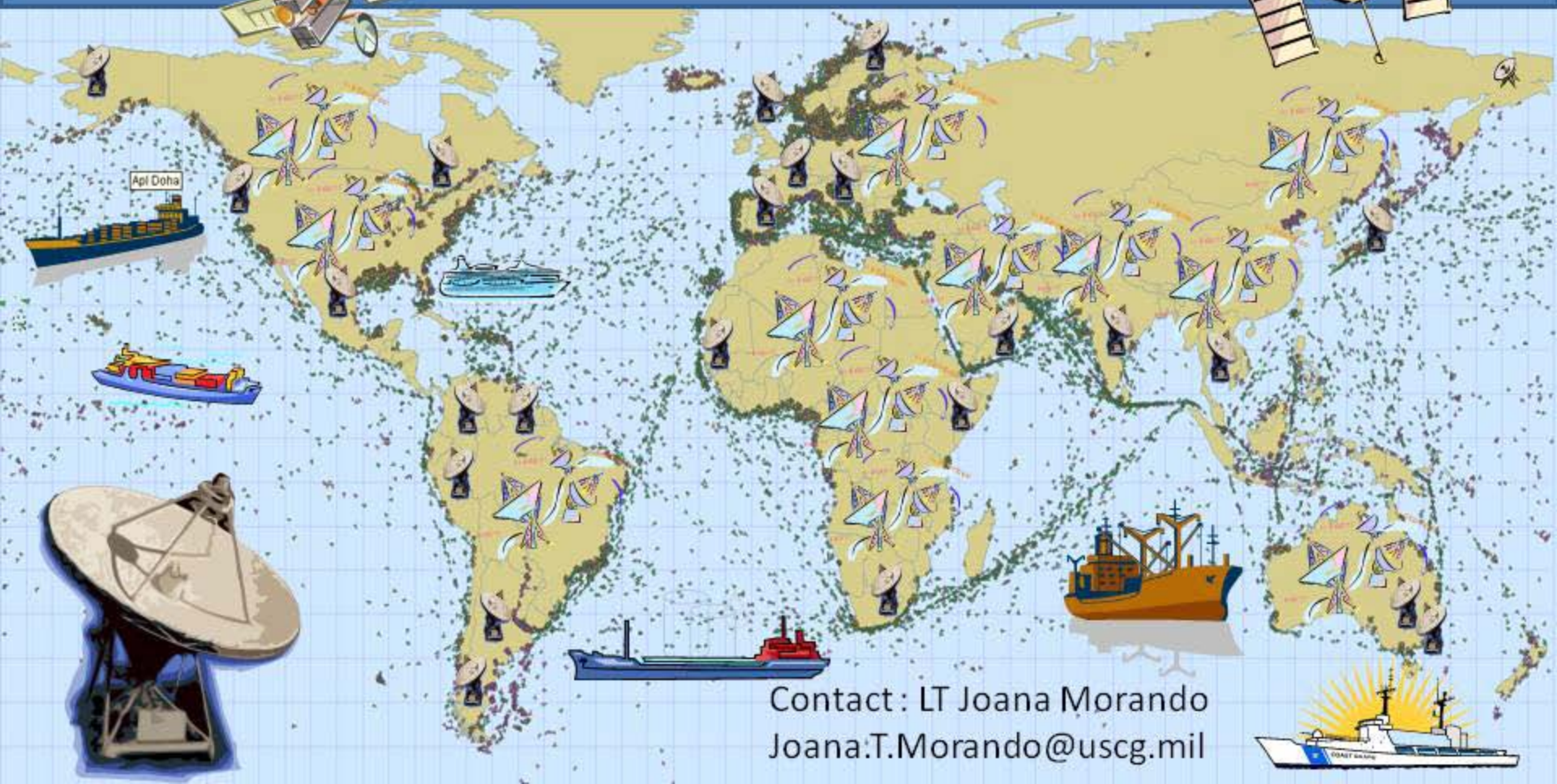
Purpose

- Achieve consensus:
  - With international and inter-agency partners
  - Need to build an unclassified system using available space based (+ Terrestrial) systems
  - To establish a mechanism for Global Maritime Awareness (GMA)
- Identify:
  - Basic System Components
  - Next Steps to Implement GMA.

TEXAS IV & Delayed

NMCO,

CANADIAN EMBASSY, WASHINGTON, DC
28-30 Sept 2010



Contact : LT Joana Morando
Joana:T.Morando@uscg.mil

Bottomline

There is no Silver Bullet

BUT

SPACE could be HUGE!

COLLABORATION is the Key

C-SIGMA, just a concept

- "PPD-4, National Space Policy, June 28, 2010, emphasizes U.S. leadership in space and directs international collaboration on mutually beneficial space activities for the purpose of broadening and extending the benefits of space. To implement the President's direction the U.S. will begin the development of an open source system, utilizing government and commercial capabilities, to enhance global maritime domain awareness."

QUESTIONS ?