GLADIS: Global AIS & Data-X International Satellite Constellation

Space-Based System for Sharing Unclassified Maritime Domain Awareness Among International Partners

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Briefing Agenda

• Maritime & Technology Challenges
• GLADIS Mission Objective
• AIS & Data-X capabilities
• GLADIS Architecture
• International Strategy
  – MSSIS as Model
• Proposed Schedule
• Sustainment Option
• Benefits & Payoffs
Maritime Challenges

- Smuggling
- Fisheries violations
- Oil theft
- Illegal immigration
- Drug trafficking
- Human trafficking
- Environmental degradation
- Piracy
- Terrorism
- Criminal activity
GLADIS Mission Objective

- Constellation of 30 nano-satellites (Global persistence) with two payloads providing enhanced Maritime Domain Awareness and Safety.
  - Automated Identification System (AIS) for ship tracking
  - Data exfiltration (Data-X) for widely dispersed sensors
  - Flexible, Scalable, Standards-based architecture by U.S. provided design
    - Interdependent
    - Persistent Presence
    - Affordable
    - Partners control their information and satellites
  - JCTD Proposed for FY10 for International effort to achieve
    - 30 Satellites Constellation
    - 5 Launches Polar Orbit
    - 5 Launch Dispensers
    - U.S. Proposal provides 1 launch, 1 dispenser and 6 satellites
      - The U.S. proposal is for 1 U.S. satellite on other 4 launch vehicles and provide room for 5 partner satellites on a U.S launch
AIS Messages: Self-organized Time Division Multiple Access

- An AIS Message Contains
  - Ship Identification (Name, Call Sign, etc.)
  - Length, Breadth, Type of Ship
  - Course and Rate of Turn
  - Draft, Cargo
  - Position
  - Speed
  - ETA

The AIS of Ship A Sends the Position Message in One Time Slot. At the Same Time It Reserves Another Time Slot for the Next Position Message.

The Same Procedure Is Repeated by All Other AIS-Equipped Ships

Ship A

Ship B

Ship C
Data Exfiltration of Remote Sensors

- Data-X offers cost effective means for collecting data up to 9600 bps from:
  - Buoys
  - Moorings
  - In-Situ Floats
  - Unattended Ground Sensors
- Customizable Ground and Space Segments
  - FPGA Architecture Allows Customizing On-Orbit
    - Re-Programmable
- Two-Way Communication
  - Allows Acknowledgments, Error Correction/Sensor sleep modes
- UHF Frequency
  - Low Power / Good Foliage Penetration
  - Simple Antenna That Does Not Require Pointing
Business Case For Data Exfiltration? What Is Its Economic Value?

- Sensors will proliferate as Data-X service increases
  - Think GPS, where spin off applications proliferated after initial constellation orbited
  - Partners can stimulate domestic industry

- Partners who cannot afford organic sensors, (airplanes, ships etc) to monitor their EEZ may find GLADIS to be significantly cheaper option to cover portions of their needs.

Multi-source data (acoustic, EO/IR, RF) from distributed sensors can help fill current gaps in MDA picture
GLADIS: Point Design

- **Spacecraft**
- **AIS Payload**
- **Ground Terminal/Router**

- **Launch Vehicle (Baseline)**
- **Launch Adaptor/Dispenser**
GLADIS: AIS / Data-X NanoSat Constellation for Access to Any Point on the Globe in <10 Minutes

30 NanoSats in 5 Planes at 550 km, Polar Orbit
GLADIS Concept for Space-Based AIS & Data-X Collection and Data Sharing

- International Constellation Collects AIS Signals Globally via NanoSats
- Ground Terminal/Router Collects Downlinked Data bent pipe to satellite owner
- Data Processed/Posted via Internet, MSSIS used to Distro AIS
- Data is Global, Protected, Transparent, Frequent
- Each Nation provides their own crypto
  - _____ Encrypted
  - _____ SSL
GLADIS Concept for Space-Based AIS & Data-X Collection and Data Sharing
GLADIS: International Strategy

• International partners Build or Buy their own GLADIS satellite or ground terminal
  – Specifications/Designs provided by US Government as part of agreement

• Only Government sponsored partners can participate
  – Partners can acquire satellite and/or terminal to participate
  – Data may be provided to non-participating Nations in accordance with data sharing agreements

• Specifications to build or buy hardware and software include:
  – Tailored MIL-Standard documentation; interface control documentation; test plans.
  – Launch vehicle integration guides, orbital insertion guidance, etc.
Maritime Safety and Security Information System (MSSIS)

- **Genesis:** US Department of Transportation (DoT)
  - Network for US Coast Guard with data viewer (TV-32)
- **Simple, unclassified, freely shared, open architecture**
- **Uses Internet to share data**
  - Well-defined international data format (ITU-R M.1371-1)
- **Authorized users access through commercial security**
  - Navies, Coast Guards, agencies, ministries, Border Police, port authorities
  - Password protected with secure socket layer (SSL) encryption

Diagram:
- VHF antenna → AIS receiver → Laptop / TV-32 viewer → SSL → Internet → MSSIS server
## MSSIS – Member Nations

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More being added every day!
Gambia, Liberia, Cape Verde, Sierra Leone

South America Coming Soon!
Maritime Safety and Security Information System (MSSIS) Server

SSL

Internet

Iridium

aerial

SATCOM

ships

Commercial IP Services

All willing nations

TV32 Clients

MSSIS DATA

Collector → Thinner → Distributor

GLADIS DATA

Collector → Thinner → Distributor

Maritime Safety and Security Information System (MSSIS) Server

Data X

GLADIS

Ground Terminal

GLADIS

Ground Terminal

AIS
We need more dots !!!

We know they are out there.....
Proposed Schedule, with Scenario Options

30 Months from ATP* to ready for Launch
- U.S. Design, Build Dispenser and 6 satellites
- Pursue International Partners in Parallel
- Provide Interface specifications, satellite plans, software, plans for antennas and ground terminals

Possible Scenarios:
- Worst case - no or little interest, cancel program after PDR
- Next best - US build/launch six satellites, no other nation participates
- Goal - International Partners join at PDR, cost share on Dispensers, Rockets, and 24 more satellites as soon as possible. U.S. adds one satellite per plane
- Transition to International Consortium for sustainment

ATP = Authorization to Proceed
CoDR = Concept Design Review
PDR = Preliminary Design Review
CDR = Critical Design Review
FRR = Flight Readiness Review

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Possible Sustainment Option

• Transfer of U.S. R&D designs/software to International Consortium
  – Maritime organizations already exist that maintain National, Industrial and Scientific membership that could coordinate and manage such a consortium (i.e. International Association of Lighthouse Authorities (IALA) or International Maritime Organization (IMO))
    - Combination of subscriptions and grants to maintain system

• Internationally recognized Maritime organization assisted by space knowledgeable entity would reduce risk
  – Commercial profit and/or non-profit U.S. and International space firms could form consortium and participate with Government Labs, Universities, Technical Institutes etc.
Benefits and Payoffs

• Persistence - Expand Nations Perspectives From Local to Global
  – Partners Obtain Ocean Maritime Monitoring Tools
    - Monitor Own Shipping Beyond Line-of-Sight
    - Monitor International Shipping in Their Exclusive Economic Zones
    - Enforce Maritime Laws and Agreements (Piracy, Drugs, Terrorism, Ecology, Fisheries, and Mining)

• Government-to-Government Sponsored, Vice full Commercial
  – Information Controlled for Safety and Security.
    - Pure commercial capability lacks transparency for international partners.
    - Joint ownership breeds confidence in data fidelity/availability.
  – Unclassified/Non-Proprietary Data.
    - Expands opportunity to share information.
    - Nations determine cost benefit of commercial AIS/Data-X.
GLADIS S/C Configuration

Top View
- 10.31” SQ
- 10.56”

Front View
- 30.00”
- 10.25”

Isometric View
- 162 MHz Quadrifilar Feed Network
- 401 MHz Quadrifilar Electronics Enclosure
- Thruster Exhaust
- 4X Cups I/F to Dispenser
Launch Dispenser Configuration

AIS Spacecraft (6)

Battery

Frame Assembly

Cup/Cone and Separation Devices (Typical)

LV Interface Cone

Isometric View
Launch Configuration in U.S. Fairings

- **Pegasus**: 3.84” Static Clearance
- **Minotaur I**: 4.29” Static Clearance
- **Taurus**: Large Clearances
- **Falcon 1**: 1.15” Static Clearance, 1.66” Static Clearance
GLADIS Ground Terminal

Antenna
Antenna Controller
RF Cable
ACU Cable
Laptop
RF-ACU Box

Ethernet
Power
SMA
Antenna Control
Separate Ground Terminal-to-Router Configuration for Data-X Distribution

- Service Oriented Architecture (SOA) Enables Data-X Partners to Publish and Subscribe to Data-X info
  - Each Nation Posts Its Own Satellite’s Information for Authorized Partnering Nations
  - Handled differently from AIS as not inherently Safety and Security like AIS. Data can be provided to MSSIS as desired
  - Defined Distribution Plan Lists Satellite (Source) and Nation’s Routing Address (Destination)
  - Satellite Data Receipt and Transmission Via Routing Function Determines Data Travel Between Different Nations’ Networks Via the Internet
  - Routing Function Sees Only the Message Envelope – Not the Information to Ensure Message Privacy
GLADIS Coverage Gaps w/ 6 satellites in one plane

Caribbean
Avg: 49 min.
Max: 548 min.

North Atlantic
Avg: 44 min.
Max: 523 min.

Mediterranean
Avg: 40 min.
Max: 510 min.

Gulf of Guinea
Avg: 52 min.
Max: 553 min.

Indian Ocean
Avg: 50 min.
Max: 553 min.

West Pac
Avg: 52 min.
Max: 553 min.

6 Satellites in 1 Orbital Plane
Walker 6/1/0, i = 90 deg, alt = 550km
GLADIS Coverage Gaps w/30 satellite Constellation

30 Satellites in 5 Orbital Planes
Walker 30/5/0, i = 90 deg, alt = 550km
Ground Terminal and Micro Satellite