
International Space-Based AIS and Data Extraction Backbone

High Level Requirements

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INTRODUCTION

With greater emphasis being placed on global situational awareness, global asset monitoring, and environmental monitoring, maritime and terrestrial sensor and data acquisition systems are critical enabling capabilities that are becoming more ubiquitous. The need is driven by global security and safety initiatives responsive to the new face of conflict, which involves every sector of society and knows no geographic boundaries. Because much of the Earth's surface is "unwired" and governed loosely, if at all, and because illicit activity seems to flourish where transparency is lacking, there may be important gains in collecting data and monitoring activity in just such places: the open seas, jungles, deserts, and the polar regions. We feel that moving data out of these areas, which are not supported by electrical or communications grids, suggests the need for a global space-based data collection and distribution backbone.. Furthermore, we feel that creating such a system should be undertaken as an international collaborative effort, with no significant barriers to entry.

A number of national space agencies, consortia, and commercial interests have been active in deploying AIS receivers and data extraction capabilities on satellites; however, there currently exists no global partnership to coordinate and organize all the disparate efforts – especially one that ensures the availability of these capabilities to otherwise underserved countries. To further develop the concept of an internationally shared data collection and distribution backbone in space, CANEUS is organizing a workshop to explore technical, policy, and financial issues, and to frame an implementation plan. The eventual goal is to establish a public/private partnership that would create a low-cost, internationally shared data collection and distribution backbone in space with exceptionally low barriers to entry for participating nations.

To set the stage for the workshop, a series of three separate articles address issues associated with establishing a space-based data extraction and distribution backbone. Existing data streams, notably the ships' Automatic Identification System (AIS) give concrete context to the articles, while thinking about the future will involve data streams with diverse content. This, the first article, canvases the globe and summarizes the presentations and policy statements created by organizations that have an interest in extracting and distributing of data from "unwired" areas of the world. This article focuses on efforts to establish a satellite "backbone" to acquire and share critical parametric packet data (as distinct from the streaming data associated with voice and imagery) in support of international safety, security, environmental protection, and economic prosperity. The article finishes with an amalgamation of end user requirements.

The second article will address system requirements and a concept of operation for a small satellite communications backbone and will explore the business case and international shared asset framework for a global monitoring system. Having reviewed both articles, the workshop attendees will be prepared to participate in the system definition, deployment planning and funding identification activities slated for the "CANEUS – Collective Security, Safety and Prosperity (CSSP)" workshop.

BACKGROUND

The potential for international collaboration in space to materially improve maritime security was recently articulated by Guy Thomas, Science and Technology Advisor for the US Coast Guard: “The maritime entities of the world, military, civil, and private alike looked at their situation in the new reality (after 9/11/2001) and quickly understood their vulnerabilities and the potential consequences. Since that terrible day a number of national and international organizations have addressed how to protect their maritime assets, both individually, and in growing numbers, collectively. Most saw increased maritime domain awareness (MDA) as of first importance to the smooth functioning of commerce on the world’s oceans, the crucial supporting frame of the world’s economy, and crucial to their national interests. The potential unique contributions of current and planned space systems, owned by a wide range of nations and available to many others, to international global maritime awareness is a subject of growing interest to many.”¹

Knowing where ships are located is a necessary element of Maritime Domain Awareness, though not sufficient in itself to achieve an “effective understanding”² of maritime activity and its impact on safety, security, the environment and the economy. Current practice relies on a diverse set of sensors to garner the positions of ships; a fundamental contribution to the art and practice of ship tracking can be credited to the International Maritime Organization, which in 2004 mandated the use of an Automatic Ship Identification System (AIS) for many commercially important ships. AIS is a “self-reporting” system that broadcasts each participating ship’s identity and position (among many data fields) over VHF channels; the original intent was to provide collision-avoidance information to nearby ships and shore stations.³ Shortly after the IMO carriage requirements became effective, the US Navy in the Mediterranean began to collaborate with European and African governments to establish a network of shore stations, all of which contributed the AIS signals they received locally to a consolidated data stream, which was then shared among participating nations. This Maritime Safety and Security Information System (MSSIS) has since grown into a network of over 100 AIS base stations in over 60 participating nations around the world, providing current positions for over 15,000 ships. The major strengths of this innovative collaboration are the trust and interdependence it generates, and of course, an unprecedented picture of maritime activity. The major shortcomings are the limited set of ships broadcasting AIS, and the limited reception range for VHF signals; no data is received from non-cooperative vessels, or from the open oceans or areas near non-participating nations. Herein lies the key point made by Guy Thomas: the entire planet is “visible” from space, and many of the sensors (including AIS receivers) needed for a much more complete picture of maritime activity are already on orbit or planned.

1 Thomas, Guy, International Collaboration is THE Silver Bullet, Global Space Partnership-Collaboration in Space for International Global Maritime Awareness (C-SIGMA)

2 <http://www.gmsa.gov/twiki/bin/view/Main/MDAConOps>, accessed 14 May 2010

3 http://www.imo.org/conventions/contents.asp?topic_id=257&doc_id=647, accessed 14 May 2010

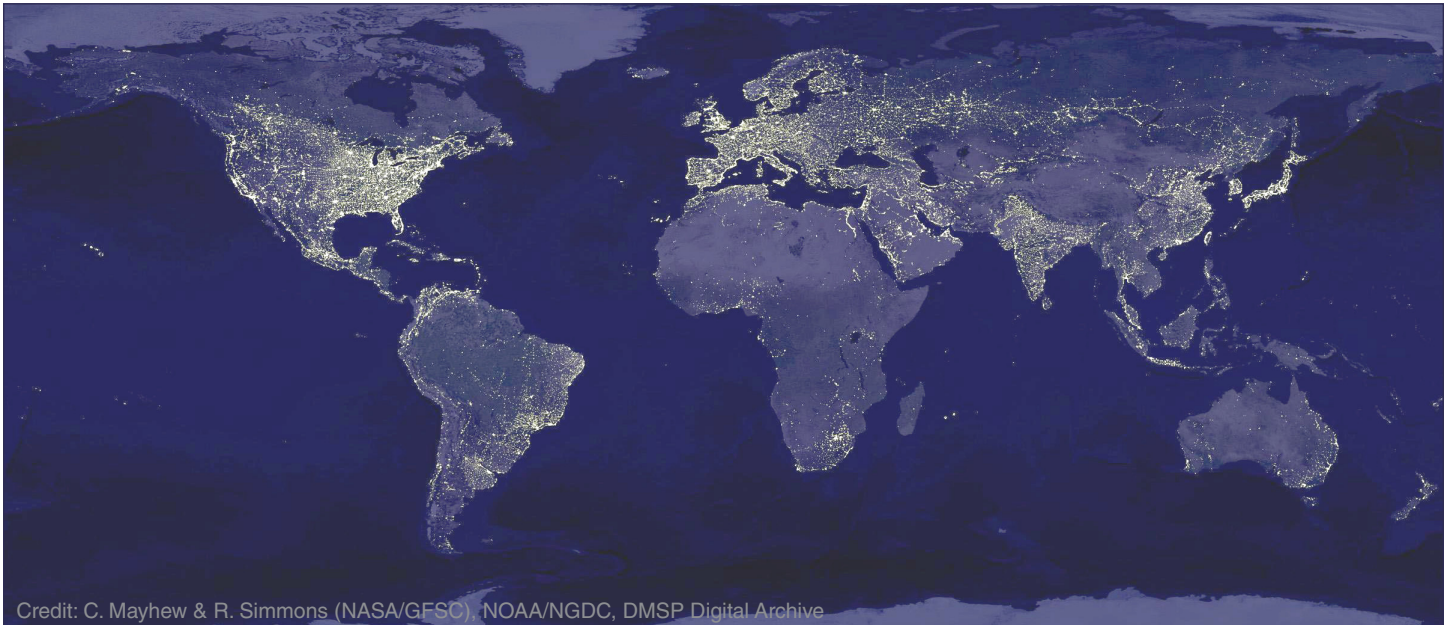


Fig 1. Approximately 84% of the Earth's surface is unwired.

That space will be the key enabler for truly global situational awareness is suggested by the exceptional composite image of the earth at night (Figure 1). Lights which are clearly visible from space define the “wired” world, served by grid electricity and more recently, internet connectivity. This leaves the oceans, the polar regions, deserts and jungles “unwired” and often undergoverned. Moving data out of these areas, which comprise roughly 84% of the Earth's surface, is important: a key strategic principle in warfare is to deny the enemy sanctuary, and for illicit activities ranging from illegal trafficking to training terrorists, sanctuary is found in the unwired world. Quite separate from the challenge of moving data out of unwired areas is the related question of generating that data in remote regions; this will be addressed with a review of the State of the Art in unattended sensors in the context of the business case for small satellite systems. This article will focus on the “bent pipe” link that can connect the “unwired” and “wired” regions of the world via satellite, using AIS data as a convenient example of interesting data that is routinely generated by ships that are only in the “wired” world when they are pier-side or close to a shore-based AIS receiver. This will allow us to develop a concept for collaboration in space with a concrete use-case, that being to extend the current AIS picture from regional near-shore areas to the entire world. Additional utility can be had if the data collection and transport backbone in space, which handles AIS data, would also handle data signals from maritime and terrestrial sensors that transmit short bursts of data. Finally, we advance the notion that approaching the problem as a global governance issue (rather than any one country's intelligence mission) points us to international collaboration, open to all countries, large and small. Already, a number of national space agencies, regional consortia and commercial interests are active in deploying space-based AIS and data extraction capabilities but it is not clear that these disparate systems are sufficiently interoperable, affordable, and transparent enough to support a global cooperative framework of nations, including those nations with austere finances and inadequate technical infrastructure. The measures of these important system characteristics will be developed in this and the subsequent articles in this series.

GLOBAL SURVEY OF CURRENT SPACE-BASED DATA EXTRACTION ACTIVITIES

David Meldrum from the Scottish Association for Marine Science and chair of the Data Buoy Cooperation Panel (DBCP) authored an overview of the current status (just updated in 2008) of the mobile satellite systems that provide support for data buoy operations and data collection. One trend recognized by Meldrum is the cost and power reductions that are possible with small satellites. In the study he states “Less energy is, however, generally required for LEO and MEO satellite communication because of the shorter average distance between transmitter and satellite. Some systems implement several high-gain antennas to generate ‘spot beams’ and so reduce the requirement of the mobile to have a complex antenna and/or high output power. Another trend is towards much smaller and cheaper satellites: minisats, microsats, nanosats, picosats and even femtosats — credit-card-sized satellites.”⁴

Meldrum also pointed out a few of the challenges facing commercial satellite systems providers:

“Due to the commercial forces which are driving the implementation of the new systems, many will primarily focus on land masses and centres of population, and will not offer truly global or polar coverage. These systems will not in general be acceptable for global ocean monitoring. Furthermore, while the technical capabilities for the new systems do currently exist, delays are inevitable due to problems with spectrum allocation, licensing (in each country where the service will be offered), company financing, and availability of launch vehicles and ground stations. It is unlikely that all of the planned systems will overcome all of these hurdles. Indeed, major financial difficulties have hit a number of systems, including Iridium, Orbcomm and Globalstar. Mergers are becoming increasingly common, as market reality forces system planners to cut their losses and pool resources.”⁵

Focusing just on the global data extraction capability for a moment, or what the International Telecommunications Union classifies as NVNG MSS (Non-Voice, Non-Geostationary Mobile Satellite Service), we find that a number of the mobile satellite systems support this fundamental utility. Table 1 is based on Meldrum’s study which lists the NVNG MSS systems that provide the minimum data set needed to support basic reporting requirements for remote terrestrial sensors. This set of capabilities will be the target service level proposed at the CANEUS Small Satellite Global Partnership workshop, to initiate discussions on technical complexity, power budget, and cost.

4 Meldrum, David, Developments in Satellite Communication Systems, Useful Satellite Systems for Data Buoy Operators, Data Buoy Cooperation Panel, paper updated Feb. 2008 (www.jcommops.org/doc/satcom/satcom.pdf)

5 *ibid*

Table 1. Representative Overview of Mobile Satellite Systems with Possible Data Buoy Applications (NVNG MSS only) ⁶

System	Status	Date	Orbit Type	Buoy (asset) position	Message Type	Terminal Size	Power (W)	Comments
APRIZESAT	Operational	AprizeSats 1 & 2: June 2004 AprizeSats 3 & 4: July 2009	Little LEO ⁷	GPS required	Data: TBD	Handheld	7	4 nanosatellites in orbit, 2-way comms, directed at asset tracking
ARGOS	Operational	February 1999	Little LEO	Doppler Shift	Data: 32 bytes	Handheld	1	Various enhancements, incl 2-way messaging with PMTs, are scheduled under Argos 3. Payload on MetOp sat.
Global Star	Operational	1999	Big LEO ⁸	GPS Required	Voice/ data: no maximum	Handheld	1	48 satellites + spares (constellation complete). 2 nd generation system comprised of 56 LEO satellites and 5 GEO satellites.
GONETS-D1	Operational	February 1996 through December 2001	Little LEO	GPS/ GLONASS	Data	Handheld	TBD	10 satellites in orbit
GONETS-D1M1	Operational	December 2005	Little LEO	GPS/ GLONASS	Data	Handheld	TBD	3 satellites (of 12 in 4 planes)
Iridium	Revived	May 1997 through June 2002	Big LEO	GPS preferred	Voice/data no maximum	Handheld	1	66 satellites plus 7 backup and 11 in orbital storage.
ORBCOMM	Operational	December 1997 through June 2008	Little LEO	Doppler or GPS	Data: no maximum	Handheld	5	35 satellites in orbit, 30 operational. 6 AIS satellites deployed, only one is delivering AIS data – replacements coming in 2012

6 ibid

7 “Little LEO” refers to Low Earth Orbit satellites that offer data capability only, either on a real-time direct readout (‘bent pipe’) basis, or as a store-and-forward service.

8 “Big LEO” refers to Low Earth Orbit satellites that offer voice, fax, telex, paging and data capability

ASSESSMENT OF CURRENT SPACE-BASED AIS ACTIVITY

Carriage requirements for AIS are established under the IMO International Convention for the Safety of Life at Sea (SOLAS) Chapter V, Safety of Navigation, Regulation 19, 1974/1980. Technical characteristics are given in the International Telecommunications Union specification ITU-R M.1371. Currently operating on two channels in the maritime VHF band, AIS is a shipborne broadcast transponder system designed to transmit information such as vessel identity, position, heading, nature of cargo, etc. Ships send reports periodically – as often as every 2 seconds. The range for littoral AIS is typically 20 nautical miles for ship-to-ship communication and somewhat larger for ship-to-shore communications in coastal waters. The system uses Self-Organizing Time Division Multiple Access (SOTDMA) technology that assigns approximately 2000 time slots, automatically and dynamically, to ships in local “cells”; that is, ships within VHF range of each other.

To paraphrase the investigators from the Norwegian Defense Research Establishment (FFI) “The AIS systems now mandatory under UN regulations greatly influence the field of maritime surveillance. All vessels using the AIS within VHF range [of a receiver] can be located and identified in near real time. Still, sovereign states need some non-cooperative measures to complement the littoral AIS. There are new roles for microsattellites here, both for detection of navigation radars and for extending AIS coverage to remote ocean areas.”⁹

Figure 2 illustrates the extent of the additional information that is available with satellite based AIS – in particular, mid-ocean ship traffic, and thus the far reaching potential such a service affords global maritime situational awareness.

Space-based AIS data streams are relatively new and neither policy nor their market value is fully established, though it is clear that the data are valuable. The value of AIS for navigational safety has not diminished, but other uses have raised interesting questions regarding collection, processing, and sharing.¹⁰ Maritime agencies, nation-state safety and security agencies, defense agencies, and environmental agencies are stakeholders in maritime governance, and may benefit from satellite-based AIS collection to more fully develop their “operating picture”. Organizations involved in global commerce and transportation may also have an interest in AIS signals from space, since knowledge of the locations of ships at sea can contribute to predictive models for commodity spot market prices. Further from these near real-time uses for the data, analyzing historical archives may reveal patterns and capabilities that can be turned into a competitive advantage, or may infringe on legal rights to privacy. A review of the literature associated with:

- Search and Rescue (SAR);
- Disaster Management and Emergency Response;

9 Terje Wahl, Gudrun K. Høye - Norwegian Defence Research Establishment (FFI), cite reference.

10 <http://www.thefederalregister.com/d.p/2010-01-15-2010-632>, accessed 14 MAY 2010

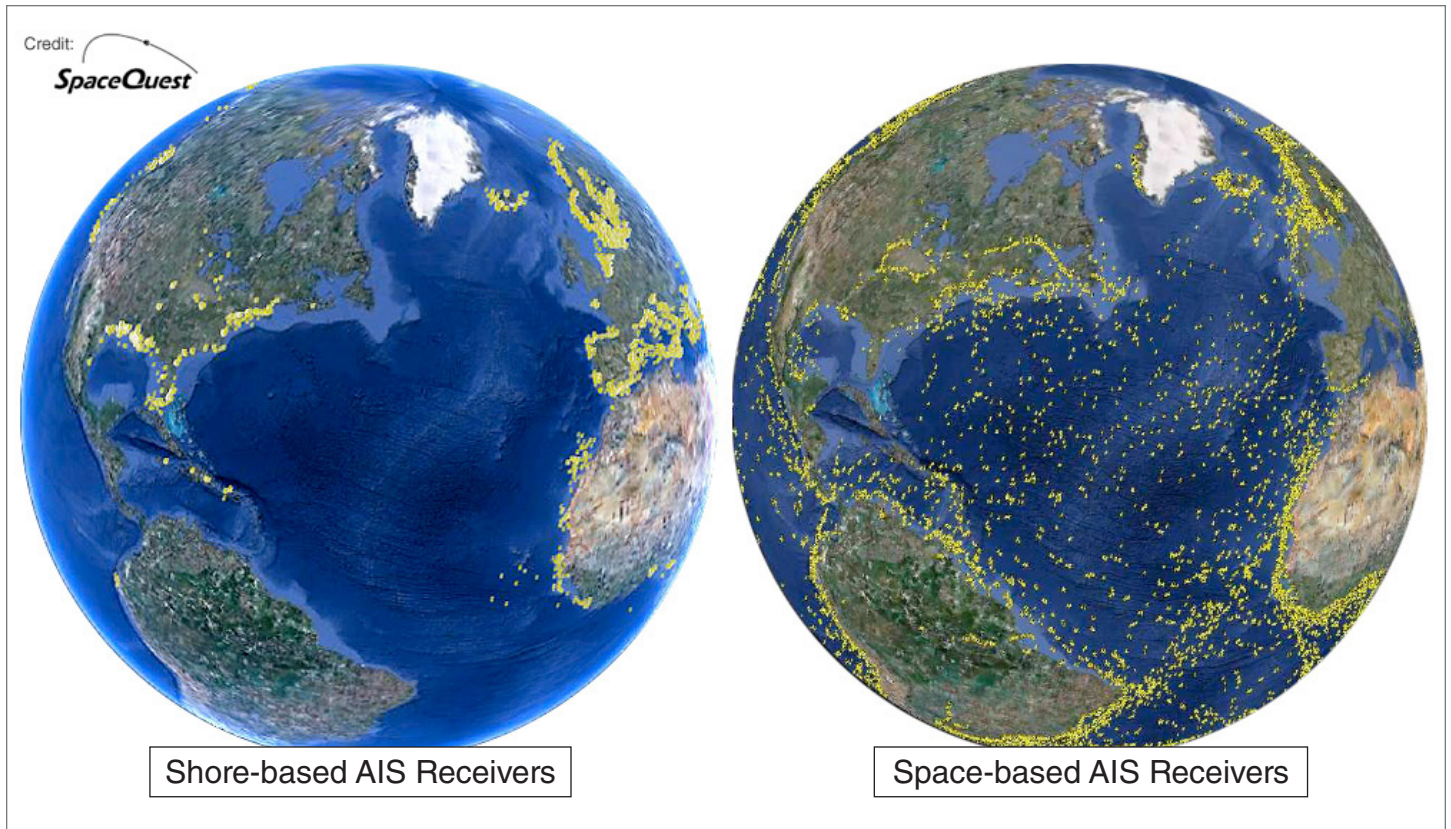


Figure 2. Added Information Provided by satellite-based AIS collection

- Vessel Detection Systems, Vessel Monitoring Systems, Exclusive Economic Zone (EEZ) monitoring;
- Maritime Situational Awareness (MSA), Maritime Domain Awareness (MDA);
- Maritime and Border Region Monitoring, Environmental and Surface Weather Monitoring, Ocean Monitoring;
- Remote Fixed and Mobile Asset Monitoring;

strongly suggests that access to data from remote un-wired assets is essential, and that these programs are more effective with data collected from space.

TYPICAL AIS PROGRAMS

Most AIS systems are implemented at the national level or among allied countries and organized regionally to establish monitoring networks that are able to support all the previously mentioned applications. In this article, rather than summarizing all the national AIS programs from around the globe (well over 100 such programs exist), an overview of 4 different AIS programs is presented, to illustrate the complementary roles of shore-based and space-based AIS collection.

MSSIS – The Maritime Safety and Security Information System (MSSIS) is a freely-shared, unclassified, near real-time data collection and distribution network. Its member countries share AIS data, with no filtering, analysis, or other “value added” operations; this preserves the all-important “freely-shared” character of the network, making it appropriate for all countries, regardless of their technological sophistication or financial condition. MSSIS is intended to promote multilateral collaboration and data-sharing among international participants, with a primary goal of increasing maritime security and safety. Data sources may range from a single sensor to an entire national vessel tracking network. Because the data distributed by MSSIS maintains its original, internationally recognized format and is delivered to users in near real time, member organizations are able to utilize the feed to meet their specific mission requirements.

Members joining the MSSIS network can immediately begin to leverage its capabilities. Transview (TV32), the client software for MSSIS which is distributed free of charge, serves as a common system interface and vessel tracking display for its users. It offers a variety of standalone display features and also functions as a gateway for users to access and contribute to the aggregated global data stream. With frequent enhancements to the system’s capabilities and a continuously growing MSSIS community, government organizations can capitalize on the services of MSSIS to improve and maintain Maritime Domain Awareness. MSSIS was developed by the Volpe National Transportation Systems Center at the US Department of Transportation’s Research and Innovative Technology Administration and is available to nations worldwide to improve and maintain Maritime Domain Awareness. The system is currently used by over 60 nations worldwide.

A major enhancement that is currently in testing for this system is the addition of AIS data collected by satellites. Technical issues being addressed include the latency of data delivered only periodically (as satellites pass over downlink stations) and the problem of data collisions when more than one vessel transmits in a given time slot. Preliminary data collections show tremendous potential, however, as seen in Figure 2.

EU – The European Maritime Safety Administration (EMSA) has recently (March 2010) added a ship tracking module, STIRES (SafeSeaNet tracking Information and Exchange System), to the existing SafeSeaNet maritime data exchange. The information in SafeSeaNet derives from several message types, including Port notification messages, Ship Notification messages (based on AIS data), Hazardous Materials Notification messages, and Incident Reports. The new module, STIRES, makes surveillance, monitoring, tracking and reporting systems more efficient and interoperable:

“This approach will give Member State users a whole range of important new capabilities to work with,” says EMSA Executive Director, Willem de Ruyter. “Instead of just accessing a database, they will be able to see the whole near-real-time situation for the EU displayed on a map right in front of them, and to select all ships, ports, sea areas and many other elements at the click of a button. Much better still, we will soon be in a position to offer an integrated display system which will be able to identify and locate ships

anywhere in the world and also show the EU pollution and accident pictures. The user base is expanding all the time, with port state control officers being among the latest to join the system.”¹¹

The importance of satellite-based ship tracking information is underscored in near-term plans to integrate LRIT (Long Range Identification and Tracking) data into the display available to authorized STIRES users:

“Later this year the STIRES/SafeSeaNet system will be integrated with the satellite-based global Long Range Identification and Tracking system and the CleanSeaNet pollution monitoring system in a single display. The EU anti-piracy force is already using information from the EMSA-operated EU LRIT Data Centre to track ships in the Gulf of Aden and the Indian Ocean, and port authorities wishing to locate ships heading for their ports will be able to see exactly where they are, anywhere in the world.”¹²

EMSA has been working with EU Member States since 2002, when they were directed to establish SafeSeaNet, to collect and share AIS and other maritime safety information.¹³ The architecture envisioned by EMSA in 2007 consolidated AIS reports at the national level to feed regional STIRES systems, which in turn fed European Union systems that would consolidate Short Range Identification and Tracking (SRIT) with LRIT and other vessel traffic system data to produce the integrated, enhanced SafeSeaNet content.¹⁴

Also, the European Space Agency has been working very closely with commercial satellite suppliers and EU members to deploy AIS capable satellites. The first step in this process, already underway, uses the International Space Station to host AIS receivers mounted external to ESA's Columbus Science Module. Knowledge gained through this collection, and the development of algorithms to deconflict AIS messages from crowded areas, will be incorporated into satellite systems planned for launch in 2011.¹⁵

NATO – The NATO Component Command, Maritime (CCMAR) in Naples, Italy, in partnership with the US Naval Forces Europe (NAVEUR, also in Naples), were the operational drivers behind the development of MSSIS, and largely responsible for disseminating it among European and African countries. CCMAR maintains responsibility for the Mediterranean, using MSSIS as the primary

11 <http://www.porttechnology.org/Security%20+%20Logistics/EMSA-casts-its-all-seeing-eye-over-EU-waters/5671.html>, accessed 14 MAY 2010

12 Ibid

13 European Commission Directive 2009/59/EC

14 http://meeting.helcom.fi/c/document_library/get_file?folderId=75181&name=DLFE-30249.pdf, accessed 14 MAY 2010

15 http://www.esa.int/esaMI/Technology/SEMVDZ9NJTF_0.html, accessed 14 MAY 2010

real-time data stream feeding two important visualization and analysis tools: BRITE and FastC2AP. FastC2AP (Fast Connectivity for Coalition Agents Program) was among the first intelligent agent programs to be applied to maritime awareness problems, based primarily on AIS data; alerts have been created for numerous “suspicious” conditions (ship rendezvous, for example, which might indicate trans-shipment of illicit goods). BRITE (Baseline for Rapid Iterative Transformational Experimentation), on the other hand, fuses AIS data with a number of other data sources which contain information about the vessels (ownership, insurance, etc.) and interacts with FastC2AP to give a richer understanding of maritime activity.

Other European military initiatives are also noteworthy; for example, the Virtual Regional Maritime Traffic Centre (run by the Italian Navy) is a network connecting naval operational centers located in the European area. It is based on a specific “Operational Agreement” among 23 “Wider Mediterranean Community” countries’ navies, collecting and providing unclassified information about vessel movement in the area.¹⁶ While the nature of information exchanged between military activities may be different from the information flowing between civil agencies, the basic ships’ positional data is generally identical, at least to the extent that it is AIS data.

US – The US Coast Guard is implementing a program known as Nationwide Automatic Identification System (NAIS). The system will enable the USCG to identify, track and communicate with marine vessels using AIS, and to compare information submitted as Advanced Notice of Arrival messages against ships observed to be headed for US ports. The data collected by NAIS will be combined with other government intelligence and surveillance data to form a holistic, overarching view of maritime traffic within or near U.S. and territorial waters. Additionally, NAIS will provide an alternative to traditional maritime voice communications: command center personnel will be able to transmit text messages (e.g., safety notices, control of shipping instructions, etc.) via the AIS channels to individual vessels or multiple vessels in defined geographic areas.

The goal of NAIS is to enhance Maritime Domain Awareness (MDA), with particular focus on improving maritime security, marine and navigational safety, search and rescue, and environmental protection services. NAIS will allow the USCG to collect vessel safety and security data from AIS-equipped vessels in the nation’s territorial waters and adjacent sea areas out to approximately 2,000 nautical miles and share the data with USCG operators and other government partners.¹⁷ Since AIS is carried on VHF channels, which typically transmit only as far as “line of sight” permits, the 2000 mile goal clearly calls for more than shore-based receivers. In fact, ships at sea, aircraft, buoys, and satellites might all contribute to the future NAIS system, which will then provide data to a host

16 <http://www.marina.difesa.it/vrmtc/2007/uk/vrmtcen.asp>, accessed 14 MAY 2010

17 The 2000 mile criteria comes from a time/distance calculation: Notice of Arrival is required 96 hours in advance of making port; at 20 knots, this means that ships are within a US area of interest when they are approximately 2000 miles out.

of applications supporting governance and law enforcement.

The USCG has partnered with a commercial satellite operator to demonstrate AIS collection from space, and to determine the impact of long range AIS on Maritime Domain Awareness. As of this date, there are still commercial restrictions on this data that prevent sharing it freely among international partners; however, the value to Department of Homeland Security functions such as Customs and Border Protection seems clear.

SATELLITE AIS COLLECTION SYSTEMS

As with the assessment of mobile satellite systems for data extraction previously presented in this article, a review of AIS capable satellites is in order. Like the assessment of data extraction satellites, we will focus on small satellite low earth orbit, non-voice/non-geostationary mobile satellite service (NVNG MSS) systems. While there are larger, more capable satellite systems that can collect AIS signals, they are more costly to build and launch, and take longer to construct and deploy into space – therefore, we will not include such systems in this review.

Table 2 lists the AIS capable satellites that have been launched to date. One issue with these existing and, for that matter, proposed commercial space systems is inherent in their being commercial: they are not designed to engage international partners and foster collaboration, nor do they consider “donations in kind” a legitimate payment for use of the on-orbit capabilities or the data collected. Instead of facilitating the ubiquitous exchange of maritime and border region information at the lowest possible cost, global situational awareness is divided between the “haves” and “have-nots”.

Table 2. Overview of AIS-Capable Satellite Systems (NVNG MSS only)

System	Constellation	Orbit	Mass (kg)	Ground Stations	Data Extract Ch.	Down Link	Up Link	Power (W)	Coverage
AISSat-1*	1	LEO, Polar, 600km	6	1	no	S band at 32 to 256 Kbps	UHF receiver, at 4 kbps	.967	1pass/90min.
AprizeSat ** (AIS capable)	2 of 10	LEO, sun-sync. 565 km x 677 km	12	3	yes	UHF and S band 38.8Kbps	UHF and S band	1	1pass/90min.
exactEarth (Com Dev)	1 Demo	LEO, 630km	8	1	no	32kbps			
Orbcomm (AIS capable)	1 (currently)	LEO, 679 km	80						

* Built by University of Toronto – not a commercial vendor

** Built by Space Quest

Nations without the resources to monitor activity offshore, over the horizon, in their Exclusive Economic Zones have little or no information about the illegal activities that impact their economy (such as longline fishing or waste dumping) and therefore are unable or don't believe there is a need to apply their own resources against these violations. In fact, they may have no motivation to budget for a Coast Guard or Navy, being unaware of the loss to their country that is on-going, out of sight of land. The more affluent countries, those with global situational awareness, may have data which, if analyzed would reveal illegal activity in another country's territorial waters, but have no authority, motivation, or financial interest in intervening. The result of concentrating space-based maritime domain awareness capabilities solely in the commercial sector is that the benefits are unlikely to help those most in need.

In most instances, standard customer pricing and services policies have not been settled on as yet, since a fully functioning program that includes adequate fly over coverage (commensurate with the applications previously identified) has not yet been implemented. As satellites are added to existing constellations, the commercial satellite suppliers' business case for AIS becomes increasingly harder to justify. Based on this author's interviews with the business development personnel from a number of the suppliers, each has admitted to a conflict between their need to sell long range AIS data services to individual nations, and their customers' wish to openly share the data with their global partners (in the same manner as the AIS data is currently shared under the framework of MSSIS). One supplier described how their next generation of AIS-capable satellites will be more functionally rich, larger, and more expensive just so that additional services can be added to create a viable business case for the satellite company.

HIGH LEVEL REQUIREMENTS FOR SPACE-BASED AIS AND DATA EXTRACTION BACKBONE

Up to this point in this article, we have assessed the need, applications, representative end user concepts, and satellite systems, for a proposed global space-based AIS and data extraction backbone. Now, in further preparation for the CANEUS CSSP workshop, we need to take the lessons learned and bundle them up into a high level description of what an ideal system could potentially look like. This "ideal concept" will then be used as a basis for discussion and critique at the workshop, however, for purposes of the workshop, no constraints are presumed: to achieve the goal of a highly accessible communications infrastructure in space, existing satellites as well as purpose-build satellites might be part of the solution.

A good candidate for our "ideal concept," or at least one that represents a very good starting point, is the GLADIS concept from the United States Navy, Naval Research Laboratory. GLADIS is an acronym for the Global Awareness Data Extraction International Satellite constellation. NRL has been a leader in satellite technology since the dawn of space exploration with artificial satellites

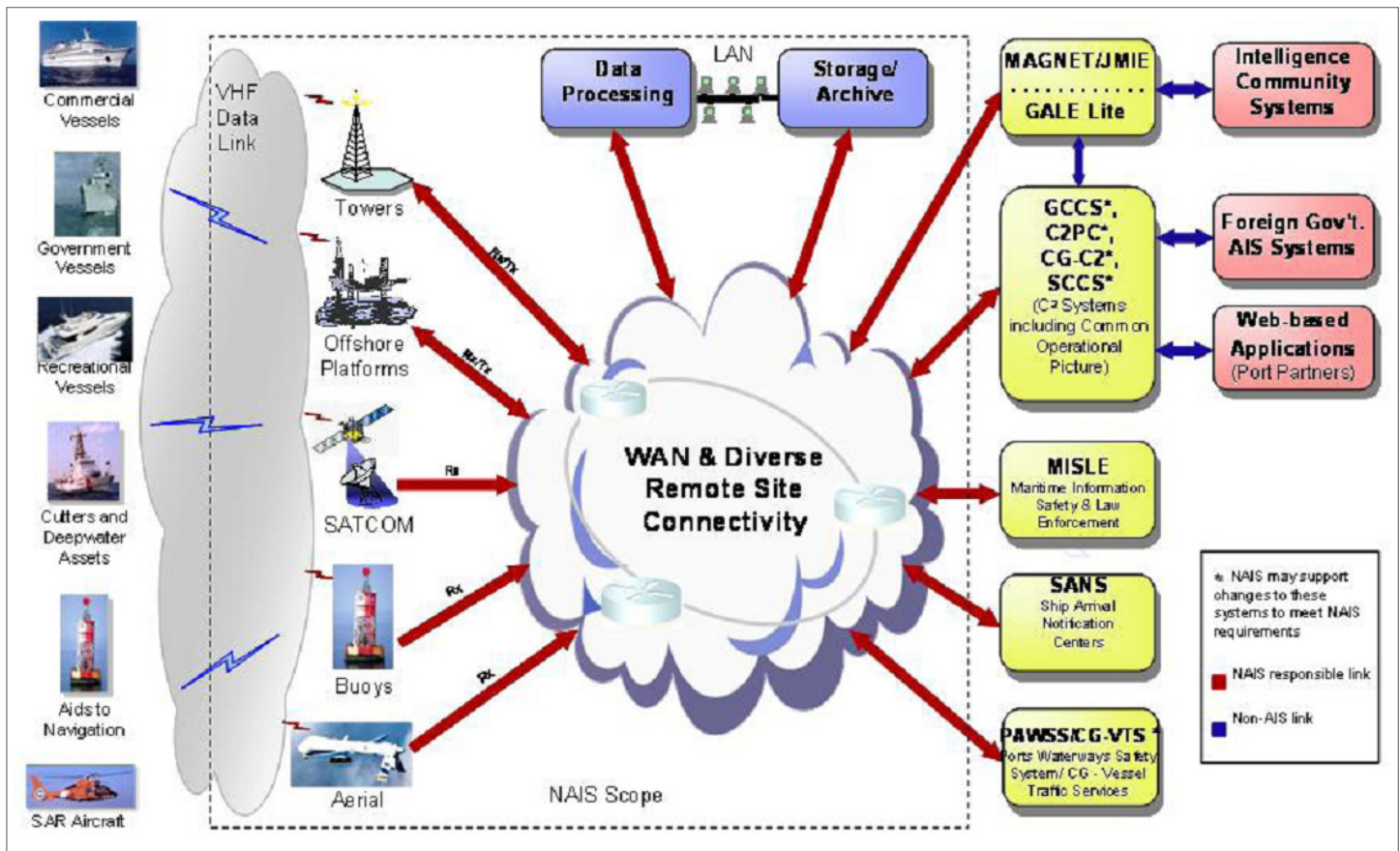


Figure 3. NAIS Integrated System

dating back to the Vanguard Program, in 1958, in conjunction with the International Geophysical Year. The GLADIS concept is an outgrowth of that experience and technical excellence as it frames an affordable, internationally shared long range AIS and data extraction backbone in space with exceptionally low barriers to entry for participating nations.

GLADIS is envisioned as a constellation of 30 low-cost polar-orbiting nanosatellites, owned and operated by a consortium of nations sharing resources and responsibilities through a “fractional ownership” plan. The satellites would be arranged in five planes with six satellites in each plane, at an altitude of 550 kilometers. This would provide a data link within 10 minutes for every location on earth, allowing data from ground transmitters to be collected nearly continuously, wherever the transmitter is located. This includes AIS data routinely transmitted by over 80,000 ships at sea.

Other land or sea-based transmitters from unattended sensors for example, would operate through a bi-directional UHF link hosted on GLADIS satellites, which would receive the sensor data, package it for secure transmission, and forward it to the nearest low-cost GLADIS-capable ground station. From there, the data would enter the “wired” world via the Internet and be delivered to the sensor owner. Figure 4 illustrates the concept.

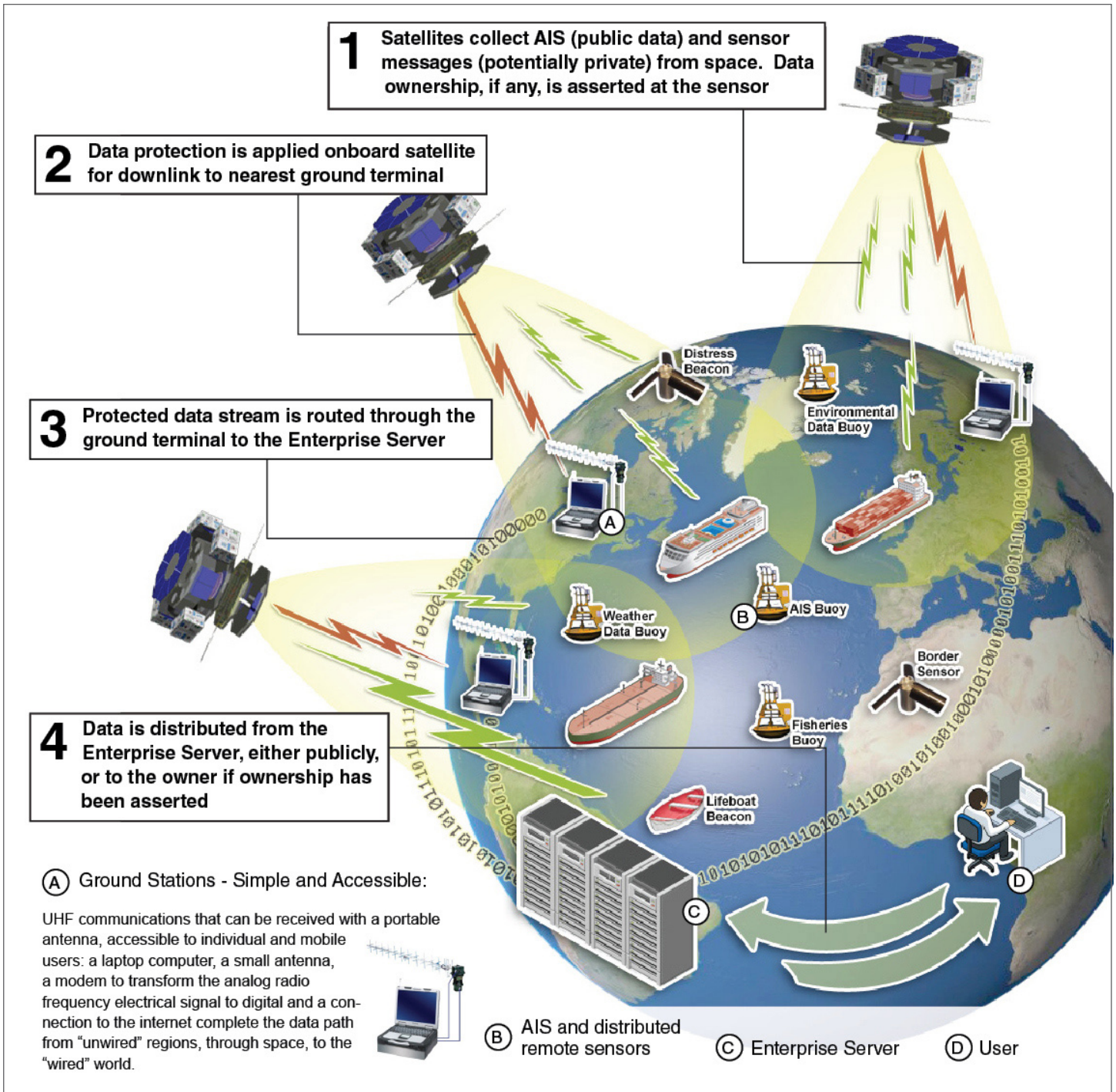


Figure 4. The Space-Based AIS and Data Extraction Backbone

The satellites that form the GLADIS constellation are intentionally simple to keep costs low, but they are fully capable of providing a path for data to move from remote regions anywhere on earth to users in the "wired" world. Each satellite is a 30 cm (12") cube weighing about 15 kg (35 lb) that produces about 20 watts of electrical power. This class of satellites is large enough to carry data

link payload but small enough to “hitch” a ride with other satellites to lower launch costs. From the policy perspective, which is often plagued by ITAR (International Trade in Arms Regulations) restrictions on space technology, GLADIS is intentionally designed to be fully releasable. A fully-shareable design specification would allow countries to participate at the level of their interest and competencies through their laboratories, industry, and academic institutions.

The key components of the satellites are the two communications packages (VHF for AIS reception, and UHF for receiving sensor data and for communicating data back to ground stations), VHF and UHF antennas, power generation, and flight control. Simplicity and low cost figure prominently in the GLADIS design; for example, the VHF antenna (for AIS signals) is a simple tilted dipole design that effectively reduces “data collisions” resulting from the tremendously wide field of view that a satellite has, by comparison to a ship at sea. The flight control, similarly, uses passive “brakes” rather than thrusters to keep satellites in each plane properly spaced. Satellites are designed for at least three years on orbit.

GLADIS DATA EXTRACTION

GLADIS is intended for low bit-rate data streams. The constellation and its components are “data agnostic” in the sense that any data stream conforming to basic message conventions, regardless of content, can be accommodated. GLADIS will receive, process, and forward two classes of data: AIS data broadcast in the VHF frequency range (two channels near 160 MHz) and other data broadcast in the UHF range (frequency allocations to be determined). One key enabler of the latter data set is the Ocean Data Telemetry Microsat Link (ODTML) which translates raw sensor data into standard RF messages and transmits to satellite (or earth-bound) receivers. AIS collected by GLADIS would be unclassified, sharable with the consortium of participating nations, and not sold on a subscription basis. This makes it uniquely suited to feeding cooperative security and maritime governance missions in the EEZs of participating nations.

To cope with known problems (“data collisions”) related to the wide field of view that satellites have, the AIS antenna designed for GLADIS intentionally restricts the field of view to approximately half of the possible field of view. Simulations show that this tactic, implemented with a simple tilted dipole antenna, more than doubles the probability of receiving a “clean” AIS message from any given ship in a congested area, significantly closing the gap between the open ocean (where satellite collection is effective) and near-shore areas (where land or ship based collection is effective). For data from other sensors, standardization of the message format and protection of the carrier frequencies are both issues that are being addressed in a collaborative international forum. The GLADIS project, with satellites that play no favorites in countries that fall into their uplink or downlink footprint, may serve to focus attention on the importance of global standards that are practical for nations spanning the full range of economic and political development.

The AIS data collected by GLADIS would be freely shared among all participants, whereas the GLADIS concept for data extraction from other sensors provides for commercial encryption either at the sensor (a capability of the ODTML hardware, for example) or on-board the spacecraft, with “ownership” (in the sense of having the ability to decrypt data) ascribed to the sensor owner. This is done because the downlink may well be received at a ground station operated by a participant other than the data owner. Once received at a ground station, the encrypted data is fed via the internet to the GLADIS enterprise server, from which it can be retrieved and decrypted only by the owner. In concept, the responsibility for content lies with the data owner; anything which needs protection exceeding commercial encryption should not move through the GLADIS network.

The GLADIS concept does make an excellent candidate for our “ideal concept” in that it is a highly functional, low-cost hardware concept incorporating the lessons learned from our assessments, designed to be internationally sharable, and encouraging multinational collaboration to make data downlink possible around the world. It will be used as a basis for discussion and critique as our efforts progress to define and deploy a global space-based AIS and data extraction backbone.

WHAT’S NEXT

This is the first of three articles intended to familiarize prospective CANEUS CSSP participants with the range of topics that will be addressed in October 2010. Article 2 will take a closer look at the System Requirements and Concept of Operation, while article 3 will explore the Business Case, the Internationally Shared Asset Framework, and the actions needed to implement the Global Partnership. The CANEUS web site (www.caneus.org) will publish these articles and workshop-related information, and condensed versions may appear in popular maritime periodicals.

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