FSpace laboratory, FPT Technology Research Institute, FPT University

Title: Global ship monitoring using space-based AIS receivers

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Need

Many countries need ship traffic monitoring capability, locally and globally. Since December 2004 the International Maritime Organization's (IMO) International Convention for the Safety of Life at Sea (SOLAS) requires AIS (Automatic Identification System) to be fitted aboard international voyaging ships with gross tonnage (GT) of 300 or more tons, and all passenger ships regardless of size. Shore-based AIS receiving station usually cannot cover ships over the horizon (about 50km range). With the possibility of receiving AIS signal from satellites, it is now possible to provide ship monitoring data as a service for maritime administrations, cargo liners and even navies.

Here's the list of possible needs for any country with maritime interest that can be satisfied with space-based AIS receiver:

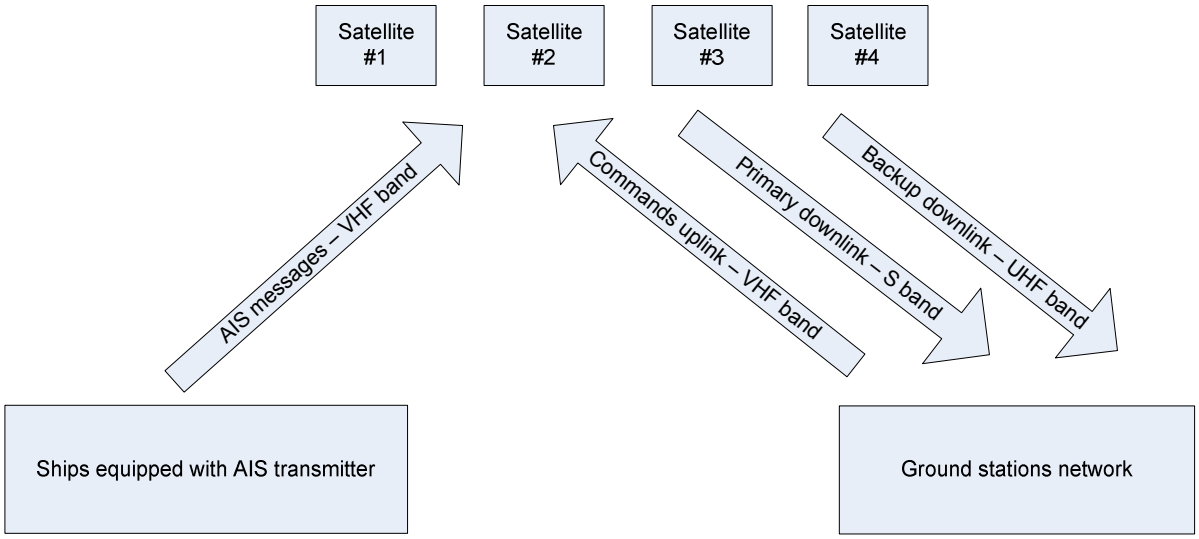
- Ship traffic situation awareness
- Detection of illegal fishing, smuggling, trafficking of drugs or weapons
- Aid in detection of illegal/accidental oil dumping
- Border surveillance

Mission Objectives

- Be able to collect at least 80% of AIS messages from ships anywhere in the world, store and transmit to ground stations. In dense traffic areas, space-based AIS data may need to complement ground-based AIS data.
- AIS data collected from space must be transmitted to the ground as soon as possible, at the latest 3 hours after collection time
- The satellite constellation must be functional for at least 5 years

Concept of Operations

A constellation of 4 similar nanosatellites is launched into Low Earth, polar orbit(s) carrying AIS receivers. As the satellites move around the world, they collect AIS messages (on VHF band) from the ships below for storage in onboard computer and later download to ground stations (via S-band or UHF band downlink). Commands are sent to the satellites from ground stations via VHF or UHF band uplink.



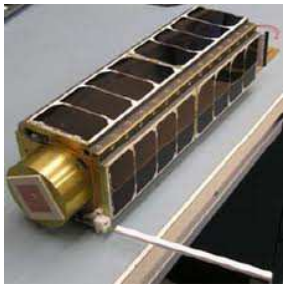
Key Performance Parameters

- AIS receiver: must be able to receive 80% of AIS messages, system link margin more than 10dBm
- Onboard storage: must be able to accommodate at least 1 week of AIS data collection
- Primary S-band transmitter: 0.5-1W output, 38400bps and up downlink speed

Space Segment Description

Satellite key specifications:

- Size and shape: standard 3U cubesat structure 10x10x30cm
- Mass: 3-5kg
- Power: body mounted high efficiency solar cells (28%), 5W average power
- Link margin: 10dBm for AIS signal receiving, commands uplink and data downlink
- Attitude control: passive attitude stabilization using permanent magnets and hysteresis rods
- De-orbit mechanism: deployable membrane, targeted orbital lifetime of maximum 25 years



A 3U cubesat - GeneSat

Orbit/Constellation Description

This proposal targets Low Earth (<1000km), polar orbits for the constellation to have full coverage of the Earth.

All satellites in the constellation are similar and the system can function with at least one satellite. However more satellites can be added to the constellation to increase data reception, coverage and provide redundancy in case of failure of one or more satellite(s). This proposal calls for 4 identical satellites in the constellation.

Implementation Plan

At the moment, FSpace laboratory is working in F-1 cubesat project with the goal to build capacity in small satellites development. We have signed an agreement with an European university (in December, 2010) for collaboration in designing, manufacture and testing of F-1 cubesat. Our plan is to complete and launch F-1 in Q4 2011. We are open to collaboration with other parties who are also interested in small satellites development.

We have also signed a Letter of Intent (in August, 2010) with LuxSpace Sarl - one of the leading European companies for space-based AIS activities for collaboration in design and manufacture of small satellites equipped with AIS receiver. LuxSpace has developed the Pathfinder 2 satellite and another advanced payload onboard the International Space Station and both are operational, collecting AIS signal around the world, they also have extensive know-how in data processing for an efficient maritime surveillance. LuxSpace will be responsible to develop, test and deliver AIS receivers for our satellites.

Our approach to implement this idea is to use flight-provent Commercial-Off-The-Shelf components to build the satellites. These components are available from several commercial companies like Pumpkin Inc., ISIS, ClydeSpace… and we will perform integration, software development, testing and operation of the system.

Also currently there are some organizations which are also interested in acquiring AIS-data such as COM DEV, SpaceQuest, ISIS, LuxSpace… as well as maritime authority many countries (the US, Canada, Norway, the UK, Japan, Vietnam…) and we plan to contact them regarding the possibility of collecting and sharing AIS-data. The business model of DMC International Imaging (DMCII) that manages the Disaster Monitoring Constellation is a very good example to follow.

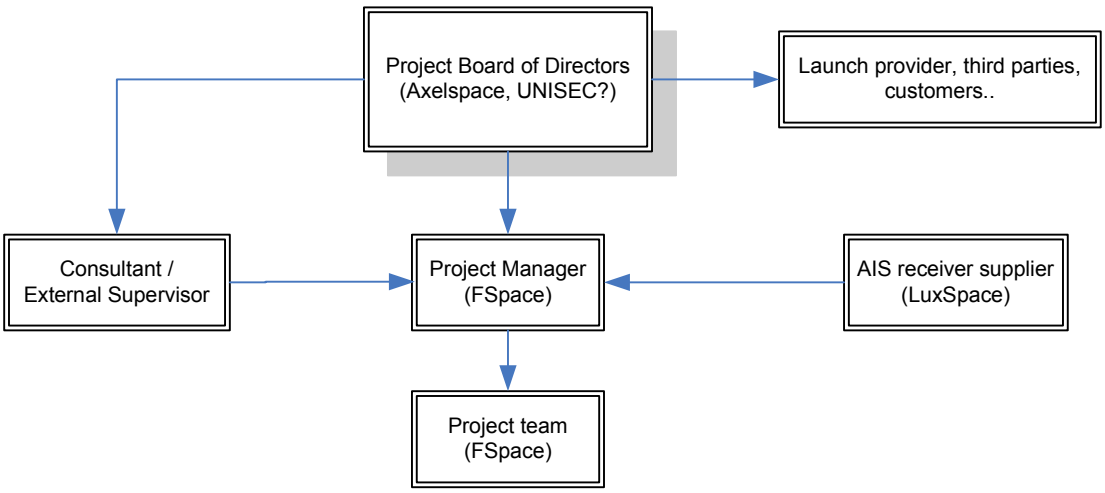
Ground segment specifications

- VHF transmitter for command uplink
- UHF receiver for backup data downlink
- S-band receiver for primary data downlink
- Data storage
- Connectivity to other ground stations and AIS-data sharing centers

Cost estimation (excluding launch)

Item	Cost (EUR)	Note
3U structure	3,800	Pumpkin
Solar panels	24,000	ClydeSpace
EPS	3,500	ClydeSpace
Battery, 8.2V, 10Whr	1,200	ClydeSpace
S-band transmitter	8,500	ISIS
VHF/UHF telemetry/telecommand	8,500	ISIS
Antenna	5,500	ISIS
Passive Magnetic Attitude Stabilization	3,000	ISIS
OBC	4,750	ISIS
Space-grade AIS receiver	20,000	LuxSpace
Others	10,000	
Sub total	**92,750**	
Estimated labor cost (same as hardware cost)	92,750	FSpace
Total cost for 1 satellite (EUR)	**185,500**	
Total cost for 1 satellite (USD)	**243,000**	1EUR = 1.31USD
Total cost for 4 satellites (USD)	**972,000**	
Estimated cost of setting up ground stations and connection to other AIS data distribution system (USD)	**1,000,000**	*Need more thorough study and refinement!*
Operation cost for 5 years (USD)	**600,000**	10,000 USD/month
Grand total (USD)	**2,572,000**	

Project organization



Project schedule

Step	Description	End time
1.	Project kick-off	T
2.	Mission analysis and design	T+3 months
3.	Delivery of the first AIS receiver, first prototype of satellite and testing	T+6 months
4.	Design refinement and necessary adjustment	T+9 months
5.	Second prototype and testing	T+12 months
6.	Manufacture of the first satellite and testing	T+15 months
7.	Manufacture of the second satellite and testing	T+17 months
8.	Manufacture of the third satellite and testing	T+19 months
9.	Manufacture of the fourth satellite and testing	T+21 months
10.	**Delivery of all 4 satellites to launch site for integration with launch vehicle**	**T+24 months**
11.	Launch campaign support and initial verification of the satellites in orbit	T+30 months
12.	Operation of the satellite constellation, collect and distribute AIS data. Launch additional satellites if needed.	T+90 months
13.	An extended mission may be considered based on the health of satellites	T+90 months
14.	Disposal, de-orbit of the satellites	max T+25 years

Risks

Risk	Probability	Impact	Mitigation	Contingency
Space-based AIS receiver cannot receive/decode AIS messages due to high number of message collisions in crowded areas	High	High	Have at least 2 suppliers of space-based AIS receiver to buy the better one	Use data from ground-based AIS receivers in crowded areas
Quality of the design, manufacture is not good enough due to lack of experience of the project team	Low	High	Contract an external consultant/supervision and use flight proven COTS components	N/A
Failure of a satellite	Low	Medium	Have multiple (4) satellites in the constellation	Use other satellites in the constellation or launch a replacement
Failure of a ground station	Low	Medium	Join ground stations network, collaborate with other organizations	Use backup ground stations
The International Maritime Organization revokes its AIS regulation due to security concern	Very low	Very high	N/A	Use the constellation for educational purposes

References

http://www.cubesatshop.com/