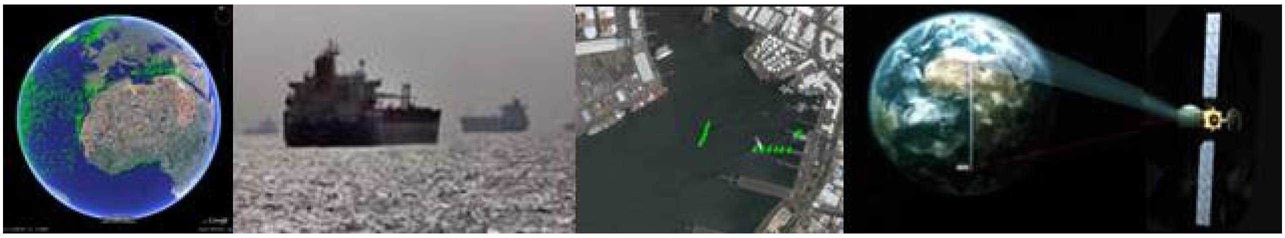
in cooperation with

Institute of Space Systems

Flight Operations



Technical Note 1:

Vessel location data sources: terrestrial and spaceborne AIS data, LRIT and others

Preparatory Action for Assessment of the Capacity of Spaceborne Automatic Identification System Receivers to Support EU Maritime Policy

DG MARE Service Contract MARE/2008/06 – SI2.517298

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DOCUMENT CHANGE RECORD			
ISSUE	*DATE*	*CHANGE AUTHORITY*	*REASON FOR CHANGE AND AFFECTED SECTIONS*
1	02/07/2009	FDC	Initial version
2	06/07/2009	LXS	First review LXS
3	15/07/2009	LXS	Updates from ComDev included

Applicable and Reference Documents

RD 1	IALA Technical Clarifications on Recommendation ITU-R M.1371-1", edition 1.5
RD 2	INTERIM LRIT TECHNICAL SPECIFICATIONS AND OTHER MATTERS Ref. T2-OSS/1.4 MSC.1/Circ.1219 15 December 2006
RD 3	Preparatory Action for Assessment of the Capacity of Spaceborne Automatic Identification System Receivers to Support EU Maritime Policy – Pasta Mare Technical Proposal Call for Tenders No MARE/2008/06
RD4	ORBCOMM (2008): AIS DATA COLLECTION SYSTEM DESCRIPTION & CUSTOMER INTERFACES SPECIFICATIONS, Version 1.5 (Draft), Dulles

TABLE OF CONTENT

1. INTRODUCTION

1.1 PASTA MARE PROJECT

PASTA MARE project aims at increase the understanding of the potential performance of space-based AIS and its potential effectiveness as a tool to support the maritime policy of EU as well as to improve efficiency of governmental and commercial activities in the maritime sector.

To reach this objective the following main tasks have been established:

- Establishment of an improved understanding of global transport in terms of vessel traffic density information as input and benchmarking of the spaceborne and airborne AIS data performance tests
- Identification of legal and illegal sources of interference of the AIS signal
- Testing of space based AIS payloads already in orbit in terms of their performance versus other available vessel data (LRIT, ground based AIS)
- Development of a most advanced and innovative AIS receiver payload system and to test it through extended airborne campaigns and cross check results with ground and space based AIS as well as LRIT data
- Drawing up of conclusions of the different developments and tests in terms of lessons learned and provide recommendations for possible next steps towards a spaceborne AIS service

1.2 DOCUMENT OBJECTIVE

To better understand what space AIS is able to provide to Maritime Stakholders, the methodology adopted in PASTA MARE project is compare its outputs to available data provided today by "ground" AIS and LRIT.

Therefore one of the first steps in Pasta Mare project is the collection of comparable data based on which the capabilities of space borne AIS data can be assessed. This document presents all the data sources which were addressed within this collection task and provide, as far as possible, information on data sets collected, such as:

- Data Descriptions,
- Formats,
- Area covered/concerned,
- Periods of times,
- Limitations (if any)…

Chapter 2.2 presents current “ground” information sources and provides information on data formats.
Chapter 2.3 present Spaces sources with information on data transmitted to the Earth which a supposed to be compared to “ground” information.

2. DATA SOURCES

2.1 VESSEL LOCATION SYSTEMS AND DATA SOURCES

This part investigates existing ship reporting requirements and assesses the suitability of using the information within Pasta Mare for validation of AIS space.

2.1.1 MANUALLY GENERATED MANDATORY, VOLUNTARY AND COMPULSORY REPORTING.

Apart from AIS and LRIT, there is other reporting requirements that are applicable for certain kinds of ships, all ships within certain areas, or ships witnessing or part of an event. These other reports are identified and the suitability for use within the project for validation assessed.
The reports are required for safety, security and for environmental protection, originally the schemes were based on voluntary reporting to support navigation safety and search and rescue, and in regard to long range requirements for SAR, to know a vessel’s last position in case she is lost, or to determine the closest and most appropriate ships for search and rescue, more latterly after a number of pollution events, to determine the risk to the environment, especially in special sea areas. LRIT is a new Long Range reporting requirement that has evolved from security concerns and requires all vessels over 299grt to report periodically.
Within Europe responsibility is placed within the ship monitoring directive 2002/59, on both the Ship and Members States regarding the use and monitoring of IMO adopted Mandatory Reporting systems in Europe.
Though IMO guidelines are given for the content of ship reports, in fact there are differences between different systems. The messages are at the moment quite wasteful in the data that is included, for example, the information provided is often in text rather than using UN coding to save on the amount of data sent.
There are in total 64 reporting systems in the world. They are listed in the following table.

Name of Report Area	Region Or Country	Mandatory, Voluntary and Compulsory (M, V or C)
ADRIREP	Adriatic	M
ISLEREP	Andeman & Nicobar Islands	V

Name of Report Area	Region Or Country	Mandatory, Voluntary and Compulsory (M, V or C)
SECOSENA	Argentina	V
REEFREP	Australia	M
AUSREP	Australia	V
BAREP	Baltic - HelCom	M
SISTRAM	Brazil	V
SURNAV	Caledonia	V
ECAREG (Security)	Canada	C
ECAREG (VTS)	Canada	V
ECAREG ICE	Canada	M
NORDREG (Security)	Canada	C
NORDREG ICE	Canada	V
NORDREG (VTS)	Canada	V
CVTS (Security)	Canada	C
CHILREP	Chile	V
CHISREP	China	V
CHENGSHAN JIAO	China	M
BONIFREP	Corsica & Sardinia St.	M
GBT REP - GREAT BELT	Denmark	M
SHIPPOS	Denmark	V
COGUAR	Ecuador	V
SAFESEANET	Europe	M
WETREP	Europe (Western Europe)	M
STANLY	Falklands	V
FIJI	Fiji	V
GOFREP	Finland & Latvia	M
SURNAV	France	V
MANCHEREP	France	M
OUESREP	France	M
GEOREP	Georgia	M
GIBREP	Gibraltar	M
COASTAL CONTROL	Greenland	M
GREENPOS	Greenland	M
IEZ	Iceland	V
INSPIRES	India	V
INDSAR	India	V
IMOT	Israel	V
ARES	Italy	V
JASREP	Japan	V
KOSREP	Korea	V
ISLEREP	Lakshadweep & Minicoy	M
SOUCENCORSAU	Madagascar	M
STRAITREP	Malacca & Singapore	M
NZAR	New Zealand	M
PASREP	Pakistan	V
SHIPREP	Peru	V
SURNAV	Reunion	V
BELOYE MORE	Russia White Sea	V
SSRS	Saudi Arabia	V
SINGREP	Singapore	V
SOLOMON	Solomons	V
SAMSA	South Africa	M
SAFREP	South Africa	V
FINREP	Spain (Cabo Finisterre)	M
TUBREP	Turkey - Canakkale Bogazi &	M
CALL DOVER	UK	M
LITTLE MINCH	UK	M

Name of Report Area	Region Or Country	Mandatory, Voluntary and Compulsory (M, V or C)
LANDS END	UK	M
MAREP	UK W. Approaches	V
URUGUAYAN	Uruguay	C
WHALESNORTH	USA	M
WHALESOUTH	USA	M
AMVER	USA	V

Table 1: Maritime world reporting systems

Within the table there are three types, Mandatory, Voluntary and Compulsory (M, V or C). The Mandatory reports are the result of acceptance of a request by a flag state within IMO. Mandatory reporting systems are within Economic Exclusion Zones (200NM) (or Continental Shelf Zone (350NM)) limits and often within contiguous zones (24NM). Because each contracting state has a duty to look after the seas within their EEZ, it is not difficult, providing they can prove the benefit to safety or the environment, to have a reporting system adopted as mandatory by IMO. In the spirit of UNCLOS (United Nations Convention on the Law Of the Sea) extended reporting systems outside these limits is difficult due to the rights of free passage.

Compulsory reporting systems, are declared as such by the flag state that is responsible for the system, however, they are not accepted by IMO as being mandatory. The Flag State, though, requires all vessels that will be visiting their ports to use the prescribed systems; it should remain voluntary for transiting ships.

Voluntary reports are usually mandatory for vessels of the flag state of the country that, the reporting limits often extend far out of the Economic Exclusion Zone (or continental shelf). However, in reality, because the voluntary reports are usually associated with the flag states SAR coverage areas, most mariners and their companies realize that it is in their interest to use them. Additionally, some administrations use a carrot and stick. Because, no company wants to suffer delays there is encouragement to use these systems.

There have been accounts of some administrations will even stop transiting ships with warships well outside their territorial waters and contiguous zone.

These reports contain the following elements.

2.1.1.1 SAILING PLAN AND FINAL REPORT

The Sailing Plan is sent as near as possible to the time of departure from a port within a system or when entering the area covered by a system.

The Final report, is sent on arrival at destination and when leaving the area covered by the system.

2.1.1.2 DEVIATION REPORT

This is required when ships position varies significantly from the position that would have been predicted from previous reports. Should an event happen during the voyage that requires a deviation from the route as registered prior to sailing, or since the last deviation report, and because vessel will report the position frequently, there seem little need in providing new route information, the port or area of destination would seem to suffice.

2.1.1.3 INCIDENT REPORTS

Probably the best way do deal with these required data sets is to have a record covering the cargo in a voyage cargo database, accessible from the internet and held by a competent authority, and having the location of that database indexed to the ID of the ship within the competent authority database of the ships flag, similar to the procedures used within SAFESEASNET.

2.1.1.4 DANGEROUS GOODS REPORT

This report is required when an incident takes place involving the loss or likely loss overboard of goods, including those in containers, portable tanks, road and rail vehicles and shipborne barges, into the sea.

2.1.1.5 HARMFUL SUBSTANCES REPORT,

A Harmful Substance report is required when an incident takes place involving the discharge or probable discharge of oil (Annex I of MARPOL 73/78) or noxious liquid substances in bulk (Annex II of MARPOL 73/78)

2.1.1.6 MARINE POLLUTANTS REPORT

The Marine Pollutants report is required In the case of loss or likely loss overboard of harmful substances packaged, including those freight containers, portable tanks, road and rail vehicles and shipborne barges, identified in the international Maritime Dangerous Goods Code as marine pollutants (Annex III of MARPOL 73/78)

2.1.2 COMMERCIAL ROUTING AND MONITORING

Many charters require that ships are weather routed. This may be either for preservation of cargo, or to reduced insurance risk of cargo and or vessel. Some ships such as cruise ships are routed for passenger comfort. It is likely that as sensor information from satellite imaging and hydro-meteo buoys improves, that the "risk" to a vessels from ambient conditions can mitigated by correlating periodic reports with ambient conditions by dynamic routing services.

To ensure that the vessels are following the prescribed routing, vessels will be required to give periodic position reports, these may be for intervals of 3, 6 or 12hrs.

Ships traditionally sent a noon report to their company (once per day) which amongst other information would have the position of the ship at noon. It is also recommended by IMO that if a vessel is not reporting to any reporting system, they should report to their company at least once every 24 hours. Some commercial organisations such as Polestar Purple Finder" offer tracking services whereby the position of ships is updated to companies or operators periodically from satellite earth stations. Owner or operating companies have a legitimate need to know where there ships are to assist in commercial planning and transactions.

Vessels with sophisticated communication fits may also provide engine and ship system telemetry information periodically to assist in preventative and pre-planned maintenance to optimise ship engine performance and minimise downtime for maintenance.

A number of third parties would be able to make their operations more efficient if they had periodic information provided automatically to them so they may ensure that sufficient stocks of consumables such as lube oils, hydraulic oils and chemicals scheduled for delivery to various ports based on the probable ETA of their customers' ships. Delays of products, or re-shipping of products that have missed the ship can cause increased overhead costs of supply, and reduced efficiency of on-board systems.

2.1.3 EVENT REPORTING

There are many types of event reporting ranging from Severe weather warnings to Tsunamis to Piracy to harm full substances and pollution.

2.1.3.1 DISASTERS, EMERGENCIES AND WARNING REPORTS

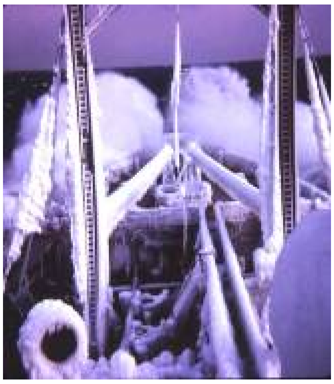
2.1.3.1.1 TSUNAMI AND SEVERE STORMS (FORCE 10 +)

Ships have a statutory obligation to report sightings or occurrences of Tsunami and other freak waves, storms of force 10 on the beaufort scale and above, including hurricanes and typhoons, and sandstorms.

2.1.3.1.2 ICE AND ICE ACCRETION

In Higher latitudes during winter stormy weather, spray and precipitation causes the deposition of a coating of ice on the ship's superstructure and deck cargo due to the freezing of spray, rain, or drizzle, on contact with the vessel or cargo surface. It is a common and sometimes dangerous occurrence. Icing may also occur even in relatively calm weather, due to the formation of a coating of rime ice that is formed when a ship is passing through freezing fog as droplets freeze on the superstructure.

Ice accretion, can accumulate not just on the deck, but on one or both sides of the vessel's hull, superstructure and deck cargo (containers). This can cause raising of the centre of gravity height which can result in a vessel heeling, and in extreme cases cause loss of stability, and result in the worst case lead to capsize. Because it is extremely serious, mariners are required to report occurrences of ice accretion on their ships wherever it is observed.



Sea Ice itself presents different problems. We all know well the fate of vessels that collide with Icebergs, however had the Titanic not altered course to avoid, but steered straight for it, she would have survived, moderately embarrassed with a crumpled bow, but still afloat. Though bergs present a serious hazard, they are only a small part of the problem. Many ships that are not ice strengthened, trade in areas where sea ice can appear in hours. If a vessel is stopped in such ice, very quickly pressure can build up on the hull causing in extreme cases distortion and structural failure. Therefore it is a requirement to report the location and type of sea ice.

2.1.3.1.3 QPAR, QUARANTINE AND FREE PRATIQUE REPORTS

All ships prior to arrival are required to inform the status of health of the vessel and animals and crew aboard. This includes de-rat certification. If a vessel is healthy then it will send a request for "Free pratique". Otherwise it will have to send information of the status of the vessel. The QPAR details the condition of the vessel including human health, cargoes and ballast water management. Vessel Masters or Medical Officers who knowingly give false or misleading information or negligently give false or misleading information are guilty of an offence. Vessel

Masters/agents are required to submit the QPAR to normally no more than 48 hours and no less than 12 hours prior to the vessel's arrival.

However, should there be medical problems aboard the vessel the reports can be much longer.

2.1.3.1.4 PIRACY REPORTS PIRACY AND ARMED ROBBERY AGAINST SHIPS

The fight to prevent and suppress acts of piracy and armed robbery against ships is linked to the measures to improve security on ships and with port installations, adopted in December 2002 (ISPS code). The following definition of piracy is contained in article 101 of the 1982 United Nations Convention on the Law of the Sea (UNCLOS):

"Piracy consists of any of the following acts:

a) any illegal acts of violence or detention, or any act of depredation, committed for private ends by the crew or the passengers of a private ship or a private aircraft, and directed:

- on the high seas, against another ship or aircraft, or against persons or property on board such ship or aircraft;
- against a ship, aircraft, persons or property in a place outside the jurisdiction of any State;

b) any act of voluntary participation in the operation of a ship or of an aircraft with knowledge of facts

- making it a pirate ship or aircraft;
- any act inciting or of intentionally facilitating an act described in sub-paragraph (a) or (b)."

2.1.3.1.5 ALIEN & MIGRANT SMUGGLING REPORTS

There are two problem areas here, stowaways and migrant smuggling, both cause a major problem to the maritime community as ships finding a stowaway are often obliged to return him to the port he boarded the vessel. The total number of incidents related to unsafe practices associated with the trafficking or transport of migrants by sea so far reported to the Organization from 1 January 1999 to 31 December 2007 is 1,253 involving 61,806 migrants. Alien smuggling as in a stowaway situation usually involves just one or two persons, between 1st January and 31 December 2007 there had been 252 incidents reported to the IMO, involving 889 stowaways.

2.1.3.2 STRUCTURE AND CONTENT OF SHIP REPORTING INFORMATION

The structure and scale of reports are set by IMO, and are designed for voice or written (computer / telex). They were designed using the assumption that the report is the only method of retrieving the information required, and that all data sets it should be derived from the ship.

IMO Standard For Mandatory Report Fields Of Ship Reports		
ID	Function	Information required
A	Ship	Name, call sign or ship station identity, and flag
B	Date and time of event	A 6-digit group giving, day of month (first two digits), hours and minutes (last four digits). If other than UTC state time zone used
C	Position	A 4-digit group giving latitude in degrees and minutes suffixed with N (north) or S (south) and a 5- digit group giving longitude in degrees and minutes suffixed with E (east) or W (west); or
D	Position	True bearing (first 3 digits) and distance (state distance) in nautical miles from a clearly identified landmark (state landmark)
E	Course	A 3-digit group
F	Speed in knots and tenths of knots	A 3-digit group
G	Port of departure	Name of last port of call
H	Date, time and point of entry into system	Entry time expressed as in (B) and entry position expressed as in (C) or (D)
I	Destination and expected time of arrival	Name of port and date time group expressed as in (B)
J	Pilot	State whether a deep-sea or local pilot is on board
K	Date, time and point of exit from system or arrival at the ship's destination	Exit time expressed as in (B) and exit position expressed as in (C) or (D)
L	Route information	Intended track
M	Radiocommunications	State in full names of stations/frequencies guarded
N	Time of next report	Date time group expressed as in (B)
O	Maximum present static draught in metres	4-digit group giving metres and centimetres
P	Cargo on board	Cargo and brief details of any dangerous cargoes as well as harmful substances and gases that could endanger persons or the environment (See detailed reporting requirements)
Q	Defects/damage/ deficiencies/other limitations	Brief details of defects, damage, deficiencies or other limitations (See detailed reporting requirements)
R	Description of pollution or dangerous goods lost overboard	Brief details of type of pollution (oil, chemicals, etc.) or dangerous goods lost overboard; position expressed as in (C) or (D) (See detailed reporting requirements)
S	Weather conditions	Brief details of weather and sea conditions prevailing
T	Ship's representative and/or owner	Details of name and particulars of ship's representative or owner or both for provision of information (See detailed reporting requirements)
U	Ship size and type	Details of length, breadth, tonnage, and type, etc., as required
V	Medical personnel	Doctor, physician's assistant, nurse, personnel without medical training
W	Total number of persons on	State number

IMO Standard For Mandatory Report Fields Of Ship Reports		
	board	
X	Miscellaneous	Any other information as appropriate
Y	Request to relay report to another system.	Content of report
Z	End of report	No further information required

Table 2: Mandatory Report Fields Of Ship Reports

The information from the above table is required within the following kinds of reports.

Kinds Of Periodic & Event Reports		
Sailing Plan	SP	Before or as near as possible to the time of departure from a port within a system or when entering the area covered by a system.
Position report	PR	When necessary to ensure effective operation of the system.
Deviation report	DR	When the ships position varies significantly from the position that would have been predicted from previous reports, when changing the reported route, or as decided by the master.
Final report	FR	On arrival at destination and when leaving the area covered by the system.
Dangerous goods report	DG	When an incident takes place involving the loss or likely loss overboard of packaged goods, including those in containers, portable tanks, road and rail vehicles and shipborne barges, into the sea.
Harmful Substances report	HS	When an incident takes place involving the discharge or probable discharge of oil (Annex I of MARPOL 73/78) or noxious liquid substances in bulk (Annex II of MARPOL 73/78)
Marine Pollutants report	MP	In the case of loss **or likely** loss overboard of harmful substances packaged, including those freight containers, portable tanks, road and rail vehicles and shipborne barges, identified in the international Maritime Dangerous Goods Code as marine pollutants (Annex III of MARPOL 73/78)
Any other report		Any other report should be made in accordance with the system procedures as notified in accordance with paragraph 9 of the General Principals.

Table 3: Kinds of Periodic & Event Reports

Because there are the several kinds of reports as shown above, and because they will substantially affect the size of the message. Analysis of scale and scope of reports depends on the number of ships and percentage of ship types, whether sailing plans need updating, and whether of course there is an incident to report.

There are no overall statistics for world-wide ship reporting, however, the USCG have provided some statistics on the vessels using AMVER for a given day. These show that approximately 12.22% of vessels would send a sailing plan, 11.82% would send a Final report, 1.7% a deviation report and 74.26% a position report. If we also assume that super tankers make up 10.5%, product and chemical tankers, 15%, Bulkers 20%, Container ships, 10.5% and Passenger ships and others 44%. It is possible to determine the scale and scope of ship reporting. There area also special reports required when hazardous goods are overboard or pollution has occurred, there are about 100 such incidents per year. These special reports' vary considerably in size.

IMO Guidelines for detailed Incident Reporting requirements.			
Dangerous Goods Report DG	Primary reports should contain items A, B, C (or D), M,Q,R,S,T,U,X of the standard reporting format; details for R should be as follows:		
	R	1	Correct technical name of goods.
		2	UN Number or numbers of goods.
		3	IMO hazard class or classes.
		4	Names of manufacturers of goods when known, or consignee or consignor.
		5	Types of packages, including identification marks. Specify whether portable tank or tank vehicle, or whether vehicle or freight container or other cargo transport unit containing packages. Include official registration marks and numbers assigned to the unit.
		6	An estimate of the quantity and likely condition of the goods.
		7	Whether lost goods floated or sank.
		8	Whether loss is continuing.
		9	Cause of loss.
	If the condition of the ship is such that there is danger of further loss of packaged dangerous goods into the sea, items P&Q of the standard position format should be reported; details for P should be as follows:		
	Q	1	Correct technical name of goods.
		2	UN Number or numbers of goods.
		3	IMO hazard class or classes.
		4	Names of manufacturers of goods when known, or consignee or consignor.
		5	Types of packages, including identification marks. Specify whether portable tank or tank vehicle, or whether vehicle or freight container or other cargo transport unit containing packages. Include official registration marks and numbers assigned to the unit.
		6	An estimate of the quantity and likely condition of the goods.
	Particulars not immediately available should be inserted in a supplementary message or messages.		
Harmful substances reports (HS)	In the case of actual discharge, primary HS reports should contain items A,B,C (ORD), E,F,L,M,N,Q, R, S, T, U, X of the standard reporting format. In the case of probable discharge (see 3.4) item P should also be included. Details for P, Q, R, T, and X should be as follows:		
	P	1	Type of oil or correct technical name of the noxious liquid substances on board.
		2	UN Number or numbers.
		3	Pollution category (A, B, C or D), for noxious liquid substances.
		4	Name of manufacturers of substances, if appropriate, when known or consignee or consignor.
		5	Quantity.
	Q	1	Condition of the ship as relevant
		2	Ability to transfer cargo/ballast/fuel.
	R	1	Type of oil or correct technical name of the noxious liquid substances on board.
		2	UN Number or numbers.
		3	Pollution category (A, B, C or D), for noxious liquid substances.
		4	Name of manufacturers of substances, if appropriate, when known or

IMO Guidelines for detailed Incident Reporting requirements.			
			consignee or consignor.
		5	An estimate of the quantity of the substances.
		6	Whether lost substances floated or sank.
		7	Whether loss is continuing.
		8	Cause of loss
		9	Estimate of the movement of the discharge or lost substances, giving current conditions if known.
		10	Estimate of the surface area of the spill if possible.
	T	1	Name, address, telex and telephone number of the ship's owner and representative (charterer, manager, or operator of the ship or their agent).
	X	1	Action being taken with regard to the discharge and the movement of the ship.
		2	Assistance or salvage efforts which have been requested or which have been provided by others.
		3	The master of an assisting or salvage ship should report the particulars of the action undertaken or planned.
	After the transmissions of the information referred to above in the initial report, as much as possible of the information essential for the protection of the marine environment as is appropriate to the incident should be reported in a supplementary report as soon as possible. That information should include items P, Q, R, S ands X.		
	The master of any ship engaged in or requested to engage in an operation to render assistance or undertake salvage should report, as far as practicable, items A, B, C (or D), E, F, L, M ,Q, R, S, T, U, X of the standard reporting format. The master should also keep the coastal state informed or developments.		
Marine pollutants reports (MP)	In the case of actual discharge, primary reports should contain items A, B, C, (or D), E, F, L, M, N, P, Q, R, S, T, U, X of the standard reporting format. The master should also keep the coastal State informed of developments:		
	P	1	Correct technical name of goods.
		2	UN Number or numbers of goods.
		3	IMO hazard class or classes.
		4	Names of manufacturers of goods when known, or consignee or consignor.
		5	Types of packages, including identification marks. Specify whether portable tank or tank vehicle, or whether vehicle or freight container or other cargo transport unit containing packages. Include official registration marks and numbers assigned to the unit.
		6	An estimate of the quantity and likely condition of the goods.
	Q	1	Condition of the ship as relevant.
		2	Ability to transfer cargo/ballast/fuel.
	R	1	Correct technical name of the goods.
		2	UN Number or numbers.
		3	IMO hazard class or classes
		4	Names of manufacturers of goods when known, or consignee or consignor.
		5	Types of packages, including identification marks. Specify whether portable tank or tank vehicle, or whether vehicle or freight container or other cargo transport unit containing packages. Include official registration marks and numbers assigned to the unit.
		6	An estimate of the quantity and likely condition of the goods.
		7	Whether lost goods floated or sank.
		8	Whether loss is continuing.
		9	Cause of loss.
	T	1	Name, address, telex and telephone number of the ship's owner and representative (charterer, manager, or operator of the ship or their agent).
	X	1	Action being taken with regard to the discharge and the movement of the ship.
		2	Assistance or salvage efforts which have been requested or which have been provided by others.

IMO Guidelines for detailed Incident Reporting requirements.		
	3	The master of an assisting or salvage ship should report the particulars of the action undertaken or planned.
		After the transmissions of the information referred to above in the initial report, as much as possible of the information essential for the protection of the marine environment as is appropriate to the incident should be reported in a supplementary report as soon as possible. That information should include items P, Q, R, S and X.
		The master of any ship engaged in or requested to engage in an operation to render assistance or undertake salvage should report, as far as practicable, items A, B, C (or D), E, F, L, M, Q, R, S, T, U, X of the standard reporting format. The master should also keep the coastal state informed or developments.
Probability of discharge.		The probability of a discharge resulting from damage to the ship or its equipment is a reason for making a report. In judging whether there is such a probability and whether the report should be made, the following factors, among others, should be taken into account:
	1	The nature of the damage, failure or breakdown of the ship, machinery or equipment; and
	2	Sea and wind state an also traffic density in the area at the time an place of the incident.
		It is recognised that it would be impracticable to lay down precise definitions of all types of incidents involving probable discharge which would warrant an obligation to report. Never the less, as a general guideline the master of the ship should make reports in cases of:
	1	Damage, failure or breakdown which affects the safety of ships; examples of such incidents are collision, grounding, fire, explosion, structural failure, flooding, cargo shifting; and
	2	Failure or breakdown of machinery or equipment which results in impairment of the safety of navigation, examples of such incidents are failure or breakdown of steering gear, propulsion plant, electrical generating system, essential shipborne navigational aids.

Table 4: IMO Guidelines for detailed Incident Reporting requirements

2.1.4 VESSEL MONOTORING USING AUTOMATED SHIP REPORTING

This includes AIS, LRIT and VMS.

2.1.4.1 AIS (AUTOMATIC IDENTIFICATION SYSTEM)

The AIS is a system used by ships and Vessel Traffic Services (VTS) principally for identification and locating vessels. AIS provides a means for ships to electronically exchange ship data including: identification, position, course, and speed, with other nearby ships and VTS stations. This information can be displayed on a screen or an ECDIS display. AIS is intended to assist the vessel's watchstanding officers and allow maritime authorities to track and monitor vessel movements. It works by integrating a standardized VHF transceiver system with an electronic navigation system, such as a LORAN-C (LOng RAnge Navigation Version C) or Global Positioning System receiver, and other navigational sensors on board ship (gyrocompass, rate of turn indicator, etc.).

The International Maritime Organization's (IMO) International Convention for the Safety of Life at Sea (SOLAS) requires AIS to be fitted aboard international voyaging ships with gross tonnage (GT) of 300 or more tons, and all passenger ships regardless of size. It is estimated that more than 40,000 - 70000 ships currently carry AIS class A equipment

The following table is extracted from [RD 1] and summarise defined messages in AIS:

Message ID	Name	Description
1	Position Report	Scheduled position report; (Class A Shipborne Mobile Equipment)
2	Position Report	Assigned Scheduled position report; (Class A Shipborne Mobile Equipment)
3	Position Report	Special position report, response to interrogation; (Class A Shipborne Mobile Equipment)
4	Base Station Report	Position, UTC, Date and current Slot number of base station
5	Static and Voyage Related Data	Scheduled static and voyage related vessel data report; (Class A Shipborne Mobile Equipment)
6	Binary Addressed Message	Binary data for addressed communication
7	Binary Acknowledgement	Acknowledgement of received addressed binary data
8	Binary broadcast message	Binary data for broadcast communication
9	Standard SAR Aircraft Position Report	Position Report for airborne stations involved in SAR operations, only
10	UTC/Date inquiry	Request UTC and date
11	UTC/Date Response	Current UTC and date if available
12	Addressed Safety Related Message	Safety related data for addressed communication
13	Safety Related Ac knowledgement	Acknowledgement of received addressed safety related message
14	Safety Related broadcast Message	Safety related data for broadcast communication
15	Interrogation	Request for a specific message type (can result in multiple responses from one or several stations)(
16	Assignment Mode Command	Assignment of a specific report behaviour by competent authority using a base station
17	DGNSS Broadcast Binary Message	DGNSS corrections provided by a base station
18	Standard Class B Equipment Position	Standard Position Report for Class B Shipborne Mobile Equipment to be used instead of Messages 1, 2, 3
19	Extended Class B Equipment Position Report	Extended Position Report for Class B Shipborne Mobile Equipment; contains additional static information(
20	Data Link Man agement Message	Reserve slots for base station(s)
21	Aids-to-Navigation Report	Position and Status Report for Aids-to- Navigation
22	Channel Management	Management of channels and transceiver modes by a base station

Table 5: AIS Messages

In the frame of mapping ships density, we mainly need the position information which is provided in message 1. The structure of this message is the following:

Parameter	Number of bits	Description
Message ID	6	Identifier for this message 1, 2 or 3
Repeat Indicator	2	Used by the repeater to indicate how many times a message has been repeated. Refer to § 4.6.1; 0 -3; default = 0; 3 = do not repeat any more.
User ID	30	MMSI number
Navigational status	4	0 =under way using engine, 1 =at anchor, 2 =not under command, 3 =restricted manoeuvrability, 4 = Constrained by her draught; 5 = Moored; 6 = Aground; 7 = Engaged in Fishing; 8 = Under way sailing; 9 = reserved for future amendment of Navigational Status for HSC; 10 = reserved for future amendment of Navigational Status for WIG; 11 – 14 = reserved for future use; 15 = not defined = default
Rate of turn ROTAIS	8	±127 (–128 (80 hex) indicates not available, which should be the default). Coded by ROTAIS =4.733 SQRT(ROTINDICATED) degrees/min ROTINDICATED is the Rate of Turn (720 degrees per minute), as indicated by an external sensor. +127 = turning right at 720 degrees per minute or higher; –127 = turning left at 720 degrees per minute or higher 0...+ 126 = turning right at up to 708 degrees per minute or higher; 0...-126 = turning left at up to 708 degrees per minute or higher Values between 0 and 708 degrees/min coded by ROTAIS =4.733 SQRT(ROTsensor) degrees/min where ROTsensor is the Rate of Turn as input by an external Rate of Turn Indicator. ROTAIS is rounded to the nearest integer value. + 127 = turning right at more than 50/30s (No TI available) -127 = turning Left at more than 50/30s (No TI available) –128 (80 hex) indicates no turn information available (default).
SOG	10	Speed over ground in 1/10 knot steps (0-102.2 knots) 1 023 = not available, 1 022 = 102.2 knots or higher.
Position accuracy	1	1 =high (<10 m; Differential Mode of e.g. DGNSS receiver or equivalent methods) 0 =low (>10 m; Autonomous Mode of e.g. GNSS receiver or of other Electronic Position Fixing Device receiver or equivalent methods), 0 = default
Longitude	28	Longitude in 1/10 000 min (±180 degrees, East =positive (as per 2´s complement), West =negative(as per 2´s complement). 181 degrees (6791AC0 hex) = not available = default)
Latitude	27	Latitude in 1/10 000 min (±90 degrees, North =positive (as per 2´s complement), South =negative (as per 2´s complement), 91 degrees (3412140 hex) = not available = default)

COG	12	Course over ground in 1/10°(0-3599). 3600 (E10 hex) = not available = default; 3 601 – 4 095 should not be used.
True Heading	9	Degrees (0-359) (511 indicates not available = default).
Time stamp	6	UTC second when the report was generated by the EPFS (0-59, or 60 if time stamp is not available, which should also be the default value, or 62 if Electronic Position Fixing System operates in estimated (dead reckoning) mode, or 61 if positioning system is in manual input mode or 63 if the positioning system is inoperative).
Reserved for regional applications	4	Reserved for definition by a competent regional authority. Should be setto zero, if not used for any regional application. Regional applications should not use zero.
Spare	1	Not used. Should be set to zero. Reserved for future use.
RAIM-Flag	1	RAIM (Receiver Autonomous Integrity Monitoring) flag of Electronic Position Fixing Device; 0 = RAIM not in use = default; 1 = RAIM in use)
Communication State	19	See below.
Total number of bits	168	

Table 6: AIS message 1 structure

2.1.4.2 LRIT (LONG RANGE IDENTIFICATION AND TRACKING)

The LRIT system consists of the shipborne LRIT information transmitting equipment, the Communication Service Provider(s), the Application Service Provider(s), the LRIT Data Centre(s), including any related Vessel Monitoring System(s), the LRIT Data Distribution Plan and the International LRIT Data Exchange. Certain aspects of the performance of the LRIT system are reviewed or audited by an LRIT Co-ordinator acting on behalf of all Contracting Governments.

LRIT information is provided to Contracting Governments and Search and rescue services entitled to receive the information, upon request, through a system of National, Regional, Co operative and International LRIT Data Centres, using where necessary, the LRIT International Data Exchange.

Each Administration should provide to the LRIT Data Centre it has selected, a list of the ships entitled to fly its flag, which are required to transmit LRIT information, together with other salient details and should update, without undue delay, such lists as and when changes occur. Ships should only transmit the LRIT information to the LRIT Data Centre selected by their Administration.

The obligations of ships to transmit LRIT information and the rights and obligations of Contracting Governments and of Search and rescue services to receive LRIT information are established in regulation V/19-1 of the 1974 SOLAS Convention.

The following table indicates data to be transmitted by LRIT from shipborne equipment:

Parameter	Comments
Shipborne equipment Identifier	The identifier used by the shipborne equipment.
Positional data	The GNSS position (latitude and longitude) of the ship (based on theWGS 84 datum). Position: The equipment should be capable of transmitting the GNSS position (latitude and longitude) of the ship (based on WGS 84 datum) as prescribed by SOLAS regulation V/19-1, without human interaction on board the ship. On-demand position reports: The equipment should be capable of responding to a request to transmit LRIT information on demand without human interaction onboard the ship, irrespective of where the ship is located. Pre-scheduled position reports: The equipment should be capable of being remotely configured to transmit LRIT information at intervals ranging from a minimum of 15 minutes to periods of 6 hours to the LRIT Data Centre, irrespective of where the ship is located and without human interaction on board the ship.
Time Stamp 1	The date and time associated with the GNSS position. The equipment should be capable of transmitting the timeassociated with the GNSS position with each transmission of LRIT information.

Table 7: LRIT data

Summary of LRIT exiting messages (extracted from RD 2)

Message Type	Message Name	Message Description/Purpose
LRIT positional data (position report) messages		
1	Periodic Position Report	Regular periodic ship position reports.
2	Polled Position Report	Ship position report as a result of a poll request.
3	SAR Position Report	Ship's position report; for a special purpose(SAR); reported by Data Centres with shipsin the area.
LRIT request messages		
4	Ship Position Request	To enable a LRIT Data Centre to requestLRIT positional data for ships beingmonitored by another LRIT Data Centre (following request from a LRIT Data User).
5	SAR Poll Request	Specific ship poll. Received from polling Data Centre and routed to ship's DC using Registerinformation (addressed).

		Data poll is always addressed to a specificship using MMSI. Can be a —send once“ or —send at rate.“
6	SAR SURPIC Request	Area poll; routed to all Data Centres.
Other messages		
7	Error message	Error message relating to an inability to process a LRIT request message
8	Receipt message	To enable a Providing LRIT Data Centre toconfirm the receipt and processing status of a Request Message from a Requesting LRIT Data Centre.
9	Data Distribution Plan (DDP)Update	This is a routine update of the DDP by theDDP server sent to all Data Centres and the IDE.
10	Data Distribution Plan Request	This is a request for the DDP server to senda copy of the current DDP.
11	System Status message	To enable the International LRIT Data Exchange to communicate a status message every [30] minutes to each Data Centre advising that the system is —healthy“ and receive status messages from the DCs.

Table 8: LRIT messages

In the frame of mapping ships density, we mainly need the position information which are provided in message 1. The structure of this message is the following:

Parameter	Description
Latitude	Latitude position of the ship.
Longitude	Longitude position of the ship.
Time Stamp 1	Date and time when position was taken.
Shipborneequipment identifier	Unique LRIT shipborne equipment (terminal) number used for communication.
ASP ID#	LRIT ASP unique identification number. All Data Centres must ensure that all of their ASPs have a unique number.
Message type	Message identification number: 1 œ Periodic Report2 œ Polled Report3 œ SAR Report
Message ID#	Unique message number generated by using: Message type, IMO ship identification number of ship being tracked, ASP ID# and Time Stamp 2.
Reference ID#	The message ID of the associated request message. It is only valid for a response to a request message (a 0 value indicates the message is not a result of a request message).
IMO#	IMO ship identification number of the ship being tracked.

MMSI#	Maritime Mobile Service Identity number of the ship being tracked.
Time Stamp 2	Date and time ASP receives message.
Time Stamp 3	Date and time ASP transmits message.
Other	Reserved field that may include price or billing specific information.
DC ID#	LRIT Data Centre unique identification number.
Time Stamp 4	Date and time when the Data Centre receives message from ASP.
Time Stamp 5	Date and time when the Data Centre transmits a message to a LRIT Data User.
Response type	One of these four values is added by the DataCentre when the message is transmitted.
LRIT Data User (Requestor)	Unique identification number identifying Requesting LRIT Data User. Every participatingLRIT Data User has a unique number. For a coastal State the request is part of theStanding Order in the Data Distribution Plan.
Ship Name	Name of ship associated with position report.
LRIT Data User (Provider)	Unique identification number identifying Contracting Government to which the ship is registered.

Table 9: LRIT message 1 structure

2.1.4.3 VMS (VESSEL MONITORING SYSTEM)

Within the world wide fishing community over the past few years, there has slowly evolved international consensus to manage fishing within Exclusive Economic Zones of all flag states, though there are different scales of monitoring ranging from:

- Making declarations by electronic means direct from the vessel whilst at sea,
- Making paper declarations when arriving in port,
- A combination of both above declarations.

Some 90 Million tonnes are fished world-wide every year. Flag states have an implicit responsibility to ensure that they are able to conserve species for the long term future whilst being able to ensure provision of affordable high nutrition quality food to the market place. Fishery provide direct employment and revenue to an estimated 38 million people; mainly fisherman. Detailed statistics are not easily available, especially for small scale fishing activities in developing countries. However, there are though to be some 3.8 million vessels in the world. Fishing vessels, locate, hunt, catch, load (and sometimes discharges or tranships), as well as process and conserve its cargo at sea, all in variable weather conditions. The vessels are often highly specialised and well able to carry out their roles in the most efficient manner possible.

Within Europe, Canada, USA, Japan and Australia, for some time now there have been fishery - monitoring schemes to try to preserve stocks and prevent illegal fishing. Now there is a also a major initiative of the United Nations Fisheries and Agriculture Organisation (FAO) to extend and harmonise monitoring to the world-wide fleet of vessels 100 grt or more. (100grt is equivalent to 24 metres in length). There are approximately 23,000 vessels of this category in the world.

In Europe, all fishing vessels over 15 meters in length have to carry VMS equipment, and also will have to carry Class A AIS from 2010 onwards over an implementation time line. There are approximately 11500 such fishing vessels.

2.1.4.4 INLAND VESSEL RIS (RIVER INFORMATION SERVICES) SYSTEM

There are some 10000 inland vessels that are required to be fitted with class A AIS, these vessels though visible to terrestrial AIS receivers used for River information systems, may not be visible to satellite detection due to their proximity within cities or mountainous terrain.

2.1.5 SUITABILITY OF REPORTING TYPES FOR VALIDATION PURPOSES

Though there is a large amount of data manually generated for ship reporting, as yet it is a mix of and manually generated reports either sent by Telex, Satellite of even Morse code. Because the manually generated reports are subject to errors and would be very time consuming to include to database for validation purposes, they are not considered for inclusion into Pasta Mare.

The Automated systems used in Europe for traffic and fishery monitoring though present an ideal opportunity for use for correlation with space AIS for validation purposes.

However VMS, though useful can only provide a correlation for vessels that are also fitted with AIS, as the AIS satellite will only detect the AIS transmission. Though many fishing vessels might already carry AIS voluntarily, the number of so fitted vessels is unknown. The project however hopes to use AIS information from fishing vessels, and will enquire whether a database of information exists that identifies which vessels are appropriately fitted with both AIS and VMS.

As inland vessels may not be visible to the satellites they will not be considered for use in the validation exercise.

Therefore the project proposes to use the information derived from the European AIS Master plan and LRIT information of European Flagged vessels.

2.2 SPACE BORNE AIS DATA SOURCES

In the following chapter a description of the space borne AIS receiver is presented, providing some insight to the functionalities of the systems.

2.2.1 ORBCOMM

The AIS Data Collection system is a subset of the ORBCOMM system [RD3]. Most of the infrastructure used by the AIS Data Collection is shared with the ORBCOMM messaging system. Figure 1 represents the ORBCOMM system with its satellites, its Ground Earth Station (GES) and its Control Center.

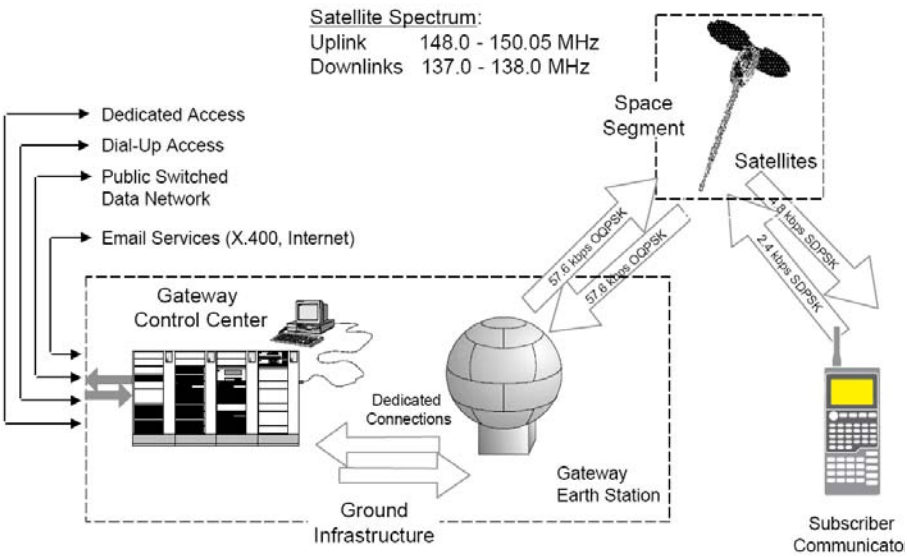


Figure 1: ORBCOMM System

Six of the ORBCOMM satellites are equipped with an AIS receiver and an AIS antenna capable of receiving the AIS signals transmitted by ships. The AIS messages recovered by the satellite are downloaded to the GES and processed by the Control Center.

Figure 2 shows an overview of the overall signal flow of the AIS data from the ORBCOMM satellite up to the customer.

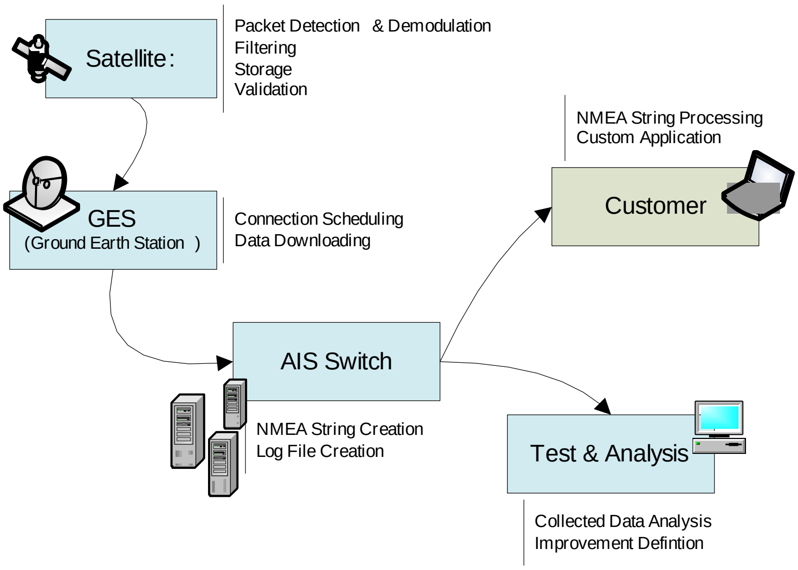


Figure 2: Overall Signal Flow

2.2.1.1 SATELLITE

2.2.1.1.1 SATELLITE ORBIT

All AIS capable satellites are in a circular orbit at an altitude of about 670 km and an inclination of 48 degrees. The satellite mean motion is 14.68 rev/day (consequently each revolution takes about 98 minutes). The 10 degrees elevation footprint of the satellite on the ground is a circle with an arc radius of about 1900 km (1026 nm). The satellite can see vessels up to a latitude of 69 degrees (when the vessel sees the satellite with a 5 degrees elevation)

2.2.1.1.2 SATELLITE AIS RECEIVER

The collection of the AIS data on the satellite relies on the existence of a receiver capable of receiving the two international AIS frequencies 161.975 MHz and 162.025 MHz. This receiver can also be commanded to listen to AIS signal at other frequencies with a resolution of 25 KHz.
The internal architecture of the receiver consists of an analog RF front-end, a Digital Signal Processing Section and a Data Processing Section.
The RF Front End performs coarse filtering and down-converts the received signals to a digital format. The Digital Signal Processing performs AIS packet detection, packet demodulation, Packet Frequency Measurement and Packet Time of Arrival Measurement.
The Data Processing performs Message Filtering, Message Validation and Message Storage.

The AIS antenna on the spacecraft is a normal mode quadrifilar helix antenna.

2.2.1.1.3 AIS MESSAGE VALIDATION

For each message received, the satellite measures the RF frequency of the received packets and the time of arrival of the received packet. From the data extracted from the packet, the position of the AIS transponder which sent the message is known. The "Data Processing" software, knowing the reported position of the AIS transponder and the position of the satellite can compute the "Expected Frequency" and the "Expected Propagation Time" of the received packet.

The difference between the Measured Frequency and the Expected Frequency is compared to a threshold. Similarly, the difference between the measured propagation time (derived from the Measured Time of Arrival) and the Expected Propagation Time is compared to another threshold. The results of these comparisons are used to mark the result as "Valid" or "Invalid". If the Time of Arrival cannot temporarily be measured due to poor GPS conditions ,or the satellite position is not known accurately, the message is marked as "Unchecked".

A valid flag indicates that the reported position of the vessel is +/- 50 nm (TBR) from the estimated position. Currently thresholds for message validation are set to a high level so that almost all messages are marked as valid.

3.5 AIS Messages Received

The demodulator on board of the satellite receiver allows detecting and demodulating AIS messages of type 2 and 5 (per ITU M1371-3). Once demodulated these messages are either downloaded to the ground immediately (if the satellite is in view of an ORBCOMM ground earth station) or stored in the internal memory of the satellite if the satellite is not in view of a ground station.

The satellite software categorizes each received AIS message in one of four categories:

- Valid Native Position
- Valid Abbreviated Position
- Invalid Position
- Type 5 Message

Each of these categories requires different amount of storage in the satellite.

Valid Native Position

AIS Valid Position Reports corresponds to the AIS messages type 1, 2 and 3 which have been validated per section 5.4. AIS Valid Position Reports are 21 bytes when transmitted from the ORBCOMM satellites to the ground infrastructure. They contain the information as noted in the ITU-R M.1371-3 documentation as follows:

- Message ID
- Repeat Indicator
- User ID (MMSI)
- Navigational Status

- Rate of Turn
- Speed Over Ground
- Position Accuracy
- Longitude
- Latitude
- Course Over Ground
- True Heading
- Time Stamp
- Reserved for Regional Applications
- Spare
- RAIM Flag
- Communication State

Unchecked Position Reports

AIS Unchecked Position Report corresponds to the AIS messages type 1, 2 and 3 which have neither been validated nor been invalidated per section 5.4. This typically occurs in scenarios when the satellite does not know its position or the time accurately. The content of these reports is similar to the content of the “Valid native Position” report

Invalid Position Reports

Invalid Position Reports corresponds to the AIS messages type 1, 2 and 3 which have been flagged. They contain the original 21 byte position report as described above as well as additional information to assist in analysis of the data as follows:

- DOPT (Difference of Propagation Time) Difference in microseconds between the expected propagation time computed by the satellite and the propagation time derived by a measurement of the time of arrival of the packet
- DODF (Difference of Doppler frequency): Difference in Hz between the expected Doppler Frequency of the packet computed by the satellite and the measured Doppler Frequency of the signal.
- Spacecraft Position
- Calculated EPT (Expected Propagation Time): Expected propagation time in microseconds are computed by the satellite
- Calculated EDF (Expected Doppler Frequency) Expected Doppler frequency in Hz as computed by the satellite.
- 21 Byte Received Position Report

Type 5 Messages

Type 5 Messages are 53 bytes long (424 bits) and contain, as described in the ITU-R M.1371-3 documentation, the following information:

- Message ID
- Repeat Indicator
- User ID (MMSI)
- AIS Version Indicator
- IMO Number
- Call Sign
- Name
- Type of Ship and Cargo Type
- Dimension / Reference for Position
- Type of Electronic Position Fixing Device
- ETA
- Maximum Present Static Draught
- Destination
- DTE
- Spare

2.2.1.1.4 FILTERING

In order to limit the amount of memory on the satellite to store the messages and the amount of bandwidth required to download the received messages to the ground, the satellite software performs filtering of the messages received. Figure 3 represents the flow of message validation and message filtering.

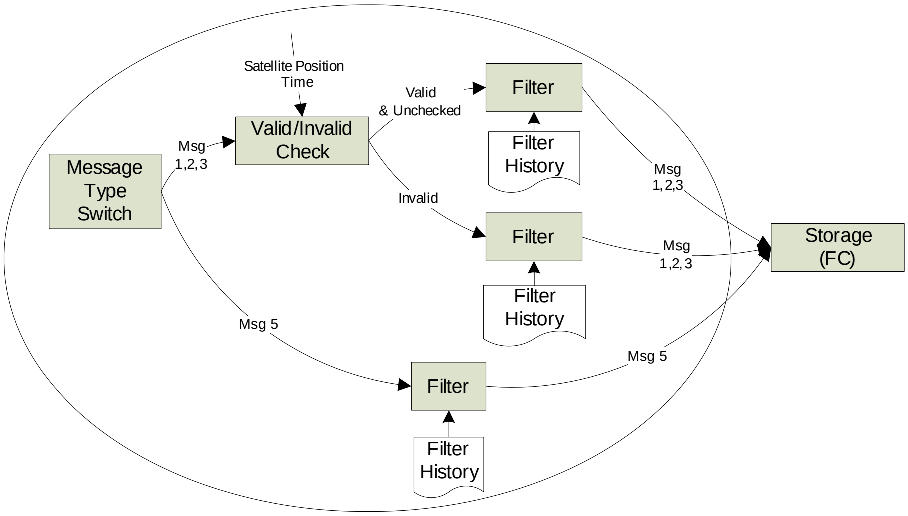


Figure 3: Validation & Filtering Flow

The filter rate depends on the type of message, the validation state of the message and the operation status of the satellite.

	Satellite connected to GES	Satellite NOT connected to GES
AIS Message 1,2,3 Valid or Unchecked	One message of any of these three types for a given MMSI is saved every 5 minutes. However if the distance between a received message and the last one stored is above 100 km, the received message is stored.	One message of any of these three types for a given MMSI is saved every 30 minutes However if the distance between a received message and the last one stored is above 100 km, the received message is stored.
AIS Messages 1,2,3 Invalid	One message of any of these three types for a given MMSI is saved every 1 minutes	One message of any of these three types for a given MMSI is saved every 1 minutes
AIS Message 5	One message of that type for a given IMO number is collected every 240 minutes. Filtering is based on the IMO number	One message of that type for a given IMO Number is collected every 240 minutes. Filtering is based on the IMO number

Each spacecraft has a storage capacity of 500 Kbytes. All message types share the same storage. The storage capacity corresponds to the storage of approximately 18,000 type 1, 2 or 3 messages (combined number assuming no type 5 messages).

2.2.1.2 DATA DOWNLOADING TO GROUND

ORBCOMM has multiple ground stations spread across the world to communicate with its satellite. Once a ground station (GES) is connected to a satellite, it downloads the AIS data.

The satellites communicate with the ground station using a bidirectional VHF link. The link has a TDMA access scheme and typically uses one slot of the link (one on the uplink and one in the downlink) to access the satellite.
On this link, the AIS data is sent in a frame to the ground station

2.2.1.2.1 AIS DATA DOWNLOAD SCHEDULE

The satellite downlink bandwidth is shared between the different type of data available from the satellite. This includes telemetry, normal ORBCOMM mobile terminal traffic and AIS data. North America and South America GES are currently used to download the AIS data to the ground.

2.2.1.2.2 DOWNLOAD DATA FORMAT

The download data format is compatible with the GLPM data format used for normal operation of the ORBCOMM satellite.

Each AIS Report as described in section 5.5 is preceded by a header as shown in Figure 4, AIS Report Format for Satellite to Ground Download. Multiple reports with their headers are then packet in a single frame and downloaded to the Ground Earth Station. The frame contains an identifier called NID to identify that this is AIS data.

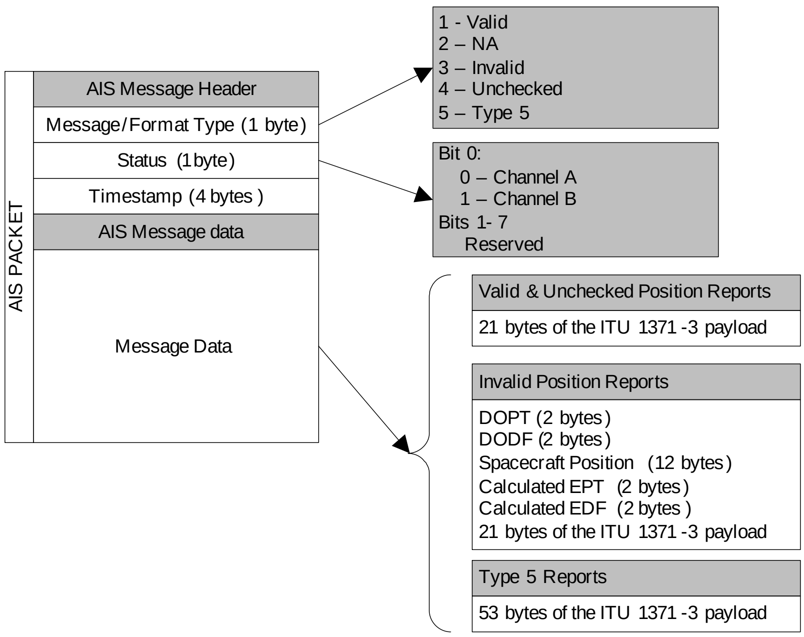


Figure 4: AIS Report Format for Satellite to Ground Download

2.2.1.2.3 AIS GROUND PROCESSING

Once the frames coming from the satellite are received by the ORBCOMM GES, they are forwarded to the Control center.

Thanks to the frame NID, the AIS switch is able to recognize the AIS frames. It parses each frame into its individual AIS reports, create an NMEA string and forward the string to the customer. Simultaneously, the NMEA string is routed to another process which extract the different fields per ITU M1371-3.
Both NMEA strings and ITU ASI fields are stored in log files for future reference.

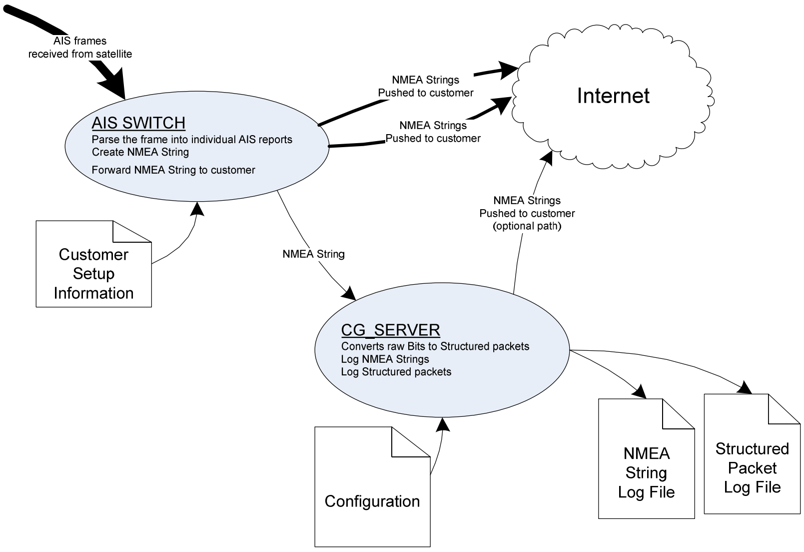


Figure 5: Orbcomm AIS ground processing

2.2.1.3 ORBCOMM TO CUSTOMER INTERFACE

The ORBCOMM to Customer interface consists of ORBCOMM pushing the AIS data on a line per line basis as it becomes available. The customer is required to provide to ORBCOMM an IP address and a port number. Each line of the NMEA information will then be pushed to this IP/Port.

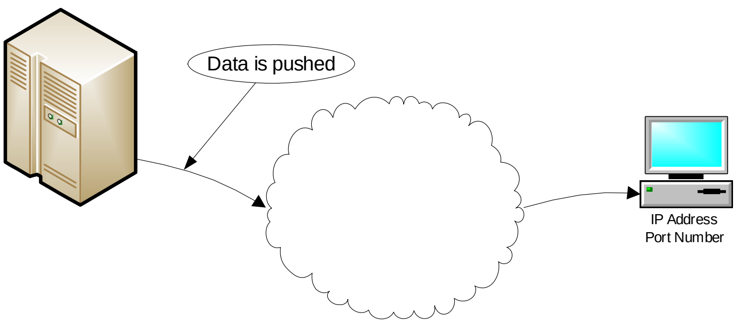


Figure 6: Customer Interface architecture

Optionally, a VPN connection between ORBCOMM and the customer equipment can be established. The AIS reports will then be pushed over this VPN connection.

2.2.2 LUXSPACE AIS RECEIVER

LuxSpace has designed two payloads, which will be in orbit till end of 2009:

- PSLV/Rubin 9.1 - operational in August 2009
- ISS - operational in Jan 2010

and is planning the launch of a AIS mission in 2010 (currently in phase B), the so-called AIS COM, operational in Oct 2010.

2.2.2.1 LUXSPACE PSLV/RUBIN 9.1

The first one is the PSLV attached satellite.

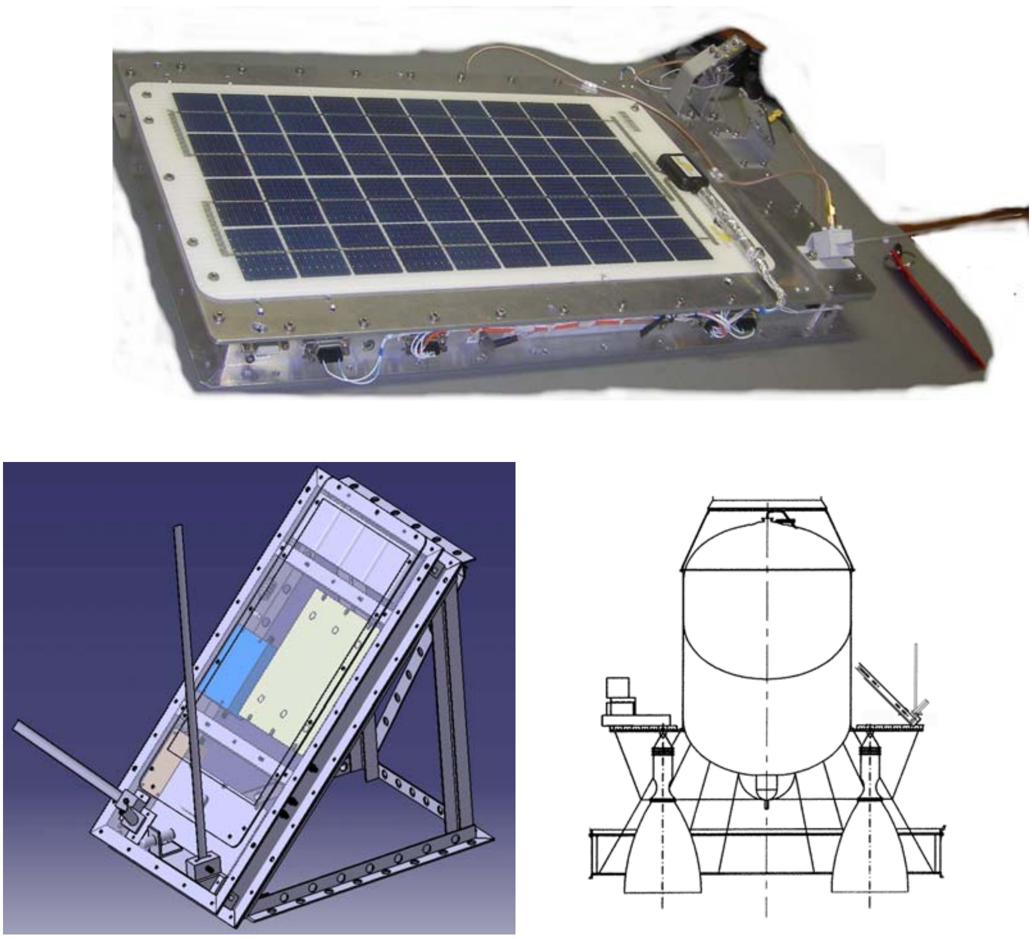


Figure 7: LuxSpace PSLV payload

This satellite, being retained on the upper stage in orbit, is fully autonomous. It is equipped with a solar panel, accumulators, downlink and the GENERATION 1 AIS receiver from LuxSpace.

It has the capacity to receive on the two AIS frequencies, store and forward up to 50.000 AIS messages and an additional capacity to sample one channel for 1 minute, for channel analysis purposes.

2.2.2.2 LUXSPACE - COLAIS

The second LuxSpace AIS receiver generation (LUXAIS) will be flown o the International Space Station (ISS). The first model is due to be shipped to the International Space Station at the end of August 2009 for an operational phase of 2 years starting in January 2010.

The implementation in the ISS offers high flexibility in the configuration so that the design will be used in the other projects of LUXSPACE.

The LUXAIS receiver will be implemented in the ESA COLOMBUS module, fitted with an external antenna. It will be operated in shared time with the Norwegian receiver (NORAIS) on a trimester swap basis.

The main point is that the COLOMBUS module provides for a continuous high speed downlink that enable data collection over the entire footprint of the ISS with a 1 hour latency.

Figure 8: LuxSpace second generation AIS receiver

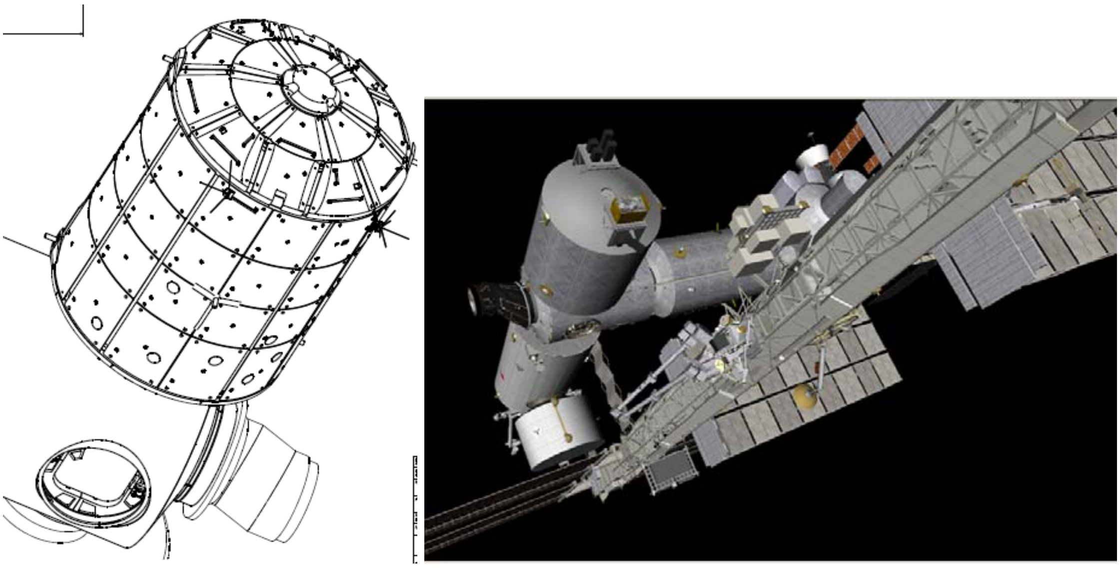


Figure 9: LuxSpace AIS receiver mounted on ISS

2.2.2.3 AISCOM

The AISCOM project is currently in phase B. The mission comprises of three satellites, fitted with AIS Generation 2 receivers, polarization discrimination and downlink. The three satellites will be launched together and will allow for some kind of ‘formation flight’ giving enhanced system efficiency and additional capabilities to the system.

Operation in orbit is planned for begin 2011.

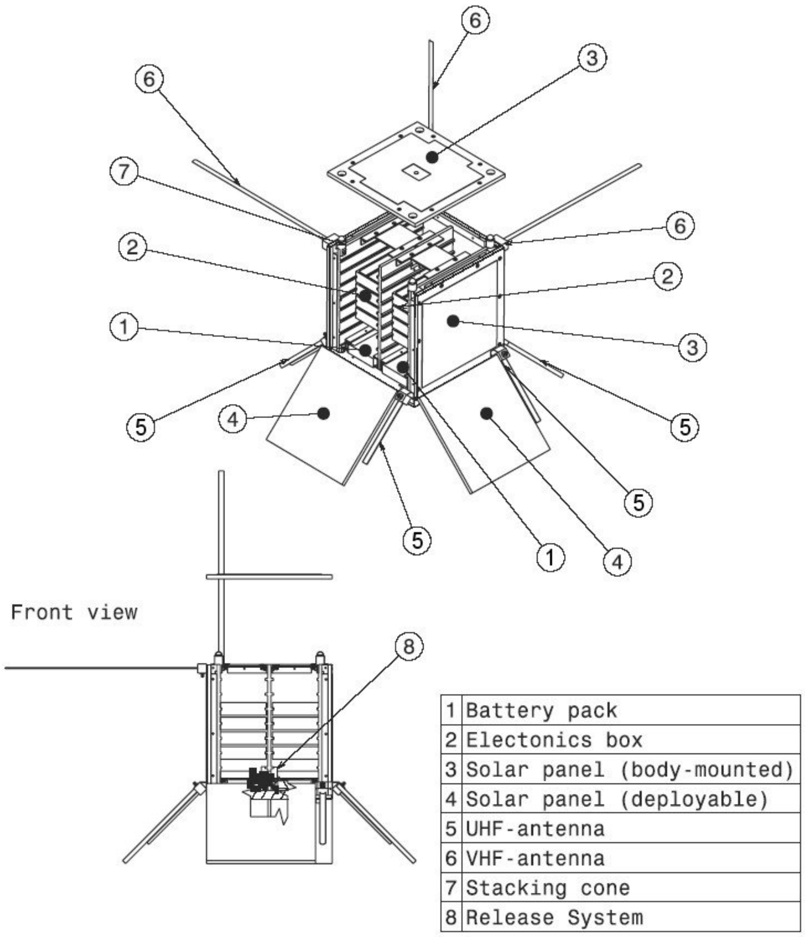


Figure 10: LuxSpace AISCOM satellite

2.2.2.4 LUXSPACE AIS - GROUND SEGMENT.

The LuxSpace ground segment is comprised of two parts:

- the ground station, which is located at ESA's facility in REDU (Belgium) and operated by Redu Satellite Services (a SES subsidiary). More station are planned in order to reduce the system latency and enhance its efficiency.
- the processing centre, located at LUXSPACE. This computing centre is dedicated to the processing, archiving and dissemination of the data to the end customer. It is already in operation and processes on a 'on demand' basis the ORBCOM data collected by the latest generation of ORBCOM satellites.

It will also process the data acquired from the LUXSPACE or the Norwegian AIS receiver onboard the COLOMBUS module. The Data will be collected at the N-USOC (Norwegian User Support and Operations Centre) and made available within one hour latency to the processing centre.

An example of user interface is shown below.

Figure 11: LuxSpace ShipViewer user interface

2.2.2.5 OVERALL AIS DATA FLOW

The data are collected at REDU or at the N-USOC, are checked for integrity, and are then made available for the processing centre. The Redu facility and the N-USOC are connected by WAN to the processing centre. In the processing centre the AIS messages of type 1,2 and 3 that contain dynamic vessel information are combined with less frequently transmitted AIS messages of type 5 which contain static vessel information. In other words, every AIS message that is stored as new entry in the database also contains the static vessel information as name, call-sign, vessel dimensions etc. The only information contained in a type 5 message which is dynamic is the vessel destination. During data processing this information is also coupled to the type 1,2 and 3 messages in combination with a date and time when the vessel destination information was last updated. All database fields correspond to the AIS message fields of combined type 1,2,3 and 5 messages.

The data are then made available to the end user by the data distribution service or via data reports retrievable from an ftp server.

The data distribution service provides the interface between the LuxSpace central data server and the end user. The two major aspects of the distribution service are:

- Fast data retrieval which requires, due to the vast amount of data, a highly optimized database design
- Secure data retrieval. Since SATAIS data is a valuable and security sensitive resource a well developed security system must be in place in order to prevent unauthorized access to the central data server or interception of data streams between the server and the end-user

An efficient database design is therefore in place together with a number of optimization techniques in order to deal with an increasing server load and increasing database size. The security is provided by a highly secure log-in system using SSL encryption which at the same time will provide a secure data link to the end-user. The central database server is protected by several local firewalls and completely shielded from outside access. Each request for data from outside will be forwarded through a gateway which then passes the data request internally to the data server on the intranet. The actual data link between the LuxSpace central server and the end-user is provided by means of a web service over the internet which functions as a pull service outputting the requested data stream in a standardized format.

2.2.2.6 PLANNED LUXSPACE AIS RECEIVER ORBITS

The orbits for the LUXSPACE satellite are the following :

PSLV launcher, RUBIN 9-1 payload:

- Altitude: 720km
- Inclination: 98.3°
- Sun Synchronous Orbit: descending node local time: 12h00 +/- 10min
- Field of View radius: 3000km

ISS Orbit

- Altitude: 360 - 400km
- Inclination: 51.6°
- Field of View radius: 2100 km

AISCOM (planned orbits)

- Altitude : 550km
- Inclination: 61°
- Field of view radius: 2500km

2.2.2.7 LUXSPACE – AIS SATELLITE AIS RECEIVER

PSLV / RUBIN9.1 satellite is equipped with Generation 1 receiver, as described in a previous chapter. This receiver is the firs development of LUXSPACE and the RoE of the design along with the Pathfinder 1A project (ESA contract in 2007) is the basis for the generation 2.

COLAIS project receiver.

That receiver is partly based on the same design as the Generation1, with largely improved performances in sensitivity, memory capacity and processing power. It also includes a highly flexible architecture that allows for full software demodulation. That capability offers in orbit modifications and improvements.

AISCOM receivers

The receivers that will be used onboard the AISCOM satellites are the same than the COLAIS project, with the necessary adaptation for a spacecraft bus interface. Higher performances will be used, since they were not possible in the COLAIS project due to inherent limitations of the interface of the Colombus (ESA module, part of the ISS)

2.2.2.7.1 SATELLITE ANTENNA

The antenna is a major constituent of any AIS based system.

This is due to the fact that the AIS system was not designed for space communication. Apart from other difficulties, receiving AIS from space induces many collisions due to the asynchronous transmissions of the AIS transmitters. Part of the solution is to divide the field of view in as many sectors as possible. However, due to basic physic, such an antenna is not easy to design and is the subject of in depth study at LUXSPACE.

PSLV/RUBIN9.1 satellite.

The volume limitations imposed a basic antenna which is a simple quarter wave antenna.

The uncontrolled attitude of the satellite and the other limitations made it impossible to use a more elaborate antenna.

COLAIS project antenna

The same basic limitations imposed a simple antenna on the COLOMBUS module. This is also a suboptimum system.

AISCOM

On these small size satellites, it is not possible to afford a large deployable antenna. However, size and volume allow for a more elaborate system to be used.
An orthogonal polarization system will be used. This will allow some form of field of view division by the mean of the radiating diagram and the polarization discrimination.
That will give a better system efficiency.

Future antenna system.
LUXSPACE has already started some analysis of a large deployable antenna that will lead to an optimum division of the field of view and maximize the system efficiency.

2.2.2.7.2 AIS MESSAGE VALIDATION

By its definition, (ITU 1371 normative document), an AIS message is tagged with an error detection code. A message can then be declared ‘technically’ good or rejected.

The base position report message’s contents can however be used to further investigate its validity to some extend, but without any absolute proof.
For this matter, the message content can be extracted onboard, some technical parameters can be derived and compared to the same actually measured parameters. Allowing for some technical error margins, some indicator of message content coherency can be derived. Again, it is pointed out that it is only rough indicators.
Further onboard, or ground processing can be performed to derive a possible actual position of the transmitter, independently from the message content. However, the computed position has very large inacurracies (50 to 300 km), this can be improved to some extend by multiple measurements.

2.2.2.7.3 AIS MESSAGES RECEIVED

The LUXSPACE receivers can receive and decode any type of AIS messages.
The most interesting messages are the following types:

- Type 1,2,3: position reports
- Type 5: experience shows that the content of these messages is subject to great variability in the validity of the content. They are manually updated, and it is not always done
- Type 9,12,13,14: safety related messages. The system should focus to give the lowest latency to this messages. So far, no guarantee can be given on delivery and delay of delivery.
- Type 18, 19, AIS class B position report messages.

2.2.2.7.4 FILTERING

Filtering can be used when onboard memory or downlink limitations impose to do so.
Basic filtering is to keep only the latest received message of a given ship until it is downloaded to ground station.
PSLV/RUBIN9.1 receive performs no filtering and stores all received messages. COLAIS receiver does not perform filtering and forwards to ground all received messages.

Filtering is considered in the AISCOM satellite, and the advantages/ disadvantages are studied.
One major point to be addressed is the observed inconsistencies in the MMSI updates of the AIS ship's equipment. It is observed that many equipment have not their internal setup updated with the ship's MMSI, leading to a confusion in the tracking of the ships. (manufacturer's default MMSI is not updated, like 123456789 for example). The consequence is that it is impossible to track a ship by its position reports based on the MMSI identification. This could be one reason not to filter manufacturer default MMSI messages.

2.2.2.7.5 DATA DOWNLOADING TO GROUND

The PSLV/RUBIN9.1 can download its entire memory content (5MB) in one pass over the ground station. However, this memory size does not allow (as estimated so far) for a continuous message acquisition in orbit.

COLAIS receiver makes use of the permanent downlink between the ISS/COLOMBUS and the ground via the TDRS. Every received message is immediately downloaded to ground.

For the AISCOM data download, several operational modes are studied. In view of the ground station, one operational mode is the direct downlink of received messages, with no latency and no filtering.
In the other cases, messages will be stored, possibly filtered and downloaded at the first available pass over a ground station.
Under consideration is a direct link to a GEO satellite, which would allow no latency over wide regions of the globe. However, this implies a more complex hardware and bus system, along with higher power requirements.

2.2.3 NANOSATELLITE TRACKING OF SHIPS (NTS)

The Nanosatellite Tracking of Ships (NTS) spacecraft was launched on April 28th, 2008 after an 8-month development from program kick-off to launch.

NTS is a 6.5 kg nanosatellite that consists of a generic bus provided by the University of Toronto Institute for Aerospace Studies / Space Flight Laboratory (UTIAS/SFL) and a custom designed Automated Identification System (AIS) receiver payload provided by COM DEV Ltd.

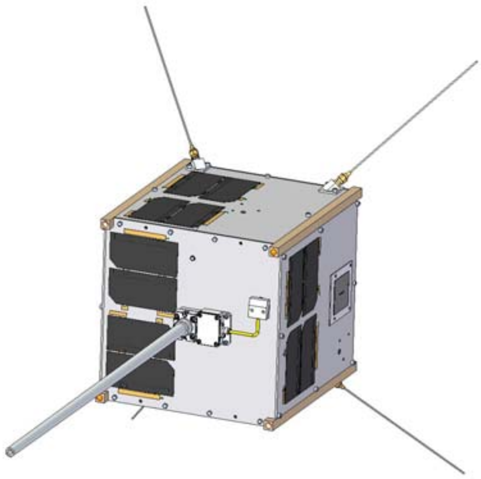


Figure 12: NTS1 satellite

COM DEV is the mission prime and also performs the role of principle investigator. The NTS mission was conceived by COM DEV in order to demonstrate the ability to collect AIS messages from space using a new technique developed by COM DEV. Being a terrestrial system, AIS signals were not intended to be collected from space which presents a number of unique challenges.

NTS was designed to provide risk-reduction for the new COM DEV AIS technology through making use of a rapid, but limited, mission capability. NTS completed its key commissioning activities within eight days of launch so that the first four payload cycles could be completed within the first month of operation, the minimum mission lifetime required. The spacecraft has far exceeded this lifetime and payload operations have continued beyond even the mission goal of 6 months of activity. The NTS mission has provided a much larger quantity of data and experience of collecting AIS messages from space than foreseen

2.2.3.1 OPERATION OVERVIEW

NTS provides simple bus operations with no orbital determination or control. The bus has passive attitude control through the use of permanent magnets and hysteresis rods which provides a damped alignment with the earth's magnetic field. There is a limited attitude determination means through the use of coarse sun sensors. The spacecraft design and orbit provide a benign thermal environment such that no thermal control is required. Spacecraft operations consequently consist of power monitoring, payload operations, bus and payload data and telemetry management and communications management. Spacecraft orbit knowledge is achieved through NORAD twoline element (TLE) data and is sufficient for satellite acquisition.

The NTS spacecraft has limited payload data storage capacity so that when recording both AIS channels, the payload is able to record approximately 90 seconds of data before filling its on-board memory. The spacecraft's S-band downlink nominally operates at 32 kbps and operations were originally baselined to use a single earth station located near Toronto, Canada. This offers up to six passes per day, but is shared with two other missions. It can take up to a week to download the 90 seconds of data collected during a payload operating cycle, but the mission objectives relating to technology risk reduction do not have any data latency constraints, therefore such latencies are acceptable.

NTS operations are currently shared between UTIAS/SFL for spacecraft monitoring and control and COM DEV for payload operations.

2.2.3.2 INITIAL DATA COLLECTION

The first payload operation was performed over an area where there were expected to be few ships, and away from major landmasses, to maximize the chance of collecting low-noise, non-overlapping AIS signals.

After the initial acquisition, spacecraft and payload commissioning activities proceeded in parallel with data collection cycles, to maximize useful data collected during the short targeted mission life. The final bus commissioning activity, consisting of approximate determination of the attitude stabilization in line with the earth's magnetic field lines using the coarse sun sensors, was not completed until about two months after launch. By this time, eight data collection cycles had already been completed.

The first payload cycles on NTS were designed to capture data from areas of low, modest and heavy ship traffic, to demonstrate the COM DEV technology performance in increasingly difficult signal environments. The cycles were completed within the first month of operation, and the results were in line with simulated performance analyses prior to launch, confirming the expected performance of the COM DEV technology and providing a means to validate the "AIS signal from space" simulator also developed by COM DEV earlier during the technology concept development phases.

2.2.3.3 ROUTINE DATA COLLECTION

Having completed the main risk-reduction activities within the mission lifetime requirement of one month, operations shifted to a routine data collection phase with an aim of gathering AIS signals from every area of the globe, to gain insight into the AIS signal environment as observed from low earth orbit. Over the first 6 months, a total of 33 payload cycles were performed, covering the globe with 52 minutes of cumulative payload operation (built up from the 33 "snapshots" over any location, of around 90 seconds).

In this time, over 42,000 individual AIS messages have been collected from over 14,000 unique ships and base stations, at an average rate of some 800 messages per minute, and collecting over a fifth of the world's shipping population expected to carry AIS class A transmitters. Some statistics for the messages collected over the 90-second cycles in the first six months of NTS operations, covering all parts of the globe, are captured in Table 10. This demonstrates some of the elements of the variability of ship density over different parts of the world, illustrating one part of the expected complexity of the AIS signal environment seen from space.

	Number of messages collected			
	AIS Channel A	AIS Channel B	Total messages in any data collection	Unique ships
Max	1454	1444	2898	915
Min	0	8	13	13
Mean	612	663	1275	435

Table 10: Number of AIS messages collected during each payload cycle during the first 6 months of operation.

Following illustration presents AIS messages recovered during the first six months of NTS operations. The high density of ships in the coastal regions can be seen clearly. The footprint of the NTS satellite is also illustrated, showing the large area within the footprint of the COM DEV AIS receiver at any instant of time.

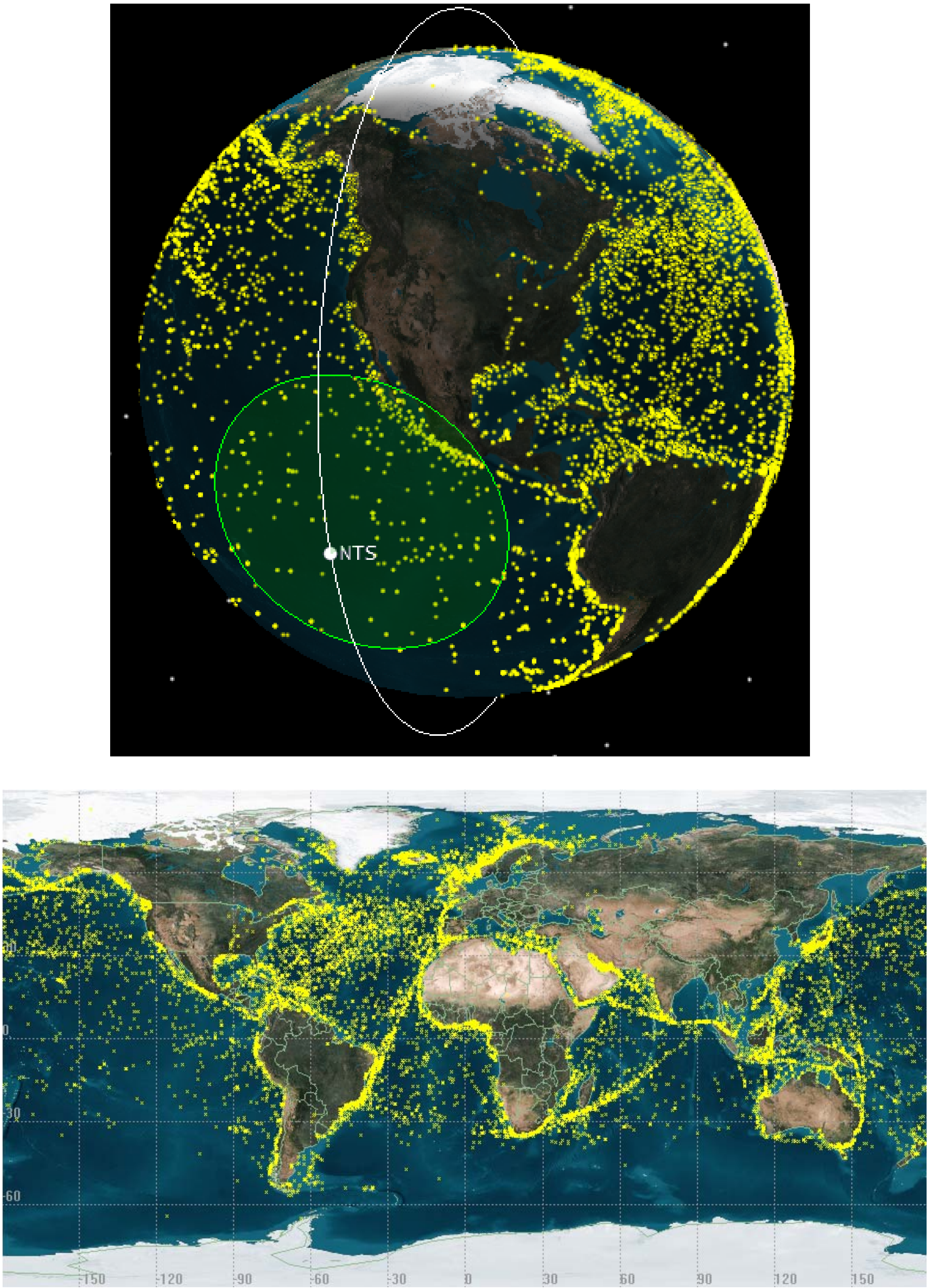


Figure 13: AIS messages recovered during NTS operations.

The comparison of the number of messages collected from AIS channel A versus AIS channel B for each of the 33 payload cycles is illustrated below. As can be seen, the number of messages collected on both channels is approximately equal for almost all the collection cycles.

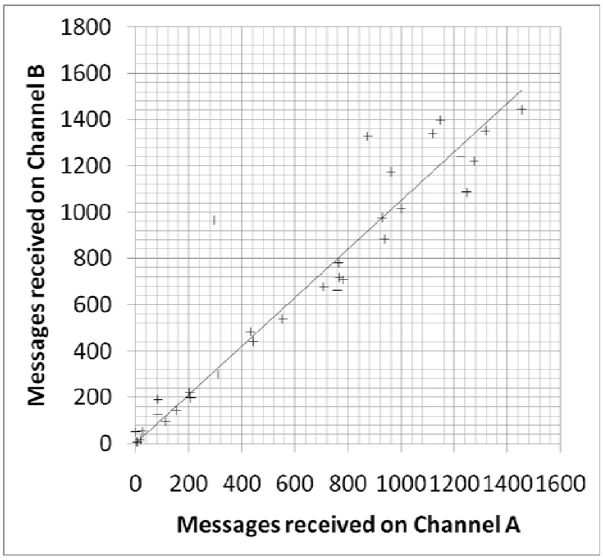


Figure 14: Comparison of the nb. of messages received on AIS channel B vs. channel A

During the first six months of NTS operations; COM DEV was able to capture a number of key physical characteristics relating to both the AIS environment from space and the performance of the COM DEV technology in this environment.

2.2.4 COM DEV EXACTEARTH AIS PAYLOAD ON RESOURCESAT2

In collaboration with ISRO, COM DEV will fly a hosted payload on the ResourceSat2 satellite. The satellite is planned to operate on a sun synchronous orbit, at an altitude of 817km.
The payload is composed of AIS antennas located on the earth facing side of the satellite, an AIS receiver derived from the NTS receiver, but capable of operating 100% of the time and downloading at 16 Mbps. The data will be downloaded through an S band transmitter provided by ISRO and totally dedicated to the AIS payload. The receiver is being designed and manufactured by COM DEV Europe, who is also responsible for the payload AIT at ISRO.

The satellite will download the AIS data to Bangalore and to the network of ground stations that is being set-up to support the deployment of all COM DEV AIS payloads and satellites.

The payload planning will be performed using a tool specifically designed for the purpose of optimizing the use of the various AIS payloads and ground stations. The tool will be configured to provide the best world-wide coverage, revisit time and latency, based on the availability of space and ground assets.

The payload tasks will be passed on to ISRO for transmission to the satellite during passes over Bangalore. The data from various earth stations will be backhauled to the exactEarth Data Center (Canada) for consolidation, analysis and distribution.

2.2.5 COM DEV EXACTEARTH SATELLITE ADS1B, LAUNCHING Q1-Q2 2010

ADS-1B is under construction at SSTL, and will carry an AIS payload as primary payload. The design of the satellite is derived from the UK-DMC2 satellite.

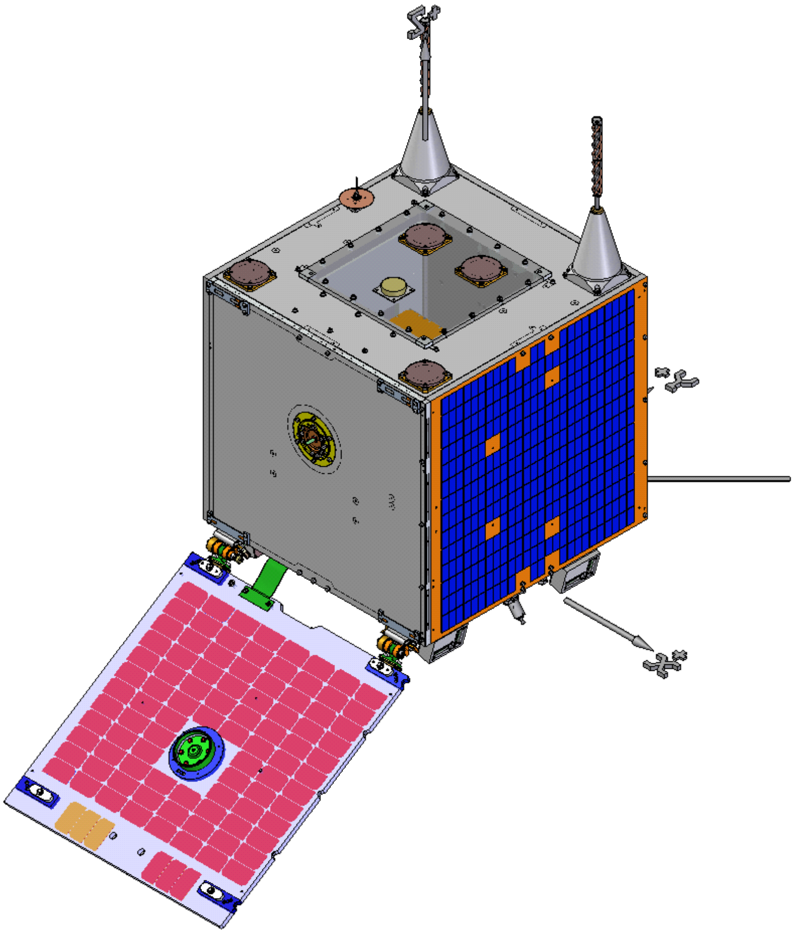


Figure 15: ComDev EXACTEARTH Satellite

The diagram below provides an overview of the system

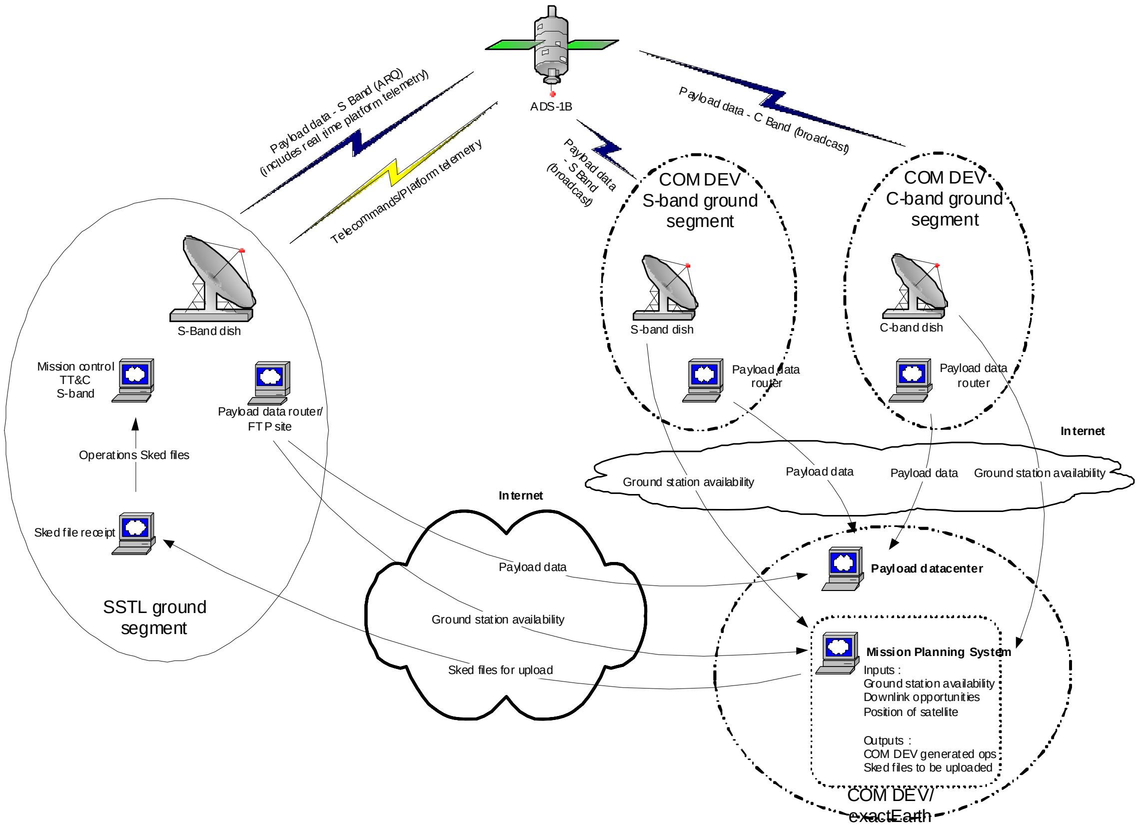


Figure 16: ComDev EXACTEARTH system overview

The payload is composed of AIS antennas, AIS Receivers (similar to the one flown on ResourceSat-2), SSTL's solid state recorders (SSDR/HSDR), and makes use of COM DEV's C Band high speed downlink (20Mbps), with SSTL's high speed S band downlink (8Mbps) acting as back-ups. The payload is capable of operating 100% of the time.

The AIS receiver is being designed and manufactured by COM DEV Europe, who is also responsible for the payload AIT at SSTL. The payload diagram is provided below.

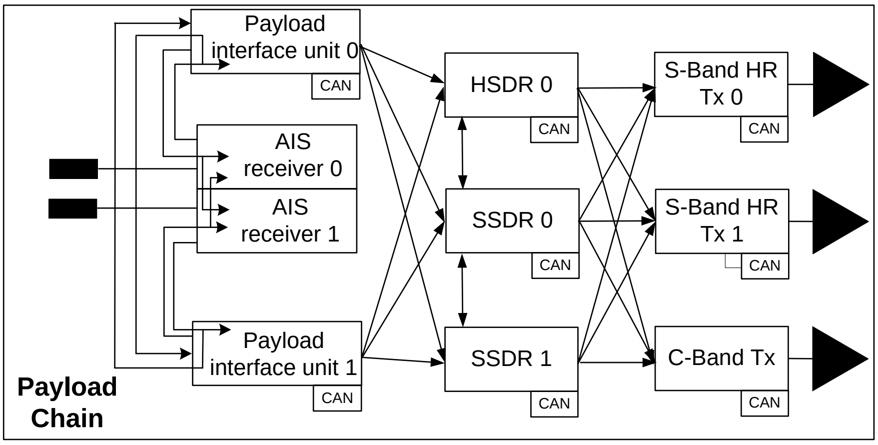


Figure 17: Payload Chain

The payload will be programmed using the same tool than the one used for the Indian Hosted Payload, i.e. a tool specifically designed for the purpose of optimizing the use of the various payloads and ground stations. The tool will be configured to provide the best world-wide coverage, revisit time and latency, based on the availability of space and ground assets (including the deployment phase).

SSTL will operate the satellite on behalf of COM DEV. The payload tasks will be passed on to SSTL for transmission to the satellite during passes over Surrey. The data from various earth stations will be backhauled to the exactEarth Data Center (Canada) for consolidation, analysis and distribution.

The satellite is planned to be launched in Q1-Q2 2010 into a sun synchronous orbit. Orbital parameters are dictated by the primary payload, but injection parameters have been selected such that ADS-1B complements the ResourceSat-2 hosted payload (i.e. reduce revisit time)

2.2.6 COM DEV EXACT EARTH / GOC M3M SAT

COM DEV is under contract by the Government of Canada to design and build a satellite with three payloads

- An advanced AIS payload
- A Low Data Rate messaging payload
- A tertiary payload

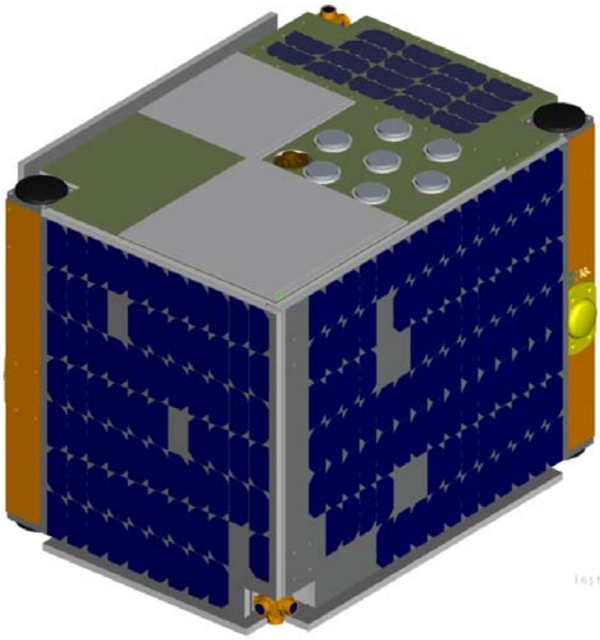


Figure 18: COM DEV EXACT EARTH / GOC M3M SAT

The advanced AIS payload is composed of advanced AIS antennas, and an advanced AIS receiver with increased data processing capabilities. The payload uses COM DEV C band downlink transmitter and antenna (20Mbps) for data download.

The bus used is a COM DEV bus, developed in collaboration with Space Flight Laboratories (University of Toronto), and compliant with the Canadian Space Agency's Multi Mission Bus (MMB) requirements.

The advanced AIS receiver and the LDR receiver are designed and manufactured by COM DEV Europe. The satellite is capable of downloading data both to Government ground stations and to the network of ground stations that is being set-up to support the deployment of all COM DEV AIS payloads and satellites.

2.2.7 RUBIN 7

The RUBIN-7 spacecraft was launched together with the main payload, German military satellite SAR-Lupe 3 2007 November 1 into 473 x 494 km 98.2° Node RA = 272 deg orbit. The RUBIN-7 spacecraft is a non separable payload on the Cosmos-3M launch vehicle upper stage and consists of three units – see Figure 19.

Figure 19: Overview of Rubin-7 spacecraft accommodation on Cosmos-3M launch vehicle

The unit R7.1 was equipped with AIS receivers from ComDev (two commercial type receivers with LNA and filter). Unit R7.2 – with AIS receiver from OHB (commercial receiver from True Heading company, Sweden) and unit R7.3 was used for launch vehicle telemetry acquisition and includes small onboard camera. All three units have an independent power source (see the solar generators in Figure 2.2.8-1) and are slowly tumbling in space on the launch vehicle upper stage.

Due to the launch vehicle upper stage anomaly after payload separation (spinning off and stabilization of spinning axis in space) the unit R7.1 was lost due to the impossible communication link. The units R7.2 and R7.3 are recovered after decrease of upper stage spinning rate and are operational since February 2008. The operational scenario is driven by the available power. This means that the AIS receiver is switched on automatically if power is available. The board computer records limited number of AIS messages and then transmitts to ground. The mission goal was to test the commercial AIS hardware in space and collect a set of data for demonstration purposes.

Description of Provided Data

The R7.2 system provides received the AIVDM messages, every one transmission packet consist of one AIVDM message – see example below, which was received 29. Jun, 2009 13:45

!AIVDM,1,1,,A,138Do:002GJIlW9qg89<g:=B08H1,0*01

The data set will be provided as ASCII file containing the time of message delivery and AIVDM message itself.

A limited number of actual AIS data from R7.2 could be found also online on www.rubin-x.com/R7.Mail.php - see Table 2.2.8-1 (the bold marked data is AIVDM message bytes in decimal coding)

MAIL NR. 3 [GLOBALGRAM:SAT=14] MODEM: 420 RECEIVED: 29 Jun 2009 10:07:52 +0000 SAT= 14 GW= 1
48 31 77 55 52 64 178 238 238 238 **33 65 73 86 68 77 44 49 44 49 44 44 65 44 49 56 49 53 53 111 80 117 66 64 114 58 108 101 73 115 83 108 52 86 56 84 111 52 48 60 48 50 44 48 42 52 57**

Table 11: Example of data received from R7.2

Covered Areas

The R7.2 experiment is flying on near polar orbit, therefore a global coverage is provided.
The date or period of data recording is random and as explained previously driven by R7.2 power budget in orbit.

2.2.8 RUBIN 8 - PSLV (OHB)

Description of Source

The RUBIN-8 spacecraft was launched on the Indian launcher PSLV in April 28 2008. Similar to previously launched R7.2 also this spacecraft is a non separable payload on the launch vehicle upper stage – see Figure 20.

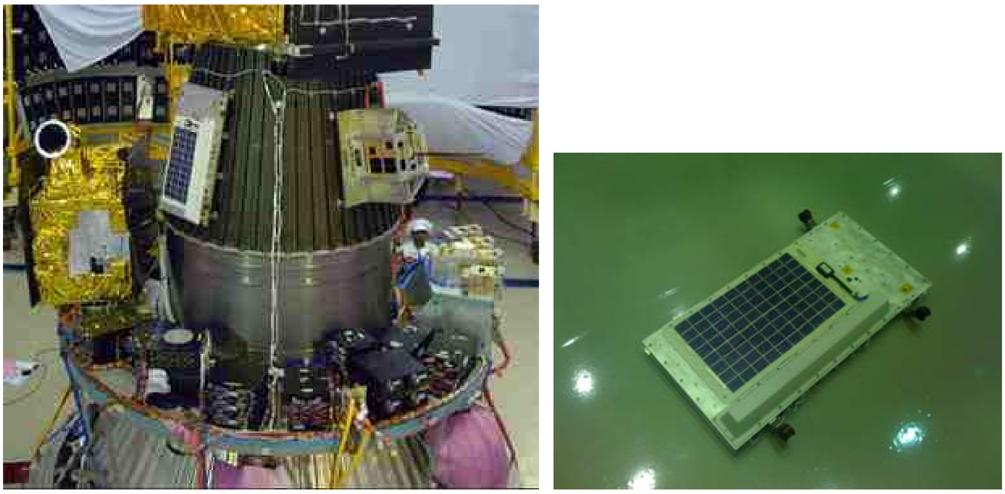


Figure 20: Overview of Rubin-8 spacecraft accommodation on PSLV launch vehicle

The Rubin-8 was equipped with two commercial type AIS receivers (SR162). The operational scenario was limited to approx. two weeks in orbit (April 28 – May 7 2008). During the missions time more than 700 000 AIS messages was received in orbit and a small part of 150 messages was downloaded to ground. Following figure shows the message counter in orbit.

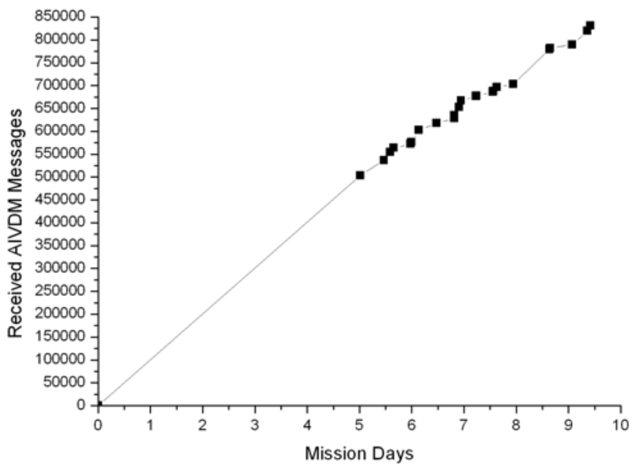


Figure 21: R8 message counter in orbit (first 5 days the counter value was not downloaded)

Description of Provided Data

The R8 system provides the AIVDM messages and the time stamp at the moment of message receiving in orbit. The overview of all down loaded messages (ships coordinates) is shown in the following.

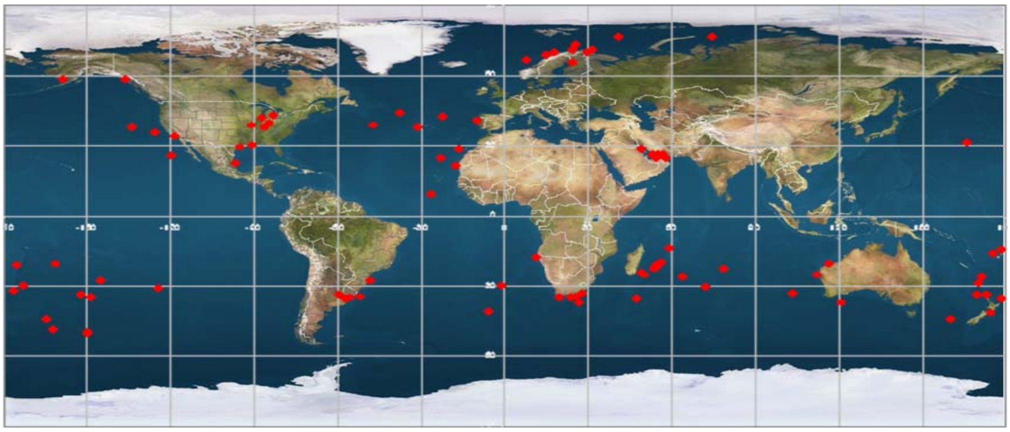


Figure 22: R8 downloaded AIS messages and ships coordinates

The time and orbit information allows the data processing on ground and the analysis of range, elevation and Doppler shift effects.
The data set will be provided as ASCII file containing the time of message receiving in orbit and AIVDM message itself.

Covered Areas

The R8 experiment was launched in near polar orbit, therefore a global coverege was provided.

2.2.9 RUBIN 9.2 (UNIVERSITY BREMEN)

Description of Source

The RUBIN-9.2 spacecraft is prepared for the launch on the Indian launcher PSLV in August 2008. Similar to previously launched R7.2 and R8 also this spacecraft is a non separable payload on the launch vehicle upper stage – see next figure.

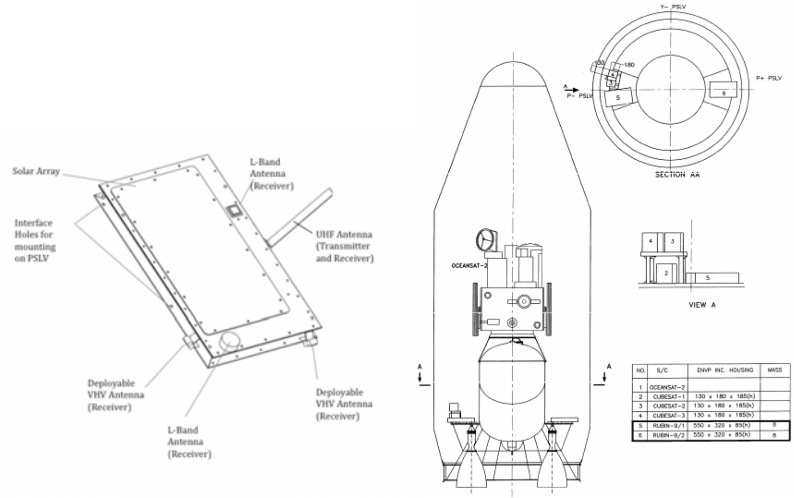


Figure 23: Overview of Rubin-9.2 spacecraft accommodation on PSLV launch vehicle

The R9.2 is equipped with one commercial type AIS receiver (SR162 – flown also on R8).

The opeartional scenario will enable the following features:

- controlled AIS receiver activation (time commands and geo commands)
- onboard recording of AIS messages (approx. 400KB memory used)
- onboard AIS message decoding and selected ship traking
- AIS data download to ground station in Bremen
- Attitude measurements by magnetometer and sun-sensor (enables post processing on ground for antenna orientation determination)

Description of Provided Data

The R9.2 system will provide the AIVDM messages and the time stamp at the moment of message receiving in orbit. The data will be provided as ASCII files.

Covered Areas

The R9.2 experiment will be launched in near polar orbit, therefore a global coverege will be provided.

2.2.10 MAX VALLIER (OHB)

Description of Source

The MaxValier spacecraft is a nano satellite build by OHB and GOB, Italy. Two following main payloads will be accommodated:

- X-Ray telescope (scientific experiment supported by Max Planck institute, Munich)
- AIS receiver (provided by LuxSpace)

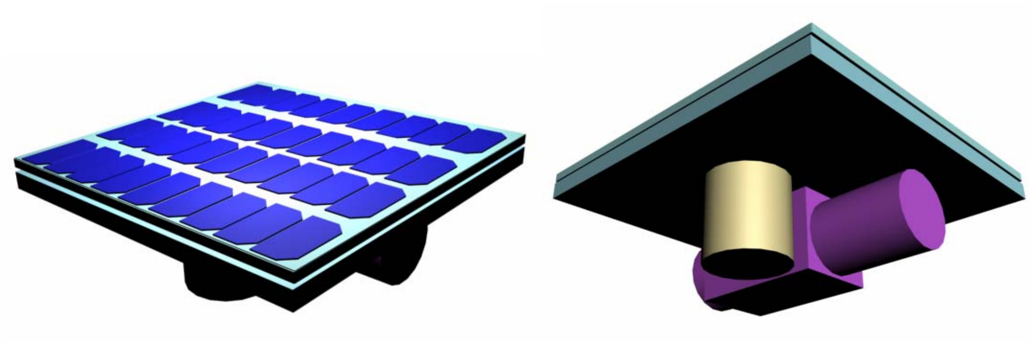


Figure 24: Overview of MaxValier spacecraft

The nano satellite will be launched in to sun synchronous orbit (baseline is PSLV end of 2010). The solar generator will be sun pointed and the spacecraft will slowly rotate around the axis to sun. The AIS antenna will be oriented in radial direction to the rotation axis.

The main features of the AIS payload and MaxValier mission are:

- advanced decoding (implemented by LuxSpace)
- 250MB for data storage
- exact spacecraft position and time measurements by GPS, full attitude information
- data download via VHF and S-Band to ground stations in Bremen and Bozen, Italy

Description of Provided Data

MaxValier will provide received AIS messages as data files with time information and AIVDM messages itself.

Covered Areas

The MaxValier spacecraft will be launched in near polar orbit, therefore a global coverege will be provided.

2.2.11 AISAT (UNIVERSITY OF APPLIED SCIENCES BREMEN AND DLR)

Description of Source

The AISat spacecraft is a nano satellite build by University of Applied Sciences under contract for the Institute of Space Systems DLR, Bremen.

The following AIS payloads will be accommodated:
Upgraded commercial AIS receiver from True Heading, Sweden (flown on R7.2)
AIS receiver provided by LuxSpace

The overview of AISat spacecraft is shown in the following figure (stored launch configuration).

Image missing

Figure 25: Overview of MaxValier spacecraft

AISat will test the approach of “AIS Magnifier” (patent in progress). The main idea is to use a high gain / narrow field of view antenna and the necessary attitude control maneuvres for AIS signal receiving in selected areas. The onboard data processing and storage will provide direct services to the end users (similar system as on VENTA-1 spacecraft – see next paragraph).

Description of Provided Data

AISat will provide received AIS messages as data files with time information and AIVDM messages itself.

Covered Areas

The AISat spacecraft will be launched in near polar orbit, therefore a global coverage will be provided.

2.2.12 VENTA-1 (UNIVERSITY OF APPLIED SCIENCES BREMEN - EARLY 2010)

Description of Source

The VENTA-1 spacecraft is a nano satellite build by University of Applied Sciences under contract for the University and High Technology Park in Ventspils, Latvia.

The following AIS payloads will be accommodated:
Upgraded commercial AIS receiver
AIS receiver provided by LuxSpace

The mechanical design of VENTA-1 is similar to AISat.
The target orbit is sun synchronous and the launcher baseline is PSLV.

Description of Provided Data

VENTA-1 will provide received AIS messages as data files with time information and AIVDM messages itself.

Covered Areas

The VENTA-1 spacecraft will be launched in near polar orbit, therefore a global coverege will be provided.