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European Satellite AIS under Joint EMSA/ESA Integrated Applications Programme

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The Automatic Identification System (AIS) is a short range coastal tracking system currently used on ships. Space-based, or SAT-AIS will provide AIS data via satellite, allowing for the detection of seafaring vessels on a global scale. A European-based SAT-AIS is being investigated in partnership with the European Maritime Safety Agency (EMSA) and ESA. The ARTES 21 SAT-AIS design element was approved July 2010 and defines the design/investigation of a sustainable space-based system that will provide AIS data.

SafeSeaNet (SSN), a Community vessel traffic monitoring and information system operated by EMSA, ensures the effective tracking of vessels through a centralised European platform for maritime data exchange, linking together maritime authorities from across Europe. It enables European Union Member States, Norway, and Iceland, to provide and receive information on ships, ship movements, and hazardous cargoes. Main sources of information include Automatic Identification System (AIS) based position reports captured from AIS shore based stations (terrestrial “nodes”), and notification messages sent by designated authorities in participating countries.

The provision of SAT-AIS data (via “space node”) would bring additional added value to existing maritime information services. SAT-AIS will be able to assist European entities and institutions in law enforcement, fisheries control campaigns, maritime border control operations, maritime safety and security issues including marine pollution response, search and rescue and anti-piracy.

EMSA/ESA SAT-AIS is implemented through three ARTES programme elements, which will be discussed in detailed in the paper:

- **ARTES 5** – technology activities, currently underway as antenna miniaturisation, receiver developments and performance testbed.
- **ARTES 20** – implementation and validation of the SAT-AIS Data Processing Centre as “space node” in close cooperation with EMSA.
- **ARTES 21** – covers the initial steps of the system design and implementation, also including the investigation of opportunities via a cost benefit analysis of an Operational Demonstration Mission (ODEM), system design phase B1 studies, comparative performance assessments, as well the exploration of possible Public Private Partnership (PPP) implementation scheme for the European SAT-AIS operational system.

Consultation with users has taken place through workshops hosted jointly by ESA and EMSA. Feedback from users and stakeholders at these workshops has been instrumental for the user requirements validation in further development of this programme.

I. INTRODUCTION

The Automatic Identification System (AIS) is a short range coastal tracking system used on ships. It was developed to provide identification and location information to vessels and shore stations with the aim of exchanging different types of data including position, identification, course, speed and others. This allows vessels to anticipate and thus avoid collisions at sea by means of continuous traffic monitoring. Additionally it offers important ship monitoring services to coastal guards as well as search and rescue organizations.

AIS transponders automatically broadcast information at regular intervals. Navigational status data is transmitted every 2 to 180 seconds, e.g. every 3 minutes while a vessel is at anchor or moored or not moving faster than 3 knots. In addition, voyage related data is broadcast every 6 minutes.

These signals are received by AIS transponders integrated on other ships or by land based systems. Ships of 300 gross tonnage and upwards engaged on international voyages, cargo ships of 500 gross tonnage and upwards not engaged on international voyages and all passenger ships irrespective of size are mandated by the International Maritime Organisation (IMO) to carry AIS equipment.

The AIS signals have a horizontal range of about 40 nautical miles (74 km), meaning that AIS traffic information is only available around coastal zones or in a ship-to-ship zone. AIS communication takes place using two VHF frequencies: 161.975 MHz, and 162.025 MHz. Both frequencies make use of a bandwidth of 25 kHz. Although only one radio channel is necessary, each station transmits and receives over two radio channels to avoid interference problems, and to allow channels to be shifted without communications loss from other ships.

Control of the AIS transmission network is accomplished using the SOTDMA (Self Organized Time Division Multiple Access) protocol. Using this protocol, the various AIS transmitters' structure the time slots in the AIS communication frequencies such that no overlap (collision) between signals will take place.

Satellite based AIS is seen as a promising solution to overcome the terrestrial coverage limitation with the potential to provide AIS service for any given area on Earth.

SAT-AIS does face technical challenges that were not considered in the original AIS standard (ITU-R M.1371-4 [8]), for example colliding messages from ships transmitting from different SOTDMA cells and lower signal to noise ratios. These issues required particular care and ESA initiated and conducted internal and external activities with the objective to improve the technology and system concepts. One of the outcomes of these activities is the ESA patent proposal "Advanced Receiver Design for SAT-AIS Detection" which in combination with an advanced antenna concept can improve the vessel detection probability in high traffic zones significantly.

In coordination with DG MARE, ESA performed two parallel SAT-AIS Phase-A system feasibilities studies in 2009/2010. In continuation, the participating member States for the ESA Advanced Research in Telecommunication Systems (ARTES) approved the SAT-AIS initiative (ARTES 21), for design of a SAT-AIS element, including technology developments, and a data processing centre development.

This paper will explain the European and the International context for SAT-AIS in the next chapter (II). The process for User Requirements consolidation and main key requirements are outlined in chapter III. The work plan of the ESA/EMSA SAT-AIS Initiative is described in chapter IV.

II.1. ESA-EMSA COOPERATION

The European Maritime Safety Agency (EMSA) as a regulatory agency originated in the late 1990s along with a number of other major European level maritime safety initiatives. EMSA was established by Regulation (EC) 1406/2002 [5] as a major source of support to the European Commission and the Member States in the field of maritime safety and prevention of pollution from ships, and subsequent amendments have refined and enlarged its mandate.

EMSA's objectives are addressed through a matrix of mainly preventive, but also reactive, tasks in a number of key areas. Firstly, the Agency has been tasked with assisting the European Commission in monitoring the implementation of EU legislation relating, among others, to ship construction and planned maintenance, ship inspection and the reception of ship waste in EU ports, certification of marine equipment, ship security and the training of seafarers in non-EU countries. Secondly, the Agency sets up EU level support capabilities. Significant examples are the SafeSeaNet system, to ensure effective tracking of vessels and their cargoes, and the EU LRIT Data Centre, to ensure the identification and tracking of EU flagged ships worldwide.

In parallel, a marine pollution preparedness and response capability has been established, including a European network of stand-by pollution response vessels as well as a European satellite oil spill monitoring service (CleanSeaNet), both with the aim of contributing to an effective system for protecting EU coasts and waters from pollution by ships.

The Agency provides technical and scientific advice to the European Commission in the field of maritime safety and prevention of pollution by ships in the continuous process of evaluating the effectiveness of the measures in place, and in the updating and development of new legislation. It also provides support to, and

facilitates co-operation between, the Member States and disseminates best practices. As a body of the European Union, the Agency sits at the heart of the EU maritime safety network and collaborates with many industry stakeholders and public bodies, in close cooperation with the European Commission.

With its current and future portfolio of maritime information services EMSA will certainly play a key role in assisting the Commission in establishing a common information sharing environment through the use of such services. With the provision of SAT-AIS data processing services, EMSA could continue to build on what it has done so far thus maximising the provision of maritime information services that it provides to the European Community.

EMSA and ESA identified the added value of close cooperation in the context of SAT-AIS. As a consequence, the parties intend to continue and enlarge their cooperation for another term of five years. On July 2nd 2010, ESA Director General and EMSA's Executive Director signed a five year renewable agreement concerning cooperation for the use of space based system and data in support of maritime activities. The cooperation established by this agreement has been proven very fruitful and satisfactory for both parties.

In order to inform and exchange views with all ESA/ EMSA Member States and EU on the European SAT-AIS initiative, information meetings were jointly organised at EMSA's premises in Lisbon in January 2010 and 2011.

Close to 50 representatives from EU Member States, ESA, the European Maritime Safety Agency (EMSA) and ESA Joint Communication Board (JCB) delegates attended the second joint EMSA/ESA SAT-AIS initiative information meeting in Lisbon [4] on 26 January 2011. This meeting reviewed the achievements and work in progress since the first information meeting held one year ago.

Following the information meeting, a User Requirement Consolidation Meeting took place on 27 January 2011 at EMSA in Lisbon. Close to 100 participants from representatives from EU Member States, ESA, European Commission Services, the user community, service providers and industry were consulted on the outcome of a 'User Benefit Analysis on a European space-based AIS system' and as a result of this consultation, the User Requirements were consolidated[7].

II.2. INTERNATIONAL FRAMEWORK

The International Telecommunication Union (ITU) and the International Maritime Organisation (IMO) are both leading specialised United Nations agencies which have a direct interest in the SAT-AIS issue. ITU has a membership of 191 Member States and more than 700 Sector Members and Associates and through this means has a global fo1cus on information and communication technology issues to develop worldwide telecommunication networks and services in conjunction with national governments and the private sector.

ITU has coordinated the shared global use of the radio spectrum through the World Radiocommunciation Conference (WRC), promoted international cooperation in assigning satellite orbits, worked to improve telecommunication infrastructure in the developing world, established the worldwide standards that foster seamless interconnection of a vast range of communications systems and addressed the global challenges including mitigating climate change and strengthening cyber security.

WRC 2007 decided that AIS 1 & AIS 2 may be used by the mobile-satellite service (Earth–to-space) for the reception of AIS transmissions from ships (Appendix 18 of the Radio Regulations - Note (p) referring to table). This provision provided a legal basis that allowed Low earth orbit mobile satellites to detect AIS transmissions from ships for purposes of security, environmental protection and satellite detection of AIS.

IMO currently has 170 Member States and three Associate Members and its overall objectives can be summed up in the IMO slogan which is "safe, secure and efficient shipping on clean oceans". The Organisation's main role is to develop and maintain a comprehensive regulatory framework for shipping and its remit today includes safety, environmental concerns, legal matters, technical co-operation, maritime security and the efficiency of shipping.

On Satellite detection of AIS, IMO has taken note of the result of the ITU studies that, amongst other things, proposed the introduction of a new message 27 dedicated to satellite detection of AIS messages and highlighted the need for new frequencies for the AIS satellite detection. As a result of this, for the upcoming World Radiocommunciation Conference (WRC 12 - 23 January-17 February 2012), IMO, through an IMO position paper, will be supporting an allocation to the mobile service (earth-to-space) relating to the frequencies of Channel 75 and 76 of Appendix 18 of the Radio Regulations and the consequential modification of Appendix 18 and Article 5 to reflect this new allocation. IMO believes that these changes will be required to accommodate global ship-tracking capabilities and to also to enhance ships' safety and security[*]. IMO is currently awaiting the results of further ITU studies on SAT-AIS before making further commitment on satellite detection of AIS.

[*] IMO Position on WRC12 Agenda items concerning Matters relating to maritime servicers Ref T2-Oss/1.4

IALA[10] is a non-governmental organization with the aim of fostering the safe, economic and efficient movement of vessels, through improvement and harmonization of aids to navigation worldwide and other appropriate means, for the benefit of the maritime community and the protection of the environment.

IALA-NET[11] will be a worldwide, unclassified, voluntary, web-based, open architecture, maritime data sharing exchange. It would use the example of existing systems such as the HELCOM agreement between the Baltic States, the NORTHSEA agreement between North Sea States and the Maritime Security and Safety Information System (MSSIS) run by the USA. It is a worldwide service available only to National Competent Authorities who provides the AIS data from their own country.

III.1. USER REQUIREMENTS CONSOLIDATION

The user requirements [6] are the results of several questionnaires, interviews and a user benefit analysis [7] with a number of representatives of the user community, including Coast Guards and Port Authorities, Military Bodies, Commercial Operators, National and European Institutions. The overall process that was applied to gather and consolidate the user requirements by ESA, EMSA and EC is depicted in figure 2.

The identified users' needs are grouped in different scenarios, each corresponding to a set of services that can be supported by SAT-AIS. Such scenarios present homogeneous requirements and can be therefore studied separately.

- **Scenario 1** addressing:
  - Maritime Security services: support of security operations
  - Law-enforcement services: anti-piracy, illegal fishing, enforcement of international/ national regulations, support of enforcement operations
  - Search and Rescue (SAR)
- **Scenario 2** addressing:
  - Maritime surveillance services: monitoring of vessels in sensitive areas, anti-drug smuggling, border control
  - Environmental services: hazardous cargos monitoring, prevention of pollution caused by ships, pollution response
- **Scenario 3** addressing:
  - Maritime Safety services: vessel traffic/navigation monitoring, vessel traffic management, support of safety operations
- **Scenario 4** addressing:
  - Fleet management services for commercial users (shipping companies, ship owners,…)

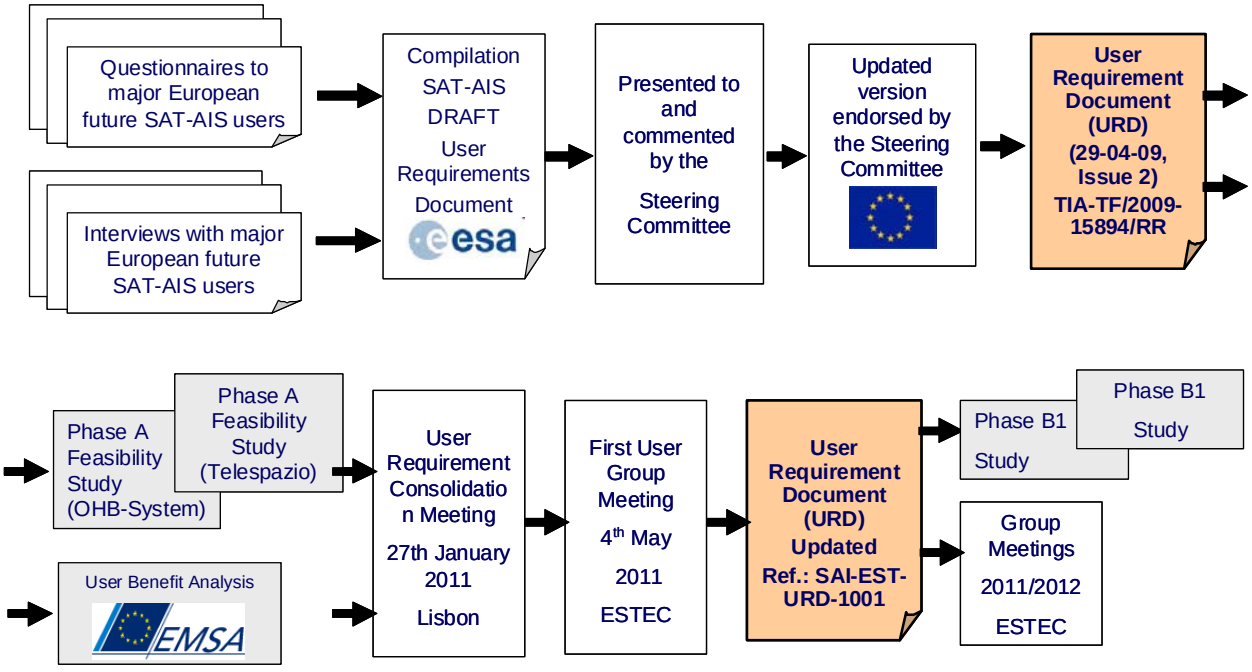

Figure 1: User Requirements Consolidation Process

The following performance requirements are stated separate per scenario (High Traffic Zones - HTZ, strong message interference, due to high no of ships in field of view from a satellite):

	Time Update Interval (world wide)	Time Update Interval (HTZ)	Timeliness
Sceanrio-1	1hr – 95%	1hr – 80%	1hr – 95%
Sceanrio-2	2hr – 95%	2hr – 80%	1hr – 95%
Sceanrio-3	3hr – 95%	3hr – 70%	1,5hr – 95%
Sceanrio-4	6hr – 95%	6hr – 70%	3hr – 95%

Table 1 Key Performance Requirements for SAT-AIS

The main functional requirement for a European SAT-AIS is a guaranteed operational service for 15 years, resulting in 70,000 – 110,000 ship detections every 1-6 hours and ensuring functions such as redundancy, spares, Data Integrity/Encryption, User Authentication, etc. The long time horizon requires also flexibility, e.g. for inclusion of the recommended AIS channels 3 and 4 dedicated for long range messages (type 27).

The current user requirements consider also the complementarity of terrestrial AIS data, that is available e.g. via EMSA services, in order to relax SAT-AIS requirements around European coasts. Furthermore the separation of global services and local augmentation for real-time data services is considered.

ESA established a User Group with 21 members (incl. Observer and Secretary), who will discuss and endorse further requirements consolidation as results of the reviews and results of the Phase-B1 studies.

III.2. DATA FUSION

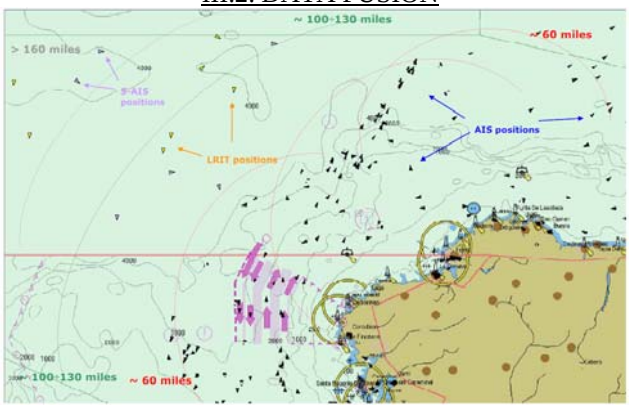

Figure 2: Combining Information Sources [EMSA]

On its own, the terrestrial based AIS-based picture is of major benefit to users, such as port authorities, maritime administrations, search and rescue organisations, port state control officers and many others. However, when satellite based AIS data would be integrated the benefit will be far greater, extending the SSN range to become a worldwide system.

Figure 3 shows the possibility of the combined information sources, e.g. as planned for EMSA's Integrated Maritime Data Environment (IMDatE), that will allow the combination of different data sources (AIS, SAT-AIS, LRIT etc) to provide a more complete maritime picture for the its user community (see also 9).

III.3. CURRENT SAT-AIS APPLICATION PILTO-PROJECT

Piracy off the coast of Somalia is an increasing threat to international shipping, many international organizations, including the International Maritime Organization have expressed concern over the rise in acts of piracy.

The European Union under the Common Security and Defence Policy (CSDP) launched EU NAVFOR Somalia – Operation Atlanta. This operation is working to protect humanitarian aid and reduce the disruption to the shipping routes and the de-stabilising of the maritime environment in the region (see also: Reference [12])

Until December 2010, 26 countries had brought contributions to the operation. EU NAVFOR operates in a zone comprising the south of the Red Sea, the Gulf of Aden and the western part of the Indian Ocean including the Seychelles, which represents an area of 2,000,000 square nautical miles (see figure 4).

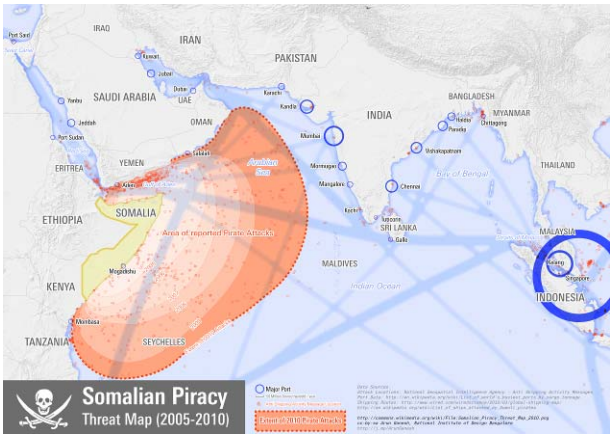

Figure 3: Piracy Threat Map

The effectiveness of the surveillance picture is dependent on optimising the tracking of a very high percentage of all merchant ship transiting the high risk area. The provision of SAT-AIS data will significantly enhance and support EUNAVFOR and other Naval Counter Piracy Operations to merchant shipping under threat from piracy.

IV. SAT-AIS INITIATIVE

The overall objectives of the SAT-AIS initiative [1,2,3] is the preparation of a proposal for the next ESA Ministerial Council for the implementation of a European and Canadian SAT-AIS, taking into account the needs of and possible partnerships with relevant stakeholders, under the consideration of existing capabilities and/or planned systems.

The overall ESA budget for the current SAT-AIS initiative including the budget allocated for the ongoing technology pre-developments covers the following activities:

- **Data Processing Centre:** ESA Element (Block 2), EMSA Element (Block-3) providing 6 services, e.g. enhanced, missing & predicted AIS messages, and EO data service
- **Short term demo projects** using SAT-AIS for areas of interest, e.g. support of EMSA Blue Belt project,
- **Medium term Operational Demo Mission (ODEM):** 4x studies on data services and/or demo satellites on-going for service in 2013-2015
- **System Design Element**: 2x Phase-B1 studies for full system
- **Technologies**:
  - Advanced Algorithm Patented by ESA
  - Receiver developments – Algorithm Improvement
  - Antenna Miniaturisation development
  - Testbed (8-12 channels, beam forming)
  - Comparative Performance Assessment, performing blind testing of proposed solutions
- **Implementation Options:**
  - Private public partner ship – business model evaluation covering Hybrid / Alternative SAT-AIS Solutions

IV.1. DATA PROCESSING CENTRE

At this time the SafeSeaNet (SSN) operated by EMSA ensures the effective tracking of vessels based on data received from Member States (through AIS shore based stations, coastal stations, port authorities etc.). From the coastal stations the AIS messages are transferred via national shore-based stations to four regional AIS servers:

- HELCOM (Helsinki Commission – Baltic Sea);
- North Sea;
- Mediterranean;
- Northern North Atlantic.

They provide the data to the EMSA SafeSeaNet server (there are exceptions in terms of additional data paths from national servers directly to the SafeSeaNet server).

The idea is to add another stream of AIS data received via Satellite(s) which will be stored and processed by the SAT-AIS Data Processing service that will be developed as a module within EMSA's Integrated Maritime Data Environment (IMDatE).

The objective of the demonstration project is the development, integration, testing and validation of a *"demo version"* of the Data Processing Centre (DPC). The DPC is composed of two main elements (see figure 6) and will be implemented by EMSA and ESA under a joint project team and will consists of two main elements: the ESA part of the DPC (DPC ESA Element, or Block-2) and the EMSA contribution (DPC EMSA Element, or Block-3). The Data Processing Centre block diagram is depicted in Figure 2.

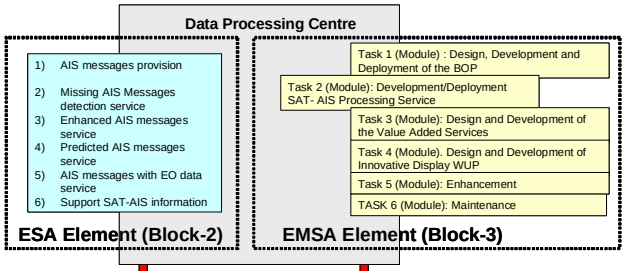

Figure 4: Data Processing Centre Block-2 and 3

The entry point for the AIS messages into the DPC from the ground station network will be the ESA DPC element. In order to perform its functions, the DPC shall receive:

- the AIS messages and ancillary information from ground stations;
- SAT-AIS orbit and events files from the SAT-AIS ground control centre;
- EO data

The DPC ESA Element (Block-2) will deliver the following services:

1. AIS messages provision (Service 1) : it provides well-received AIS messages, without any further enhancement processing;
2. Missing AIS Messages detection service (Service 2): it provides indication of the times during which AIS messages were lost as well as times where the contacts were expected;
3. Enhanced AIS messages service (Service 3): it provides AIS messages that have been reconstructed and/or enhanced by using ancillary data;
4. Predicted AIS messages service (Service 4): it provides AIS messages prediction, based on previous SAT-AIS messages from the same ship;

5. AIS messages with EO data service (Service 5): it provides validated positions of ships by correlating EO images with AIS messages:
6. Support SAT-AIS information (Service 6): it provides satellite orbital data and events information in support of AIS messages processing.

EMSA is currently developing the Integrated Maritime Data Environment (IMDatE) that will host EMSA's new SAT-AIS data processing service (block-3).

The IMDatE environment will provide new services to SafeSeaNet, and other EMSA applications, and will allow the combination of different data sources (AIS, SAT-AIS, LRIT etc) to provide a more complete maritime picture for the its user community. The EMSA Satellite AIS processing service will receive data from the different data providers and allow distribution of satellite-originated data to the maritime community.

IV.2. DATA PROVISION - BLUE BELT

The Blue Belt project was initiated by the Belgian EU Presidency to promote Short Sea Shipping, using the EU SafeSeaNet (SSN) data to deliver information in real time or near real time to customs authorities on a ships' voyage. The project concept is based on the combination of the vessel monitoring information provided through the pilot project, with existing customs tools, in order to provide a higher degree of certainty regarding vessel voyage information, and support an easier decision making process for customs formalities. The overall Blue Belt pilot project will be carried out by the European Maritime Safety Agency (EMSA) [Reference[13]].

In the frame of the Blue Belt pilot project, the movements of "blue ships" (circa 250 ships, identified with the help of European Community Ship owners' Associations and the World Shipping Council) will be monitored via the EU SSN application, and e-mail reports will be automatically generated and sent to the Customs authorities two hours before the expected time of arrival of each ship at a destination port. These e-mail-reports will contain information on the current and previous voyages of the ship (expected or actual arrival and departure times, previous and next ports), and other pertinent data. A link to the Blue Belt web-interface for more in depth analysis of the last voyage track and voyage picture will also provided.

The main objective data from existing space-assets, in order to complement the of the ESA Blue Belt demonstration project is to actively support the EMSA Blue Belt pilot project, through the acquisition and provision to the EMSA Blue Belt system of relevant space-based AIS terrestrial data. This project will allow demonstrating that Satellite based AIS services can provide a suitable and relevant complement and back-up solution to terrestrial AIS data.

IV.3. ODEM

This activity aims at performing a cost benefit assessment for a possible operational demonstration mission (ODEM) required and supported by the users/stakeholders. ODEM is intended as an early and cost-effective demonstration of capabilities and performance of space-based AIS in an operational environment, e.g. for a limited geographical area and time period:

- Start of service not later than end 2013
- Service life time minimum 2 years
- Areas of Interest are the Gulf of Aden/Horn of Africa/West Indian Ocean, the south Mediterranean Sea, and the South Atlantic Approach to Europe.
- Detection probability of 90% within 3 hours
- Time update Interval 1,5 till 6 hours (90%-80%)
- Timeliness between 15 and 30 minutes (90%)
- Delivery of auxiliary data (Doppler frequency, satellite position, time stamps) for ship position verification service

Currently four industry contracts are conducted for the definition of possible ODEM Concepts. This includes data service from existing space and ground assets, the provision of new space assets as well as the combination of both concepts.

One main objective of the ODEM industry activities is the comparison of the performance assessment directly from industry with an ESA defined, independent and consistent blind testing methodology for all proposed concepts. Furthermore the activity is aimed at elaborating in the definition of mission concepts and determining associated cost, schedule and risks.

Based on the results of industry studies, ESA and EMSA are jointly performing the cost benefit analysis for the proposed concepts.

IV.4. TECHNOLOGIES

The SAT-AIS initiative comprises also the following technology developments.

Flexible AIS receiver Prototype : The FlexiblE InNovative AIS receiver prototype (**FENICE)** is an ESA co-funded project (ARTES 5.2) that aims at developing a SAT-AIS receiver prototype implementing and validating the detection algorithms devised in the Phase A system.

The proposed implementation is fully flexible and covers both the case of on-ground and on-board processing, as well as the deployment of different antenna subsystems. In addition it can also support possible The design and development of the prototype will allow assessing in detail the performances and complexity of the receiver. The trade-off on-board versus on-ground processing will be analyzed through further verification of the complexity and performance of the two options.

Space-Based AIS Receiver Phase B/C/D: The SAT-AIS Receiving System Phase B/C/D was initiated under the General Support Technology Programme (GSTP) and has as main objective the design, development and testing of Space-based AIS receiver in representative test conditions.

The SB-AIS receiving system comprises three chains of VHF receivers interfacing with three VHF antennas in an orthogonal configuration and associated digital signal processing units. The advanced demodulation algorithms included in the ESA patent application are implemented. In order to maintain the flexibility of the receiver to be upgraded with enhanced receiver techniques, the SAT-AIS receiver architecture is based on Software Defined Radio (SDR) design.

The SAT-AIS receiver system is designed for low Earth orbit and a minimum of 2 years in-orbit operations lifetime. It will be tested under representative space environmental conditions, compliant to requirements defined for spacecraft units (experiment payloads).

Miniaturised Low-Weight Space Antenna for AIS VHF Applications: This activity, in the following named “antenna pre-development”, has the main goal of pre-develop the antenna elements exploiting an advanced technology for decreasing the antenna mass and ease accommodation on micro-satellite platforms

AIS End-to-end Testbed development: The main aim of this activity is to develop an end-to-end validation platform of space based AIS solutions, which will be referred to as *AIS end-to-end Testbed* hereafter. The testbed shall be utilized in the comparative performance assessment activity (ARTES 21) for evaluating the performances of existing/planned systems and of the underlying technologies. In addition, it is also a tool to enable the study and validation of new payload technologies (digital beam forming, new detection algorithms).

The end-to-end AIS Testbed shall include an AIS emulator as well as a physical layer test bench. The physical layer test bench shall be capable of interfacing with different Space-based AIS receivers (prototype, engineering model, EQM, FM, etc.) to asses their functionality and performance.

The AIS emulator shall be capable of modelling any SAT-AIS constellation with configurable key system parameters, and shall provide an evaluation of the system-level performances of different SAT-AIS solutions in terms of detection probability, time update interval, and other relevant figures of merit. To this aim, different elements of the complete satellite AIS, including traffic model, constellation emulation, Self-Organized TDMA (SOTDMA) protocol and all the relevant sub-systems shall be modelled.

Comparative Performance Assessment (CPA): Different Space-based AIS exist at different development and deployment stages. Performance is reported by system proponents based on unknown traffic models, performance assessment tools, underlying assumptions and even with diverse definitions of performance parameters. In order to allow the assessment of the reported performance in the context of SAT-AIS requirements and to compare the performance of different systems or combinations thereof, there is the need for an independent undisputed methodology, processes and tools for objective performance assessment.

This activity aims at the setting up of such Comparative Performance requirements, methodology, processes and tools allowing the assessment at system level, satellite level and subsystem/equipment level. In order to build the necessary consensus the Agency has set up a Working Group of currently 11 members (incl. secretary) formed by representatives of Member States, Academic entities and National Agencies.

IV.5. PHAE-B1 SYSTEM DESIGN

This is the main activity foreseen within the SAT-AIS Design Element. The activity consists of a design definition of the European SAT-AIS, including space segment (constellation of LEO satellites) and ground segment (control centre and receiving stations), meeting the institutional (and possibly commercial) user requirements. The objectives of Phase B1 are, in particular:

- Consolidate of the user requirements;
- Analyse the legal/regulatory framework and possible impact into the SAT-AIS design;
- Preliminarily design the SAT-AIS space and ground segment;
- Assess the compliance to the user requirements;
- Investigate the impact of additional optional payloads (e.g. EO, data collection)
- Refine and consolidate the costing elements;
- Assess technical and programmatic risks;
- Establish a SAT-AIS consolidated development plan;
- Optimize/revise the system design depending on PPP activity(ies) outcomes;
- Analyze the hybrid solution;
- Define the SAT-AIS baseline;

Parallel Phase B1 studies are performed as defined by the Agency's Procurement Policy reform by maintaining competition in the early phases of the SAT-AIS Initiative. Within ARTES 21 Design Element, the Phase B1 will have close interaction with all other planed activities within ARTES 21 Design Element, in particular the ODEM Cost-Benefit Analysis, with the PPP Schemes Elaboration and with the Hybrid Model Elaboration.

Figure 7 shows the high-level SAT-AIS end-to-end architecture. The data transmitted by the ship borne AIS equipments are collected and processed by the payload on-board the satellites composing the SAT-AIS constellation. Received signals are relayed through a feeder data link to the network of AIS receiving ground stations. From there, the AIS messages together with the associated ancillary information are sent to a data processing centre which elaborates the data for providing services to the user communities. A control centre station performs the mission management and control of the satellites in the constellation.

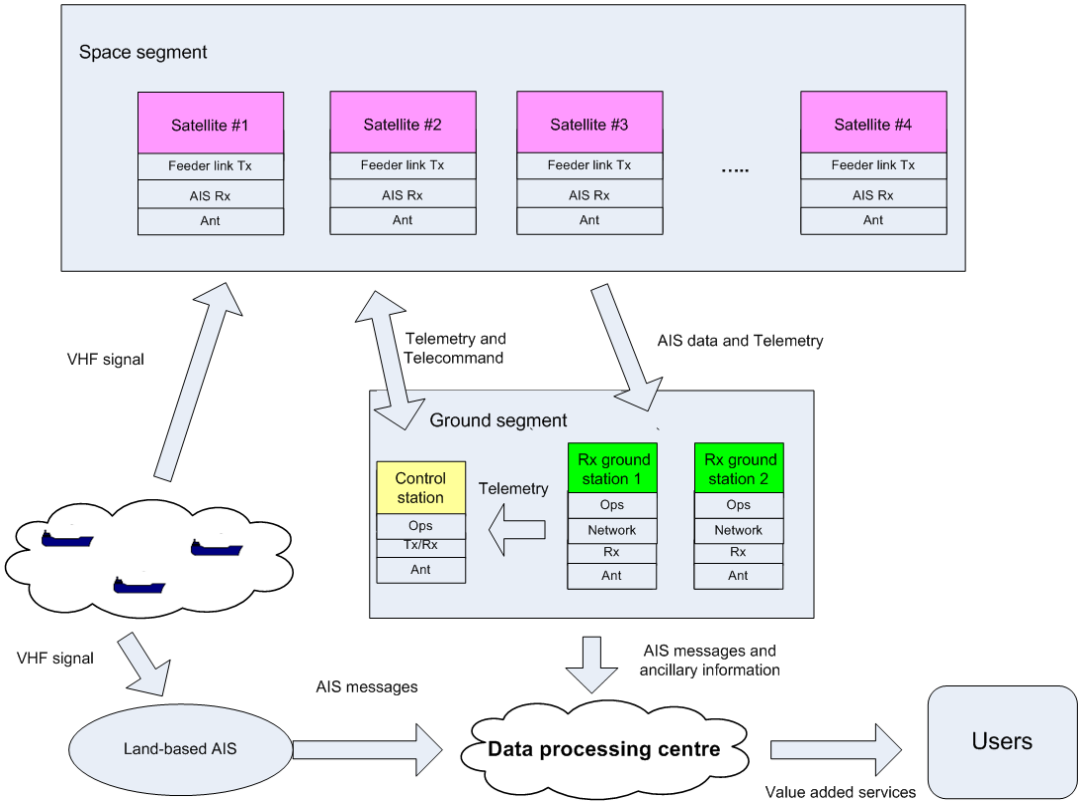

Figure 5: End-to-End SAT-AIS Architecture

IV.6. IMPLEMENTATION OPTIONS

The development and service delivery model for SAT-AIS envisages that ESA will establish cooperation with EU institutions and/or other parties for the funding of the development, deployment and operations of the SAT-AIS infrastructure to serve the needs of the EU/National users. In this respect, a Public Private Partnership (PPP) might be established with private entities like Operators and/or Service Providers.

The **Public-Private Partnership (PPP)** activity aims at the assessment of possible schemes for the development/deployment and operation of the SAT-AIS infrastructure and/or provision of the SAT-AIS data and services to institutional and/or private users. Several possible PPP schemes are foreseen in terms of the role of the private partner where the private partner becomes the owner of the SAT-AIS infrastructure:

- Baseline System Operator and Service Provider (responsible for the development/deployment of the SAT-AIS infrastructure and for the provision of services to institutional as well as commercial users);
- Hybrid System Operator and Service Provider, normally the owner of an existing/planned space-based AIS infrastructure, which is interested in complementing his assets with additional elements in order to meet the user requirements of the targeted user scenarios and to provide services to institutional and commercial users;
- Alternative System Operator and Service Provider, normally the owner of an existing/planned space-based AIS infrastructure, which is interested in providing services to institutional and commercial users with the existing/planned assets with, possibly, compromised user requirements.

In all schemes listed above the private partner becomes the owner of the SAT-AIS infrastructure and is responsible for infrastructure maintenance and replenishment to guarantee a service availability and continuity.

In addition, there are also possible roles where the private partner is not owner or operator of the SAT-AIS infrastructure and is not involved in the SAT-AIS infrastructure deployment and maintenance:

- Commercial Service Provider, exploiting the SAT-AIS data stream to provide services to commercial users exclusively (as a complement to services to institutions) using the SAT-AIS infrastructure.

Several other roles and schemes might exist. The list is not intended to be exhaustive but illustrates different possible schemes.

In case the **Hybrid Model** would prove to be worthwhile exploring, after promising results in the Comparative Performance Assessment exercise, further work would be required for the proponent of the system to define in sufficient detail its possible contribution (SAT-AIS subset) in terms of technical, operational, cost, schedule, risk and commitment aspects such that an overall assessment of the hybrid system can be made within Phase B1.

Alternative System Solution(s) could be further elaborated, in case the Comparative Performance Assessment determines that existing or planned (private/national) Space-based systems are able to meet fully or partly the user requirements consolidated within phase B1. An industrial activity is foreseen to cover the effort of proponents of viable Alternative System Solutions in defining technical, performance, operational aspects of the Alternative System Solution and to define cost, schedule, risks and commitment in the required level of detail.

V. REFERENCES

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