RADAR AND AIS SENSORS CONSTELLATION FOR GLOBAL MARITIME SURVEILLANCE

Sophie Ramongassié, Nicolas Taveneau, Thibaud Calmettes, Jacques Richard, Remi Challamel, Olivier Autran (1), Valérie Foix, Philippe Durand (2)

(1) Thales Alenia Space, 26 av. J-F Champollion, 31037 Toulouse, France
Tel: +33 (0)5 34 35 36 37 ; Fax: +33 (0)5 34 35 52 05

2) CNES, 18 av. Edouard Belin, 31401 Toulouse, France
Tel: +33 (0)5 61 27 31 31

1. INTRODUCTION

Maritime surveillance is of utmost importance to ensure the safe use of the seas and maritime border security. These activities deal with many problems and threats related to safety of navigation, the application of regulation to protect the marine environment, fisheries control, and the fight against trafficking of all kinds of illegal immigration, and security in general. These missions are currently covered by ground and airborne sensors with a limited coverage over all the seas. Better time and spatial coverage can be done only with space sensors which can bring a global coverage and permanent revisit time.

The space based system presented here below consists in a constellation of four satellites, in which an AIS (Automatic Identification System) receiver instrument and a Radar instrument are embarked together. This innovative concept covers either cooperative vessels, thanks to its sensor allowing AIS messages exploitation and non cooperative vessels thanks to radar sensor. These synchronous and geographically overlapping data can be processed further on the ground and can allow data fusion for cross-validation and for high level interpretation.

In the frame of SMAR study (Feasibility study of a space-based maritime surveillance system), funded by CNES, several concepts for this dual sensor constellation have been addressed. One of them supported by Thales Alenia Space is described in this paper. The performance of this constellation in terms of revisit time and detection probability for each sensor before data fusion processing is presented. Its interest for global maritime surveillance is discussed. Instruments are described as well as the proposed satellite concept.

2. SENSORS CONCEPT

2.1. Detection Radar

The Radar concept is specifically oriented for ship detection, and not for land or sea imaging. It exhibits high detection performances of small ships even in adverse sea states conditions. The principle is based on low PRF Radar, which allows wide swath coverage (as high as 1000 km) at low grazing incidence to reduce the sea clutter contribution as much as possible. The Radar operates in HH polarization more interesting to enhance the contrast Target/clutter. The on-board processing provides coherent gain through azimuth synthesis and incoherent gain through multi-looking averaging. This instrument is optimized for low power consumption allowing a quasi-permanent operation on the orbit. The Radar output data are detection maps, where ship have been detected and localized. In addition, the defined concept can also be used for imagery over limited areas through a conventional SAR (Synthetic Antenna Radar) mode.

2.2. AIS sensor

A cooperative, large scale systematic open seas ship identification function can be provided using spaceborne sensing and relay of the AIS signal. The specific issue raised by a "spaceborne extended AIS" is to manage the cell congestion in dense traffic areas, which dramatically degrades the quality of service expected from such system. The first solution to overcome this issue is to use an advanced space based AIS payload concept. This concept is based on a multi-antenna system, which enables efficient signal discrimination, and on high level processing algorithms, split between board and ground. The heritage of the processing developed for ARGOS mission in Thales Alenia Space is of great help to tackle this technical issue.

A second solution, more focused on the maritime segment, is the introduction of a 3rd VHF frequency (future standard AIS 3 & 4), dedicated to the space based AIS, and potentially tuned (in term of protocol) in order also to greatly improve the quality of service over dense maritime areas. This approach is not considered here, since this is not yet decided in international committees.

2.3. Constellation definition

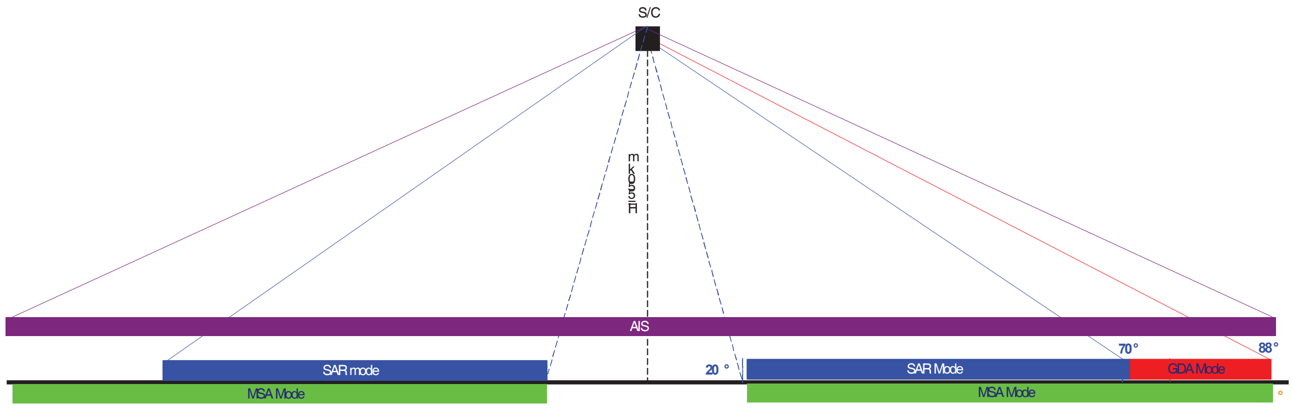
The altitude of the constellation is fixed to 550 km as a trade-off between revisit performance, radar link budget and orbit altitude maintenance.

3 main services for maritime surveillance have been currently defined and are displayed on the figure below:

- The Global Data Acquisition (GDA mode) is used for global surveillance in less than 24 hours, with a Radar swath width between 600 km and 1000 km, which is tuned to optimize the detection performance with regard to the current latitude.
- The Monitoring of Sensitive Areas (MSA mode), of about 100 Nm*100 Nm. This mode is the most driving mode in terms of revisit time with an objective of few hours. So it has been defined to provide the largest accessibility domain between 20° and 88° of incidence angles on right or left side of the track thanks to satellite agility.
- End to end vessels tracking (VT mode) with a revisit as short as necessary to avoid the lost of the track.

- The “SAR” mode is a conventional imaging mode, which can be used from 20° to 70° max of incidence angles, but with a reduced swath with regard to MSA detection mode. It is used as much as possible, depending on the satellite resources.

The AIS antennas are nadir looking to receive all ships signal from nadir to the horizon.

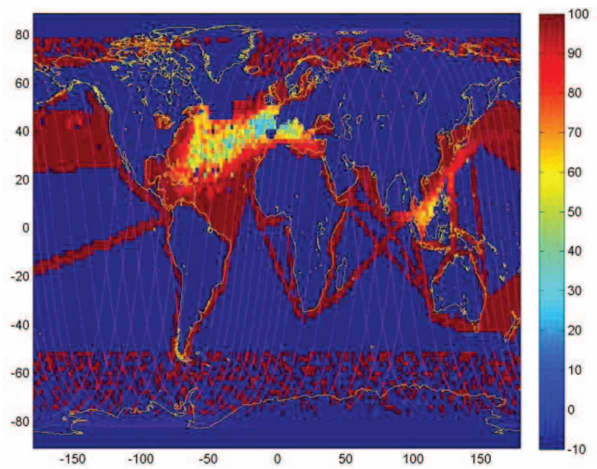


Range of incidence of Sensor modes

3. SENSOR PERFORMANCE

The paper will address the performance of the AIS and Radar sensors in the different mission modes. The improvement given by the AIS+Radar concept shall be quantified. An example of concept performances (swath width, detection probability, false alarm probability, number of detected vessels) will be given. A first indication is given below.

<ins>AIS sensor</ins> : The expected performance for AIS detection are displayed on the figure besides. It shows that 90% of moving vessels are detected assuming today’s world vessel fleet.



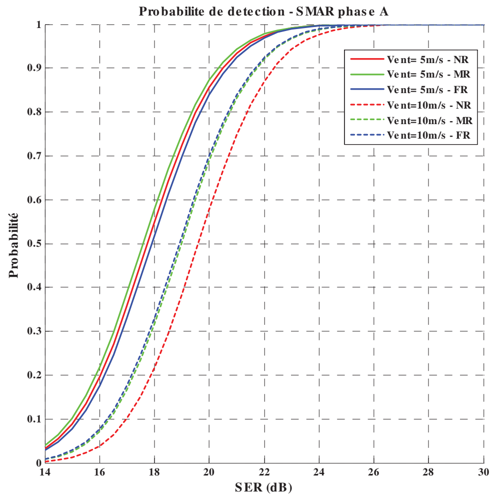
Probability of ship detection around the world (red colour means 100% of vessels with AIS are detected

<u>Radar sensor</u> : An example of Radar detection probability as function of the ship RCS (Radar Cross Section) in dBm² is given hereafter. The false alarm probability is fixed at 10-7.

<u>Detection performances</u>

GDA Mode : more than 80% of commercial vessels and 45% of the total fleet including small fishing boats.

MSA Mode : 80% to 90% of ships depending on localization of the sensitive areas and sea state conditions.



Probability of detection for a given ship RCS

4. SENSORS DESIGN

The proposed Radar and AIS sensor architectures will be outlined, the main technologies described and the mass / power / data rate budgets given. The main challenge is to design the RF and mechanical architecture of the 10m Radar antenna in X-band.

5. SATELLITE CONCEPT

The proposed satellite architecture will be outlined. The baseline is to reuse the PRIMA platform, which has been successfully designed for similar Radar instruments as RADARSAT 2 and COSMO SkyMed. The main accommodation issues addressed including launcher accommodation (single launch or dual launch). The mass and power budget will be given.

6. REFERENCES

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