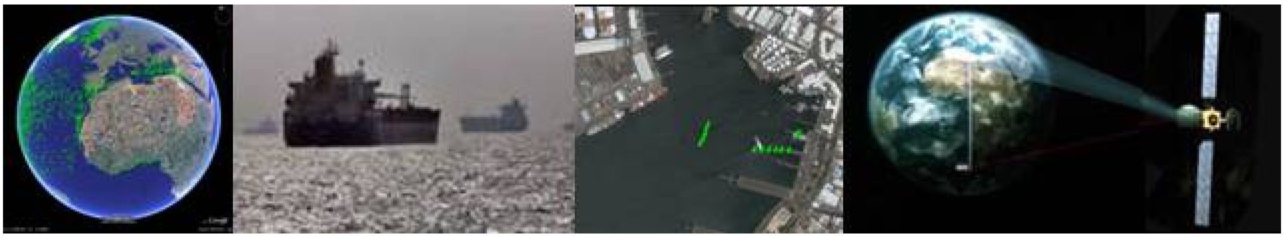
in cooperation with

Institute of Space Systems

Flight Operations



Technical Note TN-13-1:

Optimisation of the Receiver Following Airborne Campaign

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

Doc.Type: Technical Note			DRD N°: TN-13-1
Doc. N°: TN-13-1	Issue: 1	Date: 21.09.10	Page 2 Of 8
Title: **Optimisation of the Receiver Following Airborne Campaign**			

	Name & Function	Signature	Date
Prepared by:	Adrian Nash Chief Engineer COM DEV Europe		05.10.2010
Approved by:	Rob Goldsmith Business Development Director, COM DEV Europe		05.10.2010
Application authorized by:			
Customer / Higher Level Contractor			
Accepted by:			
Approved by:			

DISTRIBUTION LIST	N	A	I
Consortium Internal G Eiden (Luxspace)			
External Iain Shepherd *(DG MARE)* Giovanni Garofalo *(ESA)*			
N=Number of copy A=Application I=Information			

Data Management: ------------------------ *Signature* *Date*	File: 0501 PASTA MARE Optimisation of Receiver TN 13-1_Issue1.doc

DOCUMENT CHANGE RECORD			
ISSUE	*DATE*	*CHANGE AUTHORITY*	*REASON FOR CHANGE AND AFFECTED SECTIONS*
1	05.10.2010		Initial Release

1. TABLE OF CONTENTS

2. INTRODUCTION

COM DEV provided an AIS receiver to the PASTA MARE project for the airborne AIS data collection trial carried out between July 17th 2010 and July 31st 2010 inclusive. The RF section of the receiver was virtually identical to that used in COM DEV's AIS Missions (HIP-1, ADS-1B, M3MSAT). The main difference was in the digital data processing and storage, which was performed by a COTS DSP system (X5-400M + eInstrument EPC). Full details of the receiver hardware and software may be found in AD1 and AD2. The results of the flight trial may be found in AD3.

This report presents "Lessons Learned" in respect of the receiver from the flight campaign, and also considers the implications for the design of a satellite AIS receiver in light of what was learned from this project. The report concludes with a look at future enhancements in particular support of future AIS channels.

3. APPLICABLE DOCUMENTS

Reference	Description	Issue
AD1	TNO 11-1 Receiver Hardware ICD	2
AD2	TNO 11-2 Receiver Software ICD	A
AD3	TNO 15-1 Flight Trial Report	1

Table 3-1: List of Applicable Documents

4. ABBREVIATIONS

The following abbreviations are used in this document.

Abbreviation	Full
A/D	Analogue-to-Digital Converter
AGC	Automatic Gain Control
AIS	Automatic Identification System
COTS	Commercial off-the Shelf
DSP	Digital Signal Processor
GMSK	Gaussian Minimum Shift Keying
RF	Radio Frequency
s-AIS	Satellite AIS data
t-AIS	Terrestrial AIS (EMSA) data

Table 4-1: List of Abbreviations.

5. SUMMARY OF RECEIVER PERFORMANCE

The COM DEV AIS Receiver used for the AIS data collection is a dual channel receiver capable of receiving on AIS Channels A (161.975 MHz) and B (162.025 MHz) simultaneously. Its RF input band ranges approximately from 161 to 163 MHz. The two receivers are identical, but independently controllable and are a phase-coherent dual-conversion Superheterodyne type.

The flight trial software (defined in AD2) enables the channel frequency and gain of each receiver to be independently controlled. The gain is controllable over a 0 to –30dB range by means of a programmable attenuator. The outputs from the two channel receivers were digitised, processed into baseband I/Q samples and stored to a hard disk drive in real-time using a COTS DSP system (see AD1 and AD3 for details).

It was found that shortly after take-off the gain of the receivers had to be reduced due to a tendancy for the receiver to be overloaded. Close to the ground (i.e. before take-off) the receiving antenna was so close to the ground that very little signal energy was picked up. Once the aircraft had gained sufficient height, the path loss to the AIS transponders in the field of view was increased sufficiently that the gain could be increased. At cruising altitude little or no adjustment to the receiver gain was required.

The receiver has no Automatic Gain Control (AGC) as it has a >50dB dynamic range and is designed to operate on a LEO satellite at 650-860km altitude.

The receiver is designed to offer a sensitivity of about –120dBm for a 10% Packet Error Rate (PER) (Corresponding to an Eb/No of about 7.5B for a typical AIS GMSK detector). With the gain set to its optimum level (about –4dB), the maximum signal that the receiver can accommodate on-channel is about –65dBm before the onset of self-generated intermodulation noise. The A/D converter is normally full-scale at around –67dBm.

Given the quantity of AIS data received and correctly decoded including a significant amount of Message type 18 (Class-B position reports) from 39,000 ft sometimes in the presence of interference (from land services), it appears that the receiver performed well. This in itself was a useful indicator for COM DEV in terms of the likely performance expected of the new s-AIS receivers to be shortly launched.

6. LESSONS LEARNED FOR THE RECEIVER

The receiver would have benefited from having Automatic Gain Control (AGC) specifically for aircraft AIS reception due to the tendency for the large number of AIS signals to overload the receiver at low altitude over busy sea areas. However, interestingly, it appears that some moderate overloading of the A/D converters appears to have not had a significant impact on the AIS message detection. This is not surprising since (a) the modulation is GMSK (essentially FM) and (b) there are many AIS messages being received every minute and only a few may exceed the full scale input voltage of the receiver.

For space-based use, the large simultaneous dynamic range of the receiver should be sufficient to avoid the need for AGC even in the presence of land-based interference. The next generation of COM DEV AIS receiver pushes the dynamic range to over 60dB and has increased sensitivity.

7. FUTURE OPTIMISATION

The narrow-band dual-conversion receiver technique appears to offer high performance. However, in supporting future additional AIS channels, the restricted RF bandwidth would be a problem. Also, simultaneous reception of more than two AIS channels is not possible without adding additional radios (though the front-end low-noise amplifier could be shared). In order to support more flexibility in the radio, an IF-sampling or RF-sampling architecture with more in-board signal processing would be considered.

From an s-AIS mission perspective, the more channels that are received, the greater the downlink data capacity that is required. Additional receiving channel capability would offer greater frequency and spatial (i.e. polarisation/beam-forming) diversity. An optimised receiver architecture should therefore provide for a flexible allocation in both frequency and spatial diversity as a means to avoid land-based interference for example. Of course, the receiving channels must be phase-coherent.

8. CONCLUSION

The COM DEV AIS receiver used for the PASTA MARE airborne AIS trial performed well and a valuable set of data was collected. For specifically airborne use, an automatic gain control would be a useful enhancement but for s-AIS use would be of limited benefit.

Future optimisation would centre around being able to flexibly support additional AIS channels and with additional polarisations.