Stationary Cassidian FM Passive Radar demonstrator for 24/7 operation and sensor cluster measurements

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Abstract*: In 2010 Cassidian initiated the development of an improved multiband Passive Radar demonstrator, processing FM, DAB and DVB-T waveforms in real-time, [1]-[8]. System architecture and design considerations were directed towards an operationally full mobile PCL system. The Passive Radar vehicle possesses an integrated mast system and accommodates the electronic equipment as well as the operator's work station. The chosen design enables full mobility, flexible deployment and short installation times in various environments. In 2012 Cassidian decided to set up a second stationary FM Passive Radar system on top of a building on the Cassidian premises in Ulm for permanent 24/7 operation and first sensor cluster measurements.*

1. Introduction

Following the impressive results and long detection ranges Cassidian could achieve with the FM part of its mobile system, the decision was made to set up a second stationary FM system until the end of 2012. The stationary Passive Radar system, see Figure 1, was realized as a nearly one-to-one copy of the FM part of the mobile van (Figure 2). Passive Radar 3D localisation is based on the intersection of multiple ellipsoids. The ellipsoid geometry is based on different focal points for the different transmitter positions and the same focal point for a single sensor position. By means of a second sensor further ellipsoids with focal point in the second sensor position will additionally contribute to the localisation process. Therewith Cassidian will be able to conduct sensor cluster measurements to enhance the target detection and tracking accuracy performance. Track data of both systems (the stationary and the mobile one) can be fed in external networks via standardised ASTERIX protocol. In addition the Passive Radar data is injected into a Cassidian internal multi source integration (MSI) system for 24/7 operation. Since the end of 2012 the system is up and running. First measurements took place in early 2013.

2. System architecture

The antenna system consists of 7 elements for the combined FM/DAB frequency range (88-240MHz) and allows future growths potential by adding an additional DAB receiver component. According to the multiband equivalent the antenna is designed and manufactured in a product-oriented way and comprises an integrated calibration system for improved bearing accuracy.

The FM subsystems use 7 channel direct sampling and down conversion. Real-time processing and tracking is realized by COTS PC hardware. The fused output tracks are visualized on the GIADS compatible operator console ViSys (Visualization System). For a referenced air picture ADS-B data is displayed in parallel on the ViSys for real-time comparison between actual air situation and the Passive Radar performance. Further the Passive Radar tracks can be fed in external networks using standardized ASTERIX cat. 48/62 protocol.

The system architecture is sketched in Figure 3.

3. Mission planning and measurement results

In the planning phase the 8 most appropriate transmitters are selected using the "Cassidian Passive Radar Performance Analysis Tool", [9]. The selection criterion is to optimise the cumulative detection probability around the sensor position in all directions.

The transmitter-receiver situation is sketched in Figure 4. The stationary FM Passive Radar demonstrator is installed on top of a building on the Cassidian premises in Ulm (black dot). The sensor antenna height is 40m above ground. 8 analogue radio transmitters (red dots with additional information on the azimuthal antenna characteristics) situated around the receiver serve as illuminators of opportunity and are processed simultaneously. The distances between transmitters and receiver are ranging from 53km to 135km. Transmit powers are up to 100kW.

Figure 5 shows a snapshot of the operator console ViSys. Passive Radar tracks are displayed as red arrows respectively ADS-B reference in yellow. Passive Radar tracks are generated up to 100km regularly. In consequence of the highly elevated position of the receiver antenna the sensor has line of sight to a strong (10kW) nearby transmitter (2km, Ulm-Kuhberg) which impacts the sensor overall performance due to signal dynamic reasons.

To determine the coverage of the permanently installed sensor in the given environment the system is operated in a continuous running mode. Figure 6 depicts all Passive Radar tracks within a trial duration of 3,5 days. Again a nearly circular coverage around the sensor up to 100km and beyond can be verified. Extended ranges up to almost 200km can be reached in the north of the sensor. In further steps the predicted and the measured coverage will be compared within the validation process of the "Passive Radar Performance Analysis Tool".

3. ASTERIX protocol and fusion into external networks

To use existing infrastructures the Passive Radar output data has to be mapped into standard ASTERIX protocol formats. Active radars typically transfer their data in cat.48 (incl. cat.34) for plots respectively cat.62 for tracks.

For Passive Radar by measurement of the bistatic range each transmitter-sensor pair provides a three-dimensional ellipsoid (foci are transmitter and sensor) on which the target could be located. The 3D localisation is based on the intersection of multiple ellipsoids. These ellipsoids all have the same focal point for the single sensor location and different focal points for the different transmitter positions. Unlike active radar plots the individual bistatic Passive Radar plots do not allow a location of the target in 2D/3D. Therewith the transmission of real Passive Radar plot data is meaningless to standard MST systems and operators. Hence the same tracker output data is used for coding track positions as "pseudo plots" in cat.48 as well as track positions including velocity and heading as tracks in cat.62.

Since common visualisation tools do not provide track history information for cat.62, the additional parallel display of "pseudo plots" in cat.48 visualises both, the high update rate as well as the track behaviour including track attributes as heading and speed. Figure 7 shows the combined information on ViSys.

The Passive Radar is able to provide the ASTERIX data over a TCP/IP data link for the immediate vicinity of the system. For long distance data transfer an UMTS interface has been installed. Cassidian internal the ASTERIX protocol of the stationary demonstrator is fed into the demonstration clone of a multi source integration (MSI) system based on the Cassidian products SurV-In NCW / MONETA for 24/7 operation. In Figure 8 ADS-B and MSSR data are displayed as flags with individual heading vectors. Passive Radar tracks which could be correlated to ADS-B or MSSR are marked as yellow circles.

4. Conclusions and outlook

In this paper an overview of the new Cassidian Stationary FM Passive Radar System is given. The tracking results of the stationary single FM sensor demonstrate very good detection performance for commercial airliners up to 100 km wrt the receiver location.

In summer 2013 Cassidian will conduct sensor cluster measurements, operating the mobile and the stationary system simultaneously to increase the system coverage and track accuracy.

Until the end of the year 2013 Cassidian will upgrade the stationary system by adding DAB capability to increase the track accuracy in the sensor near field.

5. Acknowledgment

The authors would like to thank the representatives of the German Ministry of Defence (BAAINBw, WTD81), the Armed Forces and Fraunhofer FHR/FKIE for their continuous support and numerous discussions on the future potential of Passive Radar.

6. Illustrations

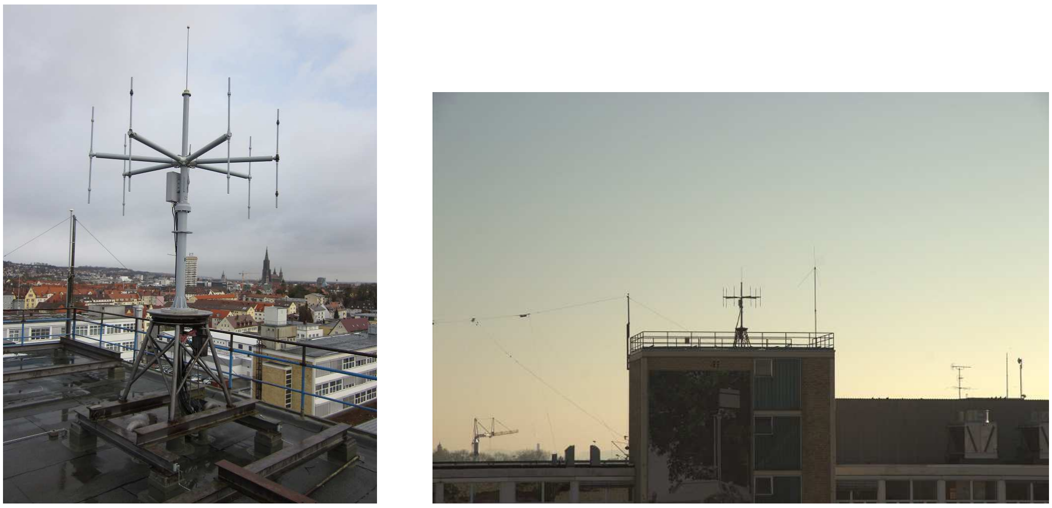

Figure 1: Cassidian Stationary FM Passive Radar Demonstrator

Figure 2: Cassidian Mobile Multiband Passive Radar Demonstrator

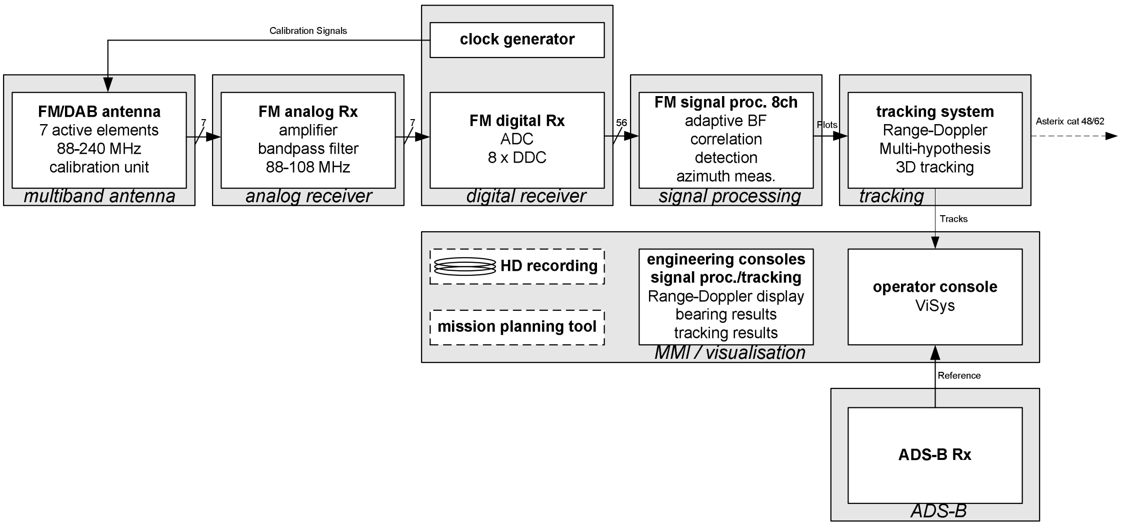

Figure 3: System structure Cassidian Stationary FM Passive Radar Demonstrator

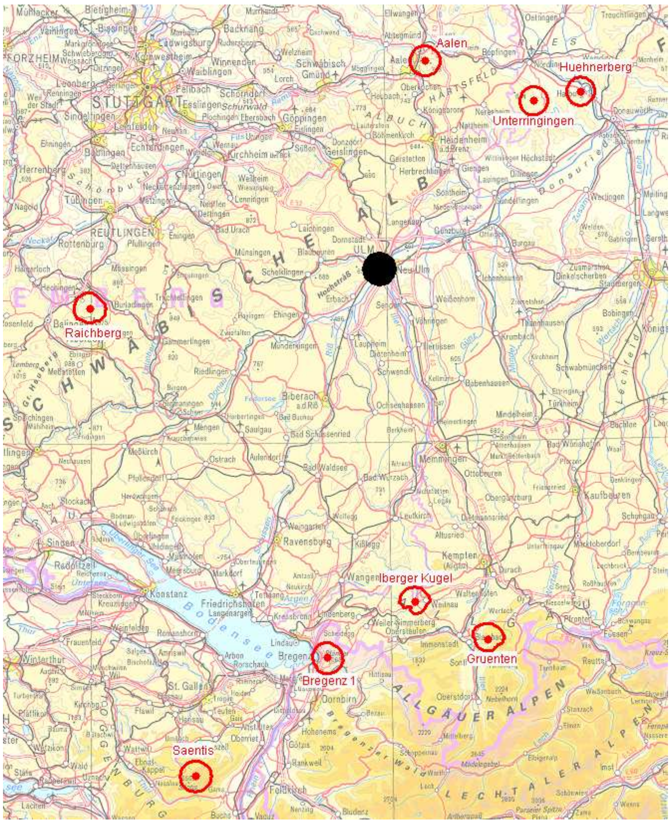

Figure 4: Measurement scenario for Cassidian Stationary FM Passive Radar Demonstrator

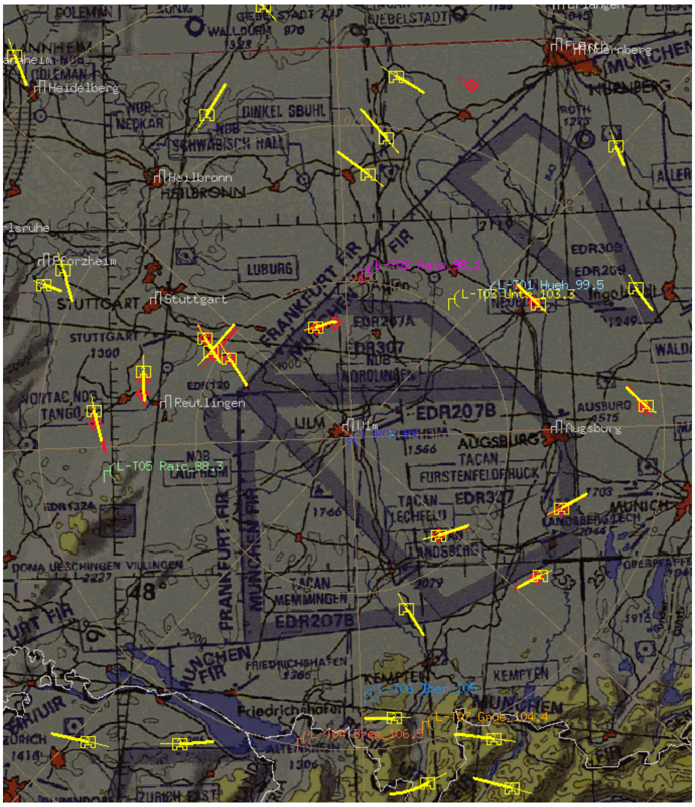

Figure 5: Passive Radar tracks and ADS-B reference in ViSys (Snapshot)

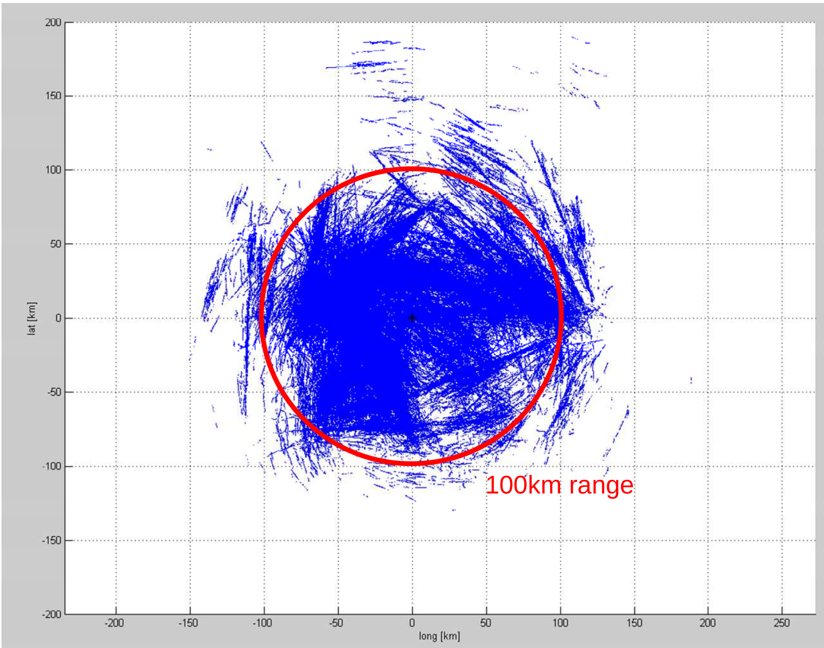

Figure 6: Display of all Passive Radar tracks during a long-time (3,5 days) measurement

Figure 7: Display of Passive Radar data in cat.48/62 in parallel

Figure 8: Passive Radar, ADS-B and MSSR data correlated in MONETA

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