Radar Signature Management Research at PVTT and within PVTO2010 SUOJA

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INTRODUCTION

Radar research in Finnish Defence Forces was originally built around aerial situational awareness and it started with short pulse radars to get range resolution. As the data processing capacity improved defence forces started looking for radars with some pulse compression in order to reach better range resolution and yet to have enough energy to detect targets. Today radar research focuses ever higher pulse compression with wider radar bandwidths. It is not only high range resolution and detailed Doppler processing but also other methods such as (inverse) synthetic aperture radar (I)SAR processing, smart radar control and adaptive waveforms, etc. that has been researched. In the same time noise and multistatic radars impose growing capabilities.

Indeed, it is possible to reach resolutions of 10 cm with today's measurement systems. This makes it possible to detect small targets among clutter and to identify interesting features. For example, in air defence it would be possible to measure length and width and reveal dominant scattering centres of the aircraft depending on the target's flight path. Furthermore, the above developments especially with SAR-image processing (improved resolutions, real time automatic target recognition, interferometry, tomography, polarimetry and moving target identification) require advanced countermeasures for the target to be able to survive in combat. In future satellite -SAR - constellations, and multistatic radars can be expected to enter the area. All this opens an interesting and wide field for research both on radars and radar countermeasures with plenty of challenges.

RESEARCH FACILITIES AT PVTT

Radar signature management is basically studying countermeasures to different radar threats. However, for the survivability and countermeasure studies, it is useful to be able to emulate threat radar up to its signal processing. This is however not straightforward and in some cases it may be even impossible. Therefore, it is usually, taken a consensus with general radars as threat, and yet valuable information can be drawn for operational analysis. The biggest challenge has been to measure the target from different threat angels.

To cope with this an open field test range has been built at Lakiala. It consists of an instrumentation radar from VFH - to Ka-band. The radar has two configuration, the transportable (Fig. 1) and the fixed arm configuration. In the latter case it is installed on the lift at Lakiala's old copper mine tower, which lies ashore of Paroisjärvi -lake.

Figure 1: PVTT instrumentation radar in transportable configuration (left);
And heavy duty tilting turntable with a target (right)

A heavy duty tilting turn table has been constructed on the other side of the lake (Fig. 1) at the distance of 230 m from the radar. The tilting turn table is placed more than 4 m above the lake surface in order to ensure that the lake surface will not cause unwanted ground bounce. The radar can be moved up and down in the tower to minimize the multipath effect. The multipath effect due to the lake was modelled in advance to make certain that an acceptable level can be reached. The ground, after radar reflection measurements, was covered with gravel of size 3-6 mm. The table itself was considered on the stealth point of view to provide as low radar cross section (σ) as possible. However, the reflection from the table to target was not minimized, and radar absorbing material is being used to minimize it.

We have measured objects with σ of -60 to -70 dBsm (dB as referred to 1 square meter) on the table, and these results can still be markedly improved (Fig. 2, left). The resolution at certain bands is limited by FICORA (Finnish Communication Regulatory Authority), but in 26 - 40 GHz band the 1 cm resolution can be reached. If we predict radar signatures over the prohibited bands with the help of data measured at allowed bands, comparable resolution can be reached at 2-18 GHz. Besides integrated stealth, radars can be countered with active and passive measures such as for example jamming, decoys, chaff and radar camouflage as shown in Fig 2 (top right Land Rover, bottom right Land Rover with radar camouflage.

Radar cross section prediction and analysis play an essential role in defence procurements or product development projects. Typically σ values of new vehicles and decoys are calculated before prototypes are made.

PVTT relies mostly on the CAST software which is based on physical optics combined with physical diffraction theory. Furthermore, method of moments is also implemented in the software, and is used when electrically small targets such as antennae are studied. The software is built by VTT. To have realistic σ it is usually calculated over the **hemisphere** with 1 degree steps or smaller. In addition to the CAST, We use Finite Domain Time Difference methods to study antennae and radar absorbing materials.

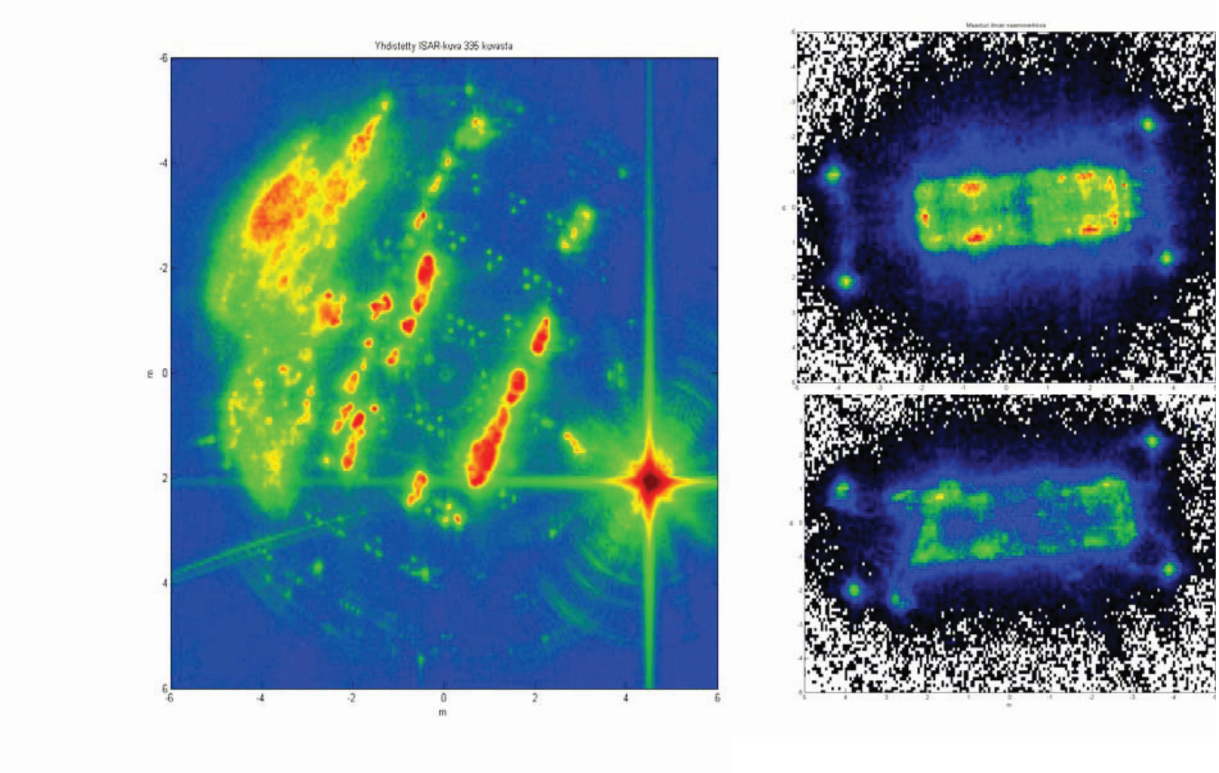

Figure 2: Left motion corrected ISAR –image of the turntable; Top right ISAR-image of a car without radar camouflage; And bottom right ISAR-image of the same car with radar camouflage

The method together with the current processing capacity has not reached to point where the σ values of real size targets can be predicted effectively enough. Indeed, typical target sizes are several metres and the interesting frequency bands may go up to 100 GHz. Therefore, the targets are electrically huge.

Currently PVTT is building intensively methods improve the ISAR image processing capacity, including automatic target recognition viewpoints, and tomographic imaging. In the same time tools are being developed to analyze both radar measurements and signature prediction results. The aim is to analyze the results in terms of battlefield survivability.

PVTO2010 SUOJA

Defence Forces Tecnology Program 2010 (PVTO2010) on Protection is a three year program ending 2012, and its budget is 7.5 MEUR, which is shared on three main tasks: ballictic protection, platform stealth technology, and protection integration (which is mostly simulation and operational analysis).

From the radar signature management viewpoint, the PVTO2010 on Protection includes three interesting branches: 1) low observable unmanned aerial vehicle (UAV) demonstration, which includes state of art available stealth technology (Fig 3), 2) development of a radar cross section prediction software, and

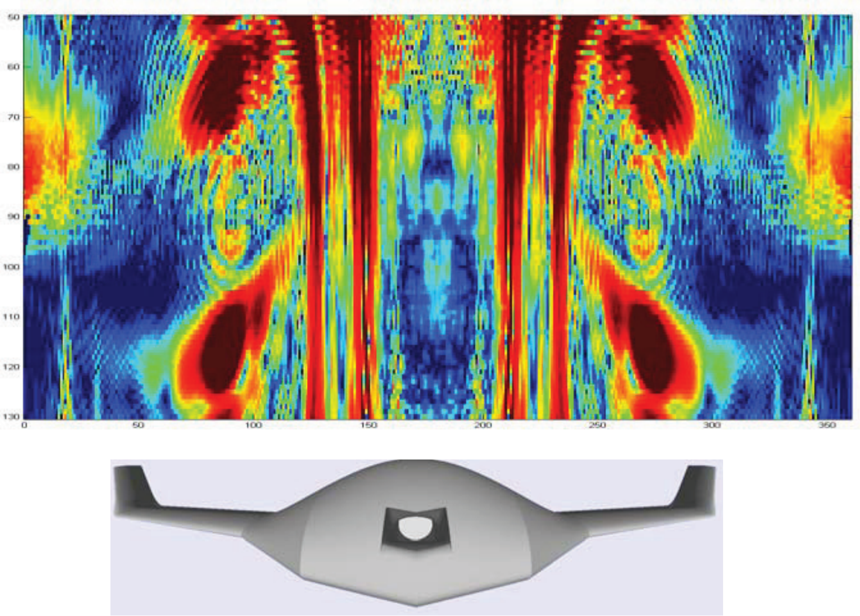

Figure 3: Top radar cross section values of one version of unmanned aerial vehicle as a function of angle at an interesting frequency; Bottom UAV model

an analysis tool to estimate the survivability of targets in a given scenario, and 3) a multistatic radar cross section measurement system.

The low observable UAV produces valuable information, how stealth technology can be utilized in the industry and it also gives a good insight of the effectiveness of different low observable methods in overall. An example of calculated radar cross section is show in the Fig 3. The radar cross section is calculated as a function of horizontal and vertical angle so that the nose of the UAV is in the middle of the figure. It can be easily seen that the winglets cause considerable radar reflection. Thus a new version of the UAV is currently under development. Calculations are completed with CAST software. The model will also be measured at PVTT in order to verify theoretical calculations.

Similarly interesting results can be expected from the software development and the multistatic radar measurement system. The latter ready provides valuable insight in usability of such systems and their challenges.

Fast development of radars and their countermeasures offer an interesting and wide field for research. Multitude of research questions arise from hardware challenges and materials (including metamaterials), as well as from radar cross section calculation and radar data processing, and finally from operational analysis.

POINT OF CONTACT

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