Polarisation

Hello all, so as Chris said I have been studying the potential applications of using polarisation in a radar system.   
  
So In the first few slides I will talk through what polarisation means to a radar and some of the hardware implications before discussing its potential application to EPM. So onto the first slide.  
  
So why is polarisation useful?  
Well, from a radar point of view polarisation is potentially useful as targets and interference can often have different polarisations characteristics. Therefore, if the polarisation is measured this information could be used as a mechanism to tell them apart. In the literature polarisation techniques have been proposed as a means to allow for improved target detectability, target discrimination and target classification.   
  
Presently conventional radar systems do not exploit this information. Most radar systems are single-pol systems which transmit and receive the same polarisation and so all the information about the orthogonal component is lost. In order to capture this information two orthogonally polarised components of the signal must be measured. The radar systems which do this, so-called polarimetric radars, come in two main varieties.

Firstly, There are dual-pol systems which transmit in one polarisation and receive in both and secondly, there are quad-pol systems which transmit and receive in both polarisations, as shown in the figure. These polarimetric systems allow more of the polarisation information to be obtained but are more complex in terms of hardware than the single-pol systems. And In the next slide the hardware implications will be discussed.

Hardware is one of key hurdles in developing a polarimetric radar. The additional complexity required affects all stages of the receive chain.   
At the antenna front end the TRMs become more complex having extra receive and transmit paths. These additional paths require amplifiers, phase shifters and attenuators and All of these additional components must be packaged into a small area. For frequencies above S-band this remains a challenging problem.

Following the AESA the different polarisation components require separate RF beamforming networks. These networks require a high degree of isolation to maintain polarisation purity with isolations of greater than 35dB being quoted in the literature.

At the backend a separate receiver is required for each polarisation component. Therefore, in an antenna with multiple subarrays this doubling of the number of receivers can significantly increase the weight and power requirements of the radar.

And finally, the polarisation-based algorithms themselves can often be computationally demanding thereby resulting in an increased load on the signal processor.

The combined effect of all these factors means that developing a polarimetric radar remains a significant challenge. However, the next few slides discuss some of the potential benefits of polarisation diversity as an EPM technique.

The key idea is that polarisation provides an additional degree of freedom with which to distinguish between signals. For example if a jammer and target signal are both present and their polarisations are sufficiently distinct then a polarisation based filter could be used to block out the jammer while leaving the target signal behind.

In general Polarisation diversity can be applied to both the transmitted and received signals to improve performance. However, In the transmit case, some prior knowledge about the outside world is required to prime the transmit waveform. For example if you knew you were flying against a certain type of jammer then the waveform could be appropriately adjusted. However, in general this might not be the case. In the receive case, by contrast, this is not necessary as the optimal polarisation can be adaptively estimated from the data. This makes receive adaption potentially a more useful strategy. In the following slides two such adapation techniques from the literature will be discussed. Namely, Space-Time-Polarisation Processing and False Target Discrimination.   
  
Let’s start with Space-Time-Polarisation Processing. Conventional STAP algorithms work by taking advantage of spatial and temporal degrees of freedom, to discriminate between targets and interference. In space-time-polarisation processing Polarization is added to provide yet another degree of freedom. Therefore, the usual STAP techniques that are used for jammer rejection are simply extended to incorporate this additional information.

The key advantage of this technique is that it promises improvement in target detection when the interference and target are closely spaced in both the angle and Doppler domains.   
  
A key use case would be against a self-screening mainlobe jammer as shown in the next slide

In the figure on the left the target of interest is obscuring itself and possibly other targets with noise. In this case applying a technique like post-Doppler STAP would simplly place a null on the jammer and so would not reveal the number of targets or their kinematics as in the middle figure.   
  
If, however, the jammer signal is polarised then space-time-polarisation processing can be applied. This would allow the adaptive algorithms to filter out the noise and reveal the targets as shown in the third figure. A key operational advantage.   
  
The second concept is false target discrimination whereby polarisation is used as a means to distinguish between real and DRFM generated false targets. DRFMs work by mimicking the victim’s waveforms to produce target-like signals and so confuse the radar operator, as shown in figure. The problem is that as technology advances the realism of the false signals is continually increasing. This makes the job of detecting these false targets increasingly difficult.

Adding polarisation information would provide another metric with which to try and distinguish between genuine and false targets. For example, If the DRFM has a specific polarisation then all the false targets it produces will have similar polarisation characteristics. The signal processing could then flag these detections as suspicious as shown in the figure. This information combined with other metrics could be used to suppress false targets.

The next stage of work is comprised of two main features, simulation and feasibility. In the simulation stage the effectiveness of these techniques is tested by producing a model of an airborne radar with polarisation diversity. This model will incorporate realistic hardware effects such as cross-polarisation and finite isolation. A number of scenarios will be constructed and the performance of the polarisation based radar will be compared against a fixed polarisation system. This will give an indication of under what scenarios does polarisation give benefit and how much.   
In the feasibility stage collaboration with other Leonardo sites will allow more specific hardware questions to be answered. Firstly, investigate further what specific hardware changes would be necessary in order to implement polarisation diversity in our system. Secondly, how easily can polarisation based processing be defeated by modifying the jammers. If the required changes are minor then this must be taken into consideration.

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So, technically polarization describes the orientation of the electric field vector of a propagating electromagnetic wave. However,   
  
  
that when an electromagnetic wave strikes an object, characteristic information about the object is encoded in the polarisation of the reflected wave. Measuring and using this information is what polarisation radar is all about.

In the literature the key interest behind polarisation diversity is

From a radar point of view polarisation is interesting as it provides an additional degree of freedom with which to discriminate between targets of interest and interference. Targets and interference such as clutter or jammers can have different polarisation characteristics. Measuring and using this information is what polarisation radar is all about. This can either mean that the radar uses polarisation as means to either detect new targets, discriminate between potential targets of interest and interference or identify the t So, technically polarization describes the orientation of the electric field vector of a propagating electromagnetic wave. However,